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TECHNOLOGY DEMONSTRATION PLAN FOR BUILDING 1419 SITE NSWC INDIAN HEAD MD

02/01/2006

SOLUTIONS IES INC

Evaluation of Potential for Monitored Natural Attenuation of Perchlorate in Groundwater

Technology Demonstration Plan
for
Building 1419 Site, Naval Surface Warfare Center,
Indian Head, MD
ESTCP Project No. ER-0428

Prepared by:

Solutions-IES
Industrial & Environmental Services

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LIST OF ABBREVIATIONS USED IN THIS DOCUMENT

1. AFCEE – Air Force Center for Environmental Excellence
2. BOD – Biochemical Oxygen Demand
3. CD – Chlorite Dismutase
4. CVOC – Chlorinated Volatile Organic Compound
5. DNA – Deoxyribonucleic Acid
6. DO – Dissolved Oxygen
7. DoD – Department of Defense
8. ESTCP – Environmental Security Technology Certification Program
9. ft bgs – Feet below ground surface
10. HASP – Health and Safety Plan
11. IC – Ion Chromatography
12. IC/MS/MS – Ion Chromatography/Dual Mass Spectroscopy
13. IDW – Investigation-Derived Waste
14. IHDIV – Indian Head Division
15. ITRC – Interstate Technology Regulatory Council
16. K – Hydraulic Conductivity
17. MCL – Maximum Contamination Limits
18. MNA – Monitored Natural Attentuation
19. mRNA – Messenger Ribonucleic Acid
20. MSDS – Material Safety Data Sheet
21. MTBE – Methyl-*tert*-Butyl Ether
22. NPV – Net Present Value
23. NSWC – Naval Surface Warfare Center
24. O&M – Operation and Maintenance
25. ORP – Oxidation-Reduction Potential
26. PI – Principal Investigator
27. PID – Photoionization Detector
28. PPE – Personal Protective Equipment
29. RNA – Ribonucleic Acid
30. TOC – Total Organic Carbon
31. USEPA – United States Environmental Protection Agency

32. VOC – Volatile Organic Compound

1.0 Introduction

The purpose of the following Technology Demonstration Plan is to describe how Solutions-IES will evaluate the potential for monitored natural attenuation (MNA) of perchlorate in groundwater at the selected site in Indian Head, Maryland. The demonstration is funded by ESTCP under Project No. ER-0428. This Technology Demonstration Plan details the performance measurements and metrics for success.

1.1 Background

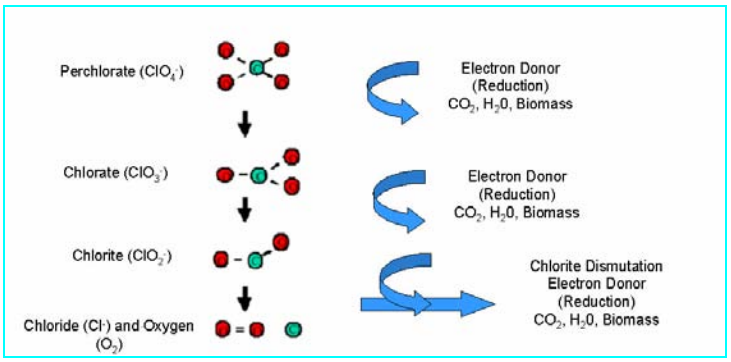
Groundwater and surface water contaminated with perchlorate (ClO_4^-) has become a major environmental issue for the US Department of Defense (DoD) due to the use, release and/or disposal of solid rocket fuel and munitions containing ammonium perchlorate. These releases have resulted in extensive contamination of surface and groundwater supplies. In the western US, over 15 million people consume water with some level of perchlorate. This is a significant concern because high levels of perchlorate interfere with iodide uptake by the thyroid (USACHPPM). Currently, there is no federal cleanup standard for perchlorate in groundwater or soil (US EPA, 2005; ITRC, 2005), however, in January 2006, the USEPA issued "Assessment Guidance for Perchlorate" identifying 24.5 µg/L as the recommended "to be considered" (TBC) value and preliminary remediation goal for perchlorate (USEPA, 2006). Several states have identified advisory levels that range in concentration from 1 µg/L to 52 µg/L. Specifically, the state of Maryland has identified an advisory level of 1 µg/L for perchlorate in drinking water (US EPA, 2005).

Perchlorate is a highly mobile, soluble anion that sorbs poorly to most aquifer material, and can persist for decades under aerobic conditions. As a consequence, discharge of perchlorate to the environment can impact ground and surface water with the potential for human consumption through direct (drinking water) and indirect (crop uptake from irrigation water) pathways. However, recent research has shown that a diverse array of bacteria can anaerobically degrade perchlorate to chloride and oxygen. These organisms appear to be widespread in the environment and can use a variety of different organic substrates as electron donors for perchlorate reduction. This suggests that perchlorate may naturally degrade at some sites without active human intervention.

In recent years, an extensive body of information has been developed demonstrating that a large and diverse population of microorganisms can degrade perchlorate to chloride and oxygen (Coates *et al.*, 1999; Coates and Pollock, 2003). Perchlorate-reducing organisms are widespread in the environment (Coates *et al.*, 1999; Logan, 2001) and can use a variety of different organic substrates (e.g., acetate, propionate, lactate, etc.) as electron donors for perchlorate reduction (Herman and Frankenberger, 1998; Coates *et al.*, 1999). Perchlorate biodegradation can occur under strict anaerobic conditions as well as facultative anaerobic conditions. Facultative anaerobic microorganisms are capable of both aerobic respiration under low oxygen tension and fermentation when anaerobic conditions prevail. This metabolic versatility suggests that environments exist that can support a variety of perchlorate-reducing microbial populations.

Facultative anaerobic metabolism is inhibited by dissolved oxygen concentrations in excess of 2 mg/L (Rikken *et al.*, 1996; Chaudhuri *et al.*, 2002). However, when biodegradable organic substrates are present, the available dissolved oxygen will be consumed and there is a very high probability that perchlorate will biodegrade in the natural environment. The biodegradation pathway of perchlorate is illustrated below (**Figure 1-1**).

Figure 1-1 Perchlorate Biodegradation Pathway



Work by Coates *et al.* (1999), Chaudhuri *et al.* (2002), and Bender *et al.* (2002) indicates that the Dechloromonas and Dechlorosoma groups represent the primary chlorate and perchlorate reducing bacteria in the environment, but more that 30 different strains of perchlorate-reducing microbes have been identified (US EPA, 2005). The rate-limiting step in the three-step degradation process is the conversion of perchlorate to chlorate by a perchlorate reductase enzyme. Subsequent conversion of chlorate to chlorite is also catalyzed by a perchlorate reductase enzyme. Chlorite removal by the chlorite dismutase (CD) enzyme is the final step in perchlorate reduction. Its specificity may be useful as an indicator of perchlorate biodegradation and therefore, provide supporting evidence for MNA of perchlorate at certain sites.

Because there is a strong potential for MNA of perchlorate where site conditions are appropriate, identifying lines of evidence that suggest which sites are amenable to perchlorate MNA is highly important. During an extensive site selection process, lines of evidence were evaluated for use in evaluating perchlorate MNA at sites throughout the United States including sites in Utah, Maryland, Mississippi, Alabama, and California. The Naval Surface Warfare Center (NSWC), Building 1419 site in Indian Head, Maryland site was selected for technical demonstration to confirm that the lines of evidence selected for perchlorate MNA are appropriate for conditions that may be encountered by engineers and scientists in the field. This demonstration should enable Solutions-IES to confirm common characteristics of perchlorate attenuation, and can be utilized to evaluate sites for perchlorate MNA in engineering practice. The characteristics of the demonstration site will be discussed in greater detail in Section 3.

1.2 Objectives of the Demonstration

Natural attenuation is defined by the US EPA as the "biodegradation, diffusion, dilution, sorption, volatilization, and/or chemical and biochemical stabilization of contaminants to effectively reduce contaminant toxicity, mobility or volume to levels that are protective of human health and the environment." The term MNA refers to the reliance on natural attenuation processes, within the context of a carefully controlled and monitored site cleanup, to achieve site-specific remedial goals. There are two overall goals of this project:

1. Provide DoD managers with the tools needed to evaluate whether MNA may be appropriate for management of perchlorate releases on their site(s); and
2. Demonstrate to regulatory agencies that perchlorate MNA is effective for controlling adverse impacts to the environment.

To achieve these goals, the following objective was established for the site selection phase of the project.

- Evaluate the rate and extent of perchlorate biodegradation in aquifer material and groundwater from a variety of sites that potentially received perchlorate through microcosm studies.

During the site selection process, the rate and extent of perchlorate biodegradation was evaluated at seven sites: Little Mountain Test Annex, Utah; ATK-Elkton, Maryland; Stennis Space Center, Mississippi; NSWC Indian Head Division, Maryland; Redstone Arsenal; Alabama; ATK Thiokol, Utah; and Beale Air Force Base, California. This information was used in part to assist Solutions-IES in identifying Indian Head Division, Maryland as a technical demonstration site. The site selection process was also used to indicate which lines of evidence should be tested for eventual use in a MNA protocol.

The objectives for the next phase of the project, the technical demonstration, are:

- Verify biodegradation rates established with microcosm studies that were performed during the site selection process.
- Evaluate the use of the chlorite dismutase (CD) enzyme analysis and isotopic ratios as indicators of perchlorate biodegradation.
- Continue to develop and test multiple lines of evidence established during the site selection process to evaluate the MNA of perchlorate.

Once the technical demonstrations are complete and the lines of evidence are tested in the field, Solutions-IES will:

- Develop a protocol for monitoring the natural attenuation of perchlorate.
- Transfer the knowledge gained about perchlorate MNA to the regulatory community.

1.3 Regulatory Drivers

Currently, there is no federal cleanup standard for perchlorate in groundwater or soil (US EPA, 2005) although a TBC guidance concentration of 24.5 µg/L has been recommended (USEPA, 2006). However, several states have identified advisory levels that range in concentration from 1 µg/L to 52 µg/L. Specifically, the State of Maryland, location of the demonstration site, has identified an advisory level of 1 µg/L for groundwater (ITRC, 2005). The State of Maryland does not have a surface water standard for perchlorate[1].

1.4 Stakeholder/End-User Issues

An overall objective of this project is to produce a protocol that can be used by scientists and engineers as a guide to implement the MNA of perchlorate as a remedial strategy. Demonstrating MNA of perchlorate may be difficult because of large plume areas, poorly defined source areas, and absence of easily monitored degradation products.

[1] Personal communication from John McGillen, Maryland Department of the Environment, to M. Tony Lieberman, Solutions-IES, January 26, 2006.

The technical demonstration at the selected site in Indian Head, MD will allow Solutions-IES to test in the field the lines of evidence identified during the site selection process. Assuming that the demonstration is successful and the lines of evidence evaluated are useful, stakeholders such as local regulators and the general public will gain confidence that MNA of perchlorate is an effective remediation option to implement while protecting the public welfare and environmental health.

End-users may include regulators and consultants who will rely on the protocol that will be supported by the technical demonstration. The protocol will provide end-users with guidance for designing monitoring well networks in locations to optimize gathering useful information about plume movement and attenuation. The protocol will also present guidance for obtaining appropriate analytical data from the site and evaluating the data to understand its meaning with regard to indicating if MNA of perchlorate is the best remedial strategy in whole or in part for the site in question.

2.0 Technology Description

2.1 Technology Development and Application

Currently, Solutions-IES is developing lines of evidence for the MNA of perchlorate that could ultimately be used in a protocol to guide scientists and engineers when they implement the technology. A goal of the demonstration is to test these lines of evidence in the field to verify if they will be adequate for use in the protocol.

Some lines of evidence that we will evaluate during the technical demonstration include:

- Using existing and new monitoring wells to determine the horizontal and vertical distribution of perchlorate and mass flux with distance;
- Observe changes in groundwater bio-geochemistry as supporting evidence for attenuation;
- Confirm and obtain additional microbiological evidence for the *in situ* activity of perchlorate-degrading organisms using an analysis for CD and *in situ* biodegradation study results; and
- Identify changes in isotopic composition of perchlorate as an indicator of biodegradation.

2.2 Previous Testing of the Technology

MNA of perchlorate has not been tested in the field. However, as discussed in Section 1.1, laboratory studies have shown that perchlorate-reducing organisms are widespread in the environment and can use a variety of different organic substrates. One objective of the demonstration is to evaluate which characteristics of perchlorate attenuation that have been tested in the laboratory apply to field sites where perchlorate MNA may be applied.

2.3 Factors Affecting Cost and Performance

The primary capital costs associated with implementing a MNA groundwater strategy associated with chlorinated solvents or petroleum fuels is the installation of a well network to monitor the progress of natural attenuation of the respective constituents. The costs of installing the well network are affected by the subsurface lithology, the depth to groundwater, and the vertical extent of contamination. These same factors will influence the cost of the MNA of perchlorate.

We are also investigating the use of innovative indicator parameters to help identify perchlorate biodegradation, and these will be used during the technical demonstration. These indicator parameters include CD enzyme analysis and stable isotope studies. Using these parameters to identify perchlorate biodegradation will have significant impact on the cost of the technical demonstration, and the frequency that they are used at field sites will have a significant impact to cost where MNA of perchlorate is implemented as a remedy.

Another factor that will effect cost in the technical demonstration and eventually at field sites will be the cost of perchlorate analysis using EPA Method 330 where ion chromatography (IC) is used in tandem with a mass spectrometer detector (MS) in lieu of perchlorate analysis via Method 314, which relies on IC alone. Currently, Solutions-IES expects to collect a large number of samples for perchlorate analysis during the field demonstration and confirm the results of 10% of those samples with IC/MS/MS method. If EPA Method 330 is eventually required for all perchlorate analysis in the perchlorate MNA protocol, it could represent a significant increase in cost to implement the MNA of perchlorate at field sites.

The cost of an MNA project is also influenced by the rate of biodegradation of the contaminant of concern, and the mechanical aspects of attenuation such as dilution and dispersion. It is anticipated that these same factors will influence the cost of implementing a MNA strategy because they will affect the length of time required to monitor a site (i.e., the slower the rate of biodegradation the longer the monitoring time and the higher the cost).

2.4 Advantages and Limitations of the Technology

2.4.1 Advantages of MNA of Perchlorate

The primary advantages of MNA of perchlorate:

- No remediation equipment
- Lower capital costs
- Low maintenance cost
- No artificial impact to groundwater geochemistry and biology

2.4.2 Limitations of MNA of Perchlorate

The use of MNA for perchlorate may be limited by hydrogeology, groundwater geochemistry, high contaminant concentrations, microbiology, and location of receptors.

2.4.2.1 Hydrogeology

An important part of implementing an MNA remedy is to identify the groundwater flow characteristics and the fate and transport of the contaminant of interest. At sites where hydrogeology is not well understood, it may not be possible to accurately determine the transport mechanisms of perchlorate or its fate in the environment. For example, in a strongly heterogeneous aquifer, it may be difficult to determine whether perchlorate has degraded or if it has been transported to another part of the aquifer system. At the Indian Head site, the hydrogeology should not prevent a clear understanding of the fate and transport of perchlorate. Based on current information, the site geology is fairly consistent with a mixed layer of a clay, silt, sand to a depth of approximately 15 to 16 feet below ground surface (ft bgs), resting upon a layer of gravel, silt, sand mixture less than 2 feet in thickness, resting upon a grey clay confining unit.

2.4.2.2 Groundwater Geochemistry

Perchlorate is known to biodegrade anaerobically, so depletion of dissolved oxygen (DO) and nitrate may be required prior to perchlorate biodegradation. Therefore, high concentrations of DO and nitrate coupled with low concentrations of total organic carbon (TOC) could inhibit biodegradation of perchlorate.

Recent DO concentrations measured at the Indian Head site range from 0.1 to 7.0 ppm; therefore, DO concentrations are not optimal, at all locations, since DO concentrations greater that 2.0 ppm are expected to inhibit perchlorate biodegradation. However, nitrate concentrations are low at the Indian Head site and would not expected to inhibit perchlorate biodegradation.

2.4.2.3 Commercialization of the Chlorite Dismutase Enzyme Assay

Available information indicates that the CD enzyme is only present in organisms that are actively reducing perchlorate or chlorate. As a consequence, detection of the CD enzyme should provide a direct indication that perchlorate is being degraded under *in situ* conditions, and therefore, use of the enzyme assay would provide another tool to evaluate the potential for MNA of perchlorate. Until recently, methods to detect the presence of the CD enzyme have been available on a limited basis.

During the site selection process previously performed for this project, Solutions-IES evaluated two methods under development. Sediment samples were sent to Dr. John Coates at the University of California-Berkeley, and some were split with Microbial Insights, Inc. in Rockford, TN. Initially, Dr. Coates employed a simple, relatively inexpensive immunoassay to measure RNA activity. However, the test was subject to matrix interference and the results proved generally inconsistent and unreliable. Microbial Insights used a DNA-based assay to determine the presence of the functional gene for chlorite dismutase in the sample matrices. Results from this approach determined if organisms with the genetic potential to degrade perchlorate were present or absent in the groundwater sample provided. However, presence of the organisms alone does not indicate that the bacteria are alive and metabolically active or expressing a particular function.

Concurrent with our site selection activities, both Dr. Coates and Microbial Insights were also working to develop and refine a more reliable RNA-based assay to directly identify perchlorate-reducing activity. While these prototype methods were available during the site selection process on a limited basis, neither was completely ready for commercialization at that time, and the prototype methods were used on a limited basis by Solutions-IES during the site selection phase of the project. However, recently Microbial Insights has completed development of an RNA-based test to identify the expression of a CD gene. Using this approach, RNA, as opposed to DNA, is extracted from the microbial population in the groundwater sample. The RNA is then subject to electrophoresis and the resultant protein band signature is compared with the RNA of known perchlorate-reducing microorganisms. The RNA is used to determine the expression of a particular functional gene based upon the abundance of messenger RNA (mRNA). The perchlorate reducing microorganisms use the mRNA to assemble the CD enzyme, and its

abundance in the groundwater sample is a direct indication of enzyme activity and, therefore, the active biodegradation of perchlorate.

The mRNA approach is now commercially available from Microbial Insights. Solutions-IES intends to use this method as part of the monitoring program for the field demonstrations that are being planned. However, the RNA approach is still relatively new, and if problems with the analytical method are recognized during our technical demonstration, identifying perchlorate biodegradation would be more difficult, and therefore proving the MNA of perchlorate might be less convincing.

2.4.2.4 Cleanup Objectives

The use of MNA as a remedial strategy at some sites may be limited to relatively low concentrations of perchlorate. High concentrations would likely require active treatment. In addition, the use of MNA may require a long period of monitoring before perchlorate concentrations are less than remediation goals, so in cases where cleanup goals must be met very quickly because of the use of the property or because of potential receptors, MNA of perchlorate may not be an appropriate strategy for the site.

At the Indian Head site, the regulatory pressure to implement a remedy is not evident at the current time, but that may change as the State of Maryland identifies a remedial goal for perchlorate. After the technical demonstration, the Navy may have the information necessary to show that MNA for perchlorate can be applied as a remedial strategy at the Indian Head site.

3.0 Demonstration Design

3.1 Performance Objectives

The overall objective of this demonstration project is to evaluate MNA for remediating perchlorate in groundwater. The performance will be evaluated by monitoring changes in perchlorate concentrations, mass flux, and plume stability. In addition, Solutions-IES will evaluate innovative tools that can be used to determine if biodegradation is occurring and at what rates. The performance objectives are summarized in **Table 3-1** and the performance criteria are discussed in Section 4.0.

Table 3-1
Performance Objectives

Type of Performance Objective	Primary Performance Criteria	Expected Performance (Metric)	Actual Performance (Objective Met?)
Qualitative	1. Reduce risk	Reduce concentrations and mass flux of perchlorate during downgradient migration.	
	2. Capital costs	**Capital costs are significantly lower than active remedial alternatives.**	
	3. Maintenance	Maintenance costs are low and are typical of those associated with maintaining a monitoring well network.	
	4. Uncomplicated implementation	Implementation is similar to that of a typical monitoring program.	
	5. Regulatory acceptance	MNA approach is generally accepted by regulatory community, with conditions.	
	6. Monitoring approach	Monitoring approach is consistent with current industry practice. Results are easy to understand and interpret.	
Quantitative	1. Reduce perchlorate concentrations	> 90% reduction in average perchlorate concentration in wells downgradient of the probable source area.	
	2. Reduce mass flux of perchlorate	Reduce mass flux of perchlorate by >75% between source area and the most downgradient line of monitor wells.	
	3. Multiple lines of evidence	Two or more lines of evidence support perchlorate attenuation.	
	4. Stable isotope ratios	Observe statistically significant change in isotopic ratio of perchlorate during downgradient migration.	
	5. Enzyme activity	RNA levels of perchlorate degraders are elevated at some locations in the plume relative to background locations.	
	6. Meet regulatory standards	Perchlorate concentrations are below regulatory levels at compliance point.	

3.2 Site Selection for Demonstration

To identify sites for participation in the perchlorate MNA project, three levels of site evaluation were conducted. The first level of site identification (Screening Level 1) was performed in the office and involved gathering information from as many sites across the United States as possible. The second level of site identification (Screening Level 2) included reviewing the gathered information, and selecting up to seven sites for initial and comparative field characterization. The third level of screening (Screening Level 3) included actual collection and analysis of samples from the selected field sites, use of microcosm tests to examine degradation under ambient and augmented conditions, and testing innovative measures of enzyme activity to assist in identifying microbial activity on perchlorate. For a detailed description of the site evaluation process, please refer to the Site Selection Memorandum dated September 20, 2005.

Subsequent to the field work performed during Screening Level 3, a scoring system was devised to assist in the evaluation of the seven sites of interest for technical demonstration. In similar fashion to the Bioscreen model for evaluating the MNA of CVOCs, (AFCEE, 1996), a variety of parameters were assigned scores based on the likelihood that each criterion would be conducive to natural attenuation and a successful technical demonstration. Several criteria were scored including, but not limited to, field parameters such as pH and oxidation-reduction potential (ORP), total organic carbon (TOC) concentration, percent perchlorate removal estimated by microcosm studies, CD analytical results, and long term biological oxygen demand (BOD) studies.

Several additional criteria were also factored into the evaluation. These included site logistics like accessibility, weather, presence of unexploded ordnance, and terrain. Additional criteria included depth and type of drilling required, which relates to cost, and interest of the base managers in supporting the project at their site. The scores were totaled and the site with the highest total score was located at Building 1419 (Indian Head site) at Indian Head, MD. The Indian Head site was selected for technical demonstration and approved by ESTCP in a conference call on October 12, 2005

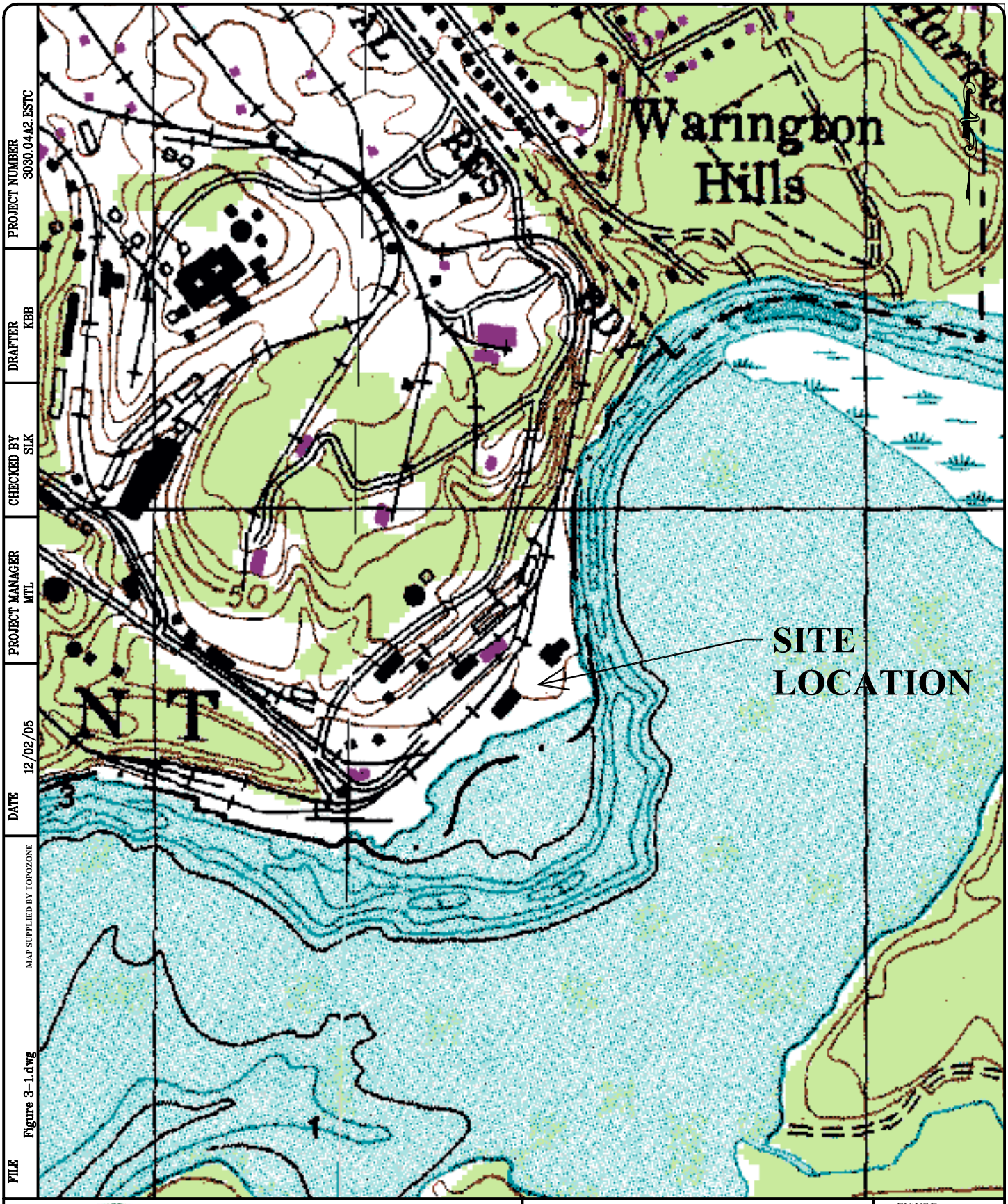
3.3 Test Site History/Characteristics

During preliminary work at Indian Head, Mr. Randall Cramer was identified as the site contact for the Indian Head site. The following report prepared by Randall J. Cramer and Cary Yates, Indian Head Division (IHDIV) and Paul Hatzinger and Jay Diebold of Shaw Environmental, Inc. (Shaw) was used as the primary source of historical information about the site.

