INSTALLATION RESTORATION PROGRAM

FINAL
FOCUSED FEASIBILITY STUDY REPORT
SITE 21

148th FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA

Prepared For:

NGB/A7OR
Joint Base Andrews, Maryland

September 2010

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Prepared By:

MWH Americas, Inc.

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ACRONYMS AND ABBREVIATIONS

ANG	Air National Guard
ARARs	Applicable or Relevant and Appropriate Requirements
AS	air sparging
Bay West	Bay West, Inc.
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
cis-1,2-DCE	cis-1,2-dichloroethylene
cm	centimeter
COC	contaminant of concern
DCE	dichloroethylene
DO	dissolved oxygen
DIA	Duluth International Airport
DPT	direct push technology
DRO	diesel range organics
Ecolotree	Ecolotree, Inc.
EOS®	emulsified oil substrate
ERM	ERM, Inc.
Exponent	Exponent, Inc.
FFS	Focused Feasibility Study
f_{oc}	fraction total organic carbon
ft/day	feet per day
ft/ft	feet per foot
ft^2	square feet
FW	Fighter Wing
g/cm^3	gram per cubic centimeter
gpd	gallons per day
gpm	gallons per minute
GRA	General Response Action
GRO	gasoline range organics
GW_{ISV}	Groundwater Screening Values for Vapor Intrusion Pathway

ACRONYMS AND ABBREVIATIONS

HRC	Hydrogen Release Compound®
HRL	Health Risk Limit
IRP	Installation Restoration Program
ISCO	In-situ chemical oxidation
K_d	aquifer distribution coefficient
K_{oc}	Soil sorption coefficient normalized for total organic carbon
K_{ow}	octanol-water partition coefficient
lbs	pounds
L/kg	liters per kilogram
LTM	long-term monitoring
LUC/ICs	land use controls/institutional controls
MCL	maximum contaminant level
µg/kg	microgram per kilogram
µg/L	microgram per liter
MCL	maximum containment levels
mg/kg	milligrams per kilogram
MNA	monitored natural attenuation
MNANG	Minnesota Air National Guard
MOSHA	Minnesota Occupational Safety and Health Administration
MPCA	Minnesota Pollution Control Agency
MWH	MWH Americas, Inc.
NCP	National Oil and Hazardous Substance Contingency Plan
NGB	National Guard Bureau
OHSA	Occupational Health & Safety Act
OpTech	Operational Technologies Corporation, Inc.
ORC®	Oxygen Releasing Compound®
O&M	operation and maintenance
ORP	oxidation-reduction potential
PCE	tetrachloroethylene
PCM	post closure monitoring
PRB	permeable reactive barrier
PV	Present Value

ACRONYMS AND ABBREVIATIONS

PVC	polyvinyl chloride
R	coefficient of retardation
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RI/FS	remedial investigation/feasibility study
ROI	radius of influence
SARA	Superfund Amendments and Reauthorization Act
SI	Site Investigation
SRVs	Soil Reference Values
SVE	soil vapor extraction
SVOCs	semi-volatile organic compounds
TCE	trichloroethylene
TI	Technical Impracticability
TPH	total petroleum hydrocarbons
1,2,4-TMB	1,2,4-Trimethylbenzene
U.S.	United States
USEPA	United States Environmental Protection Agency
VAS	vertical aquifer sampling
VC	vinyl chloride
VOC	volatile organic compound
ZVI	zero-valent iron

EXECUTIVE SUMMARY

This document presents the Focused Feasibility Study (FFS) Report prepared for the Air National Guard (ANG) for Installation Restoration Program (IRP) Site 21 at the 148th Fighter Wing (FW) at the Minnesota Air National Guard (MNANG) Base in Duluth, Minnesota. This report was prepared by MWH Americas, Inc. (MWH) under Contract No. DAHA92-01-D-0007, Delivery Order No. 91. The purpose of this FFS is to identify, screen, and evaluate remedial technologies for Site 21, a plume of dissolved trichloroethylene (TCE) along with limited detections of vinyl chloride (VC), and petroleum hydrocarbon contamination (benzene and 1,2,4-trimethylbenzene[1,2,4-TMB]), and to recommend a remedial alternative. This FFS builds on the Final Data Gap Remedial Investigation (RI) Technical Memorandum (MWH, 2010) that summarized RI data gap field investigations.

The Site 21 TCE plume likely discharges to the marsh area associated with Miller Creek. At Site 21, TCE is the main contaminant of concern (COC) and it is limited to groundwater. Other contaminants have been detected at Site 21, such as petroleum hydrocarbon contamination (benzene and 1,2,4-TMB) and diesel range organics (DRO), but are not migrating downgradient towards the marsh. Solubilized TCE has migrated in the aquifer from an unidentified area originating in the vicinity of Building 252. VC also has been detected at the site and is likely the result of in-situ reductive dechlorination of TCE.

Based on an evaluation of chemical-, location-, and action-specific Applicable or Relevant and Appropriate Requirements (ARARs), the remedial action objectives (RAOs) for screening of remedial alternatives described herein were determined to be as follows:

- Provide protection of human health and the environment by achieving the appropriate water quality standards (Health Risk Limit [HRL]), which is 5 micrograms per liter (µg/L) for TCE, and 0.2 µg/L for VC, at the marsh boundary.

- Provide protection of human health and the environment by achieving the appropriate water quality standards (HRL), which is 2 µg/L for benzene, at monitoring well 021-029MW.

Based on the RI data gap investigation, Site 21 site characteristics do not appear to diminish the engineering feasibility of the selected remedial alternative to achieve RAOs; therefore, there appears to be no justification for a Technical Impracticability (TI) waiver at Site 21 at this time.

Prescreening of potential remedial alternatives in the general categories of No Action, Institutional Controls, Intrinsic Remediation (monitored natural attenuation), Extraction and *Ex-situ* Treatment Actions, *In-situ* Treatment Actions, Removal/Disposal, and Containment was conducted. Thereafter, four remedial alternatives were retained and developed in greater detail as follows:

Alternative #1 – Intrinsic Remediation;
Alternative #2 – Phytoremediation;
Alternative #3 – Enhanced Bioremediation;
Alternative #4 – Permeable Reactive Barrier (PRB) Zero-Valent Iron (ZVI).

Each of the retained remedial alternatives was evaluated based upon the following criteria: overall protection of human health and the environment; compliance with ARARs; long-term effectiveness; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and an estimate of probable cost.

Based on this analysis, the combination of Phytoremediation and Enhanced Bioremediation emerged as the most optimal combination of effectiveness, technical feasibility, and duration of performance period. Final selection of the appropriate remedial alternative by the ANG will ultimately depend upon the actual financial scenario and the risk tolerance of the ANG. The combination of Phytoremediation and Enhanced Bioremediation has a higher combined Present Value (PV) cost than PRB ZVI, but is more aggressive in addressing the TCE origination area and effectively treats the entire TCE plume footprint. PRB ZVI may need periodic rejuvenation to restore permeability lost due to accumulation of precipitates and to restore any lost reactivity of the iron, while once in place, phytoremediation can be effective indefinitely. This combination of the two alternatives is expected to reduce concentrations in site wide groundwater to less than the cleanup criterion for TCE (5 µg/L) and VC (0.2 µg/L). The combination of Phytoremediation and Enhanced Bioremediation has a moderately high likelihood of achieving the proposed RAOs.

Additionally, the use of Oxygen Releasing Compound® (ORC®) socks at monitoring well 021-029MW is recommended to address petroleum hydrocarbon contamination (benzene and 1,2,4-TMB). ORC® socks at monitoring well 021-029MW are expected to reduce benzene concentrations in groundwater to less than the cleanup criterion (2 µg/L). Costs for ORC® socks at 021-029MW were not developed as part of this FFS, but are anticipated to be minimal when compared to the evaluated alternatives.

1.0 INTRODUCTION

This report presents the Focused Feasibility Study (FFS) completed for Installation Restoration Program (IRP) Site 21 the 148th Fighter Wing (FW) at the Minnesota Air National Guard (MNANG) Base in Duluth, Minnesota. This FFS Report summarizes the activities conducted during the remedial investigation (RI) data gap investigation, presents zero-valent iron (ZVI) bench scale treatability study results, presents the laboratory analytical results, and evaluates the possible remedial alternatives for groundwater contamination at the site. The IRP at MNANG is being conducted in accordance with the provisions of the of Minnesota Pollution Control Agency (MPCA), and the Resource Conservation and Recovery Act (RCRA), using the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process pursuant to the United States (U.S.) Code, Title 10, Subtitle A, Part IV, Chapter 160. This work is being performed for the National Guard Bureau under Contract No. DAHA92-01-D-0007, Delivery Order No. 91.

1.1 PURPOSE AND ORGANIZATION OF REPORT

The purpose of this FFS is to identify, screen, and evaluate remedial technologies for Site 21, a plume of dissolved trichloroethylene (TCE) and localized dissolved petroleum hydrocarbon contamination (benzene and 1,2,4-trimethylbenzne [1,2,4-TMB]) in groundwater, and to recommend a remedial alternative for this site. This FFS builds on the Final RI Data Gap Investigation (MWH Americas, Inc [MWH], 2010) at Site 21.

This report is intended to summarize a technology screening - based on effectiveness, implementability, and cost - used to select or complete the final remedy for Site 21. Remedial technologies were assembled into alternatives to address the remedial action objectives (RAOs) proposed in Section 2.0 of this report. The retained alternatives were evaluated using the United States Environmental Protection Agency's (USEPA's) nine criteria for evaluating RAOs at CERCLA sites (USEPA, 1988).

This FFS report is divided into six sections and four appendices. Supplemental supporting documentation appears in the Final RI Data Gap Investigation Technical Memorandum (MWH, 2010). Report sections and appendices are described briefly below.

- **Section 1.0,** Introduction, presents the purpose and organization of the report, briefly summarizes site background information, the nature and extent of contamination, contaminant fate and transport, and results of a focused risk review.
- **Section 2.0,** Identification and Screening of Technologies, presents a summary of the Applicable or Relevant and Appropriate Requirements (ARARs) of environmental laws, establishes the RAOs and General Response Actions (GRAs), and evaluates potentially applicable remedial technologies (screened in accordance with USEPA criteria).
- **Section 3.0,** Detailed Analysis of Alternatives, develops the remedial alternatives for Site 21, and presents the detailed analysis of alternatives, including overall protection of human health and the environment, compliance with the ARARs, effectiveness (both long and short term), reduction of toxicity, mobility, and volume; implementability; and cost.
- **Section 4.0,** Screening of Retained Remedial Alternatives, provides a more detailed analysis of the costs associated with each alternative.
- **Section 5.0,** Recommendation, recommends a specific alternative to implement at Site 21.
- **Section 6.0**, References, lists the documents cited in this FFS.
- **Appendix A**, Focused Risk Review
- **Appendix B**, Natural Attenuation Study
- **Appendix C**, Enhanced Bioremediation Substrate Design Calculations
- **Appendix D**, Permeable Reactive Barrier Supporting Design and Vendor Information

1.2 SITE BACKGROUND

This section presents an abbreviated overview of the background for Site 21. Additional details are included in the Final RI Data Gap Investigation Technical Memorandum cited earlier (MWH, 2010).

1.2.1 Site Description

The MNANG Base (Figure 1-1), located at the Duluth International Airport (DIA), is home to the 148th FW. The mission of the 148th FW is to maintain air sovereignty, provide atmospheric attack warning and assessment, and support the air defense of its assigned airspace according to applicable plans and directives. The 148th FW facilities are located on leased property at several locations in the vicinity of the east-west runway of the DIA. The main 148th FW is located on the east side of the airport (Figure 1-2). The City of Duluth owns the main east-west runway and supporting taxiways. Ownership of the remaining property at the airport is divided among the federal government, the State of Minnesota, and the City of Duluth.

Site 21 (Figure 1-2), Imhoff Tank Treatment System, is a former treatment system that provided primary and secondary sewage treatment for the industrial and administrative areas of the Base. Constructed in 1949, the system was comprised of an Imhoff tank, sludge drying beds, and a biological filter bed. A 750-foot outfall pipe discharged the system's liquid effluent into the wetland that is associated with Miller Creek. The City of Duluth connected the area to the municipal sewage system in 1969. No spills or releases have been reported from Site 21.

A Base Entrance Relocation Project has been completed, which relocated the Base entrance road to traverse Site 21. The adjacent wetland, which Miller Creek flows through to the south, is an ecological receptor of concern. The marsh area south and east of Site 21 is part of the Miller Creek wetland. Miller Creek is a designated trout stream (Minnesota Rules 6264.0050) and a protected watercourse subject to Minnesota Statutes Section 105.42. The marsh area is defined by a bermed perimeter road and fence line for the MNANG base to the east and south. Groundwater flow data for Site 21 suggest that groundwater ultimately discharges to this receptor. Surface water from Miller Creek also flows into the marsh area from two infall culverts under the perimeter road near the northeast end of the marsh area, and out of the marsh area from an outfall culvert under the perimeter road near the southeast corner of the marsh area.

1.2.2 Site History

Site 21 was identified in a *RCRA Facility Assessment Sampling Visit Report* completed in July 1988 by Operational Technologies, Inc. (OpTech). A RCRA Facility Investigation was conducted from January to April 1992 (OpTech, 1992). Toluene, xylenes, phenanthrene, pyrene, lead, and total petroleum hydrocarbons (TPH) were detected in soil samples, while TCE and lead were detected in groundwater. An amendment to the RCRA Facility Investigation was completed in November 1993 (OpTech, 1993). A RCRA Facility Investigation addendum submitted in October 1995 stated that volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), TPH, metals, and pesticides were detected at Site 21. A Site Investigation (SI) conducted in 1995 (OpTech, 1996) identified the source of VOC and TPH contamination to be Site 25, which is located adjacent and to the west of Site 21 (Figure 1-2). A Corrective Measures Study completed in March 1996 recommended excavation with thermal treatment and groundwater air sparging for Sites 21 and 25 concurrently. Results of the air sparging and soil vapor extraction (SVE) pilot tests indicated that the application of SVE was considered unfeasible. Results of a field pilot test conducted to evaluate the feasibility of Oxygen Releasing Compound® (ORC®) injections were inconclusive, deeming the remedy unfeasible for the site. Groundwater monitoring was conducted at the site from 1999 through May 2005.

Between March 2005 and October 2006, additional investigation activities were conducted at Site 21 (ERM, Inc. [ERM], 2007), which consisted of installing seven additional monitoring wells at Site 21 and collecting soil and groundwater samples from the site. Results of soil sampling indicated that no compounds were detected in soil greater than Tier 2 Industrial Soil Reference Values (SRVs). Results of the groundwater sampling indicated benzene, TCE, tetrachloroethylene (PCE), and vinyl chloride (VC) were the primary groundwater contaminants of concern at the site.

In July 2006, approximately 1,495 tons of contaminated soil were excavated and removed from Site 21 during the installation of a sanitary sewer line along a new road alignment related to the

Base Entrance Relocation Project (American Engineering Testing, Inc., 2006). Laboratory analysis of the excavated soils indicated diesel range organic (DRO) and gasoline range organic (GRO) concentrations up to 120 milligrams per kilogram (mg/kg) and 16 mg/kg, respectively. No VOCs, SVOCs, metals or pesticides were detected greater than their respective MPCA Tier 2 SRVs.

1.2.3 Site Hydrogeology

Two hydrogeologic units underlie the airport. One unit is the Duluth Gabbro within which groundwater is found in limited quantities in fracture zones. The other unit is the overlying glacial drift consisting of unsorted, nonstratified till, 10 to 60 feet thick within which groundwater generally occurs in limited quantities.

The glacial till forms the principal aquifer, estimated to vary from 20 feet to 25 feet in thickness. The water table occurs at depths of approximately 5 feet below ground surface and is believed to be continuous with surface drainage. The groundwater gradient at Site 21 is to the east and southeast, towards the marsh, with an average hydraulic gradient of approximately 0.0154 ft per foot. Average groundwater flow velocities were calculated using the horizontal hydraulic conductivities from slug injection data. Velocities are likely to range from 6.8 feet per year to 70 feet per year.

Because of their limited capacity to produce water and the availability of abundant surface water, the bedrock and glacial drift have not been developed extensively as aquifers in the Duluth area. The glacial drift, however, is used in rural areas for farm and domestic use. There are many individual water supply wells completed in both the glacial drift and bedrock near the MNANG Base.

1.2.4 Site Surface Water Hydrology

The DIA belongs to the St. Louis River Watershed of the Great Lakes Basin. The southeastern corner of this watershed north of the St. Louis River is drained by several small creeks which flow southeast and join the St. Louis River near its mouth. The rest of the watershed north of the river drains to the southwest and the smaller streams and tributaries join the St. Louis River along its upper reaches.

The airport lies on a drainage divide between the Midway River, Wild Rice Lake, and Miller Creek. Drainage from the eastern and southern part of the airport drains east and south to Miller Creek, which flows into the St. Louis River at St. Louis Bay. Drainage from the northern and western areas of the airfield drain north to Beaver Creek and an improved drainage ditch, both of which discharge into Wild Rice Lake. Wild Rice Lake is drained by the Beaver River and then the Cloquet River which joins the St. Louis River about 19 miles west of the airport. The Midway River drains much of the region southwest of the airport, but does not appear to drain the airport itself.

The adjacent wetland, which Miller Creek flows through to the south, is an ecological receptor of concern. The marsh area south of Site 21 is part of the Miller Creek wetland. Miller Creek is a designated trout stream (Minnesota Rules 6264.0050) and a protected watercourse subject to Minnesota Statutes Section 105.42. The marsh area south of Site 21 is part of the Miller Creek wetland. The marsh area is defined by a bermed perimeter road and fence line for the MNANG base to the east and south. Groundwater flow data for Site 21 suggest that groundwater ultimately discharges to this receptor. Surface water from Miller Creek also flows into the marsh area from two culverts under the perimeter road near the northeast end of the marsh area, and out of the marsh area form an outfall culvert under the perimeter road near the southeast corner of the marsh area.

1.3 NATURE AND EXTENT OF CONTAMINATION

This section presents an abbreviated review of the nature and extent of remaining groundwater contamination at Site 21, based on the results of sampling activities conducted at Site 21 during the MWH RI data gap field investigation and the ERM investigations that preceded it. The RI data gap investigation activities included vertical aquifer sampling (VAS), soil borings with temporary well sampling, permanent monitoring well sampling, and PushPoint (pore water) sampling. The reader is referred to the Final RI Data Gap Investigation Technical Memorandum (MWH, 2010) and the Draft Technical Memo for Sites 3, 4, 21, and 25 (ERM,

2007) for a detailed discussion of these findings, including groundwater analytical summary tables and other supporting documents appended to either report.

1.3.1 Soil Contamination

Between March 2005 and October 2006, soil investigation activities were conducted at Site 21 (ERM, 2007). Results of soil sampling indicated that no compounds were detected in soil greater than MPCA Tier 2 Industrial SRVs. Only one soil sampling location (ERM 7) contained concentrations greater than laboratory reporting limits, for naphthalene at a concentration of 464 microgram per kilogram (µg/kg). Based on the lack of soil detections greater than reporting limits at Site 21, a source for TCE and petroleum hydrocarbon contamination (benzene) in groundwater has not been identified. However, groundwater contamination has been delineated, and the origination area (source areas) has been identified for petroleum hydrocarbon contamination, TCE, and TPH-DRO in the vicinity of Building 252. The MPCA suspects that there are multiple small releases near Building 252, or a release of diluted dissolved phase contamination from a stormwater outfall of the former Imhoff sewage treatment system, but at this time there is no evidence to verify the source of TCE or petroleum hydrocarbon contamination at the site.

1.3.2 Groundwater Contamination

Following groundwater sampling activities during the RI data gap investigation at Site 21, the groundwater contaminants of concern (COCs) are TCE, VC, benzene, and 1,2,4-TMB. The main contaminant of concern at Site 21 is TCE, as it is detected at several locations throughout the site. VC detections greater than the Minnesota Health Risk Limit (HRL) of 0.2 micrograms per liter (µg/L) are limited to two sampling locations (PP-02 and 021-033MW) and are likely the result of reductive dechlorination of TCE. Other TCE daughter products (cis-1,2-dichloroethylene and trans-1,2-dichloroethylene) are present in groundwater but are less than ARARs and therefore considered secondary COCs. Benzene has historically been detected in groundwater at one location (021-029MW), of which the petroleum hydrocarbon source has not been identified. 1,2,4-TMB has been identified at one location (021-029MW) at concentrations greater than the vapor intrusion screening criterion (GW_{ISV}). Naphthalene, ethylbenzene, and xylenes have been detected in groundwater at concentration less than ARARs, and are therefore considered secondary COCs. Previously, PCE was detected in groundwater and was identified as a COC for Site 21 (ERM, 2007). PCE was not detected during subsequent investigations conducted as part of the RI data gap investigation (MWH, 2010).

The nature and extent of groundwater contamination at Site 21 are summarized in Figures 1-3 and 1-4. TCE analytical results from the RI data gap investigation are compared with the Minnesota Health Risk Limit (HRL) for TCE (5 µg/L). The northern extent of TCE contamination is just south of Building 252 (021-033MW), while the southern (downgradient) extent is the marsh boundary near the intersections Mustang Drive and Perimeter Road. Results for Site 21 plume delineation enhancement efforts using VAS, temporary wells, and permanent monitoring well sampling during August 2008, and May 2009 are indicated in plan view on Figure 1-3. Results of confirmatory sampling of permanent groundwater monitoring wells and PushPoint (pore water just below surface water body) sampling conducted during September are indicated in plan view on Figure 1-4. The analytical data for VOCs and diesel range organics (DRO) are summarized in Table 1-1 for VAS and temporary monitoring well sampling locations and in Table 1-2 for permanent monitoring wells. The analytical data for total and dissolved metal concentrations at permanent monitoring wells is summarized in Table 1-3. The analytical data for monitored natural attenuation parameters at permanent monitoring wells is summarized in Table 1-4. Fixed laboratory results from the RI data gap investigation are also summarized in the Final RI Data Gap Investigation Technical Memorandum (MWH, 2010, Tables 2 through 5, and Appendix I, respectively).

The maximum concentrations of dissolved TCE in groundwater were encountered at GP05 (88 µg/L in August 2008) and at 021-036MW (78 µg/L in September 2009). The maximum concentration of TCE adjacent to the marsh boundary was encountered at 021-040MW (46 µg/L). The plume appears to be bifurcated near the marsh boundary, in the vicinity of GP14 and the intersection of Mustang Drive and Perimeter Road. For the purpose of this report, the two TCE legs at the marsh boundary will be referred to as the eastern TCE plume leg and western TCE plume leg.

As a result of the RI data gap investigation field efforts, the vertical extent of TCE has been delineated to the HRL at the marsh boundary. At the western plume leg, TCE was present at 29 feet bgs at monitoring well 021-041MW at a concentration 5 µg/L. The western plume leg is approximately 120 feet wide at the marsh boundary, being bound by non-detect TCE concentrations at GP14 on the eastern edge, and GP11/021-027MW on the western edge. At the eastern plume leg, the plume is estimated to be approximately 55 feet wide at the marsh boundary, being bound by non-detect concentrations at 021-043MW on the northern edge, and GP14 and GP09 on the western edge. The horizontal extent of the eastern plume leg has been approximated as utilities near the intersection of Mustang Drive and Perimeter Road limited further delineation of the eastern TCE plume leg to the west. The vertical extent of TCE in the eastern plume leg at 021-038MW is 20 feet bgs.

Groundwater sampling results upgradient from the marsh and at the marsh boundary revealed the presence of breakdown products of TCE (cis-1,2-dichloroethylene [cis-1,2-DCE]) in the plume (021-14MW, 021-32MW, 021-033MW, 021-036MW, 021-038MW,021-040MW, 021-041MW, 021-042MW, and 021-044MW), implying that biodegradation is a significant attenuation mechanism at this site. Additionally, VC was detected at two sampling locations (monitoring well 021-033MW and PushPoint 021-PP02) at concentration greater than the HRL, further implying that biodegradation is occurring at the site.

In addition, petroleum hydrocarbon contamination (benzene and 1,2,4-TMB) was detected at Site 21 in samples from monitoring well 021-029MW at concentration greater than the HRL or GW_{ISV}. However, the petroleum hydrocarbon contamination was not detected at down gradient sampling locations or at upgradient temporary well locations. TPH-DRO was also detected at upgradient temporary monitoring well sampling locations 021-SB02 and 021-SB03, but was not detected at down gradient sampling locations 021-014MW, GP16(18-22), GP17(26-30). The source areas for current detections TCE, benzene, TPH-DRO and VC at Site 21 have not been identified. However, groundwater contamination has been delineated, and the origination area (source areas) has been identified for petroleum hydrocarbon contamination, TCE, and TPH-DRO in the vicinity of Building 252. The MPCA suspects that there are multiple small releases near the building 252, or a release of diluted dissolved phase contamination from a stormwater outfall of the former Imhoff sewage treatment system, but at this time there is no evidence to verify the source of TCE or petroleum hydrocarbon contamination at the site.

Construction details for monitoring wells with concentrations greater than the HRL for TCE are included in Table 1-5.

1.4 CONTAMINANT FATE AND TRANSPORT

This section briefly discusses physical and chemical processes that affect dissolved phase TCE, dissolved phase VC, and dissolved phase benzene migration at Site 21. Prediction of the behavior of organic chemicals is based on the physical and chemical properties of a contaminant. The significant physical properties of these compounds are listed in Table 1-6.

1.4.1 Trichloroethylene

At Site 21, TCE is the major COC, and it is limited to groundwater. TCE has not been identified in the soil at Site 21 (ERM, 2007). TCE was detected at several sampling locations upgradient of the marsh at concentrations exceeding the State of Minnesota HRL of 5 µg/L, as shown on Figures 1-3 and 1-4. Groundwater contamination has been delineated, and the origination area (source areas) has been identified for TCE in the vicinity of Building 252. The MPCA suspects that there are multiple small releases near Building 252, or a release of diluted dissolved phase contamination from a stormwater outfall of the former Imhoff sewage treatment system, but at this time there is no evidence to verify the source of TCE or petroleum hydrocarbon contamination at the site.

TCE is a solvent used in many industrial processes, especially metal degreasing and dry cleaning. TCE will volatilize from groundwater during seasonal fluctuations in the water table and groundwater temperature fluctuations. Its relatively high water solubility and low octanol-water partitioning coefficient (K_{ow}) value indicate that solubilized TCE may weakly sorb onto soils. TCE can be biodegraded under anaerobic (low oxygen) conditions.

Dissolved TCE will continue to interact with the aquifer media as it migrates advectively, resulting in changes in concentrations and the extent of contamination. Potential reductive transformation pathways for TCE are shown on Figure 1-5. An analysis of the potential for reductive dechlorination was completed based on the RI data investigation and through other available monitoring data. Results of this analysis are included in Section 2.4.4.

1.4.2 Vinyl Chloride

At Site 21, VC is a COC, and it is limited to groundwater. VC has not been identified in the soil at Site 21 (ERM, 2007). VC was detected at two sampling locations (021-033MW and PushPoint 021-PP02) at concentrations exceeding the HRL (0.2 µg/L). 021-PP02 is located within the marsh boundary, while 021-033MW is located up gradient, in the vicinity of Building 252.

The significant physical properties of VC are listed in Table 1-6. VC is a colorless gas used in making polyvinyl chloride (PVC). VC can also be formed when other substances such as trichloroethane, TCE, and PCE are broken down. Liquid VC evaporates easily. VC in water or soil evaporates rapidly if it is near the surface. VC can be biologically degraded in groundwater under a variety of conditions by a wide range of microorganisms. Under strongly reducing conditions, VC can be dechlorinated to ethene if a specific type of bacteria is present (*Dehalococcoides* species). VC can also be oxidized to carbon dioxide under aerobic or anaerobic conditions.

1.4.3 Benzene

At Site 21, benzene is a COC, and it is limited to groundwater. Benzene has not been identified in the soil at Site 21 (ERM, 2007). Benzene has historically been detected at monitoring well 021-029MW at concentrations exceeding the HRL (2 µg/L).

The significant physical properties of benzene are listed in Table 1-6. Benzene is relatively soluble in water and is also toxic and carcinogenic. Benzene can be biologically degraded; aerobic microorganisms readily oxidize benzene to carbon dioxide, while diverse anoxic and anaerobic bacteria can also utilize and degrade benzene to end products that include carbon dioxide and methane (Kazumi, et al., 1997).

1.4.4 Local Groundwater Flow Direction

Water table elevation data from August 2008, May 2009, and September 2009 (Table 1-5) were used to construct equipotential contours at Site 21. The equipotentials for August 2008, May 2009, and September 2009 are shown on Figures 1-6, Figures 1-7, and Figures 1-8, respectively and their configuration confirmed the expected southeasterly groundwater flow direction towards the marsh boundary. The September 2009 water level data formed the basis of a site-specific horizontal hydraulic gradient estimate calculation (discussed in detail in the Final RI Data Gap Investigation Technical Memorandum [MWH, 2010]) and average linear groundwater velocity calculations in the shallow aquifer in this area.

1.4.5 Shallow Aquifer Hydraulic Characteristics and TCE Plume Retardation

The retarded contaminant velocity is only calculated for TCE, as other constituents are not detected throughout Site 21 and do not appear to be migrating. Based on the vertical hydraulic conductivity profiling results conducted in September 2009 (MWH, 2010), the shallow aquifer appears to be laterally and vertically quite heterogeneous. Based on historical (ERM, 2007) and recent (September 2009) hydraulic conductivity tests, values of between 0.257 and 8.71 feet per day (ft/day) are reasonable estimates for shallow aquifer hydraulic conductivity. Water levels collected in 2009 allowed calculation of an approximate horizontal hydraulic gradient of 0.0154 feet per foot (ft/ft) along the plume flow path at this site (MWH, 2010).

Using the following equations, a coefficient of retardation (R) (for linear sorption) was calculated to estimate a retarded contaminant velocity of TCE at this site:

$$R = 1 + (\rho_b/n)K_d,$$

where:

ρ_b = bulk density of aquifer(g/cm^3)

n = porosity

K_d = aquifer distribution coefficient (L/kg)

and

$$K_d = K_{oc} * f_{oc},$$

where:

K_d = aquifer distribution coefficient (liters per kilogram [L/kg])

K_{oc} = soil sorption coefficient normalized for total organic carbon (L/kg)

f_{oc} = fraction total organic carbon (mg organic carbon/mg soil)

To calculate R, a value of 107 L/kg was used for K_{oc} (Wiedemeier *et al*., 1998). A value of 0.0018 was used for f_{oc} based literature values for silt with sand, gravel and clay (Wiedemeier *et al*., 1998). For bulk density an estimated value [1.625 grams per cubic centimeter (g/cm^3)] was used based on values found in literature for glacial sediments (Wiedemeier *et al*., 1998). Porosity was estimated to be 20 percent. These values used in the equations above results in a TCE coefficient of retardation of approximately 2.6. Assuming a retardation factor of 2.6 for TCE at this site, the retarded contaminant velocity is estimated to range from approximately 0.00154 to 0.0523 ft/day.

1.5 FOCUSED RISK ASSESSMENT

A Focused Risk Assessment was conducted by Exponent, Inc. (Exponent) for Site 21 to evaluate the potential human and ecological risks associated with groundwater contamination. The Focused Risk Assessment can be found in its entirety in Appendix A. Past environmental investigations have ruled out soil as a medium of concern at Site 21, and so the risk assessment was focused on the groundwater contamination present at Site 21.

The focused risk assessment evaluated which exposure pathways were potentially complete for both human and ecological receptors, using the site-specific data that were collected and considering site-specific conditions. Site 21 contains developed areas of the ANG base where buildings and roadways are present. The property adjacent to Site 21 also contains many acres of undeveloped land that contain wetlands and a portion of Miller Creek. For media of potential concern, an initial screening level evaluation was completed to compare medium-specific chemical concentrations to risk-based screening values. These screening level evaluations were used to determine if further evaluation of particular pathways were required.

The only media of potential concern identified during the site investigation was groundwater. The potentially complete exposure pathways for groundwater are summarized in the Conceptual Site Model (Appendix A - Figure 1). The contaminated groundwater forms a plume beneath the site that extends from the south side of building 252 where the highest concentration of TCE and benzene were detected to the southeast towards a wetland area. The plume appears to end in the wetlands near the location where Miller Creek flows through the wetlands. Based on site-specific conditions, there appears to be no complete exposure pathways resulting in wildlife receptor exposure to contamination in the groundwater. However, further evaluation of the groundwater contamination in the wetlands was evaluated to be consistent with MPCA surface water pathway evaluation guidelines. Based on the presence of VOCs in groundwater near building 252 greater than vapor intrusion screening criteria, additional investigation was performed by MWH in July 2010 to determine whether the vapor intrusion exposure pathway is complete and affecting indoor air quality within the building.

Based on the results of the focused screening level risk assessment, groundwater is not a medium of potential concern to either human or ecological receptors. The groundwater contamination is present at a depth below ecologically sensitive areas (wetlands), but has not apparently affected the surface water quality in Miller Creek. Based on the Tier 2 ecological evaluation performed, groundwater quality near Miller Creek is less than surface water quality standards based on the push point sampling. While there was a single chemical (i.e., VC) in the leading edge of wetland greater than its Tier 2 surface water quality criteria, this would not be expected to pose an ecological concern because it is located at depth in an isolated location. Therefore no additional ecological evaluation is recommended based on the results of the Tier 2 evaluation.

Concentrations of VOCs in groundwater (i.e., primarily TCE and benzene) are greater than screening concentrations developed by MPCA to determine if vapor intrusion could represent a potential exposure concern to people inside of buildings as a result of groundwater contamination. However, the additional vapor intrusion investigation performed by MWH showed that indoor air quality inside the building is not being affected by the groundwater contamination. While there is some limited migration of VOCs from groundwater to soil gas below the building and sump air inside the building, the indoor air concentrations of VOCs as a result of this migration are generally less than the MPCA screening values. The only exceedances of the indoor air screening values (i.e., ISV) were for benzene and 1,2,4-TMB, and the exceedances are very minor (i.e., within a factor of 2 of the screening value) and appear to be due to the storage of gasoline powered equipment in the building.

2.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

This section presents the identification and screening of remedial technologies intended to address the ARARs and propose RAOs for Site 21. Remedial technologies that can achieve the proposed RAOs for groundwater, which also satisfy the criteria described in this section, will be further developed and evaluated in Section 3.0.

2.1 POTENTIAL ARARS

The following sections describe the ARARs for groundwater at Site 21. ARARs are federal standards, requirements, criteria, or limitations that are applicable to a remedial action (USEPA, 1988). Additionally, state ARARs must be satisfied if they are more stringent than federal ARARs. CERCLA, as amended by the Superfund Amendments and Reauthorization Act (SARA), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) requires compliance with ARARs.

2.1.1 Chemical-specific ARARs

Chemical-specific ARARs are specific to the COCs detected at the site and are typically health or risk-based restrictions on the amounts or concentrations of COCs that may remain in the environment. However, acceptable COC concentrations that will be established are required to be protective of both human health and the environment. The identified chemical-specific ARARs and their consideration in this analysis are summarized in Table 2-1.

As noted in the Final RI Data Gap Investigation Technical Memorandum (MWH, 2010), TCE is the main constituent of concern, and the source has not been confirmed at this site. The release of TCE is regulated under CERCLA. Therefore, the maximum contaminant level (MCLs) established under the Safe Drinking Water Act could be applied. The Minnesota Groundwater Protection Act (Minnesota Statues, Chapter 103H, as amended) Health Risk Limits are relevant and appropriate to the restoration of the aquifer water quality to drinking water standards.

2.1.2 Location-specific ARARs

Location-specific ARARs place limitations or standards on the types of remedial activities that can be performed based solely on the locale of a particular site. The identified location-specific ARARs and their consideration in this analysis are summarized in Table 2-1.

The Clean Water Act Water Quality Effluent Limits are relevant and appropriate in the evaluation of alternatives to be protective of the intended use of the wetland area.

2.1.3 Action-specific ARARs

Action-specific ARARs are typically activity- or technology-based regulations or restrictions on remedial actions or other activities related to mitigation. These are identified based on the particular activities of a remedy. Thus action-specific requirements do not in themselves determine the remedial alternative; rather they determine the regulatory framework by which a selected action is to comply, if implemented. The identified action-specific ARARs and their consideration in this analysis are summarized in Table 2-1.

Numerous guidance documents and local regulations would be considered in the design and operation of any considered treatment facility, the storage and disposal of hazardous and non-hazardous wastes as part of a remedial action, and groundwater and system monitoring requirements. Applicable regulations include the federal Occupational Safety and Health Act (OSHA) and the Minnesota Occupational Safety and Health Act of 1973 (MOSHA).

2.2 PROPOSED REMEDIAL ACTION OBJECTIVES

As described in Section 1.0, the TCE groundwater plume extends from just south of Building 252 to the marsh boundary and appears to be bifurcated near GP14 and the intersection of Mustang Drive and Perimeter Road.

RAOs are the goals of any remedial action for the purpose of protecting human and ecological receptors. These objectives are established for each contaminated medium at the site and must address COCs, exposure pathways, potential receptors, and acceptable contaminant levels or range of levels for each exposure pathway and potential receptor. Acceptable contaminant concentrations must be consistent with the ARARs established for Site 21. The RAOs are used to develop a range of remedial alternatives intended to reduce receptor exposure to contaminated media.

2.2.1 Proposed RAO Basis

Proposed RAOs for Site 21 are to assure that concentrations of groundwater contaminants at the marsh boundary and groundwater associated with Site 21 are at levels that are protective of human health and the environment. For TCE, this protective concentration is 5 µg/L, based on both the federal MCL and the Minnesota HRL for TCE. A remedial action that meets the MCL and HRL for TCE in groundwater would be protective of other receptors and risks besides drinking water, including human contact, vapor intrusion and inhalation, and aquatic life, which all have higher screening values. The comparable protective concentrations for benzene and VC in groundwater are 2 µg/L and 0.2 µg/L, respectively, both based on their HRL. Additionally the Minnesota Class 2A surface water standards for protection of aquatic life are also applicable near Miller Creek and the adjoining wetland. Minnesota Class 2A surface water chronic standards for TCE, benzene and VC are 5 µg/L, 5 µg/L, and 0.17 µg/L respectively.

As stated in Section 1.0, the source of TCE has not been defined but was determined to be immediately south of Building 252. TCE has not been detected in soil at Site 21. The MPCA suspects that there are multiple small releases near Building 252, or a release of diluted dissolved phase contamination from a stormwater outfall of the former Imhoff sewage treatment system, but at this time there is no evidence to verify the source of TCE or petroleum hydrocarbon contamination at the site. Therefore, the proposed RAOs are directed to achieve compliance with groundwater ARARs. Human exposure to the site groundwater will be limited by land use controls/institutional controls (LUC/ICs) that prohibit the use of groundwater at the site. LUCs/ICs are documented by the Air National Guard (ANG) within the Installation Development Plan which has an extensive internal review and approval process. An Installation Development Plan is a 25 year plan and is typically updated every few years. Protection of both human health and the environment would be accomplished by achievement of HRL at the marsh boundary.

2.2.2 Recommended Treatment Area

To establish the recommended treatment area, the average TCE plume concentration and the maximum extent of TCE exceeding the HRL of 5 µg/L was estimated. Based on the RI data gap investigation, TCE concentrations across the site were plotted and contoured in two depth intervals (3 to 13 feet bgs and 13 to 22 feet bgs). Because of the limited detections of VC and petroleum hydrocarbon contamination (benzene), the recommended treatment areas were not developed for either constituent.

Figures 2-1 and 2-2 depict TCE concentrations for each depth interval, and Table 2-2 provides the mass and volume estimate calculations for TCE in groundwater and soil. Based on these calculations, the total TCE mass sorbed to soil and dissolved in groundwater at Site 21 is approximately 1.62 pounds (lbs) (Table 2-3). Figure 2-3 depicts the 5 µg/L TCE contour for the plume, which represents the maximum area exceeding 5 µg/L TCE for either depth interval. The area bounded by this contour is estimated to be 92,942 square feet (ft^2).

The average concentration of TCE within the plume was estimated by adding the volumes of groundwater from both depth intervals and for each iso-concentration contour and then calculating a volume-weighted average TCE concentration (average concentration) for the entire plume. The average concentration was also calculated for each contour interval ($C_{avg} = [C_{max} + C_{min}]/2$). The weighted-average TCE concentration for entire plume is approximately 35.68 µg/L (Table 2-4).

Due the limited detection of petroleum hydrocarbon contamination (benzene) and VC, the recommended treatment areas for both of these constituents were not calculated.

2.2.3 Recommended RAOs

An underlying assumption in this FFS is that the site will achieve RAOs under the current use. Therefore, the currently established or future LUC/ICs would apply to each of the alternatives. On the basis of the preceding discussion, the RAO recommended for Site 21 is to protect human health and the environment by achieving a concentration of 5 µg/L for TCE, 2 µg/L for benzene and 0.2 µg/L in groundwater at the marsh boundary. The general overall goal of achieving the above listed RAOs is to reduce concentrations of TCE and related byproducts in groundwater beneath the site and preventing off-site migration or discharge of contamination. Specific related goals that would be achieved by the above listed RAO are preventing migration and discharge of contaminants towards Miller Creek and wetlands; accelerating natural attenuation; and limiting future exposure to residual contaminants through the use of LUCs/ICs.

Each remedial alternative described herein (coupled with existing LUC/ICs in the short term) strives to achieve the recommended RAO described above. Cleanup requirements for TCE, benzene, and VC in groundwater at Site 21 are based on State of Minnesota's HRL (Minnesota Rules Chapter 4717). This FFS assumes that the groundwater cleanup goals for these contaminants are equal to these HRLs.

2.2.4 Remedial Action-Operation and Post Closure Groundwater Monitoring

For each remedial alternative described below, groundwater monitoring will be required as part of the remedy. The necessary long-term monitoring (LTM) will include Remedial Action-Operation monitoring while the selected remedy is active (i.e., until the RAOs are achieved site wide). Associated monitoring costs are included in cost estimates herein.

At such time as the RAOs are achieved site wide (the remedy-specific time frames necessary, as estimated in this FFS) and operation of the active remedy is curtailed, the RAO is considered met, and all monitoring can cease. Institutional controls (LUCs/ICs) can be lifted at that time, and the monitoring well network can be decommissioned. Estimated costs in this document do not include those for conducting required post closure monitoring (PCM) and decommissioning after RAOs have been achieved.

2.3 IDENTIFICATION OF GENERAL RESPONSE ACTIONS

GRA are broadly defined actions that may satisfy the proposed RAOs, individually or in combination. The response actions are further defined to specify remedial technologies in each GRA category, i.e., containment, groundwater extraction with ex-situ treatment, and *in-situ* groundwater treatment. The following have been identified as possible GRAs which could satisfy the proposed RAOs for Site 21:

- *No Action:* The no-action response provides a basis for comparison and is required by the CERCLA remedial investigation/feasibility study (RI/FS) process. The no-action response includes performing a five-year site review to determine what subsequent actions will be necessary to remediate or delist Site 21 (i.e., remove it from the list of IRP sites and recommend no further action).

- *Institutional Controls:* This response consists of administrative steps that would be undertaken to protect human health by physical restrictions, administrative restrictions, and/or monitoring of contaminants in soil and groundwater.

- *Containment:* This response action includes pump and treat, impermeable walls and trenching configurations and other barriers to contain the contaminant mass in groundwater. Groundwater monitoring, as well as reporting activities would be required to assess the exterior of the barrier system and demonstrate that containment is being achieved.

- *Intrinsic Remediation (monitored natural attenuation [MNA]):* This response action includes natural biological attenuation and other natural processes that can reduce contaminant mass. Groundwater monitoring of specific constituents and parameters, as well as reporting activities, would be periodically required to assess the stability of the contaminant plume and demonstrate the reduction of contaminant mass.

- *Extraction and Ex-situ Treatment Actions:* This response action includes treatment technologies to extract groundwater for *ex-situ* treatment. Groundwater would be pumped from the aquifer, treated to remove contaminants, and disposed (i.e., discharge to surface water or groundwater) or reused. This response would also include the continuation of LTM, system sampling and maintenance, and reporting activities.

- *In-situ Treatment Actions:* This response action includes *in-situ* treatment actions to achieve site cleanup. Possible treatment actions include air sparging (AS) and soil vapor extraction (SVE), enhanced bioremediation, chemical oxidation, phytoremediation, and a permeable reactive barrier.

- *Removal/Disposal:* This response action includes excavation and disposal or treatment of contaminated groundwater and soil as applicable. Contaminated soil would be excavated using conventional excavation equipment. Excavation of soil and groundwater creates residuals that require further management and treated groundwater that requires disposal. Extracted soil could be treated at an on-site soil treatment facility. Alternatively, excavated soil could be disposed of at an off-site commercial facility. Groundwater encountered during the excavation would be pumped and treated separately. Extracted groundwater may also be mixed with the excavated soil to be treated or disposed off site.

2.4 IDENTIFICATION AND SCREENING OF TECHNOLOGY TYPES AND PROCESS OPTIONS

The conventional CERCLA FFS involves a three-step process of considering all possible remedial technologies and systematically eliminating or accepting each option with respect to selection criteria for a particular site. This FFS approach streamlines the CERCLA process by evaluating a selected set of remedial technologies that are known to be feasible for addressing the particular contaminants at this site. A summary of the remedial technology screening is presented on Table 2-5. The technologies listed below only address TCE, and VC as a byproduct. Because the petroleum hydrocarbon detections at 021-029MW do not appear to be migrating, the use of ORC® socks at monitoring well 021-029MW will address elevated benzene detections greater than the HRL. The use of ORC® socks can be used as an interim step to observe the success of remediating the localized detections of petroleum hydrocarbons at monitoring well 021-029MW. Following implementation of ORC® socks at 021-029MW, continued monitoring will indicate if there is a rebound in concentrations. Groundwater monitoring data will be used to determine if future remedial actions may be necessary in the area of 021-029MW.

2.4.1 No Action

The no-action approach would allow contaminants greater than HRL criteria to remain at Site 21 without initiation of active remedial activities. Five-year review reports would be required to document site status. This approach represents a decrease in the level of the current LTM. Because the site does not currently meet either the HRL standard, the no-action response would not satisfy the recommended RAOs. Therefore, this approach has not been retained for further consideration.

2.4.2 Institutional Controls

Institutional controls are generally intended to prevent exposure by limiting site use and development, and include physical restrictions, administrative restrictions, and/or environmental monitoring of contaminants in soil and groundwater. Institutional controls alone would not meet the proposed RAOs and would also leave unacceptable groundwater concentrations in place. Therefore, LUC/ICs have been eliminated from consideration as a stand-alone technology. However, they are retained for use in conjunction with other remedial options. Potential institutional controls include maintaining existing or future LUC/ICs, and continuing LTM until groundwater RAOs are met and the site is returned to unrestricted use.

2.4.3 Containment

A containment response action would be intended to prevent expansion and movement of a source area and the associated contaminant plume. A typical containment system would be constructed of an impermeable barrier around the observed edges of the contamination. In order to determine whether containment is successful, environmental monitoring would be conducted along the edges of the barrier system. Containment would not meet the recommended RAOs because HRLs would still be exceeded. Thus, containment has been eliminated from consideration as a stand-alone technology.

2.4.4 Intrinsic Remediation (Monitored Natural Attenuation)

Intrinsic remediation, or MNA, is a response action in which no engineered remedial activities are performed at the site. Instead, reliance is placed on natural attenuation to reduce contaminant mass in groundwater through physical, chemical, and biological processes. Typically, these degradation processes are monitored using periodic groundwater sampling. By USEPA definition, MNA processes must be demonstrated to be viable at a site before this response alternative can be considered. In addition, USEPA prefers processes that are destructive, such as biodegradation. Advective migration and flushing to a surface water body over a period of time would not be considered MNA in the regulatory context. Furthermore, MNA within the USEPA framework also carries the expectation that it will be used in conjunction with other active remediation measures (e.g., source control).

A natural attenuation analysis performed on recent data collected at Site 21 has concluded that there is limited evidence for natural attenuation reactions occurring in groundwater (Appendix B). TCE breakdown compounds (e.g., dichloroethylene [DCE] and VC) have been detected in the plume upgradient from the marsh area; however, based on the Biochlor model, natural attenuation is not occurring significantly to reach RAOs. Therefore, MNA has been retained for further consideration with the condition that it is paired with other remedial efforts.

2.4.5 Extraction and Ex-situ Treatment Actions

Extraction and *ex-situ* treatment are response actions that rely on the extraction of the contaminated groundwater plume and treatment *ex situ*. An example is pump and treat. A major factor in the success of this treatment action would be the permeability of the impacted aquifer. Extraction and groundwater treatment is a common remedial approach, and several ex-situ treatment methods could effectively treat dissolved phase TCE (*ex situ*). Discharge of the treated groundwater to Miller Creek would be required. These treatment actions require LTM, system sampling, operation and maintenance (O&M), reporting activities, and maintenance of the LUC/ICs for a period of time. Because of the expected high cost of installation and O & M, and the unknown duration of operation, extraction and *ex-situ* treatment have not been retained for further analysis.

2.4.6 In-situ Treatment Actions

In-situ treatment actions include physical, chemical, and biological treatment technologies that are implemented within the aquifer to meet RAOs. Possible *in-situ* treatment actions for Site 21 include AS/SVE, chemical oxidation, enhanced bioremediation, phytoremediation, and a permeable reactive barrier. Each of these technologies is discussed in more detail below.

2.4.6.1 Air Sparging/Soil Vapor Extraction

AS, an *in-situ* remedial technology that volatilizes contaminants adsorbed to soils and dissolved in groundwater, is often used in conjunction with SVE. An AS system injects pressurized air into the saturated zone through wells screened below the depth of maximum contamination. The injected air moves upward through flow channels from density/buoyancy forces. It continues upward and outward by pressure differentials through capillary fringe soils, and into unsaturated vadose zone soils. As it moves upward, VOC contaminants volatilize into the air stream. An SVE system extracts these vapors with a vacuum, removing the contaminants from the subsurface. The contaminants are then typically destroyed through thermal or catalytic oxidation or sorbed to activated carbon to control air pollution.

The contaminant distribution at the site requires airflow to pass through the groundwater plume which, given the aquifer permeability and heterogeneity at this site, could be difficult to accomplish by AS. AS could reduce the treatment zone contaminant concentrations and a vapor treatment system would eliminate vapors. A corrective measures study completed in March 1996 recommended excavation with thermal treatment and groundwater air sparging for Sites 21 and 25 concurrently. Results of the AS/SVE pilot test indicated that the application of SVE was considered unfeasible (Bay West, Inc. [Bay West], 1997). Therefore, the approach of AS/SVE has not been retained for further consideration.

2.4.6.2 Chemical Oxidation

Chemical oxidation is a viable *in-situ* treatment technology for VOC destruction in a groundwater plume. *In-situ* chemical oxidation (ISCO) involves injecting a chemical oxidant into the aquifer to oxidize organic contaminants, including TCE, to non-hazardous end products. The chemical oxidants that are most commonly employed for treatment of TCE include peroxide, permanganate, and persulfate. These oxidants can facilitate the rapid and complete chemical destruction of many toxic organic chemicals; other organics are amenable to partial degradation as an aid to subsequent bioremediation. In general, oxidants can achieve high treatment efficiencies (e.g., greater than [>] 90 percent) for unsaturated aliphatic (e.g., TCE) and aromatic (e.g., benzene) compounds with very fast reaction rates (90 percent destruction in minutes). Field applications have clearly affirmed that matching the oxidant and *in-situ* delivery system to site-specific conditions is the key to successful implementation. Oxidant dosage must be sufficient to oxidize not only the target contaminants but also naturally occurring reduced species in an aquifer (e.g., natural organic matter, reduced iron). This typically requires injection of very high oxidant dosages, and as a result, treatment of relatively dilute plumes is not cost effective. Given the permeability and heterogeneous nature of the shallow aquifer at Site 21, injectable oxidants described may not be effectively applied to COCs. Therefore, ISCO has not been retained for further consideration.

2.4.6.3 Enhanced Bioremediation

Enhanced bioremediation involves the injection of substrate, electron acceptors (e.g., dissolved oxygen), nutrients, and/or microorganisms into the treatment area and possibly the surrounding groundwater plume to promote the biological degradation processes. For TCE, the fastest biodegradation pathway would likely be under anaerobic conditions, as described below.

The introduction of substrate into an aquifer is a common approach to enhance the natural biodegradation process. Typical substrates, such as lactic acid, molasses, emulsified oil substrate, and Hydrogen Releasing Compound® (HRC®), a proprietary polylactate ester that slowly releases lactate when hydrated) are added to the aquifer to provide a food and hydrogen source for biological stimulation. These substrates provide indigenous microorganisms (bacteria) with energy and function as an electron donor, resulting in acceleration of in-situ biodegradation rates for chlorinated hydrocarbons by supporting anaerobic reductive dechlorination processes. Naturally occurring microorganisms metabolize the substrate, resulting in the creation of anaerobic aquifer conditions and the production of hydrogen. Microorganisms then use the hydrogen to remove chlorine atoms progressively from chlorinated hydrocarbon contaminants (i.e., convert TCE to DCE then to VC, and finally to ethene, which is innocuous). HRC® is supplied as a viscous liquid for direct injection into saturated soils and groundwater.

Injection of substrate, and additional nutrients if necessary, into the treatment zone would allow the indigenous microbial population to increase and then degrade chlorinated compounds within the treatment zone at a faster rate than would be expected under natural conditions. If naturally occurring microorganisms are not present, or not capable of degrading chlorinated compounds, commercially available bacterial cultures that are known to facilitate complete dechlorination of TCE can be injected into the subsurface along with the substrate and nutrients. Enhanced reductive dechlorination of TCE would most likely require the reapplication/re-injection of substrate and additional nutrients, as the TCE source has not been identified and may continue to release TCE to the groundwater for an undetermined amount of time.

Enhanced bioremediation is currently being applied to IRP Site 3 at MNANG. Given the positive results of enhanced bioremediation at IRP Site 3, and the similarity of subsurface conditions to Site 21, enhanced bioremediation may enhance TCE degradation at Site 21. Therefore, this technology is retained for use in conjunction with other remedial options to enhance TCE degradation at “hot spots”, or within the area where TCE groundwater contamination appears to originate.

Some contaminants, including benzene, can be readily biodegraded under aerobic conditions. During 1996, AER, Inc. conducted at field pilot test to evaluate the feasibility of ORC® injections. Results of a field pilot test were inconclusive, deeming the remedy unfeasible for the site. However, it is recommended that ORC® socks be placed in monitoring well 021-029MW as an interim measure to address consistent benzene detections greater than the HRL in the vicinity of this well. While benzene has not been detected at concentration greater than the HRL elsewhere at Site 21, and the benzene detections are localized at 021-029MW, the use of ORC® socks would assist in stimulating aerobic biodegradation near this well.