> Randall J. Cramer and Cary Yates, Indian Head Division, Naval Surface Warfare Center and Paul Hatzinger and Jay Diebold of Shaw Environmental, Inc., *Field Demonstration of In Situ Perchlorate Bioremediation at Building 1419*, January, 2004 (Cramer *et al.*, 2004).

3.3.1 Test Site History and Description

The technical demonstration site is located at the Indian Head Division (IHDIV), Naval Surface Warfare Center, near Indian Head in Charles County, Maryland, and is located approximately 30 miles south of Washington, DC (**Figure 3-1**). The Indian Head site is also referred to as the Building 1419 site, and is located on the southeast side of the IHDIV facility. The Indian Head site consists of approximately 2 acres of grassy land containing a small drum storage building and numerous groundwater monitoring, injection, and extraction wells. The area is bordered to the southeast by Mattawoman Creek (**Figure 3-2**), which is a large tributary to the Potomac River. Building 1419 is used to clean out or "hog out" solid propellant containing ammonium perchlorate from various devices, including rockets and ejection seat



PROJECT NUMBER	3030.04A2.ESTC
DRAFTER	KBB
CHECKED BY	SLK
PROJECT MANAGER	MTL
DATE	12/02/05
	MAP SUPPLIED BY TOPOZONE
FILE	Figure 3-1.dwg

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TOPOGRAPHIC SITE MAP
INDIAN HEAD SITE
INDIAN HEAD NAVAL WARFARE CENTER
INDIAN HEAD, MARYLAND

FIGURE:

3-1

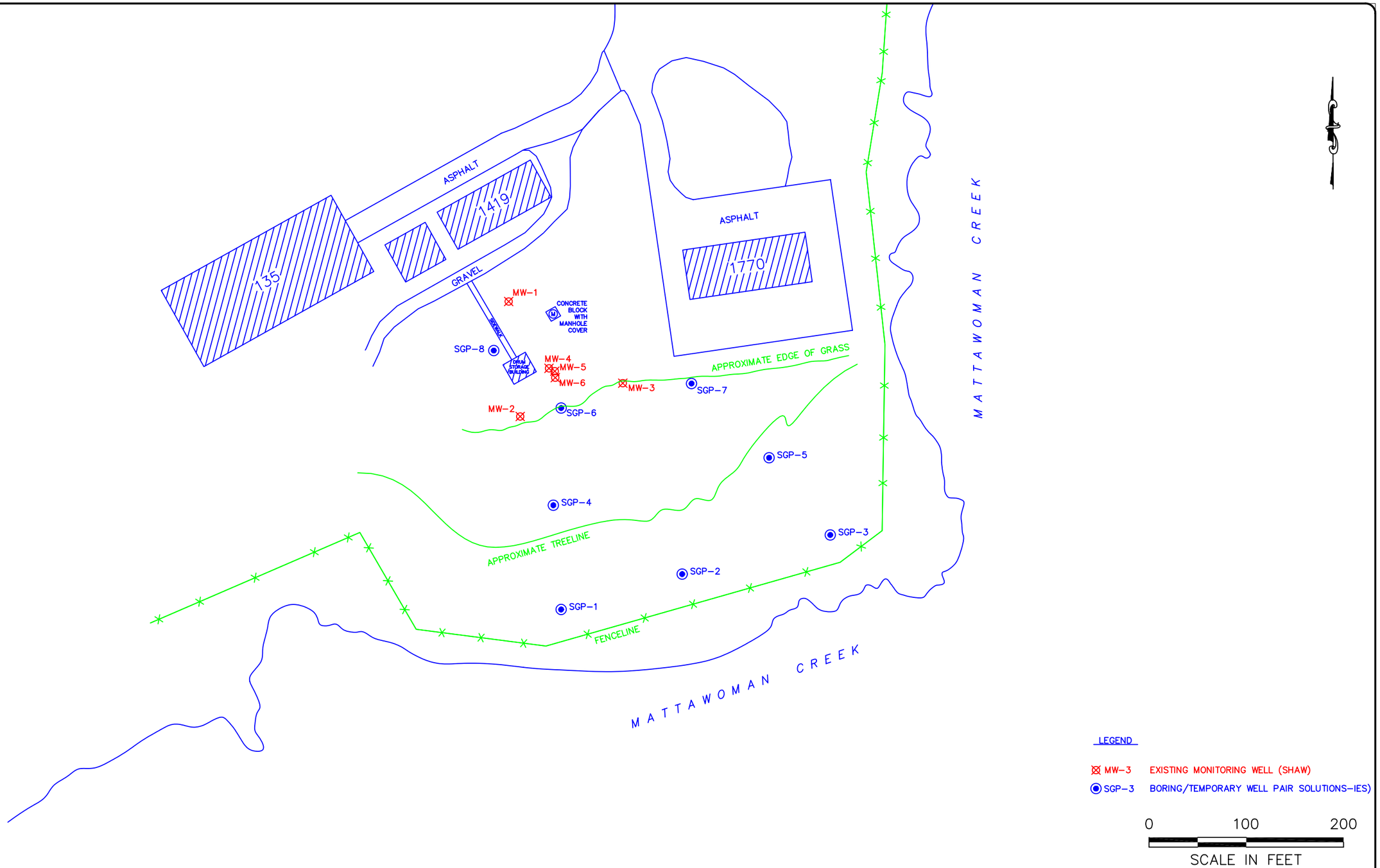

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Figure 3-2.dwg (Base Map)	11/29/05	SLK	SLK	KBB	3030.04A2.ESTC

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SITE MAP AND WELL PAIR LOCATION MAP
INDIAN HEAD SITE
INDIAN HEAD NAVAL WARFARE CENTER
INDIAN HEAD, MARYLAND

FIGURE:
3-2

motors, that have exceeded their useful life span. The hog out process and former waste handling methods have impacted the groundwater near Building 1419.

3.3.2 Historical Site Activities, Geology, and Hydrogeology

In 2002, Shaw performed an evaluation of enhanced *in situ* bioremediation by applying lactate substrate to impacted groundwater at the Indian Head site. A pilot system was created employing a recirculation cell design consisting of two field areas located in the immediate vicinity of monitoring wells MW-5 and MW-6. In the test area around MW-5, groundwater was extracted from the site, amended with a lactate substrate and a pH buffer, and then re-injected into the aquifer. Groundwater was extracted and re-injected without substrate or buffer amendment in the control area near MW-6. Each Shaw pilot test cell (test area and control area) covered an area measuring approximately 10 X 10 ft (100 sq. ft.) in the middle of the filled area south of the hog-out facility (**Appendix I**, Figure A).

The study area used by Shaw for their pilot test is located southeast of Building 1419 and approximately 350 feet northwest of Mattawoman Creek. The surficial geology of the area was derived from soil samples collected from 17 Geoprobe® borings and six test borings that ranged in depth from 16 to 20 feet bgs. The top 2 to 4 feet consisted of fill material including organic soils, gravel, and silty sand (Cramer *et al.,* 2004). The underlying 11 to 13 feet consisted of mottled light to olive brown clay to sandy silts. The clay and sand fractions of the silts varied horizontally and vertically. Fine-grained sand seams 1 to 2 inches in thickness were seen in many of the boring locations, but these seams were not continuous from boring to boring. At a depth of approximately 15 ft bgs, a 1 to 1.5 ft thick layer of sand and gravel was encountered. This layer was found to be continuous throughout the area. The sand and gravel layer is underlain by a gray clay layer, which extends to a depth of at least 20 feet bgs, the deepest extent of the Geoprobe® and test borings (**Appendix I**, Figures B, C, D). This is likely the clays of the Potomac Group.

Groundwater elevations measured in the six monitoring wells in the field indicate a groundwater flow direction to the southeast toward the Mattawoman Creek (Appendix I, Figure E). The flow direction basically follows the surface topography. Depth to groundwater ranged from approximately 6.5 to 10.3 ft bgs. The average hydraulic gradient, as measured between wells MW-1 and MW-3, was 0.023 ft/ft, indicating a relatively flat gradient. Appendix I, Figure F shows an interpretation of the 100 mg/L perchlorate isoconcentration contour from the January 2004 report. Based on historical information, the plume extends from Building 1419 to the southeast, but neither the distal end nor the lateral extent of the perchlorate migration is estimated. Pre-demonstration work was performed to update the information concerning the perchlorate concentrations downgradient at this test area. That work is discussed in greater detail in Section 3.5.

To obtain additional information for the site-selection process, Solutions-IES traveled to the site on February 14, 2005 to collect soil and groundwater samples. Monitoring well MW-1 is located about 80 feet upgradient from the Shaw pilot test cells, MW-2 is located approximately 50 ft southwest of the test cells, and MW-4 is located at the north edge of the control treatment cell (**Figure 3-2**). Groundwater samples were collected from these existing monitoring wells using a peristaltic pump and polyethylene tubing. Field parameters were collected during low flow sampling at each monitoring well. **Table 3-2** summarizes field parameters collected during the groundwater sampling activities at each monitoring well. The table also summarizes the perchlorate concentration detected in each groundwater sample.

Table 3-2 Groundwater Characterization in Selected Monitoring Wells, February 14, 2005 Indian Head Site, Naval Surface Warfare Center				
Monitoring Well Identification	pH (Standard Unit)	Oxidation/Reduction Potential (mV)	Dissolved Oxygen (ppm)	Perchlorate (µg/L)
MW-1	4.9	105.	~1.0	92,820
MW-2	6.9	< -1000	~3.5	3
MW-4	5.4	5.6	~8	36,263

Note: Laboratory analysis of perchlorate performed at NCSU Civil and Environmental Engineering Laboratory, Raleigh, NC

Solutions-IES returned to the site on September 28, 2005 and collected groundwater samples from existing monitoring wells MW-4D and MW-5, located within the lactate injection treatment cell of Shaw's pilot test, to measure perchlorate and TOC concentrations within the former test area (Appendix I, Figure A). The objective was to determine whether there was any long-term impact of the lactate injection treatment that was completed in 2002 that could complicate the current planned evaluation of the potential for MNA in this area. **Table 3-3** summarizes the current field parameters, the current TOC concentrations and the perchlorate concentrations reported measured during this event and those reported in 2002 for comparison.

Table 3-3 Groundwater Characterization in Selected Monitoring Wells, September 28, 2005 Indian Head Site, Naval Surface Warfare Center						
Monitoring Well Identification	pH (Standard Unit)	Oxidation/Reduction Potential (mV)	Dissolved Oxygen (ppm)	Perchlorate 2002 (µg/L)	Perchlorate 9/28/05 (µg/L)	TOC (mg/L)
MW-4D	5.5	117	4.5	181,000	38,500	2.2
MW-5	5.9	53	2.3	82,800	36,200	3.2

Note: Laboratory analysis of perchlorate on 9/28/05 samples performed at NCSU Civil and Environmental Engineering Laboratory, Raleigh, NC

Based on information gathered during the site visit and summarized in Table 3-3, perchlorate concentrations measured in September 2005 were much lower in the test area that had been treated with lactate than the concentrations reported in 2002. However, there was little indication of residual organic carbon in this area of the site and the perchlorate concentrations remain sufficiently elevated. Therefore, Solutions-IES concluded that the long-term impact from the lactate injection would not likely complicate the technical demonstration of MNA at the Indian Head site.

3.4 Present Operations

Operations at Indian Head Site 1419 remain essentially the same as described in Section 3.3.1. In summary, propellant is removed from rocket motors by water jet extraction. All wash water is contained, analyzed, and treated as hazardous waste based on the analytical results and disposed off-site under a contract. Operations at Building 1419 can also include some ordnance handling and storage.

3.5 Pre-Demonstration Testing and Analysis

3.5.1 Pre-Demonstration Testing - Probable Source Area

During a conference call with the ESTCP project review team on October 12, 2005, the Indian Head site was approved as the first of two locations for technical demonstration of the potential for the MNA of perchlorate in groundwater. As previously discussed, a portion of this same site was used for a separate ESTCP-funded demonstration of lactate injection technology. However, according to previous reporting, a complete delineation of the perchlorate plume at this site was not performed. The last full round of sampling of the wells installed as part of the earlier demonstration was performed in winter 2002. Because the perchlorate contaminant plume had not been fully assessed, particularly in the southeast direction closer to Mattawoman Creek, pre-demonstration work was performed to accomplish this task prior to completing the Technology Demonstration Plan.

The pre-demonstration assessment work was performed during the second week of November 2005. Borings were advanced upgradient, cross-gradient, and downgradient of the probable source area (**Figure 3-2**). The Site-Specific Workplan that was implemented is included in **Appendix II**. The borings were advanced in pairs. The initial boring at each location was terminated approximately 1 to 2 inches within the clay layer (Potomac Group) located approximately 16 ft bgs. The second boring of each pair was placed approximately 2 feet from the initial boring and advanced to a total depth of 13 ft bgs. The soil profile from the initial deeper boring was continuously logged. Boring logs are provided in **Appendix III**. Each boring was then converted to 1-inch diameter PVC temporary well with a fine-filter sand packing surrounding the screen, a bentonite seal to the surface, and a PVC slip cap.

Based on the latest soil sampling activities, the geology in the study area is composed of a gray clay overlain by sandy silt to clayey silt with discontinuous fine sand seams, sand and gravel lenses with fines (**Figures 3-3, 3-4 and 3-5**). This is indicative of an urbanized fluvial depositional environment. The current riverbed runs north-south to the east of the study area. The predominant sediment type is a 10 to 15 foot thick section of sandy silt to clayey silt resting upon a gray, clay confining unit. This information is similar to the lithology described in the Shaw report (Cramer *et al.*, 2004). Historical cross-sections are provided in Appendix I for comparison.

The total well depths ranged from 13 to 16 ft bgs. The well in the initial boring was installed to a total depth of approximately 16 ft bgs with a 2-ft length of screen (14 to 16 ft bgs). The depth of this screen interval was designed to transect the gravel/sand layer, if present**.** The second well in the boring pair was installed to a total depth of approximately 13 ft bgs with a 5-foot length of screen (~8 to 13 ft bgs), which was designed to transect sandy silt/clayey silt layer expected to be present a depths less than 13 ft bgs. The bottom of the screened interval in the second, shallower well was positioned at least one foot above the top of the screen interval in the deeper, first well of each pair. The 5-ft screen interval in the shallower well was intended to screen across suspected sand stringers that may be present in the upper zone. For detailed information regarding the advancement of borings using the Geoprobe®, or well installation, see **Appendix IV**.

Groundwater samples were also collected from each of the temporary wells and the existing monitoring wells (MW-1, MW-2, MW-3, MW-4, MW-5, MW-6). In addition, specific capacity tests were performed on control plot monitoring well (CPMW)–2S and CPMW-2D (Appendix I) installed by Shaw, and Solutions-IES Geoprobe® (SGP)-6S and SGP-6D installed by Solutions-IES (**Figure 3-2**). Based on groundwater elevations measured in old and new wells during the recent mobilization, the groundwater flow direction is to the southeast toward the Mattawoman Creek (**Figure 3-6**). The flow direction

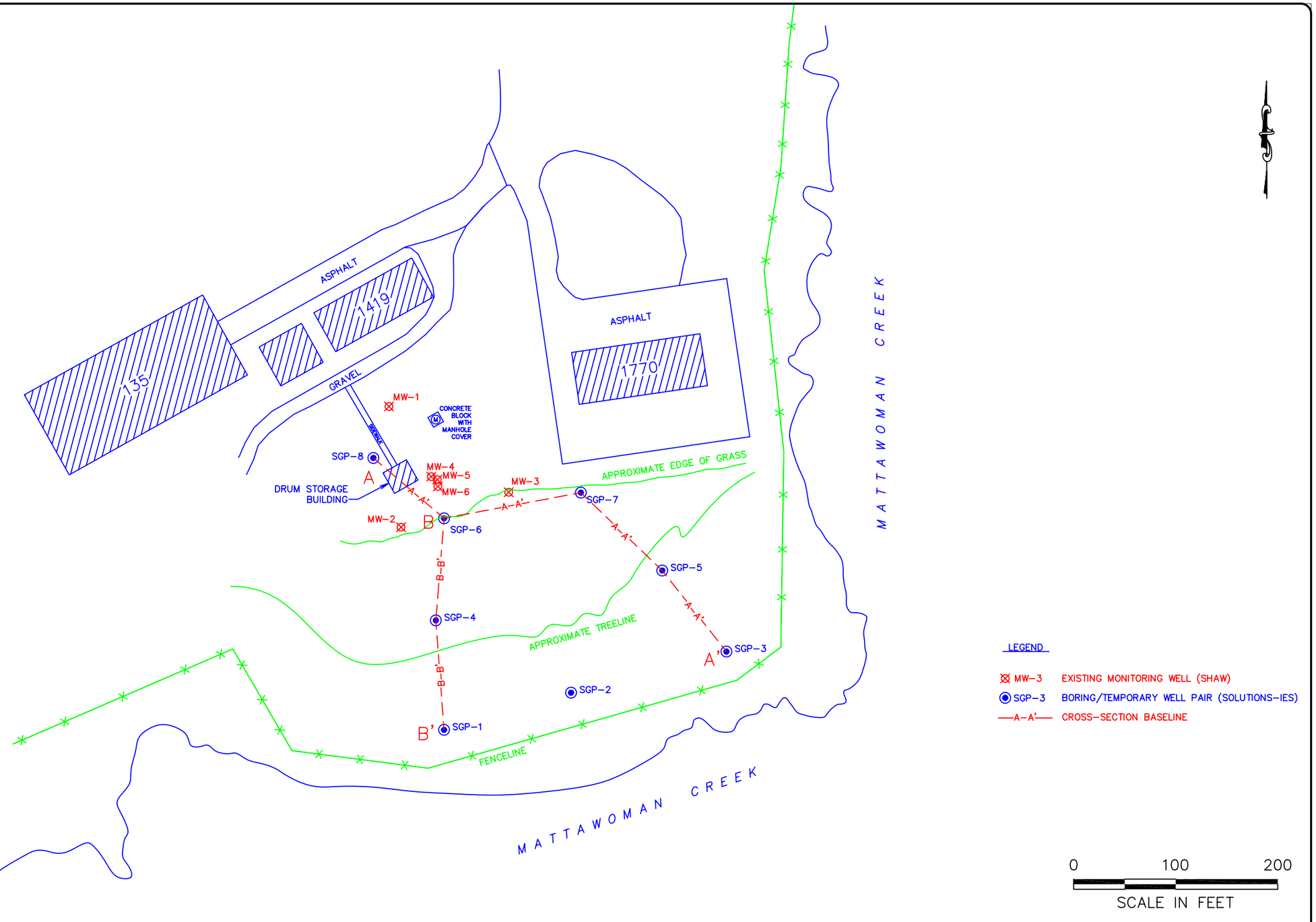

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Figure 3-3.dwg	11/29/05	SLK	SLK	KBB	3030.04A2.ESTC

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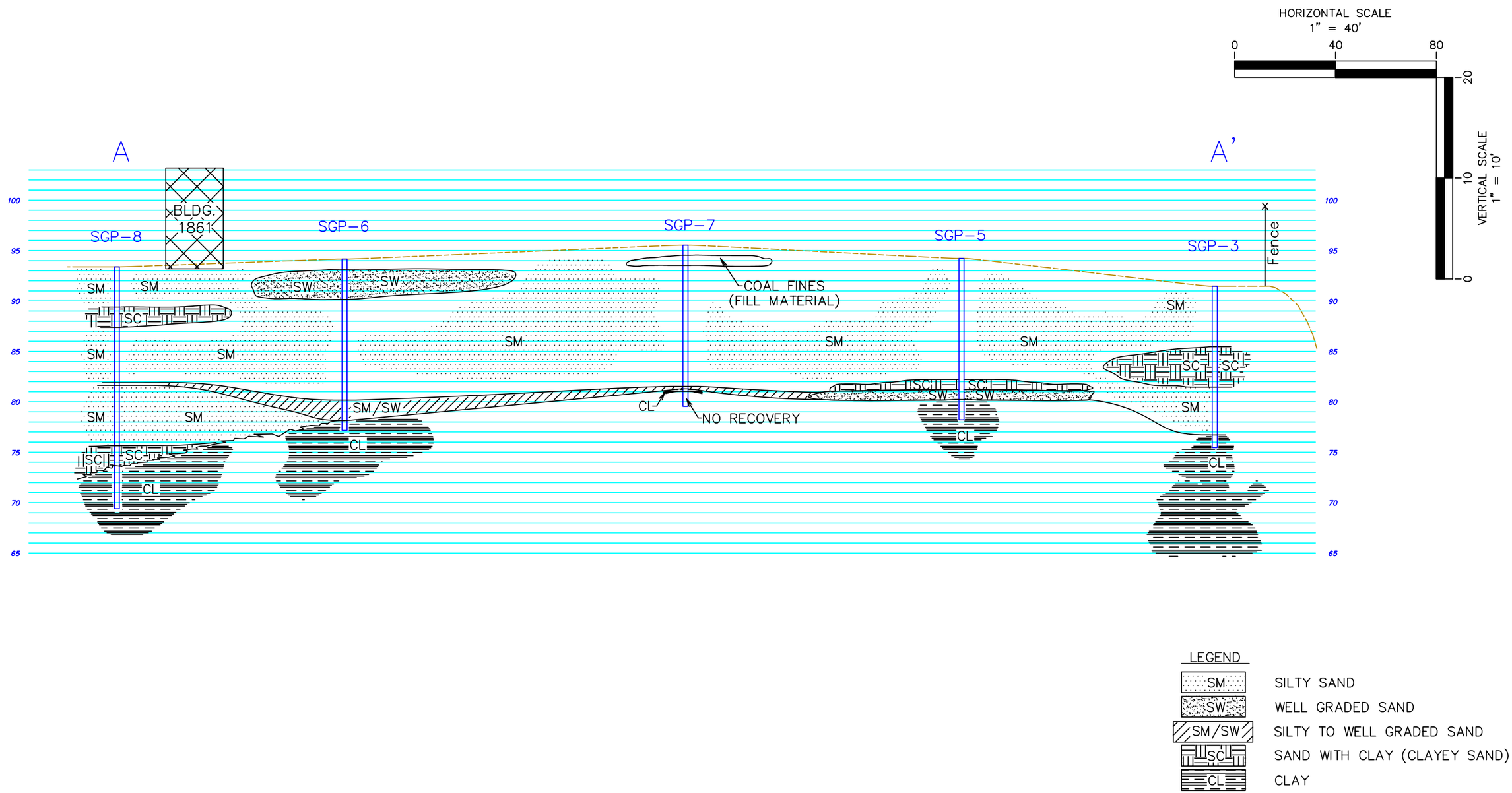
CROSS-SECTION LOCATIONS

INDIAN HEAD SITE
INDIAN HEAD NAVAL WARFARE CENTER
INDIAN HEAD, MARYLAND

FIGURE: 3-3



PROJECT NUMBER	3030.04A2.ESTC
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DATE	11/29/05
FILE	Figure 3-4.dwg

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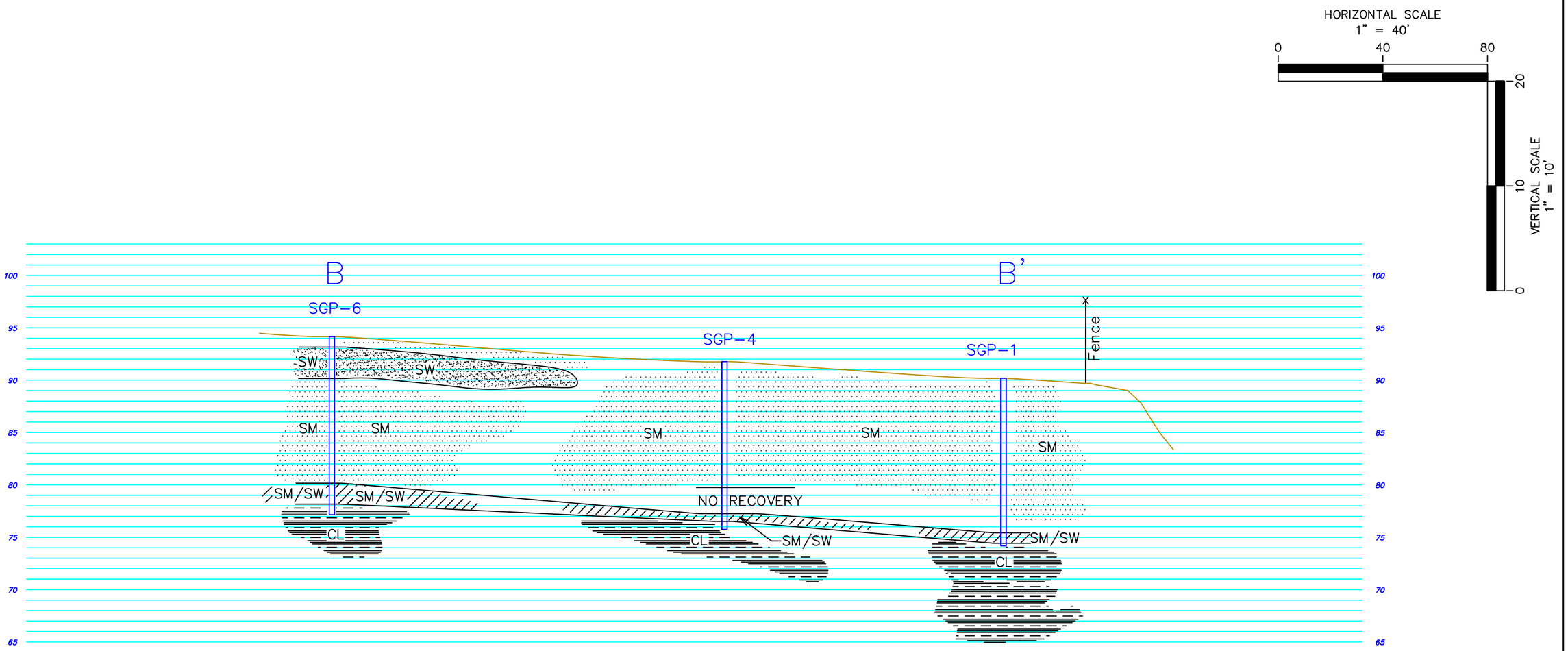
GEOLOGIC CROSS-SECTION A – A'

INDIAN HEAD SITE
INDIAN HEAD NAVAL WARFARE CENTER
INDIAN HEAD, MARYLAND

FIGURE:
3-4



LEGEND

SM	SILTY SAND
SW	WELL GRADED SAND
SM/SW	SILTY TO WELL GRADED SAND
CL	CLAY

FILE	Figure 3-5.dwg
DATE	12/15/05
PROJECT MANAGER	SLK
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PROJECT NUMBER	3030.04A2.ESTC

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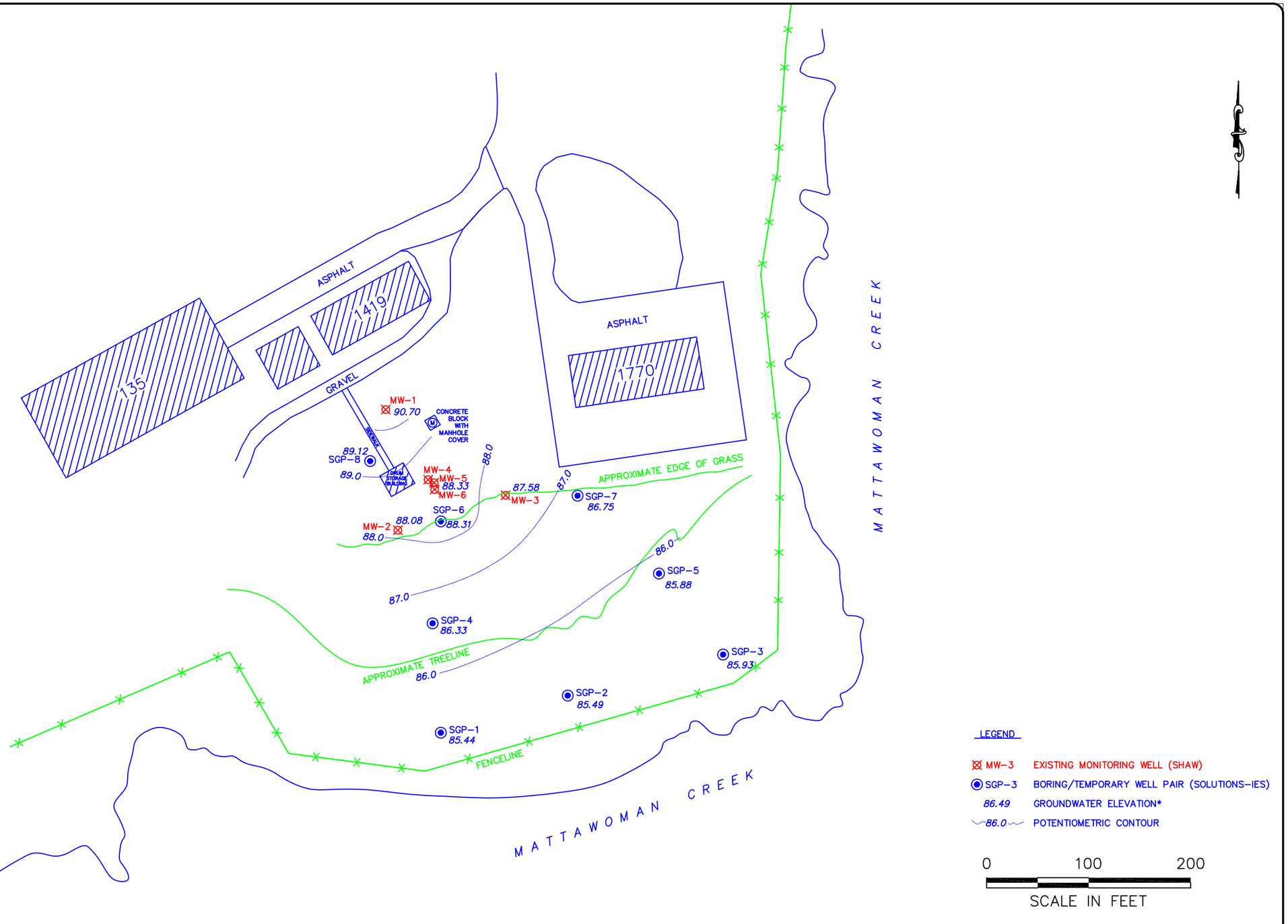
GEOLOGIC CROSS-SECTION B – B'

INDIAN HEAD SITE
INDIAN HEAD NAVAL WARFARE CENTER
INDIAN HEAD, MARYLAND

FIGURE:
3-5



FILE	DATE	PROJECT MANAGER	CHECKED BY	DRAFTER	PROJECT NUMBER
Indian Head Base.dwg	11/29/05	SLK	SLK	KBB	3030.04A2.ESTC

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* GROUNDWATER ELEVATION CALCULATED FROM TOP-OF-CASING ELEVATIONS BASED ON PREVIOUS SURVEY USING ASSUMED BENCHMARK.

GROUNDWATER POTENTIOMETRIC SURFACE MAP – SHALLOW WELLS
NOVEMBER, 2005
INDIAN HEAD SITE
INDIAN HEAD NAVAL WARFARE CENTER
INDIAN HEAD, MARYLAND

FIGURE:
3-6

basically follows the surface topography. Depth to groundwater ranged from approximately 6 to 10 ft bgs.

3.5.2 Test Site Characterization

Groundwater samples were obtained using standard collection equipment such as pumps/tubing. **Appendix IV** identifies the collection protocol specific to the Indian Head site and details for groundwater sampling**.** The groundwater samples were collected from the existing and new monitoring wells and analyzed according to the methods described in the following table:

Table 3-4
Sample Collection and Analysis Details
Indian Head Site, Naval Surface Warfare Center

Target Constituent	**Dissolved Oxygen (DO)**	**Methane[a]**	**Perchlorate[b]**	**Chloride, Nitrate, Nitrite, Sulfate, Phosphate[c]**	**Total Organic - Carbon[a]**
Method	Chemetrics	Method 8015M	Method 314.0	Method 9056	Method 9060

a. Methane and Total Organic Carbon analyses performed by Environmental Science Corp., Mt. Juliet, YN.
b. Perchlorate laboratory analysis (Method 314.0) performed by Columbia Analytical Services, Kelso, WA
c. Laboraotry analysis performed at NCSU Civil and Environmental Engineering Laboratory, Raleigh, NC

All water samples planned for laboratory analysis were labeled, packed on ice and shipped to the appropriate laboratory for overnight delivery. Laboratory results from field sampling activities are summarized below.

Table 3-5 Groundwater Characterization, November 15 and 16, 2005 Indian Head Site, Naval Surface Warfare Center							
		Target Constituent					
Monitoring Well Indentification		DO (ppm)	pH (Standard Unit	Methane (mg/L)	Perchlorate (µg/L)	Nitrate (mg/L)	TOC (mg/L)
MW-1		0.2	5.46	<0.01	24,200	136	2.2
MW-2		0.5	7.14	<0.01	16.4	3	5.2
MW-3		2 to 3	3.81	<0.01	9,240	1	2.4
MW-4		0.1	4.96	0.042	26,400	2	2.8
MW-5		0.1	3.79	0.027	16,500	2	3.5
SGP-1	Shallow	2.5	4.92	<0.01	2,610	<0.5	1.6
	Deep	4	5.39	<0.01	2,660	1	1.8
SGP-2	Shallow	1	4.65	0.059	12,800	1	1.2
	Deep	NR	4.81	0.23	12,300	<0.5	8
SGP-3	Shallow	5 to 6	5.46	<0.01	22.8	<0.5	1.3
	Deep	5 to 6	4.30	<0.01	80	1	<1.0
SGP-4	Shallow	7	10.75	<0.01	346	6	15
	Deep	8 to 10	7.78	<0.01	5,730	1.4	2.2
SGP-5	Shallow	7	5.43	<0.01	231	1	2.6
	Deep	2	3.71	<0.01	316	2	1.5
SGP-6	Shallow	5	6.62	0.083	17,800	3	3.1
	Deep	2 to 3	6.35	1.1	16,900	<0.5	29
SGP-7	Shallow	4 to 5	5.49	<0.01	40	3	3.5
	Deep	3 to 4	3.96	<0.01	41	<0.5	9.2
SGP-8	Shallow	2 to 3	4.69	0.011	27,900	8	2.1
	Deep	2	6.28	<0.01	26,800	5	3.4

The analytical results from the pre-demonstration characterization are summarized on **Table 3-5**. The laboratory analytical reports are provided in **Appendix VII**. Based on these results, the geometry of the shallow perchlorate plume (**Figure 3-7**) and deep perchlorate plume (**Figure 3-8**) appears to follow the generalized groundwater flow direction, but is still not fully delineated. In addition, the plume does not clearly indicate a source area for the release although it is commonly acknowledged that hog-out activities at Building 1419 were the primary source. Perchlorate appears to discharge into the Mattawoman Creek at a concentration of at least 10,000 µg/L along the central axis (i.e., northwest to southeast) of the plume.

In all of the sampled locations, except SGP-4, there was no appreciable difference in perchlorate concentrations between the shallow and deep monitor well intakes. Specific capacity test results from

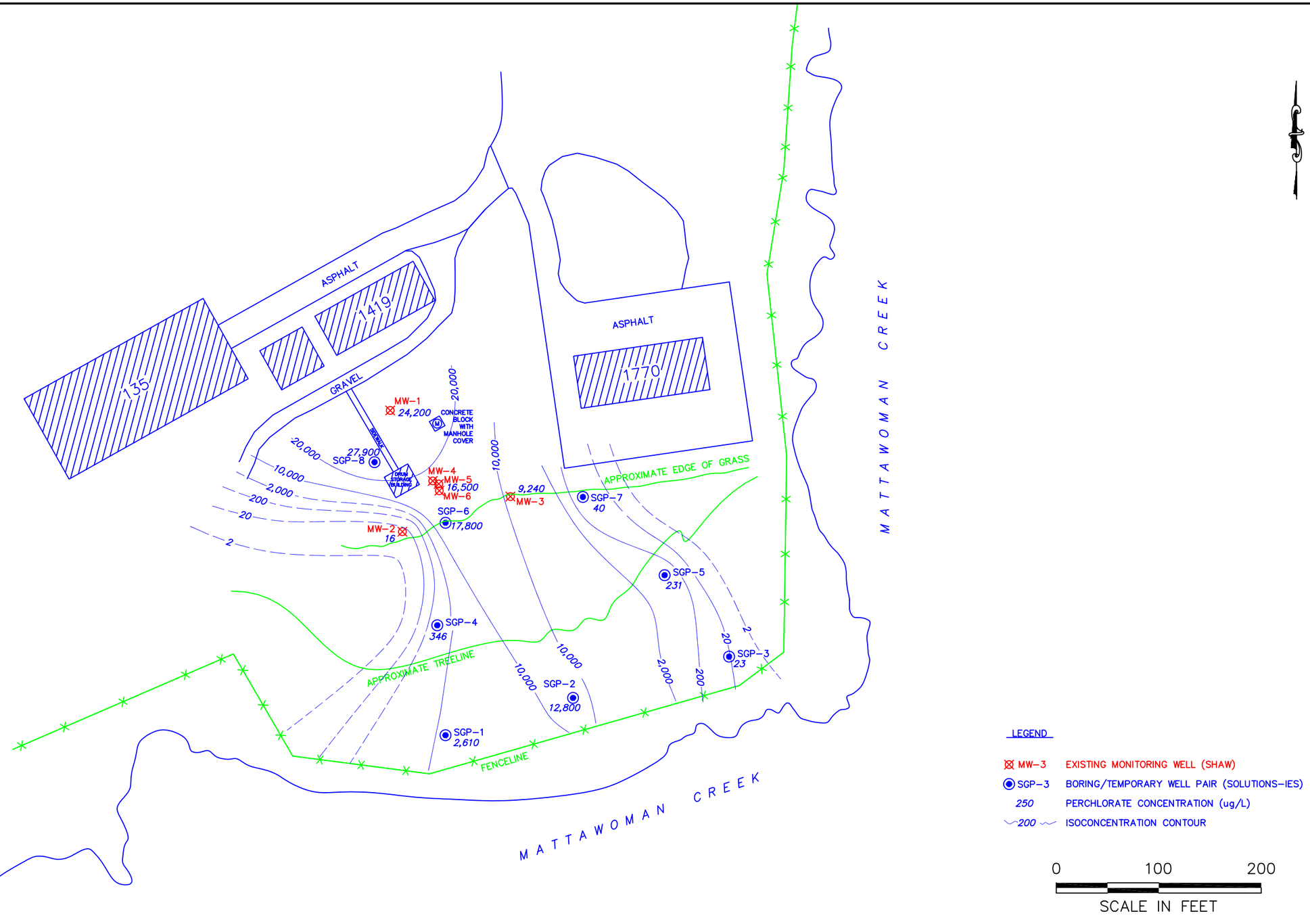

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Figure 3-7.dwg	12/08/05	SLK	SLK	KBB	3030.04A2.ESTC

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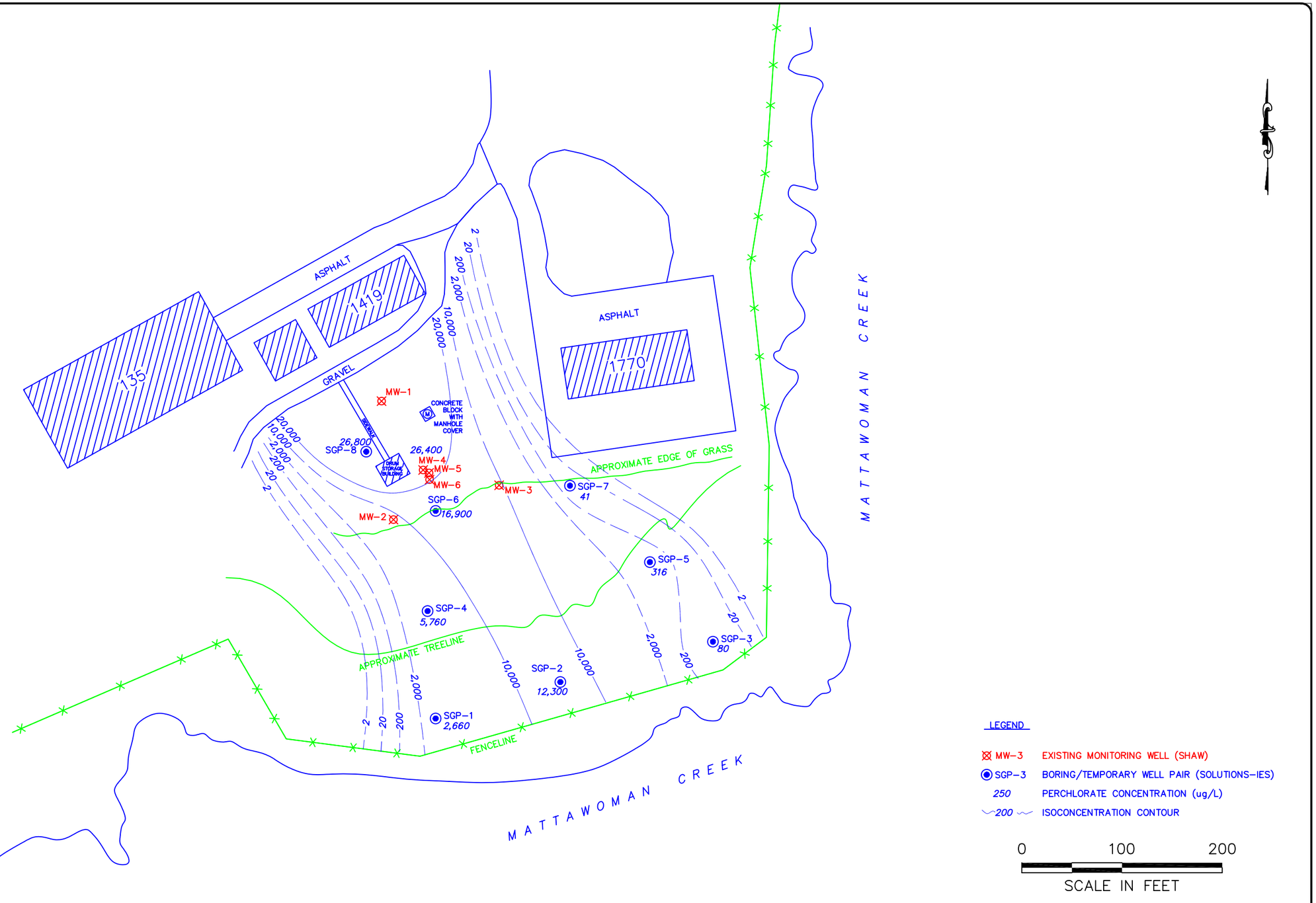
PERCHLORATE ISOCONCENTRATION MAP – SHALLOW WELLS (NOV. 2005)
INDIAN HEAD SITE
INDIAN HEAD NAVAL WARFARE CENTER
INDIAN HEAD, MARYLAND

FIGURE: 3-7



FILE	DATE	PROJECT MANAGER	CHECKED BY	DRAFTER	PROJECT NUMBER
Figure 3-8.dwg	12/08/05	SLK	SLK	KBB	3030.04A2.ESTC

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PERCHLORATE ISOCONCENTRATION MAP – DEEP WELLS (NOV. 2005)
INDIAN HEAD SITE
INDIAN HEAD NAVAL WARFARE CENTER
INDIAN HEAD, MARYLAND

FIGURE: 3-8

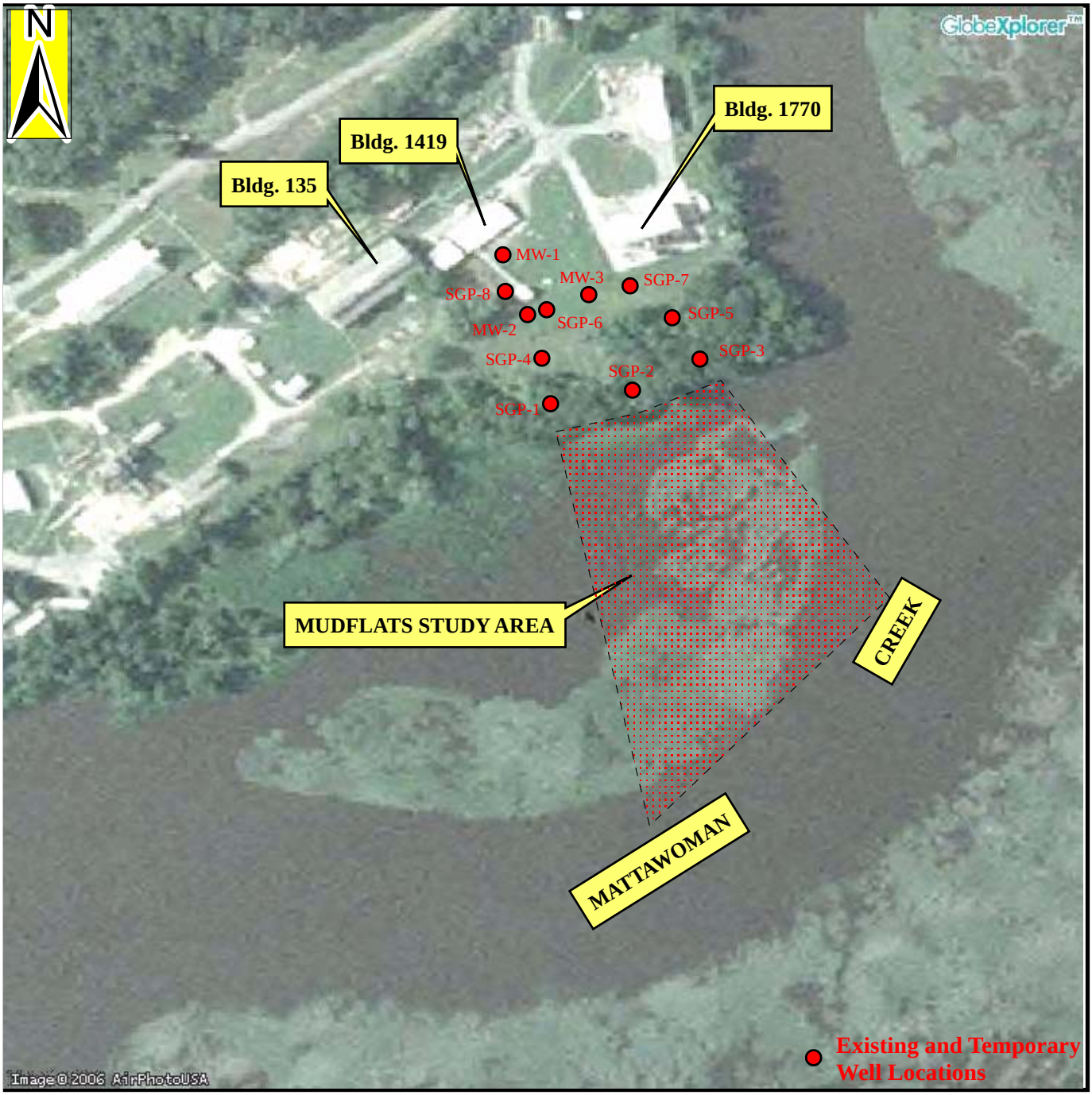
SGP-6 also indicate there is no appreciable difference in the hydraulic conductivity of the shallow zone (K = 0.49 ft/d in screened interval from 8 to 13 ft bgs) and deeper zone (K = 0.13 ft/d in screened interval from 14 to 16 ft bgs). These results indicate that a single screened interval for new monitoring wells should be sufficient to monitor contaminant concentrations and estimate the total mass flux of contaminants during the technical demonstration.