2.4.6.4 Phytoremediation

The use of phytoremediation can be an effective remedial measure to address contaminated groundwater at Site 21. Phytoremediation involves the use of plants to remediate soil or groundwater contaminated with organic contaminants such as petroleum hydrocarbons and chlorinated solvents. The use of poplar trees has been demonstrated to effectively reduce chlorinated compounds and concentrations in groundwater. The proposed phytoremediation uses deep-rooted poplar trees to pump groundwater through leaves to the atmosphere via transpiration. The root-associated microflora in the subsurface mineralize targeted the chlorinated solvents (TCE and VC) or petroleum hydrocarbons (benzene) and will eventually reach regulated action levels in the near-surface aquifer. Based on the ability of phytoremediation to lower concentrations of chlorinated solvents and petroleum hydrocarbons in groundwater, this remedial option has been retained for further analysis.

2.4.6.5 Permeable Reactive Barrier

The installation of a permeable reactive barrier (PRB), specifically a ZVI wall, can be an effective remedial measure. PRBs are installed down gradient from or in the flow path of a contaminant plume. The ZVI remediates contaminants as they move through the reactive media from which the wall is composed (i.e., iron). As TCE migrates through the ZVI wall, dehalogenation occurs due to the oxidation of the iron. The electronegativity of the iron reduces the TCE to its breakdown compounds (DCE and VC), and ultimately down to ethane and ethene. Success of a PRB is based on aquifer permeability, lateral extent of the plume, the concentration of naturally occurring inorganics, and the concentration of the COCs themselves, as they all affect the physical properties that the wall must encompass. Based on its ability to dechlorinate TCE, this remedial option has been retained for further analysis.

2.4.7 Removal/Disposal

As noted earlier, dissolved phase TCE is constantly in flux with submerged soils within the plume. Excavation of the soils interacting with the plume could be implemented to achieve the RAOs. Excavation of impacted soils involves conventional construction equipment and practices. Impacted soils are excavated, and placed into temporary stockpiles or onto haul trucks. Samples are typically collected from the excavated spoil piles and analyzed to determine the contaminant concentrations, prior to treatment or disposal in a landfill. Excavation of impacted soils at Site 21 would involve a moderately difficult active remedial approach. Given that TCE contamination reaches 25 feet bgs, is mostly saturated, and that the approximated impacted area exceeds 102,980 ft^2, the design of the excavation would be complex. Excavated materials could be treated at an off-site facility (reducing the ANG's long-term liability of the excavated material), or disposed of at an off-site location. The large volume of soil to be excavated and the depth/complexity of the excavation have deemed this alternative impracticable; therefore, it is not retained for further analysis.

3.0 DETAILED ANALYSIS OF ALTERNATIVES

In this section, the remedial technologies that passed the technology screening process are assembled to develop a suite of remedial alternatives, which are subjected to a detailed analysis. The assembled remedial alternatives, each of which would be coupled with LUC/ICs and ORC® socks in monitoring well 029-021MW to address petroleum hydrocarbon contamination (benzene) detections, are listed below:

1) Intrinsic Remediation (MNA)
2) Phytoremediation
3) Enhanced Bioremediation
4) PRB – ZVI

3.1 ASSESSMENT CRITERIA

The detailed evaluation of the alternatives in this section will be based on the following seven criteria as directed by the ANG Investigation Guidance (ANG, 2009):

- Overall protection of human health and the environment;
- Compliance with ARARs;
- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, or volume;
- Short-term effectiveness;
- Implementability; and
- Cost.

The criteria are considered individually and are equally weighted. These criteria are explained in detail in the following paragraphs.

It should be noted that two remaining assessment criteria (state acceptance and community acceptance) are also evaluated in the CERCLA remedy selection process. State and community acceptance are often considered after the FFS is completed and the proposed plan is presented and the public comment period is completed. The MPCA has been involved in reviewing and commenting on the remedy options evaluated.

3.1.1 Overall Protection of Human Health and the Environment

This analysis includes an evaluation of how the alternative achieves and maintains overall protection of human health and the environment. This includes determining if the alternative reduces the risk from potential exposure pathways through treatment, engineering, and/or institutional controls.

3.1.2 Compliance with ARARs

Under this criterion, the alternative is evaluated in terms of its compliance with federal and state ARARs, or if a waiver is required. If a waiver is required, it includes how the waiver is justified.

3.1.3 Long-term Effectiveness and Permanence

This analysis evaluates long-term effectiveness of the alternative with respect to the permanence of the alternative, whether the RAOs are met, the magnitude of residual risk, and the adequacy and reliability of controls used to manage remaining waste over the long term.

3.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

The remedial alternative is evaluated against the anticipated performance of the proposed treatment technologies.

3.1.5 Short-term Effectiveness

This criterion includes an evaluation of the effectiveness of an alternative in protecting human health and the environment during the construction and implementation of a remedy until the response objectives are met.

3.1.6 Implementability

Under this criterion, the alternative is evaluated for the technical and administrative implementability of the alternative and the availability of the goods and services needed to implement the alternative.

3.1.7 Cost

The alternative is evaluated in terms of its estimated present-worth costs, which includes capital costs, indirect costs, operation and maintenance costs, and review costs. Unit costs are based on experience at similar sites, publically available information, and information from vendors. An interest rate of four and half percent is assumed in the net present worth estimates. The actual cost for a given alternative is expected to be within the range of -20 percent to +20 percent of the cost estimate presented in this FFS.

3.2 ALTERNATIVE 1: INTRINSIC REMEDIATION (MNA)

Alternative 1 (MNA) would involve the continued sampling and analysis of groundwater from monitoring wells at Site 21. Monitoring of the site would be conducted on an annual or semiannual basis in order to track plume migration and the progress of natural attenuation. Based on the current available groundwater analytical data for Site 21, an analysis of the natural biodegradation of existing VOCs in groundwater was conducted. Biochlor software (USEPA, 2002) was used to assess the viability of MNA at this site (Appendix B). Completion of the USEPA's screening table yielded a score of 10, denoting that there is limited evidence for anaerobic biodegradation of chlorinated organics at this site. The score is based on a series of questions about the type and presence of contamination, the subsurface conditions, and evidence of degradation byproducts. The score implies that if the current biological activity is left unaided, MNA may not degrade TCE to the target criterion of 5 µg/L upgradient from the marsh and Miller Creek. Instead, the entire plume would migrate advectively (with limited degradation) and migrate into the marsh area surrounding Miller Creek at concentrations exceeding 5 µg/L.

3.2.1 Overall Protection of Human Health and the Environment

Institutional controls will provide protection of human health and prevent exposure to contaminants in groundwater while attenuation is taking place. As contaminant levels attenuate to concentrations less than HRLs, this alternative will provide overall protection of human health and the environment.

3.2.2 Compliance with ARARs

The source area has not been identified for at Site 21, therefore it is uncertain how long TCE will continue to be present in groundwater. If the source depletes, contaminant levels in groundwater will naturally attenuate, and groundwater will eventually meet ARARs.

3.2.3 Long-Term Effectiveness and Permanence

Based on the natural attenuation assessment for Site 21 (Appendix B), it is unlikely that MNA (in the regulatory sense of the term) as the sole groundwater remedy would achieve RAOs within the plume area under current conditions, within a reasonable time frame. Since very little biodegradation of TCE is expected to occur under current conditions, the contaminant mass would not be reduced significantly. If eventually the unidentified sources of the TCE and petroleum hydrocarbon contamination (benzene) are depleted, the plume concentrations would likely decrease with time as the plume mass migrates downgradient and discharges to surface water at the marsh boundary. Long term monitoring will provide an effective means for quantifying the rate of natural attenuation at the site.

3.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment

This alternative does not actively reduce the mobility, toxicity, or volume of the COCs in groundwater. If natural attenuation occurs, there will be a reduction in the toxicity and volume of the contaminants in groundwater. Groundwater monitoring will allow for periodic assessment of the decrease in contaminant concentrations as natural attenuation occurs.

3.2.5 Short-Term Effectiveness

Institutional controls will be effective in reducing the possibility of human exposure to groundwater contamination at the site while contaminant levels are attenuating. Groundwater sampling will effectively monitor attenuation. MNA would thus be effective over the short term.

3.2.6 Implementability

Technical Feasibility: Since this approach uses LTM, no technical difficulties to the implementation of this approach are anticipated.

Administrative Feasibility: No administrative difficulties are anticipated for this technology. However, incorporation of this approach into the LUC/IC management plan would be required to ensure maintenance of the LUC/ICs.

Availability of Service and Materials: All services and materials are readily available.

3.2.7 Cost

A cost was not developed for this option because the MNA screening results revealed that natural attenuation is not a viable option as the primary groundwater remediation approach at this site. However, is applicable to be used in conjunction with other remedial technologies. If MNA is used for with other remedial alternatives, the MNA cost is included within that specific alternative cost evaluation.

3.3 ALTERNATIVE 2: PHYTOREMEDIATION

3.3.1 Background

Phytoremediation uses plants to remediate contaminants in contaminated soil, sludge, sediment, ground water, surface water, and waste water. The combination of plant-related biological processes, soil agronomy, site hydrology, installation techniques, and plant physiology can develop a predictable reactor to accomplish contaminant degradation, removal, or immobilization. These processes primarily occur in the rhizosphere, an area in the soil that extends the entire depth of the active root system plus the capillary fringe. The area with the greatest microbial activity is approximately two centimeter (cm) away from the root surface, but organic and fertilizer amendments at time of planting immediately increase adsorption and microbial mineralization. The primary mechanisms include:

- **Phytosequestration**: Immobilizing compounds (e.g., metals) in the rhizosphere
- **Rhizodegradation**: Biodegradation of contaminants in the rhizosphere
- **Phytohydraulics**: The evaporation/transpiration of water (for hydraulic control)
- **Phytoextraction**: Contaminants taken up into the plant matter
- **Phytodegradation**: Degradation that occurs as part of photosynthetic processes
- **Phytovolatilization**: Contaminants taken up and transpired (e.g., volatilized)

Soil microbial activity (and resulting biodegradation) can be up to four magnitudes greater in the rhizosphere (rhizodegradation) than in other areas. The microorganisms are capable of degrading a large range of mineral and organic contaminants, including dissolved phase chlorinated solvents; therefore, contaminant mass is reduced in-situ. Dissolved phase contaminants are also entrained in root groundwater uptake and removed either through phytoextraction, phytodegradation, or phytovolatilization. Phytoremediation is typically only applicable at sites with groundwater contamination to a depth of 15 feet bgs, but is further evaluated to address contamination as there are areas within the plume foot print where groundwater contamination is at or just below 15 feet bgs.

3.3.2 Conceptual Design

This alternative evaluates the use of phytoremediation through the use of poplar trees to address contaminated groundwater. Figure 3-1 presents a conceptual design of Alternative 2. Dissolved phase contaminants will be address by phytoremediation through the use of poplar trees in an area upgradient of the marsh and Miller Creek, on the north side of Mustang Drive. Ecolotree, Inc. (Ecolotree), a phytoremediation specialty firm, was contacted for guidance in determining the estimates for phytoremediation implementation at Site 21. Ecolotree recommends implementation of an Ebuffer®, which is their patented technology that allows the growth of large stems and deep roots to address groundwater contamination. The following paragraphs discuss some of the key site-specific factors that control the overall implementability, effectiveness, and cost of phytoremediation for Site 21. Prior to implementation of phytoremediation, a pre-design evaluation would need to be conducted to further assess site soils and installation area. In addition, LTM, reporting, and maintenance of the established and future LUC/ICs would be a key component of this alternative.

Spacing / Area Requirements. The optimal tree spacing and resulting overall area required depend upon numerous factors, such as the groundwater flow velocity, the plant dormancy period, the plant moisture uptake rate, in-situ degradation rates, the tree canopy/diameter, the cutting/harvesting cycles, and many other factors. These factors will be evaluated in more detail during the design phase of this alternative, if selected.

- **Spacing**: A typical objective for spacing is achieving canopy (full aerial leaf cover) quickly, using the available space effectively, and allowing access for future maintenance. Ecolotree normally spaces the trees on 10 to 14 feet between rows and 5 to 7 feet between trees in the row.

- **Groundwater uptake Per Tree**: Site-specific effective groundwater uptake per tree is perhaps the most difficult parameter to predict because it is dependent upon so many factors. Ecolotree stated it is also one of the most over-predicted and over-promised parameters that can lead to project not meeting expectations. Two other key factors that reduce the effective rate are the dormancy period and the micro-climate effects when trees are closely spaced. For these reasons, Ecolotree uses Hydrus 1-D modeling to predict the water uptake for a tree buffer at full canopy. This takes into account the climate, the plant, and the soil texture. During the actual design of this alternative, Hydrus 1-D modeling will be used to calculate the effective annual average uptake rate. For the purpose of this alternative evaluation, an effective annual average uptake rate of 10,000 gallons per day (gpd)/acre is assumed. Ecolotree typically plants approximately 500 to 600 trees per acre.

Groundwater Flux: The *Final Site 21 Remedial Investigation Data Gap Investigation Technical Memorandum* (MWH, 2010) reports the calculated groundwater flux for the western TCE plume leg is 1.12×10^{-3} cubic feet per second (cfs), while the calculated groundwater flux for the eastern TCE plume leg is 4.834×10^{-5} cfs. The combined groundwater flux for the contaminant plume migrating to the marsh boundary is 1.16×10^{-3} cfs or 0.52 gallons per minute (gpm).

Area Required: Given the assumptions above, approximately 0.07 acre would be required to hydraulically contain the plume. To be conservative, the area proposed for planting includes a 0.5 acre area as identified in Figure 3-1. Phytoremediation is typically only applicable at sites with groundwater contamination to a depth of 15 feet bgs. Therefore, the conceptual design (Figure 3-1) proposes the phytoremediation planting area at an area up gradient from the marsh in a location where higher concentration groundwater contamination exists at shallower depths.

3.3.3 Overall Protection of Human Health and the Environment

This alternative will be effective in overall protection of human health and the environment. During installation of trees, institutional controls will reduce the likelihood of the public coming into contact with contaminated groundwater. Once treatment is complete for this alternative, groundwater will no longer pose a threat to human health or the environment down gradient of the phytoremediation area. Under this remedial alternative, areas upgradient of the phytoremediation area will not be remediated until it contaminants flow downgradient to the phytoremediation treatment zone. Existing groundwater that is downgradient of the treatment zone will not be treated via phytoremediation, but is assumed to biodegrade and discharge to the marsh. Therefore, the appropriate ICs and LUCs should be in place to restrict groundwater use upgradient and downgradient of the phytoremediation area.

3.3.4 Compliance with ARARs

Phytoremediation can achieve ARARs at locations downgradient of the installed area. Once treated, the groundwater that has migrated through the phytoremediation area will meet appropriate ARARs. Groundwater that is located downgradient of the installed area will not be treated and will continue to flush to the marsh as a contaminant slug.

3.3.5 Long-Term Effectiveness and Permanence

This alternative will be effective over the long term because it removes COCs from groundwater.

3.3.6 Reduction of Toxicity, Mobility, or Volume through Treatment

This treatment alternative will reduce the toxicity and volume of contaminated groundwater.

3.3.7 Short-Term Effectiveness

Institutional controls and health and safety measures will be effective in reducing the possibility of human exposure to groundwater contamination at the site during installation of phytoremediation plantings. Current groundwater monitoring wells adjacent to the marsh will effectively monitor remedial effectiveness.

3.3.8 Implementability

Technical Feasibility: Implementation of phytoremediation would not be difficult because the immediate vicinity is free of buildings, power lines, and utilities. The proposed planting area covers existing buildings (Building 248 and Building 249). The 148th FW has indicated that these two buildings will be ultimately demolished, per the Master Plan for the 148th, with no expected development in that area. Prior to implementation of phytoremediation a pre-design evaluation would need to be conducted to assess site soils and the installation area and to confirm that phytoremediation is applicable at Site 21.

Administrative Feasibility: No administrative difficulties are anticipated for this technology; however, MPCA approval of a work plan would be required.

Availability of Service and Materials: All services and materials are readily available.

3.3.9 Cost

Costs for phytoremediation are based on the following assumptions:

1. A predesign evaluation will be conducted prior to design and implementation and will include an assessment of soils and the installation area;
2. 0.5 acre (very conservative estimate) will be required for treatment of groundwater plume;
3. Groundwater up-take per acre is estimated at 10,000 gpd (for full canopy plants);

4. Roots will be able to address contamination at depths up to 15 feet bgs.

5. System performance monitoring costs were developed for 15 years, plus two years LTM following conclusion of performance monitoring (additional years may be necessary); and,

6. Site closure documentation and well abandonment costs are included.

The cost associated with this alternative is presented in Table 3-1. Assuming a four and half percent interest rate, the 15-year, present value (PV) for this alternative is approximately $577,072.

3.4 ALTERNATIVE 3: ENHANCED BIOREMEDIATION

Alternative 3 (Enhanced Bioremediation) would include the injection of substrate, and nutrients and microorganisms if necessary, to establish a subsurface environment upgradient from the marsh and Miller Creek that is conductive to biodegradation of TCE. In addition, LTM, reporting, and maintenance of the established and future LUC/ICs would be a key component of this alternative. The following sections present a conceptual design for evaluation, comparison, and costing purposes only. If selected, the final design would be modified based upon additional data or site constraints identified during pre-design activities. Figure 3-2 presents a conceptual design for Alternative 3.

3.4.1 Conceptual Design

The proposed enhanced bioremediation approach for Site 21 consists of injecting substrate in the saturated zone in a staggered, double-row array to reduce contaminant levels in the TCE hot spot area surrounding GP04, GP05, GP06, 021-029MW, and 021-033MW, as shown on Figure 3-2. This treatment zone is located south of Building 252 and is believed to be the origination of the TCE contamination. Preliminary design calculations resulted in an array of 20 injection points located on 10-foot centers that cover the lateral extent of where the TCE plume has been determined to originate. Additionally, three arrays of injection points are proposed to treat the TCE plume down gradient of the origination area prior to migrating to the wetland boundary. An array of 15 injection points on 10-foot centers in the middle of the plume footprint, along with two arrays (15 injection points and 9 injections points) adjacent to the wetland boundary are proposed.

Prior to implementation, a bench scale microcosm study (performed using soil and groundwater samples collected from the TCE origination area near GP04, GP05, GP06, 021-029MW, and 021-033MW) would need to be completed to confirm that enhanced bioremediation can achieve complete dechlorination of TCE at this site. A bench scale microcosm study will identify the effective formulations of bioremediation substrate and the required potential bioaugmentation bacterial culture as appropriate. Additionally an injection pilot test will be conducted prior to full scale implementation to assess the effectiveness of the substrate delivery method, to determine the radius of influence, and assess degradation of the Site contaminants of concern.

The bioremediation substrate, such as emulsified oil substrate (EOS®), could be injected using either direct push techniques (DPT) or conventional wells. The choice between these two options is normally based on the number of expected reapplications. Performance monitoring could be used to indicate when reapplication of bioremediation substrate is actually required. Monitoring of contaminant concentrations and geochemical parameters would indicate when additional substrate application is necessary.

The volume of bioremediation substrate, EOS®, material injected during each application would depend on the mass of target contamination and competing electron acceptors, as well as on practical limitations related to the mechanics of the injections. Naturally occurring electron acceptors (such as dissolved oxygen [DO], nitrates, and sulfates) present in the aquifer will need to be overcome by biological processes before reductive dechlorination of TCE and related compounds can become effective. Based upon the total soil mass in the treatment area around each injection point, the volume of bioremediation substrate needed per injection round is approximately 1,453 gallons. Design parameters for the amount of bioremediation substrate injected are included in Appendix C. Because the amount of TCE remaining upgradient after the initial injection is unknown, for design cost estimation purposes it is assumed that two additional injections will be required to address any remaining TCE contamination. At the suspected source area (origination area) it would likely be advantageous to adjust additional injection locations to address all of the TCE origination area from GP06 and 021-033MW towards Building 252.

Monitoring of selected wells should be conducted to confirm that reducing conditions are established and that natural bioremediation processes are enhanced. A baseline round of sampling should be performed to identify pre-remediation groundwater conditions. After injection of substrate, groundwater samples can be collected quarterly, and then semi-annually or annually, as biodegradation trends become established. Three new monitoring wells would be required to assess enhanced bioremediation. Two new monitoring wells would be required downgradient from the TCE origination area to monitor the central portion of the treatment area (Figure 3-2). A third monitoring well would be installed just upgradient of the injection area near Building 252 to monitor concentrations migrating to the treatment area. The monitoring program should employ low-flow groundwater sampling techniques and include the measurement of the following parameters:

- COC concentrations (TCE as well as any degradation byproducts, such as DCEs and vinyl chloride);
- Field parameters: oxidation reduction potential (ORP), pH, conductivity, temperature, DO, total manganese and iron, and dissolved (ferrous) iron; and
- Dissolved gases (methane, ethane, and ethene), total and dissolved organic carbon, nitrate/nitrite, sulfate, sulfide, chloride, and alkalinity at newly installed monitoring wells upgradient and downgradient of the treatment area.

Ideally, groundwater samples would be collected from upgradient or background locations, inside the treatment area, and downgradient from the treatment area (to identify potential residence time requirements for complete biodegradation).

3.4.2 Overall Protection of Human Health and the Environment

This alternative will be effective in overall protection of human health and the environment at the treatment area. During enhanced bioremediation injections, institutional controls will reduce the likelihood of the public coming into contact with contaminated groundwater.

3.4.3 Compliance with ARARs

Enhanced bioremediation as presented will achieve groundwater ARARs for TCE and breakdown products throughout Site 21.

3.4.4 Long-Term Effectiveness and Permanence

The effectiveness of enhanced bioremediation may be limited by the ability of bioremediation substrate to disperse through the aquifer within the treatment area and the presence of microorganisms that can dechlorinate TCE, DCE, and VC. The mass of TCE present in between the locations of the enhanced bioremediation barriers would not be treated immediately, resulting in TCE concentrations existing between treatment areas that exceed the HRL migrating down gradient towards the next treatment zone.

This alternative will be effective over the long term only in the areas of application. To meet RAOs and depending on site-specific biodegradation performance, reapplications of bioremediation substrate may be necessary every one to two years over the operational period.

3.4.5 Reduction of Toxicity, Mobility, or Volume through Treatment

This treatment alternative will reduce the toxicity and volume of contaminated groundwater throughout the plume foot print, and will likely address any potential source material if present, in the area of GP04, GP05, GP06, 021-029MW, and 021-033MW.

3.4.6 Short-Term Effectiveness

Institutional controls will be effective in reducing the likelihood of human exposure during remediation activities. Workers will need to wear protective equipment during enhanced bioremediation injections. Use of this method will mobilize metals (such as iron and manganese) within the treatment zone because the treatment will create reducing conditions at the point of treatment and a short distance downgradient. However, these metals are expected to be immobilized downgradient of the treatment areas.

3.4.7 Implementability

Technical Feasibility: When applied correctly, few difficulties are anticipated during substrate injection and groundwater treatment. One of the most important aspects of a successful application is using the appropriate well spacing and pump to inject the materials. Failure to specify and use the appropriate equipment may increase field time and result in improper application of the substrate. Otherwise, this technology has been proven to be easily implemented with readily available equipment.

Administrative Feasibility: No administrative difficulties are anticipated for this technology; however, MPCA approval of a work plan would be required.

Availability of Service and Materials: All services and materials are readily available.

3.4.8 Cost

Costs for enhanced bioremediation are based on the following assumptions:

1. Treatment area lengths of 110 feet at TCE origination area, 150 feet in the middle of the plume foot print, 150 feet at the left TCE plume leg adjacent to the wetland boundary, and 90 feet at the right plume lef adjacent to the wetland boundary.

2. At total of 59 injection locations each with a 5-foot radius of influence (ROI);

3. Saturated zone thickness requiring treatment: 25 feet (maximum);

4. 4,012 gallons of EOS® per round of injections (approximately 68 gallons per location);

5. 5,000 gallon temporary injection system;

6. A pilot study conducted to assess to assess the effectiveness of the substrate delivery method, to determine the radius of influence, and assess degradation of the Site contaminants of concern;

7. Two additional injections at all enhanced bioremediation areas may be necessary. The second injection will occur two years after the initial injection, and the third injection will occur 4 years after the initial injection;

8. Three new performance monitoring wells (2-inch Schedule 40, PVC) installed with a 5-foot screen;

9. System performance monitoring for 4 years, plus two years LTM following conclusion of performance monitoring; and,

10. Site closure documentation and well abandonment costs are included.

For this alternative, site closure documentation and well abandonment costs are not included as this alternative is designed to be used with other remedial alternatives. The total cost to complete has been estimated at a PV of $850,710 (-20 percent to +20 percent). A detailed cost estimate for this alternative is presented as Table 3-2. Estimated costs for each alternative are presented in Table 4-1 and more thoroughly discussed in Section 4.0.

3.5 ALTERNATIVE 4: PERMEABLE REACTIVE BARRIER – ZERO VALENT IRON WALL

A PRB is an *in-situ* method for remediating contaminated groundwater that combines a passive chemical reaction zone with subsurface fluid flow management. The barrier is composed of ZVI as the reactive media. The following sections present a conceptual design for evaluation, comparison, and costing purposes only. If selected, the final design would be modified based upon additional data or site constraints identified during pre-design activities. Figure 3-3 presents a conceptual design of Alternative 4.

3.5.1 Conceptual Design

ZVI has the ability to dehalogenate chlorinated compounds (including TCE) reductively. The reductive dehalogenation of these compounds occurs due to electron transfers from the iron to the halocarbon at the iron surface. This results in the halogen ions (e.g., chloride [Cl-]) being replaced by hydrogen species, ultimately yielding ethene or ethane that can be mineralized via biodegradation.

The proposed PRB would require excavation of a 160-foot trench (across the width of the TCE plume), approximately 25 feet deep. The ZVI material would be installed from 3 feet bgs to 25 feet bgs. The top 3 feet bgs would be backfilled with excavated materials. During the RI Data Gap Investigation (MWH, 2010), a groundwater sample was collected at 021-040MW and used in a treatability study. Based on the field-scale anticipated degradation rates, a residence time of 10 hours will be required to treat impacted groundwater of 90 µg/L. Based on an average linear groundwater velocity of 0.134 ft/day within the barrier, a trench approximately 2 feet wide would be required. Design parameters for the PRB dimensions are included in Appendix D. The trench excavation would require treatment of dewatering liquids and disposal of removed soils. Two new monitoring wells would be required downgradient of the PRB to monitor the treatment area (Figure 3-3).

3.5.2 Overall Protection of Human Health and the Environment

This alternative will be effective in overall protection of human health and the environment. During installation of the PRB, institutional controls will reduce the likelihood of the public coming into contact with contaminated groundwater. Once treatment is complete for this alternative, groundwater will no longer pose a threat to human health or the environment down gradient of the PRB. Under this remedial alternative, areas downgradient of the ZVI-PRB will not be remediated, but rather assumed to biodegrade. Therefore, the appropriate ICs and LUCs should be in place to restrict groundwater use upgradient of the PRB.

3.5.3 Compliance with ARARs

Once treated, the groundwater that has migrated through the PRB-ZVI will meet appropriate ARARs.

3.5.4 Long-Term Effectiveness

The PRB technology would be effective at reducing TCE concentrations upgradient from the marsh by creating a homogeneous subsurface for reliable contact between plume contaminants and the reactive iron material. The PRB would be protective of the marsh and Miller Creek and would require only limited O&M. The barrier would need to remain in place until the unidentified source appears to be depleted and concentrations most distal upgradient edge of the plume has migrated through the barrier. Rejuvenation of the iron material may be necessary depending on the remaining source duration. Because TCE concentrations are relatively low at Site 21, rejuvenation is not likely; therefore reapplication has not been included in the cost assumption listed in Section 3.5.8. It has been assumed that two years of LTM would be necessary to ensure compliance at marsh boundary. Also, the mass of contaminant present between the

PRB and the Marsh would not be treated; resulting in TCE at concentrations exceeding the HRL being discharged to the marsh for approximately 14 to 49 years after the barrier is installed.

3.5.5 Reduction of Toxicity, Mobility, or Volume through Treatment

This treatment alternative will reduce the toxicity and volume of contaminated groundwater through treatment with ZVI.

3.5.6 Short-Term Effectiveness

Institutional controls will be effective in reducing the possibility of human exposure to groundwater contamination at the site during installation of ZVI PRB. Groundwater sampling will effectively monitor remedial effectiveness.

3.5.7 Implementability

Technical Feasibility: Ostensibly, construction of the barrier would not be difficult because the immediate vicinity is free of buildings, power lines, and utilities.

Administrative Feasibility: It is assumed that compliance with applicable regulations would require analytical sampling and reporting over the operational lifetime of the PRB (estimated at 15 years). No permitting costs are included in the cost estimate. If transported off site, disposal of excavated soils would require administrative tracking and reporting of the transportation and storage of the generated waste. For the purposes of this evaluation, excavated soils are assumed to be non-hazardous and remain on the MNANG Base.

Availability of Service and Materials: All services and materials are readily available.

3.5.8 Cost

Cost estimates are based upon these primary assumptions:

1. The full-scale system has been assumed to be 160 feet long, 2 feet wide, and 25 feet deep;
2. The period of performance for the PRB has been assumed to be 15 years with no re-application of the ZVI material;

3. Excavated soils can be disposed of on the MNANGB as fill;

4. Two new performance monitoring wells (2-inch Schedule 40, PVC) installed to 17 feet bgs with a 5-foot screen;

5. System performance monitoring for 15 years, plus two years LTM following conclusion of performance monitoring; and

6. Site closure documentation and well abandonment cost are included.

Based on these assumptions, unit costs obtained from the Enhanced Bioremediation proposal were used to develop an estimate of the costs associated with PRB-ZVI. Assuming that attainment of the RAOs can be achieved at the TCE origination area within 7 years, the total cost to complete has been estimated at a PV of $686,870 (-20 percent to +20 percent). A detailed cost estimate for this alternative is presented as Table 3-3. Supporting costs and design information is also included in Appendix D. Estimated costs for each alternative are presented in Table 4-1 and more thoroughly discussed in Section 4.0.

4.0 SCREENING OF RETAINED REMEDIAL ALTERNATIVES

Assumptions used to evaluate effectiveness, implementability, and costs of each alternative are extremely important in the overall comparisons and evaluations. Details are included in the previous sections, and several key considerations are restated below.

Several of the alternatives evaluated in this document are likely to address some percentage of the contaminant mass within the plume effectively, and can be implemented easily. The primary differences are (1) the initial costs versus ongoing operational costs, (2) the risk of incorrect assumptions (e.g., period of operation, time to achieve RAOs), and (3) the likelihood that RAOs are achieved either immediately or within a reasonable period in conjunction with natural attenuation. The likelihood of each alternative achieving RAOs is described in Table 4-1.

4.1 ALTERNATIVE 1 – INTRINSIC REMEDIATION (MNA)

Alternative 1 involves continuation of LTM activities with no modification. For this evaluation, it has been assumed that LTM, including reporting, will continue for at least 15 years. Among all the alternatives examined in this analysis, this alternative poses the highest risk of not meeting RAOs. Without active treatment, TCE and VC concentrations would continue to migrate towards the marsh and Miller Creek at concentrations greater than RAOs. Therefore, this alternative has been given a low likelihood of achieving RAOs.

A cost was not developed for this alternative because the described MNA screening evaluation revealed that natural attenuation is not a viable stand-alone option for remediation at this site.

4.2 ALTERNATIVE 2 – PHYTOREMEDIATION

Alternative 2 involves the use of phytoremediation through the use of poplar trees to address shallow contaminated groundwater. Prior to implementation of phytoremediation a pre-design evaluation would need to be conducted to assess site soils and installation area, to assure phytoremediation is applicable at Site 21. The phytoremediation (Ebuffer®) implementation area would need to remain in place for approximately 15 years. However, the duration of continued TCE input to groundwater from the TCE origination area, just south of Building 252, is unknown; therefore, the poplar trees may need to be in place for an unknown duration. Because of the success of phytoremediation (Ebuffer®) at other sites with groundwater contaminated with chlorinated solvents, this alternative has been assigned a moderately high likelihood of achieving RAOs

The cost estimates for this alternative were based on previous vendor quotes and adjusted for quantity and inflation. This alternative has the lowest estimated initial capital cost of $135,000 and a PV, including LTM, of $577,072.

4.3 ALTERNATIVE 3 – ENHANCED BIOREMEDIATION

Alternative 3 involves injection of EOS® to enhance natural degradation of TCE in the area believed to be the originating zone of the TCE groundwater contamination and down gradient at in the middle of the plume footprint, and at locations adjacent to the wetland boundary. The goal of this alternative is to degrade any TCE within the unidentified groundwater contamination source area and areas downgradient in the middle of the plume and adjacent to the wetland boundary. For this evaluation, it has been assumed that LTM (including reporting) would continue for two years after the completion of injection activities (5 + 2 = 7 years total). Prior to implementation, a bench scale microcosm study (performed with soil and groundwater samples collected from the TCE origination area near GP04, GP05, GP06, 021-029MW, and 021-033MW) would need to be completed to confirm that enhanced bioremediation can achieve complete dechlorination of TCE at this site. A bench scale microcosm study will identify the formulations of bioremediation substrate needed and potential bioaugmentation bacterial culture as appropriate. Additionally an injection pilot test will be conducted prior to full scale implementation to assess the effectiveness of the substrate delivery method, to determine the radius of influence, and assess degradation of the Site contaminants of concern.

As with any *in-situ* remedial approach, there is considerable uncertainty as to whether the EOS® will disperse effectively to degrade TCE in lower permeability soils that might be encountered. This approach is also limited by groundwater flow velocities. This alternative has been given a moderate likelihood of achieving the RAOs. This technology has been effectively applied to IRP Site 3 at the MNANG. Given the positive results of enhanced bioremediation at Site 3, and the similarity of subsurface conditions to Site 21, enhanced bioremediation may enhance TCE degradation at Site 21. There is a small, but inherent associated risk that mobilized metals could migrate beyond the treatment area; however, these metals are expected to be immobilized downgradient of the treatment area. For the purpose of this evaluation, it has been assumed that three additional performance monitoring wells will be installed.

Vendor quotes were not obtained for this alternative. This alternative has the highest estimated initial capital cost of $551,000 a total project PV, including biannual reapplication of the EOS® (for three injection events total), of $850,710.

4.4 ALTERNATIVE 4 – PERMEABLE REACTIVE BARRIER - ZERO VALENT IRON WALL

Alternative 4 includes installation of a permeable reactive barrier composed of ZVI. This alternative would reductively dehalogenate TCE to ethane or ethene as it passes through the barrier. The barrier would need to remain in place for approximately 15 years. However, the duration of continued TCE input to groundwater from the TCE origination area, just south of Building 252, is unknown; therefore, the ZVI barrier may need to be rejuvenated for continued use beyond 15 years. This alternative would also require soil excavation and disposal. The treatability study conducted as part of the Final Site 21 RI Data Gap Investigation (MWH, 2010) identified design parameters for the ZVI PRB, including an estimated thickness of 2 feet. Since the treatability study found this alternative to be implementable and effective, this alternative has been assigned a moderately high likelihood of achieving RAOs.

The cost estimates for this alternative were based on vendor quotes. This alternative has the second lowest initial capital cost of $310,520 and a PV, including LTM, of $688,870.

4.5 GREEN AND SUSTAINABLE REMEDIATION (GSR) SUMMARY

In accordance with National Guard Bureau (NGB)/A7OR Memorandum, A7O 09-02 Consideration of Green and Sustainable Remediation in Environmental Restoration (NGB, 2009), the four remedial alternatives are evaluated for their sustainability and greenhouse gas emissions, energy and water usage, and waste generation. Alternative 1 (MNA) is a sustainable remedial alternative as it will not require any additional work besides monitoring. MNA also has low greenhouse gas emissions (associated with car travel), and low energy and water usage, and low waste generation.

Alternative 2 (phytoremediation) is considered a sustainable remedial alternative, as once trees are planted, phytoremediation continues to occur for an indefinite amount of time.

Phytoremediation also has low greenhouse gas emissions (associated with car travel for groundwater monitoring), and low energy and water usage (some water usage for tree watering), and low waste generation.

Alternative 3 (Enhanced Bioremediation) has a moderate sustainability, as additional injections (up to three total) may be necessary to remediate the TCE plume. Enhanced bioremediation also has a moderate to low greenhouse gas emissions (associated with car travel for groundwater monitoring and injection mobilizations), low energy usage, moderate to low water usage (some water usage for will be necessary for injection activities), and low waste generation.

Alternative 4 (ZVI PRB) has a moderate sustainability, as there is potential for rejuvenation of the iron material. ZVI PRB also has moderate to low greenhouse gas emissions (associated with car travel for groundwater monitoring and ZVI PRB installation), low energy and water usage, and low waste generation. In summary all remedial alternatives evaluated are considered “green” alternative, and have low to moderate impacts on green house gas emissions, energy and water usage, and waste generation.

5.0 RECOMMENDATIONS

A summary of the remedial alternatives analysis is presented as Table 4-1. There is uncertainty associated with each technology. MNA (Alternative 1) was determined to be not applicable as a standalone groundwater remediation approach based on the results of the Natural Attenuation Study. The remaining alternatives, Phytoremediation (Alternative 2), Enhanced Bioremediation (Alternative 3), and the PRB-ZVI (Alternative 4), have inherent uncertainties that are associated with all *in-situ* treatment technologies: (1) implications of low permeability soil to substrate transfer, (2) ability of phytoremediation poplar trees to take root and be effective at site to provide adequate air pathways within the shallow aquifer, and (3) the unknown duration of TCE input to groundwater from the TCE origination area.

An underlying assumption in this FFS is that the site will achieve RAOs under the current use. Therefore, the currently established or future LUC/ICs would apply to each of the alternatives. It should be noted that costs to maintain LUC/ICs beyond active remedial efforts have not been included in this evaluation. For Alternatives 2 and 4, which extend beyond five years, do incorporate five-year reviews into the cost estimates. Further, none of the cost estimates for any alternative includes the costs associated with preparation of a Proposed Plan or a Record of Decision. Like the long-term management of LUC/ICs in the out years, such costs would be a component of each alternative, but would not provide useful insight for the purposes of this screening process. Similarly, as noted in Section 2.2.4, estimated costs in this document do not include those for conducting required PCM after RAOs have been achieved.

Based on this analysis, the combination of two alternatives emerges as the most optimal combination of effectiveness, implementability, cost, risk, and likelihood of achieving RAOs: Alternative 2, Phytoremediation (Figure 3-1) and Alternative 3, Enhanced Bioremediation (Figure 3-2). Phytoremediation appears to be cost competitive with PRB-ZVI on the initial capital costs and PV cost. Additionally, PRB-ZVI may need periodic rejuvenation to restore permeability loss due to precipitates and to restore any lost reactivity of the iron, while once in place, phytoremediation can be effective indefinitely for shallow (up to 15 feet bgs) groundwater contamination. Enhanced bioremediation is intended to treat the entire saturated zone of TCE contamination (approximately 25 feet). The combination of Alternative 2 (Phytoremediation) and Alternative 3 (Enhanced Bioremediation) has a higher PV cost than Alternative 4, but there would be a higher likely hood of RAOs being achieved at Site 21, as the

TCE origination area and entire plume footprint would be aggressively addressed through enhanced bioremediation injections. The combined costs for Alternative 2 (Phytoremediation) and Alternative 3 (Enhanced Bioremediation) are included in Table 5-1. The combined costs presented in Table 5-1 incorporate annual groundwater monitoring and design costs for both Phytoremediation and Enhanced Bioremediation. Figure 5-1 illustrates the combined enhanced bioremediation and phytoremediation treatment areas.

Additionally, the use of ORC® socks at monitoring well 021-029MW is recommended to address benzene and 1,2,4-TMB concentrations greater than the HRL and the GW_{ISV}. Costs for ORC® socks at 021-029MW were not developed as part of this FFS, but are anticipated to minimal when compared to the evaluated alternatives.

Final selection of the most appropriate remedy would, however, depend upon the actual financial scenario and the risk tolerance of the ANG. Nevertheless, if a moderate initial capital investment is preferred, a lower risk remedy is desirable, and stated likelihood of achieving the defined RAOs is sufficient, then the ANG should consider selecting both Alternative 2, Phytoremediation, and Alternative 3, Enhanced Bioremediation for implementation at IRP Site 21.

6.0 REFERENCES

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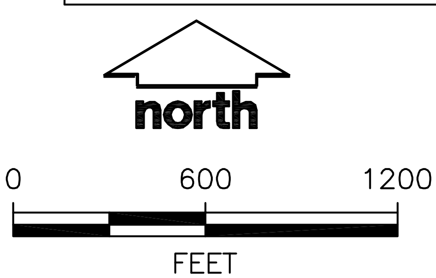
TMZ/MM/KEG/TWK/TMZ/CEK/TWK

FIGURES



SOURCE: RAND McNALLY ROAD ATLAS, 1992.

148th FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA

SITE 21

REGIONAL LOCATION MAP

FIGURE 1–1

MWH

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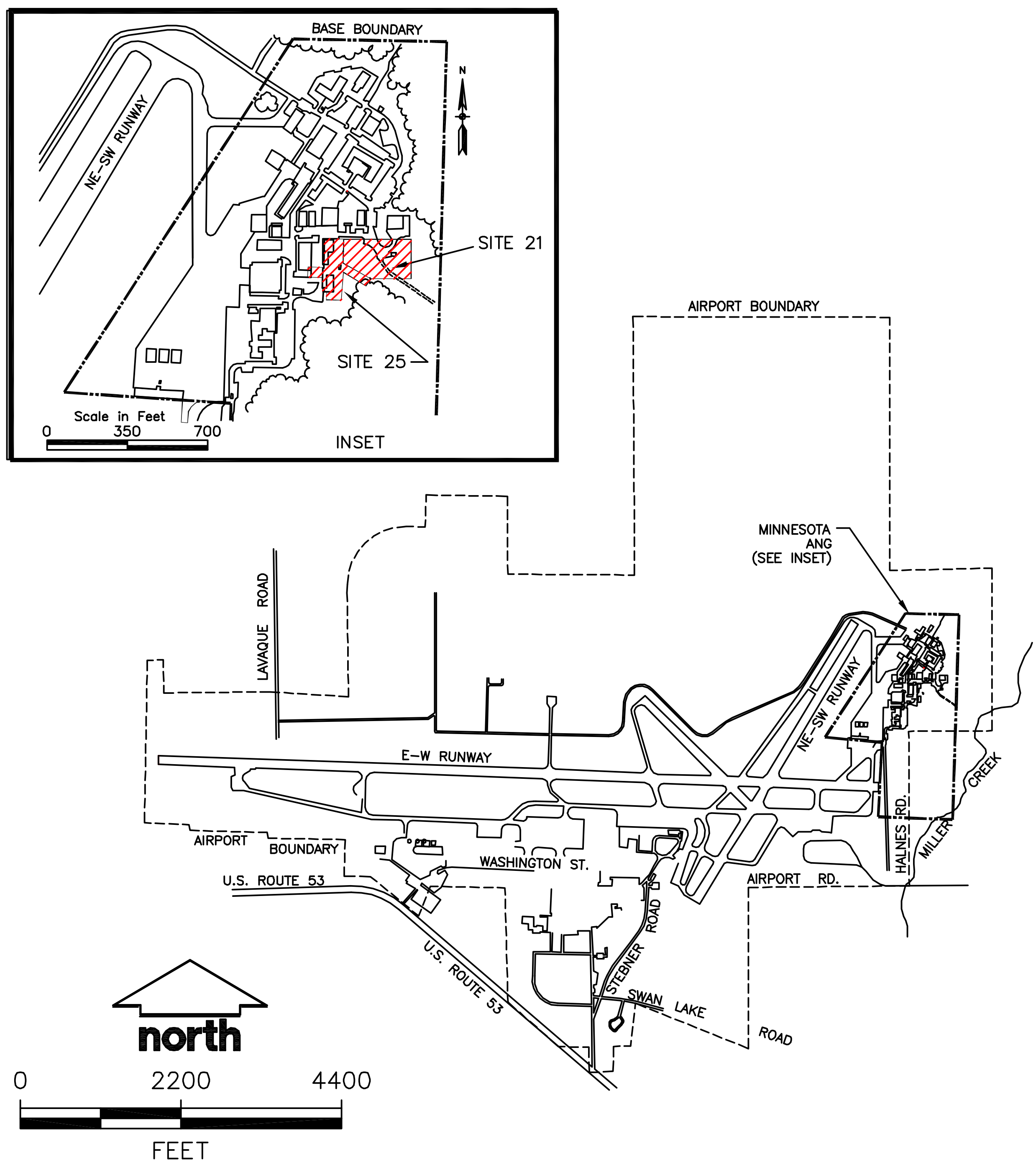

SOURCES: ENGINEERING-SCIENCE, INC., REMEDIAL INVESTIGATION REPORT, JANUARY 1990.
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LEGEND

- ENVIRONMENTAL RESTORATION PROGRAM SITE
- MINNESOTA ANG BOUNDARY
- AIRPORT BOUNDARY
- TREE LINE

SITES

SITE 21 IMHOFF TANK TREATMENT SYSTEM

SITE 25 OLD MOTOR POOL AREA

148th FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA

SITE 21
SITE LOCATION MAP

FIGURE 1-2

MWH

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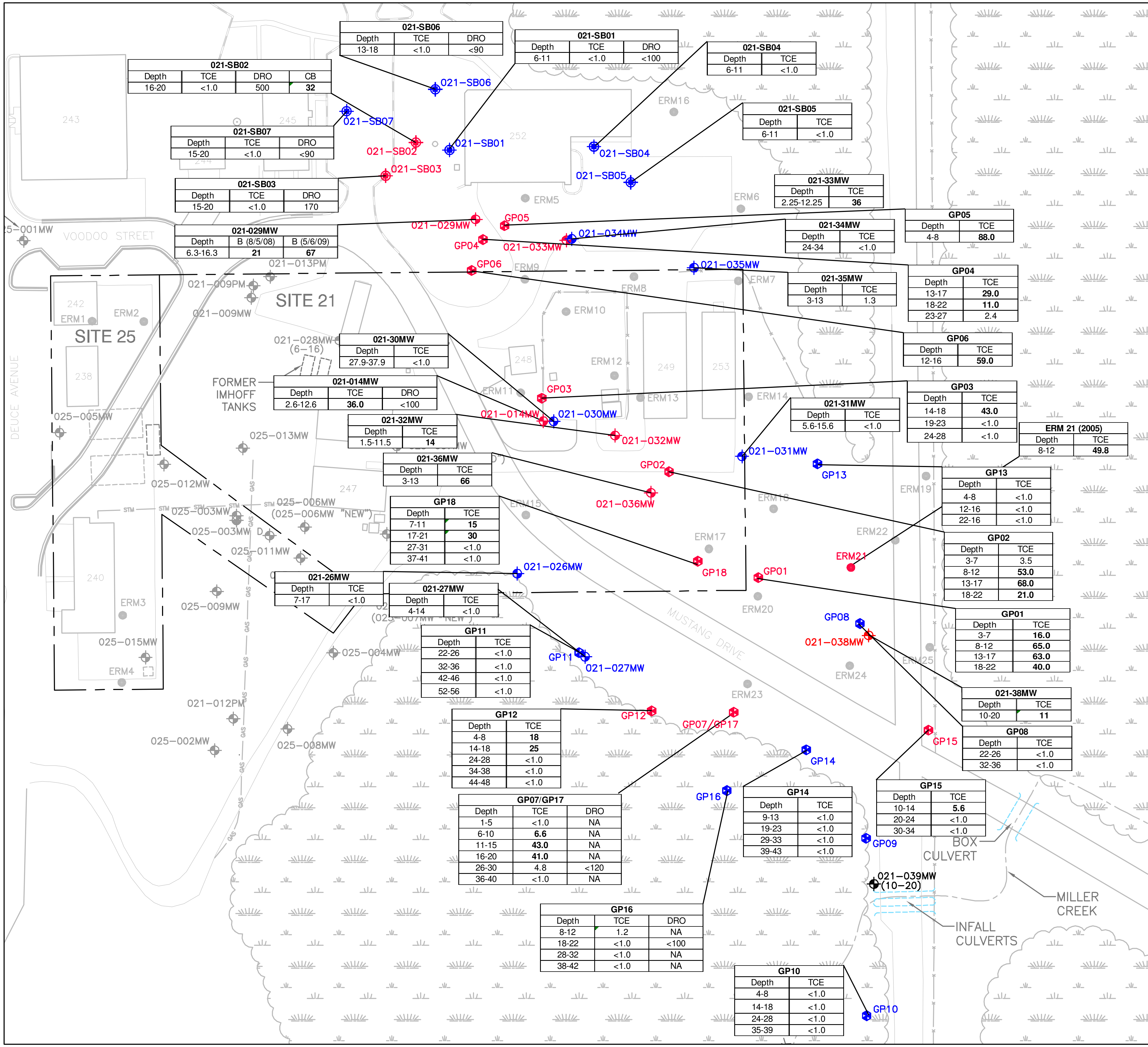

021-SB06		
Depth	TCE	DRO
13-18	<1.0	<90

021-SB01		
Depth	TCE	DRO
6-11	<1.0	<100

021-SB04	
Depth	TCE
6-11	<1.0

021-SB02			
Depth	TCE	DRO	CB
16-20	<1.0	500	**32**

021-SB05	
Depth	TCE
6-11	<1.0

021-SB07		
Depth	TCE	DRO
15-20	<1.0	<90

021-SB03		
Depth	TCE	DRO
15-20	<1.0	170

021-33MW	
Depth	TCE
2.25-12.25	**36**

021-029MW		
Depth	B (8/5/08)	B (5/6/09)
6.3-16.3	**21**	**67**

GP05	
Depth	TCE
4-8	**88.0**

021-34MW	
Depth	TCE
24-34	<1.0

GP04	
Depth	TCE
13-17	**29.0**
18-22	**11.0**
23-27	2.4

021-35MW	
Depth	TCE
3-13	1.3

GP06	
Depth	TCE
12-16	**59.0**

021-30MW	
Depth	TCE
27.9-37.9	<1.0

021-014MW		
Depth	TCE	DRO
2.6-12.6	**36.0**	<100

GP03	
Depth	TCE
14-18	**43.0**
19-23	<1.0
24-28	<1.0

021-31MW	
Depth	TCE
5.6-15.6	<1.0

ERM 21 (2005)	
Depth	TCE
8-12	**49.8**

021-32MW	
Depth	TCE
1.5-11.5	**14**

021-36MW	
Depth	TCE
3-13	**66**

GP13	
Depth	TCE
4-8	<1.0
12-16	<1.0
22-16	<1.0

GP18	
Depth	TCE
7-11	**15**
17-21	**30**
27-31	<1.0
37-41	<1.0

GP02	
Depth	TCE
3-7	3.5
8-12	**53.0**
13-17	**68.0**
18-22	**21.0**

021-26MW	
Depth	TCE
7-17	<1.0

021-27MW	
Depth	TCE
4-14	<1.0

GP01	
Depth	TCE
3-7	**16.0**
8-12	**65.0**
13-17	**63.0**
18-22	**40.0**

GP11	
Depth	TCE
22-26	<1.0
32-36	<1.0
42-46	<1.0
52-56	<1.0

021-38MW	
Depth	TCE
10-20	**11**

GP12	
Depth	TCE
4-8	**18**
14-18	**25**
24-28	<1.0
34-38	<1.0
44-48	<1.0

GP08	
Depth	TCE
22-26	<1.0
32-36	<1.0

GP15	
Depth	TCE
10-14	**5.6**
20-24	<1.0
30-34	<1.0

GP07/GP17		
Depth	TCE	DRO
1-5	<1.0	NA
6-10	**6.6**	NA
11-15	**43.0**	NA
16-20	**41.0**	NA
26-30	4.8	<120
36-40	<1.0	NA

GP14	
Depth	TCE
9-13	<1.0
19-23	<1.0
29-33	<1.0
39-43	<1.0

GP16		
Depth	TCE	DRO
8-12	1.2	NA
18-22	<1.0	<100
28-32	<1.0	NA
38-42	<1.0	NA

GP10	
Depth	TCE
4-8	<1.0
14-18	<1.0
24-28	<1.0
35-39	<1.0

LEGEND

- MARSH
- BUILDINGS
- ERM GEOPROBE POINT
- MONITORING WELL SAMPLED
- MONITORING WELL SAMPLED – EXCEEDANCE OF HRL
- SOIL BORING/TEMPORARY MONITORING WELL
- SOIL BORING/TEMPORARY MONITORING WELL – EXCEEDANCE OF HRL
- VAS LOCATION
- VAS LOCATION – EXCEEDANCE OF HRL

ALL CONCENTRATIONS IN MICROGRAMS PER LITER

VAS = VERTICAL AQUIFER SAMPLING LOCATION

BOLD VALUES > HEALTH RISK LIMIT (HRL)

B = BENZENE

CB = CHLOROBENZENE

TCE = TRICHLOROETHENE

DRO = DIESEL RANGE ORGANICS

north

0 100 200

SCALE IN FEET

148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT

VAS LOCATIONS, TEMPORARY WELL LOCATIONS, AND ANALYTICAL RESULTS
AUGUST 2008 AND MAY 2009

FIGURE 1–3

MWH

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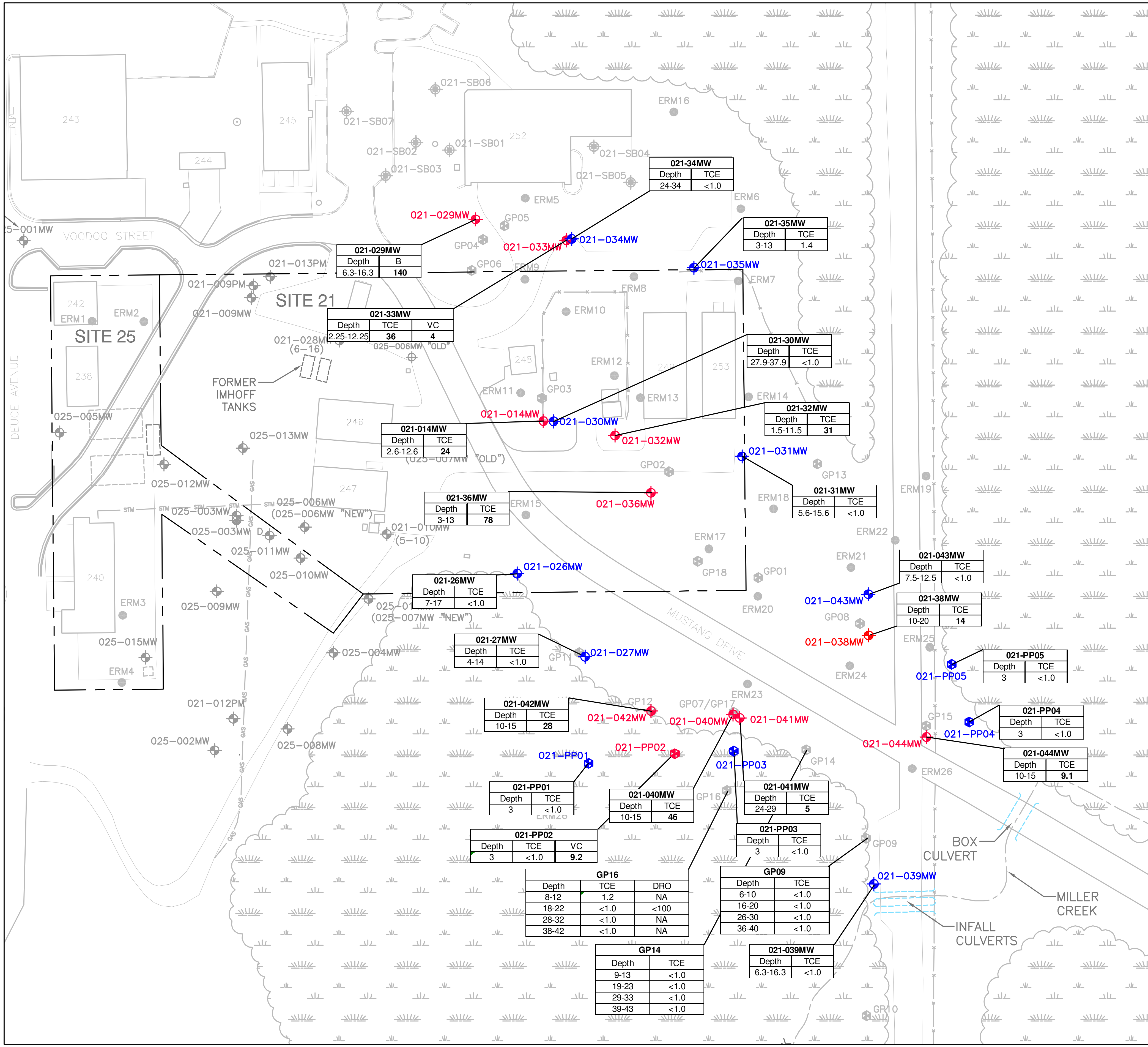

021-34MW

Depth	TCE
24-34	<1.0

021-35MW

Depth	TCE
3-13	1.4

021-029MW

Depth	B
6.3-16.3	**140**

021-33MW

Depth	TCE	VC
2.25-12.25	**36**	**4**

021-30MW

Depth	TCE
27.9-37.9	<1.0

021-32MW

Depth	TCE
1.5-11.5	**31**

021-014MW

Depth	TCE
2.6-12.6	**24**

021-31MW

Depth	TCE
5.6-15.6	<1.0

021-36MW

Depth	TCE
3-13	**78**

021-26MW

Depth	TCE
7-17	<1.0

021-043MW

Depth	TCE
7.5-12.5	<1.0

021-38MW

Depth	TCE
10-20	**14**

021-27MW

Depth	TCE
4-14	<1.0

021-PP05

Depth	TCE
3	<1.0

021-042MW

Depth	TCE
10-15	**28**

021-PP04

Depth	TCE
3	<1.0

021-044MW

Depth	TCE
10-15	**9.1**

021-PP01

Depth	TCE
3	<1.0

021-040MW

Depth	TCE
10-15	**46**

021-041MW

Depth	TCE
24-29	**5**

021-PP02

Depth	TCE	VC
3	<1.0	**9.2**

021-PP03

Depth	TCE
3	<1.0

GP16

Depth	TCE	DRO
8-12	1.2	NA
18-22	<1.0	<100
28-32	<1.0	NA
38-42	<1.0	NA

GP09

Depth	TCE
6-10	<1.0
16-20	<1.0
26-30	<1.0
36-40	<1.0

GP14

Depth	TCE
9-13	<1.0
19-23	<1.0
29-33	<1.0
39-43	<1.0

021-039MW

Depth	TCE
6.3-16.3	<1.0

LEGEND

MARSH

BUILDINGS

ERM GEOPROBE POINT

SOIL BORING LOCATION – AUGUST 2008/MAY 2009

VAS = VERTICAL AQUIFER SAMPLING LOCATION

MONITORING WELL SAMPLED

MONITORING WELL SAMPLED – EXCEEDANCE OF HRL

PUSHPOINT LOCATION SAMPLED

PUSHPOINT LOCATION – EXCEEDANCE OF HRL

APPROXIMATE LATERAL EXTENT OF TCE PLUME

ALL CONCENTRATIONS IN MICROGRAMS PER LITER

BOLD VALUES > HEALTH RISK LIMIT (HRL)

B = BENZENE

TCE = TRICHLOROETHENE

VC = VINYL CHLORIDE

A A' CROSS SECTION LOCATION

GP09, GP14, AND GP16 COLLECTED MAY 2009

north

0 100 200

SCALE IN FEET

148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT

GROUNDWATER SAMPLING ANALYTICAL RESULTS

SEPTEMBER 2009

FIGURE 1–4

MWH

Drawn By & Date: DLF 11/09/09 | Approved By & Date: | Revised By & Date: DLF 09/07/10 | Approved By & Date:

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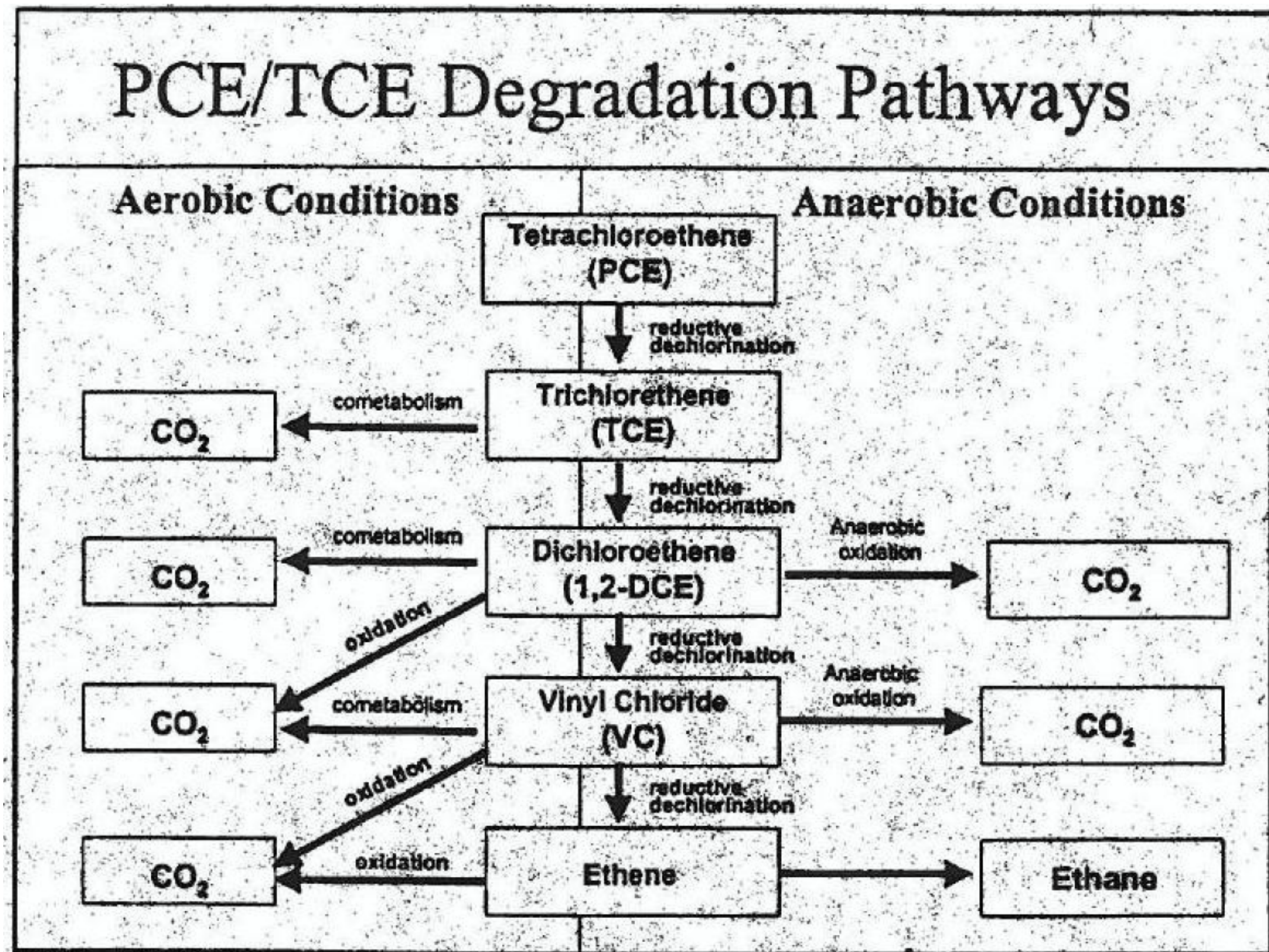

Figure excerpted from: Accelerated Bioremediation of Chlorinated Solvents; Training Course Workbook; prepared by RTDF Bioremediation Consortium; June 2000. Note that the pathways showing oxidation of DCE to CO2 should be viewed as highly unlikely, as these have not been conclusively documented in the scientific literature.

148TH FIGHTER WING, MNANG
DULUTH, MINNESOTA

SITE 21
CONTAMINANT TRANSFORMATION PATHWAYS

FIGURE 1–5

MWH

Drawn By & Date: VEN 07/23/08 | Approved By & Date: | Revised By & Date: TMZ 11/13/09 | Approved By & Date:

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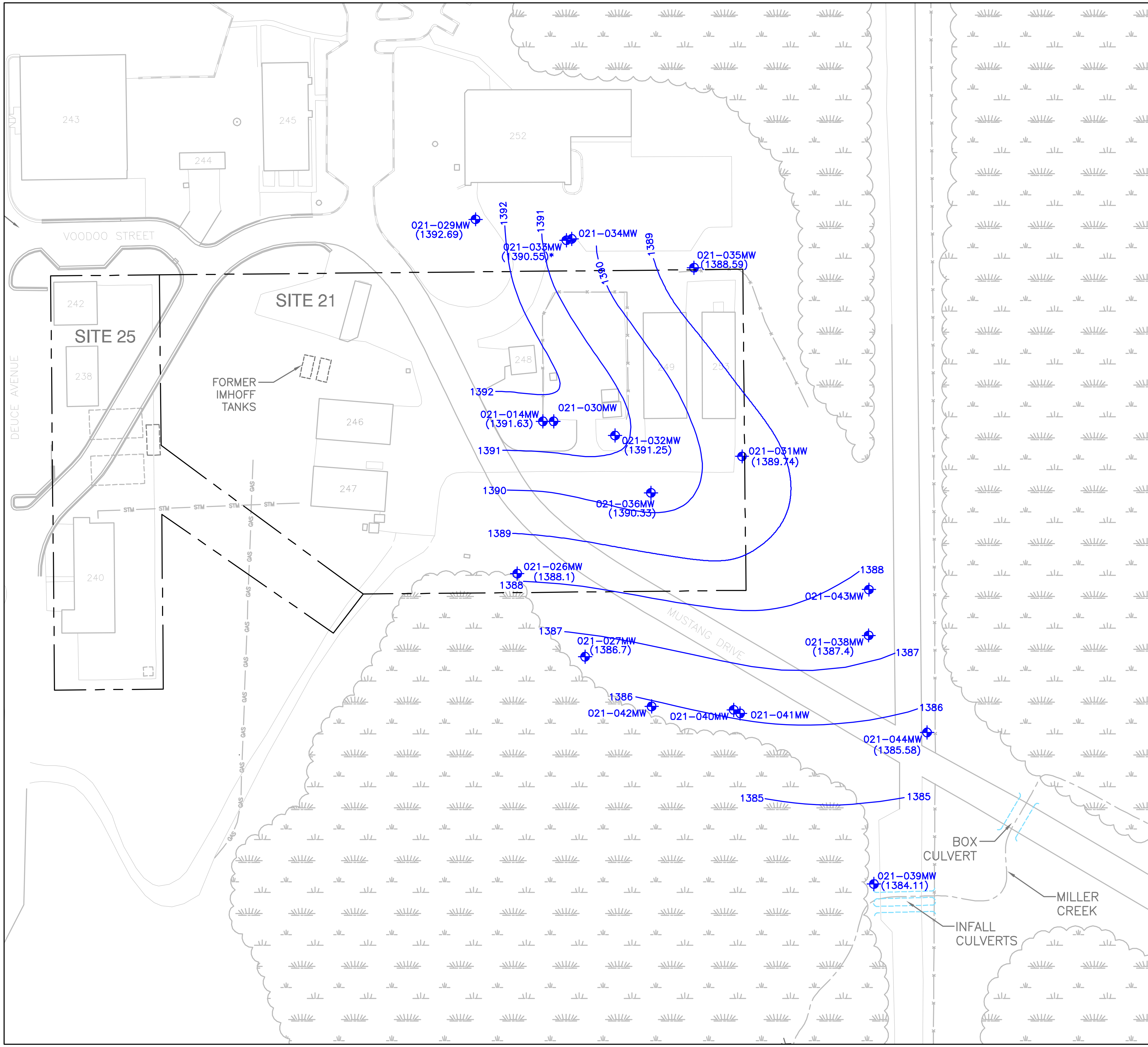
Drawn By & Date: DLF 08/26/08 | Approved By & Date: | Revised By & Date: DLF 05/28/10 | Approved By & Date:



LEGEND

- MARSH
- BUILDINGS
- MONITORING WELL
- (1390.15) GROUNDWATER ELEVATION (IN FEET)
- * ANOMOLOUS GROUNDWATER ELEVATION, NOT USED IN CONTOURING
- GROUNDWATER CONTOUR LINE

north

0 100 200

SCALE IN FEET

148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT

AUGUST 2008 GROUNDWATER CONTOUR MAP – SITE 21

FIGURE 1–6

MWH

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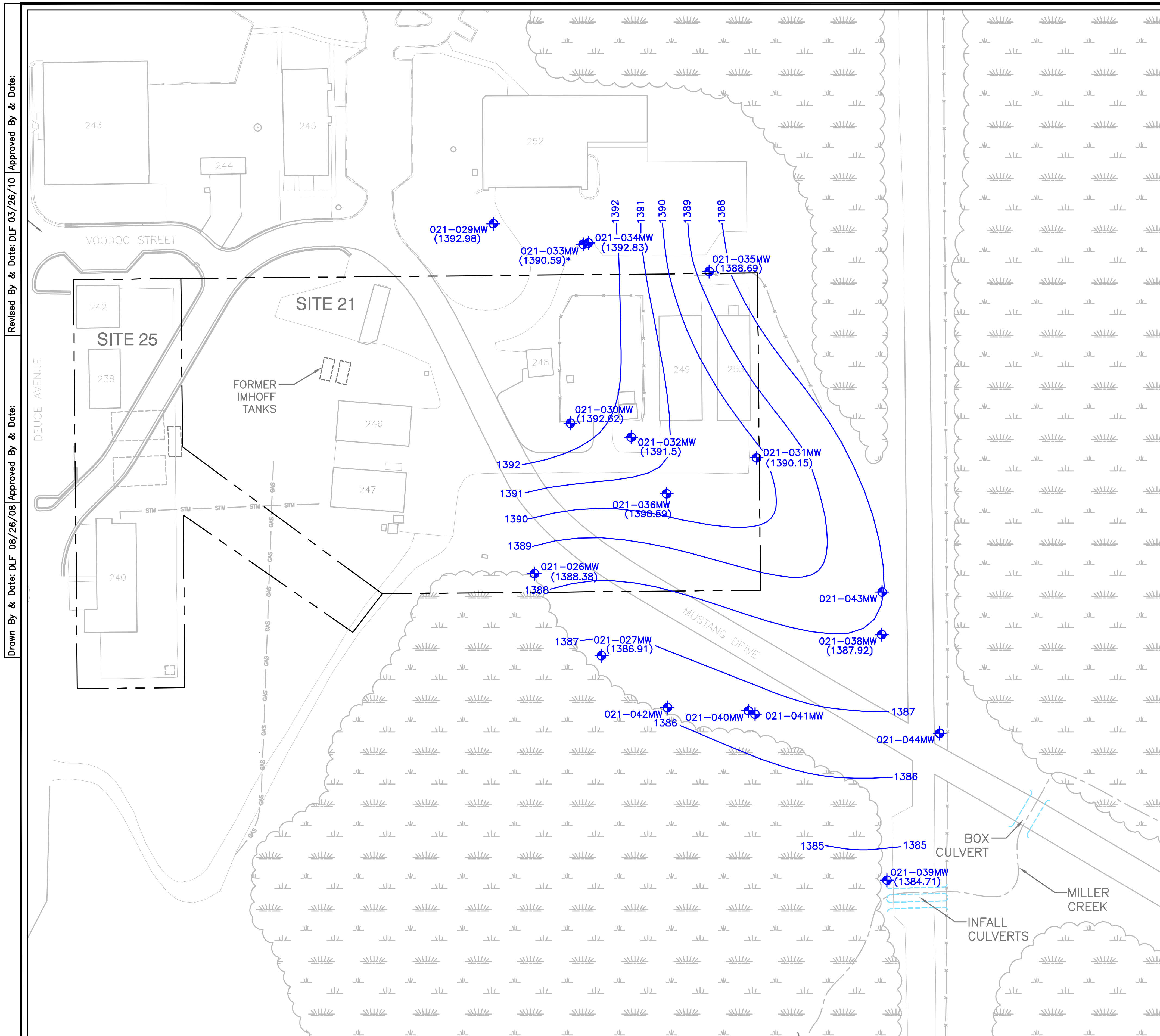

LEGEND

- MARSH
- BUILDINGS
- MONITORING WELL
- (1390.15) GROUNDWATER ELEVATION (IN FEET)
- * ANOMOLOUS GROUNDWATER ELEVATION, NOT USED IN CONTOURING
- GROUNDWATER CONTOUR LINE

north

0 100 200

SCALE IN FEET

148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT

MAY 2009 GROUNDWATER CONTOUR MAP – SITE 21

FIGURE 1–7

MWH

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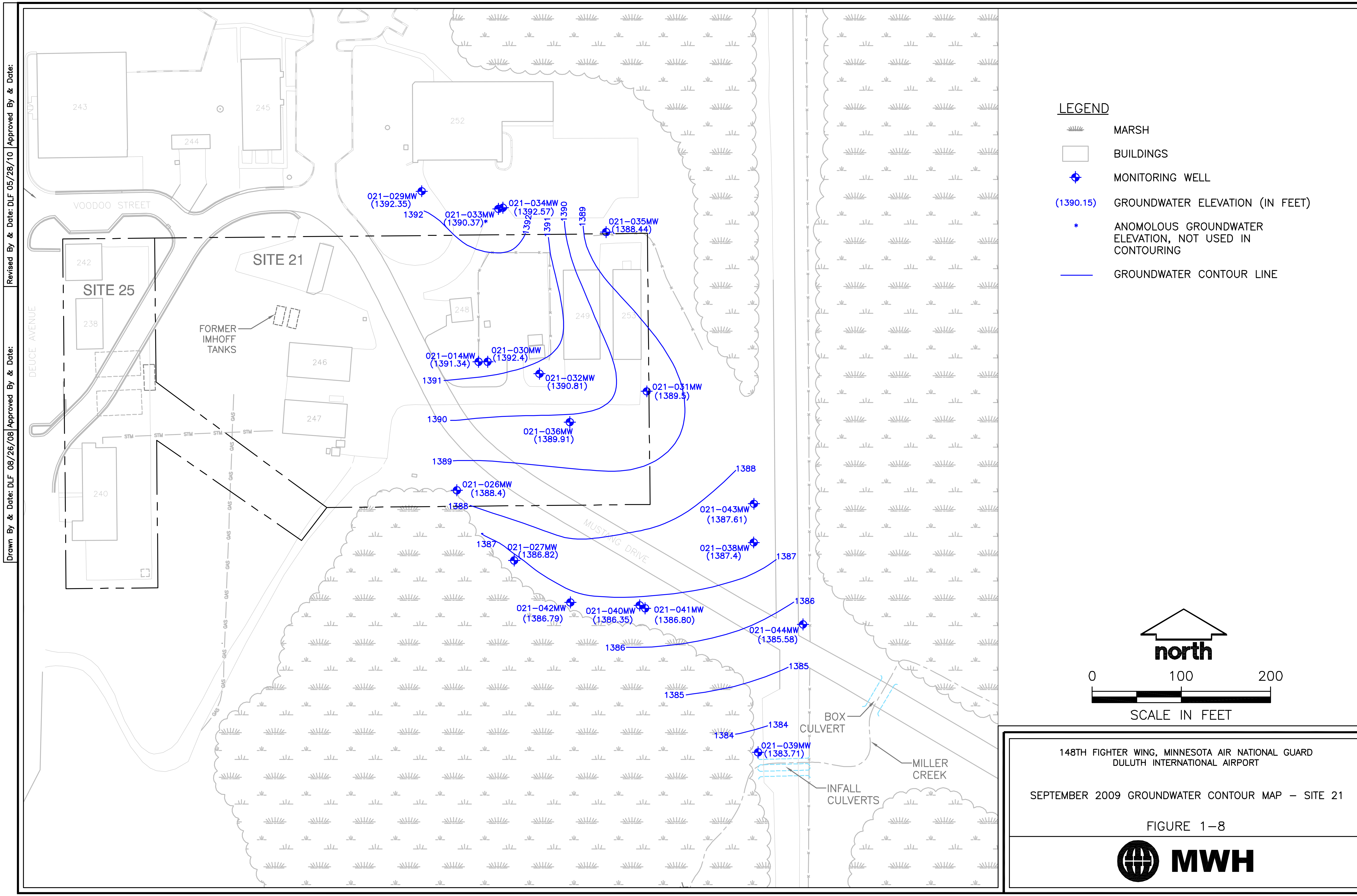
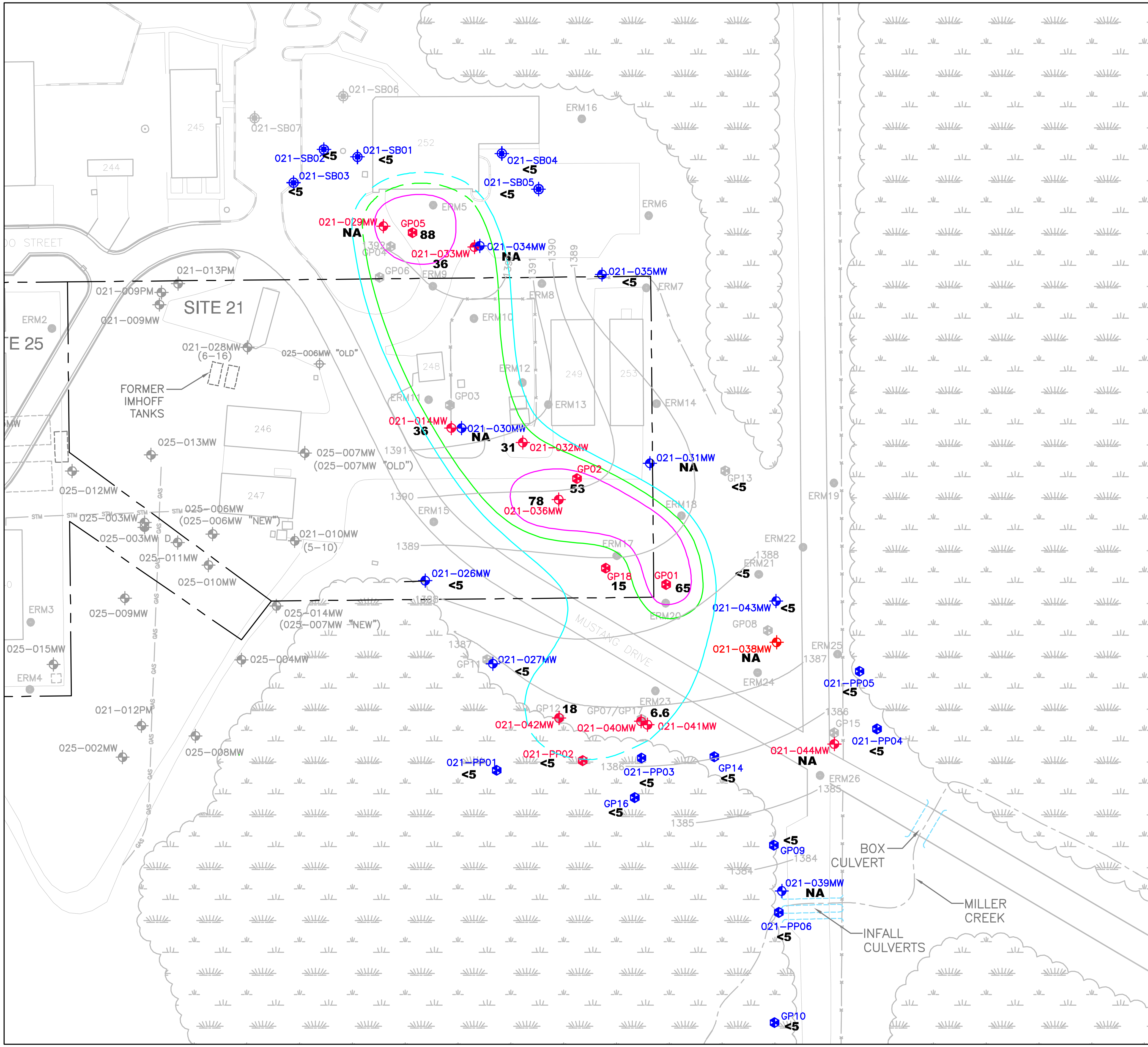


148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT

SEPTEMBER 2009 GROUNDWATER CONTOUR MAP – SITE 21

FIGURE 1–8

MWH



LEGEND

- MARSH
- BUILDINGS
- ERM GEOPROBE POINT
- SOIL BORING LOCATION – AUGUST 2008/MAY 2009
- VAS = VERTICAL AQUIFER SAMPLING LOCATION
- MONITORING WELL SAMPLED
- MONITORING WELL SAMPLED – EXCEEDANCE OF HRL
- PUSHPOINT LOCATION SAMPLED
- PUSHPOINT LOCATION – EXCEEDANCE OF HRL
- 5 PPB TCE ISOCONTOUR (APPROXIMATELY 77,981 SF)
- 30 PPB TCE ISOCONTOUR (APPROXIMATELY 43,718 SF)
- 50 PPB TCE ISOCONTOUR (APPROXIMATELY 13,526 SF)
- GROUNDWATER CONTOUR

DASHED LINE INDICATES INFERRED CONTOUR

ALL CONCENTRATIONS IN MICROGRAMS PER LITER

GP01, GP02, GP03, GP04, GP05, AND 021-SB01 THRU 021-SB05 COLLECTED AUGUST 2008

GP09, GP10, GP13, GP14, GP16, GP18 COLLECTED MAY 2009

NA = SAMPLING POINT NOT APPLICABLE FOR DEPTH INTERVAL 3'-13' BGS

north

0 100 200

SCALE IN FEET

148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
SITE 21

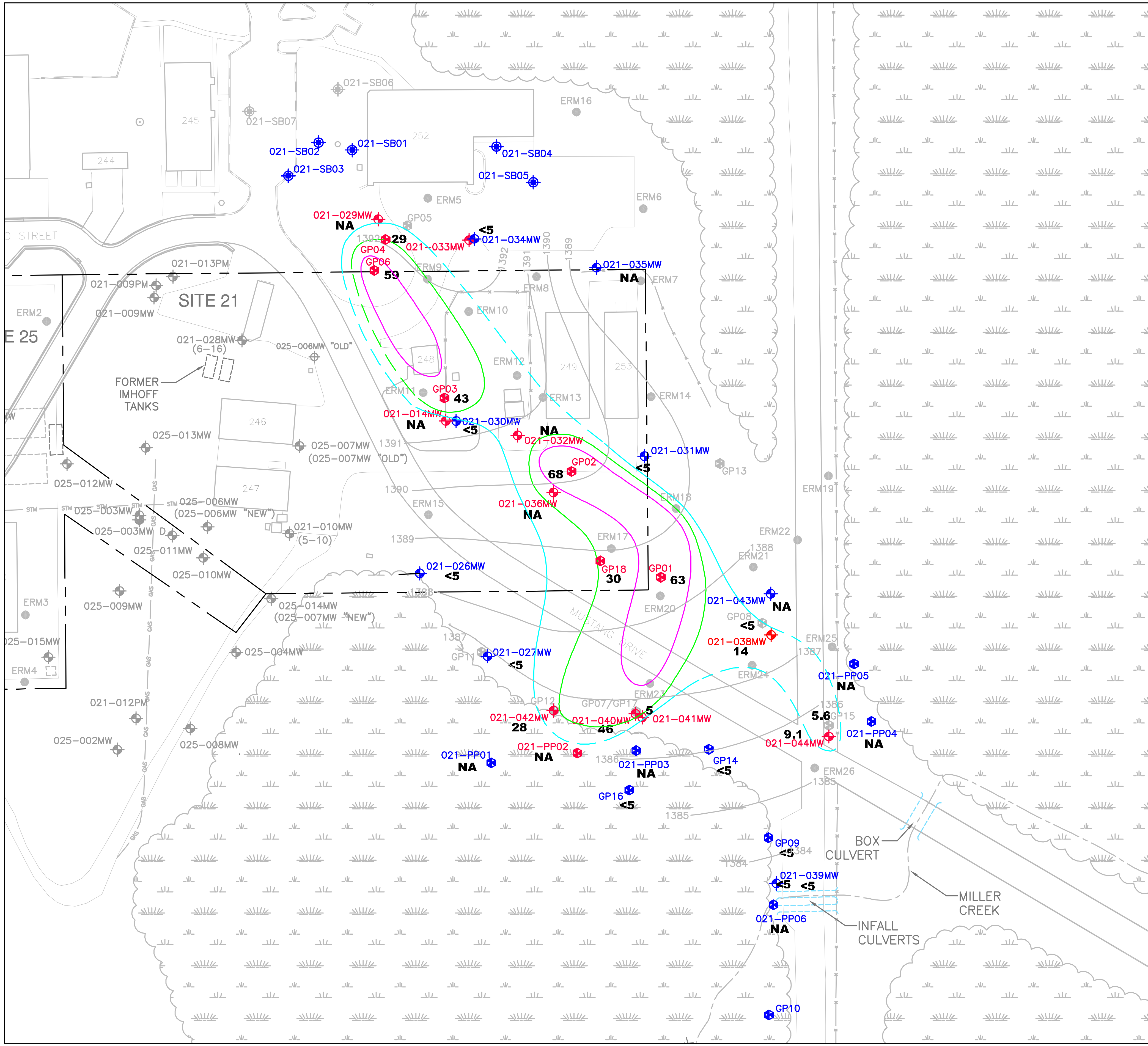
TCE PLUME ISOCONCENTRATION MAP (3'-13' BGS)
SEPTEMBER 2009

FIGURE 2-1

MWH

Drawn By & Date: DLF 11/09/09 Approved By & Date:

Revised By & Date: DLF 09/07/10 Approved By & Date:



LEGEND

- MARSH
- BUILDINGS
- ERM GEOPROBE POINT
- SOIL BORING LOCATION – AUGUST 2008/MAY 2009
- VAS = VERTICAL AQUIFER SAMPLING LOCATION
- MONITORING WELL SAMPLED
- MONITORING WELL SAMPLED – EXCEEDANCE OF HRL
- PUSHPOINT LOCATION SAMPLED
- PUSHPOINT LOCATION – EXCEEDANCE OF HRL
- 5 PPB TCE ISOCONTOUR (APPROXIMATELY 71,367 SF)
- 30 PPB TCE ISOCONTOUR (APPROXIMATELY 38,630 SF)
- 50 PPB TCE ISOCONTOUR (APPROXIMATELY 15,806 SF)
- GROUNDWATER CONTOUR

DASHED LINE INDICATES INFERRED CONTOUR

ALL CONCENTRATIONS IN MICROGRAMS PER LITER

GP01, GP02, GP03, GP04, AND GP05 COLLECTED AUGUST 2008

GP09, GP10, GP13, GP14, GP16, GP18 COLLECTED MAY 2009

NA = SAMPLING POINT NOT APPLICABLE FOR DEPTH INTERVAL 3'–13' BGS

north

0 100 200

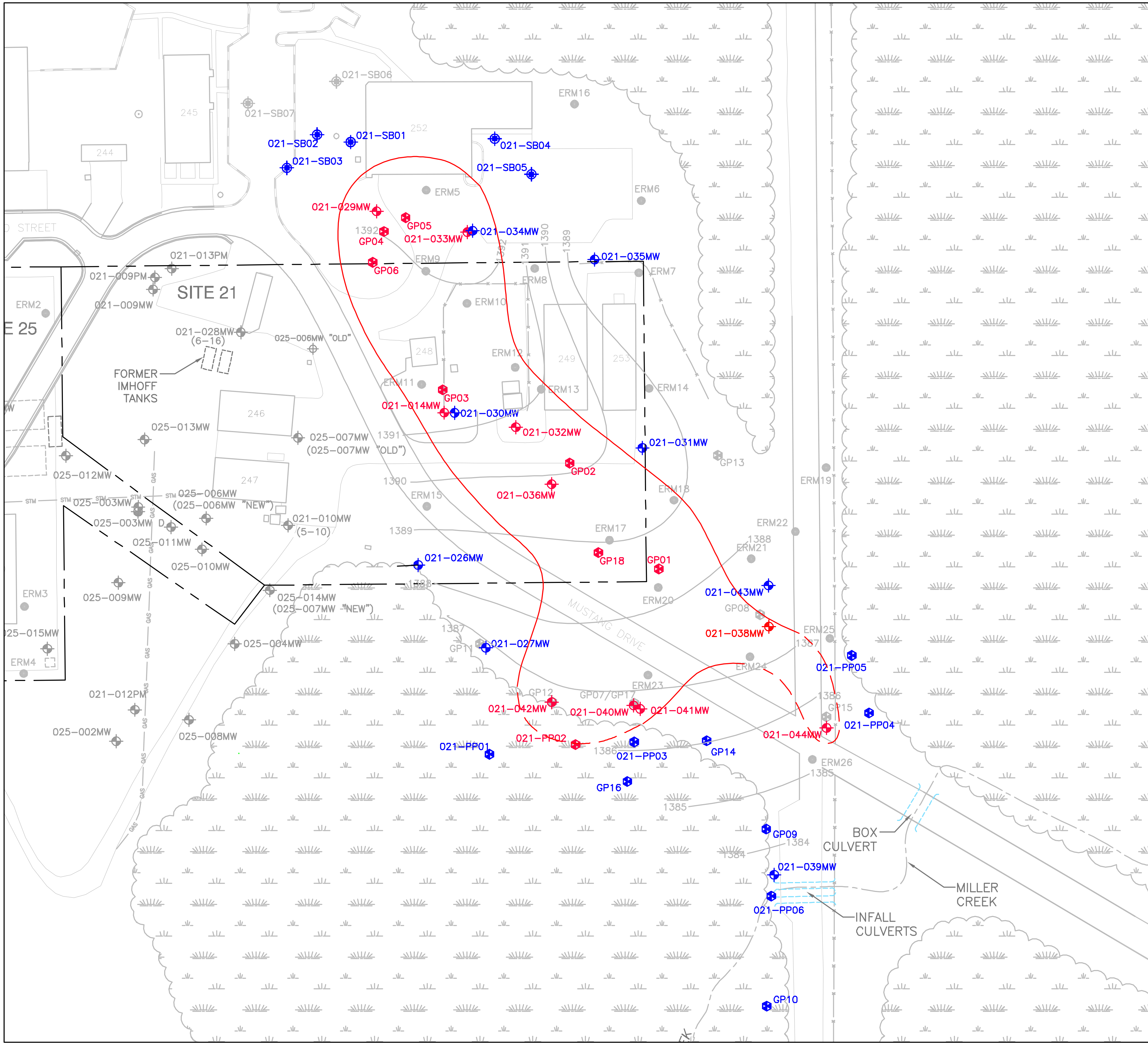
SCALE IN FEET

148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
SITE 21
TCE PLUME ISOCONCENTRATION MAP (13'–22' BGS)
SEPTEMBER 2009

FIGURE 2–2

MWH

Drawn By & Date: DLF 11/09/09 | Approved By & Date: | Revised By & Date: DLF 09/07/10 | Approved By & Date:



LEGEND

- MARSH
- BUILDINGS
- ERM GEOPROBE POINT
- SOIL BORING LOCATION – AUGUST 2008/MAY 2009
- VAS = VERTICAL AQUIFER SAMPLING LOCATION
- MONITORING WELL SAMPLED
- MONITORING WELL SAMPLED – EXCEEDANCE OF HRL
- PUSHPOINT LOCATION SAMPLED
- PUSHPOINT LOCATION – EXCEEDANCE OF HRL
- 5 PPB TCE ISOCONTOUR (APPROXIMATELY 92,942 SF)
- GROUNDWATER CONTOUR

DASHED LINE INDICATES INFERRED CONTOUR

ALL CONCENTRATIONS IN MICROGRAMS PER LITER

GP01, GP02, GP03, GP04, GP05, GP06, AND GP18 COLLECTED MAY 2009

north

0 100 200

SCALE IN FEET

148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT

SITE 21 RECOMMENDED TREATMENT AREA

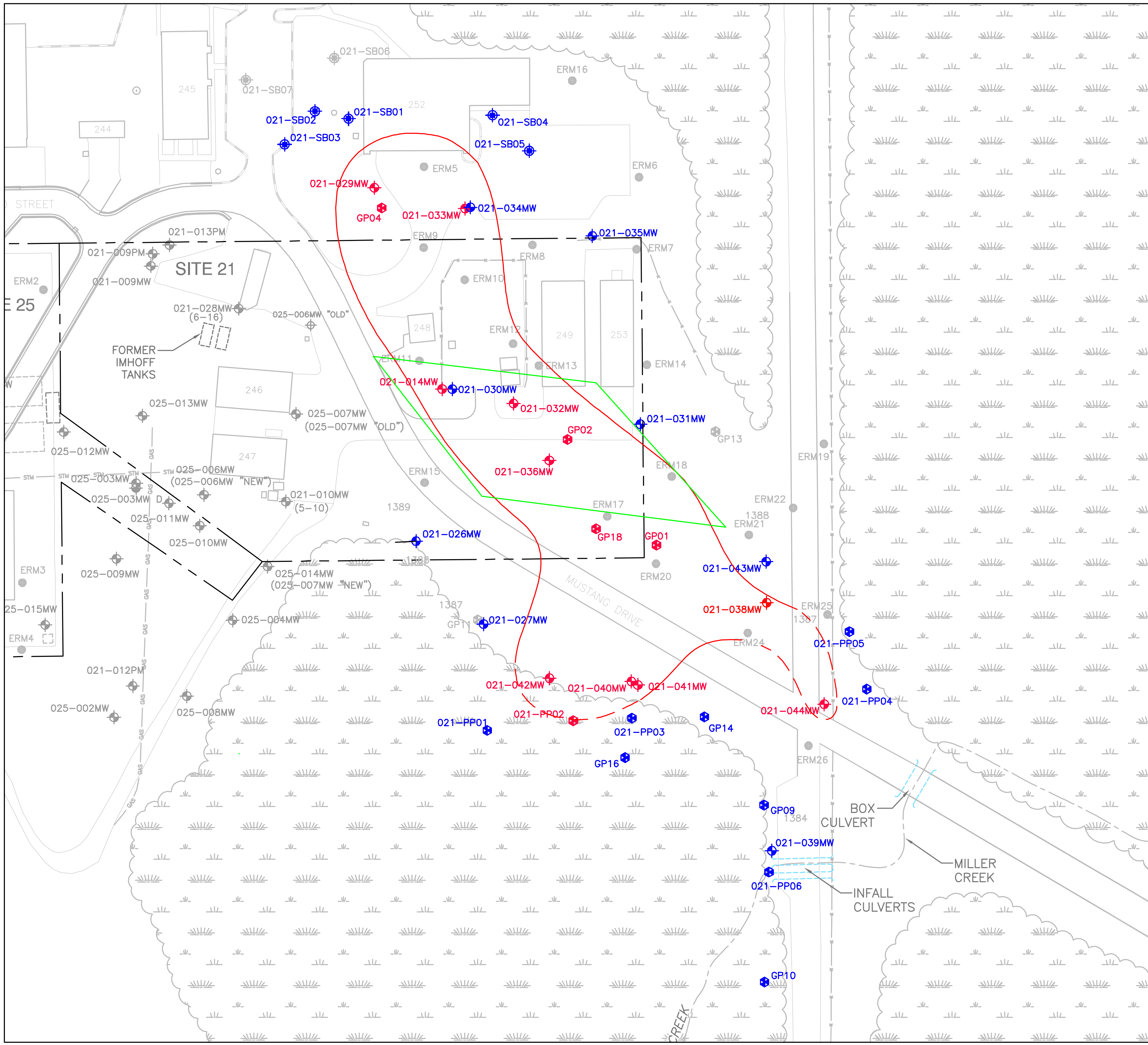
SEPTEMBER 2009

FIGURE 2–3

MWH

Drawn By & Date: DLF 11/09/09 Approved By & Date:

Revised By & Date: DLF 09/07/10 Approved By & Date:



LEGEND

- MARSH
- BUILDINGS
- ERM GEOPROBE POINT
- SOIL BORING LOCATION – AUGUST 2008/MAY 2009
- VAS = VERTICAL AQUIFER SAMPLING LOCATION
- MONITORING WELL SAMPLED
- MONITORING WELL SAMPLED – EXCEEDANCE OF HRL
- PUSHPOINT LOCATION SAMPLED
- PUSHPOINT LOCATION – EXCEEDANCE OF HRL
- 5 PPB TCE ISOCONTOUR (APPROXIMATELY 92,942 SF)
- PHYTOREMEDIATION TREATMENT AREA (~0.5 ACRE)

north

0 100 200

SCALE IN FEET

148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT

SITE 21

ALTERNATIVE 2 – PHYTOREMEDIATION

FIGURE 3–1

MWH

Drawn By & Date: DLF 11/09/09 | Approved By & Date: | Revised By & Date: DLF 08/31/10 | Approved By & Date:

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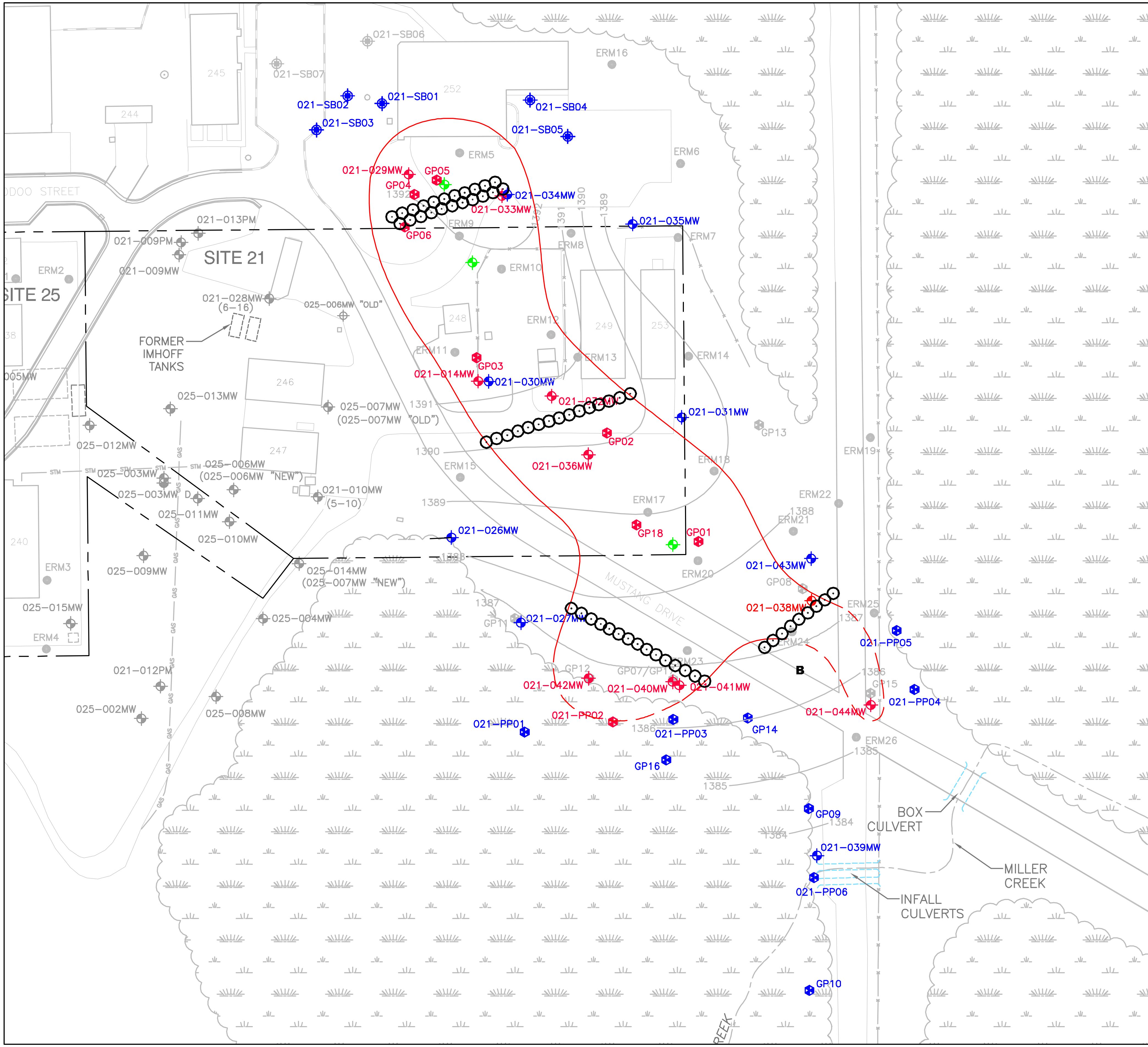

LEGEND

- MARSH
- BUILDINGS
- ERM GEOPROBE POINT
- SOIL BORING LOCATION – AUGUST 2008/MAY 2009
- VAS = VERTICAL AQUIFER SAMPLING LOCATION
- MONITORING WELL SAMPLED
- MONITORING WELL SAMPLED – EXCEEDANCE OF HRL
- PUSHPOINT LOCATION SAMPLED
- PUSHPOINT LOCATION – EXCEEDANCE OF HRL
- 5 PPB TCE ISOCONTOUR (APPROXIMATELY 92,942 SF)
- GROUNDWATER CONTOUR
- REDUCTIVE DECHLORINATION INJECTION LOCATION
- REDUCTIVE DECHLORINATION INJECTION RADIUS OF INFLUENCE
- NEW PERFORMANCE MONITORING WELL
- DASHED LINE INDICATES INFERRED CONTOUR

north

0 100 200

SCALE IN FEET

148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT

ALTERNATIVE 3 – ENHANCED BIOREMEDIATION

FIGURE 3-2

MWH

Drawn By & Date: DLF 11/09/09 Approved By & Date: Revised By & Date: DLF 09/07/10 Approved By & Date:

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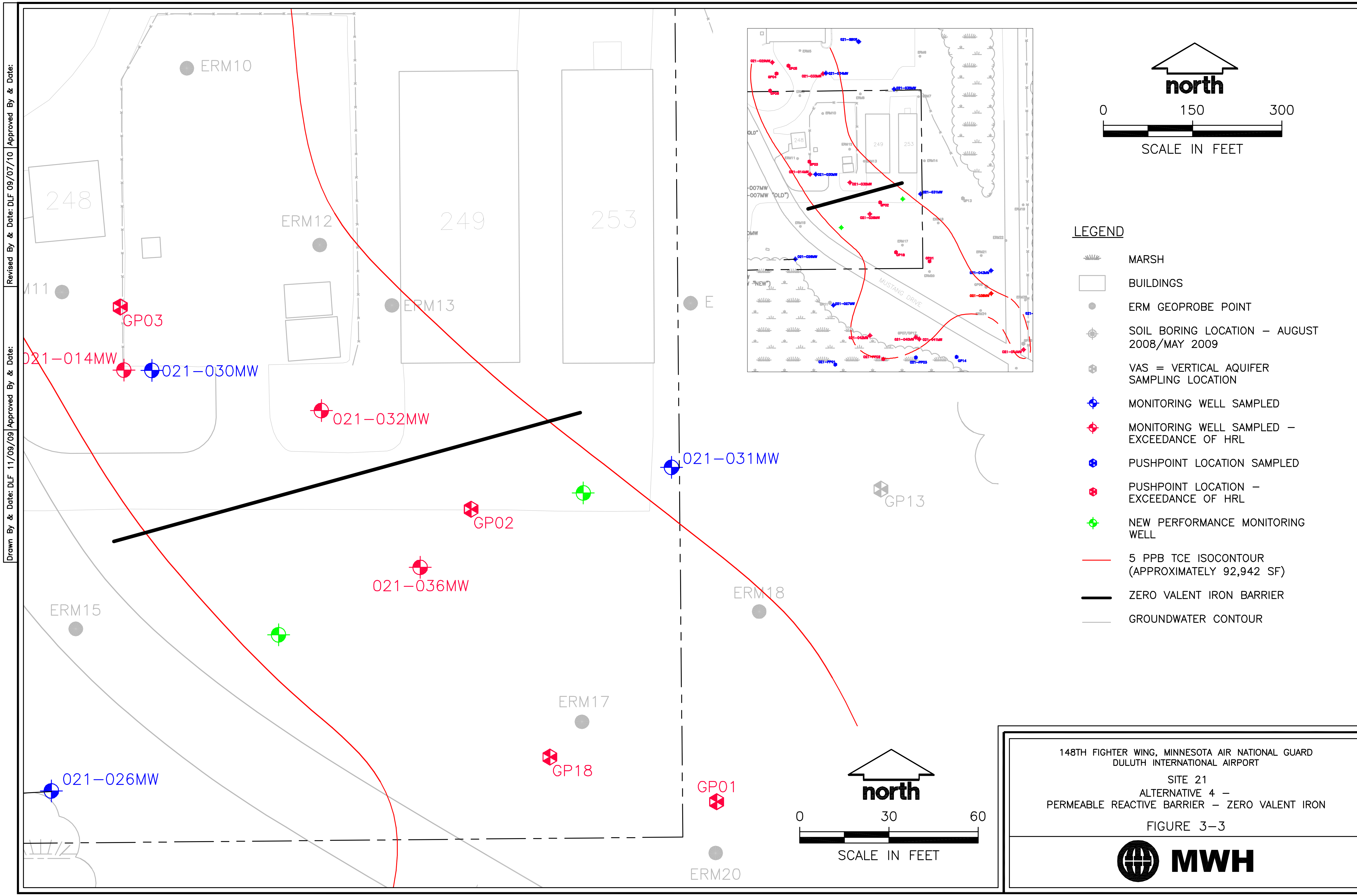
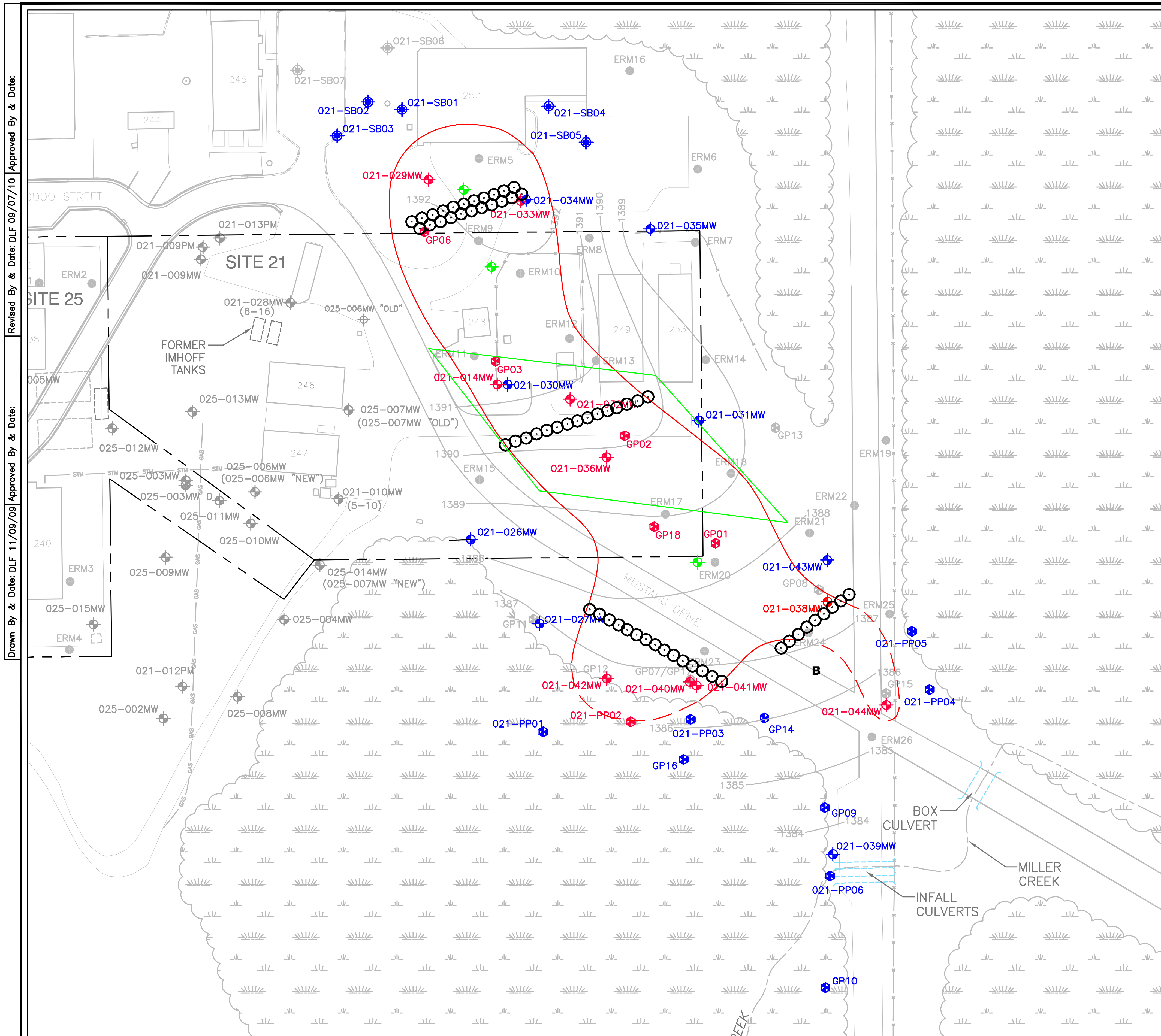


148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT

SITE 21
ALTERNATIVE 4 –
PERMEABLE REACTIVE BARRIER – ZERO VALENT IRON

FIGURE 3–3

MWH



LEGEND

- MARSH
- BUILDINGS
- ERM GEOPROBE POINT
- SOIL BORING LOCATION – AUGUST 2008/MAY 2009
- VAS = VERTICAL AQUIFER SAMPLING LOCATION
- MONITORING WELL SAMPLED
- MONITORING WELL SAMPLED – EXCEEDANCE OF HRL
- PUSHPOINT LOCATION SAMPLED
- PUSHPOINT LOCATION – EXCEEDANCE OF HRL
- 5 PPB TCE ISOCONTOUR (APPROXIMATELY 92,942 SF)
- GROUNDWATER CONTOUR
- PHYTOREMEDIATION TREATMENT AREA (~0.5 ACRE)
- REDUCTIVE DECHLORINATION INJECTION LOCATION
- REDUCTIVE DECHLORINATION INJECTION RADIUS OF INFLUENCE
- NEW PERFORMANCE MONITORING WELL
- DASHED LINE INDICATES INFERRED CONTOUR

north

0 100 200

SCALE IN FEET

148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT

ALTERNATIVE 2 AND 3

PHYTOREMEDIATION AND ENHANCED BIOREMEDIATION

FIGURE 5–1

MWH

Drawn By & Date: DLF 11/09/09 Approved By & Date:
Revised By & Date: DLF 09/07/10 Approved By & Date:

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TABLES

TABLE 1-1
VAS, TEMPORARY WELLS, AND PUSHPOINT
GROUNDWATER ANALYTICAL RESULTS - VOCS/TPH-DRO
148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
AUGUST 2008, MAY 2009, AND SEPTEMBER 2009

Date Collected					Tier 2 Surface Water Quality Standards				**8/4/2008**	**8/4/2008**	**8/4/2008**	**8/4/2008**	**8/4/2008**	**8/4/2008**	**8/4/2008**	**8/4/2008**	**8/5/2008**	**8/5/2008**
Sample ID					1B	2A	2A	2A	**GP01 (18-22)**	**GP01(13-17)**	**GP01(8-12)**	**GP01(3-7)**	**GP02(18-22)**	**GP02(13-17)**	**GP02(8-12)**	**GP02(3-7)**	**GP03(24-28)**	**GP03(19-23)**
		MCL^	HRL#	GW_{isv}	DW*	CS*	MS*	FAV*										
Volatile Organic Compounds																		
1,1,1-Trichloroethane	µg/l	200	9,000	10000	200	329	2,957	5,913	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,1-Dichloroethylene	µg/l	7	200	300	7	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2,4-Trimethylbenzene	µg/l	-	-	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2-Dichlorobenzene	µg/l	-	600	7000	600	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,3,5-Trimethylbenzene	µg/l	-	100	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,4-Dichlorobenzene	µg/l	-	10	2000	75	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Acetone	µg/l	-	700	40000000	-	-	-	-	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0
Benzene	µg/l	5	2	40	5	9.7	4,487†	8,974†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Chlorobenzene	µg/l	100	100	800	100	20	423	846	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
cis-1,2-Dichloroethene	µg/l	70	50	NA	70	-	-	-	**3.0**	**3.8**	**5.6**	**6.9**	**2.3**	**4.2**	**6.7**	**14.0**	< 1.0	< 1.0
Dichlorodifluoromethane	µg/l	-	700	70	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Dichlorofluoromethane	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethyl ether	µg/l	-	1,000	-	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Ethylbenzene	µg/l	700	700	7000	700	68	1,859	3,717	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Isopropylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
m&p-Xylenes	µg/l	-	-	800	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Methylene chloride	µg/l	-	5	400	5	45	13,875†	27,749†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**1.6**	< 1.0
Naphthalene	µg/l	-	300	1000	-	81	409	818	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
n-Propylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-Xylene	µg/l	-	-	1000	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p-Isopropyltoluene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
sec-Butylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
tert-Butylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Tetrahydrofuran	µg/l	-	-	-	-	-	-	-	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
trans-1,2-Dichloroethene	µg/l	100	100	300	100	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Trichloroethene	µg/l	5	5	20	5	25	6,988†	13,976†	**40.0**	**63.0**	**65.0**	**16.0**	**21.0**	**68.0**	**53.0**	**3.5**	< 1.0	< 1.0
Vinyl Chloride	µg/l	2	0.2	1	2	0.17	†	†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Xylenes (total)	µg/l	10,000	10,000	-	10,000	166	1,407	2,814	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0
TPH-DRO	mg/l	-	-	-	-	-	-	-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
Only detected compounds are shown
Analytical data in bold text denotes sample detections above the MDL
Analytical data outlined denotes sample detections above HRL or CS
TPH-DRO = total petroleum hydrocarbons-diesel range organics
MCL = Maximum Contaminant Level
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- = No Limit established
DW = Drinking Water
CS = Chronic Standard
FAV = Final Acute Value
MS = Maximum Standard
µg/l = micrograms per liter
mg/l = milligrams per liter
ID= Identification
QC= Quality Control
J = Estimated concentration
DUP = Duplicate
NA = not applicable
^ = Federal MCL under Safe Drinking Water Act (40 CFR Part 141).
# = State of Minnesota HRL, established in Minnesota Rules Chapter 4717.
* = State of Minnesota Specific Standards of Quality and Purity for Class 1B and 2A waters of the State.
† = For a pollutant with asterisks next to the final acute value (FAV) and the maximum standard (MS), the following applies:
For carcinogenic or highly bioaccumulative chemicals with BCF's greater than 5000 or log Kow values greater than 5.19, the human health chronic standard may be two or more orders smaller than the acute toxicity based MS.
For the MS: if the ratio of MS to the CS is greater than 100, the CS times 100 should be substituted for the applicable MS.
For the FAV: if the ratio of FAV to the CS is greater than 200, the CS times 200 should be substituted for the applicable FAV.
From Minn. R. 7050.0222, subp. 7, item E.