3.5.3 Pre-Demonstration Testing – Mudflats

Monitoring results from the pre-demonstration characterization suggest the perchlorate plume is discharging towards a large wetland / mudflat adjoining Mattawoman Creek. **Figure 3-9** shows the area surrounding the site and Mattawoman Creek with the extensive mudflats clearly visible extending over 400 ft from the shoreline; the mudflats study area is shaded on the figure. In this general location, the Mattawoman Creek experiences approximately a 2-foot tidal fluctuation. At high tide, the mudflats are submerged while at low tide much of the mudflat surface is exposed. We anticipate that groundwater will discharge from the underlying aquifer to the surface at low tide and surface water will enter the aquifer at high tide. The surficial sediments in the mudflats are expected to contain significant amounts of organic material which are expected to enhance perchlorate biodegradation. However, the varying groundwater flow direction in the mudflats (due to tidal fluctuations) may make it more difficult to interpret the field monitoring results.

During this portion of pre-demonstration testing, we will evaluate several conditions within the mudflats some of which include contaminant distribution, natural organic carbon distribution, effects on permeability caused by plant and animal life in the mudflats, groundwater discharge to surface water, and tidal effects. The following field activities will be performed prior to the demonstration set-up to help understand the perchlorate distribution considering these conditions and the potential for anaerobic biodegradation within the mudflat sediments:

- Collect groundwater samples via Geoprobe® Screen Point Sampler or temporary/permanent monitor wells. If necessary, use a Maryland-licensed well contractor to obtain the permits necessary from MDE and to perform this work
- Obtain a "dig permit" from IHDIV prior to collecting groundwater samples from borings advanced within the mudflat area.
- Observe conditions (tidal, biota, etc.) within the mudflats study area for up to one day prior to contractor mobilization to better identify boring locations.
- Advance up to 12 soil borings in the mudflats study area (**Figure 3-9a**) to a depth of approximately 11 ft bgs using a mechanical pile driver. Each boring should terminate two feet above the clay layer identified in previous work at the site; the depth of each boring could vary based on the depth to the clay layer encountered at each specific location. Although these samples will not be collected by a "Geoprobe", for consistency with the prior pre-demonstration activities, each boring will be identified as SGP-9 through SGP-20. The pile driver will also be used to push a split-spoon sampler or Geoprobe® Large Bore sampler to collect a soil/sediment sample in the upper and lower half of each boring for a total of two samples. Each sample will be designated according to the location and depth from which it was collected (i.e., SGP-9 2-3' or SGP-9 10-11', etc.). Depth will be measured from the sediment surface, not the surface water elevation. Each of these samples will be analyzed for TOC. Sampling procedures and analytical parameters are discussed in Section 3.6.
- A groundwater sample will be collected from each boring via a Geoprobe® Screen Point Sampler® or 1-inch temporary well. To collect the groundwater sample, the sampler or well screen will be installed to approximately 2 ft above the estimated clay interface.



Approximate Scale: 1" = 275'

AERIAL VIEW OF MUDFLATS AND
PROPOSED MUDFLATS STUDY AREA
INDIAN HEAD SITE
INDIAN HEAD NAVAL WARFARE CENTER
INDIAN HEAD, MARYLAND

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Checked by:	SLK	Date:	02/13/06
File:	FIG1.mxd		
Software:	ESRI ArcMap 9.0	FIGURE	3-9

NOTE: BORING LOCATIONS IN MUDFLATS ARE FOR PLANNING PURPOSES. ACTUAL LOCATIONS MAY CHANGE BASED ON FIELD CONDITIONS.

LEGEND

MW-3	EXISTING MONITORING WELL (SHAW)
SGP-3	EXISTING BORING/TEMPORARY WELL PAIR (NOVEMBER 2005)
	MUDFLATS STUDY AREA

FILE	DATE	PROJECT MANAGER	CHECKED BY	DRAFTER	PROJECT NUMBER
Figure 3-9X 2006.dwg	02/08/06	SLK	SLK	KBB	3030.04A2.ESTC

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0 120 240
SCALE IN FEET

PROPOSED MUDFLATS STUDY AREA
FEBRUARY 2006
INDIAN HEAD SITE
INDIAN HEAD NAVAL WARFARE CENTER
INDIAN HEAD, MARYLAND

FIGURE:
3-9A

Groundwater entering the screen will be extracted using a peristaltic pump with disposable tubing. Each groundwater sample will be designated by the location from which it was collected (i.e., SGP-9, SGP-10, etc.). Groundwater samples will be analyzed for TOC, perchlorate, chloride, nitrate, sulfate, and methane. See Section 3.6 for sampling details.

Solutions-IES will use the analytical results from pre-demonstration activities to further refine permanent monitoring well locations near the shore southeast of the probable source area and in the mudflats. If necessary, some of the temporary wells will be converted to permanent wells.

3.6 Testing and Evaluation Plan

3.6.1 Demonstration Set-Up and Start-Up

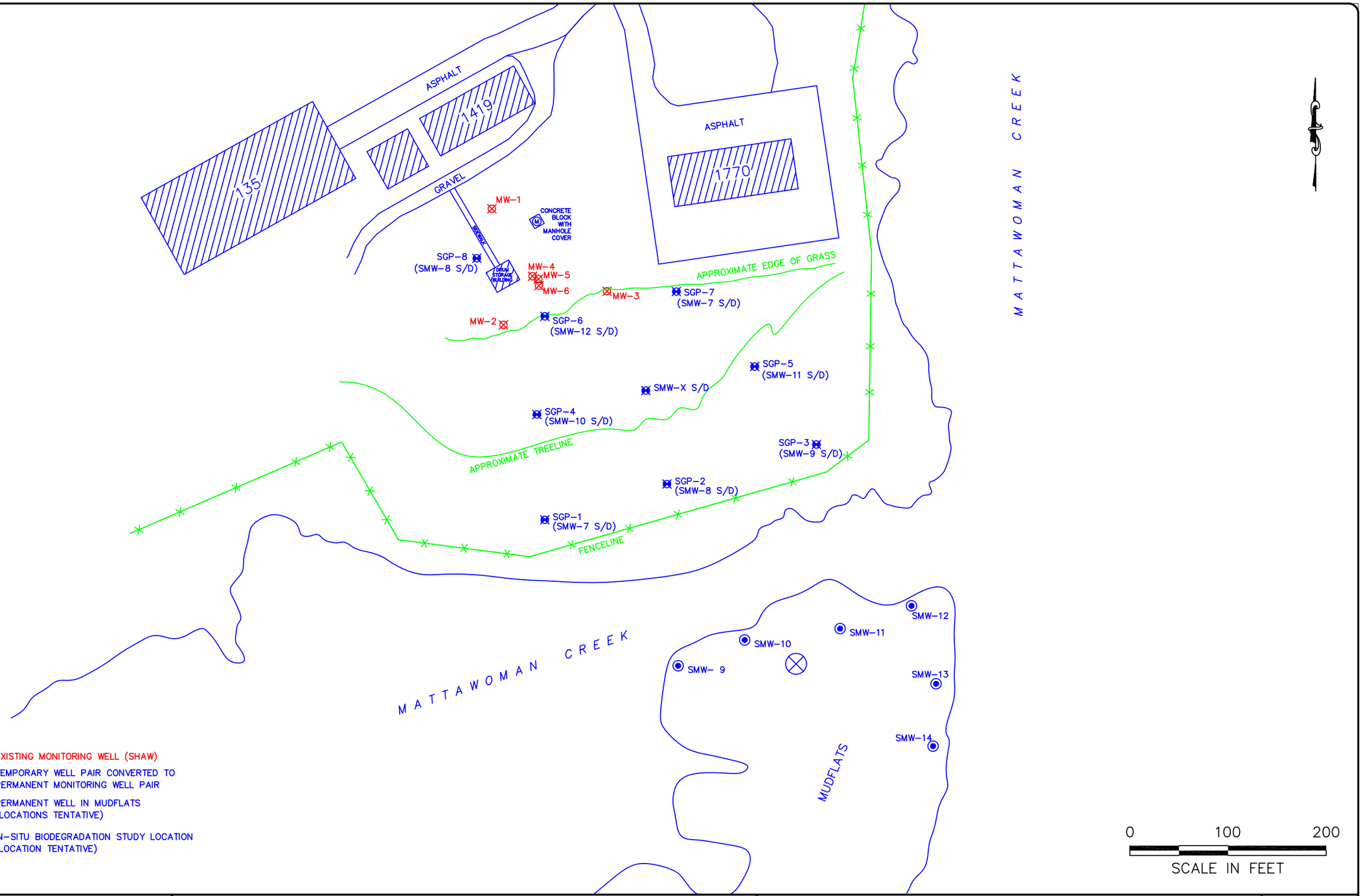
After reviewing the information from the pre-demonstration assessment near the probable source area, it appears that the residual elevated perchlorate concentrations in many of the wells may be obscuring clear evidence of natural attenuation. However, the pre-demonstration assessment activities yet to be performed in the mudflats have strong potential to illustrate that natural attenuation of perchlorate is occurring in the mudflats beyond the property line, in addition to the more contaminated portions of the plume where it may be more difficult to document.

The demonstration set-up will consist of two parts: 1) installation of a permanent monitoring well network both southeast of the probable source area and in the mudflats; and 2) installation of *in situ* biodegradation columns in the mudflats. In part one, based on field observations and contaminant concentrations, selected pre-demonstration groundwater sampling locations/temporary monitoring wells will be converted to permanent monitoring wells (Section 3.5.3). The permanent monitoring wells will be spaced to estimate the mass flux along the perchlorate plume shown on **Figures 3-7 and 3-8**. In part two, *in situ* biodegradation columns will be placed in the mudflats to assist in estimating perchlorate biodegradation rates. Additional details are provided below:

3.6.1.1 Monitoring Well Installation for Mass Flux Study

- Convert the temporary monitoring wells SGP-1 through SGP-8 located in the grassy area southeast of probable source area near the tree line and along the fence line to permanent monitoring wells as shown in **Figure 3-10**. These temporary wells will be re-named as Solutions-IES monitoring wells (SMW) starting with number SMW-1 to avoid confusion with the pilot test wells installed by Shaw. The shallow well will be designated "S" and the deeper of the pair designated "D". The designations are illustrated on **Table 3-6**.

- Obtain a "dig permit" from IHDIV prior to installation of the new mass flux wells. Upon approval, a Maryland-licensed well contractor will be used to obtain monitoring well permits from MDE in order to install one additional new well pair near the probable source area and approximately six to twelve new monitoring wells in the mudflats. The new permanent shallow/deep well pair in the probable source area will be located between SGP-4 and SGP-5 (**Figure 3-10**). This well will be named after it is determined how many permanent wells are installed in the mudflats study area. The well pair construction will be the same as those well pairs installed during pre-demonstration testing performed in November 2005, and described in the Site-Specific Workplan found in **Appendix II**. According to IHDIV, special permitting is not required for installation of wells on the mudflats.



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PROPOSED PERMANENT MONITORING WELL LOCATIONS
FEBRUARY 2006
INDIAN HEAD SITE
INDIAN HEAD NAVAL WARFARE CENTER
INDIAN HEAD, MARYLAND

FIGURE:
3-10

- Finish each monitoring well with a permanent stick-up well cover and a locking cap. The newly finished monitoring wells (SMW-1 S/D through SMW-8 S/D and SMW X S/D) located in the grassy area downgradient of the probable source, the new monitoring wells installed in the mudflats, and the four of the six wells installed by Shaw (MW-1 through MW-4), will comprise the monitoring well network for the technology demonstration. These wells will be used to measure changes in contaminant mass flux with distance. **Figure 3-10** shows six permanent monitoring well locations in the mudflats. These locations are tentative and are for illustration purposes only.

- Perform specific capacity tests on all new wells. The specific capacity test, as described by Wilson *et al.* (1997), will be performed by inserting a ¼ inch polyethylene tube to a known depth beneath the water surface. The depth of the intake tube is determined by attaching a water level gauge to the side of the tube. When the exact known depth is reached below the static water table, a peristaltic pump will be switched-on at full flow. When the drawdown is stabilized, as witnessed by the occurrence of bubbles in the tubing, a graduated cylinder will be filled. The time to fill the cylinder, volume of the cylinder, and depth of the intake is entered into a spreadsheet formula to estimate the hydraulic conductivity. A minimum of three tests will be performed at each location so that an average can be determined.

- Collect groundwater elevation data from the monitoring well located closest to edge of mudflats of Mattawoman Creek to measure the fluctuation in groundwater elevation between sampling events. The creek is tidally influenced with daily fluctuations between 1 and 2 ft and the influence on groundwater flow direction will be important to evaluate.

- Install a stream channel gauge to provide a constant measuring point for subsequent monitoring events.

Table 3-6 Sample Locations and Designations Indian Head Site, Naval Surface Warfare Center				
Pre-Demonstration Soil/Sediment Samples	**Pre-Demonstration Groundwater Samples**	**Installed by**	**Year**	**Technical Demonstration Groundwater Samples**
Sample Locations in Probable Source and Downgradient Areas				
	MW-1	Shaw	2000	MW-1
	MW-2	Shaw	2000	MW-2
	MW-3	Shaw	2000	MW-3
	MW-4	Shaw	2000	MW-4
	SGP-1 S/D	Solutions-IES	2005	SMW-1 S/D
	SGP-2 S/D	Solutions-IES	2005	SMW-2 S/D
	SGP-3 S/D	Solutions-IES	2005	SMW-3 S/D
	SGP-4 S/D	Solutions-IES	2005	SMW-4 S/D
	SGP-5 S/D	Solutions-IES	2005	SMW-5 S/D
	SGP-6 S/D	Solutions-IES	2005	SMW-6 S/D
	SGP-7 S/D	Solutions-IES	2005	SMW-7 S/D
	SGP-8 S/D	Solutions-IES	2005	SMW-8 S/D
		Solutions-IES	2006	SMW-X S/D
Proposed Sample Locations in Mudflats Beyond Property Line				
SGP-9 S/D*	SGP-9	Solutions-IES	2006	SMW-9 To SMW-20, as needed.
SGP-10 S/D*	SGP-10	Solutions-IES	2006	
SGP-11 S/D*	SGP-11	Solutions-IES	2006	
SGP-12 S/D*	SGP-12	Solutions-IES	2006	
SGP-13 S/D*	SGP-13	Solutions-IES	2006	
SGP-14 S/D*	SGP-14	Solutions-IES	2006	
SGP-15 S/D*	SGP-15	Solutions-IES	2006	
SGP-16 S/D*	SGP-16	Solutions-IES	2006	
SGP-17 S/D*	SGP-17	Solutions-IES	2006	
SGP-18 S/D*	SGP-18	Solutions-IES	2006	
SGP-19 S/D*	SGP-19	Solutions-IES	2006	
SGP-20 S/D*	SGP-20	Solutions-IES	2006	

* Actual depth of shallow (S) and deep (D) samples below the surface of the mud flats will be shown for soil/sediment samples (e.g., SGP-9 2-3' and SGP-9 10-11').

3.6.1.2 *In Situ* Biodegradation Study in the Mud Flats

An *in situ* biodegradation study will be conducted in the mudflats in an area where it is likely that perchlorate is degrading or where it is likely that perchlorate would degrade if it were present. A tentative location for this study is shown in **Figure 3-10**, but the actual location is subject to pre-demonstration results from the mudflats. The objective of this work is to estimate biodegradation rates as perchlorate migrates upward through the surficial mudflat sediments that are expected to contain elevated levels of organic carbon. The exact details of the *in situ* biodegradation test have not been finalized and will depend on the vertical distribution of organic carbon in the mudflat sediments, groundwater flow rates through this system, and physical access considerations.

One approach for measuring *in situ* biodegradation rates would be to install *in situ* (close-ended) columns within the mudflats using a design similar to the columns used by Gillham *et al*. (1990) and Borden *et al*. (1997a). Each column would consist of a 1-m long chamber that is pushed into the sediment surface allowing sediment and groundwater to be isolated from the surrounding aquifer for controlled observation. Groundwater would be extracted from the column (or an adjoining well), amended with a non-reactive bromide tracer and perchlorate (if required), and injected back into the column. Water samples will then be collected from the column over time and monitored for perchlorate and bromide. By comparing perchlorate concentrations with the non-reactive tracer, we can estimate *in situ* biodegradation rates. This *in situ* measurement approach is expected to be most appropriate when groundwater flow rates are low.

An alternative approach for measuring *in situ* biodegradation rates would be to install open-ended columns into the sediment surface extending from approximately 3 ft bgs to above the maximum high tide level. A check valve would be installed in the side of the column at the average water level in the Mattawoman Creek. When the tide is low, ambient groundwater flow will cause water to flow upward through the sediment within the column, and discharge out through the check valve. By monitoring perchlorate concentrations at the bottom (intake) of the column and at the top (discharge) of the column, we can evaluate the extent of perchlorate biodegradation under ambient conditions. This *in situ* measurement approach is expected to be most appropriate when groundwater flow rates are high, allowing collection of sufficient water for the required chemical analyses.

Once additional information is obtained on groundwater flow conditions, sediment TOC levels, and perchlorate concentrations in the mudflats, a brief memo will be submitted to ESTCP providing a detailed description of the proposed monitoring protocols.

3.6.1.3 Surveying and Initial Groundwater Sampling

This demonstration plan assumes that new monitoring well installation and *in situ* biodegradation column installation can be implemented in a relatively close time frame. If, for some reason, there is a large time period between activities, the surveying and sampling activities described below can be adjusted.

- The top-of-casing elevations for each of the new wells and *in situ* biodegradation columns will be surveyed relative to existing monitoring wells. Groundwater elevation measurements will be collected from the new wells and nearby existing wells. Surface water measurements will also be measured accordingly using the stream gage. The groundwater flow direction in the vicinity of the well network will be compared to historical information. Horizontal and vertical gradients will be calculated.

- A full round of sampling, including the monitoring wells installed by Shaw, will be performed subsequent to installation of the monitoring well network. Sampling procedures and analytical parameters are discussed in greater detail in Section 3.6.7.

3.6.2 Period of Operation

Installation of the monitoring well field for mass flux calculations, and groundwater sampling and analysis, should be completed in approximately 3 months. After those tasks are complete, four

performance monitoring events remain and will require approximately 12 months to complete. A more detailed schedule is provided in Section 3.10.

3.6.3 Amount/Treatment Rate of Materials to be Treated

Based on the site characterization and hydrogeology, the amount of perchlorate attenuated within the demonstration area will be estimated based on the change in the perchlorate concentration near Building 1419, the drum storage building (**Figure 3-2**), the last line of monitoring wells located in the mudflats, and the volume of water passing through the demonstration area. The rate of anaerobic biodegradation will be estimated during the demonstration through *in situ* biodegradation studies, mass flux calculations, and stable isotope studies.

3.6.4 Residuals Handling

Because the groundwater is being treated by natural attenuation, it will not be removed from the subsurface for treatment, and will not require disposal. However, it is anticipated that several types of investigation-derived waste (IDW) will be generated on this site, including:

- Personnel protective equipment (PPE).
- Disposable equipment, such as plastic ground and equipment covers, aluminum foil, tubing, bailers, discarded or unused sample containers, boxes, etc.
- Soil cuttings/drilling muds/cores from well installation.
- Groundwater obtained through well development or well purging.
- Cleaning fluids such as detergents, spent solvents and wash water.
- Packing and shipping materials.

Based on generator knowledge, IDW anticipated at the site will be classified as non-hazardous. At the time of generation, soil cuttings/cores will be spread on site in the grassy area south of the drum storage building.

Contaminated groundwater and decontamination fluids derived from well sampling, and equipment decontamination will also be disposed of in the grassy area south of the drum storage building. Solid IDW waste, such as PPE, bailers, tubing, in-line filters, etc., will be double-bagged and deposited in a dumpster for transport to a municipal landfill.

3.6.5 Operating Parameters for the Technology

The purpose of the technical demonstration is to evaluate the potential for monitored natural attenuation of perchlorate in groundwater. Because we are demonstrating a process that is occurring without engineered intervention, there is no aboveground equipment to operate or maintain. Consequently, there are no mechanical operating parameters for the technology.

Groundwater monitoring and hydraulic conductivity testing will be used to monitor the performance of natural attenuation and estimate mass flux. Groundwater monitoring will be conducted as described in Section 3.6.7. Hydraulic conductivity will be estimated using specific capacity tests (Section 3.6.1.1). However, alternate methods may be utilized to measure the hydraulic conductivity (slug testing) should specific capacity testing prove insufficient. Specific capacity testing will be performed on all of the monitoring wells installed during the demonstration. A data logger will be installed in the monitoring well located closest to edge of the mudflats of Mattawoman Creek to measure the fluctuation in groundwater elevation between sampling events.

3.6.6 Experimental Design

The analytical results obtained from the pre-demonstration work performed in November of 2005 (Section 3.4) and pre-demonstration work in the mudflats will be used to optimize the location of permanent monitoring wells used in the perchlorate mass flux study and the *in situ* biodegradation studies.

When all of the monitoring wells that will be used to estimate mass flux are installed, the change in downgradient mass flux will be monitored over several sampling events. Using this technique, we hope to show a consistent, reproducible decline in total contaminant mass flux during the downgradient migration of perchlorate. By collecting data on multiple dates over several years, we intend to generate statistically valid estimates of the first order degradation rate for perchlorate within 95% confidence limits. If appropriate, contaminant transport and attenuation will be simulated using a simple first order decay model similar to BIOCHLOR, an instantaneous reaction model similar to BIOPLUME (Borden and Bedient, 1986), or a three-dimension model similar to RT3D. The modeling approach selected will depend on the site-specific monitoring results.

We will likely analyze the results from the perchlorate *in situ* biodegradation study following the same general procedures employed by Borden *et al*. (1997a). The statistical significance of the slopes and 95% confidence limits will be determined following standard statistical procedures.

3.6.7 Groundwater Sampling Plan

Groundwater sampling activities will be performed to evaluate the natural conditions of the aquifer, and how those conditions affect the potential for the biodegradation of perchlorate. In general, the procedures that Solutions-IES will use for groundwater sampling are provided in *Environmental Investigations Standard Operating Procedures and Quality Assurance Manual* (EISOPQAM; US EPA, 1996), with site-specific requirements in the QAPP in **Appendix VI**, and outlined in the following paragraphs.

Prior to the collection of groundwater samples, water levels will be measured. Each well to be sampled will then be purged to remove stagnant water from the well and to allow its replacement by groundwater from the adjacent formation, which is more representative of actual aquifer conditions. Because of the anticipated shallow depth to water, the wells will be sampled using either a peristaltic pump/tubing, or disposable polyethylene bailers. When the monitoring wells are sampled using a low-flow purge and sampling method, an adequate purge is achieved when the pH, specific conductance, and temperature of the groundwater have stabilized. The number of parameters measured in wells located in the mudflats may be altered in order to collect the volume of sample required for perchlorate analysis. The goals for stabilization are as follows:

- pH- Measurements remain constant within 0.1 Standard Unit (SU).
- Specific Conductance – Measurements vary by no more than 10 percent.
- Temperature – Measurements remain constant for at least three successive readings.

After an adequate purge has been achieved, field measurements will be collected and groundwater samples will be collected for analysis. The samples will be collected in laboratory prepared sample containers appropriate for the analytical method being used. The sample containers will be immediately sealed, labeled, and placed on ice in an insulated cooler for subsequent delivery to the analytical laboratory. Chain-of-custody forms will accompany all samples sent to the laboratory. The field parameters that will be measured at each location

include: dissolved oxygen (DO); oxidation-reduction potential (ORP – Eh); pH, temperature, and specific conductance.

Assuming that most of the monitoring wells will be sampled using a peristaltic pump, a groundwater sample will be collected for DO analysis as water is flowing out of the sampling tubing by inserting a Chemetrics 0 - 1 mg/L self-filling DO ampoule into the end of the tube. The ampoule tip will be broken off inside the tube below the flowing water surface, pulling water into the ampoule while being careful to exclude any oxygen. The DO concentration will be determined by a visual comparison to color standards. If the DO exceeds 1 mg/L, the process will be repeated using the 1 – 12 mg/L DO ampoules.

After the field parameters are measured for the specific monitoring well, a groundwater sample will be collected. For pre-demonstration groundwater sampling, groundwater samples will only be collected from sampling points in the mudflats. For performance monitoring (four events), groundwater samples will be collected from the newly finished permanent monitoring well pairs (SMW-1 S/D through SMW-8 S/D and SMW-X), monitoring wells installed in the mudflats, and the existing wells MW-1 through MW-4. The first, second and third sampling events will be separated by a three month interval while the third and fourth sampling event will be separated by a six month interval.

3.6.7.1 Laboratory Analysis

Approximately 24 soil samples will be collected from borings advanced in the mudflats during pre-demonstration testing discussed in Section 3.5.2. From each boring, one soil sample will be collected from the upper half of the boring and on soil sample will be collected from the lower half of the boring prior to boring termination at approximately 11 feet bgs. Each of these soil samples will be analyzed for TOC.