TABLE 1-1
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GROUNDWATER ANALYTICAL RESULTS - VOCS/TPH-DRO
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DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
AUGUST 2008, MAY 2009, AND SEPTEMBER 2009

Date Collected					Tier 2 Surface Water Quality Standards				**8/5/2008**	**8/5/2008**	**8/5/2008**	**8/5/2008**	**8/5/2008**	**8/5/2008**	**8/5/2008**	**8/6/2008**	**8/6/2008**	**8/6/2008**
Sample ID					1B	2A	2A	2A	**GP03(14-18)**	**GP03(14-18) DUP**	**GP04(23-27)**	**GP04(18-22)**	**GP04(13-17)**	**GP05(4-8)**	**GP06 (12-16)**	**GP07(16-20)**	**GP07(11-15)**	**GP07(6-10)**
		MCL^	HRL#	GW_{isv}	DW*	CS*	MS*	FAV*										
Volatile Organic Compounds																		
1,1,1-Trichloroethane	µg/l	200	9,000	10000	200	329	2,957	5,913	< 1.0	< 1.0	< 1.0	**1.4**	**1.1**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,1-Dichloroethylene	µg/l	7	200	300	7	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2,4-Trimethylbenzene	µg/l	-	-	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**6.4**	< 1.0	< 1.0	< 1.0	< 1.0
1,2-Dichlorobenzene	µg/l	-	600	7000	600	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,3,5-Trimethylbenzene	µg/l	-	100	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**3.6**	< 1.0	< 1.0	< 1.0	< 1.0
1,4-Dichlorobenzene	µg/l	-	10	2000	75	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Acetone	µg/l	-	700	40000000	-	-	-	-	< 20.0	< 20.0	**29.0**	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0
Benzene	µg/l	5	2	40	5	9.7	4,487†	8,974†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Chlorobenzene	µg/l	100	100	800	100	20	423	846	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
cis-1,2-Dichloroethene	µg/l	70	50	NA	70	-	-	-	**3.6**	**3.6**	< 1.0	**1.4**	**3.6**	**11.0**	**2.5**	**2.7**	**3.3**	**2.6**
Dichlorodifluoromethane	µg/l	-	700	70	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Dichlorofluoromethane	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethyl ether	µg/l	-	1,000	-	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Ethylbenzene	µg/l	700	700	7000	700	68	1,859	3,717	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**7.7**	< 1.0	< 1.0	< 1.0	< 1.0
Isopropylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**1.7**	< 1.0	< 1.0	< 1.0	< 1.0
m&p-Xylenes	µg/l	-	-	800	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	**2.1**	< 2.0	< 2.0	< 2.0	< 2.0
Methylene chloride	µg/l	-	5	400	5	45	13,875†	27,749†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Naphthalene	µg/l	-	300	1000	-	81	409	818	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
n-Propylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**2.7**	< 1.0	< 1.0	< 1.0	< 1.0
o-Xylene	µg/l	-	-	1000	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**2.9**	< 1.0	< 1.0	< 1.0	< 1.0
p-Isopropyltoluene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
sec-Butylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
tert-Butylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Tetrahydrofuran	µg/l	-	-	-	-	-	-	-	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
trans-1,2-Dichloroethene	µg/l	100	100	300	100	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Trichloroethene	µg/l	5	5	20	5	25	6,988†	13,976†	**43.0**	**43.0**	**2.4**	**11.0**	**29.0**	**88.0**	**59.0**	**41.0**	**43.0**	**6.6**
Vinyl Chloride	µg/l	2	0.2	1	2	0.17	†	†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Xylenes (total)	µg/l	10,000	10,000	-	10,000	166	1,407	2,814	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	**5.0**	< 3.0	< 3.0	< 3.0	< 3.0
TPH-DRO	mg/l	-	-	-	-	-	-	-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
Only detected compounds are shown
Analytical data in bold text denotes sample detections above the MDL
Analytical data outlined denotes sample detections above HRL or CS
TPH-DRO = total petroleum hydrocarbons-diesel range organics
MCL = Maximum Contaminant Level
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µg/l = micrograms per liter
mg/l = milligrams per liter
ID= Identification
QC= Quality Control
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DUP = Duplicate
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^ = Federal MCL under Safe Drinking Water Act (40 CFR Part 141).
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† = For a pollutant with asterisks next to the final acute value (FAV) and the maximum standard (MS), the following applies:
For carcinogenic or highly bioaccumulative chemicals with BCF's greater than 5000 or log Kow values greater than 5.19, the human health chronic standard may be two or more orders smaller than the acute toxicity based MS.
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From Minn. R. 7050.0222, subp. 7, item E.

TABLE 1-1
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DULUTH, MINNESOTA
AUGUST 2008, MAY 2009, AND SEPTEMBER 2009

Date Collected					Tier 2 Surface Water Quality Standards				**8/6/2008**	**5/5/2009**	**5/5/2009**	**5/5/2009**	**5/5/2009**	**5/5/2009**	**5/5/2009**	**5/5/2009**	**5/5/2009**	**5/5/2009**
Sample ID					1B	2A	2A	2A	**GP07(1-5)**	**GP08(32-36)**	**GP08(22-26)**	**GP09(36-40)**	**GP09(26-30)**	**GP09(16-20)**	**GP09(6-10)**	**GP10(35-39)**	**GP10(24-28)**	**GP10(14-18)**
		MCL^	HRL#	GW_{isv}	DW*	CS*	MS*	FAV*										
Volatile Organic Compounds																		
1,1,1-Trichloroethane	µg/l	200	9,000	10000	200	329	2,957	5,913	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,1-Dichloroethylene	µg/l	7	200	300	7	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2,4-Trimethylbenzene	µg/l	-	-	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2-Dichlorobenzene	µg/l	-	600	7000	600	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,3,5-Trimethylbenzene	µg/l	-	100	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,4-Dichlorobenzene	µg/l	-	10	2000	75	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Acetone	µg/l	-	700	40000000	-	-	-	-	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0
Benzene	µg/l	5	2	40	5	9.7	4,487†	8,974†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Chlorobenzene	µg/l	100	100	800	100	20	423	846	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
cis-1,2-Dichloroethene	µg/l	70	50	NA	70	-	-	-	< 1.0	< 1.0	**2.1**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Dichlorodifluoromethane	µg/l	-	700	70	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Dichlorofluoromethane	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethyl ether	µg/l	-	1,000	-	-	-	-	-	**6.8**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethylbenzene	µg/l	700	700	7000	700	68	1,859	3,717	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Isopropylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
m&p-Xylenes	µg/l	-	-	800	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Methylene chloride	µg/l	-	5	400	5	45	13,875†	27,749†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Naphthalene	µg/l	-	300	1000	-	81	409	818	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
n-Propylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-Xylene	µg/l	-	-	1000	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p-Isopropyltoluene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
sec-Butylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
tert-Butylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Tetrahydrofuran	µg/l	-	-	-	-	-	-	-	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
trans-1,2-Dichloroethene	µg/l	100	100	300	100	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Trichloroethene	µg/l	5	5	20	5	25	6,988†	13,976†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Vinyl Chloride	µg/l	2	0.2	1	2	0.17	†	†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Xylenes (total)	µg/l	10,000	10,000	-	10,000	166	1,407	2,814	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0
TPH-DRO	mg/l	-	-	-	-	-	-	-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
Only detected compounds are shown
Analytical data in bold text denotes sample detections above the MDL
Analytical data outlined denotes sample detections above HRL or CS
TPH-DRO = total petroleum hydrocarbons-diesel range organics
MCL = Maximum Contaminant Level
HRL = Minnesota Health Risk Limit
GW_{isv} = Groundwater Screening Values for Vapor Intrusion Pathway as provided in the MPCA document c-s4-06, "Risk-based Guidance for the Vapor Intrusion Pathway, Superfund RCRA and Voluntary Cleanup Section" dated September 2008, unless otherwise noted. Exceptions are for acetone, cis-1,2-DCE, and 1,1,1-Trichloroethane, which required updating based on the Intrusion Screening Values (ISVs) released by MPCA in February 2009.
- = No Limit established
DW = Drinking Water
CS = Chronic Standard
FAV = Final Acute Value
MS = Maximum Standard
µg/l = micrograms per liter
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ID= Identification
QC= Quality Control
J = Estimated concentration
DUP = Duplicate
NA = not applicable
^ = Federal MCL under Safe Drinking Water Act (40 CFR Part 141).
# = State of Minnesota HRL, established in Minnesota Rules Chapter 4717.
* = State of Minnesota Specific Standards of Quality and Purity for Class 1B and 2A waters of the State.
† = For a pollutant with asterisks next to the final acute value (FAV) and the maximum standard (MS), the following applies:
For carcinogenic or highly bioaccumulative chemicals with BCF's greater than 5000 or log Kow values greater than 5.19, the human health chronic standard may be two or more orders smaller than the acute toxicity based MS.
For the MS: if the ratio of MS to the CS is greater than 100, the CS times 100 should be substituted for the applicable MS.
For the FAV: if the ratio of FAV to the CS is greater than 200, the CS times 200 should be substituted for the applicable FAV
From Minn. R. 7050.0222, subp. 7, item E.

TABLE 1-1
VAS, TEMPORARY WELLS, AND PUSHPOINT
GROUNDWATER ANALYTICAL RESULTS - VOCS/TPH-DRO
148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
AUGUST 2008, MAY 2009, AND SEPTEMBER 2009

Date Collected					Tier 2 Surface Water Quality Standards				**5/5/2009**	**5/5/2009**	**5/6/2009**	**5/6/2009**	**5/6/2009**	**5/6/2009**	**5/6/2009**	**5/6/2009**	**5/6/2009**	**5/6/2009**
Sample ID		MCL^	HRL#	GW_{isv}	1B DW*	2A CS*	2A MS*	2A FAV*	**GP10(4-8)**	**GP10(4-8) DUP**	**GP11(52-56)**	**GP11(42-46)**	**GP11(32-36)**	**GP11(22-26)**	**GP12(44-48)**	**GP12(34-38)**	**GP12(24-28)**	**GP12(14-18)**
Volatile Organic Compounds																		
1,1,1-Trichloroethane	µg/l	200	9,000	10000	200	329	2,957	5,913	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,1-Dichloroethylene	µg/l	7	200	300	7	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2,4-Trimethylbenzene	µg/l	-	-	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2-Dichlorobenzene	µg/l	-	600	7000	600	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,3,5-Trimethylbenzene	µg/l	-	100	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,4-Dichlorobenzene	µg/l	-	10	2000	75	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Acetone	µg/l	-	700	40000000	-	-	-	-	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0
Benzene	µg/l	5	2	40	5	9.7	4,487†	8,974†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Chlorobenzene	µg/l	100	100	800	100	20	423	846	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
cis-1,2-Dichloroethene	µg/l	70	50	NA	70	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**2.2**
Dichlorodifluoromethane	µg/l	-	700	70	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Dichlorofluoromethane	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethyl ether	µg/l	-	1,000	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethylbenzene	µg/l	700	700	7000	700	68	1,859	3,717	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Isopropylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
m&p-Xylenes	µg/l	-	-	800	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Methylene chloride	µg/l	-	5	400	5	45	13,875†	27,749†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Naphthalene	µg/l	-	300	1000	-	81	409	818	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
n-Propylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-Xylene	µg/l	-	-	1000	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p-Isopropyltoluene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
sec-Butylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
tert-Butylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Tetrahydrofuran	µg/l	-	-	-	-	-	-	-	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
trans-1,2-Dichloroethene	µg/l	100	100	300	100	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Trichloroethene	µg/l	5	5	20	5	25	6,988†	13,976†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**25.0**
Vinyl Chloride	µg/l	2	0.2	1	2	0.17	†	†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Xylenes (total)	µg/l	10,000	10,000	-	10,000	166	1,407	2,814	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0
TPH-DRO	mg/l	-	-	-	-	-	-	-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
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Sample ID					1B	2A	2A	2A	**GP12(4-8)**	**GP13(22-26)**	**GP13(22-26)**	**GP13(12-16)**	**GP13(4-8)**	**GP14(39-43)**	**GP14(29-33)**	**GP14(19-23)**	**GP14(9-13)**	**GP15(30-34)**
		MCL^	HRL#	GW_{isv}	DW*	CS*	MS*	FAV*										
Volatile Organic Compounds																		
1,1,1-Trichloroethane	µg/l	200	9,000	10000	200	329	2,957	5,913	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,1-Dichloroethylene	µg/l	7	200	300	7	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2,4-Trimethylbenzene	µg/l	-	-	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2-Dichlorobenzene	µg/l	-	600	7000	600	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,3,5-Trimethylbenzene	µg/l	-	100	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,4-Dichlorobenzene	µg/l	-	10	2000	75	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Acetone	µg/l	-	700	40000000	-	-	-	-	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0
Benzene	µg/l	5	2	40	5	9.7	4,487†	8,974†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Chlorobenzene	µg/l	100	100	800	100	20	423	846	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
cis-1,2-Dichloroethene	µg/l	70	50	NA	70	-	-	-	**1.7**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Dichlorodifluoromethane	µg/l	-	700	70	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Dichlorofluoromethane	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethyl ether	µg/l	-	1,000	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethylbenzene	µg/l	700	700	7000	700	68	1,859	3,717	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Isopropylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
m&p-Xylenes	µg/l	-	-	800	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Methylene chloride	µg/l	-	5	400	5	45	13,875†	27,749†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Naphthalene	µg/l	-	300	1000	-	81	409	818	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
n-Propylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-Xylene	µg/l	-	-	1000	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p-Isopropyltoluene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
sec-Butylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
tert-Butylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Tetrahydrofuran	µg/l	-	-	-	-	-	-	-	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
trans-1,2-Dichloroethene	µg/l	100	100	300	100	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Trichloroethene	µg/l	5	5	20	5	25	6,988†	13,976†	**18.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Vinyl Chloride	µg/l	2	0.2	1	2	0.17	†	†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Xylenes (total)	µg/l	10,000	10,000	-	10,000	166	1,407	2,814	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0
TPH-DRO	mg/l	-	-	-	-	-	-	-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
Only detected compounds are shown
Analytical data in bold text denotes sample detections above the MDL
Analytical data outlined denotes sample detections above HRL or CS
TPH-DRO = total petroleum hydrocarbons-diesel range organics
MCL = Maximum Contaminant Level
HRL = Minnesota Health Risk Limit
GW_{isv} = Groundwater Screening Values for Vapor Intrusion Pathway as provided in the MPCA document c-s4-06, "Risk-based Guidance for the Vapor Intrusion Pathway, Superfund RCRA and Voluntary Cleanup Section" dated September 2008, unless otherwise noted. Exceptions are for acetone, cis-1,2-DCE, and 1,1,1-Trichloroethane, which required updating based on the Intrusion Screening Values (ISVs) released by MPCA in February 2009.
- = No Limit established
DW = Drinking Water
CS = Chronic Standard
FAV = Final Acute Value
MS = Maximum Standard
µg/l = micrograms per liter
mg/l = milligrams per liter
ID= Identification
QC= Quality Control
J = Estimated concentration
DUP = Duplicate
NA = not applicable
^ = Federal MCL under Safe Drinking Water Act (40 CFR Part 141).
# = State of Minnesota HRL, established in Minnesota Rules Chapter 4717.
* = State of Minnesota Specific Standards of Quality and Purity for Class 1B and 2A waters of the State.
† = For a pollutant with asterisks next to the final acute value (FAV) and the maximum standard (MS), the following applies:
For carcinogenic or highly bioaccumulative chemicals with BCF's greater than 5000 or log Kow values greater than 5.19, the human health chronic standard may be two or more orders smaller than the acute toxicity based MS.
For the MS: if the ratio of MS to the CS is greater than 100, the CS times 100 should be substituted for the applicable MS.
For the FAV: if the ratio of FAV to the CS is greater than 200, the CS times 200 should be substituted for the applicable FAV
From Minn. R. 7050.0222, subp. 7, item E.

TABLE 1-1
VAS, TEMPORARY WELLS, AND PUSHPOINT
GROUNDWATER ANALYTICAL RESULTS - VOCS/TPH-DRO
148[TH] FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
AUGUST 2008, MAY 2009, AND SEPTEMBER 2009

Date Collected					Tier 2 Surface Water Quality Standards				**5/6/2009**	**5/7/2009**	**5/7/2009**	**5/7/2009**	**5/7/2009**	**5/7/2009**	**5/7/2009**	**5/7/2009**	**5/7/2009**	**5/7/2009**
Sample ID		MCL^	HRL#	GW_{isv}	1B DW*	2A CS*	2A MS*	2A FAV*	**GP15(20-24)**	**GP15(10-14)**	**GP15(10-14) DUP**	**GP16(38-42)**	**GP16(28-32)**	**GP16(18-22)**	**GP16(8-12)**	**GP16(8-12) DUP05**	**GP17(36-40)**	**GP17(26-30)**
Volatile Organic Compounds																		
1,1,1-Trichloroethane	µg/l	200	9,000	10000	200	329	2,957	5,913	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,1-Dichloroethylene	µg/l	7	200	300	7	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2,4-Trimethylbenzene	µg/l	-	-	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2-Dichlorobenzene	µg/l	-	600	7000	600	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,3,5-Trimethylbenzene	µg/l	-	100	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,4-Dichlorobenzene	µg/l	-	10	2000	75	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Acetone	µg/l	-	700	40000000	-	-	-	-	< 20.0	< 20	< 20	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0
Benzene	µg/l	5	2	40	5	9.7	4,487†	8,974†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Chlorobenzene	µg/l	100	100	800	100	20	423	846	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
cis-1,2-Dichloroethene	µg/l	70	50	NA	70	-	-	-	< 1.0	**2.6**	**2.7**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**1.4**
Dichlorodifluoromethane	µg/l	-	700	70	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Dichlorofluoromethane	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethyl ether	µg/l	-	1,000	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethylbenzene	µg/l	700	700	7000	700	68	1,859	3,717	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Isopropylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
m&p-Xylenes	µg/l	-	-	800	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Methylene chloride	µg/l	-	5	400	5	45	13,875†	27,749†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Naphthalene	µg/l	-	300	1000	-	81	409	818	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
n-Propylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-Xylene	µg/l	-	-	1000	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p-Isopropyltoluene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
sec-Butylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
tert-Butylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Tetrahydrofuran	µg/l	-	-	-	-	-	-	-	< 5.0	**92**	**92**	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
trans-1,2-Dichloroethene	µg/l	100	100	300	100	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Trichloroethene	µg/l	5	5	20	5	25	6,988†	13,976†	< 1.0	**5.6**	**5.5**	< 1.0	< 1.0	< 1.0	**1.2**	**1.1**	< 1.0	**4.8**
Vinyl Chloride	µg/l	2	0.2	1	2	0.17	†	†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Xylenes (total)	µg/l	10,000	10,000	-	10,000	166	1,407	2,814	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0
TPH-DRO	mg/l	-	-	-	-	-	-	-	NA	NA	NA	NA	NA	< 0.1	NA	NA	NA	< 0.12

Notes:
Only detected compounds are shown
Analytical data in bold text denotes sample detections above the MDL
Analytical data outlined denotes sample detections above HRL or CS
TPH-DRO = total petroleum hydrocarbons-diesel range organics
MCL = Maximum Contaminant Level
HRL = Minnesota Health Risk Limit
GW_{isv} = Groundwater Screening Values for Vapor Intrusion Pathway as provided in the MPCA document c-s4-06, "Risk-based Guidance for the Vapor Intrusion Pathway, Superfund RCRA and Voluntary Cleanup Section" dated September 2008, unless otherwise noted. Exceptions are for acetone, cis-1,2-DCE, and 1,1,1-Trichloroethane, which required updating based on the Intrusion Screening Values (ISVs) released by MPCA in February 2009.
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DW = Drinking Water
CS = Chronic Standard
FAV = Final Acute Value
MS = Maximum Standard
µg/l = micrograms per liter
mg/l = milligrams per liter
ID= Identification
QC= Quality Control
J = Estimated concentration
DUP = Duplicate
NA = not applicable
^ = Federal MCL under Safe Drinking Water Act (40 CFR Part 141).
# = State of Minnesota HRL, established in Minnesota Rules Chapter 4717.
* = State of Minnesota Specific Standards of Quality and Purity for Class 1B and 2A waters of the State.
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From Minn. R. 7050.0222, subp. 7, item E.

TABLE 1-1
VAS, TEMPORARY WELLS, AND PUSHPOINT
GROUNDWATER ANALYTICAL RESULTS - VOCS/TPH-DRO
148[TH] FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
AUGUST 2008, MAY 2009, AND SEPTEMBER 2009

Date Collected					Tier 2 Surface Water Quality Standards				**5/7/2009**	**5/7/2009**	**5/7/2009**	**5/7/2009**	**5/7/2009**	**8/6/2008**	**8/6/2008**	**8/6/2008**	**8/6/2008**	**8/6/2008**	**8/6/2008**	**8/6/2008**
Sample ID					1B	2A	2A	2A	**GP18(37-41)**	**GP18(27-31)**	**GP18(17-21)**	**GP18(7-11)**	**GP18(7-11) DUP06**	**021-SB01**	**021-SB02**	**021-SB02 DUP**	**021-SB03**	**021-SB04**	**021-SB04 DUP**	**021-SB05**
		MCL^	HRL#	GW_{isv}	DW*	CS*	MS*	FAV*												
Volatile Organic Compounds																				
1,1,1-Trichloroethane	µg/l	200	9,000	10000	200	329	2,957	5,913	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
1,1-Dichloroethylene	µg/l	7	200	300	7	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
1,2,4-Trimethylbenzene	µg/l	-	-	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**4.6**	NA	< 1.0	< 1.0	< 1.0	< 1.0
1,2-Dichlorobenzene	µg/l	-	600	7000	600	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**5.8**	**7.2**	NA	**6.3**	< 1.0	< 1.0	< 1.0
1,3,5-Trimethylbenzene	µg/l	-	100	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**1.8**	NA	< 1.0	< 1.0	< 1.0	< 1.0
1,4-Dichlorobenzene	µg/l	-	10	2000	75	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**4.3**	**1.2**	NA	< 1.0	< 1.0	< 1.0	< 1.0
Acetone	µg/l	-	700	40000000	-	-	-	-	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	NA	< 20.0	< 20.0	< 20.0	< 20.0
Benzene	µg/l	5	2	40	5	9.7	4,487†	8,974†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
Chlorobenzene	µg/l	100	100	800	100	20	423	846	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**32.0**	**1.7**	NA	**2.6**	< 1.0	< 1.0	< 1.0
cis-1,2-Dichloroethene	µg/l	70	50	NA	70	-	-	-	< 1.0	< 1.0	**2.7**	**1.4**	**1.4**	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
Dichlorodifluoromethane	µg/l	-	700	70	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	NA	< 2.0	< 2.0	< 2.0	< 2.0
Dichlorofluoromethane	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
Ethyl ether	µg/l	-	1,000	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 2.0	< 2.0	NA	< 2.0	< 2.0	< 2.0	< 2.0
Ethylbenzene	µg/l	700	700	7000	700	68	1,859	3,717	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
Isopropylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
m&p-Xylenes	µg/l	-	-	800	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	NA	< 2.0	< 2.0	< 2.0	< 2.0
Methylene chloride	µg/l	-	5	400	5	45	13,875†	27,749†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
Naphthalene	µg/l	-	300	1000	-	81	409	818	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	NA	< 2.0	< 2.0	< 2.0	< 2.0
n-Propylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
o-Xylene	µg/l	-	-	1000	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
p-Isopropyltoluene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
sec-Butylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
tert-Butylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
Tetrahydrofuran	µg/l	-	-	-	-	-	-	-	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	NA	< 5.0	< 5.0	< 5.0	< 5.0
trans-1,2-Dichloroethene	µg/l	100	100	300	100	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
Trichloroethene	µg/l	5	5	20	5	25	6,988†	13,976†	< 1.0	< 1.0	**30**	**15**	**16**	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
Vinyl Chloride	µg/l	2	0.2	1	2	0.17	†	†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
Xylenes (total)	µg/l	10,000	10,000	-	10,000	166	1,407	2,814	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	NA	< 3.0	< 3.0	< 3.0	< 3.0
TPH-DRO	mg/l	-	-	-	-	-	-	-	NA	NA	NA	NA	NA	< 0.1	**0.5**	**0.4**	**0.17**	NA	NA	NA

Notes:
Only detected compounds are shown
Analytical data in bold text denotes sample detections above the MDL
Analytical data outlined denotes sample detections above HRL or CS
TPH-DRO = total petroleum hydrocarbons-diesel range organics
MCL = Maximum Contaminant Level
HRL = Minnesota Health Risk Limit
GW_{isv} = Groundwater Screening Values for Vapor Intrusion Pathway as provided in the MPCA document c-s4-06, "Risk-based Guidance for the Vapor Intrusion Pathway, Superfund RCRA and Voluntary Cleanup Section" dated September 2008, unless otherwise noted. Exceptions are for acetone, cis-1,2-DCE, and 1,1,1-Trichloroethane, which required updating based on the Intrusion Screening Values (ISVs) released by MPCA in February 2009.
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For the FAV: if the ratio of FAV to the CS is greater than 200, the CS times 200 should be substituted for the applicable FAV
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GROUNDWATER ANALYTICAL RESULTS - VOCS/TPH-DRO
148[TH] FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
AUGUST 2008, MAY 2009, AND SEPTEMBER 2009

Date Collected					Tier 2 Surface Water Quality Standards				**5/5/2009**	**5/5/2009**	**9/16/2009**	**9/16/2009**	**9/16/2009**	**9/17/2009**	**9/17/2009**	**11/9/2009**	**11/9/2009**
Sample ID					1B	2A	2A	2A	**021-SB06**	**021-SB07**	**021-PP01**	**021-PP02**	**021-PP03**	**021-PP04**	**021-PP05**	**021-PP06**	**021-PP07**
		MCL^	HRL#	GW_{isv}	DW*	CS*	MS*	FAV*									
Volatile Organic Compounds																	
1,1,1-Trichloroethane	µg/l	200	9,000	10000	200	329	2,957	5,913	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,1-Dichloroethylene	µg/l	7	200	300	7	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2,4-Trimethylbenzene	µg/l	-	-	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2-Dichlorobenzene	µg/l	-	600	7000	600	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,3,5-Trimethylbenzene	µg/l	-	100	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,4-Dichlorobenzene	µg/l	-	10	2000	75	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Acetone	µg/l	-	700	40000000	-	-	-	-	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0
Benzene	µg/l	5	2	40	5	9.7	4,487†	8,974†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Chlorobenzene	µg/l	100	100	800	100	20	423	846	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
cis-1,2-Dichloroethene	µg/l	70	50	NA	70	-	-	-	< 1.0	< 1.0	**1.6**	**1.4**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Dichlorodifluoromethane	µg/l	-	700	70	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Dichlorofluoromethane	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethyl ether	µg/l	-	1,000	-	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Ethylbenzene	µg/l	700	700	7000	700	68	1,859	3,717	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Isopropylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
m&p-Xylenes	µg/l	-	-	800	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Methylene chloride	µg/l	-	5	400	5	45	13,875†	27,749†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Naphthalene	µg/l	-	300	1000	-	81	409	818	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
n-Propylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-Xylene	µg/l	-	-	1000	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p-Isopropyltoluene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
sec-Butylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
tert-Butylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Tetrahydrofuran	µg/l	-	-	-	-	-	-	-	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	**200**	< 5.0	< 5.0	< 5.0
trans-1,2-Dichloroethene	µg/l	100	100	300	100	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Trichloroethene	µg/l	5	5	20	5	25	6,988†	13,976†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Vinyl Chloride	µg/l	2	0.2	1	2	0.17	†	†	< 1.0	< 1.0	< 1.0	**9.2**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Xylenes (total)	µg/l	10,000	10,000	-	10,000	166	1,407	2,814	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0
TPH-DRO	mg/l	-	-	-	-	-	-	-	< 0.09	< 0.09	NA	NA	NA	NA	NA	NA	NA

Notes:
Only detected compounds are shown
Analytical data in bold text denotes sample detections above the MDL
Analytical data outlined denotes sample detections above HRL or CS
TPH-DRO = total petroleum hydrocarbons-diesel range organics
MCL = Maximum Contaminant Level
HRL = Minnesota Health Risk Limit
GW_{isv} = Groundwater Screening Values for Vapor Intrusion Pathway as provided in the MPCA document c-s4-06, "Risk-based Guidance for the Vapor Intrusion Pathway, Superfund RCRA and Voluntary Cleanup Section" dated September 2008, unless otherwise noted. Exceptions are for acetone, cis-1,2-DCE, and 1,1,1-Trichloroethane, which required updating based on the Intrusion Screening Values (ISVs) released by MPCA in February 2009.
- = No Limit established
DW = Drinking Water
CS = Chronic Standard
FAV = Final Acute Value
MS = Maximum Standard
µg/l = micrograms per liter
mg/l = milligrams per liter
ID= Identification
QC= Quality Control
J = Estimated concentration
DUP = Duplicate
NA = not applicable
^ = Federal MCL under Safe Drinking Water Act (40 CFR Part 141).
# = State of Minnesota HRL, established in Minnesota Rules Chapter 4717.
* = State of Minnesota Specific Standards of Quality and Purity for Class 1B and 2A waters of the State.
† = For a pollutant with asterisks next to the final acute value (FAV) and the maximum standard (MS), the following applies:
For carcinogenic or highly bioaccumulative chemicals with BCF's greater than 5000 or log Kow values greater than 5.19, the human health chronic standard may be two or more orders smaller than the acute toxicity based MS.
For the MS: if the ratio of MS to the CS is greater than 100, the CS times 100 should be substituted for the applicable MS.
For the FAV: if the ratio of FAV to the CS is greater than 200, the CS times 200 should be substituted for the applicable FAV
From Minn. R. 7050.0222, subp. 7, item E.

TABLE 1-2
MONITORING WELL
GROUNDWATER ANALYTICAL RESULTS - VOCS/TPH-DRO
148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
AUGUST 2008, MAY 2009, AND SEPTEMBER 2009

Date Collected					Tier 2 Surface Water Quality Standards				**8/5/2008**	**8/5/2008**	**9/16/2009**	**5/5/2009**	**9/14/2009**	**5/4/2009**	**5/4/2009**	**9/14/2009**	**8/5/2008**	**5/6/2009**
Sample ID					1B	2A	2A	2A	**021-014MW**	**021-014MW DUP**	**021-014MW**	**021-026MW**	**021-026MW**	**021-027MW**	**021-027MW DUP**	**021-027MW**	**021-029MW**	**021-029MW**
		MCL^	HRL#	GW_{isv}	DW	CS	MS	FAV*										
Volatile Organic Compounds																		
1,1,1-Trichloroethane	µg/l	200	9,000	10000	200	329	2,957	5,913	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,1-Dichloroethylene	µg/l	7	200	300	7	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2,4-Trimethylbenzene	µg/l	-	-	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**26.0**	**69.0**
1,2-Dichlorobenzene	µg/l	-	600	7000	600	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,3,5-Trimethylbenzene	µg/l	-	100	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**16.0**	**24.0**
1,4-Dichlorobenzene	µg/l	-	10	2000	75	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Acetone	µg/l	-	700	40000000	-	-	-	-	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0
Benzene	µg/l	5	2	40	5	9.7	4,487†	8,974†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**21.0**	**67.0**
Chlorobenzene	µg/l	100	100	800	100	20	423	846	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
cis-1,2-Dichloroethene	µg/l	70	50	NA	70	-	-	-	**2.9**	**2.9**	**2.2**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Dichlorodifluoromethane	µg/l	-	700	70	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Dichlorofluoromethane	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**1.1**	**1.1**	**4.2**	< 1.0	< 1.0
Ethyl ether	µg/l	-	1,000	-	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Ethylbenzene	µg/l	700	700	7000	700	68	1,859	3,717	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**15.0**	**48.0**
Isopropylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**8.5**	**13.0**
m&p-Xylenes	µg/l	-	-	800	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	**24.0**	**100.0**
Methylene chloride	µg/l	-	5	400	5	45	13,875†	27,749†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Naphthalene	µg/l	-	300	1000	-	81	409	818	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	**2.4**
n-Propylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**9.7**	**14.0**
o-Xylene	µg/l	-	-	1000	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p-Isopropyltoluene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**1.3**	**2.8**
sec-Butylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**2.4**	**2.8**
tert-Butylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**1.0**
Tetrahydrofuran	µg/l	-	-	-	-	-	-	-	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	**18.0**	**5.1**
trans-1,2-Dichloroethene	µg/l	100	100	300	100	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Trichloroethene	µg/l	5	5	20	5	25	6,988†	13,976†	**36**	**35**	**24**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Vinyl Chloride	µg/l	2	0.2	1	2	0.17	†	†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Xylenes (total)	µg/l	10,000	10,000	-	10,000	166	1,407	2,814	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	**25.0**	**101.5**
TPH-DRO	mg/l	-	-	-	-	-	-	-	< 0.1	NA	NA	< 0.1	NA	< 0.1	< 0.1	NA	NA	NA

Notes:
Only detected compounds are shown
Analytical data in bold text denotes sample detections above the MDL
Analytical data outlined denotes sample detections above HRL or CS
TPH-DRO = total petroleum hydrocarbons-diesel range organics
MCL = Maximum Contaminant Level
HRL = Minnesota Health Risk Limit
GW_{isv} = Groundwater Screening Values for Vapor Intrusion Pathway as provided in the MPCA document c-s4-06, "Risk-based Guidance for the Vapor Intrusion Pathway, Superfund RCRA and Voluntary Cleanup Section" dated September 2008, unless otherwise noted. Exceptions are for acetone, cis-1,2-DCE, and 1,1,1-Trichloroethane, which required updating based on the Intrusion Screening Values (ISVs) released by MPCA in February 2009.
- = No Limit established
DW = Driking Water
CS = Chronic Standard
FAV = Final Acute Value
MS = Maximum Standard
µg/l = micrograms per liter
mg/l = milligrams per liter
ID= Identification
QC= Quality Control
J = Estimated concentration
DUP = Duplicate
NA = not applicable
^ = Federal MCL under Safe Drinking Water Act (40 CFR Part 141).
# = State of Minnesota HRL, established in Minnesota Rules Chapter 4717.
* = State of Minnesota Specific Standards of Quality and Purity for Class 2B waters of the State.
† = For a pollutant with asterisks next to the final acute value (FAV) and the maximum standard (MS), the following applies:
For carcinogenic or highly bioaccumulative chemicals with BCF's greater than 5000 or log Kow values greater than 5.19, the human health chronic standard may be two or more orders smaller than the acute toxicity based MS.
For the MS: if the ratio of MS to the CS is greater than 100, the CS times 100 should be substituted for the applicable MS.
For the FAV: if the ratio of FAV to the CS is greater than 200, the CS times 200 should be substituted for the applicable FAV.
From Minn. R. 7050.0222, subp. 7, item E.

TABLE 1-2
MONITORING WELL
GROUNDWATER ANALYTICAL RESULTS - VOCS/TPH-DRO
148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
AUGUST 2008, MAY 2009, AND SEPTEMBER 2009

Date Collected					Tier 2 Surface Water Quality Standards				**9/15/2009**	**5/6/2009**	**5/6/2009**	**9/14/2009**	**5/5/2009**	**9/14/2009**	**5/5/2009**	**9/15/2009**	**5/6/2009**	**9/15/2009**	**5/6/2009**	**9/15/2009**
Sample ID					1B	2A	2A	2A	**021-029MW**	**021-030MW**	**021-030MW DUP**	**021-030MW**	**021-031MW**	**021-031MW**	**021-032MW**	**021-032MW**	**021-033MW**	**021-033MW**	**021-034MW**	**021-034MW**
		MCL^	HRL#	GW_{isv}	DW	CS	MS	FAV*												
Volatile Organic Compounds																				
1,1,1-Trichloroethane	µg/l	200	9,000	10000	200	329	2,957	5,913	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**1.4**	**1.4**
1,1-Dichloroethylene	µg/l	7	200	300	7	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**1.8**	**1.3**	< 1.0	< 1.0
1,2,4-Trimethylbenzene	µg/l	-	-	70	-	-	-	-	**79.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2-Dichlorobenzene	µg/l	-	600	7000	600	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,3,5-Trimethylbenzene	µg/l	-	100	70	-	-	-	-	**29.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,4-Dichlorobenzene	µg/l	-	10	2000	75	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Acetone	µg/l	-	700	40000000	-	-	-	-	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0
Benzene	µg/l	5	2	40	5	9.7	4,487†	8,974†	**140.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Chlorobenzene	µg/l	100	100	800	100	20	423	846	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**1.6**	< 1.0	< 1.0
cis-1,2-Dichloroethene	µg/l	70	50	NA	70	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	**9.3**	**11.0**	**4.8**	**4.3**	**8.2**	**5.7**	< 1.0	< 1.0
Dichlorodifluoromethane	µg/l	-	700	70	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	**3.4 J**	< 2.0	< 2.0
Dichlorofluoromethane	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethyl ether	µg/l	-	1,000	-	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Ethylbenzene	µg/l	700	700	7000	700	68	1,859	3,717	**54.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Isopropylbenzene	µg/l	-	-	-	-	-	-	-	**12.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
m&p-Xylenes	µg/l	-	-	800	-	-	-	-	**190.0**	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Methylene chloride	µg/l	-	5	400	5	45	13,875†	27,749†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Naphthalene	µg/l	-	300	1000	-	81	409	818	**3.0**	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
n-Propylbenzene	µg/l	-	-	-	-	-	-	-	**13.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-Xylene	µg/l	-	-	1000	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p-Isopropyltoluene	µg/l	-	-	-	-	-	-	-	**2.9**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
sec-Butylbenzene	µg/l	-	-	-	-	-	-	-	**2.8**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
tert-Butylbenzene	µg/l	-	-	-	-	-	-	-	**1.3**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Tetrahydrofuran	µg/l	-	-	-	-	-	-	-	**5.1**	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
trans-1,2-Dichloroethene	µg/l	100	100	300	100	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**1.2**	< 1.0	< 1.0
Trichloroethene	µg/l	5	5	20	5	25	6,988†	13,976†	**1.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**14**	**31**	**36**	**27**	< 1.0	< 1.0
Vinyl Chloride	µg/l	2	0.2	1	2	0.17	†	†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**2.9**	**4.0**	< 1.0	< 1.0
Xylenes (total)	µg/l	10,000	10,000	-	10,000	166	1,407	2,814	**190.0**	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0
TPH-DRO	mg/l	-	-	-	-	-	-	-	NA	NA	NA	NA	< 0.09	NA	NA	NA	NA	NA	NA	NA

Notes:
Only detected compounds are shown
Analytical data in bold text denotes sample detections above the MDL
Analytical data outlined denotes sample detections above HRL or CS
TPH-DRO = total petroleum hydrocarbons-diesel range organics
MCL = Maximum Contaminant Level
HRL = Minnesota Health Risk Limit
GW_{isv} = Groundwater Screening Values for Vapor Intrusion Pathway as provided in the MPCA document c-s4-06, "Risk-based Guidance for the Vapor Intrusion Pathway, Superfund RCRA and Voluntary Cleanup Section" dated September 2008, unless otherwise noted. Exceptions are for acetone, cis-1,2-DCE, and 1,1,1-Trichloroethane, which required updating based on the Intrusion Screening Values (ISVs) released by MPCA in February 2009.
- = No Limit established
DW = Driking Water
CS = Chronic Standard
FAV = Final Acute Value
MS = Maximum Standard
µg/l = micrograms per liter
mg/l = milligrams per liter
ID= Identification
QC= Quality Control
J = Estimated concentration
DUP = Duplicate
NA = not applicable
^ = Federal MCL under Safe Drinking Water Act (40 CFR Part 141).
# = State of Minnesota HRL, established in Minnesota Rules Chapter 4717.
* = State of Minnesota Specific Standards of Quality and Purity for Class 2B waters of the State.
† = For a pollutant with asterisks next to the final acute value (FAV) and the maximum standard (MS), the following applies:
For carcinogenic or highly bioaccumulative chemicals with BCF's greater than 5000 or log Kow values greater than 5.19, the human health chronic standard may be two or more orders smaller than the acute toxicity based MS.
For the MS: if the ratio of MS to the CS is greater than 100, the CS times 100 should be substituted for the applicable MS.
For the FAV: if the ratio of FAV to the CS is greater than 200, the CS times 200 should be substituted for the applicable FAV.
From Minn. R. 7050.0222, subp. 7, item E.

TABLE 1-2
MONITORING WELL
GROUNDWATER ANALYTICAL RESULTS - VOCS/TPH-DRO
148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
AUGUST 2008, MAY 2009, AND SEPTEMBER 2009

Date Collected					Tier 2 Surface Water Quality Standards				**5/6/2009**	**9/15/2009**	**9/15/2009**	**5/5/2009**	**9/16/2009**	**9/16/2009**	**5/4/2009**	**9/15/2009**	**5/4/2009**
Sample ID					1B	2A	2A	2A	**021-035MW**	**021-035MW**	**021-035MW DUP**	**021-036MW**	**021-036MW**	**021-036MW DUP**	**021-038MW**	**021-038MW**	**021-039MW**
		MCL^	HRL#	GW_{isv}	DW	CS	MS	FAV*									
Volatile Organic Compounds																	
1,1,1-Trichloroethane	µg/l	200	9,000	10000	200	329	2,957	5,913	< 1.0	< 1.0	< 1.0	< 1.0	**1.1**	**1.1**	< 1.0	< 1.0	< 1.0
1,1-Dichloroethylene	µg/l	7	200	300	7	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2,4-Trimethylbenzene	µg/l	-	-	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2-Dichlorobenzene	µg/l	-	600	7000	600	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,3,5-Trimethylbenzene	µg/l	-	100	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,4-Dichlorobenzene	µg/l	-	10	2000	75	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Acetone	µg/l	-	700	40000000	-	-	-	-	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0
Benzene	µg/l	5	2	40	5	9.7	4,487[†]	8,974[†]	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Chlorobenzene	µg/l	100	100	800	100	20	423	846	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
cis-1,2-Dichloroethene	µg/l	70	50	NA	70	-	-	-	< 1.0	< 1.0	< 1.0	**3.7**	**4.4**	**4.4**	**8.8**	**8.7**	< 1.0
Dichlorodifluoromethane	µg/l	-	700	70	-	-	-	-	**2.4**	**2.5 J**	**2.6 J**	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Dichlorofluoromethane	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethyl ether	µg/l	-	1,000	-	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Ethylbenzene	µg/l	700	700	7000	700	68	1,859	3,717	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Isopropylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
m&p-Xylenes	µg/l	-	-	800	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Methylene chloride	µg/l	-	5	400	5	45	13,875[†]	27,749[†]	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Naphthalene	µg/l	-	300	1000	-	81	409	818	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
n-Propylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-Xylene	µg/l	-	-	1000	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p-Isopropyltoluene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
sec-Butylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
tert-Butylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Tetrahydrofuran	µg/l	-	-	-	-	-	-	-	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
trans-1,2-Dichloroethene	µg/l	100	100	300	100	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Trichloroethene	µg/l	5	5	20	5	25	6,988[†]	13,976[†]	**1.3**	**1.4**	**1.5**	**66**	**78**	**79**	**11**	**14**	< 1.0
Vinyl Chloride	µg/l	2	0.2	1	2	0.17	[†]	[†]	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Xylenes (total)	µg/l	10,000	10,000	-	10,000	166	1,407	2,814	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0
TPH-DRO	mg/l	-	-	-	-	-	-	-	NA	NA	NA	< 0.09	NA	NA	< 0.09	NA	NA

Notes:
Only detected compounds are shown
Analytical data in bold text denotes sample detections above the MDL
Analytical data outlined denotes sample detections above HRL or CS
TPH-DRO = total petroleum hydrocarbons-diesel range organics
MCL = Maximum Contaminant Level
HRL = Minnesota Health Risk Limit
GW_{isv} = Groundwater Screening Values for Vapor Intrusion Pathway as provided in the MPCA document c-s4-06, "Risk-based Guidance for the Vapor Intrusion Pathway, Superfund RCRA and Voluntary Cleanup Section" dated September 2008, unless otherwise noted. Exceptions are for acetone, cis-1,2-DCE, and 1,1,1-Trichloroethane, which required updating based on the Intrusion Screening Values (ISVs) released by MPCA in February 2009.
- = No Limit established
DW = Driking Water
CS = Chronic Standard
FAV = Final Acute Value
MS = Maximum Standard
µg/l = micrograms per liter
mg/l = milligrams per liter
ID= Identification
QC= Quality Control
J = Estimated concentration
DUP = Duplicate
NA = not applicable
^ = Federal MCL under Safe Drinking Water Act (40 CFR Part 141).
# = State of Minnesota HRL, established in Minnesota Rules Chapter 4717.
* = State of Minnesota Specific Standards of Quality and Purity for Class 2B waters of the State.
[†] = For a pollutant with asterisks next to the final acute value (FAV) and the maximum standard (MS), the following applies:
For carcinogenic or highly bioaccumulative chemicals with BCF's greater than 5000 or log Kow values greater than 5.19, the human health chronic standard may be two or more orders smaller than the acute toxicity based MS.
For the MS: if the ratio of MS to the CS is greater than 100, the CS times 100 should be substituted for the applicable MS.
For the FAV: if the ratio of FAV to the CS is greater than 200, the CS times 200 should be substituted for the applicable FAV.
From Minn. R. 7050.0222, subp. 7, item E.

TMZ/TWK/ATF
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TABLE 1-2
MONITORING WELL
GROUNDWATER ANALYTICAL RESULTS - VOCS/TPH-DRO
148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
AUGUST 2008, MAY 2009, AND SEPTEMBER 2009

Date Collected					Tier 2 Surface Water Quality Standards				**9/14/2009**	**9/17/2009**	**9/18/2009**	**9/18/2009**	**9/18/2009**	**9/18/2009**
Sample ID					1B	2A	2A	2A	**021-039MW**	**021-040MW**	**021-041MW**	**021-042MW**	**021-043MW**	**021-044MW**
		MCL^	HRL#	GW_{isv}	DW	CS	MS	FAV*						
Volatile Organic Compounds														
1,1,1-Trichloroethane	µg/l	200	9,000	10000	200	329	2,957	5,913	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,1-Dichloroethylene	µg/l	7	200	300	7	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2,4-Trimethylbenzene	µg/l	-	-	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2-Dichlorobenzene	µg/l	-	600	7000	600	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,3,5-Trimethylbenzene	µg/l	-	100	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,4-Dichlorobenzene	µg/l	-	10	2000	75	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Acetone	µg/l	-	700	40000000	-	-	-	-	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0
Benzene	µg/l	5	2	40	5	9.7	4,487†	8,974†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Chlorobenzene	µg/l	100	100	800	100	20	423	846	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
cis-1,2-Dichloroethene	µg/l	70	50	NA	70	-	-	-	< 1.0	**3**	**1.4**	**2.2**	< 1.0	**5.2**
Dichlorodifluoromethane	µg/l	-	700	70	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Dichlorofluoromethane	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethyl ether	µg/l	-	1,000	-	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Ethylbenzene	µg/l	700	700	7000	700	68	1,859	3,717	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Isopropylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
m&p-Xylenes	µg/l	-	-	800	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Methylene chloride	µg/l	-	5	400	5	45	13,875†	27,749†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Naphthalene	µg/l	-	300	1000	-	81	409	818	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
n-Propylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-Xylene	µg/l	-	-	1000	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p-Isopropyltoluene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
sec-Butylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
tert-Butylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Tetrahydrofuran	µg/l	-	-	-	-	-	-	-	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	**29.0**
trans-1,2-Dichloroethene	µg/l	100	100	300	100	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Trichloroethene	µg/l	5	5	20	5	25	6,988†	13,976†	< 1.0	**46**	**5**	**28**	< 1.0	**9.1**
Vinyl Chloride	µg/l	2	0.2	1	2	0.17	†	†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Xylenes (total)	µg/l	10,000	10,000	-	10,000	166	1,407	2,814	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0
TPH-DRO	mg/l	-	-	-	-	-	-	-	NA	NA	NA	NA	NA	NA

Notes:
Only detected compounds are shown
Analytical data in bold text denotes sample detections above the MDL
Analytical data outlined denotes sample detections above HRL or CS
TPH-DRO = total petroleum hydrocarbons-diesel range organics
MCL = Maximum Contaminant Level
HRL = Minnesota Health Risk Limit
GW_{isv} = Groundwater Screening Values for Vapor Intrusion Pathway as provided in the MPCA document c-s4-06, "Risk-based Guidance for the Vapor Intrusion Pathway, Superfund RCRA and Voluntary Cleanup Section" dated September 2008, unless otherwise noted. Exceptions are for acetone, cis-1,2-DCE, and 1,1,1-Trichloroethane, which required updating based on the Intrusion Screening Values (ISVs) released by MPCA in February 2009.
- = No Limit established
DW = Driking Water
CS = Chronic Standard
FAV = Final Acute Value
MS = Maximum Standard
µg/l = micrograms per liter
mg/l = milligrams per liter
ID= Identification
QC= Quality Control
J = Estimated concentration
DUP = Duplicate
NA = not applicable
^ = Federal MCL under Safe Drinking Water Act (40 CFR Part 141).
# = State of Minnesota HRL, established in Minnesota Rules Chapter 4717.
* = State of Minnesota Specific Standards of Quality and Purity for Class 2B waters of the State.
† = For a pollutant with asterisks next to the final acute value (FAV) and the maximum standard (MS), the following applies:
For carcinogenic or highly bioaccumulative chemicals with BCF's greater than 5000 or log Kow values greater than 5.19, the human health chronic standard may be two or more orders smaller than the acute toxicity based MS.
For the MS: if the ratio of MS to the CS is greater than 100, the CS times 100 should be substituted for the applicable MS.
For the FAV: if the ratio of FAV to the CS is greater than 200, the CS times 200 should be substituted for the applicable FAV.
From Minn. R. 7050.0222, subp. 7, item E.

TABLE 1-3
MONITORING WELL
GROUNDWATER ANALYTICAL RESULTS - METALS
148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
SEPTEMBER 2009

Date Collected					Tier 2 Surface Water Quality Standards				9/16/2009	9/14/2009	9/14/2009	9/15/2009	9/16/2009	9/16/2009	9/15/2009	9/14/2009	9/17/2009	9/18/2009	9/18/2009	9/18/2009	9/18/2009
Sample ID					1B	2A	2A	2A	021-014MW	021-027MW	021-031MW	021-032MW	021-036MW	021-036MW DUP	021-038MW	021-039MW	021-040MW	021-041MW	021-042MW	021-043MW	021-044MW
		MCL^	HRL#	GW_{isv}	DW	CS	MS	FAV*													
Total Metals																					
Calcium	mg/L	-	-	-	-	-	-	-	89.6	126	118	11.2	117	115	121	65.1	115	104	105	100	129
Iron	µg/L	-	-	-	300	-	-	-	86.8	6890	449	1360	56.4	< 50	4140	612	143	785	608	105	678
Magnesium	mg/L	-	-	-	-	-	-	-	23.3	28.4	39.1	3.94	39.2	39.6	41.9	19.5	37.6	36.5	33.4	39.2	43.1
Manganese	µg/L	-	300	-	50 (s)	-	-	-	598	825	741	380	648	556	702	44.1	327	489	102	571	726
Potassium	mg/L	-	-	-	-	-	-	-	4.26	4.33	3.32	3.5	2.3	2.31	3.03	1.31	2.16	3.05	1.91	4.38	3.96
Sodium	mg/L	-	-	-	-	-	-	-	24.3	50	34.6	390	15.7	15.8	17.8	5.99	13.4	17.8	15.2	26.2	29.0
Dissolved Metals																					
Calcium	mg/L	-	-	-	-	-	-	-	85.8	127	115	10.4	110	108	111	61.4	108	97.6	111	93.8	125
Iron	µg/L	-	-	-	300	-	-	-	< 50	6020	64.8	< 50	< 50	< 50	110	< 50	< 50	< 50	< 50	< 50	279
Magnesium	mg/L	-	-	-	-	-	-	-	21.9	27.8	37.7	3.19	36.5	36.5	37	18	34.8	33.6	31	35.9	39.7
Manganese	µg/L	-	300	-	50 (s)	-	-	-	270	790	501	297	393	395	452	30.5	296	436	81.3	529	676
Potassium	mg/L	-	-	-	-	-	-	-	4.04	3.99	3.37	3.28	2.14	2.13	2.17	1.12	2.02	2.66	1.74	4.08	3.69
Sodium	mg/L	-	-	-	-	-	-	-	23.2	51.4	33.2	377	15.1	15	16.1	5.54	12.6	16.9	14.5	24.8	27.1

Notes:
(s) = Secondary Standard - Safe Drinking Water Regulations
Analytical data in bold text denotes sample detections above the MDL
Analytical data outlined denotes sample detections above HRL
MCL = Maximum Contaminant Level
HRL = Minnesota Health Risk Limit
GW_{isv} = Groundwater Screening Values for Vapor Intrusion Pathway as provided in the MPCA document c-s4-06, "Risk-based Guidance for the Vapor Intrusion Pathway, Superfund RCRA and Voluntary Cleanup Section" dated September 2008, unless otherwise noted. Exceptions are for acetone, cis-1,2-DCE, and 1,1,1-Trichloroethane, which required updating based on the Intrusion Screening Values (ISVs) released by MPCA
- = No Limit established
DW = Drinking Water
CS = Chronic Standard
FAV = Final Acute Value
MS = Maximum Standard
µg/l = micrograms per liter
mg/l = milligrams per liter
ID= Identification
QC= Quality Control
J = Estimated concentration
DUP = Duplicate
NA = not applicable
^ = Federal MCL under Safe Drinking Water Act (40 CFR Part 141).
# = State of Minnesota HRL, established in Minnesota Rules Chapter 4717.
* = State of Minnesota Specific Standards of Quality and Purity for Class 2B waters of the State.

TABLE 1-4
MONITORING WELL
GROUNDWATER ANALYTICAL RESULTS - MNA
148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
SEPTEMBER 2009

Date Collected					Tier 2 Surface Water Quality Standards				**9/16/2009**	**9/14/2009**	**9/14/2009**	**9/15/2009**	**9/16/2009**	**9/16/2009**	**9/15/2009**	**9/14/2009**	**9/17/2009**	**9/18/2009**	**9/18/2009**	**9/18/2009**	**9/18/**
Sample ID					1B	2A	2A	2A	**021-014MW**	**021-027MW**	**021-031MW**	**021-032MW**	**021-036MW**	**021-036MW DUP**	**021-038MW**	**021-039MW**	**021-040MW**	**021-041MW**	**021-042MW**	**021-043MW**	**021-04**
		MCL^	HRL#	GW_{isv}	DW	CS	MS	FAV													
Alkalinity, Total	mg/L as $CaCO_3$	-	-	-	-	-	-	-	**243**	**375**	**366**	**437**	**325**	**320**	**331**	**189**	**307**	**296**	**279**	**294**	
Chloride	mg/L	-	-	-	250 (s)	230	860	1,720	**57.1**	**69.4**	**82.0**	**196**	**65.9**	**66**	**67.7**	**20.0**	**66.8**	**59.1**	**67.7**	**72.2**	
Ethane	µg/L	-	-	-	-	-	-	-	< 3	< 30	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	<
Ethylene	µg/L	-	-	-	-	-	-	-	< 3	< 30	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	<
Methane	µg/L	-	-	-	-	-	-	-	< 3	**2600**	< 3	7	< 3	< 3	< 3	< 3	20	< 3	< 3	< 3	
Nitrogen, Nitrate	mg/L as N	10	10	-	10	-	-	-	0.7	< 0.05	< 0.05	**0.09**	**1.39**	**1.15**	< 0.05	< 0.05	**1.1**	**0.06**	**0.91**	< 0.05	
Nitrogen, Nitrite	mg/L as N	1	-	-	1	-	-	-	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	<
Phosphorous, Total	mg/L as P	-	-	-	-	-	-	-	< 0.1	0.2	< 0.1	< 0.1	< 0.1	< 0.1	0.28	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	<
Total Dissolved Soilds (TDS)	mg/L	-	-	-	500 (s)	-	-	-	**390**	**517**	**513**	**853**	**518**	**464**	**469**	**257**	**420**	**430**	**412**	**440**	
Total Organic Carbon	mg/L	-	-	-	-	-	-	-	**5.1**	**9.3**	**2.5**	**10.4**	**2.4**	**2.3**	**2.1**	**1.4**	**2.9**	**3.1**	**2.6**	**4.1**	
Silicon	mg/L	-	-	-	-	-	-	-	**13.2**	**13.9**	**10.0**	**13.9**	**13.2**	**12.9**	**19.2**	**10.3**	**13.2**	**12.0**	**14.1**	**8.5**	
Sulfate	mg/L	-	-	-	250 (s)	-	-	-	**14.1**	**2.92**	**20.8**	**21.6**	**17.3**	**17.4**	**19**	**14.9**	**17.9**	**19.3**	**17.3**	**20.9**	
Sulfide	mg/L	-	-	-	-	-	-	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	<
Dissolved Oxygen	mg/L	-	-	-	-	-	-	-	**0.13**	**0.12**	**0.15**	**0.12**	**0.13**	**0.13**	**0.11**	**0.18**	**0.13**	**0.14**	**0.13**	**3.97**	
Oxidation Reduction Potential	mV	-	-	-	-	-	-	-	**97**	**-175**	**-72**	**-7**	**68**	**68**	**-69**	**-62**	**-11**	**-73**	**39**	**75**	

Notes:
(s) = Secondary Standard - Safe Drinking Water Regulations
Analytical data in bold text denotes sample detections above the MDL
Analytical data outlined denotes sample detections above HRL
MCL = Maximum Contaminant Level
HRL = Minnesota Health Risk Limit
GW_{isv} = Groundwater Screening Values for Vapor Intrusion Pathway as provided in the MPCA document c-s4-06, "Risk-based Guidance for the Vapor Intrusion Pathway, Superfund RCRA and Voluntary Cleanup Section" dated September 2008, unless otherwise noted. Exceptions are for acetone, cis-1,2-DCE, and 1,1,1-Trichloroethane, which required updating based on the Intrusion Screening Values (ISVs) released by MPCA in February 2009.
- = No Limit established
DW = Drinking Water
CS = Chronic Standard
FAV = Final Acute Value
MS = Maximum Standard
µg/l = micrograms per liter
mg/l = milligrams per liter
mV = millivolts
ID= Identification
QC= Quality Control
J = Estimated concentration
DUP = Duplicate
NA = not applicable
^ = Federal MCL under Safe Drinking Water Act (40 CFR Part 141).
# = State of Minnesota HRL, established in Minnesota Rules Chapter 4717.
* = State of Minnesota Specific Standards of Quality and Purity
Dissolved oxygen and oxidation reduction potential values obtained during September 2009 groundwater sampling event

TABLE 1-4
MONITORING WELL
GROUNDWATER ANALYTICAL RESULTS - MNA
148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
SEPTEMBER 2009

Date Collected					Tier 2 Surface Water Quality Standards				**2009**
Sample ID					1B	2A	2A	2A	**14MW**
		MCL^	HRL#	GW_{isv}	DW	CS	MS	FAV	
Alkalinity, Total	mg/L as $CaCO_3$	-	-	-	-	-	-	-	**363**
Chloride	mg/L	-	-	-	250 (s)	230	860	1,720	**80.0**
Ethane	µg/L	-	-	-	-	-	-	-	30
Ethylene	µg/L	-	-	-	-	-	-	-	30
Methane	µg/L	-	-	-	-	-	-	-	**600**
Nitrogen, Nitrate	mg/L as N	10	10	-	10	-	-	-	**0.13**
Nitrogen, Nitrite	mg/L as N	1	-	-	1	-	-	-	0.2
Phosphorous, Total	mg/L as P	-	-	-	-	-	-	-	0.1
Total Dissolved Soilds (TDS)	mg/L	-	-	-	500 (s)	-	-	-	**520**
Total Organic Carbon	mg/L	-	-	-	-	-	-	-	**5.5**
Silicon	mg/L	-	-	-	-	-	-	-	**10.0**
Sulfate	mg/L	-	-	-	250 (s)	-	-	-	**31.3**
Sulfide	mg/L	-	-	-	-	-	-	-	1
Dissolved Oxygen	mg/L	-	-	-	-	-	-	-	**0.13**
Oxidation Reduction Potential	mV	-	-	-	-	-	-	-	**-96**

Notes:
(s) = Secondary Standard - Safe Drinking Water Regulations
Analytical data in bold text denotes sample detections above the MDL
Analytical data outlined denotes sample detections above HRL
MCL = Maximum Contaminant Level
HRL = Minnesota Health Risk Limit
GW_{isv} = Groundwater Screening Values for Vapor Intrusion Pathway as provided in the MPCA document c-s4-06, "Risk-based Guidance for the Vapor Intrusion Pathway, Superfund RCRA and Voluntary Cleanup Section" dated September 2008, unless otherwise noted. Exceptions are for acetone, cis-1,2-DCE, and 1,1,1-Trichloroethane, which required updating based on the Intrusion Screening Values (ISVs) released by MPCA in February 2009.
- = No Limit established
DW = Drinking Water
CS = Chronic Standard
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µg/l = micrograms per liter
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QC= Quality Control
J = Estimated concentration
DUP = Duplicate
NA = not applicable
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# = State of Minnesota HRL, established in Minnesota Rules Chapter 4717.
* = State of Minnesota Specific Standards of Quality and Purity
Dissolved oxygen and oxidation reduction potential values obtained during September 2009 groundwater sampling event

TABLE 1-5

Well Construction and Groundwater Elevation Summary

148th Fighter Wing, Minnesota Air National Guard
Duluth, Minnesota

Well ID	Northing	Easting	TOC Elevation (ft amsl)	Screened Interval (ft bgs)	August 2008		May 2009		September 2009		Rationale
					August 2008 DTW (ft below TOC)	August 2008 GW Elevation (ft amsl)	May 2009 DTW (ft below TOC)	May 2009 GW Elevation (ft amsl)	September 2009 DTW (ft below TOC)	September 2009 GW Elevation (ft amsl)	
021-014MW	455602.71	2857235.14	1396.3	2.6 - 12.6	4.67	1391.63	NG		4.96	1391.34	Monitor plume groundwater quality
021-026MW	455458.47	2857209.98	1395.9	7 - 17	7.80	1388.10	7.52	1388.38	7.5	1388.40	Water table elevation determination
021-027MW	455379.91	2857274.12	1394.41	4 - 14	7.71	1386.70	7.5	1386.91	7.59	1386.82	Water table elevation determination
021-029MW	455793.67	2857170.49	1399.1	6.3 - 16.3	6.41	1392.69	6.12	1392.98	6.75	1392.35	Monitor plume groundwater quality
021-030MW	455602.64	2857244.44	1395.72	27.9 - 37.9	NG		3.1	1392.62	3.32	1392.40	Monitor plume groundwater quality (deep well)
021-031MW	455569.39	2857422.77	1392.55	5.6 - 15.6	2.81	1389.74	2.4	1390.15	3.05	1389.50	Water table elevation determination
021-032MW	455589.09	2857302.56	1394.32	1.5 - 11.5	3.07	1391.25	2.82	1391.5	3.51	1390.81	Monitor plume groundwater quality
021-033MW	455773.97	2857256.61	1395.12	2.25-12.25	4.57	1390.55	4.53	1390.59	4.75	1390.37	Monitor plume groundwater quality
021-034MW	455775.17	2857261.64	1394.69	24 - 34	NG		1.86	1392.83	2.12	1392.57	Monitor plume groundwater quality (deep well)
021-035MW	455747.95	2857377.36	1392.91	3 - 13	4.32	1388.59	4.22	1388.69	4.47	1388.44	Water table elevation determination
021-036MW	455535	2857336.54	1394.85	3 - 13	4.52	1390.33	4.26	1390.59	4.94	1389.91	Monitor plume groundwater quality
021-038MW	455400.07	2857542.74	1391.73	10 - 20	4.33	1387.40	3.81	1387.92	4.33	1387.40	Monitor plume groundwater quality (marsh boundary)
021-039MW	455164.85	2857547.72	1389.41	6.3 - 16.3	5.30	1384.11	4.7	1384.71	5.7	1383.71	Water table elevation determination
021-040MW	455329.04	2857414.97	1388.8189	10 - 15	NG		NG		2.47	1386.35	Monitor plume groundwater quality (marsh boundary)
021-041MW	455326.4	2857421.08	1388.6384	24 - 29	NG		NG		1.84	1386.80	Monitor plume groundwater quality (marsh boundary)
021-042MW	455332.83	2857337.18	1391.1018	10 - 15	NG		NG		4.31	1386.79	Monitor plume groundwater quality (marsh boundary)
021-043MW	455443.42	2857542.86	1391.5613	7.5 - 12.5	NG		NG		3.95	1387.61	Water table elevation determination
021-044MW	455336.02	2857578.04	1392.9786	10 - 15	NG		NG		7.4	1385.58	Monitor plume groundwater quality (marsh boundary)

Notes:

TOC = top of casing
GW = groundwater
ft amsl = feet above mean sea level
ft bgs = feet below ground surface
ID = identification
Survey based on North American Vertical Datum (NAVD) 1988

NG = not gaged
DTW = depth to water

TABLE 1-6
Site 21

Physical/Chemical Parameters for Benzene, TCE and Vinyl Chloride

148th Fighter Wing, Minnesota Air National Guard
Duluth, Minnesota

Chemical	Water Solubility (mg/L)	Log K_{ow}	K_{oc} (L/kg)*	Henry's Law Constant (atm-m3/mole)
Benzene	1780	2.13	79	5.40E-03
Trichloroethylene (TCE)	1.10E+03	2.71	107	1.03E-02
Vinyl Chloride	2.76E+03	1.50	2.45	2.70E-02

Notes:

K_{ow} obtained from USEPA, Soil Screening Level Guidance Document, Technical Background Document, EPA/540/R-95/128. 1996
mg/L = milligrams per liter
L/kg = liters per kilogram
atm-m3/mole = atmosphere cubic meter per mole
K**ow =** octanol-water partition coefficient
K**oc =** soil sorption coefficient normalized for total organic carbon
* Koc values obtained from Wiedemeier, et al, 1998

TABLE 2-1

Site 21

Federal, State, and Local ARARs

Minnesota Air National Guard Base
Duluth, Minnesota

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Consideration in the Feasibility Study
1a. FEDERAL CHEMICAL - SPECIFIC ARARS					
Safe Drinking Water Act (SDWA)	National Primary Drinking Water Standards Maximum Contaminant Levels (MCLs)	40 Code of Federal Regulations (CFR) 141.61 (Organics) and 40 CFR 141.62 (Inorganics)	Establishes health-based standards for public drinking water systems.	Relevant and Appropriate	Restoration goal for off site aquifer is drinking water standards for MNANG related contaminants.
Safe Drinking Water Act (SDWA)	National Secondary Drinking Water Standards	40 Code of Federal Regulations (CFR) 141.61 (Organics) and 40 CFR 141.62 (Inorganics)	Non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water.	To be Considered	
Clean Water Act (CWA)	Ambient Water Quality Criteria (AWQC)	40 CFR 131	Sets criteria for surface water quality based on toxicity to aquatic organisms and human health.	To be Considered	May be relevant and appropriate for groundwater and wastewater discharged to surface water.
Clean Air Act (CAA)	National Ambient Air Quality Standards (NAAQS)	40 CFR 50.4 – 50.12	Establishes emission limits for seven pollutants.	To be Considered	If there are air emissions from treatment of extracted groundwater, emissions will have to meet substantive standards.
1b. STATE CHEMICAL-SPECIFIC ARARS					
Minnesota Rules	Health Risk Limit	Minnesota Rules Administrative Rules Chapter 4717	Defines water quality standards for chemicals in groundwater used as drinking water.	Relevant and Appropriate	Potential migration of contaminants offsite should meet standards as several residential wells exist surrounding the MNANG.
	State of Minnesota Specific Standards of Quality and Purity for Class 2A waters of the State	Minnesota Rules Administrative Rules Chapter 7050.0222	State of Minnesota limits for quality of water of the state that are necessary for aquatic life and recreation.	To be Considered	Restoration goal for potential impacts to Miller Creek.

TABLE 2-1

Site 21

Federal, State, and Local ARARs

Minnesota Air National Guard Base
Duluth, Minnesota

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Consideration in the Feasibility Study
	Minnesota Underground Water Regulations	Minnesota Rules Chapter 7060	Preservation and protection of underground waters by preventing and abating pollution, including nondegradation standards.	Potentially Applicable	May be applicable as groundwater is impacted by VOCs.
Minnesota Pollution Control Agency	Ground Water Screening Values for Vapor Intrusion Pathway	Risk-Based Guidance for the Vapor Intrusion Pathway Superfund RCRA and Voluntary Cleanup Section September 2008	State of Minnesota Risk Based Guidance for Vapor Intrusion.	To be Considered	The guidance utilizes a three-tiered risk-based approach for evaluating the vapor intrusion pathway. Since TCE is detected at shallow depths near Building 252, the screening is appropriate.
Minnesota Pollution Control Agency	Soil Reference Values	MPCA Risk- Based Site Evaluation Guidance	Guidance for evaluating human health risk from exposure to contaminated soil.	Not Considered.	
Minnesota Pollution Control Agency	Soil Leaching Values	MPCA Risk- Based Site Evaluation Guidance	Guidance for evaluating risk to groundwater from contaminated soil leaching.	Not Considered.	
Minnesota Pollution Control Agency	Sediment Quality Targets	MPCA Risk- Based Site Evaluation Guidance	Bench-mark sediment values for evaluating risk to aquatic life.	Not Considered.	
Minnesota Pollution Control Agency	Intrusion Screening Values	MPCA Risk- Based Site Evaluation Guidance	Guidance for evaluating human health risk from exposure to VOCs intruding into buildings.	To be Considered.	The guidance utilizes a three-tiered risk-based approach for evaluating the vapor intrusion pathway. Since TCE is detected at shallow depths near Building 252, the screening is appropriate.

TABLE 2-1

Site 21

Federal, State, and Local ARARs

Minnesota Air National Guard Base
Duluth, Minnesota

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Consideration in the Feasibility Study
2a. FEDERAL LOCATION-SPECIFIC ARARS					
Code of Federal Regulations	Federal Floodplain Management Order	40 CFR Part 6, Executive Order 11988	Regulates remedial action implementation in floodplains.	To be Considered.	Potential for remedial actions to be implemented in flood plain of Miller Creek.
Clean Water Act (CWA)	Water Quality Related Effluent Limitations	33 USC 1251 Section 302	Protection of intended uses of receiving water (e.g., public water supply, recreational uses, etc.).	To be Considered	Relevant and appropriate in the selection of remedial alternatives due to the close proximity of Miller Creek, a designated trout stream (Minnesota Rules 6264.0050)
	National Pollution Discharge Elimination System (NPDES)	33 USC 1251 Section 402 40 CFR 122 and 125	Issues permits for discharge into navigable waters.	To be Considered	Applicable to groundwater or wastewater discharged to surface water.
2b. STATE LOCATION-SPECIFIC ARARS					
Minnesota Rules	State of Minnesota Specific Standards of Quality and Purity for Class 2A waters of the State	Minnesota Rules Administrative Rules Chapter 7050.0222	Establishes standards for surface water quality, including physical characteristics, aesthetic criteria, and toxic substance limits.	To be Considered	May apply if alternative involves the discharge of contaminants to surface water.
3a. FEDERAL ACTION-SPECIFIC ARARS					
Resource Conservation and Recovery Act (RCRA)	Hazardous Waste Management Systems General	40 CFR 260	Establishes procedures and criteria for modification or revocation of any provision in 40 CFR Part 260-265.	To be Considered	Soil, groundwater, or treatment residuals may be classified as RCRA hazardous waste.
Resource Conservation and Recovery Act (RCRA)	Identification and Listing of Hazardous Waste	40 CFR 261	Defines those solid wastes that are subject to regulation as hazardous wastes under 40 CFR Parts 262-265 and Part 270.	To be Considered	Excavated soils, extracted groundwater, and treatment residuals may be hazardous as defined by RCRA and subjected to regulation. Additional data is needed to determine.

TABLE 2-1

Site 21

Federal, State, and Local ARARs

Minnesota Air National Guard Base
Duluth, Minnesota

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Consideration in the Feasibility Study
	Toxicity Characteristic Leaching Procedure (TCLP) Final Rule	40 CFR 261 Appendix H	Establishes regulatory levels for organic and inorganic chemicals based on health-based concentration thresholds and a dilution attenuation factor.	To be Considered	Excavated soils, extracted groundwater, or treatment residuals are subject to TCLP criteria.
	Standards Applicable to Generators of Hazardous Waste	40 CFR 262	Establishes standards for generators of hazardous waste.	To be Considered	If treatment of extracted groundwater generates hazardous waste the standards for hazardous waste generators apply.
	Standards Applicable to Transporters of Hazardous Waste	40 CFR 263	Establishes standards that apply to persons transporting hazardous waste within the United States if the transportation requires a manifest under 40 CFR 262.	To be Considered	Applicable if groundwater treatment generates hazardous waste requiring off-site transportation.
	Standards for Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR 264 Subpart N, O, and X	Establishes minimum national standards that define the acceptable management of hazardous waste for owners and operators of facilities that treat, store, or dispose of hazardous waste.	To be Considered	Applicable for alternatives involving on or off-site storage, treatment or disposal of hazardous waste.

TABLE 2-1

Site 21

Federal, State, and Local ARARs

Minnesota Air National Guard Base
Duluth, Minnesota

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Consideration in the Feasibility Study
Resource Conservation and Recovery Act (RCRA)	Hazardous Waste Land Disposal Restrictions (LDR)	40 CFR Part 268	Identifies hazardous wastes that are restricted from land disposal without prior treatment to universal treatment standards (UTS). Hazardous remediation wastes that are managed off-site are subject to the LDR UTS specified in Section 66268 for wastewater (liquid) and non-wastewater (solid). Hazardous soils must be treated to 90% reduction in concentration capped at 10 times the UTS for principal hazardous constituents (PHCs) (90% capped at 10 x UTS). On-site treatment or disposal of hazardous remediation wastes is not strictly subject to the LDR treatment standards, but is subject to similar treatment standards specified in the Corrective Action Management Units (CAMU) Amendment Rule codified in 40 CFR 264.500-.554.	To be Considered	LDR applicable to off-site disposal of hazardous remediation waste as determined through toxicity characteristic testing using Total Threshold Limit Concentration/ Soluble Threshold Limit Concentration (TTLC/STLC). Hazardous remediation waste must meet the treatment standards for that waste prior to off-site disposal.
Clean Water Act (CWA)	Effluent Limitations	33 USC 1251 Section 301	Technology-based discharge limitations for point sources of conventional, non-conventional and toxic pollutants.	Potentially Applicable	Applicable if alternatives involve discharge of soil and/or groundwater treatment wastewater or residuals.
	National Oil and Hazardous Substances Pollution Contingency Plan (NCP)	33 U.S.C. 26	Federal regulation governing response to the release of hazardous substance and regulations for conducting response actions.	Potentially Applicable	Applicable if alternatives involve a discharge of hazardous substance.
Safe Drinking Water Act (SDWA)	Underground Injection	40 CFR 144-147	Provides requirements for Underground Injection Control (UIC) plans and establishes classification of wells.	To be Considered	Substantive standards applicable to underground injection of extracted groundwater.
Clean Air Act (CAA)	National Ambient Air Quality Standards	40 CFR 50.4 – 50.12	Establishes emission limits for pollutants.	To be Considered	Air emissions from treatment of extracted groundwater will have to meet substantive standards.

TABLE 2-1

Site 21

Federal, State, and Local ARARs

Minnesota Air National Guard Base
Duluth, Minnesota

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Consideration in the Feasibility Study
Comprehensive Environmental Response, Compensation, & Liability Act (CERCLA)	Response Action	42 USC 103	Federal Superfund law requiring response action.	Applicable	Response required to releases or threatened releases of hazardous substances that may endanger public health or the environment.
Occupational Safety and Health Act (OSHA)	Worker Protection	29 USC Sections 651-678 29 CFR 1910, 1926 and 1904	Regulates worker health and safety. Specifies the training requirements for workers at hazardous waste operations and the type of safety equipment and procedures to be followed during site remediation.	Applicable	Under 40 CFR Section 300.38, requirements of this Act apply to all response activities under the National Contingency Plan (NCP).

TABLE 2-1

Site 21

Federal, State, and Local ARARs

Minnesota Air National Guard Base
Duluth, Minnesota

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Consideration in the Feasibility Study
3b. STATE ACTION-SPECIFIC ARARS					
Minnesota Administrative Rules	Ambient Air Quality Standards	Minnesota Rules Administrative Rules Chapter 7009	Establishes requirements for emission sources.	To be Considered	Air emissions from treatment of extracted groundwater will have to meet substantive standards.
Minnesota Rules	Solid Waste Rules	Minnesota Rules Chapter 7035	Regulations for disposal of solid waste.	Potentially Applicable	May apply to disposal of nonhazardous soil or other materials removed from the site.
	Hazardous Waste Rules	Minnesota Rules Chapter 7045	Regulations for characterizing, handling, and disposal of hazardous waste	Not Considered.	Hazardous waste is not anticipated to be encountered during remedial activities.
	Shoreland Floodplain Management Regulations	Minnesota Rules Chapter 6120	Regulates shoreland structures.	Potentially Applicable	May pertain to any construction work along Miller Creek or marsh boundary.
Minnesota Wetland Conservation Act of 1991	State Wetland Protection	Minnesota Rules, Chapter 8420	To maintain and protect Minnesota's wetlands and the benefits they provide.	Relevant and Appropriate	May be relevant and appropriate with regard to marsh area and surrounding miller creek wetlands.
Minnesota Statutes	Soil and Water Conservation Policy	Minnesota Statues 103C.005	To control or prevent erosion, sedimentation, siltation, and related pollution in order to preserve natural resources	To be Considered	May be applicable. Requirement is alternative specific.
Minnesota Environmental Response and Liability Act of 1983 (MERLA)	Restrictive Covenants	Minnesota Statues Chapter 115B Environmental Response and Liability	Provides requirements for restrictive covenants	Potentially Applicable	May be applicable if HRL criteria are not accomplished through selected remedial alternative.
	State of Minnesota Superfund Law	Minnesota Statues Chapter 115B	Superfund Law requiring response action to release of hazardous substances.	Not Considered.	It is not anticipated that hazardous substances will be released during remedial activities.

TABLE 2-1

Site 21

Federal, State, and Local ARARs

Minnesota Air National Guard Base
Duluth, Minnesota

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Consideration in the Feasibility Study
Minnesota Department of Health	Wells and borings	Minnesota Department of Health Water Well Codes	Regulations pertaining to the construction and use and sealing of wells and borings.	To be Considered	May be applicable for new monitoring wells or borings at Site 21.
Minnesota Water Law	Waters of the State	Minnesota Statues 103 A-G	Regulations pertaining to waters of the state, including surface water, wetlands, and groundwater.	Applicable	Applicable for water at Site 21.
Minnesota Occupational Safety and Health Act of 1973	Worker Protection	Minnesota Statues Chapter 182	Regulates workers health and safety.	Applicable	Requirements are applicable to all site actions and activities.

Notes:
AWQC = Ambient Water Quality Criteria
CAA = Clean Air Act
CAMU = Corrective Action Management Units
CFR = Code of Federal Regulations
CWA = Clean Water Act
LDR = Land Disposal Restrictions
MCLs = Maximum Contaminant Levels
MERLA = Minnesota Environmental Response and Liability Act
NAAQS = National Ambient Air Quality Standards
NCP = National Contingency Plan
NPDES = National Pollutant Discharge Elimination Permit
PHCs = Principal Hazardous Constituents
RCRA = Resource Conservation and Recovery Act
SDWA = Safe Drinking Water Act
TCLP = Toxicity Characteristic Leaching Procedure
TTLC/STLC = Total Threshold Limit Concentration/ Soluble Threshold Limit Concentration
UIC = Underground Injection Control
USC = United States Code
UTS = Universal Treatment Standards
WQC = Water Quality Criteria

TABLE 2-2
Site 21

Mass and Volume Estimate for TCE in Groundwater and Soil

148th Fighter Wing, MN ANG
Duluth, Minnesota

Depth Interval in Aquifer (ft bgs)	Average TCE Concentration in GW for Specified Contour Interval(µg/L)	Total Area[1] (ft^2)	Unique Area (ft^2)	Volume of soil and water (ft^3)	Volume of water (ft^3)	Volume of water (L)	Mass of TCE in GW (µg)	Mass of TCE in GW (kg)	Mass of TCE in GW (lbs)
3-13									**0.36**
50 Contour Interval	76.5	13,526	13,526	135,260	27,052	766,031	58,601,409	0.0586	0.13
30 Contour Interval	33.5	43,718	30,192	301,920	60,384	1,709,894	57,281,440	0.0573	0.13
5 Contour Interval	24.6	77,981	34,263	342,630	68,526	1,940,451	47,735,088	0.0477	0.11
13-22									**0.27**
50 Contour Interval	64	15,806	15,806	142,254	28,451	805,641	51,158,223	0.0512	0.11
30 Contour Interval	38	38,630	22,824	205,416	41,083	1,163,353	44,207,413	0.0442	0.10
5 Contour Interval	17	71,367	32,737	294,633	58,927	1,668,625	28,366,617	0.0284	0.06
TOTAL									**0.63**

Notes:

Assume porosity of glacial till = 0.2
Bulk density of glacial till = 2739.15 pounds per cubic yard
K_{OC} = 107 liters per kilogram
TOC = total organic carbon = 1800 milligrams per kilogram
TCE = trichloroethylene
ft bgs = feet below ground surface
ft^2 = square feet
[1]Total area is based on approximate lateral extent of TCE plume.

ft^3 = cubic feet
kg = kilograms
µg = micrograms
L = liter
µg/L= micrograms per liter
lbs = pounds
yd^3 = cubic yards
GW = groundwater

TABLE 2-2
Site 21

Mass and Volume Estimate for TCE in Groundwater and Soil

148th Fighter Wing, MN ANG
Duluth, Minnesota

Depth Interval in Aquifer (ft bgs)	TCE in Soil (µg/kg)	Volume of soil (ft^3)	Volume of soil (yd^3)	Mass of Soil (lbs)	Mass of Soil (kg)	Mass of TCE in Soil (µg)	Mass of TCE in Soil (kg)	Mass of TCE in Soil (lbs)
3-13								**0.56**
50 Contour Interval	14.7339	135,260	5,010	13,722,127	6,237,330	91,900,203	0.0919	0.20
30 Contour Interval	6.4521	301,920	11,182	30,629,784	13,922,629	89,830,195	0.0898	0.20
5 Contour Interval	4.73796	342,630	12,690	34,759,814	15,799,915	74,859,366	0.0749	0.16
13-22								**0.43**
50 Contour Interval	12.2301	142,254	5,269	14,431,668	6,559,849	80,227,612	0.0802	0.18
30 Contour Interval	7.3188	205,416	7,608	20,839,453	9,472,479	69,327,177	0.0693	0.15
5 Contour Interval	3.2742	294,633	10,912	29,890,518	13,586,599	44,485,243	0.0445	0.10
TOTAL								**0.99**

Notes:

Assume porosity of glacial till = 0.2
Bulk density of glacial till = 2739.15 pounds per cubic yard
K_{oc} = 107 liters per kilogram
TOC = total organic carbon = 1800 milligrams per kilogram
TCE = trichloroethylene
ft bgs = feet below ground surface
ft^2 = square feet
[1]Total area is based on approximate lateral extent of TCE plume.

ft^3 = cubic feet
kg = kilograms
µg = micrograms
L = liter
µg/L= micrograms per liter
lbs = pounds
yd^3 = cubic yards
GW = groundwater

TABLE 2-3
Site 21

Summary of TCE Mass in Groundwater and Soil

148th Fighter Wing, MN ANG
Duluth, Minnesota

Depth Interval (ft bgs)	Mass of TCE in Groundwater (lbs)	Mass of TCE in Soil (lbs)
3-13	0.36	0.56
13-22	0.27	0.43
TOTAL	**0.63**	**0.99**

Notes:
ft bgs = feet below ground surface
lbs = pounds
TCE = trichloroethylene

TABLE 2-4
Site 21

Average TCE Concentration in Groundwater

148th Fighter Wing, MN ANG
Duluth, Minnesota

Depth Interval in Aquifer (ft bgs)	Contour Inteval	Average TCE Concentration Per Contour Interval (µg/L)	Plume TCE Concentrations in Groundwater		
			Volume of water (L)	Volume %	Volume Weighted Concentration (µg/L)
3-13	50	76.5	766,031	9.51	7.28
	30	33.5	1,709,894	21.23	7.11
	5	24.6	1,940,451	24.09	5.93
13-22	50	64	805,641	10.00	6.35
	30	38	1,163,353	14.44	5.49
	5	17	1,668,625	20.72	3.52
		Total Volume	**8,053,995**		
Volume Weighted Average Concentration (µg/L)					**35.68**

Notes:
% = percent
µg = micrograms
µg/L= micrograms per liter
GW = Groundwater
L = liter
TCE = trichloroethylene

J:\N.G.B\Projects\Federal\DO 91 - Duluth Site 21\Reports\FFS\Draft\Tables\Table 2-4 GW Concentration.xlsT2-4 (Avg. Conc_PreInject)
TMZ\

TABLE 2-5
Site 21

Summary of Technology Prescreening Results

148th Fighter Wing, MN ANG
Duluth, Minnesota

Technology	Retained for Feasibility Study	Rationale
No Action	No	Does not satisfy proposed RAOs
Institional Controls	Yes	*Considered for use in conjunction with other remedial actions
Containment	No	Does not satisfy proposed RAOs
Intrinsic Remediation (MNA)	Yes	Potentially satisfies proposed RAOs
Extraction and Ex-Situ Treatment	No	Impracticable for site-specific conditions, and likely very expensive.
In-situ Treatment		
Enhanced Bioremediation	Yes	Potentially satisfies proposed RAOs
Air Sparging/Soil Vapor Extraction	No	Pilot study results determined this technology to not be effective.
Chemical Oxidation	No	Site conditions (permeability and heterogeneous nature of the shallow aquifer) Impractical for site-specific conditions
Permeable Reactive Barrier	Yes	Potentially satisfies proposed RAOs
Phytoremediation	Yes	Potentially satisfies proposed RAOs
Removal/Disposal	No	Impracticable for site-specific conditions

Notes:
RAOs = Remedial Action Objectives
MNA = monitored natural attenuation

TABLE 3-1
Site 21
Alternative #2 - Phytoremediation
Cost Estimate

148th Fighter Wing, MN ANG
Duluth, Minnesota

Item	Quantity	Unit	Unit Cost	Total Cost	Comments
Direct Capital Costs					
Equipment /Construction					
Phytoremediation (Ebuffer) Installation	1	LS	$ 60,000.00	$ 60,000.00	
MWH Oversight /Coordination Field Labor					
Construction Oversight	1	LS	$ 10,000.00	$ 10,000.00	
			Subtotal	**$ 70,000.00**	
Indirect Capital Costs					
Meetings/ Plans/ Documentation					
Predesign Evaluation	1	LS	$ 8,000.00	$ 8,000.00	
Design	1	LS	$ 12,000.00	$ 12,000.00	
Work Plans, Reports, and Permitting	1	LS	$ 35,000.00	$ 35,000.00	
Program and Project Management	1	LS	$ 10,000.00	$ 10,000.00	
			Subtotal	**$ 65,000.00**	
Total Capital Cost				**$ 135,000.00**	
Annual Costs					
Long Term Groundwater Monitoring (1 sampling event per year)					
Groundwater Sampling (7 monitoring wells)	1	EA	$ 9,500.00	$ 9,500.00	
Analytical Costs	1	EA	$ 4,000.00	$ 4,000.00	
Groundwater Monitoring Reports	1	EA	$ 10,000.00	$ 10,000.00	
			Subtotal	$ 23,500.00	
Administration (5%)				$ 1,175.00	
Contingency (15%)				$ 3,525.00	
			Subtotal	**$ 28,200.00**	
Net Present Value of Annual Costs	**ROR**	**Years**	**Per Year**		
Of Above Annual Costs	*4.5%*	15	*$ 28,200*	$ 302,855	15 Year Period of Performance
Project Closeout w/ Well Abandonment	*4.5%*	15	*$ 45,000*	$ 23,252	assumed to occur in 2026
Five Year Review #1 (2016)	*4.5%*	5	*$ 26,248*	$ 21,063	assumed to occur in 2016
Five Year Review #2 (2021)	*4.5%*	10	*$ 26,248*	$ 16,902	assumed to occur in 2021
Five Year Review #2 (2026)	*4.5%*	15	*$ 26,248*	$ 13,563	assumed to occur in 2026
			SubTotal	**$ 377,635**	
			Total	**$ 512,635**	

Notes:
LS = lump sum
EA = each
ROR = Rate of Return

TABLE 3-2
Site 21
Alternative #3 - Enhanced Bioremediation
Cost Estimate

148th Fighter Wing, MN ANG
Duluth, Minnesota

Item	Quantity	Unit	Unit Cost	Total Cost	Comments
Direct Capital Costs					
Equipment /Construction					
Pilot Study	1	LS	$ 100,000.00	$ 100,000.00	
Injections (3 injections)	1	LS	$ 300,000.00	$ 300,000.00	
Performance Monitoring Well Installation (3 wells)	1	LS	$ 18,000.00	$ 18,000.00	
MWH Oversight /Coordination Field Labor					
Construction Oversight	1	LS	$ 30,000.00	$ 30,000.00	
			Subtotal	**$ 448,000.00**	
Indirect Capital Costs					
Meetings/ Plans/ Documentation					
Design	1	LS	$ 50,000.00	$ 50,000.00	
Work Plans, Reports, and Permitting	1	LS	$ 40,000.00	$ 40,000.00	
Program and Project Management	1	LS	$ 13,000.00	$ 13,000.00	
			Subtotal	**$ 103,000.00**	
Total Capital Cost				**$ 551,000.00**	
Annual Costs					
Long Term Groundwater Monitoring (1 sampling event per year)					
Groundwater Sampling (8 monitoring wells)	1	EA	$ 5,000.00	$ 5,000.00	
Analytical Costs	1	EA	$ 17,708.00	$ 17,708.00	
Groundwater Monitoring Reports	1	EA	$ 15,000.00	$ 15,000.00	
Subtotal				$ 37,708.00	
Administration (5%)				$ 1,885.40	
Contingency (15%)				$ 5,656.20	
			Subtotal	**$ 45,249.60**	
Net Present Value of Annual Costs	**ROR**	**Years**	**Per Year**		
Of Above Annual Costs	4.5%	7	$ 45,250	$ 266,642	7 Year Period of Performance
Project Closeout w/ Well Abandonment	*4.5%*	7	*$ 45,000*	$ 33,067	assumed to occur after 7 years
			SubTotal	**$ 299,710**	
			Total	**$ 850,710**	

Notes:
LS = lump sum
EA = each
ROR = Rate of Return

TABLE 3-3
Site 21
Alternative #4 - Permeable Reactive Barrier -Zero Valent Iron
Cost Estimate
148th Fighter Wing, MN ANG
Duluth, Minnesota

Item	Quantity	Unit	Unit Cost	Total Cost	Comments
Direct Capital Costs					
Equipment /Construction					
PRB ZVI Installation	1	LS	$ 219,500.00	$ 219,500.00	
Performance Monitoring Well Installation (2 wells)	1	LS	$ 12,000.00	$ 12,000.00	
MWH Oversight /Coordination Field Labor					
Construction Oversight	1	LS	$ 17,560.00	$ 17,560.00	
			Subtotal	**$ 249,060.00**	
Indirect Capital Costs					
Meetings/ Plans/ Documentation					
Design	1	LS	$ 21,950.00	$ 21,950.00	
Work Plans, Reports, and Permitting	1	LS	$ 24,145.00	$ 24,145.00	
Program and Project Management	1	LS	$ 15,365.00	$ 15,365.00	
			Subtotal	**$ 61,460.00**	
Total Capital Cost				**$ 310,520.00**	
Annual Costs					
Long Term Groundwater Monitoring (1 sampling event per year)					
Groundwater Sampling (10 monitoring wells)	1	EA	$ 9,500.00	$ 9,500.00	
Analytical Costs	1	EA	$ 2,500.00	$ 2,500.00	
Groundwater Monitoring Reports	1	EA	$ 10,000.00	$ 10,000.00	
Subtotal				$ 22,000.00	
Administration (5%)				$ 1,100.00	
Contingency (15%)				$ 3,300.00	
			Subtotal	**$ 26,400.00**	
Net Present Value of Annual Costs	**ROR**	**Years**	**Per Year**		
Of Above Annual Costs	*4.5%*	15	*$ 26,400*	$ 283,524	15 Year Period of Performance
Project Closeout w/ Well Abandonment	*4.5%*	15	*$ 3,000*	$ 32,219	assumed to occur in 2026 ($45,000/15 yrs)
Five Year Review #1 (2016)	*4.5%*	5	*$ 5,250*	$ 23,046	assumed to occur in 2016 ($26,248/5 yrs)
Five Year Review #2 (2021)	*4.5%*	10	*$ 2,625*	$ 20,769	assumed to occur in 2021 ($26,248/10 yrs)
Five Year Review #2 (2026)	*4.5%*	15	*$ 1,750*	$ 18,793	assumed to occur in 2026 ($26,248/15 yrs)
			SubTotal	**$ 378,350**	
			Total	**$ 688,870**	

Notes:
LS = lump sum
EA = each
ROR = Rate of Return

TABLE 4-1
Site 21
Summary of Remedial Alternatives Analysis
148th Fighter Wing, MN ANG
Duluth, Minnesota

Technology	Initial Capital Cost ($)	Annual Cost ($)	Total Present Value ($)	Time to Achieve the RAOs (Years)	Likelihood of Achieving RAOs
Monitored Natural Attenuation	NA	NA	NA	NA	Low
Phytoremediation	$135,000	$34,200	$577,072	15*	Moderately High
Enhanced Bioremediation	$551,000	$45,250	$850,710	7	Moderately High
Permeable Reactive Barrier - Zero Valent Iron	$310,520	$26,400	$688,870	15^	Moderately High

Notes:

1) Monitor natural attenuation (MNA) costs were not developed as MNA screening evaluation revealed that natural attenuation is not a viable option for remediation at this site.

2) Phytoremediation assumes that following a predesign evaluation, that site conditions will conclude that phytoremediation as implementable and effective alternative.

3) Enhanced Bioremediation will drive the subsurface environment anaerobic, and degradation will then occur as observed downgradient. A bench scale microcosm study will need to be completed to determine that additional supplements (i.e., nutrients and bioaugmentation) that would create favorable conditions for reductive dechlorination. A pilot study may be required before implementation. This estimate also assumes that EOS injections would be required every two years for 5 years, with two years for monitoring after the final injection event.

4) ZVI assumes that groundwater DO will not use up the ZVI prior to treatment of the entire TCE plume (appromixately 15 years); a bench scale study has been conducted (as part of the Site 21 RI Data Gap Investigation Technical Memorandum [MWH, 2010]) and information derived from the study determined a barrier wall thickness of 2 feet.

* = costs developed are based on 15 years. Given the unknown duration of TCE in groundwater, additional years of LTM may be necessary. It is expected that RAOs will be met at the phytoremediation area within 15 years.

^ = costs were only developed for 15 years of PRB ZVI operations. Given the unknown duration of the TCE in groundwater, the ZVI PRB will likely need to be rejuvenated, with the possibility of an additional 15 years of LTM after ZVI rejuvenation. The estimated time to achieve RAOs for the entire site is unknown until the source of TCE is depleted.

Definitions:
RAOs = Remedial Action Objectives
$ - US Dollars
TCE - Trichloroethylene
EOS - Emulsified Oil Substrate
DO - Dissolved Oxygen

TABLE 5-1
Site 21
Alternative #2 - Phytoremediation and Alternative #3 - Enhanced Bioremediation
Cost Estimate

148th Fighter Wing, MN ANG
Duluth, Minnesota

Item	Quantity	Unit	Unit Cost	Total Cost	Comments
Direct Capital Costs					
Equipment /Construction					
Phytoremediation (Ebuffer) Installation	1	LS	$ 60,000.00	$ 60,000.00	
Enhanced Bioremediation Pilot Study	1	LS	$ 100,000.00	$ 100,000.00	
Enhanced Bioremediation Injections (3 injections)	1	LS	$ 300,000.00	$ 300,000.00	
Performance Monitoring Well Installation for Enhanced Bioremediation (3 wells)	1	LS	$ 18,000.00	$ 18,000.00	
MWH Oversight /Coordination Field Labor					
Construction Oversight for both phytoremediation and enhanced bioremediation	1	LS	$ 35,000.00	$ 35,000.00	
			Subtotal	**$ 513,000.00**	
Indirect Capital Costs					
Meetings/ Plans/ Documentation					
Predesign Evaluation (phytoremediation)	1	LS	$ 8,000.00	$ 8,000.00	
Design (phytoremediation and enhanced bio remediation)	1	LS	$ 40,000.00	$ 40,000.00	
Work Plans, Reports, and Permitting (phytoremediation and enhanced bio remediation)	1	LS	$ 50,000.00	$ 50,000.00	
Program and Project Management (phytoremediation and enhanced bioremediation)	1	LS	$ 20,000.00	$ 20,000.00	
			Subtotal	**$ 118,000.00**	
Total Capital Cost				**$ 631,000.00**	
Annual Costs					
Long Term Groundwater Monitoring (1 sampling event per year)					
Groundwater Sampling (8 monitoring wells)	1	EA	$ 9,500.00	$ 9,500.00	
Analytical Costs	1	EA	$ 18,000.00	$ 18,000.00	
Groundwater Monitoring Reports	1	EA	$ 15,000.00	$ 15,000.00	
Subtotal				$ 42,500.00	
Administration (5%)				$ 2,125.00	
Contingency (15%)				$ 6,375.00	
			Subtotal	**$ 51,000.00**	
Net Present Value of Annual Costs	**ROR**	**Years**	**Per Year**		
Of Above Annual Costs	4.5%	15	*$ 51,000*	$ 547,717	15 Year Period of Performance
Project Closeout w/ Well Abandonment	4.5%	15	*$ 45,000*	$ 23,252	assumed to occur in 2026
Five Year Review #1 (2016)	4.5%	5	*$ 26,248*	$ 21,063	assumed to occur in 2016
Five Year Review #2 (2021)	4.5%	10	*$ 26,248*	$ 16,902	assumed to occur in 2021
Five Year Review #2 (2026)	4.5%	15	*$ 26,248*	$ 13,563	assumed to occur in 2026
			SubTotal	**$ 622,497**	
			Total	**$ 1,253,497**	

Notes:
LS = lump sum
EA = each
ROR = Rate of Return

APPENDIX A

FOCUSED SCREENING LEVEL RISK ASSESSMENT

Appendix A - Focused Screening Level Risk Assessment

Introduction

Exponent was contracted by MWH Americas, Inc., to perform a focused screening level risk assessment for Site 21 at the 148th Fighter Wing, Minnesota Air National Guard base located at the Duluth International Airport in Duluth, Minnesota. The risk assessment is focused on groundwater contamination associated with Site 21. Previous site investigations ruled out soil as a medium of concern. MWH Americas Inc has conducted a remedial investigation (RI) data gap investigation at Site 21, the results of which are contained in the Remedial Investigation Data Gap Investigation Technical Memorandum (Tech Memo) (MWH Americans Inc., 2010). The results of the focused risk assessment are being used within the focused feasibility study to determine if potential risks exist associated with groundwater contamination that would require remedial action. This focused risk assessment is composed of the following elements:

- Conceptual Site Model
- Screening Level Risk Evaluation
- Summary, Conclusions and Recommendations

The conceptual site model (CSM) discusses the potential for both human and ecological receptor exposure to contaminants in groundwater or media potentially affected by the contaminated groundwater (e.g., soil gas above the water table, and surface water quality). The CSM is used to determine, based on site-specific environmental data and site conditions, which exposure pathways are potentially complete for both human and ecological receptors.

For those media where there is the potential for the exposure pathway to be complete, screening level risk evaluations are performed. The screening level evaluations are used to determine if additional risk evaluation is required and whether potential remedial action may be required. Conclusions and recommendations are then made based on the results of the screening level evaluations.

Conceptual Site Model

The following is a summary of the conceptual site model (CSM) for the focused risk assessment at Site 21. The CSM (Figure 1) reflects the results of previous investigations and a site visit by Exponent on December 22, 2009. The remainder of this section discusses the CSM and reflects the potential ways that human and ecological receptors may be exposed to chemical contamination at Site 21.

The site-specific CSM considers the primary site constituents detected in groundwater at the site (contaminants of potential concern [COPCs]), potential transport mechanisms, and the relevant human and ecological receptors (Figure 1) that are appropriate for the site.

At or near Site 21, there are two areas where human or ecological receptors may be exposed to constituents in environmental media—developed areas containing Air National Guard base facilities, and the adjacent undeveloped areas containing wetlands. Miller Creek flows through the wetland area located south of Site 21 and this water body is a designated trout stream (Minnesota Rules 6264.0050) and a protected watercourse subject to Minnesota Statutes Section 105.42. Human and ecological receptors interact with these two areas (developed and undeveloped natural areas) in different ways. For this reason, the CSM separates the discussion of the developed areas from the undeveloped areas. The following subsections describe potential chemicals of potential concern, media of potential concern, and then describe the potentially complete exposure pathways for both human and ecological receptors. While the focus of the risk assessment was on groundwater, the effect groundwater contamination may have on other media (e.g., indoor air, surface water and sediments) was also considered as part of the CSM.

Chemicals of Potential Concern

The site related chemicals of potential concern identified in groundwater during the site investigations conducted by MWH (MWH 2010) included primarily a specific chlorinated solvent, trichloroethene (TCE), and its degradation products (e.g., cis 1,2-dichloroethene and vinyl chloride). Also in fewer locations BTEX compounds, 1,2,4-trimethylbenzene, chlorobenzene and total petroleum hydrocarbons diesel range organic (TPH- DRO) were detected. The full list of volatile organic compounds (VOCs) detected in groundwater are presented in Tables 1 and 2. For a number of the wells sampled, one or more VOCs are present above screening level groundwater criteria presented in Table 1 and 2, and so VOCs in groundwater were selected as chemicals of potential concern. The primary VOC detected was TCE and a number of its degradation products. Refer to Tables 1 and 2 for a full list of the VOCs detected in one or more wells above groundwater screening values.

Inorganic analytes were detected in groundwater and these are presented on Tables 3 and 4. The inorganic analytes detected were primarily essential nutrients such as calcium, iron, magnesium, potassium, etc. The only inorganic analytes above a screening level groundwater criterion (refer to Table 3) were iron and manganese, but this may reflect a natural regional ambient condition present in groundwater, and not site related contamination. However, as a conservative measure these metals were carried forward into the focused risk assessment.

Media of Potential Concern

The medium of potential concern at the Site based on the results of the previous site investigations (refer to MWH 2010) appears to be groundwater. Groundwater is a medium of potential concern because it contains contaminants over the groundwater criteria set by the State of Minnesota. These criteria were summarized in Tables 1 through 4. The groundwater contamination is located close to building 252 which houses the Base Civil Engineering and so presents a potential concern associated with chemical vapor intrusion from the contaminated water table into the building interior, which could affect indoor air quality. For this reason, MWH performed a supplemental investigation in July 2010 to evaluate the completeness of this exposure pathway. The data from this evaluation showed that the exposure pathway is complete, but likely insignificant based on the site-specific data collected. The results of the vapor intrusion investigation are used within the focused risk evaluation to address the potential risk associated with the vapor intrusion exposure pathway.

Based on previous investigations, soils were not found to be of a concern as in most locations contaminants were not detected and where they were detected they were below soil screening levels.

Contaminated groundwater has migrated from the developed property near building 252 and extends under dry storage buildings and off Site 21 property into the undeveloped wetland area (refer to Figure 2). The plume of contaminated groundwater appears to have migrated near Miller Creek. For this reason the wetlands and Miller Creek are considered receptors of potential concern that require further evaluation in regard to groundwater COPC concentrations. Past surface water monitoring in this location of Miller Creek (specifically just downstream of the Infall Culverts running under Perimeter Road) has not detected any contamination in the surface water body (Refer to Attachment A – ANG surface water quality data). Based on these data, surface water in Miller Creek does not appear to have been effected by the groundwater contamination at the Site. However as described in the Working Draft Surface Water Pathway Evaluation User's Guide published in 2006 by the MPCA, surface water data alone cannot be used to evaluate whether a receptor is at risk due to groundwater contamination. For this reason, further risk evaluation of the groundwater data will be performed as part of this focused risk assessment. Therefore groundwater was selected as a medium of potential concern for further evaluation within the focused screening level risk assessment for both human and ecological receptors.

Potential Exposure Pathways—Human Health

This exposure evaluation considers current site land use, as well as potential future site land-use conditions. Under current conditions and likely future conditions people are not likely to be exposed to the contaminated groundwater, because the water supply for the base is supplied by the City of Duluth. As noted earlier, if the groundwater were to be used as a drinking water source, it would pose a human health concern, because concentrations of TCE and VC are well over the health based criteria listed in Tables 1 and 2. In additional iron and manganese are over drinking water criteria too (refer to Table 3). However, as long as the Base is supplied with drinking water from the City, this exposure pathway will remain incomplete.

The only potentially complete exposure pathway under current conditions is vapor intrusion of VOCs from the water table through the soil gas above the groundwater into building 252 which contains the offices and garage space for Base Civil Engineering. The highest concentrations of VOCs detected on-Site are located near building 252 (refer to Table 1). For this reason, in July 2010 a vapor intrusion assessment was conducted by MWH to determine if the exposure pathway was complete. The investigation included measurement of VOC concentration in soil gas in the unsaturated soils outside the building, soil gas measurements below the building slab, and ambient air inside and outside the building. In addition, head space air and water were sampled for VOCs in a sump located in the building 252. The sump is located in the southwest corner of building 252 within one of the garages. The sump collects shallow groundwater and surface water drainage that infiltrates around the footing of the building. The sump is sealed with a steel cover, but the cover is not air tight, and may provide a potential migration pathway for VOCs to volatilize from the groundwater and enter the indoor air of the building.