Groundwater samples collected for pre-demonstration testing will be analyzed for perchlorate, TOC, chloride, nitrate-N, sulfate, and methane. Groundwater samples collected from monitoring wells during performance monitoring will be analyzed for perchlorate, TOC, chloride, nitrate-N, sulfate, and methane as well as dissolved iron and manganese, ammonia-N, and alkalinity.

Table 3-7
Sample Collection and Analysis Details
Indian Head Site, Naval Surface Warfare Center

Number of Sample Bottles per Sample Location	Containers	Target Constituent/Method	Field/Laboratory
1	250-ml plastic bottle	Conductivity, temperature, pH, oxidation-reduction potential/Field Meters	Field
0	From tubing	Dissolved oxygen/Chemetrics	Field
1	0.45 µm filtered sample	Dissolved manganese and iron/Chemetrics	Field
2	40-mL VOA vial (no preservative)	Methane/gas chromatography	NCSU CCEE Lab
1	250 ml plastic bottle minimum of 120 ml sample while retaining headspace (no preservative) coupled 1.0µm and 0.45µm filtering setup	Perchlorate/ion chromatography	NCSU CCEE Lab
1	A minimum of 120 ml (no preservative) coupled 1.0µm and 0.45µm filtering setup confirmation samples (10%)	Perchlorate/Method 330	Columbia Analytical Services, Inc.
1	250-mL plastic bottle (preservative)	Chloride, nitrate, sulfate/ ion chromatography	NCSU CCEE Lab
1	500 ml plastic bottle (no preservative)	Alkalinity/Method 310.2	Environmental Science Corp.
1	250 ml plastic bottle (preservative)	Ammonia/Method 350.1	Environmental Science Corp.
1	4-oz jar	Total organic carbon (soil)/Loss on ignition	Environmental Science Corp.
1	250-mL amber bottle preserved with HCL)	Total organic carbon (groundwater)/Method 9060	Environmental Science Corp.
1	1-liter bottle (no preservative)	Chlorite Dismutase Assay/ mRNA	Microbial Insights, Inc.
1	Flow-through glass column containing ion-exchange resin	Stable Isotope Studies	Paul Hatzinger, Shaw Environmental

Table 3-7 provides the details for collecting groundwater samples for the planned analyses and shows the laboratories that will perform each analysis. Most of the analyses that are planned will be performed using standard field or laboratory methodologies. However, this demonstration relies on several relatively new approaches for collecting and processing samples. These special methods are described in the following sections:

3.6.7.1.1 Groundwater Collection for Perchlorate Analysis.

After the groundwater is withdrawn from the monitoring well, solids within the sample will be allowed to settle in a plastic container while the other groundwater samples are collected. After the other groundwater samples are collected, a 60-ml syringe will be used to withdraw the sample from the top to avoid solids. Then, the syringe will be used to push the groundwater through sequentially stacked 1.0 µm and 0.45 µm filters. The filtered groundwater will be placed into a clean plastic bottle with no preservative. Headspace will be retained within the sample bottle. Approximately 10% of groundwater samples will be sent to a certified laboratory for confirmatory analysis of perchlorate by Method 330.

3.6.7.1.2 *In Situ* Biodegradation Studies

Groundwater samples will be collected from *in situ* biodegradation columns during each of the four performance monitoring sampling events. Each of the samples will be analyzed for analyzed for perchlorate, chloride, sulfate, TOC, and DO. If *in situ* closed ended columns are used in the *in situ* biodegradation study, bromine will be added to the laboratory analysis.

We will likely analyze the results from the perchlorate *in situ* biodegradation columns following the same general procedures employed by Borden *et al.* (1997a). The statistical significance of the slopes and 95% confidence limits will be determined following standard statistical procedures

3.6.7.1.3 Chlorite Dismutase Enzyme Assays

Approximately 10 groundwater samples will be collected for CD enzyme assay during one of the five sampling events. Sampling locations will be selected to include locations where groundwater conditions suggest that perchlorate may be biodegrading, and locations where concentrations of perchlorate are low or not detected. Available information indicates that the CD enzyme is only present in organisms that are actively reducing perchlorate or chlorate. As a consequence, detection of the CD enzyme should provide a direct indication that perchlorate is being degraded under *in situ* conditions, and therefore, use of the enzyme assay would provide another tool to evaluate the potential for MNA of perchlorate.

3.6.7.1.4 Stable Isotope Studies

Microorganisms often preferentially use lighter isotopes in their metabolic processes (Mariotti *et al.*, 1981; Heaton, 1986) and, as a contaminant is degraded, the isotopic composition of the remaining material becomes progressively heavier. This isotopic shift can be described by the Raleigh Distillation formula $R/R_0 = f^{(\alpha - 1)}$, where R_0 is the isotopic ratio of the original material, R is the isotopic ratio of the remaining material, α is the

fractionation factor and f is the fraction of material degraded. If the ratio R/R_0 can be accurately measured and α is known, the fraction of material degraded can be calculated.

A variety of different investigators have successfully used stable isotope ratios to evaluate the MNA of petroleum hydrocarbons (Ahad *et al.*, 2000), methyl-*tert*-butyl ether (MTBE; Kolhatkar *et al.*, 2002), chlorinated solvents (Lollar *et al.*, 2001), and nitrate (Karr *et al.*, 2001). However, there are some important limitations to this approach: (1) a sensitive, reproducible method is needed to monitor the isotopic shifts; (2) variations in the isotopic composition of the different sources can mask isotopic shifts caused by microbial fractionation; and (3) the isotopic fractionation factor α may vary between different microorganisms and environmental conditions (Slater *et al.*, 2001).

Currently available information suggests that monitoring isotopic ratios may be a very useful tool for evaluating the extent of perchlorate attenuation. Ader *et al.* (2001) developed a highly reproducible and accurate method for stable isotopic analysis of chlorine ratios Cl^{34}:Cl^{37} ($\delta^{37}Cl$) in perchlorate. Recently, Coleman *et al.* (in press) observed that perchlorate reduction by *D. suillum* resulted in significant fractionation (~ -15‰) of the chlorine stable isotopic composition. The resulting shifts in $\delta^{37}Cl$ associated with perchlorate reduction were much larger than the isotopic variations between different sources (+0.2‰ to +2.3‰) observed by Ader *et al.* (2001). These results suggest that isotopic ratios could be used to assess perchlorate attenuation in the field.

Approximately 8 to 10 groundwater samples will be monitored for measurement of stable isotopes during one of the five sampling events. Groundwater samples will be collected from 8 to 10 wells during one of the five sampling events and assayed for $\delta^{37}Cl$ of perchlorate. Sampling locations will be selected to include locations where groundwater conditions suggest that perchlorate may be biodegrading. Because of the perchlorate concentrations present in groundwater at the Indian Head Site, several liters of groundwater will be pumped through glass columns containing ion exchange resin at a low flow rate until the column contains an estimated mass of perchlorate of approximately 10 mg (Bohlke *et al.*, 2005). Each cartridge will then be shipped to a laboratory for perchlorate extraction and $\delta^{37}Cl$ analysis. Spatial variations in $\delta^{37}Cl$ will be examined to determine if there is significant isotopic fractionation during downgradient transport. If there is clear evidence of isotopic shifts, the extent of perchlorate degradation will be estimated using the fractionation factor.

3.6.8 Demobilization

MNA does not include the installation of aboveground equipment or structures that will require removal at the end of the demonstration. At the completion of the monitoring phase of the project, the monitoring wells may be abandoned. Personnel at the Indian Head site may want some of the monitoring wells to remain in working order, so we will coordinate the abandonment activities with Indian Head personnel prior to abandoning monitoring wells installed by Solutions-IES. Each of the selected monitoring wells will be abandoned by inserting a tremie pipe to the bottom and pumping the well full of a neat cement grout mixture until filled to the surface. For the monitoring wells, each riser will be cut off below the surface and the plugged wells/columns will be covered with soil.

3.6.9 Health and Safety Plan

The Health and Safety Plan for this project is provided in **Appendix V**.

3.7 Selection of Analytical/Testing Methods and Laboratory

Table 3-7 summarizes the analytical methods and laboratories that will be used for the performance monitoring activities.

3.8 Selection of Analytical/Testing Methods

Microbial Insights has completed development of the RNA-based assay to identify the expression of a CD gene (Section 3.6.7.1.3) and maintains the expertise necessary to produce reliable and reproducible results for this assay which is not widely available.

Dr. Paul Hatzinger of Shaw Environmental will perform the stable isotope studies. This approach is not widely available and will specifically require his expertise. The addresses are listed in the **Table 3-8** below:

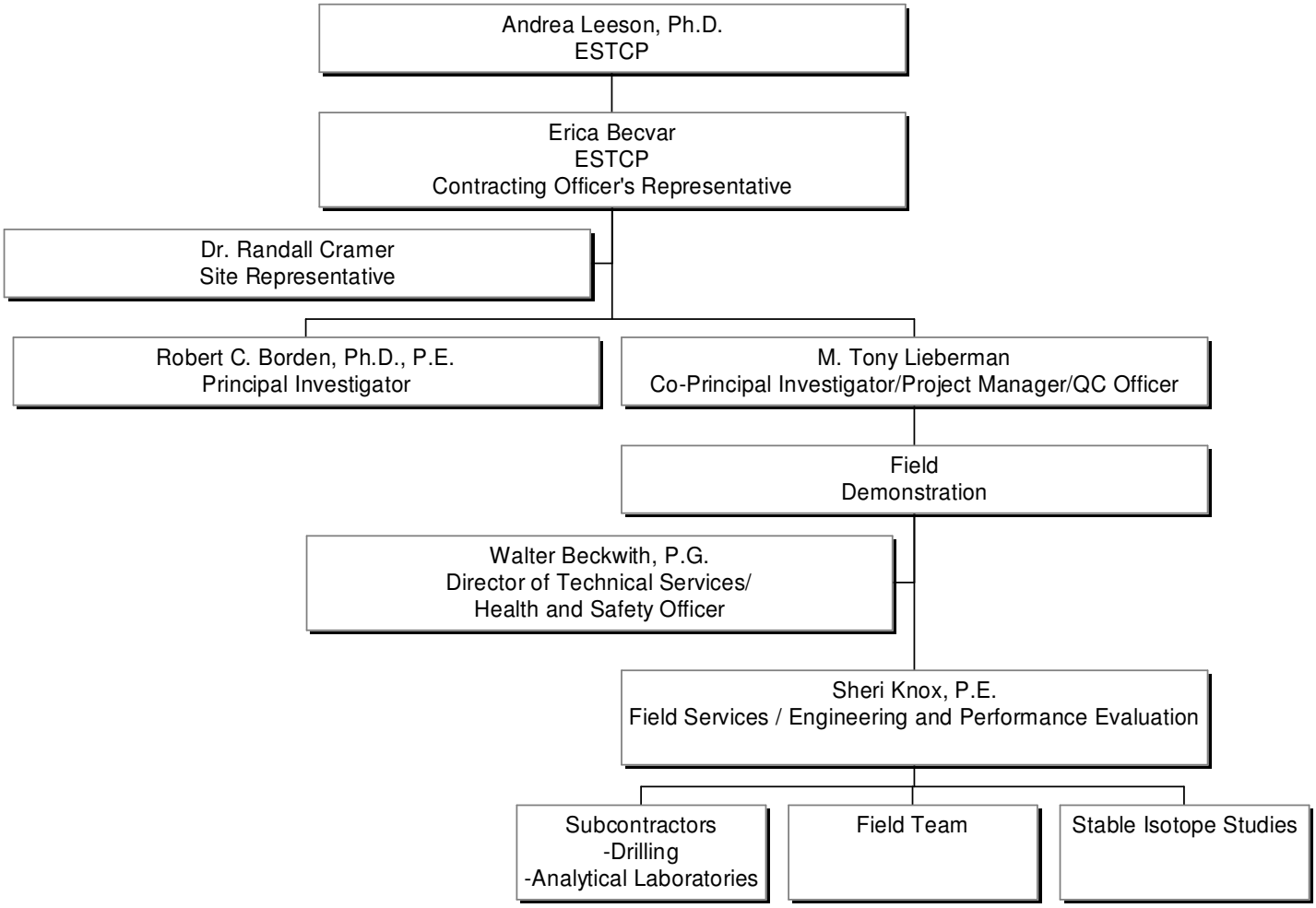
Table 3-8
Specialized Laboratory Expertise
Indian Head Site, Naval Surface Warfare Center

Laboratory/Person	Address	Expertise
Microbial Insights, Inc.	2340 Stock Creek Boulevard, Rockford, TN 37853	**mRNA chlorite dismutase assay**
Dr. Paul Hatzinger	Shaw Environmental, Inc. 17 Princess Road Lawrenceville, NJ 08648	**stable isotope assays**

3.9 Management and Staffing

Figure 3-11 provides the organizational chart for the technology demonstration project. The roles and responsibilities of relevant project personnel are summarized below.

Figure 3-11
Organizational Chart



Principal Investigator: Responsible for providing overall project direction, coordination with ESTCP, site representatives, and regulatory agencies, and final review and approval of reports.

Project Manager/Co-PI: Responsible for project coordination, scheduling, budget management, technical oversight, and report preparation.

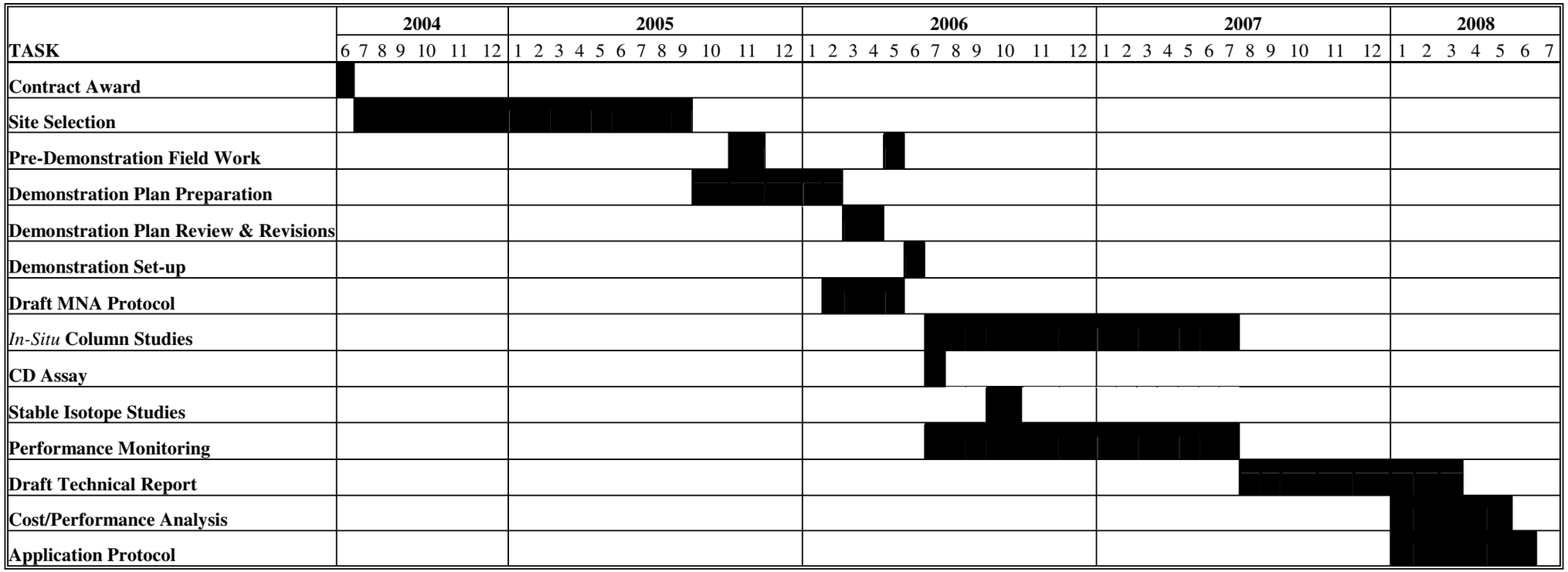
3.10 Demonstration Schedule

The milestones for the implementation of the proposed technology are summarized in **Table 3-9**, and **Figure 3-12** is a Gantt chart showing the project schedule through 2008.

Table 3-9 Demonstration Schedule Indian Head Site, Naval Surface Warfare Center		
Activity		**Estimated Completion Date**
1	Contract award	06/2/2004
2	Site Selection Memorandum	9/20/2005
3a	Pre-demonstration testing and analysis	11/16/2005
4	Submittal of draft Tech. Demonstration Plan, HASP, etc.	2/20/2006
4a	Complete Tech. Demonstration Plan review	3/20/2006
4b	Approval of revisions to Tech. Demo Plan, if needed.	4/20/2006
3b	Completion of pre-demonstration testing and analysis	5/15/2006
5	Demonstration Setup (Mass flux well installation and *in situ* closed and/or open column installation)	6/30/2006
6	Submit draft MNA Protocol	5/30/2006
7	Performance monitoring, *in situ* biodegradation studies, and CD analysis	7/31/2006
8	Performance monitoring, *in situ* biodegradation studies, & stable isotope studies	10/30/2006
9	Performance monitoring & *in situ* biodegradation studies	1/31/2007
10	Performance monitoring & *in situ* biodegradation studies	7/31/2007
11	Submit draft Technical Report	3/31/2008
12	Submit draft Cost and Performance Analysis	5/30/2008
13	Submit final Protocol (including 2nd demonstration site)	6/30/2008

Figure 3-12

Project Schedule



4.0 Performance Assessment

4.1 Performance Criteria

The performance criteria for this technology demonstration project are presented in **Table 4-1**.

Table 4-1
Performance Criteria
Indian Head Site, Naval Surface Warfare Center

Performance Criteria	Description	Primary or Secondary
Reduce perchlorate concentration	Reduce average perchlorate concentrations by 90% in the most downgradient monitor wells.	Primary
Reduce contaminant mass flux	Reduce total mass flux of perchlorate by over 75% between the source area and the most downgradient line of wells.	Primary
Biodegrade perchlorate	Stable isotope monitoring results show a statistically significant change in isotopic ratio at downgradient locations indicating biodegradation of perchlorate. *In situ* biodegradation studies indicate a measurable biodegradation rate.	Secondary
Meet regulatory standards	Maryland has a health advisory level of 1.0 µg/L for perchlorate. EPA has adopted 24.5 µg/L to be considered (TBC) as a preliminary remediation goal. Concentrations should be below the TBC goal at compliance point.	Secondary
Contaminant Mobility	The hydrogeology should not be altered by the MNA approach. However, if aquifer conditions change outside of a range that is supportive of MNA, changes will be noted and the impact identified in the protocol.	Secondary
Hazardous Materials	MNA does not produce or use hazardous materials as part of the treatment technology.	Not Applicable
Process Waste	MNA is a passive remedial strategy; therefore, waste will be limited to soil cuttings from well installation and groundwater from well development and purging. IDW could potentially contain elevated concentrations of perchlorate.	Secondary
Factors Affecting Performance	Aquifer conditions (pH, DO, ORP, etc.) that are favorable to anaerobic biodegradation support MNA performance. If the aquifer conditions are outside of a range that is supportive of anaerobic biodegradation, then the success of MNA may be affected.	Primary
Reliability	1) There should be no equipment failure since there are no aboveground appurtenances. If monitoring wells are damaged by traffic etc., replacement wells may be necessary. 2) If aquifer conditions remain amenable to MNA, the remedial approach is reliable.	Secondary
Ease of Use	1) The installation of mass flux monitoring wells/columns requires a drilling team and one geologist. 2) OSHA's health & safety training is required because the groundwater at the site may contain concentrations of unknown substances given the past use of the facility.	Primary
Versatility	The MNA remedial approach has been used for a variety of contaminants including petroleum hydrocarbons and chlorinated solvents. The MNA approach will potentially be evaluated for use with other geologic environments (sedimentary and fractured rock, deep water tables, etc.)	Secondary
Maintenance	No operation and maintenance will be required during ESTCP demonstration. General maintenance of monitoring wells may be required.	Primary

Table 4-1 Performance Criteria Indian Head Site, Naval Surface Warfare Center		
Performance Criteria	**Description**	**Primary or Secondary**
Scale-Up Constraints	There are no scale-up restraints. The successful demonstration of MNA requires a monitoring well network designed to illustrate attenuation downstream from the source and prior to intercepting sensitive receptors.	Secondary

4.2 Performance Confirmation Methods

The objective of the field demonstration is to evaluate the rate and extent of perchlorate biodegradation and natural attenuation at the Indian Head site. The effectiveness of the demonstration will be accomplished by generating multiple lines of evidence for perchlorate degradation/attenuation including:

(a) detailed field characterization results showing a decline in contaminant mass flux with distance;

(b) microbiological evidence for the *in situ* activity of perchlorate-degrading organisms (CD enzyme assays and *in situ* biodegradation studies); and

(c) changes in isotopic composition of perchlorate indicative of biodegradation.

Table 4-2 summarizes the expected performance and performance confirmation methods.

Table 4-2
Expected Performance and Performance Confirmation Methods

Performance Criteria	Expected Performance Metric (pre-demo)	Performance Confirmation Method	Actual Performance Metric (post-demo)
Primary Criteria (Qualitative Performance Objectives)			
Remediation	Reduced contaminant concentrations	Monitoring well data.	
Maintenance	General and limited maintenance to monitoring wells, if necessary	Experience from *in situ* demonstration	
Ease of Use	Contaminant reduction is part of the natural aquifer system, and is monitored by a network of wells	Experience from demonstration *in situ*	
Primary Performance Criteria (Quantitative Performance Objectives)			
Target Contaminant -- % Reduction -- Regulatory Standard	Expect concentrations of perchlorate in a portion of the source area to be around 27,000 µg/L; expect up to 90% reduction of the average perchlorate concentration in wells near downgradient receptor, resulting in concentrations <2,700 µg/L; the target concentration will be the EPA "to be considered" (TBC) preliminary remediation goal of 24.5 µg/L (99.9% reduction). Achieving 24.5 µg/L is a secondary performance criterion.	Groundwater samples collected from several locations at different distances upgradient, downgradient, and within the plume extent will be analyzed for perchlorate. Changes in concentration will be calculated both on a concentration and molar basis for comparison.	
Hazardous Materials -- Generated	Natural attenuation of perchlorate is not expected to result in production of hazardous by-products.	Analysis of groundwater samples for degradation products.	
Process Waste -- Generated	Minimal IDW from collecting soil samples and sampling monitoring wells.	Observation	
Factors Affecting Performance -- Biodegradation of perchlorate -- Microbial population -- Changes in area of plume -- Favorable aquifer conditions	 -- Biodegradation expected. A high percent reduction of perchlorate was observed during microcosm studies performed during the site screening process. -- Microbial population capable of biodegrading perchlorate is expected based on positive results for DNA based CD enzyme analysis. -- Based on historical information, plume is expected to remain stable. -- Based on historical information, and pre-demonstration testing, aquifer conditions are expected to be favorable to MNA along the fringes of the perchlorate plume and in the mud flats.	 -- Actual biodegradation rates will be estimated from the mass flux and *in situ* biodegradation studies. When biodegradation is significant, observe statistically significant change in isotopic ratio of perchlorate during downgradient migration. -- Secondary evidence of biodegradation observed in field parameters and laboratory analysis of groundwater samples. -mRNA based CD enzyme analysis will be performed during monitoring to verify CD enzyme activity. -- Plume stability or shrinkage will be verified through statistical tests. -- Groundwater samples from wells upgradient, within, and downgradient of the plume will be analyzed for DO, ORP, nitrate, sulfate, dissolved iron, and methane as secondary indicators of performance.	
Secondary Performance Criteria (Qualitative Performance Objectives)			
Plume size	Stable or smaller	Same or decreasing concentration identified during monitoring	
Safety -- Hazards -- Protective Clothing	Perchlorate is the single contaminant that has been identified at the site. Given the industrial nature of activities near the site and unknown contaminants that may be present, Level D PPE should be worn during well installation activities.	Experience	
Versatility -- Other Applications	Yes – MNA is also effective for other contaminants, such as chlorinated solvents and petroleum hydrocarbons.	Experience.	
Scale-up Constraints -- Contaminant Concentration -- Aquifer conditions	 -- Toxicity levels of solvents to bacteria can be a concern, but perchlorate is an anion of a salt. It has not been demonstrated to be toxic to bacteria. It is not expected to be applicable to this demonstration. --Varying aquifer conditions will affect performance.	 --Review of site information and information gathered during the screening process suggest concentrations downgradient of the probable source area should not be toxic to bacteria. -Aquifer conditions will be monitored throughout the demonstration.	
-- Timing	MNA is a natural process and may not be applicable to sites that require an accelerated clean-up.		