The results of the vapor intrusion assessment are summarized for soil gas, sump head space air, and indoor air in Table 5 and for sump water in Table 6. Based on the result of the supplemental investigation it appears that the exposure pathway is complete, but likely insignificant based on site-specific conditions. Based on the result of the investigation VOCs have migrated into the soil gas below the building slab, and the head space air inside the sump, however, the concentrations of VOCs in each medium are low. . Considering the exposure pathway was found to be complete, it is further evaluated in the focused risk evaluation in this document in relation to vapor intrusion screening values developed by the MPCA for the VOCs that were detected.

The only other potential human exposure pathway would be direct contact with shallow groundwater if future construction activities occurred that resulted in construction worker contact with the groundwater. Currently, no construction is planned in the area that would result in excavating soil down to the water table, and so such exposure in not expected. If such excavation activities did occur in the future, the duration of exposure would be expected to be very short in duration (a few days), and be limited to potential inhalation of VOCs that volatile into the air within the excavation and dermal absorption through the skin if the groundwater was contacted by the workers. None of the VOCs in groundwater are at concentrations that would be near limits that could cause health concerns over such a brief period of exposure (i.e, acute or subchronic period), and so this potential exposure pathway was not considered further within the focused risk evaluation.

Potential Exposure Pathways—Ecological Receptors

This section provides a site-specific evaluation of the exposure pathways for ecological receptors at Site 21. The ecological conceptual site model is shown in Figure 1. A biological habitat assessment was performed to determine the types of habitat and ecological receptors that were present at the Site and surrounding area. The habitat assessment was completed during the site visit conducted on December 22, 2009 by an Exponent environmental biologist/toxicologist. The results of the biological habitat assessment were used to develop the CSM.

During the site visit, the wetland area was viewed from the roadways and the conditions were discussed with the base personnel. The apparent wetland area are composed primarily of tag alder and black ash thickets, with more quaking poplar and maple species as the topography changes from lowland adjacent to Miller Creek and slightly higher ground away from the creek. The wetland habitat is used by white tailed deer and grouse year round and a variety of song bird species during the warmer months of the year. Miller Creek flows through the wetland area and crosses under Mustang Drive through a box culvert and Perimeter Road through a series of infall culverts. Miller Creek is a designated trout stream (Minnesota Rules 6264.0050) and a protected watercourse subject to Minnesota Statutes Section 105.42. Based on the MPCA Working Draft Surface Water Pathway Evaluation User's Guide Miller Creek is located in the Lake Superior Basin and the stream has Classifications of 1B, 2A, and 3B. The Class 1B surface quality standards are drinking water criteria based on human health, while the Class 3B criteria are industrial consumption criteria. The Class 2A surface water quality standards are chronic aquatic criteria developed for cold water trout streams. The Class 1B, and 2A standards are shown on Tables 2 through 4. The Class 3B criteria are not presented as they are much higher where they are available then the Class 1B criteria, so by default the Class 1B criteria were used in the Tier evaluation of groundwater presented herein.

Between Mustang Drive and Perimeter Road the Creek flows through a small area dominated by a cattail marsh, but this is a minor habitat type. Just downstream of the infall culvert under perimeter road is where surface water monitoring occurred annually in the creek until 2006. Photographs of Miller Creek and the surrounding wetlands are presented below.

Photograph 1 Looking at Miller Creek from Perimeter Road towards Mustang Drive

Photograph 2 Typical look of wetland environment in undeveloped area south of Site 21

The contaminated groundwater plume appears to end approximately within the wetland area near the location where Miller Creek flows through the wetlands. The groundwater plume appears to be fairly stable and does not appear based on the available rounds of groundwater data to be extending further to the southeast. The contamination in the wetlands appears to be located below the ground surface in the shallow groundwater zone, which is unavailable to wildlife receptors.

Sediment pore water measurements were collected in the wetland by MWH at seven push points (Refer to Table 1). At three of these seven locations, chemicals of potential concern were detected (i.e., cis-1,2-dichloroethene (2 locations), tetrahydrofuran (1 location), and vinyl chloride (1 location)). The pore water samples were collected at depths of approximately 3 feet below the top of sediment. These isolated detects are located away from Miller Creek, and were located at depths that would not be accessible to wildlife receptors. However, consistent with MPCA's 2006 Working Draft Surface Water Pathway Evaluation User's Guide, these pore water data are evaluated further using the MPCA's tiered approach.

The shallow contaminated groundwater does not appear to affect surface water quality in Miller Creek, as no VOCs were detected at the historic surface water quality monitoring station located where groundwater would have the potential to discharge to the Miller Creek. The surface water monitoring was conducted on an annual basis over a number of years, and no VOCs have been detected at the Site 21 sampling station within Miller Creek.

Screening Level Risk Evaluation Results – Human Receptors

A screening level evaluation was performed to address the potentially complete exposure pathways humans may have to volatile contamination in the groundwater. Inorganic analytes were detected in groundwater, but exposure to these compounds would not be expected as they are not volatile, and most are essential nutrients (e.g., calcium, potassium, etc.) and do not appear elevated in groundwater based on past site land use (i.e., Imhoff treatment system). Therefore, the screening assessment was focused on the VOCs detected in the groundwater.

As documented in the MWH Technical Memorandum (Table 1 and 2), shallow groundwater in a number of temporary or permanent monitoring wells exceed ARARs for groundwater including the State's drinking water standards. Thus the groundwater would not be considered safe as a drinking water source because of the levels of contamination primarily related to TCE and its degradation products. However, as mentioned in the CSM, consumption of the groundwater is not expected to be a complete exposure pathway because the Base is supplied with water from the City of Duluth Municipal water system, which is unaffected by Site 21. The groundwater appears to be contained well within the limits of MNANG and has not migrated beyond the beginning limits of the wetland.

The exposure pathway of potential concern associated with groundwater at Site 21 is vapor intrusion into buildings. Groundwater contamination greater than 100 feet from a building would unlikely effect the air quality in the building, as soil gas entering the building would unlikely be affected by groundwater contamination over 100 feet from the building. In the case of Site 21, the highest concentrations of VOCs in groundwater were detected within 50 feet of building 252 where office space is located. None of the other buildings at Site 21 are occupied, but rather are used for dry storage. The storage buildings at Site 21 are to be removed in the next few years due to base plans to reconfigure the new base entrance. Therefore the focus of the screening level risk evaluation was on the groundwater quality near building 252, although all groundwater data available provided in Tables 1 and 2 were considered for this screening evaluation.

Based on the results of the site visit performed in December 2009, potential vapor pathways were identified for building 252. These include vapor intrusion through cracks between the floor of the building and side wall and where utilities enter the building through the floor or walls, and through the floor sump located in the southwest corner of the building in a garage area. An initial screening assessment was performed that compared the maximum concentrations of each VOC to groundwater screening values for the vapor intrusion pathway. The screening values were obtained from MPCA document c-s4-06, "Risk-based Guidance for the Vapor Intrusion Pathway, Superfund RCRA and Voluntary Cleanup Section" dated September 2008, unless otherwise noted in Tables 2 and 3. Based on a comparison of VOC groundwater concentration to groundwater vapor intrusion screening values, there are four VOCs that were detected above their vapor intrusion screening criteria (i.e., 1,2,4-trimethylbenzene, benzene, TCE, and vinyl chloride). Of note, the maximum concentration of TCE was located at GP05(4-8), which is approximately 30 feet from building 252. Based on the exceedances of the groundwater vapor intrusion screening levels, additional investigation was performed in July 2010 to evaluate whether the contaminated groundwater is affecting the indoor air quality of building 252, and if so if that exposure would pose a health concern.

As part of the vapor intrusion investigation MWH collected soil gas outside the building in the unsaturated zone above the groundwater table to evaluate if there was migration of contamination from groundwater that could affect the air quality in the building. In addition, soil gas samples were collected beneath the building slab, and air was collected inside the building sump to further evaluate whether the vapor migration pathway was complete. Finally, indoor air samples were collected to determine if there was any impact on the air quality inside the building in the event that migration from groundwater to subslab soil gas or sump air was found. Sample locations are shown in Figure 3. Reviewing the data as a whole (i.e., groundwater, soil gas, sub-slab soil gas, and indoor air), there has been very limited migration of contaminants in groundwater into soil gas beneath the building. The primary VOC migration route from groundwater appears to be the sump and associated drain tile, which is covered and thus provides a limited source of VOCs for the building. The groundwater contamination does not appear to be affecting the indoor air quality of the building in a way that presents a health concern. This is discussed in detail below.

Based on the soil gas measurements taken in the unsaturated soil outside the building in the area where the exceedance of the groundwater vapor intrusion values occurred, there were low concentrations of benzene in 3 of 4 of the soil gas samples, 1,2,4-trimethylbenzene in 2 of 4 of soil gas samples, and TCE was detected in only one soil gas sample. Vinyl chloride was not detected in any of the soil gas samples. The concentrations of each analyte in soil gas was compared to a value representing ten times the Intrusion Screening Value (ISV) or 10X ISV, which the criteria specified in the MPCA vapor intrusion guidance to compare to soil gas measurements. None of the VOCs that were detected in groundwater above the groundwater vapor screening concentrations were detected in soil gas outside the building in exceedance of the 10X ISV criteria. A group of other VOCs were also detected in soil gas that were not identified in groundwater (refer to Table 5). Each of these VOCs also had concentrations below the 10X ISV value with the exception of a Freon compound (dichlorodifluoromethane), which was detected above the 10X ISV value at SG04. In SG04, dichlorodifluoromethane was detected at 10,000 microgram per cubic meter ($\mu g/m^3$) compared to its 10 X ISV value of 2,000 $\mu g/m^3$.

Under the Building 252 concrete slab two samples of soil gas were collected to evaluate if there was significant migration of volatile constituents from outside the building from the unsaturated soils to soil gas below the building. The concentrations of all VOCs including dichlorodifluoromethane were below their respective 10 X ISV values. In addition the concentration of VOCs detected in soil gas under the building, were at lower concentrations than soil gas collected outside the building, with only one exception, indicating significant attenuation of most VOC concentrations is occurring with distance. The one exception was a trace concentration of vinyl chloride that was detected in SS01 at a concentration of 0.46 $\mu g/m^3$. The concentration is near the reporting limit and was reported as an estimated value (i.e., flagged J), and well below the 10X ISV of 10 $\mu g/m^3$. Based on this information, there has been very limited migration of VOCs to locations below the building slab.

The head space air collected in the sump inside the building showed that the sump and associated drainage system are a source of vapor migration into the building. Two analytes were detected in head space air within the sump at concentrations above the 10X ISV value, including dichlorodifluoromethane at a concentration of 4,700 $\mu g/m^3$, and vinyl chloride at a concentration of 15 $\mu g/m^3$. The sump water was also analyzed for VOCs, but only a low concentration of dichlorodifluoromethane (5.4 micrograms per liter [µg /L]) was detected (refer to Table 6). As discussed previously, the sump is covered with a metal lid, which although not an air tight cover, limits the exchange of air inside the sump with the indoor air inside the building. The indoor air data were reviewed to evaluate whether the air quality in the sump was having an effect on the indoor quality inside Building 252.

Within the duplicate indoor air samples collected inside the building, vinyl chloride, and trichloroethene were not detected above the reporting limit. In addition, only very low concentrations of dichlorodifluoromethane (6.7 $\mu g/m^3$), well below the compounds ISV of 200 $\mu g/m^3$ were detected in indoor air. The only VOCs detected above an ISV were benzene and 1,2,4-trimethylbenzene. Benzene was measured in indoor air at concentrations ranging from 7.4 to 7.9 $\mu g/m^3$, which is only slightly above its ISV of 4.5 $\mu g/m^3$. Similarly, 1,2,4-trimethylbenzene was measured in indoor air at concentrations ranging from 5.4 to 7.4 $\mu g/m^3$, only the duplicate sample being slightly above its ISV of 7.0 $\mu g/m^3$. While benzene and 1,2,4-trimethylbenzene are slightly above their respective ISVs in indoor air, based on the fact that sump air concentrations of these analytes were below the ISV, all the soil gas and sump air concentrations for these analytes were less than the indoor air concentrations, and soil gas concentrations of these analytes were not found to be elevated above the 10X ISV screening level, it appears that there is likely an indoor source of benzene and 1,2,4-trimethylbenzene in the building. Gasoline powered equipment is stored in the building in the area where the indoor air samples were collected, and so this is a likely source of these two VOCs in the indoor air. Based on the results of the indoor air measurements, the contaminated groundwater, does not appear to be affecting the indoor air quality of the building. While there are detections of benzene and 1,2,4-trimethylbenzene above the ISV, the exceedances are just slightly above the screening value, and would not represent a significant health concern. These exceedances of the benzene and 1,2,4-trimethylbenzene ISV do not appear to be related to the groundwater contamination, but rather related to equipment storage of gasoline powered equipment inside the building, or other source from inside the building. In the winter of 2010, MWH will retest the sump air and indoor air to evaluate the air quality in the building again. It is recommended that all potential source of benzene and 1,2,4-trimethylbenzene (along with other VOCs) be removed from inside the building before this testing occurs.

Screening Level Risk Evaluation Results – Ecological Receptors

A tiered evaluation of the groundwater data at the site was performed to evaluate if the wetlands and Miller Creek would represent ecological receptors that could potentially be affected by the groundwater contamination. The Tiered evaluation follows the procedures outlined in the MPCA's 2006 Working Draft Surface Water Pathway Evaluation User's Guide. This recommends a Tier 1 evaluation using the maximum concentration of each analyte in groundwater, and comparing it to Tier 1 criteria. If the Tier 1 criteria are exceeded, then a Tier 2 evaluation can be performed.

The Tier 1 criteria in the guidance reflect in essence the human health based groundwater criteria provided in Tables 2 through 4 (HRLs and Class 1B surface water quality standards). As discussed previously, the maximum concentration of a number of analytes has exceeded these Tier 1 screening criteria in a number of wells on-site and within the wetland area. For this reason, the screening evaluation advanced to a Tier 2 evaluation.

For the Tier 2 evaluation, the groundwater concentrations of analytes at locations closest to the potential receptor are evaluated to determine if there is a potential concern for each ecological receptor (i.e., wetlands and Miller Creek). The focus of the Tier 2 evaluation was on the VOCs detected in groundwater above the Tier 1 criteria, because there were no Tier 2 criteria available from the MPCA for the inorganic analytes detected in groundwater. It should be noted though the only inorganic analytes exceeding a Tier 1 criteria were iron and manganese (refer to Table 3), and as discussed previously, these analytes are unlikely site related, but rather are likely to be elevated due to regional conditions.

For the Tier 2 evaluation the push point samples of shallow groundwater (i.e., pore water from the wetland sediment) collected at depths of approximately three feet below ground surface were used for the receptor evaluation of the wetlands and Miller Creek. Most of the monitoring well data reflects water quality at depth of 10 feet or greater, and so the push point samples were specially collected by MWH to provide a better representation of the water quality that may be released to each of these receptors. For the Tier 2 evaluation the push points were segregated into two groups to evaluate each receptor (wetlands or Miller Creek). Table 2 highlights those push points that are located along the upgradient leading edge of the wetland and away from Miller Creek (PP01,PP0 2,PP03 and PP05) and those that are just upgradient of Miller Creek (PPO4,PPO 6, and PPO7). The Tier 2 surface water criteria used for the evaluation are present on Table 2 and reflect the Class 1B (drinking water standards) and Class 2A surface water quality standards. The Class 2A surface water quality standards are represented by the chronic standards (CS) that should be protective of aquatic life even under a chronic period of exposure. The concentrations of all VOCs are below the lowest Tier 2 criteria (i.e., either Class 1B or 2A surface water quality standards) with the exception of one sample within the wetland PP02 (away from Miller Creek) where a VC concentration of 9.2 ug/L was detected. All the other probe points had no detections of VOCs above any of the Tier 2 surface water quality standards.

Based on the comparison to the Tier 2 criteria, Miller Creek would not be expected to be a receptor of concern. Each of the probes located just upgradient of Miller Creek was below the VOC Tier 2 screening criteria. This is has been further supported by the surface water quality data that was collected in 2005 and 2006 within Miller Creek just downstream of the projected edge of the groundwater plume.

Within the wetland up gradient of the Miller Creek, there was one exceedance for a single compound (VC), but based on the volatility of this compound, it is unlikely this exceedance would pose a concern to the wetland environment wildlife receptors. Vinyl chloride is a gas at room temperature so if it migrated to the surface, it would readily volatilize. The isolated location of this detection on the leading edge of the wetland shows that a limited area is affected. Ecological receptors in the wetland would not be expected to be exposed to the VC because of its subsurface location and volatility. For this reason, while there was an isolated exceedance of the VC criteria, it would not be expected to pose a threat to the wetland environment.

Summary, Conclusions and Recommendations

A focused risk assessment was performed for Site 21, which evaluated the potential human and ecological risks associated with groundwater contamination. Site 21 was the location of a former Imhoff treatment system, which was removed decades ago. Past environmental investigations have ruled out soil as a medium of concern at Site 21, and so the risk assessment was focused on the groundwater contamination present at Site 21.

The focused risk assessment evaluated which exposure pathways were potentially complete for both human and ecological receptors, using the site-specific data that were collected and considering site-specific conditions. Site 21 contains developed areas of the ANG base where buildings and roadways are present. The property adjacent to Site 21 also contains many acres of undeveloped land that contain wetlands and a portion of Miller Creek. For media of potential concern, an initial screening level evaluation was completed to compare medium-specific chemical concentrations to risk-based screening values. These screening level evaluations were used to determine if further evaluation of particular pathways were required.

The only media of potential concern identified during the site investigation was groundwater. The potentially complete exposure pathways for groundwater are summarized in the Conceptual

Site Model (Figure 1). The contaminated groundwater forms a plume beneath the site that extends from near building 252 where the highest concentration of TCE and benzene were detect to the southeast towards a wetland area. The plume appears to end in the wetlands near the location where Miller Creek flows through the wetlands. Based on site-specific conditions, there appears to be no complete exposure pathways resulting in wildlife receptor exposure to contamination in the groundwater. However, further evaluation of the groundwater contamination in the wetlands was evaluated to be consistent with MPCA surface water pathway evaluation guidelines. Based on the presence of VOCs in groundwater near building 252 above vapor intrusion screening criteria, additional investigation was performed by MWH in July 2010 to determine whether the vapor intrusion exposure pathway is complete and affecting indoor air quality within the building.

Based on the results of the focused screening level risk assessment, groundwater is not a medium of potential concern to either human or ecological receptors . The groundwater contamination is present at depth below ecologically sensitive areas (wetlands), but has not apparently affected the surface water quality in Miller Creek. Based on the Tier 2 ecological evaluation performed, groundwater quality near Miller Creek is below surface water quality standards based on the push point sampling. While there was a single chemical (i.e., VC) in the leading edge of wetland above its Tier 2 surface water quality criteria, this would not be expected to pose an ecological concern because it is located at depth in an isolated location. Therefore no additional ecological evaluation is recommended based on the results of the Tier 2 evaluation.

Concentration of VOCs in groundwater (i.e., primarily TCE and benzene) are above screening concentrations developed by MPCA to determine if vapor intrusion could represent a potential exposure concern to people inside of buildings as a result of groundwater contamination. However, the additional vapor intrusion investigation performed by MWH showed that indoor air quality inside the building is not being affected by the groundwater contamination. While there is some limited migration of VOCs from groundwater to soil gas below the building and sump air inside the building, the indoor air concentrations of VOCs as a result of this migration are generally below the MPCA screening values. The only exceedance of the indoor air screening values (i.e., ISV) were for benzene and 1,2,4-trimethylbenzene, and the exceedance are very minor (i.e., within a factor of 2 of the screening value) and appear to be due to the storage of gasoline powered equipment in the building.

References

Minnesota Pollution Control Agency (MPCA). 2008. Risk-based Guidance for the Vapor Intrusion Pathway, Superfund RCRA and Voluntary Cleanup Section. MPCA Document c-s4-06.

Minnesota Pollution Control Agency (MPCA). 2006. Working Draft Surface Water Pathway Evaluation User's Guide, MPCA Remediation Programs. MPCA Document c-s4-01.

Tables

Figures

Attachments

TABLE 1
VAS, TEMPORARY WELLS, AND PUSHPOINT
GROUNDWATER ANALYTICAL RESULTS - VOCS/TPH-DRO
148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
AUGUST 2008, MAY 2009, AND SEPTEMBER 2009

Date Collected						Tier 2 Surface Water Quality Standards				**8/4/2008**	**8/4/2008**	**8/4/2008**	**8/4/2008**	**8/4/2008**	**8/4/2008**	**8/4/2008**	**8/4/2008**	**8/5/2008**	**8/5/2008**
Sample ID						1B	2A	2A	2A	**GP01 (18-22)**	**GP01(13-17)**	**GP01(8-12)**	**GP01(3-7)**	**GP02(18-22)**	**GP02(13-17)**	**GP02(8-12)**	**GP02(3-7)**	**GP03(24-28)**	**GP03(19-23)**
		Max Conc.	MCL^	HRL#	GW_{isv}	DW*	CS*	MS*	FAV*										
Volatile Organic Compounds																			
1,1,1-Trichloroethane	µg/l	1.4	200	9,000	10000	200	329	2,957	5,913	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,1-Dichloroethylene	µg/l	1.0	7	200	300	7	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2,4-Trimethylbenzene	µg/l	6.4	-	-	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2-Dichlorobenzene	µg/l	7.2	-	600	7000	600	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,3,5-Trimethylbenzene	µg/l	3.6	-	100	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,4-Dichlorobenzene	µg/l	4.3	-	10	2000	75	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Acetone	µg/l	29.0	-	700	40000000	-	-	-	-	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0
Benzene	µg/l	1.0	5	2	40	5	9.7	4,487†	8,974†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Chlorobenzene	µg/l	**32.0**	100	100	800	100	20	423	846	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
cis-1,2-Dichloroethene	µg/l	14.0	70	50	NA	70	-	-	-	**3.0**	**3.8**	**5.6**	**6.9**	**2.3**	**4.2**	**6.7**	**14.0**	< 1.0	< 1.0
Dichlorodifluoromethane	µg/l	2.0	-	700	70	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Dichlorofluoromethane	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethyl ether	µg/l	6.8	-	1,000	-	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Ethylbenzene	µg/l	7.7	700	700	7000	700	68	1,859	3,717	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Isopropylbenzene	µg/l	1.7	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
m&p-Xylenes	µg/l	2.1	-	-	800	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Methylene chloride	µg/l	1.6	-	5	400	5	45	13,875†	27,749†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**1.6**	< 1.0
Naphthalene	µg/l	2.0	-	300	1000	-	81	409	818	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
n-Propylbenzene	µg/l	2.7	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-Xylene	µg/l	2.9	-	-	1000	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p-Isopropyltoluene	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
sec-Butylbenzene	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
tert-Butylbenzene	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Tetrahydrofuran	µg/l	200.0	-	-	-	-	-	-	-	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
trans-1,2-Dichloroethene	µg/l	1.0	100	100	300	100	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Trichloroethene	µg/l	**88.0**	5	5	20	5	25	6,988†	13,976†	**40.0**	**63.0**	**65.0**	**16.0**	**21.0**	**68.0**	**53.0**	**3.5**	< 1.0	< 1.0
Vinyl Chloride	µg/l	**9.2**	2	0.2	1	2	0.17	†	†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Xylenes (total)	µg/l	5.0	10,000	10,000	-	10,000	166	1,407	2,814	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0
TPH-DRO	mg/l	**0.5**	-	-	-	0.2	-	-	-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
Only detected compounds are shown
Analytical data in bold text denotes sample detections above the MDL
Analytical data outlined denotes sample detections above HRL, DW, or CS; analytical results highlighted in yellow denotes detections above GWisv.
TPH-DRO = total petroleum hydrocarbons-diesel range organics
MCL = Maximum Contaminant Level
HRL = Minnesota Health Risk Limit
GW_{isv} = Groundwater Screening Values for Vapor Intrusion Pathway as provided in the MPCA document c-s4-06, "Risk-based Guidance for the Vapor Intrusion Pathway, Superfund RCRA and Voluntary Cleanup Section" dated September 2008, unless otherwise noted. Exceptions are for acetone, cis-1,2-DCE, and 1,1,1-Trichloroethane, which required updating based on the Intrusion Screening Values (ISVs) released by MPCA in February 2009.
- = No Limit established
DW = Drinking Water. Note the value for TPH represents a HBV - Health Based Values derived by Minnesota Department of Health in 1999 based on using pyrene as a surrogate chemical. HBVs developed in various years from 1995-2006 are taken from a March 5, 2007, table from MDH. These values are no longer supported by MDH, however these values are kept in this table for screening purposes.
CS = Chronic Standard
FAV = Final Acute Value
Max Conc. = Maximum concentration of analyte detected in dataset. For analytes not detected, the value represents the highest reporting limit.
MS = Maximum Standard
µg/l = micrograms per liter
mg/l = milligrams per liter
ID= Identification
QC= Quality Control
J = Estimated concentration
DUP = Duplicate
NA = not applicable
^ = Federal MCL under Safe Drinking Water Act (40 CFR Part 141).
# = State of Minnesota HRL, established in Minnesota Rules Chapter 4717.
* = State of Minnesota Specific Standards of Quality and Purity for Class 1B and 2A waters of the State.
† = For a pollutant with asterisks next to the final acute value (FAV) and the maximum standard (MS), the following applies:
For carcinogenic or highly bioaccumulative chemicals with BCF's greater than 5000 or log Kow values greater than 5.19, the human health chronic standard may be two or more orders smaller than the acute toxicity based MS.
For the MS: if the ratio of MS to the CS is greater than 100, the CS times 100 should be substituted for the applicable MS.
For the FAV: if the ratio of FAV to the CS is greater than 200, the CS times 200 should be substituted for the applicable FAV.
From Minn. R. 7050.0222, subp. 7, item E.

TABLE 1
VAS, TEMPORARY WELLS, AND PUSHPOINT
GROUNDWATER ANALYTICAL RESULTS - VOCS/TPH-DRO
148^{TH} FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
AUGUST 2008, MAY 2009, AND SEPTEMBER 2009

Date Collected						Tier 2 Surface Water Quality Standards				**8/5/2008**	**8/5/2008**	**8/5/2008**	**8/5/2008**	**8/5/2008**	**8/5/2008**	**8/5/2008**	**8/6/2008**	**8/6/2008**	**8/6/2008**
Sample ID						1B	2A	2A	2A	**GP03(14-18)**	**GP03(14-18) DUP**	**GP04(23-27)**	**GP04(18-22)**	**GP04(13-17)**	**GP05(4-8)**	**GP06 (12-16)**	**GP07(16-20)**	**GP07(11-15)**	**GP07(6-10)**
		Max Conc.	MCL^	HRL#	GW_{isv}	DW*	CS*	MS*	FAV*										
Volatile Organic Compounds																			
1,1,1-Trichloroethane	µg/l	1.4	200	9,000	10000	200	329	2,957	5,913	< 1.0	< 1.0	< 1.0	**1.4**	**1.1**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,1-Dichloroethylene	µg/l	1.0	7	200	300	7	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2,4-Trimethylbenzene	µg/l	6.4	-	-	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**6.4**	< 1.0	< 1.0	< 1.0	< 1.0
1,2-Dichlorobenzene	µg/l	7.2	-	600	7000	600	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,3,5-Trimethylbenzene	µg/l	3.6	-	100	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**3.6**	< 1.0	< 1.0	< 1.0	< 1.0
1,4-Dichlorobenzene	µg/l	4.3	-	10	2000	75	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Acetone	µg/l	29.0	-	700	40000000	-	-	-	-	< 20.0	< 20.0	**29.0**	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0
Benzene	µg/l	1.0	5	2	40	5	9.7	4,487†	8,974†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Chlorobenzene	µg/l	**32.0**	100	100	800	100	20	423	846	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
cis-1,2-Dichloroethene	µg/l	14.0	70	50	NA	70	-	-	-	**3.6**	**3.6**	< 1.0	**1.4**	**3.6**	**11.0**	**2.5**	**2.7**	**3.3**	**2.6**
Dichlorodifluoromethane	µg/l	2.0	-	700	70	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Dichlorofluoromethane	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethyl ether	µg/l	6.8	-	1,000	-	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Ethylbenzene	µg/l	7.7	700	700	7000	700	68	1,859	3,717	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**7.7**	< 1.0	< 1.0	< 1.0	< 1.0
Isopropylbenzene	µg/l	1.7	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**1.7**	< 1.0	< 1.0	< 1.0	< 1.0
m&p-Xylenes	µg/l	2.1	-	-	800	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	**2.1**	< 2.0	< 2.0	< 2.0	< 2.0
Methylene chloride	µg/l	1.6	-	5	400	5	45	13,875†	27,749†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Naphthalene	µg/l	2.0	-	300	1000	-	81	409	818	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
n-Propylbenzene	µg/l	2.7	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**2.7**	< 1.0	< 1.0	< 1.0	< 1.0
o-Xylene	µg/l	2.9	-	-	1000	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**2.9**	< 1.0	< 1.0	< 1.0	< 1.0
p-Isopropyltoluene	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
sec-Butylbenzene	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
tert-Butylbenzene	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Tetrahydrofuran	µg/l	200.0	-	-	-	-	-	-	-	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
trans-1,2-Dichloroethene	µg/l	1.0	100	100	300	100	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Trichloroethene	µg/l	**88.0**	5	5	20	5	25	6,988†	13,976†	**43.0**	**43.0**	**2.4**	**11.0**	**29.0**	**88.0**	**59.0**	**41.0**	**43.0**	**6.6**
Vinyl Chloride	µg/l	**9.2**	2	0.2	1	2	0.17	†	†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Xylenes (total)	µg/l	5.0	10,000	10,000	-	10,000	166	1,407	2,814	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	**5.0**	< 3.0	< 3.0	< 3.0	< 3.0
TPH-DRO	mg/l	**0.5**	-	-	-	0.2	-	-	-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
Only detected compounds are shown
Analytical data in bold text denotes sample detections above the MDL
Analytical data outlined denotes sample detections above HRL, DW, or CS; analytical results highlighted in yellow denotes detections above (
TPH-DRO = total petroleum hydrocarbons-diesel range organics
MCL = Maximum Contaminant Level
HRL = Minnesota Health Risk Limit
GW_{isv} = Groundwater Screening Values for Vapor Intrusion Pathway as provided in the MPCA document c-s4-06, "Risk-based Guidance for the Vapor Intrusion Pathway, Superfund RCRA and Voluntary Cleanup Section" dated September 2008, unless otherwise noted. Exceptions are for acetone, cis-1,2-DCE, and 1,1,1-Trichloroethane, which required updating based on the Intrusion Screening Values (ISVs) released by MPCA in February 2009.
- = No Limit established
DW = Drinking Water. Note the value for TPH represents a HBV - Health Based Values derived by Minnesota Department of Health in 1999 based on using pyrene as a surrogate chemical. HBVs developed in various years from 1995-2006 are taken from a March 5, 2007, table from MDH. These values are no longer supported by MDH, however these values are kept in this table for screening purposes.
CS = Chronic Standard
FAV = Final Acute Value
Max Conc. = Maximum concentration of analyte detected in dataset. For analytes not detected, the value represents the highest reporting limit
MS = Maximum Standard
µg/l = micrograms per liter
mg/l = milligrams per liter
ID= Identification
QC= Quality Control
J = Estimated concentration
DUP = Duplicate
NA = not applicable
^ = Federal MCL under Safe Drinking Water Act (40 CFR Part 141).
# = State of Minnesota HRL, established in Minnesota Rules Chapter 4717.
* = State of Minnesota Specific Standards of Quality and Purity for Class 1B and 2A waters of the State.
† = For a pollutant with asterisks next to the final acute value (FAV) and the maximum standard (MS), the following applies:
For carcinogenic or highly bioaccumulative chemicals with BCF's greater than 5000 or log Kow values greater than 5.19, the human health chronic standard may be two or more orders smaller than the acute toxicity based MS.
For the MS: if the ratio of MS to the CS is greater than 100, the CS times 100 should be substituted for the applicable MS.
For the FAV: if the ratio of FAV to the CS is greater than 200, the CS times 200 should be substituted for the applicable FAV.
From Minn. R. 7050.0222, subp. 7, item E.

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148[TH] FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
AUGUST 2008, MAY 2009, AND SEPTEMBER 2009

Date Collected						Tier 2 Surface Water Quality Standards				**8/6/2008**	**5/5/2009**	**5/5/2009**	**5/5/2009**	**5/5/2009**	**5/5/2009**	**5/5/2009**	**5/5/2009**	**5/5/2009**	**5/5/2009**
Sample ID						1B	2A	2A	2A	**GP07(1-5)**	**GP08(32-36)**	**GP08(22-26)**	**GP09(36-40)**	**GP09(26-30)**	**GP09(16-20)**	**GP09(6-10)**	**GP10(35-39)**	**GP10(24-28)**	**GP10(14-18)**
		Max Conc.	MCL^	HRL#	GW_{isv}	DW*	CS*	MS*	FAV*										
Volatile Organic Compounds																			
1,1,1-Trichloroethane	µg/l	1.4	200	9,000	10000	200	329	2,957	5,913	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,1-Dichloroethylene	µg/l	1.0	7	200	300	7	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2,4-Trimethylbenzene	µg/l	6.4	-	-	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2-Dichlorobenzene	µg/l	7.2	-	600	7000	600	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,3,5-Trimethylbenzene	µg/l	3.6	-	100	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,4-Dichlorobenzene	µg/l	4.3	-	10	2000	75	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Acetone	µg/l	29.0	-	700	40000000	-	-	-	-	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0
Benzene	µg/l	1.0	5	2	40	5	9.7	4,487†	8,974†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Chlorobenzene	µg/l	**32.0**	100	100	800	100	20	423	846	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
cis-1,2-Dichloroethene	µg/l	14.0	70	50	NA	70	-	-	-	< 1.0	< 1.0	**2.1**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Dichlorodifluoromethane	µg/l	2.0	-	700	70	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Dichlorofluoromethane	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethyl ether	µg/l	6.8	-	1,000	-	-	-	-	-	**6.8**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethylbenzene	µg/l	7.7	700	700	7000	700	68	1,859	3,717	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Isopropylbenzene	µg/l	1.7	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
m&p-Xylenes	µg/l	2.1	-	-	800	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Methylene chloride	µg/l	1.6	-	5	400	5	45	13,875†	27,749†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Naphthalene	µg/l	2.0	-	300	1000	-	81	409	818	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
n-Propylbenzene	µg/l	2.7	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-Xylene	µg/l	2.9	-	-	1000	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p-Isopropyltoluene	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
sec-Butylbenzene	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
tert-Butylbenzene	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Tetrahydrofuran	µg/l	200.0	-	-	-	-	-	-	-	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
trans-1,2-Dichloroethene	µg/l	1.0	100	100	300	100	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Trichloroethene	µg/l	**88.0**	5	5	20	5	25	6,988†	13,976†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Vinyl Chloride	µg/l	**9.2**	2	0.2	1	2	0.17	†	†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Xylenes (total)	µg/l	5.0	10,000	10,000	-	10,000	166	1,407	2,814	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0
TPH-DRO	mg/l	**0.5**	-	-	-	0.2	-	-	-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
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Analytical data in bold text denotes sample detections above the MDL
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AUGUST 2008, MAY 2009, AND SEPTEMBER 2009

Date Collected						Tier 2 Surface Water Quality Standards				**5/5/2009**	**5/5/2009**	**5/6/2009**	**5/6/2009**	**5/6/2009**	**5/6/2009**	**5/6/2009**	**5/6/2009**	**5/6/2009**	**5/6/2009**
Sample ID						1B	2A	2A	2A	**GP10(4-8)**	**GP10(4-8) DUP**	**GP11(52-56)**	**GP11(42-46)**	**GP11(32-36)**	**GP11(22-26)**	**GP12(44-48)**	**GP12(34-38)**	**GP12(24-28)**	**GP12(14-18)**
		Max Conc.	MCL^	HRL#	GW_{isv}	DW*	CS*	MS*	FAV*										
Volatile Organic Compounds																			
1,1,1-Trichloroethane	µg/l	1.4	200	9,000	10000	200	329	2,957	5,913	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,1-Dichloroethylene	µg/l	1.0	7	200	300	7	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2,4-Trimethylbenzene	µg/l	6.4	-	-	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2-Dichlorobenzene	µg/l	7.2	-	600	7000	600	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,3,5-Trimethylbenzene	µg/l	3.6	-	100	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,4-Dichlorobenzene	µg/l	4.3	-	10	2000	75	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Acetone	µg/l	29.0	-	700	40000000	-	-	-	-	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0
Benzene	µg/l	1.0	5	2	40	5	9.7	4,487†	8,974†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Chlorobenzene	µg/l	**32.0**	100	100	800	100	20	423	846	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
cis-1,2-Dichloroethene	µg/l	14.0	70	50	NA	70	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**2.2**
Dichlorodifluoromethane	µg/l	2.0	-	700	70	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Dichlorofluoromethane	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethyl ether	µg/l	6.8	-	1,000	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethylbenzene	µg/l	7.7	700	700	7000	700	68	1,859	3,717	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Isopropylbenzene	µg/l	1.7	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
m&p-Xylenes	µg/l	2.1	-	-	800	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Methylene chloride	µg/l	1.6	-	5	400	5	45	13,875†	27,749†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Naphthalene	µg/l	2.0	-	300	1000	-	81	409	818	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
n-Propylbenzene	µg/l	2.7	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-Xylene	µg/l	2.9	-	-	1000	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p-Isopropyltoluene	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
sec-Butylbenzene	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
tert-Butylbenzene	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Tetrahydrofuran	µg/l	200.0	-	-	-	-	-	-	-	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
trans-1,2-Dichloroethene	µg/l	1.0	100	100	300	100	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Trichloroethene	µg/l	**88.0**	5	5	20	5	25	6,988†	13,976†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**25.0**
Vinyl Chloride	µg/l	**9.2**	2	0.2	1	2	0.17	†	†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Xylenes (total)	µg/l	5.0	10,000	10,000	-	10,000	166	1,407	2,814	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0
TPH-DRO	mg/l	**0.5**	-	-	-	0.2	-	-	-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
Only detected compounds are shown
Analytical data in bold text denotes sample detections above the MDL
Analytical data outlined denotes sample detections above HRL, DW, or CS; analytical results highlighted in yellow denotes detections above (
TPH-DRO = total petroleum hydrocarbons-diesel range organics
MCL = Maximum Contaminant Level
HRL = Minnesota Health Risk Limit
GW_{isv} = Groundwater Screening Values for Vapor Intrusion Pathway as provided in the MPCA document c-s4-06, "Risk-based Guidance for the Vapor Intrusion Pathway, Superfund RCRA and Voluntary Cleanup Section" dated September 2008, unless otherwise noted. Exceptions are for acetone, cis-1,2-DCE, and 1,1,1-Trichloroethane, which required updating based on the Intrusion Screening Values (ISVs) released by MPCA in February 2009.
- = No Limit established
DW = Drinking Water. Note the value for TPH represents a HBV - Health Based Values derived by Minnesota Department of Health in 1999 based on using pyrene as a surrogate chemical. HBVs developed in various years from 1995-2006 are taken from a March 5, 2007, table from MDH. These values are no longer supported by MDH, however these values are kept in this table for screening purposes.
CS = Chronic Standard
FAV = Final Acute Value
Max Conc. = Maximum concentration of analyte detected in dataset. For analytes not detected, the value represents the highest reporting limit
MS = Maximum Standard
µg/l = micrograms per liter
mg/l = milligrams per liter
ID= Identification
QC= Quality Control
J = Estimated concentration
DUP = Duplicate
NA = not applicable
^ = Federal MCL under Safe Drinking Water Act (40 CFR Part 141).
# = State of Minnesota HRL, established in Minnesota Rules Chapter 4717.
* = State of Minnesota Specific Standards of Quality and Purity for Class 1B and 2A waters of the State.
† = For a pollutant with asterisks next to the final acute value (FAV) and the maximum standard (MS), the following applies:
For carcinogenic or highly bioaccumulative chemicals with BCF's greater than 5000 or log Kow values greater than 5.19, the human health chronic standard may be two or more orders smaller than the acute toxicity based MS.
For the MS: if the ratio of MS to the CS is greater than 100, the CS times 100 should be substituted for the applicable MS.
For the FAV: if the ratio of FAV to the CS is greater than 200, the CS times 200 should be substituted for the applicable FAV.
From Minn. R. 7050.0222, subp. 7, item E.

TABLE 1
VAS, TEMPORARY WELLS, AND PUSHPOINT
GROUNDWATER ANALYTICAL RESULTS - VOCS/TPH-DRO
148[TH] FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
AUGUST 2008, MAY 2009, AND SEPTEMBER 2009

Date Collected						Tier 2 Surface Water Quality Standards				**5/6/2009**	**5/6/2009**	**5/6/2009**	**5/6/2009**	**5/6/2009**	**5/6/2009**	**5/6/2009**	**5/6/2009**	**5/6/2009**	**5/6/2009**
Sample ID		Max Conc.	MCL^	HRL#	GW_{isv}	1B DW*	2A CS*	2A MS*	2A FAV*	**GP12(4-8)**	**GP13(22-26)**	**GP13(22-26)**	**GP13(12-16)**	**GP13(4-8)**	**GP14(39-43)**	**GP14(29-33)**	**GP14(19-23)**	**GP14(9-13)**	**GP15(30-34)**
Volatile Organic Compounds																			
1,1,1-Trichloroethane	µg/l	1.4	200	9,000	10000	200	329	2,957	5,913	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,1-Dichloroethylene	µg/l	1.0	7	200	300	7	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2,4-Trimethylbenzene	µg/l	6.4	-	-	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2-Dichlorobenzene	µg/l	7.2	-	600	7000	600	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,3,5-Trimethylbenzene	µg/l	3.6	-	100	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,4-Dichlorobenzene	µg/l	4.3	-	10	2000	75	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Acetone	µg/l	29.0	-	700	40000000	-	-	-	-	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0
Benzene	µg/l	1.0	5	2	40	5	9.7	4,487†	8,974†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Chlorobenzene	µg/l	**32.0**	100	100	800	100	20	423	846	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
cis-1,2-Dichloroethene	µg/l	14.0	70	50	NA	70	-	-	-	**1.7**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Dichlorodifluoromethane	µg/l	2.0	-	700	70	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Dichlorofluoromethane	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethyl ether	µg/l	6.8	-	1,000	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethylbenzene	µg/l	7.7	700	700	7000	700	68	1,859	3,717	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Isopropylbenzene	µg/l	1.7	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
m&p-Xylenes	µg/l	2.1	-	-	800	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Methylene chloride	µg/l	1.6	-	5	400	5	45	13,875†	27,749†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Naphthalene	µg/l	2.0	-	300	1000	-	81	409	818	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
n-Propylbenzene	µg/l	2.7	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-Xylene	µg/l	2.9	-	-	1000	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p-Isopropyltoluene	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
sec-Butylbenzene	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
tert-Butylbenzene	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Tetrahydrofuran	µg/l	200.0	-	-	-	-	-	-	-	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
trans-1,2-Dichloroethene	µg/l	1.0	100	100	300	100	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Trichloroethene	µg/l	**88.0**	5	5	20	5	25	6,988†	13,976†	**18.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Vinyl Chloride	µg/l	**9.2**	2	0.2	1	2	0.17	†	†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Xylenes (total)	µg/l	5.0	10,000	10,000	-	10,000	166	1,407	2,814	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0
TPH-DRO	mg/l	**0.5**	-	-	-	0.2	-	-	-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
Only detected compounds are shown
Analytical data in bold text denotes sample detections above the MDL
Analytical data outlined denotes sample detections above HRL, DW, or CS; analytical results highlighted in yellow denotes detections above (
TPH-DRO = total petroleum hydrocarbons-diesel range organics
MCL = Maximum Contaminant Level
HRL = Minnesota Health Risk Limit
GW_{isv} = Groundwater Screening Values for Vapor Intrusion Pathway as provided in the MPCA document c-s4-06, "Risk-based Guidance for the Vapor Intrusion Pathway, Superfund RCRA and Voluntary Cleanup Section" dated September 2008, unless otherwise noted. Exceptions are for acetone, cis-1,2-DCE, and 1,1,1-Trichloroethane, which required updating based on the Intrusion Screening Values (ISVs) released by MPCA in February 2009.
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µg/l = micrograms per liter
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ID= Identification
QC= Quality Control
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DUP = Duplicate
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^ = Federal MCL under Safe Drinking Water Act (40 CFR Part 141).
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For carcinogenic or highly bioaccumulative chemicals with BCF's greater than 5000 or log Kow values greater than 5.19, the human health chronic standard may be two or more orders smaller than the acute toxicity based MS.
For the MS: if the ratio of MS to the CS is greater than 100, the CS times 100 should be substituted for the applicable MS.
For the FAV: if the ratio of FAV to the CS is greater than 200, the CS times 200 should be substituted for the applicable FAV.
From Minn. R. 7050.0222, subp. 7, item E.

TABLE 1
VAS, TEMPORARY WELLS, AND PUSHPOINT
GROUNDWATER ANALYTICAL RESULTS - VOCS/TPH-DRO
148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
AUGUST 2008, MAY 2009, AND SEPTEMBER 2009

Date Collected						Tier 2 Surface Water Quality Standards				**5/6/2009**	**5/7/2009**	**5/7/2009**	**5/7/2009**	**5/7/2009**	**5/7/2009**	**5/7/2009**	**5/7/2009**	**5/7/2009**	**5/7/2009**
Sample ID		Max Conc.	MCL$^{\wedge}$	HRL$^{\#}$	GW_{isv}	1B DW*	2A CS*	2A MS*	2A FAV*	**GP15(20-24)**	**GP15(10-14)**	**GP15(10-14) DUP**	**GP16(38-42)**	**GP16(28-32)**	**GP16(18-22)**	**GP16(8-12)**	**GP16(8-12) DUP05**	**GP17(36-40)**	**GP17(26-30)**
Volatile Organic Compounds																			
1,1,1-Trichloroethane	µg/l	1.4	200	9,000	10000	200	329	2,957	5,913	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,1-Dichloroethylene	µg/l	1.0	7	200	300	7	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2,4-Trimethylbenzene	µg/l	6.4	-	-	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2-Dichlorobenzene	µg/l	7.2	-	600	7000	600	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,3,5-Trimethylbenzene	µg/l	3.6	-	100	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,4-Dichlorobenzene	µg/l	4.3	-	10	2000	75	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Acetone	µg/l	29.0	-	700	40000000	-	-	-	-	< 20.0	< 20	< 20	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0
Benzene	µg/l	1.0	5	2	40	5	9.7	4,487†	8,974†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Chlorobenzene	µg/l	**32.0**	100	100	800	100	20	423	846	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
cis-1,2-Dichloroethene	µg/l	14.0	70	50	NA	70	-	-	-	< 1.0	**2.6**	**2.7**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**1.4**
Dichlorodifluoromethane	µg/l	2.0	-	700	70	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Dichlorofluoromethane	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethyl ether	µg/l	6.8	-	1,000	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethylbenzene	µg/l	7.7	700	700	7000	700	68	1,859	3,717	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Isopropylbenzene	µg/l	1.7	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
m&p-Xylenes	µg/l	2.1	-	-	800	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Methylene chloride	µg/l	1.6	-	5	400	5	45	13,875†	27,749†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Naphthalene	µg/l	2.0	-	300	1000	-	81	409	818	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
n-Propylbenzene	µg/l	2.7	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-Xylene	µg/l	2.9	-	-	1000	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p-Isopropyltoluene	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
sec-Butylbenzene	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
tert-Butylbenzene	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Tetrahydrofuran	µg/l	200.0	-	-	-	-	-	-	-	< 5.0	**92**	**92**	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
trans-1,2-Dichloroethene	µg/l	1.0	100	100	300	100	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Trichloroethene	µg/l	**88.0**	5	5	20	5	25	6,988†	13,976†	< 1.0	**5.6**	**5.5**	< 1.0	< 1.0	< 1.0	**1.2**	**1.1**	< 1.0	**4.8**
Vinyl Chloride	µg/l	**9.2**	2	0.2	1	2	0.17	†	†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Xylenes (total)	µg/l	5.0	10,000	10,000	-	10,000	166	1,407	2,814	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0
TPH-DRO	mg/l	**0.5**	-	-	-	0.2	-	-	-	NA	NA	NA	NA	NA	< 0.1	NA	NA	NA	< 0.12

Notes:
Only detected compounds are shown
Analytical data in bold text denotes sample detections above the MDL
Analytical data outlined denotes sample detections above HRL, DW, or CS; analytical results highlighted in yellow denotes detections above (
TPH-DRO = total petroleum hydrocarbons-diesel range organics
MCL = Maximum Contaminant Level
HRL = Minnesota Health Risk Limit
GW_{isv} = Groundwater Screening Values for Vapor Intrusion Pathway as provided in the MPCA document c-s4-06, "Risk-based Guidance for the Vapor Intrusion Pathway, Superfund RCRA and Voluntary Cleanup Section" dated September 2008, unless otherwise noted. Exceptions are for acetone, cis-1,2-DCE, and 1,1,1-Trichloroethane, which required updating based on the Intrusion Screening Values (ISVs) released by MPCA in February 2009.
- = No Limit established
DW = Drinking Water. Note the value for TPH represents a HBV - Health Based Values derived by Minnesota Department of Health in 1999 based on using pyrene as a surrogate chemical. HBVs developed in various years from 1995-2006 are taken from a March 5, 2007, table from MDH. These values are no longer supported by MDH, however these values are kept in this table for screening purposes.
CS = Chronic Standard
FAV = Final Acute Value
Max Conc. = Maximum concentration of analyte detected in dataset. For analytes not detected, the value represents the highest reporting limit
MS = Maximum Standard
µg/l = micrograms per liter
mg/l = milligrams per liter
ID= Identification
QC= Quality Control
J = Estimated concentration
DUP = Duplicate
NA = not applicable
^ = Federal MCL under Safe Drinking Water Act (40 CFR Part 141).
# = State of Minnesota HRL, established in Minnesota Rules Chapter 4717.
* = State of Minnesota Specific Standards of Quality and Purity for Class 1B and 2A waters of the State.
† = For a pollutant with asterisks next to the final acute value (FAV) and the maximum standard (MS), the following applies:
For carcinogenic or highly bioaccumulative chemicals with BCF's greater than 5000 or log Kow values greater than 5.19, the human health chronic standard may be two or more orders smaller than the acute toxicity based MS.
For the MS: if the ratio of MS to the CS is greater than 100, the CS times 100 should be substituted for the applicable MS.
For the FAV: if the ratio of FAV to the CS is greater than 200, the CS times 200 should be substituted for the applicable FAV.
From Minn. R. 7050.0222, subp. 7, item E.

TABLE 1
VAS, TEMPORARY WELLS, AND PUSHPOINT
GROUNDWATER ANALYTICAL RESULTS - VOCS/TPH-DRO
148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
AUGUST 2008, MAY 2009, AND SEPTEMBER 2009

Date Collected						Tier 2 Surface Water Quality Standards				5/7/2009	5/7/2009	5/7/2009	5/7/2009	5/7/2009	8/6/2008	8/6/2008	8/6/2008	8/6/2008	8/6/2008	8/6/2008	8/6/2008
Sample ID		Max Conc.	MCL^	HRL#	GW_{isv}	1B DW*	2A CS*	2A MS*	2A FAV*	GP18(37-41)	GP18(27-31)	GP18(17-21)	GP18(7-11)	GP18(7-11) DUP06	021-SB01	021-SB02	021-SB02 DUP	021-SB03	021-SB04	021-SB04 DUP	021-SB05
Volatile Organic Compounds																					
1,1,1-Trichloroethane	µg/l	1.4	200	9,000	10000	200	329	2,957	5,913	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
1,1-Dichloroethylene	µg/l	1.0	7	200	300	7	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
1,2,4-Trimethylbenzene	µg/l	6.4	-	-	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**4.6**	NA	< 1.0	< 1.0	< 1.0	< 1.0
1,2-Dichlorobenzene	µg/l	7.2	-	600	7000	600	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**5.8**	**7.2**	NA	**6.3**	< 1.0	< 1.0	< 1.0
1,3,5-Trimethylbenzene	µg/l	3.6	-	100	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**1.8**	NA	< 1.0	< 1.0	< 1.0	< 1.0
1,4-Dichlorobenzene	µg/l	4.3	-	10	2000	75	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**4.3**	**1.2**	NA	< 1.0	< 1.0	< 1.0	< 1.0
Acetone	µg/l	29.0	-	700	40000000	-	-	-	-	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	NA	< 20.0	< 20.0	< 20.0	< 20.0
Benzene	µg/l	1.0	5	2	40	5	9.7	4,487†	8,974†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
Chlorobenzene	µg/l	**32.0**	100	100	800	100	20	423	846	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**32.0**	**1.7**	NA	**2.6**	< 1.0	< 1.0	< 1.0
cis-1,2-Dichloroethene	µg/l	14.0	70	50	NA	70	-	-	-	< 1.0	< 1.0	**2.7**	**1.4**	**1.4**	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
Dichlorodifluoromethane	µg/l	2.0	-	700	70	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	NA	< 2.0	< 2.0	< 2.0	< 2.0
Dichlorofluoromethane	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
Ethyl ether	µg/l	6.8	-	1,000	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 2.0	< 2.0	NA	< 2.0	< 2.0	< 2.0	< 2.0
Ethylbenzene	µg/l	7.7	700	700	7000	700	68	1,859	3,717	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
Isopropylbenzene	µg/l	1.7	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
m&p-Xylenes	µg/l	2.1	-	-	800	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	NA	< 2.0	< 2.0	< 2.0	< 2.0
Methylene chloride	µg/l	1.6	-	5	400	5	45	13,875†	27,749†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
Naphthalene	µg/l	2.0	-	300	1000	-	81	409	818	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	NA	< 2.0	< 2.0	< 2.0	< 2.0
n-Propylbenzene	µg/l	2.7	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
o-Xylene	µg/l	2.9	-	-	1000	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
p-Isopropyltoluene	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
sec-Butylbenzene	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
tert-Butylbenzene	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
Tetrahydrofuran	µg/l	200.0	-	-	-	-	-	-	-	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	NA	< 5.0	< 5.0	< 5.0	< 5.0
trans-1,2-Dichloroethene	µg/l	1.0	100	100	300	100	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
Trichloroethene	µg/l	**88.0**	5	5	20	5	25	6,988†	13,976†	< 1.0	< 1.0	**30**	**15**	**16**	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
Vinyl Chloride	µg/l	**9.2**	2	0.2	1	2	0.17	†	†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	NA	< 1.0	< 1.0	< 1.0	< 1.0
Xylenes (total)	µg/l	5.0	10,000	10,000	-	10,000	166	1,407	2,814	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	NA	< 3.0	< 3.0	< 3.0	< 3.0
TPH-DRO	mg/l	**0.5**	-	-	-	0.2	-	-	-	NA	NA	NA	NA	NA	< 0.1	**0.5**	**0.4**	**0.17**	NA	NA	NA

Notes:
Only detected compounds are shown
Analytical data in bold text denotes sample detections above the MDL
Analytical data outlined denotes sample detections above HRL, DW, or CS; analytical results highlighted in yellow denotes detections above (
TPH-DRO = total petroleum hydrocarbons-diesel range organics
MCL = Maximum Contaminant Level
HRL = Minnesota Health Risk Limit
GW_{isv} = Groundwater Screening Values for Vapor Intrusion Pathway as provided in the MPCA document c-s4-06, "Risk-based Guidance for the Vapor Intrusion Pathway, Superfund RCRA and Voluntary Cleanup Section" dated September 2008, unless otherwise noted. Exceptions are for acetone, cis-1,2-DCE, and 1,1,1-Trichloroethane, which required updating based on the Intrusion Screening Values (ISVs) released by MPCA in February 2009.
- = No Limit established
DW = Drinking Water. Note the value for TPH represents a HBV - Health Based Values derived by Minnesota Department of Health in 1999 based on using pyrene as a surrogate chemical. HBVs developed in various years from 1995-2006 are taken from a March 5, 2007, table from MDH. These values are no longer supported by MDH, however these values are kept in this table for screening purposes.
CS = Chronic Standard
FAV = Final Acute Value
Max Conc. = Maximum concentration of analyte detected in dataset. For analytes not detected, the value represents the highest reporting limit
MS = Maximum Standard
µg/l = micrograms per liter
mg/l = milligrams per liter
ID= Identification
QC= Quality Control
J = Estimated concentration
DUP = Duplicate
NA = not applicable
^ = Federal MCL under Safe Drinking Water Act (40 CFR Part 141).
# = State of Minnesota HRL, established in Minnesota Rules Chapter 4717.
* = State of Minnesota Specific Standards of Quality and Purity for Class 1B and 2A waters of the State.
† = For a pollutant with asterisks next to the final acute value (FAV) and the maximum standard (MS), the following applies:
For carcinogenic or highly bioaccumulative chemicals with BCF's greater than 5000 or log Kow values greater than 5.19, the human health chronic standard may be two or more orders smaller than the acute toxicity based MS.
For the MS: if the ratio of MS to the CS is greater than 100, the CS times 100 should be substituted for the applicable MS.
For the FAV: if the ratio of FAV to the CS is greater than 200, the CS times 200 should be substituted for the applicable FAV.
From Minn. R. 7050.0222, subp. 7, item E.