The rate and extent of perchlorate biodegradation will be evaluated by measuring changes in concentrations of perchlorate over time in wells within, and downgradient of the contaminant plume. In the field, it can be difficult to distinguish between reduced contaminant concentrations due to dissolution versus biodegradation. To assist with the interpretation of the data, in addition to the measurement of perchlorate, other typical bio-geochemical parameters will also be utilized as secondary indicators to monitor aquifer conditions. These parameters include:

- Dissolved Oxygen (DO) – DO concentrations <1 mg/L are favorable to MNA.
- Oxidation-reduction potential (ORP) – ORP measurements less than less than -50 mV are favorable to MNA.
- Electron Acceptors – Lower concentrations of nitrate (< 5 mg/L) are favorable to MNA. .
- Dissolved iron (Fe^{+2}) – If the aquifer conditions support anaerobic biodegradation of perchlorate, higher concentrations of dissolved iron (> 0.5 mg/L) may be observed during groundwater monitoring
- Methane – The presence of methane indicates microbial degradation (methanogenesis) is occurring and conditions are favorable for anaerobic biodegradation.

4.3 Data Analysis, Interpretation and Evaluation

Data will be tabulated and graphed as it is obtained during the course of the performance monitoring period. Combinations of line graphs and bar graphs will be used to illustrate MNA.

The effectiveness of MNA for perchlorate will be determined by evaluating changes in contaminant concentrations and indicator parameters over time. Changes in the indicator parameters discussed in Section 4.2 will be evaluated throughout the course of the demonstration project to evaluate whether aquifer conditions are favorable for biodegradation. Changes in perchlorate will be evaluated on a concentration and molar basis and percent reductions will be calculated.

In addition, results from the mass flux, *in situ* biodegradation, and stable isotope studies will be combined to provide an overall summary of the rate and extent of perchlorate biodegradation. Effective 1st order decay rates with associated 95% confidence limits will be calculated from the mass flux data using the statistical procedures employed by Borden *et al.* (1997b). If appropriate, contaminant transport and attenuation will be simulated using a simple first order decay model similar to BIOCHLOR, an instantaneous reaction model similar to BIOPLUME (Borden and Bedient, 1986), or a three-dimension model similar to RT3D. The modeling approach selected will depend on the site-specific monitoring results.

5.0 COST ASSESSMENT

5.1 Cost Reporting

Throughout the demonstration project, costs will be tracked and recorded to allow estimation of the costs associated with implementation of the MNA. The primary costs will be associated with mobilization, the installation of permanent mass flux wells downgradient of the probable source area and in the mudflats, *in situ* biodegradation columns, CD enzyme analysis, and stable isotope studies. After this part of the project has been completed, subsequent costs will be associated with monitoring and evaluating the performance of MNA. **Table 5-1** summarizes the anticipated categories of costs that will be tracked.

Table 5-1
Cost Tracking
Indian Head Site, Naval Surface Warfare Center

Cost Category	Sub-Category	Details
START-UP COSTS	Mobilization	Includes (but not limited to) planning, contracting, personnel mobilization, transportation, site preparation.
CAPITAL COSTS	Equipment Purchase/Rental	Monitoring well supplies, Sampling Equipment
	Installation	Includes costs of installing mass flux wells.
	Design	Includes costs for designing the well field.
OPERATING COSTS Direct Environmental Activity Costs	Sampling and Analysis	Labor and analytical costs for monitoring performance of MNA including *in situ* biodegradation studies, CD enzyme analysis and stable isotope analysis. Additional costs incurred by sending 10% of samples for perchlorate confirmation using Method 330.
	Long-term Monitoring	Anticipated long-term monitoring costs.
Indirect Environmental Activity Costs	Environmental and Safety Training	Indirect costs required on most environmental projects. However, the cost of training may change based on the selected approach or technology.

Table 5-1 Cost Tracking Indian Head Site, Naval Surface Warfare Center		
Cost Category	**Sub-Category**	**Details**
	OSHA Ambient Environment Sampling	Indirect costs required on most environmental projects. However, the cost of training may change based on the selected approach or technology.
	Waste Manifesting (if any)	The cost of waste manifesting is important to consider when comparing cost of remedial alternatives.
Demobilization		Includes (but not limited to) removal of equipment and structures, site restoration, decontamination, and personnel demobilization.

5.2 Cost Analysis

-- *Cost Comparison*

In the ESTCP final technical report and the ESTCP cost and performance report, costs for the innovative technology will be compared with two alternative technologies: (1) pump-and-treat with ion exchange; and (2) emulsified oil barriers.

-- *Cost Basis*

Costs will be assessed on a basis of the cost per gallon of groundwater managed and cost per monitoring well.

-- *Cost Drivers*

The primary cost drivers associated with the MNA approach for perchlorate are related to the installation of mass flux wells, *in situ* biodegradation studies, CD enzyme analysis, and stable isotope studies. These costs are primarily influenced by the subsurface lithology and contaminant mass (time associated with monitoring). A sensitivity analysis will be performed to evaluate how different factors impact costs. Factors that will be considered include contaminant concentrations, presence of co-contaminants, impacted depth, lithology, and groundwater velocity.

-- *Life Cycle Costs*

An analysis of the total cost of completion for the technology and the two alternatives listed above (pump-and-treat and emulsified oil barrier) will be performed. The total net present value (NPV) for implementation of the technology will also be calculated over a 30-year period using the current discount rate established by the Office of Management and Budget. The major cost factors for the technology are expected to be: initial set-up costs including well field installation and monitoring costs. To the extent possible, we will separate out costs for regulatory compliance monitoring which would likely include fewer analytical parameters and a lower monitoring frequency and MNA performance monitoring.

6.0 Implementation Issues

6.1 Environmental Checklist

Monitor well permits will be obtained from the MDE by the Maryland-certified driller prior to installation of the new mass flux wells and in situ biodegradation columns. Solutions-IES does not anticipate that any other permits will be required from MDE to complete the technical demonstration at the Indian Head site. However, environmental "dig" permits will be required from the IHDIV to complete well installations at the site.

An on-site incinerator is operated in the vicinity of the Indian Head site. The fieldwork will be coordinated with Indian Head personnel to address safety concerns while working in the vicinity of the incinerator located in a building nearby. According to Indian Head personnel, permits are not necessary for work performed in the mudflats.

6.2 Other Regulatory Issues

The Navy regulatory contact for the site is Mr. Shawn Jorgenson of the Naval Support Facility- East Potomac.

6.3 End-User Issues

Potential end users of the technology include a variety of agencies within the federal government (Dept. of Defense, Dept. of Energy, and Environmental Protection Agency), state and local governments and private industry.

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8.0 Points of Contact

Table 8-1 Points of Contact Indian Head Site, Naval Surface Warfare Center			
POINT OF CONTACT NAME	**ORGANIZATION NAME ADDRESS**	**PHONE/FAX/EMAIL**	**ROLE IN PROJECT**
M. Tony Lieberman, R.S.M.	Solutions-IES, Inc. 1101 Nowell Road Raleigh, NC 27607	919-873-1060 919-873-1074 (fax) tlieberman@solutions-ies.com	Co-Principal Investigator; Project Manager
Dr. Robert C. Borden, P.E.	North Carolina State University Civil, Construction & Environmental Engineering Mann Hall Raleigh, NC 27695	919-515-1625 919-515-7908 (fax) rcborden@eos.ncsu.edu	Principal Investigator
Erica Becvar	AFCEE 3300 Sidney Brooks Brooks City-Base, TX 78235-5112	210-536-4314 210-536-5989 (Fax)	Contracting Officer Representative (COR)
Dr. Randall Cramer	IHDIV Naval Surface Warfare Center Indian Head, MD 20640	301-744-2878 301-744-4843 (Fax) 703-568-0560 (Cell)	Site Representative
Shawn Jorgenson	Naval Support Facility-East Potomac	301-744-2263	Navy Environmental

APPENDIX I

HISTORICAL INFORMATION

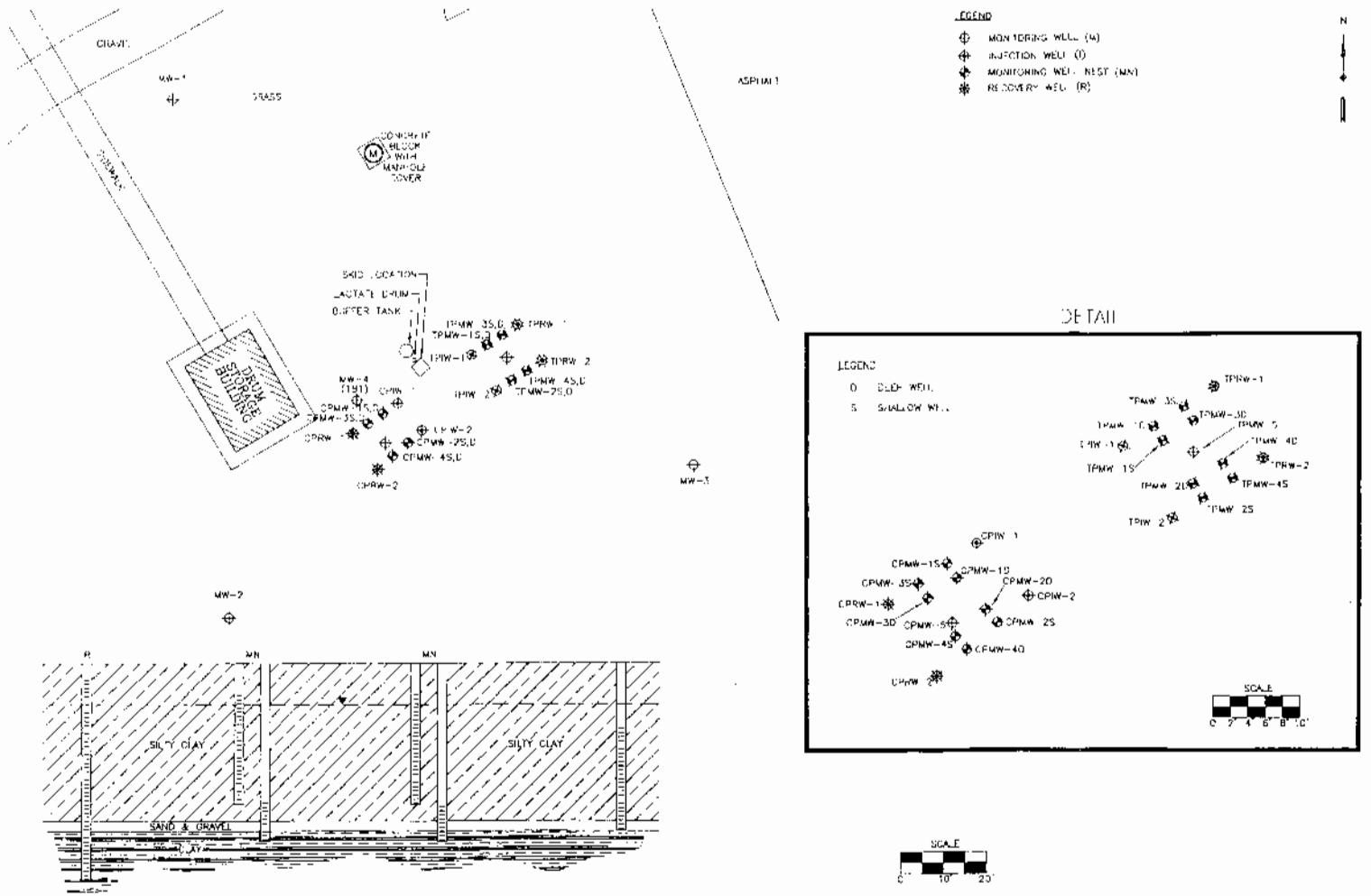


FIGURE A *Recirculation Cell Layouts and Schematic Cross-Section View*

For Official Use Only

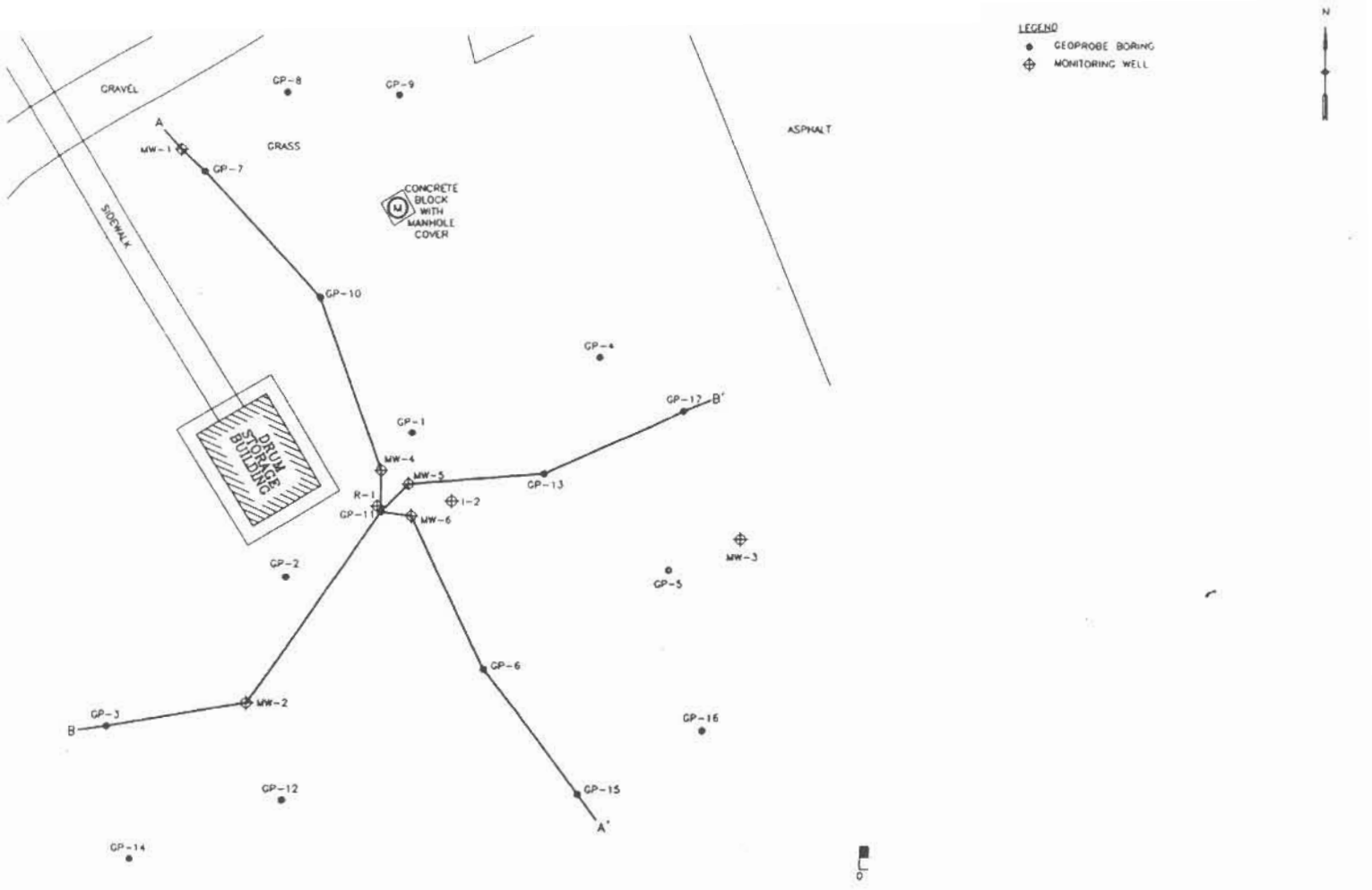
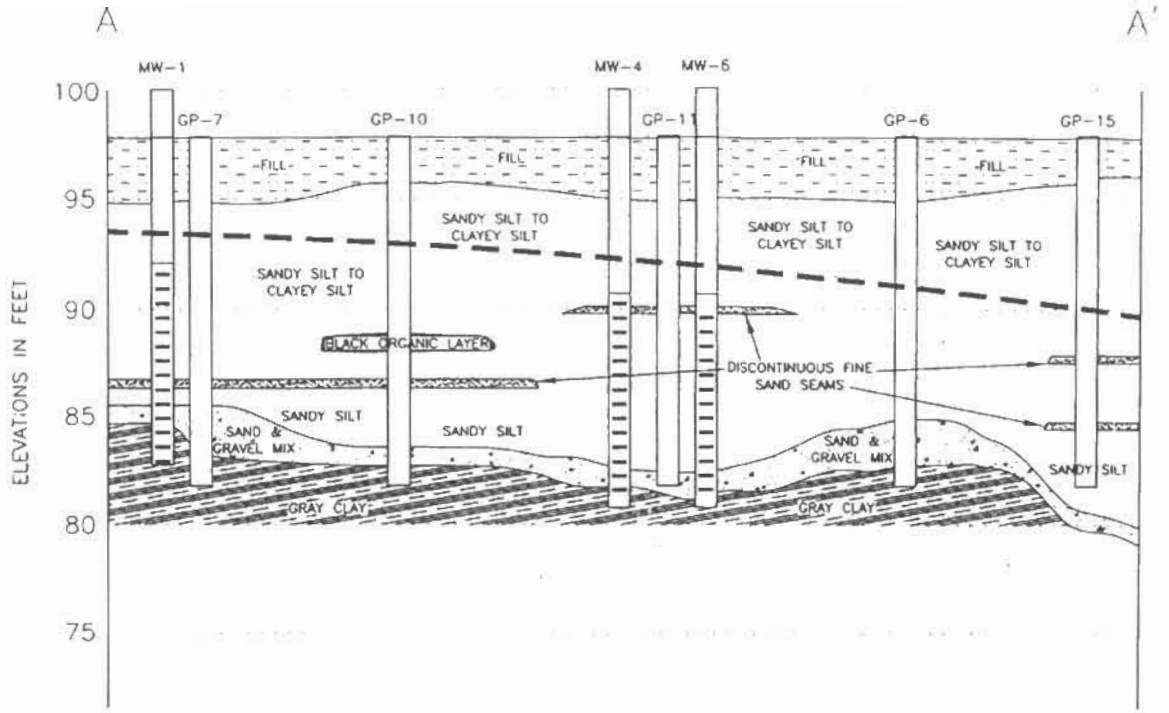
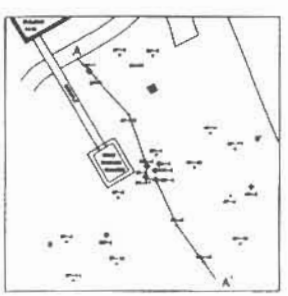


FIGURE B *Boring Location and Cross-Section Plan View*

For Official Use Only





GROUNDWATER TABLE

FIGURE C *Geologic Cross-Section A-A'*

For Official Use Only

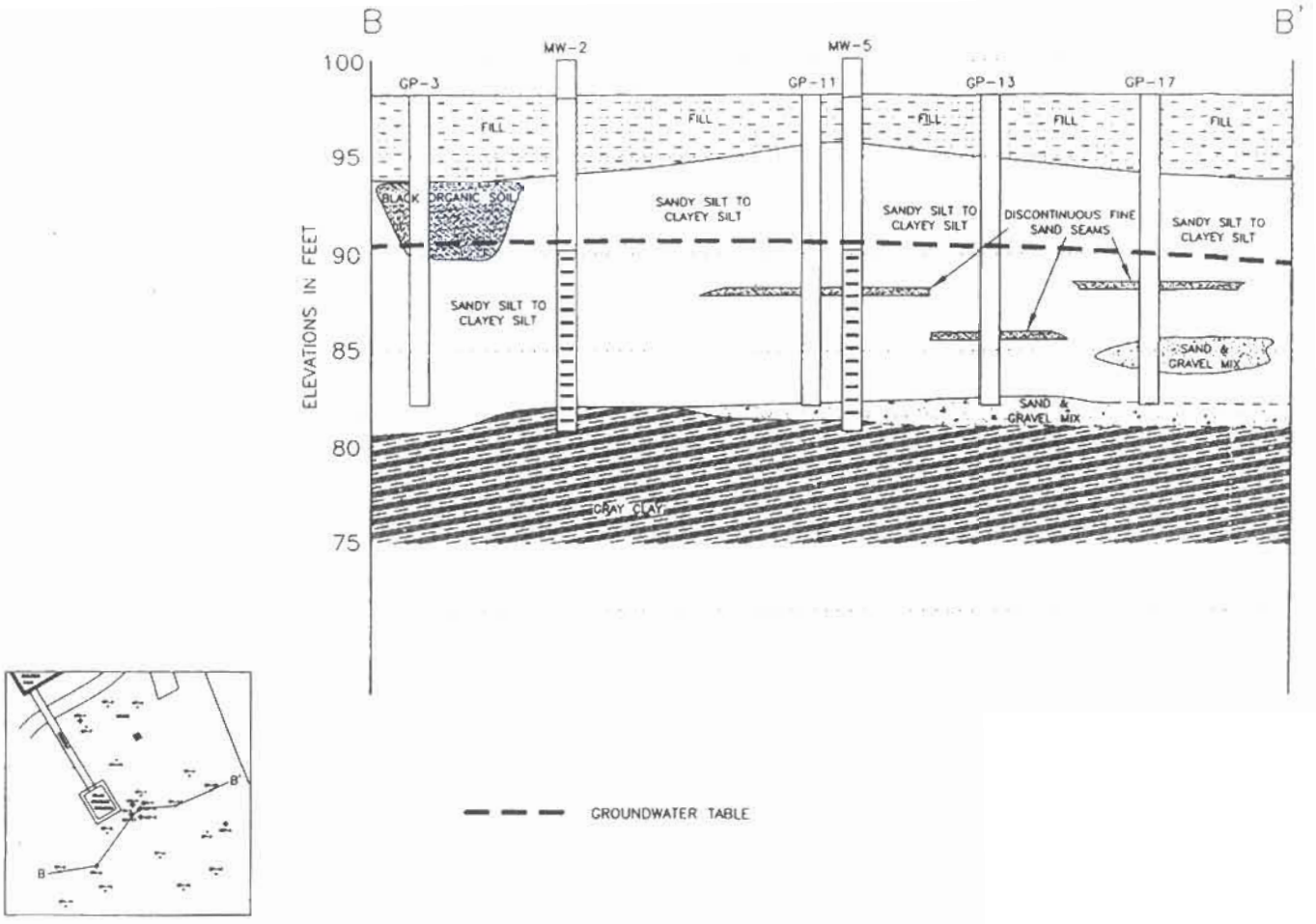


FIGURE D *Geologic Cross-Section B-B'*

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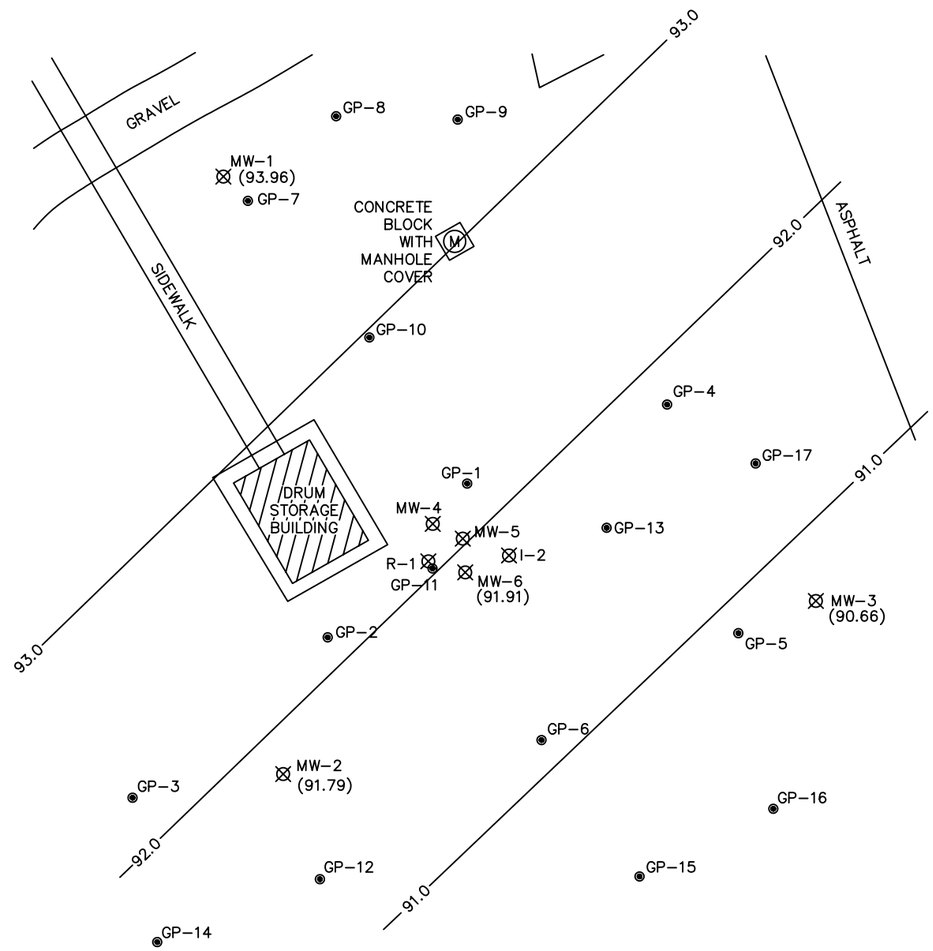


LEGEND

●GP-17	GEOPROBE BORING
⊠ MW-3	MONITORING WELL
(91.57)	GROUNDWATER ELEVATION
92.0	POTENTIOMETRIC CONTOUR

0 30 60

SCALE IN FEET

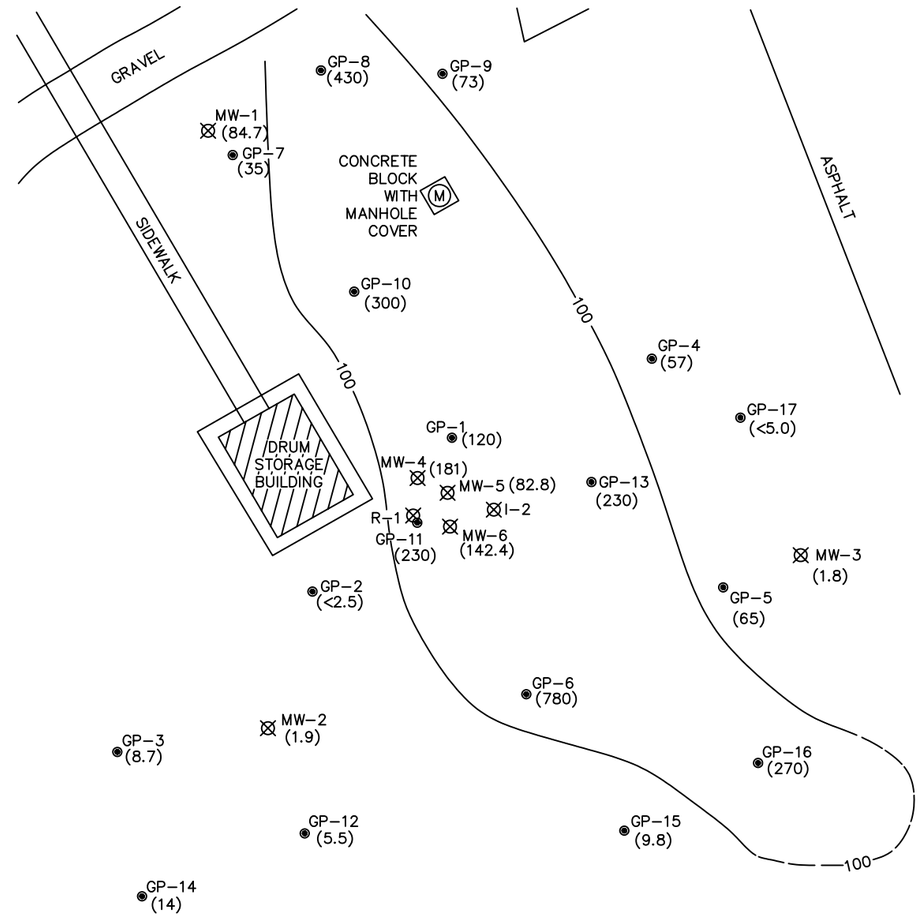
Solutions-IES
Industrial & Environmental Services
1101 NOWELL ROAD
RALEIGH, NORTH CAROLINA 27607
TEL.: (919) 873-1060 FAX.: (919) 873-1074

GROUNDWATER POTENTIOMETRIC SURFACE MAP
INDIAN HEAD SITE
INDIAN HEAD NAVAL WARFARE CENTER
INDIAN HEAD, MARYLAND

FIGURE:

E

FILE	DATE	PROJECT MANAGER	CHECKED BY	DRAFTER	PROJECT NUMBER
Figure 2.dwg	11/04/05	MTL	SLK	KBB	3030.04A2.ESTC



LEGEND

◉GP-17	GEOPROBE BORING
⊠ MW-3	MONITORING WELL
( )	PERCHLORATE CONCENTRATION IN PPM
—100—	PERCHLORATE ISOCONTOUR

NOTE
GEOPROBE RESULTS ARE FROM WATER SAMPLES COLLECTED BETWEEN JAN. 22 & JAN. 24, 2002.

MONITORING WELL RESULTS ARE FROM SAMPLES COLLECTED ON FEB. 5–6, 2002.

0 30 60
SCALE IN FEET

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GROUNDWATER PERCHLORATE DISTRIBUTION
INDIAN HEAD SITE
INDIAN HEAD NAVAL WARFARE CENTER
INDIAN HEAD, MARYLAND

FIGURE: F

FILE	DATE	PROJECT MANAGER	CHECKED BY	DRAFTER	PROJECT NUMBER
Figure 3.dwg	11/04/05	MTL	SLK	KBB	3030.04A2.ESTC

APPENDIX II

SITE-SPECIFIC WORKPLAN FOR PRE-DEMONSTRATION SAMPLING (NOVEMBER 2005)

SITE-SPECIFIC WORK PLAN
INDIAN HEAD DIVISION
NAVAL SURFACE WARFARE CENTER
INDIAN HEAD SITE
INDIAN HEAD, CHARLES COUNTY, MARYLAND

Prepared by:

Solutions-IES, Inc.
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Solutions-IES Project No. 3030.04A2.ESTC

November 3, 2005

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Sheri L. Knox, P.E.
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Industrial & Environmental Services

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APPENDIX A

Appendix A – Site-Specific Health & Safety Plan
Appendix B – Boring Advancement and Sample Collection Procedures

1.0 INTRODUCTION

Groundwater and surface water contaminated with perchlorate (ClO_4^-) has become a major environmental issue for the US Department of Defense (DoD) due to the use, release and/or disposal of solid rocket fuel and munitions containing ammonium perchlorate. Perchlorate is a highly mobile, soluble salt that sorbs poorly to most aquifer material, and can persist for decades under aerobic conditions. As a consequence, discharge of perchlorate to the environment can impact ground and surface water with the potential for human consumption through direct (drinking water) and indirect (crop uptake from irrigation water) pathways. Currently, there is no federal cleanup standard for perchlorate in groundwater or soil. However, several states have identified health-based goals, cleanup goals and action levels for groundwater, surface water and drinking water that range in concentration from 1 µg/L to 18 µg/L. Specifically, the State of Maryland has identified a health-based goal of 1 µg/L[2].

As an emerging technology, the promise of using monitored natural attenuation (MNA) as a groundwater remediation strategy for perchlorate is significant. Recent laboratory research has shown that a diverse array of bacteria can anaerobically degrade perchlorate to chloride and oxygen. These organisms appear to be widespread in the environment and can use a variety of different organic substrates as electron donors for perchlorate reduction. This suggests that perchlorate may naturally degrade at some sites without active human intervention. However, field demonstrations are essential to show that perchlorate does naturally attenuate, and the conditions where attenuation is most likely to occur.

The current project is being conducted under funding provided by the Environmental Security Technology Certification Program (ESTCP Project: ER-0428). During a conference call with the ESTCP project review team on October 12, 2005, the site at Building 1419 at the Naval Surface Warfare Center, Indian Head Division (IHDIV), Indian Head, Maryland was approved as the first of two locations for technical demonstration of the potential for the MNA of perchlorate in groundwater. A portion of this same site was used previously for a separate ESTCP-funded demonstration of an enhanced *in situ* bioremediation technology (see Section 2.1). However, according to previous reporting, a complete delineation of the perchlorate plume at this site has not been conducted. The last full round of sampling of the wells installed as part of the earlier demonstration was performed in winter 2002. As part of the forthcoming technical demonstration of the potential for MNA at the site, the installation of a number of monitoring wells will be required to assist us in determining mass flux and perchlorate degradation rates. However, because the perchlorate contaminant plume has not been fully assessed, particularly in the southeast direction closer to Mattawoman Creek, this Site-Specific Work Plan (SSWP) has been prepared to describe steps to accomplish this task prior to completing the Technology Demonstration Plan for this site.

This SSWP describes the methods and procedures to perform preliminary groundwater assessment field work at the Indian Head site. The following sections provide details regarding monitoring well installation, sample collection, and field and laboratory testing from of the area identified as the Building 1419 site at Indian Head. A site-specific Health and Safety Plan (HASP) is provided in Appendix A.

2.0 SITE BACKGROUND AND DESCRIPTION

In December 2004, Solutions-IES initially contacted personnel at Indian Head familiar with the Building 1419 site about the potential for including the site in the MNA investigation. Mr. Cary Yates completed a questionnaire prepared by Solutions-IES and provided invaluable information about the history and site

[2] Interstate Technology & Regulatory Council, 2005. *Perchlorate: Overview of Issues, Status, and Remedial Options,* September 2005.

conditions. Recently, Mr. Randall Cramer was identified as the site contact for this area. A report entitled *Field Demonstration of In Situ Perchlorate Bioremediation at Building 1419* prepared in January 2004 ("the January 2004 report") was used as the primary source of historical information about the site[3].

Based on the information in the January 2004 report, Solutions-IES conducted a sampling event on February 14, 2005 to obtain information about groundwater conditions for use in the site selection process for the current project. Subsequently, additional samples were collected on September 28, 2005 in anticipation of the selection of the Building 1419 site at Indian Head for a field demonstration of the technology. The background information from the January 2004 report and the groundwater results from Solutions-IES' testing in 2005 are described in the following section.

2.1 Location and Background

The IHDIV is located near Indian Head in Charles County, Maryland, and is approximately 30 miles south of Washington, DC. The Building 1419 site, also referred to as the Hog-out Facility, is located on the southeast side of the IHDIV. The perchlorate-impacted groundwater is located southeast of Building 1419 in a 2-acre grassy area containing a small drum storage building, and numerous groundwater monitoring, injection, and extraction wells. The area is bordered to the southeast by Mattawoman Creek which is a large tributary to the Potomac River (Figure 1). Building 1419 was used to clean out or "hog out" solid propellant containing ammonium perchlorate from various devices, including rockets and ejection seat motors, that had exceeded their useful life span. According to Randall Cramer, historically the hog-out liquid was simply washed out of Building 1419 into a marshy area between the building and Mattawoman Creek. When this process was stopped, the marshy area was filled in and seeded with grass cover. The hog-out process and former waste handling methods have impacted the groundwater near Building 1419.

To evaluate remedial alternatives for impacted groundwater at Building 1419, an investigation to determine the effectiveness of injecting lactate substrate into the subsurface was performed by Shaw Environmental, Inc. A pilot system was created employing a recirculation cell design consisting of two field areas: a test area and a control area. In the test area, groundwater was extracted from the site, amended with a lactate substrate and a pH buffer, and then re-injected into the aquifer. Groundwater was extracted and re-injected without substrate or buffer amendment in the control area. Each Shaw pilot test cell covered an area measuring approximately 10 X 10 ft (100 sq. ft) in the middle of the filled area south of the hog-out facility.

2.2 Site Geology, Hydrogeology and Plume Geometry

The study area used by Shaw Environmental for their pilot test is located southeast of Building 1419 and is approximately 220 to 300 feet north of Mattawoman Creek. The surficial geology of the area was derived from soil samples collected from 17 Geoprobe borings and six test borings that ranged in depth from 16 to 20 feet below ground surface (bgs). The top 2 to 4 feet consisted of fill material including organic soils, gravel, and silty sand. The underlying 11 to 13 feet consisted of mottled light to olive brown clay to sandy silts. The clay and sand fractions of the silts varied horizontally and vertically. Fine-grained sand seams 1 to 2 inches in thickness were seen in many of the boring locations, but these seams were not continuous from boring to boring. At a depth of approximately 15 ft bgs, a 1 to 1.5 ft thick layer of sand and gravel was encountered. This layer was found to be continuous throughout the area. The sand and gravel layer is underlain by a gray clay layer, which extends to a depth of at least 20 feet bgs, the deepest extent of the Geoprobe® and test borings. This is likely the clays of the Potomac Group.

[3] Randall J. Cramer and Cary Yates, Indian Head Division, Naval Surface Warfare Center and Paul Hatzinger and Jay Diebold of Shaw Environmental, Inc., *Field Demonstration of In Situ Perchlorate Bioremediation at Building 1419* (Appendix E), January, 2004.

Groundwater elevations measured in the six monitoring wells in the field indicate a groundwater flow direction to the southeast toward the Mattawoman Creek (Figure 2). The flow direction basically follows the surface topography. Depth to groundwater ranged from approximately 6.5 to 10.25 ft bgs. The average hydraulic gradient, as measured between wells MW-1 and MW-3, was 0.023 ft/ft, indicating a relatively flat gradient. Figure 3 shows an interpretation of the 100 mg/L perchlorate isoconcentration contour from the January 2004 report. The plume extends from Building 1419 to the southeast, but neither the distal end or lateral extent of the migration is estimated.

In order to obtain additional information for the site-selection process, Solutions-IES traveled to the site on February 14, 2005 to collect soil and groundwater samples. Monitoring well MW-1 is located about 80 feet upgradient from the Shaw pilot test cells, MW-2 is located approximately 50 ft southwest of the test cells and MW-4 was located at the north edge of the control treatment cell. Groundwater samples were collected from these monitoring wells using a peristaltic pump polyethylene tubing. Field parameters were collected during low flow sampling at each monitoring well. Table 1 summarizes field parameters collected during the groundwater sampling activities at each monitoring well. The table also summarizes the perchlorate concentration detected in each groundwater sample.

Table 1
Groundwater Characterization in Selected Monitoring Wells, February 14, 2005
Building 1419 Site, Naval Surface Warfare Center
Solutions-IES Project No. 3030.04A2.ESTC

Monitoring Well Identification	pH (Standard Unit)	Oxidation/Reduction Potential (mV)	Dissolved Oxygen (ppm)	Perchlorate (µg/L)
MW-1	4.9	105.	~1.0	92,820
MW-2	6.9	< -1000	~3.5	3
MW-4	5.4	5.6	~8	36,263

Solutions-IES returned to the site on September 28, 2005 and collected groundwater samples from monitoring wells MW-4D and MW-5, located within the lactate injection treatment cell of Shaw's pilot test, to measure perchlorate and total organic carbon (TOC) concentrations within the test area. The objective was to determine whether there was any long-term impact of the lactate injection treatment that was ended in 2002 that could complicate the planned evaluation of the potential for MNA in this area. Table 2 summarizes the field parameters, the current TOC concentrations and the perchlorate concentrations reported in 2002 and measured during this event.

Table 2
Groundwater Characterization in Selected Monitoring Wells, September 28, 2005
Building 1419 Site, Naval Surface Warfare Center
Solutions-IES Project No. 3030.04A2.ESTC

Monitoring Well Identification	pH (Standard Unit)	Oxidation/Reduction Potential (mV)	Dissolved Oxygen (ppm)	Perchlorate (µg/L) 2002	Perchlorate (µg/L) 9/28/05	TOC (mg/L)
MW-4D	5.5	117	4.5	181,000	38,500	2.2
MW-5	5.9	53	2.3	82,800	36,200	3.2

Although it appears that perchlorate concentrations are currently much lower in the test area that had been treated with lactate than the concentrations reported in 2002, there is no indication of residual organic carbon in this area of the site and the perchlorate concentrations remain sufficiently elevated to perform the technical demonstration proposed for the current project.

3.0 Site Characterization and Sample Collection

3.1 Overall Project Objectives

The overall objective of this project is to provide DoD managers with the tools needed to: (1) identify sites where MNA may be appropriate for management of perchlorate releases; and (2) demonstrate to regulatory agencies that perchlorate MNA is effective for controlling adverse impacts to the environment at some sites. Overall objectives to be accomplished in this project are listed below.

Evaluate the rate and extent of perchlorate biodegradation in aquifer material and groundwater from a variety of sites that received perchlorate.

Evaluate the use of enzyme assays and isotopic ratios as indicators of perchlorate biodegradation in laboratory incubations and field trials.

Develop multiple lines of evidence to evaluate the monitored natural attenuation of perchlorate at two field sites.

Develop a protocol for monitoring the natural attenuation of perchlorate.

Transfer the knowledge gained about perchlorate MNA to the regulatory community.

3.2 Site-Specific Sampling Objective

The site-specific objective is to better define the existing perchlorate contaminant plume, obtain updated information on the hydrogeology, and collect monitoring data which will aid Solutions-IES in locating monitoring wells associated with the technical demonstration. Field work will include installing additional temporary/permanent monitoring wells, collecting groundwater samples from new and existing monitoring wells, and performing specific capacity tests to confirm and extend the information previously obtained at Indian Head.

This SSWP outlines the methods for temporary/permanent well installation, and groundwater sampling which will be performed at the Building 1419 site. The results of the activities described in this SSWP will provide a more complete characterization of the groundwater perchlorate plume and help optimize the selection of well locations for use in the technical demonstration.

3.3 Scope of Work

The scope of work for this portion of the project includes updating the perchlorate plume delineation, hydrogeology, and groundwater data previously obtained for Indian Head.

3.3.1 Soil Boring and Monitor Well Installation

Based on a review of the January 2004 report and Solutions-IES' field observations and testing during the site selection process, approximately two days of Geoprobe® work (10 to 20 borings) will be performed to advance soil borings in the vicinity of the existing perchlorate plume at the Building 1419 site. Figure 4 shows the proposed locations of new pairs of borings across the site in relation to the site features and the previously drawn 100 mg/L perchlorate isoconcentration contour. The proposed layout covers areas upgradient, cross-gradient, and downgradient of the existing plume. At each location, a pair of borings will be advanced, and the soil profile from the deeper boring will be continuously logged. Each boring will then be converted to 1-inch diameter PVC temporary well with a bentonite seal and locking or PVC slip cap.

Total well depths ranged from 13 to 16 ft bgs where the clay layer identified as the Potomac Group is encountered. Although actual depths may vary slightly, for purposes of this SSWP, we have assumed that the initial boring at each location will be advanced to the clay layer approximately 16 ft bgs, taking care to terminate the boring an inch or two within the clay layer. The well in this boring will be installed to a total depth of approximately 16 ft bgs with a 2-ft length of screen (14 to 16 ft bgs). ***The depth of this screen interval is targeted to transect the gravel/sand layer, if present. Based on field observations, the well depth will be adjusted to screen the gravel layer***. The second boring of each pair will then be placed approximately 2 feet from the initial boring and advanced to a total depth of 13 ft bgs. The second well in the pair will be installed to a total depth of approximately13 ft bgs with a 5-foot length of screen (~8 to 13 ft bgs) which is designed to transect sandy silt/clayey silt layer predominately present a depths less than 13 ft bgs. ***The actual depths may vary depending on the final depth of the deeper well. However, the bottom of the screened interval in the second, shallower well should be at least one foot higher than the top of the screen interval in the deeper, first well of each pair. The 5-ft screen interval in the shallower well is intended to screen across suspected any sand stringers that may be present in the upper zone***. Figure 4 also shows a cross-section depicting general location of screened intervals for well pairs installed at the site. For detailed information regarding the advancement of borings using the Geoprobe®, or well installation see Appendix B.

For this scope of work, the location of the temporary wells will be established by measuring from existing site features. A licensed survey will not be performed at this time. The locations will be recorded with sufficient accuracy to place them on a scaled map suitable for selecting well locations for the technology demonstration. Solutions-IES personnel will survey the elevation of the top-of-casing of each well based on an assumed benchmark of 100 ft established on site or tied into an existing well elevation, if available.

Groundwater samples will be collected from each of the new temporary wells, and the existing monitoring wells (MW-1, MW-2, MW-3, MW-4, MW-5, MW-6). Prior to sample collection, each of the wells will be developed with a peristaltic pump. In addition, specific capacity tests will be performed on one new well and one well installed during previous work (old well) screened over the deeper gravel/sand layer and two wells (one old and one new) screened in the shallower sandy silt/clayey silt zone. The results will be compared to permeability information previously identified at Building 1419.

After the groundwater results are analyzed, some of the temporary wells may be converted to permanent monitoring wells for possible use in the technical demonstration. To convert temporary wells to permanent, the well will be finished with a flush-mount manhole cover. All other temporary wells will be abandoned in place by pulling downhole materials from the borehole and filling the borehole from the bottom with a bentonite-grout mix. A licensed well contractor will abandon the wells.

3.3.2 Groundwater Sampling Procedures

Groundwater samples will be obtained using standard collection equipment such as pumps/tubing. Appendix B identifies the collection protocol specific to the Building 1419 site**.** The procedure for collecting samples at each of the new and existing monitoring wells will be as follows.

(a) Water level: Measure the depth to water from the top-of-casing elevation using electronic water level meter and record measurement in the field book. Elevations will be measured to the nearest 0.01 ft.

(b) Groundwater collection: Pump groundwater at a low flow rate to minimize the disturbance to oxygen concentration in the sampled wells. Use a peristaltic pump with new disposable tubing for each well.

(c) Field parameters: Periodically collect groundwater quality parameters until conditions stabilize (i.e., less than 10% change over 5 minutes of pumping) by collecting a 100-mL water sample in a 250-mL plastic jar and measure pH, temperature, conductivity and oxidation-reduction potential (ORP) using standard field meters.

(d) Dissolved oxygen: As water is flowing out of the sampling tubing, insert a Chemetrics 0 - 1 mg/L self-filling dissolved oxygen (DO) ampoule into the end of the tube. Break off the ampoule tip below the water surface, pulling water into the ampoule while being careful to exclude any oxygen. Read the DO concentration by visual comparison to color standards or using a field photometer. If the DO exceeds 1 mg/L, repeat this process with the 1 – 12 mg/L DO ampoules.

(e) Total organic carbon: Collect one 250-ml amber bottle preserved with hydrochloric acid for TOC analysis.

(f) Methane and permanent gases: Collect two 40-ml VOA vial with no preservative and no headspace for analysis of permanent gases.

(g) Perchlorate: Fill a 200-ml plastic bottle with groundwater. Insert a 50-ml plastic disposable syringe into the sample and withdraw the groundwater sample into the syringe. Prepare a sequential filtering stack by affixing a disposable 0.45 µm pore size filter to a 0.20 µm pore size filter. Place the coupled syringe filter stack onto the end of the syringe and filter the volume into a clean 200 ml plastic bottle with no preservative. Repeat until approximately 125 ml of sample have been filtered into the bottle. Close the bottle while retaining the headspace.

(i) Collect one 250-ml plastic bottle with no preservative and no headspace for anion analysis (Cl^-, NO_2, NO_3, SO_4, PO_4).

All water samples planned for laboratory analysis will be labeled, packed on ice and shipped to the appropriate laboratory for overnight delivery. Chemical analyses and required glassware are summarized in Table 3.

Table 3
Sample Collection and Analysis Details
Building 1419 Site, Naval Surface Warfare Center
Solutions-IES Project No. 3030.04A2.ESTC

Number of Sample Bottles	Containers	Target Constituent/Method	Field/Laboratory
1	250-mL plastic bottle	Conductivity, temperature, pH, oxidation-reduction potential/Field Meters	Field
0	From tubing	Dissolved oxygen/Chemetrics	Field
2	40-mL VOA vial (no preservative)	Methane/Method 8015M	Environmental Science Corp.
1	A minimum of 100 ml (no preservative) coupled 0.45µm and 0.20 µm filtering setup	Perchlorate/Method 314	Columbia Analytical Services
1	250-mL plastic bottle (preservative)	Chloride, nitrate, nitrite, sulfate, phosphate/Method 9056	NCSU CCEE Lab
1	250-mL amber bottle preserved with HCL)	Total organic carbon/Method 9060	Environmental Science Corp.

4.0 QA/QC Samples

Selected QA/QC samples will be prepared. New disposable polyethylene tubing will be used to purge and sample each well. Therefore, no rinse blank will be collected. One duplicate groundwater sample will be collected from one well. One duplicate sample from one well will be subjected to analysis for perchlorate and TOC, only. All sample containers will be new and will be supplied directly from the laboratory. They will be labeled immediately upon filling, stored on ice and submitted to the laboratory under chain-of-custody control.

5.0 Investigation-Derived Waste (IDW)

Minimization of IDW is an important aspect of the sampling and sample collection activities. All disposal of IDW will be coordinated with the IHDIV personnel. Personnel will segregate all clean wastes from impacted materials. Clean waste would include plastic sheeting, boxes, and packaging materials. These materials will be contained in plastic bags and disposed of as directed by IHDIV personnel. Soiled or impacted disposable personal protective equipment such as Tyveks® and gloves will be cleaned to the extent possible, double bagged and also disposed as directed in coordination with IHDIV.

Purge water and soil cores will be handled as directed by IHDIV personnel. IHDIV personnel are aware of the amount and kind of waste that may be generated and are prepared to dispose of it accordingly.

6.0 Results Evaluation and Reporting

The results of the site characterization activities described in this SSWP will be incorporated in the Technical Demonstration Plan. If requested, a table summarizing the data will be made available to IHDIV.

7.0 Project Schedule

Implementation of the SSWP includes the following activities:

1. Coordinate access, digging permits or boring permits.
2. Mobilization, boring advancement, groundwater sample collection, permeability tests and demobilization.
3. Conversion of selected temporary wells to permanent wells. Abandonment of other temporary wells not needed for the technology demonstration.

Laboratory analyses will be requested using a standard turnaround of two weeks from sample submittal except for perchlorate analyses which may be requested using a one week turnaround.