TMZ/TWK/ATF
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TABLE 1
VAS, TEMPORARY WELLS, AND PUSHPOINT
GROUNDWATER ANALYTICAL RESULTS - VOCS/TPH-DRO
148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
AUGUST 2008, MAY 2009, AND SEPTEMBER 2009

Date Collected						Tier 2 Surface Water Quality Standards				**5/5/2009**	**5/5/2009**	**9/16/2009**	**9/16/2009**	**9/16/2009**	**9/17/2009**	**9/17/2009**	**11/9/2009**	**11/9/2009**
Sample ID						1B	2A	2A	2A	**021-SB06**	**021-SB07**	**021-PP01**	**021-PP02**	**021-PP03**	**021-PP04**	**021-PP05**	**021-PP06**	**021-PP07**
		Max Conc.	MCL^	HRL#	GW_{isv}	DW*	CS*	MS*	FAV*									
Volatile Organic Compounds																		
1,1,1-Trichloroethane	µg/l	1.4	200	9,000	10000	200	329	2,957	5,913	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,1-Dichloroethylene	µg/l	1.0	7	200	300	7	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2,4-Trimethylbenzene	µg/l	6.4	-	-	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2-Dichlorobenzene	µg/l	7.2	-	600	7000	600	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,3,5-Trimethylbenzene	µg/l	3.6	-	100	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,4-Dichlorobenzene	µg/l	4.3	-	10	2000	75	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Acetone	µg/l	29.0	-	700	40000000	-	-	-	-	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0
Benzene	µg/l	1.0	5	2	40	5	9.7	4,487†	8,974†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Chlorobenzene	µg/l	**32.0**	100	100	800	100	20	423	846	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
cis-1,2-Dichloroethene	µg/l	14.0	70	50	NA	70	-	-	-	< 1.0	< 1.0	**1.6**	**1.4**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Dichlorodifluoromethane	µg/l	2.0	-	700	70	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Dichlorofluoromethane	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethyl ether	µg/l	6.8	-	1,000	-	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Ethylbenzene	µg/l	7.7	700	700	7000	700	68	1,859	3,717	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Isopropylbenzene	µg/l	1.7	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
m&p-Xylenes	µg/l	2.1	-	-	800	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Methylene chloride	µg/l	1.6	-	5	400	5	45	13,875†	27,749†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Naphthalene	µg/l	2.0	-	300	1000	-	81	409	818	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
n-Propylbenzene	µg/l	2.7	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-Xylene	µg/l	2.9	-	-	1000	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p-Isopropyltoluene	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
sec-Butylbenzene	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
tert-Butylbenzene	µg/l	1.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Tetrahydrofuran	µg/l	200.0	-	-	-	-	-	-	-	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	**200**	< 5.0	< 5.0	< 5.0
trans-1,2-Dichloroethene	µg/l	1.0	100	100	300	100	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Trichloroethene	µg/l	**88.0**	5	5	20	5	25	6,988†	13,976†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Vinyl Chloride	µg/l	**9.2**	2	0.2	1	2	0.17	†	†	< 1.0	< 1.0	< 1.0	**9.2**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Xylenes (total)	µg/l	5.0	10,000	10,000	-	10,000	166	1,407	2,814	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0
TPH-DRO	mg/l	**0.5**	-	-	-	0.2	-	-	-	< 0.09	< 0.09	NA	NA	NA	NA	NA	NA	NA

Push points within wetland but not located adjacent to Miller Creek.

Closest push points to Miller Creek

Notes:
Only detected compounds are shown
Analytical data in bold text denotes sample detections above the MDL
Analytical data outlined denotes sample detections above HRL, DW, or CS; analytical results highlighted in yellow denotes detections above (
TPH-DRO = total petroleum hydrocarbons-diesel range organics
MCL = Maximum Contaminant Level
HRL = Minnesota Health Risk Limit
GW_{isv} = Groundwater Screening Values for Vapor Intrusion Pathway as provided in the MPCA document c-s4-06, "Risk-based Guidance for the Vapor Intrusion Pathway, Superfund RCRA and Voluntary Cleanup Section" dated September 2008, unless otherwise noted. Exceptions are for acetone, cis-1,2-DCE, and 1,1,1-Trichloroethane, which required updating based on the Intrusion Screening Values (ISVs) released by MPCA in February 2009.
- = No Limit established
DW = Drinking Water. Note the value for TPH represents a HBV - Health Based Values derived by Minnesota Department of Health in 1999 based on using pyrene as a surrogate chemical. HBVs developed in various years from 1995-2006 are taken from a March 5, 2007, table from MDH. These values are no longer supported by MDH, however these values are kept in this table for screening purposes.
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ID= Identification
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DUP = Duplicate
NA = not applicable
^ = Federal MCL under Safe Drinking Water Act (40 CFR Part 141).
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For the MS: if the ratio of MS to the CS is greater than 100, the CS times 100 should be substituted for the applicable MS.
For the FAV: if the ratio of FAV to the CS is greater than 200, the CS times 200 should be substituted for the applicable FAV.
From Minn. R. 7050.0222, subp. 7, item E.

TABLE 2
MONITORING WELL
GROUNDWATER ANALYTICAL RESULTS - VOCS/TPH-DRO
148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
AUGUST 2008, MAY 2009, AND SEPTEMBER 2009

Date Collected						Tier 2 Surface Water Quality Standards				**8/5/2008**	**8/5/2008**	**9/16/2009**	**5/5/2009**	**9/14/2009**	**5/4/2009**	**5/4/2009**	**9/14/2009**	**8/5/2008**	**5/6/2009**
Sample ID						1B	2A	2A	2A	**021-014MW**	**021-014MW DUP**	**021-014MW**	**021-026MW**	**021-026MW**	**021-027MW**	**021-027MW DUP**	**021-027MW**	**021-029MW**	**021-029MW**
		Max Conc.	MCL^	HRL#	GW_{isv}	DW	CS	MS	FAV*										
Volatile Organic Compounds																			
1,1,1-Trichloroethane	µg/l	1.4	200	9,000	10000	200	329	2,957	5,913	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,1-Dichloroethylene	µg/l	1.8	7	200	300	7	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2,4-Trimethylbenzene	µg/l	**79**	-	-	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**26.0**	**69.0**
1,2-Dichlorobenzene	µg/l	1.0	-	600	7000	600	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,3,5-Trimethylbenzene	µg/l	29.0	-	100	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**16.0**	**24.0**
1,4-Dichlorobenzene	µg/l	1.0	-	10	2000	75	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Acetone	µg/l	20.0	-	700	40000000	-	-	-	-	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0
Benzene	µg/l	**140**	5	2	40	5	9.7	4,487†	8,974†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**21.0**	**67.0**
Chlorobenzene	µg/l	1.6	100	100	800	100	20	423	846	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
cis-1,2-Dichloroethene	µg/l	11.0	70	50	NA	70	-	-	-	**2.9**	**2.9**	**2.2**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Dichlorodifluoromethane	µg/l	2.4	-	700	70	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Dichlorofluoromethane	µg/l	4.2	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**1.1**	**1.1**	**4.2**	< 1.0	< 1.0
Ethyl ether	µg/l	2.0	-	1,000	-	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Ethylbenzene	µg/l	54.0	700	700	7000	700	68	1,859	3,717	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**15.0**	**48.0**
Isopropylbenzene	µg/l	13.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**8.5**	**13.0**
m&p-Xylenes	µg/l	190.0	-	-	800	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	**24.0**	**100.0**
Methylene chloride	µg/l	1.0	-	5	400	5	45	13,875†	27,749†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Naphthalene	µg/l	3.0	-	300	1000	-	81	409	818	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	**2.4**
n-Propylbenzene	µg/l	14.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**9.7**	**14.0**
o-Xylene	µg/l	1.0	-	-	1000	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p-Isopropyltoluene	µg/l	2.9	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**1.3**	**2.8**
sec-Butylbenzene	µg/l	2.8	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**2.4**	**2.8**
tert-Butylbenzene	µg/l	1.3	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**1.0**
Tetrahydrofuran	µg/l	29.0	-	-	-	-	-	-	-	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	**18.0**	**5.1**
trans-1,2-Dichloroethene	µg/l	1.2	100	100	300	100	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Trichloroethene	µg/l	**79**	5	5	20	5	25	6,988†	13,976†	**36**	**35**	**24**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Vinyl Chloride	µg/l	**4.0**	2	0.2	1	2	0.17	†	†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Xylenes (total)	µg/l	190.0	10,000	10,000	-	10,000	166	1,407	2,814	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	**25.0**	**101.5**
TPH-DRO	mg/l	0.1	-	-	-	0.2	-	-	-	< 0.1	NA	NA	< 0.1	NA	< 0.1	< 0.1	NA	NA	NA

Notes:
Only detected compounds are shown
Analytical data in bold text denotes sample detections above the MDL
Analytical data outlined denotes sample detections above HRL, DW or CS; analytical results highlighted in yellow denotes detections above GWisv.
TPH-DRO = total petroleum hydrocarbons-diesel range organics
MCL = Maximum Contaminant Level
HRL = Minnesota Health Risk Limit
GW_{isv} = Groundwater Screening Values for Vapor Intrusion Pathway as provided in the MPCA document c-s4-06, "Risk-based Guidance for the Vapor Intrusion Pathway, Superfund RCRA and Voluntary Cleanup Section" dated September 2008, unless otherwise noted. Exceptions are for acetone, cis-1,2-DCE, and 1,1,1-Trichloroethane, which required updating based on the Intrusion Screening Values (ISVs) released by MPCA in February 2009.
- = No Limit established

DW = Drinking Water. Note the value for TPH represents a HBV - Health Based Values derived by Minnesota Department of Health in 1999 based on using pyrene as a surrogate chemical. HBVs developed in various years from 1995-2006 are taken from a March 5, 2007, table from MDH. These values are no longer supported by MDH, however these values are kept in this table for screening purposes.
CS = Chronic Standard
FAV = Final Acute Value
Max Conc. = Maximum concentration of analyte detected in dataset. For analytes not detected, the value represents the highest reporting limit.
MS = Maximum Standard
µg/l = micrograms per liter
mg/l = milligrams per liter
ID= Identification
QC= Quality Control
J = Estimated concentration
DUP = Duplicate
NA = not applicable
^ = Federal MCL under Safe Drinking Water Act (40 CFR Part 141).
# = State of Minnesota HRL, established in Minnesota Rules Chapter 4717.
* = State of Minnesota Specific Standards of Quality and Purity for Class 2B waters of the State.
† = For a pollutant with asterisks next to the final acute value (FAV) and the maximum standard (MS), the following applies:
For carcinogenic or highly bioaccumulative chemicals with BCF's greater than 5000 or log Kow values greater than 5.19, the human health chronic standard may be two or more orders smaller than the acute toxicity based MS.
For the MS: if the ratio of MS to the CS is greater than 100, the CS times 100 should be substituted for the applicable MS.
For the FAV: if the ratio of FAV to the CS is greater than 200, the CS times 200 should be substituted for the applicable FAV.
From Minn. R. 7050.0222, subp. 7, item E.

TABLE 2
MONITORING WELL
GROUNDWATER ANALYTICAL RESULTS - VOCS/TPH-DRO
148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
AUGUST 2008, MAY 2009, AND SEPTEMBER 2009

Date Collected						Tier 2 Surface Water Quality Standards				**9/15/2009**	**5/6/2009**	**5/6/2009**	**9/14/2009**	**5/5/2009**	**9/14/2009**	**5/5/2009**	**9/15/2009**	**5/6/2009**	**9/15/2009**	**5/6/2009**	**9/15/2009**
Sample ID		Max Conc.	MCL^	HRL#	GW_{isv}	1B DW	2A CS	2A MS	2A FAV*	**021-029MW**	**021-030MW**	**021-030MW DUP**	**021-030MW**	**021-031MW**	**021-031MW**	**021-032MW**	**021-032MW**	**021-033MW**	**021-033MW**	**021-034MW**	**021-034MW**
Volatile Organic Compounds																					
1,1,1-Trichloroethane	µg/l	1.4	200	9,000	10000	200	329	2,957	5,913	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**1.4**	**1.4**
1,1-Dichloroethylene	µg/l	1.8	7	200	300	7	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**1.8**	**1.3**	< 1.0	< 1.0
1,2,4-Trimethylbenzene	µg/l	**79**	-	-	70	-	-	-	-	**79.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2-Dichlorobenzene	µg/l	1.0	-	600	7000	600	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,3,5-Trimethylbenzene	µg/l	29.0	-	100	70	-	-	-	-	**29.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,4-Dichlorobenzene	µg/l	1.0	-	10	2000	75	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Acetone	µg/l	20.0	-	700	40000000	-	-	-	-	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0
Benzene	µg/l	**140**	5	2	40	5	9.7	4,487†	8,974†	**140.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Chlorobenzene	µg/l	1.6	100	100	800	100	20	423	846	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**1.6**	< 1.0	< 1.0
cis-1,2-Dichloroethene	µg/l	11.0	70	50	NA	70	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	**9.3**	**11.0**	**4.8**	**4.3**	**8.2**	**5.7**	< 1.0	< 1.0
Dichlorodifluoromethane	µg/l	2.4	-	700	70	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	**3.4 J**	< 2.0	< 2.0
Dichlorofluoromethane	µg/l	4.2	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethyl ether	µg/l	2.0	-	1,000	-	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Ethylbenzene	µg/l	54.0	700	700	7000	700	68	1,859	3,717	**54.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Isopropylbenzene	µg/l	13.0	-	-	-	-	-	-	-	**12.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
m&p-Xylenes	µg/l	190.0	-	-	800	-	-	-	-	**190.0**	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Methylene chloride	µg/l	1.0	-	5	400	5	45	13,875†	27,749†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Naphthalene	µg/l	3.0	-	300	1000	-	81	409	818	**3.0**	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
n-Propylbenzene	µg/l	14.0	-	-	-	-	-	-	-	**13.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-Xylene	µg/l	1.0	-	-	1000	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p-Isopropyltoluene	µg/l	2.9	-	-	-	-	-	-	-	**2.9**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
sec-Butylbenzene	µg/l	2.8	-	-	-	-	-	-	-	**2.8**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
tert-Butylbenzene	µg/l	1.3	-	-	-	-	-	-	-	**1.3**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Tetrahydrofuran	µg/l	29.0	-	-	-	-	-	-	-	**5.1**	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
trans-1,2-Dichloroethene	µg/l	1.2	100	100	300	100	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**1.2**	< 1.0	< 1.0
Trichloroethene	µg/l	**79**	5	5	20	5	25	6,988†	13,976†	**1.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**14**	**31**	**36**	**27**	< 1.0	< 1.0
Vinyl Chloride	µg/l	**4.0**	2	0.2	1	2	0.17	†	†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	**2.9**	**4.0**	< 1.0	< 1.0
Xylenes (total)	µg/l	190.0	10,000	10,000	-	10,000	166	1,407	2,814	**190.0**	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0
TPH-DRO	mg/l	0.1	-	-	-	0.2	-	-	-	NA	NA	NA	NA	< 0.09	NA	NA	NA	NA	NA	NA	NA

Notes:
Only detected compounds are shown
Analytical data in bold text denotes sample detections above the MDL
Analytical data outlined denotes sample detections above HRL, DW or CS; analytical results highlighted in yellow denotes detections above GWisv.
TPH-DRO = total petroleum hydrocarbons-diesel range organics
MCL = Maximum Contaminant Level
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FAV = Final Acute Value
Max Conc. = Maximum concentration of analyte detected in dataset. For analytes not detected, the value represents the highest reporting limit.
MS = Maximum Standard
µg/l = micrograms per liter
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ID= Identification
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NA = not applicable
^ = Federal MCL under Safe Drinking Water Act (40 CFR Part 141).
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* = State of Minnesota Specific Standards of Quality and Purity for Class 2B waters of the State.
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For carcinogenic or highly bioaccumulative chemicals with BCF's greater than 5000 or log Kow values greater than 5.19, the human health chronic standard may be two or more orders smaller than the acute toxicity based MS.
For the MS: if the ratio of MS to the CS is greater than 100, the CS times 100 should be substituted for the applicable MS.
For the FAV: if the ratio of FAV to the CS is greater than 200, the CS times 200 should be substituted for the applicable FAV.
From Minn. R. 7050.0222, subp. 7, item E.

TABLE 2
MONITORING WELL
GROUNDWATER ANALYTICAL RESULTS - VOCS/TPH-DRO
148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
AUGUST 2008, MAY 2009, AND SEPTEMBER 2009

Date Collected						Tier 2 Surface Water Quality Standards				**5/6/2009**	**9/15/2009**	**9/15/2009**	**5/5/2009**	**9/16/2009**	**9/16/2009**	**5/4/2009**	**9/15/2009**	**5/4/2009**
Sample ID						1B	2A	2A	2A	**021-035MW**	**021-035MW**	**021-035MW DUP**	**021-036MW**	**021-036MW**	**021-036MW DUP**	**021-038MW**	**021-038MW**	**021-039MW**
		Max Conc.	MCL^	HRL#	GW_{isv}	DW	CS	MS	FAV*									
Volatile Organic Compounds																		
1,1,1-Trichloroethane	µg/l	1.4	200	9,000	10000	200	329	2,957	5,913	< 1.0	< 1.0	< 1.0	< 1.0	**1.1**	**1.1**	< 1.0	< 1.0	< 1.0
1,1-Dichloroethylene	µg/l	1.8	7	200	300	7	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2,4-Trimethylbenzene	µg/l	**79**	-	-	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2-Dichlorobenzene	µg/l	1.0	-	600	7000	600	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,3,5-Trimethylbenzene	µg/l	29.0	-	100	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,4-Dichlorobenzene	µg/l	1.0	-	10	2000	75	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Acetone	µg/l	20.0	-	700	40000000	-	-	-	-	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0
Benzene	µg/l	**140**	5	2	40	5	9.7	4,487†	8,974†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Chlorobenzene	µg/l	1.6	100	100	800	100	20	423	846	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
cis-1,2-Dichloroethene	µg/l	11.0	70	50	NA	70	-	-	-	< 1.0	< 1.0	< 1.0	**3.7**	**4.4**	**4.4**	**8.8**	**8.7**	< 1.0
Dichlorodifluoromethane	µg/l	2.4	-	700	70	-	-	-	-	**2.4**	**2.5 J**	**2.6 J**	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Dichlorofluoromethane	µg/l	4.2	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethyl ether	µg/l	2.0	-	1,000	-	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Ethylbenzene	µg/l	54.0	700	700	7000	700	68	1,859	3,717	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Isopropylbenzene	µg/l	13.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
m&p-Xylenes	µg/l	190.0	-	-	800	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Methylene chloride	µg/l	1.0	-	5	400	5	45	13,875†	27,749†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Naphthalene	µg/l	3.0	-	300	1000	-	81	409	818	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
n-Propylbenzene	µg/l	14.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-Xylene	µg/l	1.0	-	-	1000	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p-Isopropyltoluene	µg/l	2.9	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
sec-Butylbenzene	µg/l	2.8	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
tert-Butylbenzene	µg/l	1.3	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Tetrahydrofuran	µg/l	29.0	-	-	-	-	-	-	-	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
trans-1,2-Dichloroethene	µg/l	1.2	100	100	300	100	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Trichloroethene	µg/l	**79**	5	5	20	5	25	6,988†	13,976†	**1.3**	**1.4**	**1.5**	**66**	**78**	**79**	**11**	**14**	< 1.0
Vinyl Chloride	µg/l	**4.0**	2	0.2	1	2	0.17	†	†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Xylenes (total)	µg/l	190.0	10,000	10,000	-	10,000	166	1,407	2,814	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0
TPH-DRO	mg/l	0.1	-	-	-	0.2	-	-	-	NA	NA	NA	< 0.09	NA	NA	< 0.09	NA	NA

Notes:
Only detected compounds are shown
Analytical data in bold text denotes sample detections above the MDL
Analytical data outlined denotes sample detections above HRL, DW or CS; analytical results highlighted in yellow denotes detections above GWisv.
TPH-DRO = total petroleum hydrocarbons-diesel range organics
MCL = Maximum Contaminant Level
HRL = Minnesota Health Risk Limit
GW_{isv} = Groundwater Screening Values for Vapor Intrusion Pathway as provided in the MPCA document c-s4-06, "Risk-based Guidance for the Vapor Intrusion Pathway, Superfund RCRA and Voluntary Cleanup Section" dated September 2008, unless otherwise noted. Exceptions are for acetone, cis-1,2-DCE, and 1,1,1-Trichloroethane, which required updating based on the Intrusion Screening Values (ISVs) released by MPCA in February 2009.
- = No Limit established

DW = Drinking Water. Note the value for TPH represents a HBV - Health Based Values derived by Minnesota Department of Health in 1999 based on using pyrene as a surrogate chemical. HBVs developed in various years from 1995-2006 are taken from a March 5, 2007, table from MDH. These values are no longer supported by MDH, however these values are kept in this table for screening purposes.
CS = Chronic Standard
FAV = Final Acute Value
Max Conc. = Maximum concentration of analyte detected in dataset. For analytes not detected, the value represents the highest reporting limit.
MS = Maximum Standard
µg/l = micrograms per liter
mg/l = milligrams per liter
ID= Identification
QC= Quality Control
J = Estimated concentration
DUP = Duplicate
NA = not applicable
^ = Federal MCL under Safe Drinking Water Act (40 CFR Part 141).
# = State of Minnesota HRL, established in Minnesota Rules Chapter 4717.
* = State of Minnesota Specific Standards of Quality and Purity for Class 2B waters of the State.
† = For a pollutant with asterisks next to the final acute value (FAV) and the maximum standard (MS), the following applies:
For carcinogenic or highly bioaccumulative chemicals with BCF's greater than 5000 or log Kow values greater than 5.19, the human health chronic standard may be two or more orders smaller than the acute toxicity based MS.
For the MS: if the ratio of MS to the CS is greater than 100, the CS times 100 should be substituted for the applicable MS.
For the FAV: if the ratio of FAV to the CS is greater than 200, the CS times 200 should be substituted for the applicable FAV.
From Minn. R. 7050.0222, subp. 7, item E.

TABLE 2
MONITORING WELL
GROUNDWATER ANALYTICAL RESULTS - VOCS/TPH-DRO
148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
AUGUST 2008, MAY 2009, AND SEPTEMBER 2009

Date Collected						Tier 2 Surface Water Quality Standards				**9/14/2009**	**9/17/2009**	**9/18/2009**	**9/18/2009**	**9/18/2009**	**9/18/2009**
Sample ID						1B	2A	2A	2A	**021-039MW**	**021-040MW**	**021-041MW**	**021-042MW**	**021-043MW**	**021-044MW**
		Max Conc.	MCL^	HRL#	GW$_{isv}$	DW	CS	MS	FAV*						
Volatile Organic Compounds															
1,1,1-Trichloroethane	µg/l	1.4	200	9,000	10000	200	329	2,957	5,913	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,1-Dichloroethylene	µg/l	1.8	7	200	300	7	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2,4-Trimethylbenzene	µg/l	**79**	-	-	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2-Dichlorobenzene	µg/l	1.0	-	600	7000	600	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,3,5-Trimethylbenzene	µg/l	29.0	-	100	70	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,4-Dichlorobenzene	µg/l	1.0	-	10	2000	75	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Acetone	µg/l	20.0	-	700	40000000	-	-	-	-	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0
Benzene	µg/l	**140**	5	2	40	5	9.7	4,487†	8,974†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Chlorobenzene	µg/l	1.6	100	100	800	100	20	423	846	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
cis-1,2-Dichloroethene	µg/l	11.0	70	50	NA	70	-	-	-	< 1.0	**3**	**1.4**	**2.2**	< 1.0	**5.2**
Dichlorodifluoromethane	µg/l	2.4	-	700	70	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Dichlorofluoromethane	µg/l	4.2	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethyl ether	µg/l	2.0	-	1,000	-	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Ethylbenzene	µg/l	54.0	700	700	7000	700	68	1,859	3,717	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Isopropylbenzene	µg/l	13.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
m&p-Xylenes	µg/l	190.0	-	-	800	-	-	-	-	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Methylene chloride	µg/l	1.0	-	5	400	5	45	13,875†	27,749†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Naphthalene	µg/l	3.0	-	300	1000	-	81	409	818	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
n-Propylbenzene	µg/l	14.0	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-Xylene	µg/l	1.0	-	-	1000	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p-Isopropyltoluene	µg/l	2.9	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
sec-Butylbenzene	µg/l	2.8	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
tert-Butylbenzene	µg/l	1.3	-	-	-	-	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Tetrahydrofuran	µg/l	29.0	-	-	-	-	-	-	-	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	**29.0**
trans-1,2-Dichloroethene	µg/l	1.2	100	100	300	100	-	-	-	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Trichloroethene	µg/l	**79**	5	5	20	5	25	6,988†	13,976†	< 1.0	**46**	**5**	**28**	< 1.0	**9.1**
Vinyl Chloride	µg/l	**4.0**	2	0.2	1	2	0.17	†	†	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Xylenes (total)	µg/l	190.0	10,000	10,000	-	10,000	166	1,407	2,814	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0
TPH-DRO	mg/l	0.1	-	-	-	0.2	-	-	-	NA	NA	NA	NA	NA	NA

Notes:
Only detected compounds are shown
Analytical data in bold text denotes sample detections above the MDL
Analytical data outlined denotes sample detections above HRL, DW or CS; analytical results highlighted in yellow denotes detections above GWisv.
TPH-DRO = total petroleum hydrocarbons-diesel range organics
MCL = Maximum Contaminant Level
HRL = Minnesota Health Risk Limit
GW$_{isv}$ = Groundwater Screening Values for Vapor Intrusion Pathway as provided in the MPCA document c-s4-06, "Risk-based Guidance for the Vapor Intrusion Pathway, Superfund RCRA and Voluntary Cleanup Section" dated September 2008, unless otherwise noted. Exceptions are for acetone, cis-1,2-DCE, and 1,1,1-Trichloroethane, which required updating based on the Intrusion Screening Values (ISVs) released by MPCA in February 2009.
- = No Limit established

DW = Drinking Water. Note the value for TPH represents a HBV - Health Based Values derived by Minnesota Department of Health in 1999 based on using pyrene as a surrogate chemical. HBVs developed in various years from 1995-2006 are taken from a March 5, 2007, table from MDH. These values are no longer supported by MDH, however these values are kept in this table for screening purposes.
CS = Chronic Standard
FAV = Final Acute Value
Max Conc. = Maximum concentration of analyte detected in dataset. For analytes not detected, the value represents the highest reporting limit.
MS = Maximum Standard
µg/l = micrograms per liter
mg/l = milligrams per liter
ID= Identification
QC= Quality Control
J = Estimated concentration
DUP = Duplicate
NA = not applicable
^ = Federal MCL under Safe Drinking Water Act (40 CFR Part 141).
# = State of Minnesota HRL, established in Minnesota Rules Chapter 4717.
* = State of Minnesota Specific Standards of Quality and Purity for Class 2B waters of the State.
† = For a pollutant with asterisks next to the final acute value (FAV) and the maximum standard (MS), the following applies:
For carcinogenic or highly bioaccumulative chemicals with BCF's greater than 5000 or log Kow values greater than 5.19, the human health chronic standard may be two or more orders smaller than the acute toxicity based MS.
For the MS: if the ratio of MS to the CS is greater than 100, the CS times 100 should be substituted for the applicable MS.
For the FAV: if the ratio of FAV to the CS is greater than 200, the CS times 200 should be substituted for the applicable FAV.
From Minn. R. 7050.0222, subp. 7, item E.

TABLE 3
MONITORING WELL
GROUNDWATER ANALYTICAL RESULTS - METALS
148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
SEPTEMBER 2009

Date Collected						Tier 2 Surface Water Quality Standards				9/16/2009	9/14/2009	9/14/2009	9/15/2009	9/16/2009	9/16/2009	9/15/2009	9/14/2009	9/17/2009	9/18/2009	9/18/2009	9/18/2009	9/18/2009
Sample ID						1B	2A	2A	2A	021-014MW	021-027MW	021-031MW	021-032MW	021-036MW	021-036MW DUP	021-038MW	021-039MW	021-040MW	021-041MW	021-042MW	021-043MW	021-044MW
		Max Conc.	MCL^	HRL#	GW_{isv}	DW	CS	MS	FAV*													
Total Metals																						
Calcium	mg/L	129	-	-	-	-	-	-	-	89.6	126	118	11.2	117	115	121	65.1	115	104	105	100	129
Iron	µg/L	6890	-	-	-	300	-	-	-	86.8	6890	449	1360	56.4	< 50	4140	612	143	785	608	105	678
Magnesium	mg/L	43.1	-	-	-	-	-	-	-	23.3	28.4	39.1	3.94	39.2	39.6	41.9	19.5	37.6	36.5	33.4	39.2	43.1
Manganese	µg/L	825	-	-	-	300	-	-	-	598	825	741	380	648	556	702	44.1	327	489	102	571	726
Potassium	mg/L	4.4	-	-	-	-	-	-	-	4.26	4.33	3.32	3.5	2.3	2.31	3.03	1.31	2.16	3.05	1.91	4.38	3.96
Sodium	mg/L	390	-	-	-	-	-	-	-	24.3	50	34.6	390	15.7	15.8	17.8	5.99	13.4	17.8	15.2	26.2	29.0
Dissolved Metals																						
Calcium	mg/L	127	-	-	-	-	-	-	-	85.8	127	115	10.4	110	108	111	61.4	108	97.6	111	93.8	125
Iron	µg/L	6020	-	-	-	300	-	-	-	< 50	6020	64.8	< 50	< 50	< 50	110	< 50	< 50	< 50	< 50	< 50	279
Magnesium	mg/L	39.7	-	-	-	-	-	-	-	21.9	27.8	37.7	3.19	36.5	36.5	37	18	34.8	33.6	31	35.9	39.7
Manganese	µg/L	790	-	-	-	300	-	-	-	270	790	501	297	393	395	452	30.5	296	436	81.3	529	676
Potassium	mg/L	4.1	-	-	-	-	-	-	-	4.04	3.99	3.37	3.28	2.14	2.13	2.17	1.12	2.02	2.66	1.74	4.08	3.69
Sodium	mg/L	377	-	-	-	-	-	-	-	23.2	51.4	33.2	377	15.1	15	16.1	5.54	12.6	16.9	14.5	24.8	27.1

Notes:
(s) = Secondary Standard - Safe Drinking Water Regulations
Analytical data in bold text denotes sample detections above the MDL
Analytical data outlined denotes sample detections above the HRL or DW.
MCL = Maximum Contaminant Level
HRL = Minnesota Health Risk Limit
GW_{isv} = Groundwater Screening Values for Vapor Intrusion Pathway as provided in the MPCA document c-s4-06, "Risk-based Guidance for the Vapor Intrusion Pathway, Superfund RCRA and Voluntary Cleanup Section" dated September 2008, unless otherwise noted. Exceptions are for acetone, cis-1,2-DCE, and 1,1,1-Trichloroethane, which required updating based on the Intrusion Screening Values (ISVs) released by MPCA in February 2009.
- = No Limit established

DW = Drinking Water; Note the DW for iron represent a SDWR - Secondary Drinking Water Regulations, which are non-enforceable Federal guidelines. The DW value for manganese is a RAA (Risk Assessment Advice), which is developed when available toxicity data do not meet the requirements necessary for development of an HBV or it is not a priority contaminant. RAA typically contains greater uncertainty.
CS = Chronic Standard
FAV = Final Acute Value
Max Conc. = Maximum concentration of analyte detected in dataset. For analytes not detected, the value represents the highest reporting limit.
MS = Maximum Standard
µg/l = micrograms per liter
mg/l = milligrams per liter
ID= Identification
QC= Quality Control
J = Estimated concentration
DUP = Duplicate
NA = not applicable
^ = Federal MCL under Safe Drinking Water Act (40 CFR Part 141).
# = State of Minnesota HRL, established in Minnesota Rules Chapter 4717.
* = State of Minnesota Specific Standards of Quality and Purity for Class 2B waters of the State.

TABLE 4
MONITORING WELL
GROUNDWATER ANALYTICAL RESULTS - MNA
148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
SEPTEMBER 2009

Date Collected / Sample ID		Max Conc.	MCL[^]	HRL[#]	GW_{isv}	Tier 2 Surface Water Quality Standards 1B DW	2A CS	2A MS	2A FAV
Alkalinity, Total	mg/L as $CaCO_3$	437	-	-	-	-	-	-	-
Chloride	mg/L	196	-	-	-	250 (s)	230	860	1,720
Ethane	µg/L	30	-	-	-	-	-	-	-
Ethylene	µg/L	30	-	-	-	-	-	-	-
Methane	µg/L	2600	-	-	-	-	-	-	-
Nitrogen, Nitrate	mg/L as N	1	10	10	-	10	-	-	-
Nitrogen, Nitrite	mg/L as N	0.20	1	-	-	1	-	-	-
Phosphorous, Total	mg/L as P	0.28	-	-	-	-	-	-	-
Total Dissolved Soils (TDS)	mg/L	853	-	-	-	500 (s)	-	-	-
Total Organic Carbon	mg/L	10	-	-	-	-	-	-	-
Silicon	mg/L	19	-	-	-	-	-	-	-
Sulfate	mg/L	31	-	-	-	250 (s)	-	-	-
Sulfide	mg/L	1	-	-	-	-	-	-	-
Dissolved Oxygen	mg/L	4	-	-	-	-	-	-	-
Oxidation Reduction Potential	mV	97	-	-	-	-	-	-	-

Date Collected	**9/16/2009**	**9/14/2009**	**9/14/2009**	**9/15/2009**	**9/16/2009**	**9/16/2009**	**9/15/2009**	**9/14/2009**	**9/17/2009**	**9/18/2009**	**9/18/2009**	**9/18/**
Sample ID	**021-014MW**	**021-027MW**	**021-031MW**	**021-032MW**	**021-036MW**	**021-036MW DUP**	**021-038MW**	**021-039MW**	**021-040MW**	**021-041MW**	**021-042MW**	**021-04**
Alkalinity, Total	**243**	**375**	**366**	**437**	**325**	**320**	**331**	**189**	**307**	**296**	**279**	
Chloride	**57.1**	**69.4**	**82.0**	**196**	**65.9**	**66**	**67.7**	**20.0**	**66.8**	**59.1**	**67.7**	
Ethane	< 3	< 30	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	<
Ethylene	< 3	< 30	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	<
Methane	< 3	**2600**	< 3	7	< 3	< 3	< 3	< 3	20	< 3	< 3	<
Nitrogen, Nitrate	0.7	< 0.05	< 0.05	**0.09**	**1.39**	**1.15**	< 0.05	< 0.05	**1.1**	**0.06**	**0.91**	<
Nitrogen, Nitrite	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	<
Phosphorous, Total	< 0.1	0.2	< 0.1	< 0.1	< 0.1	< 0.1	0.28	< 0.1	< 0.1	< 0.1	< 0.1	<
Total Dissolved Soils (TDS)	**390**	**517**	**513**	**853**	**518**	**464**	**469**	**257**	**420**	**430**	**412**	
Total Organic Carbon	**5.1**	**9.3**	**2.5**	**10.4**	**2.4**	**2.3**	**2.1**	**1.4**	**2.9**	**3.1**	**2.6**	
Silicon	**13.2**	**13.9**	**10.0**	**13.9**	**13.2**	**12.9**	**19.2**	**10.3**	**13.2**	**12.0**	**14.1**	
Sulfate	**14.1**	**2.92**	**20.8**	**21.6**	**17.3**	**17.4**	**19**	**14.9**	**17.9**	**19.3**	**17.3**	
Sulfide	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	<
Dissolved Oxygen	**0.13**	**0.12**	**0.15**	**0.12**	**0.13**	**0.13**	**0.11**	**0.18**	**0.13**	**0.14**	**0.13**	
Oxidation Reduction Potential	**97**	**-175**	**-72**	**-7**	**68**	**68**	**-69**	**-62**	**-11**	**-73**	**39**	

Notes:
(s) = Secondary Standard - Safe Drinking Water Regulations
Analytical data in bold text denotes sample detections above the MDL
Analytical data outlined denotes sample detections above HRL
MCL = Maximum Contaminant Level
HRL = Minnesota Health Risk Limit
GW_{isv} = Groundwater Screening Values for Vapor Intrusion Pathway as provided in the MPCA document c-s4-06, "Risk-based Guidance for the Vapor Intrusion Pathway, Superfund RCRA and Voluntary Cleanup Section" dated September 2008, unless otherwise noted. Exceptions are for acetone, cis-1,2-DCE, and 1,1,1-Trichloroethane, which required updating based on the Intrusion Screening Values (ISVs) released by MPCA in February 2009.
\- = No Limit established
DW = Drinking Water
CS = Chronic Standard
FAV = Final Acute Value
Max Conc. = Maximum concentration of analyte detected in dataset. For analytes not detected, the value represents the highest reporting limit.
MS = Maximum Standard
µg/l = micrograms per liter
mg/l = milligrams per liter
mV = millivolts
ID= Identification
QC= Quality Control
J = Estimated concentration
DUP = Duplicate
NA = not applicable
^ = Federal MCL under Safe Drinking Water Act (40 CFR Part 141).
# = State of Minnesota HRL, established in Minnesota Rules Chapter 4717.
* = State of Minnesota Specific Standards of Quality and Purity
Dissolved oxygen and oxidation reduction potential values obtained during September 2009 groundwater sampling event

TABLE 4
MONITORING WELL
GROUNDWATER ANALYTICAL RESULTS - MNA
148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
SEPTEMBER 2009

Date Collected						Tier 2 Surface Water Quality Standards				**2009**	**9/18/2009**
Sample ID						1B	2A	2A	2A	**43MW**	**021-044MW**
		Max Conc.	MCL^	HRL#	GW_{isv}	DW	CS	MS	FAV		
Alkalinity, Total	mg/L as $CaCO_3$	437	-	-	-	-	-	-	-	**294**	**363**
Chloride	mg/L	196	-	-	-	250 (s)	230	860	1,720	**72.2**	**80.0**
Ethane	µg/L	30	-	-	-	-	-	-	-	3	< 30
Ethylene	µg/L	30	-	-	-	-	-	-	-	3	< 30
Methane	µg/L	2600	-	-	-	-	-	-	-	3	**600**
Nitrogen, Nitrate	mg/L as N	1	10	10	-	10	-	-	-	0.05	**0.13**
Nitrogen, Nitrite	mg/L as N	0.20	1	-	-	1	-	-	-	0.2	< 0.2
Phosphorous, Total	mg/L as P	0.28	-	-	-	-	-	-	-	0.1	< 0.1
Total Dissolved Soilds (TDS)	mg/L	853	-	-	-	500 (s)	-	-	-	**440**	**520**
Total Organic Carbon	mg/L	10	-	-	-	-	-	-	-	**4.1**	**5.5**
Silicon	mg/L	19	-	-	-	-	-	-	-	**8.5**	**10.0**
Sulfate	mg/L	31	-	-	-	250 (s)	-	-	-	**20.9**	**31.3**
Sulfide	mg/L	1	-	-	-	-	-	-	-	1	< 1
Dissolved Oxygen	mg/L	4	-	-	-	-	-	-	-	**3.97**	**0.13**
Oxidation Reduction Potential	mV	97	-	-	-	-	-	-	-	**75**	**-96**

Notes:
(s) = Secondary Standard - Safe Drinking Water Regulations
Analytical data in bold text denotes sample detections above the MDL
Analytical data outlined denotes sample detections above HRL
MCL = Maximum Contaminant Level
HRL = Minnesota Health Risk Limit
GW_{isv} = Groundwater Screening Values for Vapor Intrusion Pathway as provided in the MPCA document c-s4-06, "Risk-based Guidance for the Vapor Intrusion Pathway, Superfund RCRA and Voluntary Cleanup Section" dated September 2008, unless otherwise noted. Exceptions are for acetone, cis-1,2-DCE, and 1,1,1-Trichloroethane, which required updating based on the Intrusion Screening Values (ISVs) released by MPCA in February 2009.
- = No Limit established
DW = Drinking Water
CS = Chronic Standard
FAV = Final Acute Value
Max Conc. = Maximum concentration of analyte detected in dataset. For analytes not detected, the value represents the highest reporting limit.
MS = Maximum Standard
µg/l = micrograms per liter
mg/l = milligrams per liter
mV = millivolts
ID= Identification
QC= Quality Control
J = Estimated concentration
DUP = Duplicate
NA = not applicable
^ = Federal MCL under Safe Drinking Water Act (40 CFR Part 141).
# = State of Minnesota HRL, established in Minnesota Rules Chapter 4717.
* = State of Minnesota Specific Standards of Quality and Purity
Dissolved oxygen and oxidation reduction potential values obtained during September 2009 groundwater sampling event

TABLE 5
VAPOR INTRUSION ASSESSMENT - SOIL GAS, SUB-SLAB SOIL GAS, AND AMBIENT AIR MONITORING
148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
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JULY 2010

						Soil Gas Outside of Building 252					Sub-Slab Soil Gas	
Date Collected						**7/13/2010**	**7/13/2010**	**7/13/2010**	**7/13/2010**	**7/13/2010**	**7/13/2010**	**7/13/2010**
Sample ID		**ISV**	**10X ISV**	**100X ISV**	**Acute Screening Value**	**Site 21-SG01**	**Site 21-SG02**	**Site 21-SG03**	**Site 21-SG03 DUP**	**Site 21-SG04**	**Site 21-SS01**	**Site 21-SS02**
Volatile Organic Compounds												
Benzene	μg/m3	4.5	45	450	1000	**5.7**	**1.5 J**	**1.6**	**1.2**	47 U	**0.34 J**	3.9 U
Bromodichloromethane	μg/m3	0.6	6	60	NA	1.3 U	6.7 U	1.3 U	1.3 U	98 U	2 U	8.1 U
Bromoethene (Vinyl Bromide)	μg/m3	5	50	500	2000	0.87 U	4.4 U	0.87 U	0.87 U	64 U	1.3 U	5.3 U
Bromoform	μg/m3	9	90	900	NA	2.1 U	10 U	2.1 U	2.1 U	150 U	3.1 U	13 U
Bromomethane	μg/m3	5	50	500	2000	0.78 U	3.9 U	0.78 U	0.78 U	57 U	1.2 U	4.7 U
1,3-Butadiene	μg/m3	0.3	3	30	NA	**0.54**	2.2 U	**2.7**	**1.5**	32 U	0.66 U	2.7 U
Carbon tetrachloride	μg/m3	0.7	7	70	1900	0.49 J	6.3 U	**0.54 J**	**0.5 J**	92 U	1.9 U	7.6 U
Chloroethane	μg/m3	10000	100000	1000000	100000	1.3 U	**4 J**	1.3 U	1.3 U	97 U	2 U	8 U
Chloroform	μg/m3	100	1000	10000	150	**5.2**	4.9 U	0.98 U	0.98 U	72 U	1.5 U	5.9 U
3-Chloropropene	μg/m3	NL	NL	NL	NL	1.6 U	7.8 U	1.6 U	1.6 U	110 U	2.3 U	9.5 U
Cyclohexane	μg/m3	6000	60000	600000	NA	**0.33 J**	3.4 U	0.98	1.1	51 U	1 U	4.2 U
Dibromochloromethane	μg/m3	0.4	4	40	NA	1.7 U	8.5 U	1.7 U	1.7 U	130 U	2.6 U	10 U
1,2-Dibromoethane (EDB)	μg/m3	0.02	0.2	2	NA	1.5 U	7.7 U	1.5 U	1.5 U	110 U	2.3 U	9.3 U
Dichlorodifluoromethane	μg/m3	200	2000	20000	NA	**2.7 J**	**510 J**	**15 J**	**11 J**	**10000 J**	**150 J**	**950 J**
1,1-Dichloroethane	μg/m3	500	5000	50000	NA	0.81 U	4 U	0.81 U	0.81 U	59 U	1.2 U	4.9 U
1,2-Dichloroethane	μg/m3	0.4	4	40	NA	0.81 U	4 U	0.81 U	0.81 U	59 U	1.2 U	4.9 U
1,1-Dichloroethylene	μg/m3	200	2000	20000	NA	0.79 U	4 U	0.79 U	0.79 U	58 U	1.2 U	4.8 U
1,2-Dichloroethene, Total	μg/m3	200	2000	20000	NA	0.79 U	4 U	0.79 U	0.79 U	58 U	1.2 U	4.8 U
cis-1,2-Dichloroethene	μg/m3	40	400	4000	NA	0.79 U	4 U	0.79 U	0.79 U	58 U	1.2 U	4.8 U
trans-1,2-Dichloroethene	μg/m3	60	600	6000	825	0.79 U	4 U	0.79 U	0.79 U	58 U	1.2 U	4.8 U
1,2-Dichloropropane	μg/m3	4	40	400	235	0.92 U	4.6 U	0.92 U	0.92 U	68 U	1.4 U	5.6 U
cis-1,3-Dichloropropene	μg/m3	3	30	300	NA	0.91 U	4.5 U	0.91 U	0.91 U	67 U	1.4 U	5.5 U
trans-1,3-Dichloropropene	μg/m3	3	30	300	NA	0.91 U	4.5 U	0.91 U	0.91 U	67 U	1.4 U	5.5 U
1,2-Dichlorotetrafluoroethane	μg/m3	NA	NA	NA	NA	1.4 U	7 U	1.4 U	1.4 U	100 U	2.1 U	8.5 U
Ethylbenzene	μg/m3	1000	10000	100000	10000	**7.6**	**77**	**1.3**	**1.5**	**140**	**2.3**	**2.1 J**
4-Ethyltoluene	μg/m3	NA	NA	NA	NA	**4.2**	4.9 U	0.98 U	0.98 U	72 U	1.5 U	6 U
n-Heptane	μg/m3	NA	NA	NA	NA	**1.3**	**3.4 J**	**2.1**	**1.5**	60 U	**0.3 J**	5 U
n-Hexane	μg/m3	2000	20000	200000	NA	**0.97**	**3.8**	**3**	**2**	52 U	**0.33 J**	4.3 U
Methylene chloride	μg/m3	20	200	2000	10000	**0.83 J, B, U**	**2.6 J, B, U**	**1.3 J, B, U**	**1.6 J, B, U**	**41 J, B**	**1 J, B, U**	**3.1 J, B, U**
Methyl-tert-butyl-ether (MTBE)	μg/m3	3000	30000	300000	7300	0.72 U	3.6 U	0.72 U	0.72 U	53 U	1.1 U	4.4 U
Tetrachloroethene	μg/m3	20	200	2000	20000	**0.27 J**	**65**	**0.36 J**	1.4 U	100 U	**2.8**	8.2 U
1,1,2,2-Tetrachloroethane	μg/m3	0.2	2	20	NA	1.4 U	6.9 U	1.4 U	1.4 U	100 U	2.1 U	8.3 U
Toluene	μg/m3	5000	50000	500000	37000	**36**	**26**	**29**	**67**	**50 J**	**12**	**5.2**
Trichloroethene	μg/m3	3	30	300	2000	1.1 U	5.4 U	**0.24 J**	1.1 U	79 U	1.6 U	6.5 U
1,1,1-Trichloroethane	μg/m3	1000	10000	100000	140000	1.1 U	**2.8 J**	1.1 U	1.1 U	80 U	**2.1**	**3 J**
1,1,2-Trichloroethane	μg/m3	0.6	6	60	NA	1.1 U	5.5 U	1.1 U	1.1 U	80 U	1.6 U	6.6 U
Trichlorofluoromethane	μg/m3	700	7000	70000	NA	**1.5**	**200**	**1.7**	**1.6**	180 U	**27**	**15**
1,2,4-Trimethylbenzene	μg/m3	7	70	700	NA	**16.71**	0.98 U	**0.79 J**	**0.84 J**	0.98 U	**0.74 J**	0.98 U
1,3,5-Trimethylbenzene	μg/m3	6	60	600	NA	**4.9**	**1.7 J**	0.98 U	0.98 U	72 U	1.5 U	6 U
2,2,4-Trimethylpentane	μg/m3	NL	NL	NL	NL	**0.74 J**	4.7 U	**2.5**	**0.84 J**	69 U	1.4 U	5.7 U
Vinyl Chloride	μg/m3	1	10	100	180000	0.51 U	2.6 U	0.51 U	0.51 U	38 U	**0.46 J**	3.1 U
m&p-Xylenes	μg/m3	100	1000	10000	43000	**31**	**220**	**3**	**3.1**	**480**	**11**	**7 J**
o-Xylene	μg/m3	100	1000	10000	43000	**8.7**	**36**	**0.92**	**0.92**	**75**	**7.8**	**3.8 J**
Xylenes (total)	μg/m3	100	1000	10000	43000	**40**	**260**	**3.9**	**4**	**560**	**19.0**	**11.0**

Notes:
Detected compounds are shown bold.
ISV - Intrusion Screening Value
10X ISV= ten times the ISV
100X ISV = one hundred times the ISV
μg/m3 = micrograms per liter
B = Compound was found in the blank and sample.
DUP = Duplicate
ID= Identification
J = Result is less than the reporting limit but greater than or equal to the MDL and the concentration is an approximate value.
NA = no toxicity data available
NS = not sampled for
SG = Soil Gas
SS = Sub-Slab Soil Gas
U = Indicates the analyte was analyzed for but not detected.
Intrusion Screening Values obtained from Minnesota Pollution Control Agency (MPCA) Risk-Based Guidance for the Vapor Intrusion Pathway (September 2008)

(blue) analytes detected in groundwater above a groundwater vapor intrusion screening value (i.e., Gwisv)
(green) soil gas or sub-slab soil gas sample is greater than 10X ISV
(yellow) ambient air sample is greater than ISV

TABLE 5
VAPOR INTRUSION ASSESSMENT - SOIL GAS, SUB-SLAB SOIL GAS, AND AMBIENT AIR MONITORING
148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
JULY 2010

						Ambient Air			
Date Collected						**7/13/2010**	**7/13/2010**	**7/13/2010**	**7/13/2010**
Sample ID		**ISV**	**10X ISV**	**100X ISV**	**Acute Screening Value**	**252-Sump**	**252-Background**	**252-Indoor**	**252-Indoor DUP**
Volatile Organic Compounds									
Benzene	$\mu g/m^3$	4.5	45	450	1000	19 U	0.22	**7.4**	**7.9**
Bromodichloromethane	$\mu g/m^3$	0.6	6	60	NA	40 U	0.067 U	1.3 U	1.3 U
Bromoethene (Vinyl Bromide)	$\mu g/m^3$	5	50	500	2000	26 U	0.087 U	0.87 U	0.87 U
Bromoform	$\mu g/m^3$	9	90	900	NA	62 U	0.1 U	2.1 U	2.1 U
Bromomethane	$\mu g/m^3$	5	50	500	2000	23 U	0.078 U	0.78 U	0.78 U
1,3-Butadiene	$\mu g/m^3$	0.3	3	30	NA	13 U	0.044 U	0.44 U	0.44 U
Carbon tetrachloride	$\mu g/m^3$	0.7	7	70	1900	37 U	**0.46**	**0.56 J**	**0.52 J**
Chloroethane	$\mu g/m^3$	10000	100000	1000000	100000	39 U	0.053 U	1.3 U	1.3 U
Chloroform	$\mu g/m^3$	100	1000	10000	150	29 U	**0.071**	0.98 U	0.98 U
3-Chloropropene	$\mu g/m^3$	NL	NL	NL	NL	47 U	0.063 U	1.6 U	1.6 U
Cyclohexane	$\mu g/m^3$	6000	60000	600000	NA	21 U	**0.042**	**1.2**	**1.3**
Dibromochloromethane	$\mu g/m^3$	0.4	4	40	NA	51 U	0.085 U	1.7 U	1.7 U
1,2-Dibromoethane (EDB)	$\mu g/m^3$	0.02	0.2	2	NA	46 U	0.077 U	1.5 U	1.5 U
Dichlorodifluoromethane	$\mu g/m^3$	200	2000	20000	NA	**4700 J**	**1.3**	**6.7 J**	**6.7** J
1,1-Dichloroethane	$\mu g/m^3$	500	5000	50000	NA	24 U	0.04 U	0.81 U	0.81 U
1,2-Dichloroethane	$\mu g/m^3$	0.4	4	40	NA	24 U	0.081 U	0.81 U	0.81 U
1,1-Dichloroethylene	$\mu g/m^3$	200	2000	20000	NA	24 U	0.04 U	0.79 U	0.79 U
1,2-Dichloroethene, Total	$\mu g/m^3$	200	2000	20000	NA	24 U	0.04 U	0.79 U	0.79 U
cis-1,2-Dichloroethene	$\mu g/m^3$	40	400	4000	NA	24 U	0.04 U	0.79 U	0.79 U
trans-1,2-Dichloroethene	$\mu g/m^3$	60	600	6000	825	24 U	0.04 U	0.79 U	0.79 U
1,2-Dichloropropane	$\mu g/m^3$	4	40	400	235	28 U	0.092 U	0.92 U	0.92 U
cis-1,3-Dichloropropene	$\mu g/m^3$	3	30	300	NA	27 U	0.045 U	0.91 U	0.91 U
trans-1,3-Dichloropropene	$\mu g/m^3$	3	30	300	NA	27 U	0.045 U	0.91 U	0.91 U
1,2-Dichlorotetrafluoroethane	$\mu g/m^3$	NA	NA	NA	NA	42 U	**0.087**	1.4 U	1.4 U
Ethylbenzene	$\mu g/m^3$	1000	10000	100000	10000	26 U	**0.18**	**3.9**	**4.4**
4-Ethyltoluene	$\mu g/m^3$	NA	NA	NA	NA	29 U	**0.067**	**1.6**	2.1 U
n-Heptane	$\mu g/m^3$	NA	NA	NA	NA	24 U	**0.12**	**8.6**	**9.2**
n-Hexane	$\mu g/m^3$	2000	20000	200000	NA	21 U	**0.25**	**13**	**14**
Methylene chloride	$\mu g/m^3$	20	200	2000	10000	**17 J, B, U**	0.69 U	**0.92 J, B, U**	**1.8 B, U**
Methyl-tert-butyl-ether (MTBE)	$\mu g/m^3$	3000	30000	300000	7300	21 U	0.036 U	0.72 U	0.72 U
Tetrachloroethene	$\mu g/m^3$	20	200	2000	20000	40 U	0.068 U	1.4 U	1.4 U
1,1,2,2-Tetrachloroethane	$\mu g/m^3$	0.2	2	20	NA	41 U	0.069 U	1.4 U	1.4 U
Toluene	$\mu g/m^3$	5000	50000	500000	37000	**73**	**2**	**100**	**120**
Trichloroethene	$\mu g/m^3$	3	30	300	2000	32 U	0.054 U	1.1 U	1.1 U
1,1,1-Trichloroethane	$\mu g/m^3$	1000	10000	100000	140000	33 U	0.055 U	**0.38 J**	**0.42 J**
1,1,2-Trichloroethane	$\mu g/m^3$	0.6	6	60	NA	33 U	0.055 U	1.1 U	1.1 U
Trichlorofluoromethane	$\mu g/m^3$	700	7000	70000	NA	**42**	**1.1**	**11**	**11**
1,2,4-Trimethylbenzene	$\mu g/m^3$	7	70	700	NA	**2.7**	NS	**5.41**	**7.37**
1,3,5-Trimethylbenzene	$\mu g/m^3$	6	60	600	NA	29 U	0.098 U	**1.9**	**2.3**
2,2,4-Trimethylpentane	$\mu g/m^3$	NL	NL	NL	NL	28 U	**0.078**	**2.3**	**2.4**
Vinyl Chloride	$\mu g/m^3$	1	10	100	180000	**15.0**	0.051 U	0.51 U	0.51 U
m&p-Xylenes	$\mu g/m^3$	100	1000	10000	43000	65 U	**0.5**	**15**	**17**
o-Xylene	$\mu g/m^3$	100	1000	10000	43000	26 U	**0.18**	**4.9**	**5.4**
Xylenes (total)	$\mu g/m^3$	100	1000	10000	43000	26 U	**0.68**	**20.0**	**22**

Notes:
Detected compounds are shown bold.
ISV - Intrusion Screening Value
10X ISV= ten times the ISV
100X ISV = one hundred times the ISV
µg/m3 = micrograms per liter
B = Compound was found in the blank and sample.
DUP = Duplicate
ID= Identification
J = Result is less than the reporting limit but greater than or equal to the MDL and the concentration is an approximate value.
NA = no toxicity data available
NS = not sampled for
SG = Soil Gas
SS = Sub-Slab Soil Gas
U = Indicates the analyte was analyzed for but not detected.
Intrusion Screening Values obtained from Minnesota Pollution Control Agency (MPCA) Risk-Based Guidance for the Vapo

(blue) analytes detected in groundwater above a groundwate
(green) soil gas or sub-slab soil gas sample is greater than 10
(yellow) ambient air sample is greater than ISV

TABLE 6
BUILDING 252 SUMP WATER ANALYTICAL RESULTS - VOCS
148[TH] FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
JULY 2010

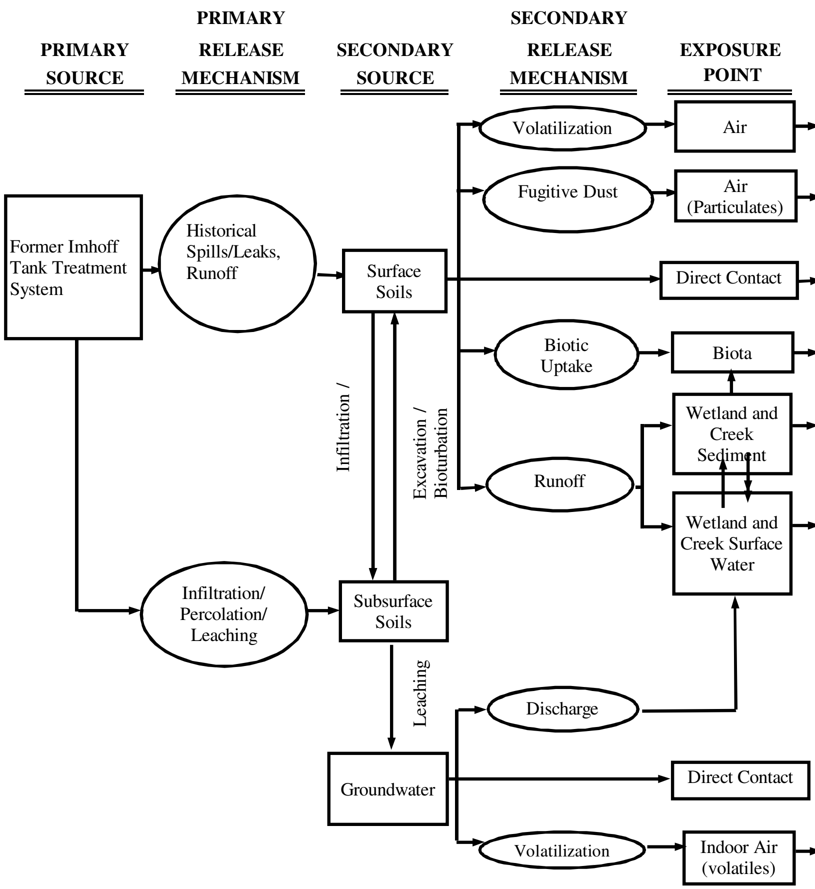
Date Collected					Tier 2 Surface Water Quality Standards				**7/13/2010**	**7/13/2010**
Sample ID					1B	2A	2A	2A	**252-Sump**	**252-Sump-DUP**
		MCL^	HRL#	GW_{isv}	DW*	CS*	MS*	FAV*		
Volatile Organic Compounds										
1,1,1,2-Tetrachloroethane	µg/l	-	70	-	-	-	-	-	< 0.5	< 0.5
1,1,1-Trichloroethane	µg/l	200	9,000	3,000	200	329	2,957	5,913	< 1.0	< 1.0
1,1,2,2-Tetrachloroethane	µg/l	-	2	40	-	1.1	1127†	2253†	< 0.5	< 0.5
1,1,2-Trichloroethane	µg/l	5	3	40	5	-	-	-	< 1.0	< 1.0
1,1,2-Trichlorotrifluoroethane	µg/l	-	-	3000	-	-	-	-	< 1.0	< 1.0
1,1-Dichloroethane	µg/l	-	70	4000	-	-	-	-	< 1.0	< 1.0
1,1-Dichloropropene	µg/l	-	-	-	-	-	-	-	< 0.5	< 0.5
1,2,3-Trichlorobenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0
1,2,3-Trichloropropane	µg/l	-	40	-	-	-	-	-	< 1.0	< 1.0
1,2,4-Trichlorobenzene	µg/l	70	-	200	70	-	-	-	< 1.0	< 1.0
1,1-Dichloroethylene	µg/l	7	200	300	7	-	-	-	< 1.0	< 1.0
1,2,4-Trimethylbenzene	µg/l	-	100	70	-	-	-	-	< 1.0	< 1.0
1,2-Dibromo-3-chloropropane	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0
1,2-Dibromoethane (EDB)	µg/l	-	0.004	2	-	-	-	-	< 1.0	< 1.0
1,2-Dichlorobenzene	µg/l	-	600	7,000	600	-	-	-	< 1.0	< 1.0
1,2-Dichloroethane	µg/l	5	4	20	5	3.5	45050†	90100†	< 0.5	< 0.5
1,2-Dichloropropane	µg/l	-	5	70	-	-	-	-	< 1.0	< 1.0
1,3,5-Trimethylbenzene	µg/l	-	100	70	-	-	-	-	< 1.0	< 1.0
1,3-Dichlorobenzene	µg/l	-	-	2,000	-	-	-	-	< 1.0	< 1.0
1,4-Dichlorobenzene	µg/l	-	10	2,000	75	-	-	-	< 0.5	< 0.5
1-3-Dichloropropane	µg/l	5	-	-	5	-	-	-	< 1.0	< 1.0
2,2-Dichloropropane	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0
2-Chlorotoluene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0
4-Chlorotoluene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0
Acetone	µg/l	-	700	50,000,000	-	-	-	-	< 20.0 J	< 20.0 J
Allyl Chloride	µg/l		30	-	-	-	-	-	< 1.0	< 1.0
Benzene	µg/l	5	2	40	5	5.1	4,487†	8,974†	< 0.5	< 0.5
Bromobenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0
Bromochloromethane	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0
Bromodichloromethane	µg/l	-	6	20	-	-	-	-	< 0.5	< 0.5
Bromoform	µg/l	-	40	1000	-	33	2900†	5800†	< 1.0	< 1.0
Bromomethane	µg/l	-	10	30	-	-	-	-	< 1.0	< 1.0
Carbon tetrachloride	µg/l	5	3	1	5	1.9	1750	3500	< 1.0	< 1.0
Chlorobenzene	µg/l	100	100	800	100	20	423	846	< 1.0	< 1.0
Chloroethane	µg/l	-	-	40000	-	-	-	-	< 1.0	< 1.0
Chloroform	µg/l	-	60	1000	-	53	1392	2784	< 1.0	< 1.0
Chloromethane	µg/l	-	-	20	-	-	-	-	< 1.0	< 1.0
cis-1,2-Dichloroethene	µg/l	70	50	500	70	-	-	-	< 0.5	0.5
cis-1,3-Dichloropropene	µg/l	-	2	60	-	-	-	-	< 0.5	< 0.5
Dibromochloromethane	µg/l	-	10	20	-	-	-	-	< 1.0	< 1.0
Dibromomethane	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0
Dichlorodifluoromethane	µg/l	-	1000	-	-	-	-	-	**5.4**	**5.5**
Dichlorofluoromethane	µg/l	-	-	70	-	-	-	-	< 0.5	< 0.5
Ethyl ether	µg/l	-	1,000	-	-	-	-	-	< 2.0	< 2.0
Ethylbenzene	µg/l	700	700	7000	700	68	1,859	3,717	< 1.0	< 1.0
Hexachlorobutadiene	µg/l	-	1	-	-				< 1.0	< 1.0

TABLE 6
BUILDING 252 SUMP WATER ANALYTICAL RESULTS - VOCS
148[TH] FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA
JULY 2010

Date Collected					Tier 2 Surface Water Quality Standards				**7/13/2010**	**7/13/2010**
Sample ID					1B	2A	2A	2A	**252-Sump**	**252-Sump-DUP**
		MCL^	HRL#	GW_{isv}	DW*	CS*	MS*	FAV*		
Isopropylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0
m&p-Xylenes	µg/l	-	-	800	-	-	-	-	< 1.0	< 1.0
Methyl Ethyl Ketone	µg/l	-	4000	4000000	-	-	-	-	< 5.0	< 5.0
Methyl Isobutyl Ketone	µg/l	-	300	1000000	-	-	-	-	< 5.0	< 5.0
Methylene chloride	µg/l	-	5	400	-	45	13,875†	27,749†	< 1.0	< 1.0
Methyl-tert-butyl-ether (MTBE)	µg/l	-	-	200000	-	-	-	-	< 1.0	< 1.0
n-Butylbenzene	µg/l	-	-		-	-	-	-	< 1.0	< 1.0
Naphthalene	µg/l	-	300	1,000	-	65	409	818	< 1.0	< 1.0
n-Propylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0
o-Xylene	µg/l	-	-	1,000	-	-	-	-	< 1.0	< 1.0
p-Isopropyltoluene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0
sec-Butylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0
Styrene	µg/l	100	-	20000	100		-	-	< 1.0	< 1.0
Tetrachloroethene	µg/l	5	5	60	5	3.8	428†	857†	< 1.0	< 1.0
tert-Butylbenzene	µg/l	-	-	-	-	-	-	-	< 1.0	< 1.0
Tetrahydrofuran	µg/l	-	100	-	-	-	-	-	< 5.0	< 5.0
Toluene	µg/l	1000	1,000	40000	1000	253	1352	2703	< 1.0	< 1.0
trans-1,2-Dichloroethene	µg/l	100	100	300	100	-	-	-	< 0.5	< 0.5
trans-1,3-Dichloropropene	µg/l	-	2	200	-	-	-	-	< 0.5	< 0.5
Trichloroethene	µg/l	5	5	20	5	25	6,988†	13,976†	< 1.0	1.0
Trichlorofluoromethane	µg/l	-	2000	300	-		-	-	< 1.0	< 1.0
Vinyl Chloride	µg/l	2	0.2	1	2	0.17	†	†	< 0.5	< 0.5
Xylenes (total)	µg/l	10,000	10,000	-	10,000	166	1,407	2,814	< 2.0	< 2.0

Notes:
Analytical data in bold text denotes sample detections above the MDL
Analytical data outlined denotes sample detections above HRL or CS
MCL = Maximum Contaminant Level
HRL = Minnesota Health Risk Limit
GW_{isv} = Groundwater Screening Values for Vapor Intrusion Pathway as provided in the MPCA document c-s4-06, "Risk-based Guidance for the Vapor Intrusion Pathway, Superfund RCRA and Voluntary Cleanup Section" dated September 2008, unless otherwise noted. Exceptions are for acetone, cis-1,2-DCE, and 1,1,1-Trichloroethane, which required updating based on the Intrusion Screening Values (ISVs) released by MPCA in February 2009.
- = No Limit established
DW = Drinking Water
CS = Chronic Standard
FAV = Final Acute Value
MS = Maximum Standard
µg/l = micrograms per liter
ID= Identification
QC= Quality Control
J = Estimated concentration
DUP = Duplicate
NA = not applicable
^ = Federal MCL under Safe Drinking Water Act (40 CFR Part 141).
# = State of Minnesota HRL, established in Minnesota Rules Chapter 4717.
* = State of Minnesota Specific Standards of Quality and Purity for Class 1B and 2A waters of the State.
† = For a pollutant with asterisks next to the final acute value (FAV) and the maximum standard (MS), the following applies:
For carcinogenic or highly bioaccumulative chemicals with BCFs greater than 5000 or log Kow values greater than 5.19, the human health chronic standard may be two or more orders smaller than the acute toxicity based MS.
For the MS: if the ratio of MS to the CS is greater than 100, the CS times 100 should be substituted for the applicable MS.
For the FAV: if the ratio of FAV to the CS is greater than 200, the CS times 200 should be substituted for the applicable FAV.
From Minn. R. 7050.0222, subp. 7, item E.

FIGURE 1
CONCEPTUAL SITE MODEL FOR IRP SITE 21



EXPOSURE ROUTE	POTENTIAL ECOLOGICAL EXPOSURE PATHWAYS: Terrestrial – Soil Inverts.	Terrestrial – Mammal	Terrestrial – Avian	Aquatic/Benthic – Sediment Inverts.	Aquatic/Benthic – Fish	Aquatic/Benthic – Avian	POTENTIAL HUMAN EXPOSURE PATHWAYS: Residential	Recreational	ANG Worker	Construction Worker
Inhalation	–	○	○	–	–	○	○	○	○	○
Inhalation	–	○	○	–	–	○	○	○	○	○
Ingestion	○	○	○	–	–	○	○	○	○	○
Contact	○	○	○	–	–	○	○	○	○	○
Ingestion	○	○	○	○	○	○	○	○	○	○
Ingestion	–	○	○	○	○	○	○	○	○	○
Dermal Contact	–	○	○	○	○	○	○	○	○	○
Ingestion	–	○	○	○	○	○	○	○	○	○
Dermal Contact	–	○	○	○	○	○	○	○	○	○
Ingestion	–	–	–	–	–	–	○	○	○	○
Dermal Contact	–	–	–	–	–	–	○	○	○	●[2]
Inhalation	–	–	–	–	–	–	○	○	●[1]	○

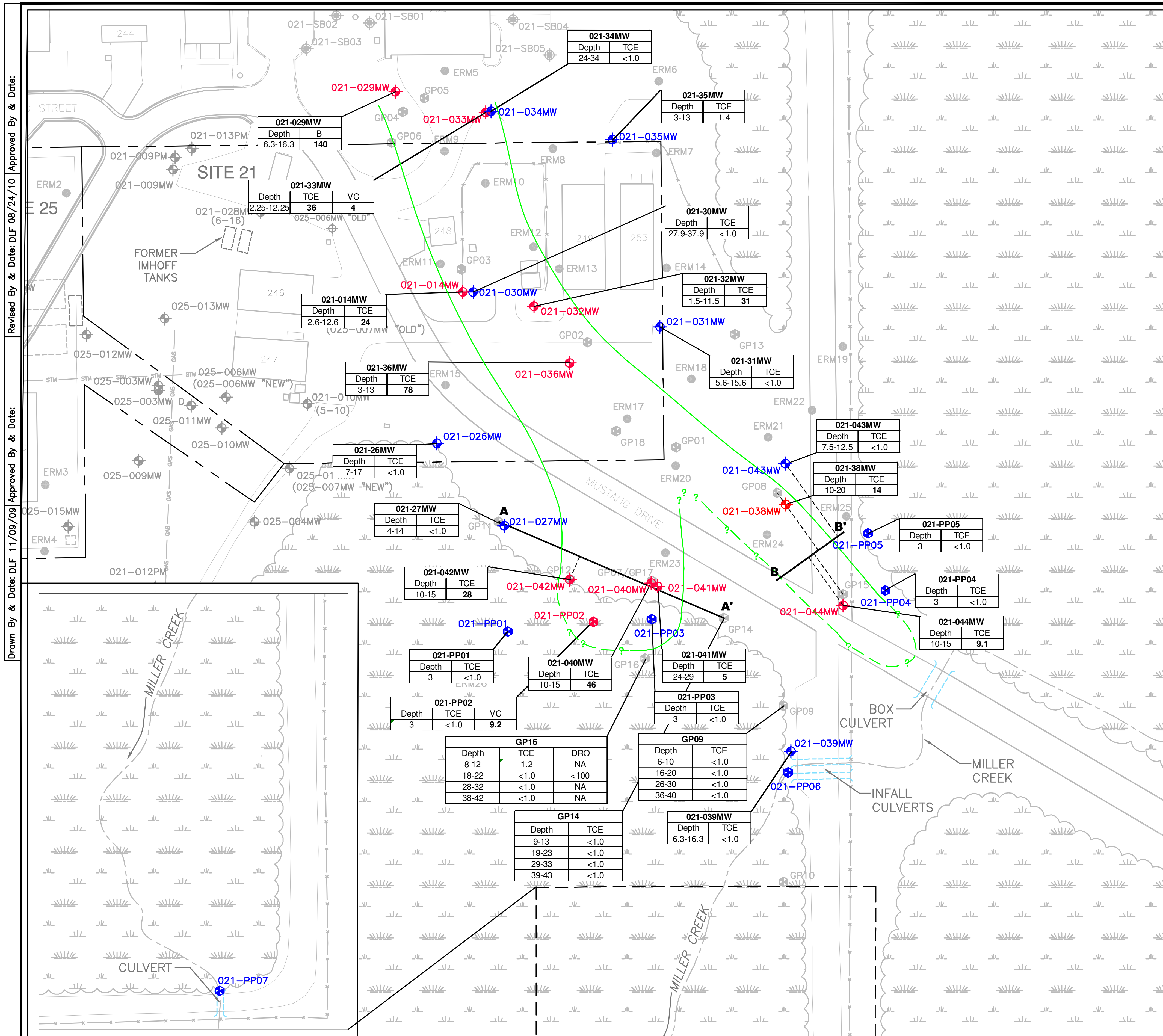
Legend

→ = Pathways -- past, current, and hypothetical future
● = Pathways potentially complete; further qualitative or quantitative evaluation performed
○ = Pathways considered incomplete or insignificant; a qualitative explanation of why the pathway is incomplete is provided in the focused risk assessment.
– = Exposure pathway not applicable to the particular receptor

Footnotes related to potentially complete exposure pathways:

1. There is the potential for vapor intrusion into building 252 based on the presence of shallow contaminated groundwater near it. However, based on current indoor air sampling this pathway appears to be insignificant based on the indoor air sampling conducted in the summer of 2010. Additional air sampling will be performed in the winter of 2010 to evaluate indoor air quality again.
2. Construction workers may be exposed to shallow groundwater if subsurface maintenance activities are required in the future. No such activities are currently planned.

9/3/2010



LEGEND

- MARSH
- BUILDINGS
- ERM GEOPROBE POINT
- SOIL BORING LOCATION – AUGUST 2008/MAY 2009
- VAS = VERTICAL AQUIFER SAMPLING LOCATION
- MONITORING WELL SAMPLED
- MONITORING WELL SAMPLED – EXCEEDANCE OF HRL
- PUSHPOINT LOCATION SAMPLED
- PUSHPOINT LOCATION – EXCEEDANCE OF HRL
- APPROXIMATE LATERAL EXTENT OF TCE PLUME

ALL CONCENTRATIONS IN MICROGRAMS PER LITER

BOLD VALUES > HEALTH RISK LIMIT (HRL)

B = BENZENE

TCE = TRICHLOROETHENE

VC = VINYL CHLORIDE

A A' CROSS SECTION LOCATION

GP09, GP14, AND GP16 COLLECTED MAY 2009

north

0 100 200

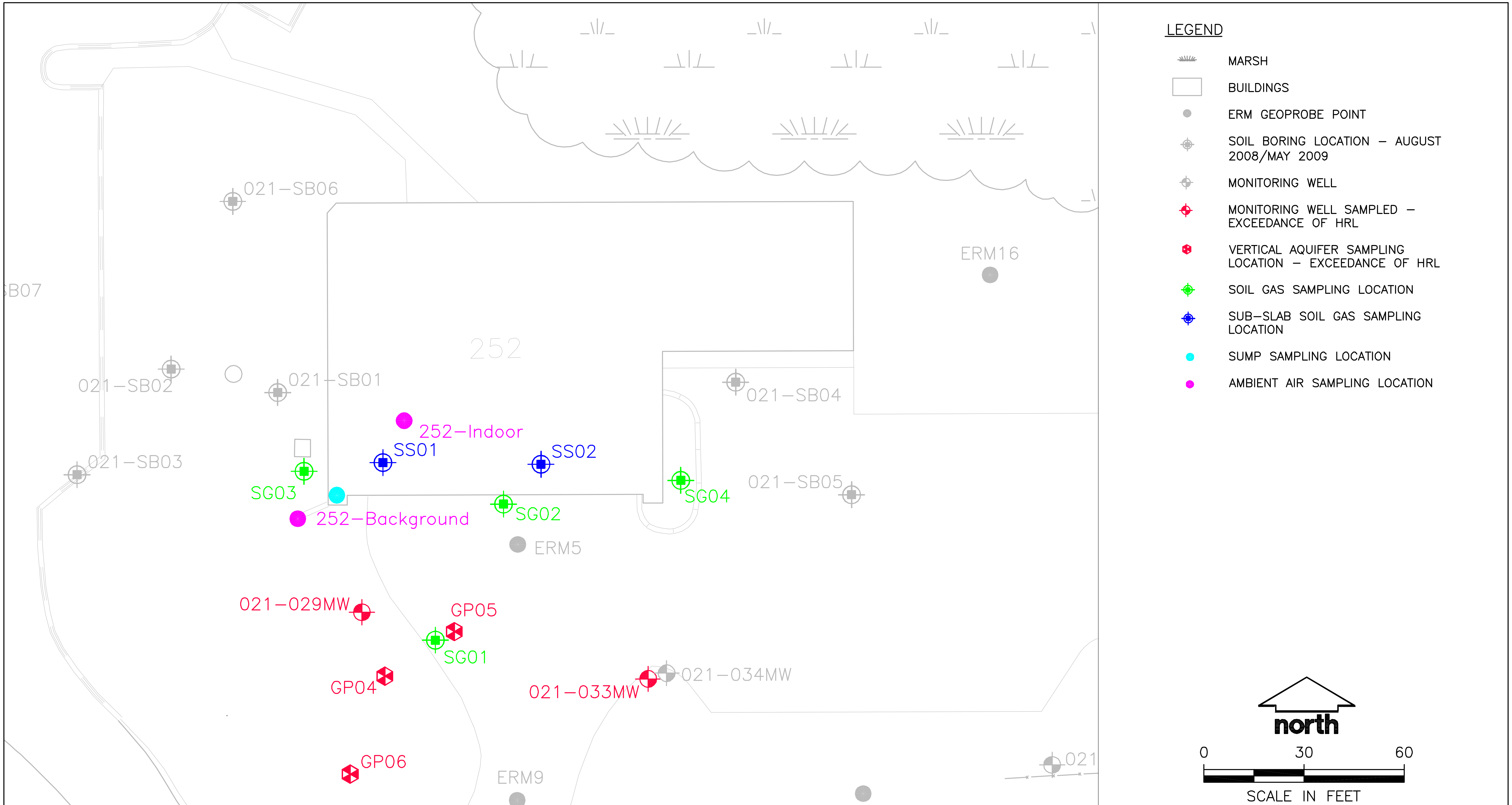
SCALE IN FEET

148TH FIGHTER WING, MINNESOTA AIR NATIONAL GUARD
DULUTH INTERNATIONAL AIRPORT

FOCUSED SCREENING LEVEL RISK ASSESSMENT
GROUNDWATER SAMPLING ANALYTICAL RESULTS
SEPTEMBER 2009

FIGURE 2

MWH



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SUMP WATER SAMPLING, SOIL GAS, AND SUB–SLAB SOIL GAS SAMPLING LOCATIONS

FIGURE 3

MWH

Drawn By & Date: TMZ 3/19/2010 | Approved By & Date: | Revised By & Date: DLF 09/07/10 | Approved By & Date:

Attachment A

MNANG Historical Surface Water Quality Test Data

2006 SPRING STORM WATER SAMPLING & ANALYSIS RESULTS

INORGANIC RESULTS	1 Dam	2 Ramp	4 Miller Creek	5 Runway	6 Hush House	7 C.E.	8 Landfill	10 W. POL	11 N. POL
Arsenic (ug/L)	<20	<20	<20	<20	<20	<20	<20	<20	<20
Barium (ug/L)	23.0	19.0	14.0	20.0	<5.0	17.0	21.0	22	26
BOD (mg/L)	4.9	5.4	2.8	2.3	3.2	<2.0	3.8	<4.0	4.2
Cadmium (ug/L)	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Chromium (ug/L)	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
COD (mg/L)	57	44	50	79	41	<50.0	63	57	50
Cyanide, total (mg/L)	<0.020	<0.020	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Lead (ug/L)	<10.0	<10.0	<10.0	<10.0	<100.	<10.0	<10.0	<10.0	<10.0
Mercuy (ug/L)	<0.20	<0.20	<0.20	<0.20	0.22	<0.20	<0.20	<0.20	<0.20
Nitrogen, ammonia (mg/L)	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Nitrogen, NO3 + NO2 (mg/L)	<0.25	0.30	<0.25	0.42	0.28	0.30	<0.25	<0.25	0.41
Nitrogen,total Kjeldahl (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Oil & Grease, total recoverable (mg/L)	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Phenolics, total recoverable (mg/L)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Phosphorus, ortho (mg/L)	<0.70	<0.70	<0.70	<0.70	<0.70	<0.70	<0.70	<0.70	<0.70
Phosphorus, total (mg/L)	<0.50	<0.50	<0.50	<0.50	1.5	<0.50	<0.50	<0.50	<0.50
Selenium (mg/L)	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0
Silver (ug/L)	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
TOC as NPOC (mg/L)	19.0	13.0	11.0	14.0	<2.0	13.0	12.0	15.0	10.0
ORGANIC RESULTS VOLATILES (ug/L)	**1**	**2**	**4**	**5**	**6**	**7**	**8**	**10**	**11**
Acetone	5.4	<5.0	<5.0	37.0	16.0	<5.0	<5.0	<5.0	150.0
Allyl Chloride	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Benzene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Bromochloromethane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Bromodichloromethane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Bromoform	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Bromobenzene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Bromomethane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Butanone	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
s-Butylbenzene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
t-Butylbenzene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
n-Butylbenzene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Carbon tetrachloride	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chloroform	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chlorobenzene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chlorodibromomethane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chloroethane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chloromethane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Chlorotoluene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4-Chlorotoluene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,2-Dibromo-3-chloropropane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,2-Dibromoethane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dibromomethane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,3-Dichlorobenzene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

- * = Sample results not reported do to exceeded laboratory hold time.
- **NOTE:** Sites # 3, # 9, and # 12 have been deleted do to no flow during sample collection.

1,4-Dichlorobenzene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,2-Dichloroethane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,2-Dichlorobenzene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,1-Dichloroethene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
cis-1,2-Dichloroethene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dichlorodifluoromethane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Trans-1,2-Dichloroethene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dichlorofluoromethane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,2-Dichloropropane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,1-Dichloroethane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,3-Dichloropropane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,2-Dichloropropane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,1-Dichloropropene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Cis-1,3-Dichloropropene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Trans-1,3-Dichloropropene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Ethylebenzene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Diethyl ether	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Fluorotrichloromethane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Hexachlorobutadiene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Isopropylbenzene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
p-Isopropyltoluene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Methylene chloride	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4-Methyl-2-pentanone	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Methyl-tert-butyl-ether	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Naphthalene	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
n-Propylbenzene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Styrene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,1,2,2-Tetrachloroethane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,1,1,2-Tetrachloroethane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Tetrachloroethene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Toluene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,2,3-Trichlorobenzene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,2,4-Trichlorobenzene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,1,1-Trichloroethane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,1,2-Trichloroethane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,1,2-Trichlorotrifluoroethane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,2,4-Trimethylbenzene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	3.2
Trichloroethene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,2,3-Trichloropropane	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Tetrahydrofuran	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
1,3,5-Trimethylbenzene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Vinyl chloride	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Xylenes, -m, -p	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Xylene, -o	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

ORGANIC RESULTS SEMIVOLATILES (ug/L)	1	2	4	5	6	7	8	10	11
Acenaphthene	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Acenaphthylene	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Anthracene	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Benzo(a)anthracene	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Benzo(b)fluoranthene	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Benzo(k)fluoranthene	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Benzo(a)pyrene	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Benzo(g,h,i)perylene	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Chrysene	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Dibenzo(a,h)anthracene	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Fluoranthene	0.052	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Fluorene	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Indeno(1,2,3-cd) pyrene	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Naphthalene	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Phenanthrene	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Pyrene	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
1-Methylnaphthalene	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
2-Methylnaphthalene	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Organic Results: TPH-IR	**1**	**2**	**4**	**5**	**6**	**7**	**8**	**10**	**11**
TPH-IR (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylene Glycol (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND
Propylene Glycol (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND

APPENDIX B

NATURAL ATTENUATION STUDY

Natural Attenuation Screening Protocol

The following is taken from the USEPA protocol (USEPA, 1998). The results of this scoring process have no regulatory significance.

Interpretation	Score
Inadequate evidence for anaerobic biodegradation* of chlorinated organics	0 to 5
Limited evidence for anaerobic biodegradation* of chlorinated organics	6 to 14
Adequate evidence for anaerobic biodegradation* of chlorinated organics	15 to 20
Strong evidence for anaerobic biodegradation* of chlorinated organics	>20

* reductive dechlorination

Score: 10

Scroll to End of Table

Analysis	Concentration in Most Contam. Zone	Interpretation	Yes	No	Points Awarded
Oxygen*	<0.5 mg/L	Tolerated, suppresses the reductive pathway at higher concentrations	◉	○	3
	> 5mg/L	Not tolerated; however, VC may be oxidized aerobically	○	◉	0
Nitrate*	<1 mg/L	At higher concentrations may compete with reductive pathway	○	◉	0
Iron II*	>1 mg/L	Reductive pathway possible; VC may be oxidized under Fe(III)-reducing conditions	○	◉	0
Sulfate*	<20 mg/L	At higher concentrations may compete with reductive pathway	◉	○	2
Sulfide*	>1 mg/L	Reductive pathway possible	○	◉	0
Methane*	>0.5 mg/L	Ultimate reductive daughter product, VC Accumulates	○	◉	0
Oxidation Reduction Potential* (ORP)	<50 millivolts (mV)	Reductive pathway possible	◉	○	1
	<-100mV	Reductive pathway likely	○	◉	0
pH*	5 < pH < 9	Optimal range for reductive pathway	◉	○	0
TOC	>20 mg/L	Carbon and energy source; drives dechlorination; can be natural or anthropogenic	○	◉	0
Temperature*	>20°C	At T >20°C biochemical process is accelerated	○	◉	0
Carbon Dioxide	>2x background	Ultimate oxidative daughter product	○	◉	0
Alkalinity	>2x background	Results from interaction of carbon dioxide with aquifer minerals	○	◉	0
Chloride*	>2x background	Daughter product of organic chlorine	○	◉	0
Hydrogen	>1 nM	Reductive pathway possible, VC may accumulate	○	◉	0
Volatile Fatty Acids	>0.1 mg/L	Intermediates resulting from biodegradation of aromatic compounds; carbon and energy source	○	◉	0
BTEX*	>0.1 mg/L	Carbon and energy source; drives dechlorination	○	◉	0
PCE*		Material released	○	◉	0
TCE*		Daughter product of PCE a/	○	◉	0
DCE*		Daughter product of TCE. If cis is greater than 80% of total DCE it is likely a daughter product of TCE a/; 1,1-DCE can be a chem. reaction product of TCA	◉	○	2
VC*		Daughter product of DCE a/	◉	○	2
1,1,1-Trichloroethane*		Material released	○	◉	0
DCA		Daughter product of TCA under reducing conditions	○	◉	0
Carbon Tetrachloride		Material released			0
Chloroethane*		Daughter product of DCA or VC under reducing conditions			0
Ethene/Ethane	>0.01 mg/L	Daughter product of VC/ethene			0
	>0.1 mg/L	Daughter product of VC/ethene			0
Chloroform		Daughter product of Carbon Tetrachloride			0
Dichloromethane		Daughter product of Chloroform			0

* required analysis.
a/ Points awarded only if it can be shown that the compound is a daughter product (i.e., not a constituent of the source NAPL).

End of Form

APPENDIX C

ENHANCED BIOREMEDIATION – BIOREMEDIATION SUBSTRATE DESIGN CALCULATION

Determine volume of EOS needed to treat TCE groundwater concenrations.

Assumptions:

Treatment area depth = 25ft
TCE orgination treatment area width = 20 ft
TCE orgination treatment area length = 110 ft
Bulk density of soil is 1.625 mg/m^3 .
Density of EOS is 920 kg/m^3

Mid-Plume treatment area width = 10 ft
Mid-Plume treatment area length = 150 ft
Right TCE plume leg treatment width = 10 ft
Right TCE plume leg treatment length = 90 ft
Left TCE plume leg treatment width = 10 ft
Left TCE plume leg treatment length = 150 ft

Determine volume of soil:

Area = square footage (ft^2) multiplied by total depth (ft)

TCE Origination Area South of Building 252

Area =	110	ft	X	20	ft	X	25	ft	=	**55,000**	ft^3

Mid-Plume Injection Area

Area =	150	ft	X	10	ft	X	25	ft	=	**37,500**	ft^3

Right TCE Plume Leg - Adjacent to marsh boundary

Area =	90	ft	X	10	ft	X	25	ft	=	**22,500**	ft^3

Left TCE Plume Leg - Adjacent to marsh boundary

Area =	150	ft	X	10	ft	X	25	ft	=	**37,500**	ft^3

Total Area **152,500** **ft^3**

Bulk density =	1.63	g/cm^3	Total volume of soil =	**4,318**	m^3
Bulk density =	**1,625,000**	g/m^3			
			Mass of soil requiring treatment =	**7,017,268,546**	g
			Mass of soil =	**7,017,269**	kg
EOS required =	0.2%	of soil mass for 3 years			
			Mass of EOS required\=	**14,035**	kg
Density of EOS=	920	kg/m^3	Volume of EOS required=	**4,030**	gallons
Injection locations =	59		Volume of EOS required per location=	**68**	gallons

Notes

Inserted Value
Calculated Value

Definitions

g = gram
kg = kilogram
m^3 = cubic meter
ft = feet
ft^3 = cubic feet
g/cm^3 = gram per cubic centimeter
g/m^3 = gram per cubic meter
kg/m^3 = kilo per cubic meter
% = Percent
EOS = Emulsified Oil Substrate

APPENDIX D

PERMEABLE REACTIVE BARRIER – SUPPORTING DESIGN AND VENDOR INFORMATION

enviro**metal** technologies inc.
an Adventus company

To:	Todd Zynda – MWH Americas, Inc. *Email: Todd.Zynda@us.mwhglobal.com*
From:	John Vogan
Date:	1 February 2010
Re:	Construction Cost Estimate for Iron Permeable Reactive Barrier at Duluth ANG – EnviroMetal Technologies Inc. Project # 32520.20

Further to our recent discussions, we have prepared a cost estimate for the installation of an iron permeable reactive barrier (PRB) at the Duluth Air National Guard site (ANG) based on bench-scale study results and current dimensions of the PRB provided by MWH Americas Inc. (Table 1). We requested costs from the proposed iron supplier (Connelly GPM), and DeWind Trenching (DeWind), a continuous trenching contractor. Their quotations are summarized in Table 2 and appended to this memo. We suggest that continuous trenching is appropriate for the site, given the required PRB dimensions, what we understand to be the fairly open access along the line if installation, and DeWind's experience in similar applications. As discussed, one concern expressed by DeWind was the location of the water table and whether the upper part of the excavation will stay open without caving. DeWind has assumed that a bench on top of existing grade will not be needed to accommodate the shallow water table. We suggest that this activity might be included as an optional part of site preparation costs, in case a bench is indeed deemed necessary as implementation proceeds.

Costs for activities such as site preparation, permitting, site construction management, soil disposal, etc., which are not included in the following estimate, should also be taken into account. Please also review the other assumptions listed in the DeWind quotation.

ETI has prepared templates for specifications for construction of PRBs. We can provide these templates to you and assist you in preparing a formal specification for the project, should it proceed.

745 Bridge St. W., Suite 7
Waterloo, Ontario, Canada, N2V 2G6
Tel: 519-746-2204, Fax: 519-746-2209
www.eti.ca / www.adventusgroup.com

Table 1: Revised PRB Design Parameters, Duluth ANG

Design Parameter	
Length of PRB	160 feet
Depth to Water Table	3 ft
Depth to Bottom of PRB	25 ft
Vertical Thickness of PRB	22 feet
Groundwater Flow Velocity	~~0.26~~ ft/day → 0.134
Residence Time Required for Treatment	0.42 days
Required Iron Flow-through Thickness	0.11 ft
Practical Iron Flow-through Thickness [a]	0.4 ft
Volume of Iron	1,408 ft^3
Field Bulk Density of Iron	0.075 $tons/ft^3$
Mass of Iron Required	106 tons

a Assuming a 20% (vol) iron - 80% (vol) sand mix used on a 2 ft wide trench.

Table 2: PRB Construction Cost Estimate, Duluth ANG

Estimated Cost	
Iron Including Delivery [a]	$ 76,000
Construction [b]	$ 110,000
Iron and Sand Mixing	$ 10,000
Subtotal	$ 196,000
ETI's License Fee (12%) [c]	$ 23,500
TOTAL [d]	**$ 219,500**

a Based on quotation from Connelly GPM, attached.

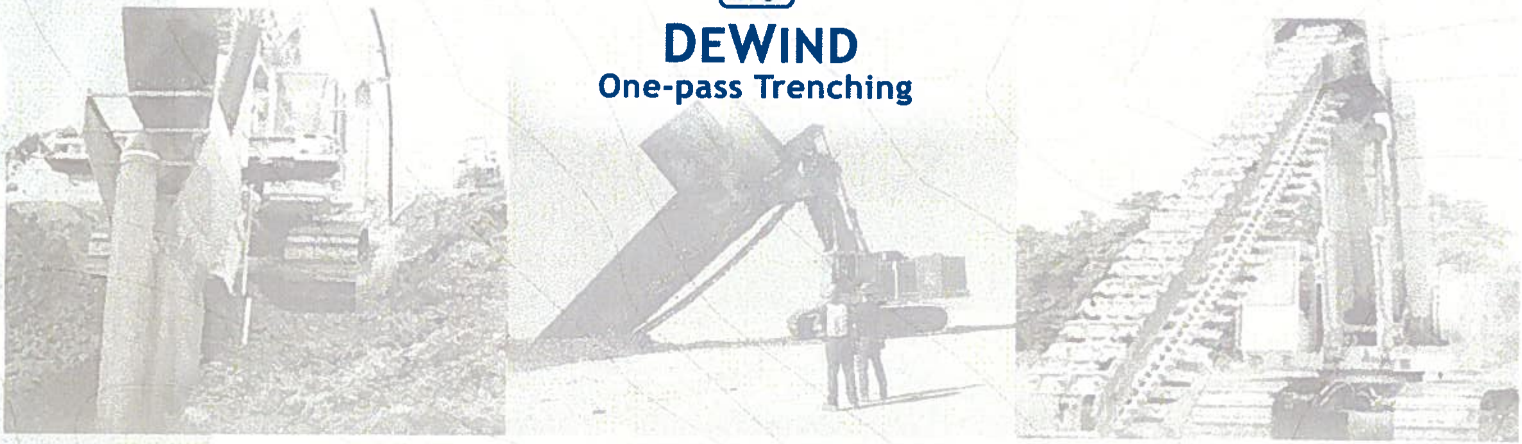
b Based on quotation from DeWind Trenching, attached.

c current license rate on US government projects.

d Based on cost data from other sites. Does not include costs for activities such as site preparation/restoration, permitting, soil/water disposal, site construction management, etc.

(Admin/Projects & Proposals/Projects/32520.20 Feb 1 2010 Duluth PRB Cost Estimate)

DEWIND
One-pass Trenching



1-29-2010

ETI
Attn; John Vogan

Cost Estimate for the One-Pass Trencher Installation of a ZVI Wall
Air National Guard
Duluth MN

Mobilization/ set up / Demobilization
30,000.00

Installation of a 160' long x 25' Deep x 2' wide Iron/Sand wall installed.
70,000.00 to 80,000.00+/-

Assumptions for ZVI wall installations

* Soils conditions to be mostly sand, clay or other non-consolidated soils.
* Water table more than 7' blg.
* All site prep and restoration including spoils handling by others.
* Iron/sand mix provided by others. Mixing by others.
* Royalty fees paid by Client.
* Site clear, level and free of any underground or above ground utilities, structures or debris.
* Site stable and able to withstand 175,000 lb track machine.
* Support equipment provided by others; One loader with forks and one 200 sized excavator.
* No union labor required or bonding.
* A fuel surcharge will be applied if the cost of fuel rises over 10% from the date of the original proposal.

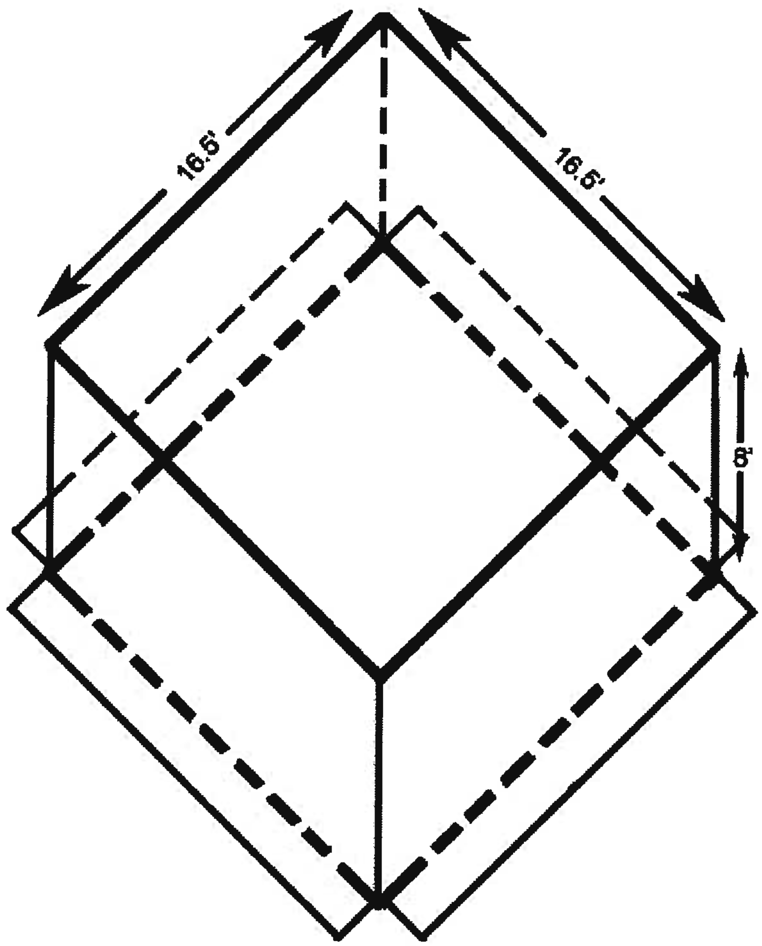
9150 96th Avenue Zeeland, Michigan 49464 Phone 616 875-7580 Fax 616 875-7334
dewinddewatering.com *e-mail* info@dewindonepass.com

CONNELLY – GPM, INC.

ESTABLISHED 1875

3154 SOUTH CALIFORNIA AVENUE · CHICAGO, ILLINOIS 60608-5176

PHONE: (773) 247-7231 www.ConnellyGPM.com FAX: (773) 247-7239



3' Unsewn Flap on 4 Sides

-

PRICE: $800.00 ea., (F.O.B. Chicago, IL)
(could accompany Iron shipments)

TARP SPECIFICATIONS:
16 ½' W x 16 ½' D x 11' H O.A.
22 oz. Vinyl Coated Polyester
All Seams Sealed and Watertight
Approximate Wt: 150 lbs.

SHOULD COVER:
64 Bulk Bags (4 Bags Deep, 4 Bags Wide, 4 Bags High)
@ 3000#/Bag = 96 Net Tons ($8.33/N.T. Storage Cost)

DISCLAIMER: Connelly-GPM, Inc. does not guarantee the reliability of the tarps to repel water or to protect from moisture if used improperly.

May 24, 2006

CONNELLY – GPM, INC.

ESTABLISHED 1875
3154 SOUTH CALIFORNIA AVENUE CHICAGO, ILLINOIS 60608-5176
PHONE: (773) 247-7231 • www.ConnellyGPM.com • FAX: (773) 247-7239

Sent via Email: jvogan@eti.ca

January 29, 2010

Mr. John Vogan
EnviroMetal Technologies, Inc.
745 Bridge Street West, Suite 7
Waterloo, Ontario Canada
N2V 2G6

Re: Approximately 106.5 Net Tons (71-3000 Lb. Bulk Bags) Iron Aggregate ETI CC-1004 for Duluth (MN) International Airport

Dear John:

As you requested, following is a quotation you may forward to your customer for approximately 106.5NT of Iron Aggregate ETI CC-1004 (-8 +50):

Pricing: (see * below)

IRON AGGREGATE ETI CC-1004 (-8 +50)	$631.65/NT
3000 Lb. Bulk Bags (1.5NT per Bulk Bag) ($21.00 ea)	$ 14.00/NT
42" x 42" Pallets - RECONDITIONED ($6.525 ea)	$ 4.35/NT
Total/NT, F.O.B. Chicago, IL:	(US$) $650.00/NT

Our material is shipped F.O.B. Chicago, IL. Freight is billed to you separately by the carrier of your choice (see *Freight* on Page 3)
All taxes are the responsibility of the purchaser.
If stored outside, bulk bags must remain under tarp and dry at all times.

*** Most of our products are iron based and are directly impacted by the cost of scrap metal. Due to the volatility in the steel and scrap markets, we are only able to quote pricing for material shipping by January 31, 2010. Accordingly, current pricing can only be guaranteed through February 28, 2010. Pricing for material shipping after that date will need to be established based on current market conditions at the time of shipment.**

Terms of Purchase:

Upon receipt of your purchase order and payment, we will initiate our production scheduling and provide you with a best-case/worst-case ship date. Should, however, the schedule we discuss not meet with your approval, we would immediately refund your deposit and cancel your purchase order.

(At this time, John, we have 106.5 NT available, in stock)

Please understand that we are working on a first come-first serve basis at this time due to the increased demand for our Iron Aggregate. Receipt of your purchase order and 25% deposit will ensure placement into our production schedule.

Schedule/Delivery:

Connelly-GPM, Inc. can load up to 30 trucks per week (6 per day) to one site. For 106.5NT (5 to 6 loads), shipments could complete within 1 to 2 days. This schedule would allow you to establish pricing for the month of shipment, thereby avoiding any pricing fluctuations that may occur from month to month. We will work together with all parties involved and provide the high level of service that the industry has come to expect from us. We have already supplied many of the largest sites to date using Iron Aggregate for groundwater remediation, including one over 10,000NT. In completing those orders, we met or exceeded all planned production and delivery expectations.

It is our policy that we cannot accept iron back once it has been shipped; however, we always work closely with our customers to avoid supplying excess material. We recommend holding the last truckload for you at our plant to ensure that over-shipment does not occur. When your construction starts, and you begin getting your installation results, you can then take time to recalculate your iron needs. Should you require the additional tonnage we are holding for you at our plant, we would ship the material at once upon your release.

We also realize more tonnage may be required over the amount you initially stated in your purchase order. We always regard the project under construction as a priority; therefore, should additional iron be required, we would immediately assist you in making the arrangements to ship the additional material.

Storage of Material:

The Iron Aggregate should be kept dry at all times. We recommend storing the bulk bags in a dry (warehouse) environment. If stored outside, the bulk bags must remain under tarp. Connelly-GPM, Inc. offers a unique tarp system; each tarp will cover up to 96NT (or 64 bulk bags). In addition, the tarps could ship on the same truck as your Iron Aggregate, thus avoiding any additional freight cost to you. For more information, please see attached Tarp Specification.

Specifications and Pre-Shipment Samples:

Connelly-GPM, Inc. is an iron grinder only. Our Iron Aggregate is used primarily as a raw material for the manufacture of construction materials and for use in the chemical industry worldwide. Although, for many years, it has been used successfully at sites around the world for groundwater remediation; we make no claim for its performance other than to assure you that our material will be within your specification for particle size distribution, bulk density, oil and grease content, and percentage of iron.

We take great pride in the quality and consistency of our product, but we are not in a position to test for or guarantee the specific results of the use of that iron for groundwater remediation. We recommend that our customers test the suitability of our iron for their proposed application. Accordingly, the Purchase Order should not stipulate water purification performance or effectiveness. We are, however, willing to discuss providing pre-shipment samples for testing and approval prior to shipment.

Quality Control and Certification:

Connelly-GPM, Inc.'s Quality Control process is considered to be the industry standard for ground Iron Aggregate, and has allowed us to maintain the highest standards of quality while fulfilling the largest orders in the history of this groundwater remediation technology.

These procedures begin with analytical selection of cast iron sources along with screening and approval of every individual truckload of raw iron delivered to the plant. The iron sources are then blended to provide the proper mixture to feed into the production process. The finished product is sampled at regular intervals, and those samples are grouped to provide a combined representative sample, which more accurately represents the contents of a group of bags than any individual sample would. These samples are continuously taken, combined, and tested during the production process.

Upon request, Connelly-GPM, Inc. will furnish Certificates of Analysis for each truckload of material certifying that the material shipped meets all specifications as outlined above (*Specifications and Pre-Shipment Samples*).

Freight:

Our material is sold *F.O.B. Chicago, IL* – freight is billed directly to you by the carrier. We will investigate freight rates, contact the carrier of your choice for pick-up, and work closely with that carrier to make all transportation arrangements (ie, Bills of Lading, Commercial Invoice, NAFTA Certificates, etc.). Copies of the bills of lading will be sent to you upon shipment.

The best freight rates we found from Chicago, IL to Duluth International Airport were quoted by Midwestern Transit (815-671-8210) and are as follows: (rates quoted are good for 30 days.)

5 FULL VANS @ 21NT EA AND 1 PARTIAL VAN @ 1.5NT

FULL LOAD Closed Van — We have obtained a freight rate of **US$ 1,350/Truckload**, which includes fuel surcharge and tolls. A closed van will carry 14-3000# bulk bags for a payload of 21NT of material, which would be a **freight cost of $64.29/NT**, based on a full truckload of material. For unloading you would need a loading dock or ramp, or the pallets may be pulled out with chains.

PARTIAL LOAD Closed Van quoted at **US$475.00**, which would be a **freight cost of $316.67/NT**.

4 FULL FLAT BEDS @ 22.5 EA AND 1 (3/4) FLAT BED @ 16.5NT

FULL LOAD Flatbed Truck — We have obtained a freight rate of **US$1,450/Truckload**, which includes fuel surcharge, tarp and tolls. A flatbed will carry 15-3000# bulk bags, for a payload of 22.5NT of material, which would be a **freight cost of $64.45/NT**, based on a full truckload of material. This type of truck can be unloaded with a forklift from either side of the flatbed directly from the ground.

¾ LOAD Flatbed Truck quoted at **US$1,100**, which would be a **freight cost of $66.67/NT.**

Be advised that, due to the current fuel prices, any freight quotes are subject to a fuel surcharge that varies from week to week. They have gone as high as 33% (and could go even higher), so keep this in mind when planning your budget. Freight rate information given to you by Connelly-GPM, Inc. is our understanding of the freight charges in effect at that time. Connelly-GPM, Inc. takes no responsibility for the completeness or accuracy of such information and you are encouraged to obtain confirmation of freight rates on your own. Connelly-GPM, Inc. cannot guarantee truck availability.

Support Documentation:

Attached is our Iron Aggregate Label with the World Logo, a News Release on Ground Water Remediation with Zero-Valent Iron, a Screen Specification on ETI CC-1004, a Material Safety Data Sheet on Iron Aggregate, and a Company Background on Connelly-GPM, Inc. for your information.

Summation:

Connelly-GPM, Inc. has been in business since 1875. We can custom grind to meet your needs. We have provided the majority of Iron Aggregate to sites around the world; many over 2,000 Net Tons, a few over 3,500 Net Tons, and the largest site to date of over 10,000 Net Tons. Our record of delivering orders on time and within specifications has made us the supplier of choice for this rapidly growing technology.

John, thank you for the opportunity to provide you and your customer with this quotation, and if you have any questions, please feel free to contact me.

Sincerely,

CONNELLY-GPM, INC.
THE IRON AGGREGATE PEOPLE™

Amy Marchefka
Office Manager

Attachments

D:\WORD\WT\EthruH\ETI\Duluth Airpt Terms ReQte