FIGURES

APPENDIX A

(UPDATED HEALTH AND SAFETY PLAN PROVIDED IN APPENDIX V OF TECHNOLOGY DEMONSTRATION PLAN)

SITE-SPECIFIC HEALTH AND SAFETY PLAN: BUILDING 1419, IHDIV

ESTCP PROJECT NO. ER-0428
SOLUTIONS-IES PROJECT NO. 3030.04A2.ESTC

A. General Information

Site Name: Building 1419, Indian Head Division, Naval Surface Warfare Center (IHDIV)

Site Contact: Mr. Randall Cramer

Contact Address: Indian Head Division, Naval Surface Warfare Center
101 Strauss Avenue, Indian Head, Maryland, 20640

Contract Office Phone No.: (301) 744-2578
Site Location: The site is on the southeast side of IHDIV near Indian Head, MD.

Date(s) of Reconnaissance/Assessment: SSWP activities are planned for November 2005.

Nature of Visit (check all that apply)**:**

On-Site Reconnaissance	
Boring Advancement	X
Temporary Well Installation	X
Groundwater Sampling	X
Remediation Overview	

Site Investigation Team: All site personnel have read the site-specific Health and Safety Plan and are familiar with its provisions.

Personnel	Responsibilities	Signature
	Well Installation, Groundwater Sampling, and Permeability Tests	
	Groundwater Sampling, and Permeability Tests	

Site Health and Safety Officer: _____ _____

Plan Prepared by: Sheri L. Knox, P.E. _____

Plan Reviewed by: Walt Beckwith, P.G. _____

APPENDIX III

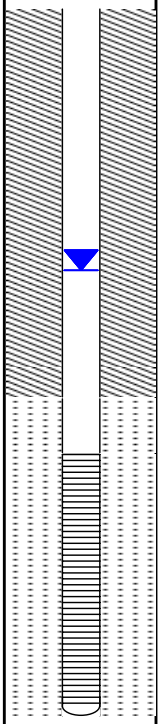
BORING LOGS

Log of Soil Boring SGP-1S

Project: Perchlorate MNA *Solutions-IES Project No.:* 3030.04A2.ESTC *Client:* ESTCP

Drilling Method: Geoprobe *City:* Indian Head
Sampler Type: Macro-Core *County:* Charles *Water Level From TOC:* 7.89 feet
Boring Date: 11/15/05 *State:* Maryland *Water Level BGS:* 4.74 feet
Installed By: Vironex
Logged By: DH *Checked By:* DH *Depth of Well:* 12.71 feet bgs

SUBSURFACE PROFILE			SAMPLE					
Depth	USCS Symbol	Description	Sample Interval	Type	% Recovery	PID Field Screen (ppm 250 500 750) / OVA Field Screen (ppm 250 500 750)	Lab Sample Depth	Well Data
ft / m		Ground Surface						
0 / 0		Boring Not logged. Refer to adjacent boring SGP-1D						
1								
2								
3 / 1								
4								
5								
6 / 2								
7								
8								
9								
10 / 3								
11								
12								
13 / 4								
14								
15								
16 / 5								
17								
18								
19								
20 / 6								



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Log of Soil Boring SGP-1D

Project: Perchlorate MNA *Solutions-IES Project No.:* 3030.04A2.ESTC *Client:* ESTCP

Drilling Method: Geoprobe *City:* Indian Head
Sampler Type: Macro-Core *County:* Charles *Water Level From TOC:* 5.38 feet
Boring Date: 11/15/05 *State:* Maryland *Water Level BGS:* 4.52 feet
Installed By: Vironex
Logged By: DH *Checked By:* DH *Depth of Well:* 16.01 feet bgs

SUBSURFACE PROFILE			SAMPLE					
Depth (ft / m)	USCS Symbol	Description	Sample Interval	Type	% Recovery	PID Field Screen (ppm 250 500 750) / OVA Field Screen (ppm 250 500 750)	Lab Sample Depth	Well Data
Ground Surface								
0	SM	Brown, silty fine sand with organic matter						
1	SM	Tan, silty fine sand		MC	100			
2	SM	Tan and grey, silty fine sand						
3	SM	Grey, silty fine sand						
4	SM	Wet, tan and grey, silty fine sand		MC	100			
5								
6				MC	100			
7								
8								
9				MC	100			
10								
11								
12				MC	100			
13								
14								
15	GM	Tan, silty fine sand, grading to a medium sand at the bottom 4 inches (quartz grained >1 inch)						
16	CL	Light grey, dense plastic clay						
17		Boring terminated at 16 feet bgs						
18								
19								
20								

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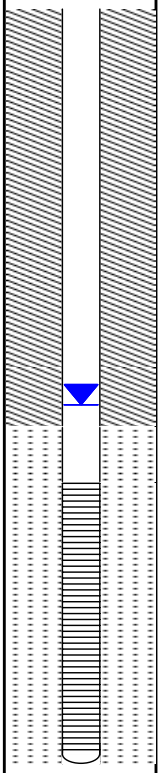
Log of Soil Boring SGP-2S

Project: Perchlorate MNA *Solutions-IES Project No.:* 3030.04A2.ESTC *Client:* ESTCP

Drilling Method: Geoprobe *City:* Indian Head
Sampler Type: Macro-Core *County:* Charles *Water Level From TOC:* 8.49 feet
Boring Date: 11/15/05 *State:* Maryland *Water Level BGS:* 7.14 feet
Installed By: Vironex
Logged By: DH *Checked By:* DH *Depth of Well:* 13.56 feet bgs

SUBSURFACE PROFILE			SAMPLE					
Depth	USCS Symbol	Description	Sample Interval	Type	% Recovery	PID Field Screen (ppm 250 500 750) / OVA Field Screen (ppm 250 500 750)	Lab Sample Depth	Well Data
ft / m		Ground Surface						
0 / 0		Boring not logged. Refer to adjacent boring SGP-2D						
1								
2								
3 / 1								
4								
5								
6 / 2								
7								
8								
9								
10 / 3								
11								
12								
13 / 4								
14								
15								
16 / 5								
17								
18								
19								
20 / 6								



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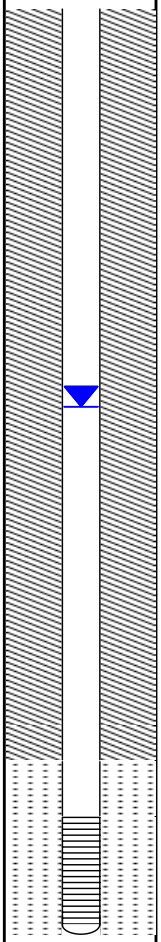
Log of Soil Boring SGP-2D

Project: Perchlorate MNA *Solutions-IES Project No.:* 3030.04A2.ESTC *Client:* ESTCP

Drilling Method: Geoprobe *City:* Indian Head
Sampler Type: Macro-Core *County:* Charles *Water Level From TOC:* 7.64 feet
Boring Date: 11/15/05 *State:* *Water Level BGS:* 7.16 feet
Installed By:
Logged By: DH *Checked By:* DH *Depth of Well:*

SUBSURFACE PROFILE			SAMPLE			PID Field Screen (ppm 250 500 750) / OVA Field Screen (ppm 250 500 750)	Lab Sample Depth	Well Data
Depth (ft / m)	USCS Symbol	Description	Sample Interval	Type	% Recovery			
0 / 0		Ground Surface						
0–1	SW	Brown, silty fine sand with organic material						
1–3	SW	Brown, silty fine sand with gravel fill material		MC	100			
3–4 (1)	SW	Tan, silty fine sand						
4–6	SC	Wet, tan, clayey fine- sand		MC	100			
6–8 (2)	SW	Tan, silty fine sand						
8–12 (3)	SW	Tan, silty fine sand		MC	100			
12–13	SW	Tan, silty fine sand with <1/2 inch dia. gravel						
13–14 (4)	CL	Tan, plastic and dense clay		MC	100			
14–16	SW	Tan, silty fine sand.						
16–18 (5)	SW	Tan, silty fine sand with slightly more clay.		MC	100			
18–20 (6)	GC	Tan, clayey fine- sand						



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Log of Soil Boring SGP-2D

Project: Perchlorate MNA | *Solutions-IES Project No.:* 3030.04A2.ESTC | *Client:* ESTCP

Drilling Method: Geoprobe | *City:* Indian Head | *Initial Water Level:* 6 feet
Sampler Type: Macro-Core | *County:* Charles | *Stabalized Water Level:* N/A
Boring Date: 11/15/05 | *Cave In Depth:* N/A

Logged By: DH | *Checked By:* DH | *Total Depth of Boring:* 16.62 feet

SUBSURFACE PROFILE			SAMPLE					
Depth	USCS Symbol	Description	Sample Interval	Type	% Recovery	PID Field Screen (ppm 250 500 750) / OVA Field Screen (ppm 250 500 750)	Lab Sample Depth	Well Data
21		***CL*** Bluish, grey sandy clay						
22				MC	100			
23	7							
24								
25		Boring terminated at 24 feet bgs						
26	8							
27								
28								
29								
30	9							
31								
32								
33	10							
34								
35								
36	11							
37								
38								
39	12							
40								

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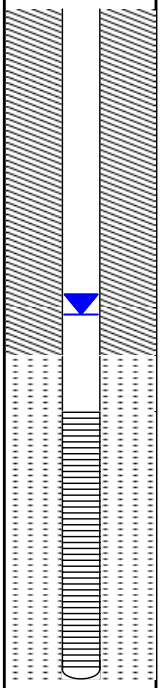
Log of Soil Boring SGP-3S

Project: Perchlorate MNA *Solutions-IES Project No.:* 3030.04A2.ESTC *Client:* ESTCP

Drilling Method: Geoprobe *City:* Indian Head
Sampler Type: Macro-Core *County:* Charles *Water Level From TOC:* 8.46 feet
Boring Date: 11/15/05 *State:* Maryland *Water Level BGS:* 5.53 feet
Installed By: Vironex
Logged By: DH *Checked By:* DH *Depth of Well:* 12.04 feet bgs

SUBSURFACE PROFILE			SAMPLE					
Depth	USCS Symbol	Description	Sample Interval	Type	% Recovery	PID Field Screen (ppm 250 500 750) / OVA Field Screen (ppm 250 500 750)	Lab Sample Depth	Well Data
ft / m		Ground Surface						
0 / 0		Boring not logged. Refer to adjacent boring SGP-3D						
1								
2								
3 / 1								
4								
5								
6 / 2								
7								
8								
9								
10 / 3								
11								
12								
13 / 4								
14								
15								
16 / 5								
17								
18								
19								
20 / 6								



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Log of Soil Boring SGP-3D

Project: Perchlorate MNA *Solutions-IES Project No.:* 3030.04A2.ESTC *Client:* ESTCP

Drilling Method: Geoprobe *City:* Indian Head
Sampler Type: Macro-Core *County:* Charles *Water Level From TOC:* 7.55 feet
Boring Date: 11/15/05 *State:* Maryland *Water Level BGS:* 5.82 feet
Installed By: Vironex
Logged By: DH *Checked By:* DH *Depth of Well:* 15.52 feet bgs

SUBSURFACE PROFILE			SAMPLE					
Depth (ft / m)	USCS Symbol	Description	Sample Interval	Type	% Recovery	PID Field Screen (ppm 250 500 750) / OVA Field Screen (ppm 250 500 750)	Lab Sample Depth	Well Data
0		Ground Surface						
0–1		***SM*** Brown silty fine sand with organic matter						
1–6		***SM*** Tan, brown, orange, silty fine sand (dense and dry)		MC	100			
6–7		***SC*** Wet, tan, grey, clayey fine sand.		MC	100			
7–10		***SC*** Grey, green, clayey fine sand		MC	100			
10–15		***SM*** Wet, tan, orange, silty fine sand (no gravel at bottom, and white in color from 14.5 to 14.75 feet bgs)		MC	100			
15–16		***CL*** Light grey, plastic and dense clay		MC	100			
16		Boring terminated at 16 feet bgs						

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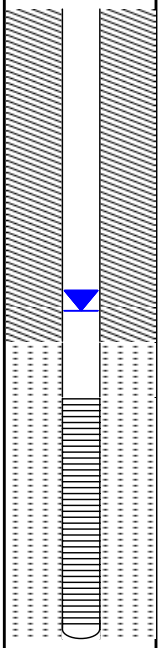
Log of Soil Boring SGP-4S

Project: Perchlorate MNA *Solutions-IES Project No.:* 3030.04A2.ESTC *Client:* ESTCP

Drilling Method: Geoprobe *City:* Indian Head
Sampler Type: Macro-Core *County:* Charles *Water Level From TOC:* 8.67 feet
Boring Date: 11/15/05 *State:* Maryland *Water Level BGS:* 5.43 feet
Installed By: Vironex
Logged By: DH *Checked By:* DH *Depth of Well:* 11.31 feet bgs

SUBSURFACE PROFILE			SAMPLE					
Depth	USCS Symbol	Description	Sample Interval	Type	% Recovery	PID Field Screen (ppm 250 500 750) / OVA Field Screen (ppm 250 500 750)	Lab Sample Depth	Well Data
ft / m		Ground Surface						
		Boring not logged. Refer to adjacent boring SGP-4D						



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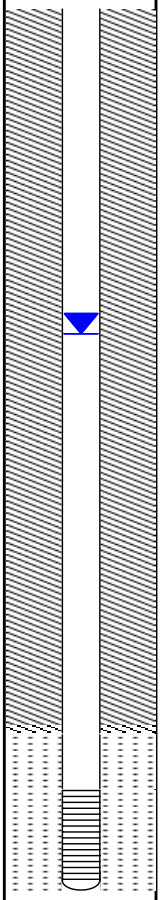
Log of Soil Boring SGP-4D

Project: Perchlorate MNA *Solutions-IES Project No.:* 3030.04A2.ESTC *Client:* ESTCP

Drilling Method: Geoprobe *City:* Indian Head
Sampler Type: Macro-Core *County:* Charles *Water Level From TOC:* 7.08 feet
Boring Date: 11/15/05 *State:* Maryland *Water Level BGS:* 5.86 feet
Installed By: Vironex
Logged By: DH *Checked By:* DH *Depth of Well:* 15.83 feet bgs

SUBSURFACE PROFILE			SAMPLE					
Depth (ft / m)	USCS Symbol	Description	Sample Interval	Type	% Recovery	PID Field Screen (ppm, 250 500 750) / OVA Field Screen (ppm, 250 500 750)	Lab Sample Depth	Well Data
0		Ground Surface						
0–3		***SM*** Brown silty fine sand with organic matter						
2–3		***SM*** Tan, orange, silty fine sand with approx. 3% asphalt (fill material)		MC	100			
3–6		***SM*** Tan, orange, silty fine sand						
6–9		***SM*** Tan, silty fine sand		MC	100			
9–12				MC	100			
12–15		No recovery			0			
15–16		***GM*** Orange, silty coarse sand with gravel (< 1/4 inch)		MC	37			
16–18		***CL*** Light grey, plastic and dense clay						
18		Boring terminated at 16 feet bgs						



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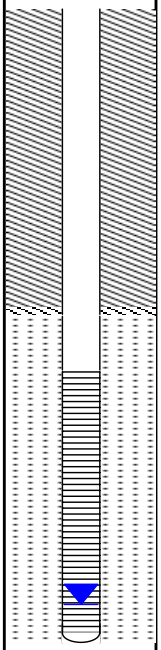
Log of Soil Boring SGP-5S

Project: Perchlorate MNA *Solutions-IES Project No.:* 3030.04A2.ESTC *Client:* ESTCP

Drilling Method: Geoprobe *City:* Indian Head
Sampler Type: Macro-Core *County:* Charles *Water Level From TOC:* 14.32 feet
Boring Date: 11/15/05 *State:* Maryland *Water Level BGS:* 10.7 feet
Installed By: Vironex
Logged By: DH *Checked By:* DH *Depth of Well:* 11.38 feet bgs

SUBSURFACE PROFILE			SAMPLE					
Depth	USCS Symbol	Description	Sample Interval	Type	% Recovery	PID Field Screen (ppm 250 500 750) / OVA Field Screen (ppm 250 500 750)	Lab Sample Depth	Well Data
ft / m		Ground Surface						
0 / 0		Boring not logged. Refer to adjacent boring SGP-5D						
1								
2								
3 / 1								
4								
5								
6 / 2								
7								
8								
9								
10 / 3								
11								
12								
13 / 4								
14								
15								
16 / 5								
17								
18								
19								
20 / 6								



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Log of Soil Boring SGP-5D

Project: Perchlorate MNA *Solutions-IES Project No.:* 3030.04A2.ESTC *Client:* ESTCP

Drilling Method: Geoprobe *City:* Indian Head
Sampler Type: Macro-Core *County:* Charles *Water Level From TOC:* 10.98 feet
Boring Date: 11/15/05 *State:* Maryland *Water Level BGS:* 8.41 feet
Installed By: Vironex
Logged By: DH *Checked By:* DH *Depth of Well:* 14.43 feet bgs

SUBSURFACE PROFILE			SAMPLE					
Depth (ft / m)	USCS Symbol	Description	Sample Interval	Type	% Recovery	PID Field Screen (ppm, 250 500 750) / OVA Field Screen (ppm, 250 500 750)	Lab Sample Depth	Well Data
		Ground Surface						
0		***SM*** Tan, brown, silty fine sand with approx. 3% asphalt (dense)						
2		***SM*** Tan, silty fine sand (dry and dense)		MC	100			
6				MC	100			
7		***SM*** Tan, silty fine sand (wet)						
10				MC	100			
11		***SM / SC*** Tan, silty fine sand transitioning to tan, clayey fine sand (wet)						
13		***GW*** White, medium sand with < 1/2 inch dia. quartz gravel in bottom 3 inches		MC	50			
15		No recovery			0			
17		Boring terminated at 14.43 feet bgs						

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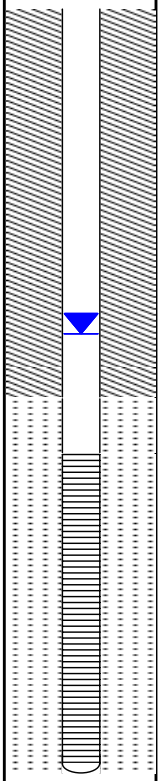
Log of Soil Boring SGP-6S

Project: Perchlorate MNA *Solutions-IES Project No.:* 3030.04A2.ESTC *Client:* ESTCP

Drilling Method: Geoprobe *City:* Indian Head
Sampler Type: Macro-Core *County:* Charles *Water Level From TOC:* 8.11 feet
Boring Date: 11/15/05 *State:* Maryland *Water Level BGS:* 5.85 feet
Installed By: Vironex
Logged By: DH *Checked By:* DH *Depth of Well:* 13.72 feet bgs

SUBSURFACE PROFILE			SAMPLE					
Depth	USCS Symbol	Description	Sample Interval	Type	% Recovery	PID Field Screen (ppm 250 500 750) / OVA Field Screen (ppm 250 500 750)	Lab Sample Depth	Well Data
ft / m		Ground Surface						
0 / 0		Boring not logged. Refer to adjacent boring SGP-6D						
1								
2								
3 / 1								
4								
5								
6 / 2								
7								
8								
9								
10 / 3								
11								
12								
13 / 4								
14								
15								
16 / 5								
17								
18								
19								
20 / 6								



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Log of Soil Boring SGP-6D

Project: Perchlorate MNA *Solutions-IES Project No.:* 3030.04A2.ESTC *Client:* ESTCP

Drilling Method: Geoprobe *City:* Indian Head
Sampler Type: Macro-Core *County:* Charles *Water Level From TOC:* 7.04 feet
Boring Date: 11/15/05 *State:* Maryland *Water Level BGS:* 5.99 feet
Installed By: Vironex
Logged By: DH *Checked By:* DH *Depth of Well:* 16.04 feet bgs

SUBSURFACE PROFILE			SAMPLE					
Depth (ft / m)	USCS Symbol	Description	Sample Interval	Type	% Recovery	PID Field Screen (ppm, 250 500 750) / OVA Field Screen (ppm, 250 500 750)	Lab Sample Depth	Well Data
		Ground Surface						
0		**SM** Brown, silty fine sand with organic material and gravel						
2		**SW** Red, fine sand with gravel		MC	100			
4		**SM** Tan, orange, silty fine sand (dry)						
6		**SM** Tan, silty fine sand (wet). Low strength zone from 14 to 16 feet. 50% recovery from 12 to 16 feet due to 1 inch sized gravel blocking Geoprobe sleeve		MC	100			
10				MC	100			
14		**GM** Silty gravel, inferred.		MC	50			
16		**CL** Light tan, plastic and dense clay		MC	100			
18		Boring terminated at 17 feet bgs						

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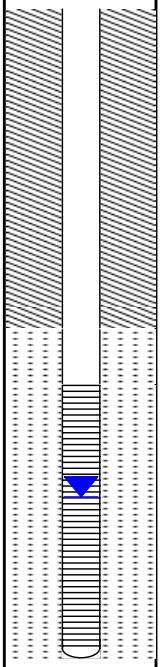
Log of Soil Boring SGP7-S

Project: Perchlorate MNA *Solutions-IES Project No.:* 3030.04A2.ESTC *Client:* ESTCP

Drilling Method: Geoprobe *City:* Indian Head
Sampler Type: Macro-Core *County:* Charles *Water Level From TOC:* 12.07 feet
Boring Date: 11/15/05 *State:* Maryland *Water Level BGS:* 8.79 feet
Installed By: Vironex
Logged By: DH *Checked By:* DH *Depth of Well:* 11.65 feet bgs

SUBSURFACE PROFILE			SAMPLE					
Depth	USCS Symbol	Description	Sample Interval	Type	% Recovery	PID Field Screen (ppm 250 500 750) / OVA Field Screen (ppm 250 500 750)	Lab Sample Depth	Well Data
ft / m		Ground Surface						
		Boring not logged. Refer to adjacent boring SGP-7D						



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Log of Soil Boring SGP-7D

Project: Perchlorate MNA *Solutions-IES Project No.:* 3030.04A2.ESTC *Client:* ESTCP

Drilling Method: Geoprobe *City:* Indian Head
Sampler Type: Macro-Core *County:* Charles *Water Level From TOC:* 11.25 feet
Boring Date: 11/15/05 *State:* Maryland *Water Level BGS:* 8.79 feet
Installed By: Vironex
Logged By: DH *Checked By:* DH *Depth of Well:* 14.67 feet bgs

SUBSURFACE PROFILE			SAMPLE					
Depth (ft / m)	USCS Symbol	Description	Sample Interval	Type	% Recovery	PID Field Screen (ppm, 250 500 750) / OVA Field Screen (ppm, 250 500 750)	Lab Sample Depth	Well Data
		Ground Surface						
0		***SM*** Brown, orange, silty fine sand (fill material)						
1		***PT*** Black coal fines (fill material)		MC	100			
2		***SM*** Tan, orange, silty fine sand (dry)						
3								
4								
5								
6		***SM*** Tan, orange, silty fine sand (wet)		MC	100			
7								
8		***SM*** Tan, silty fine sand (dry)						
9								
10				MC	100			
11								
12								
13				MC	100			
14		***GM*** Tan, silty fine sand mixed with gravel <1.5 inches dia.			0			
15								
16		***CL*** Light tan, plastic and dense clay						
17		No recovery.						
18		Boring terminated at 16 feet bgs.						
19								
20								

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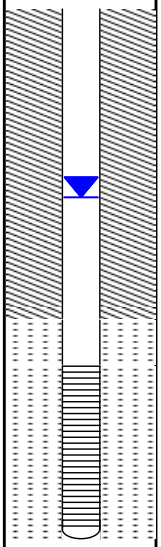
Log of Soil Boring SGP-8S

Project: Perchlorate MNA *Solutions-IES Project No.:* 3030.04A2.ESTC *Client:* ESTCP

Drilling Method: Geoprobe *City:* Indian Head
Sampler Type: Macro-Core *County:* Charles *Water Level From TOC:* 7.33 feet
Boring Date: 11/15/05 *State:* Maryland *Water Level BGS:* 4.27 feet
Installed By: Vironex
Logged By: DH *Checked By:* DH *Depth of Well:* 11.91 feet bgs

SUBSURFACE PROFILE			SAMPLE					
Depth	USCS Symbol	Description	Sample Interval	Type	% Recovery	PID Field Screen (ppm 250 500 750) / OVA Field Screen (ppm 250 500 750)	Lab Sample Depth	Well Data
ft / m		Ground Surface						
		Boring not logged. Refer to adjacent boring SGP-8D						



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Log of Soil Boring SGP-8D

Project: Perchlorate MNA *Solutions-IES Project No.:* 3030.04A2.ESTC *Client:* ESTCP

Drilling Method: Geoprobe *City:* Indian Head
Sampler Type: Macro-Core *County:* Charles *Water Level From TOC:* 19.48 feet
Boring Date: 11/15/05 *State:* Maryland *Water Level BGS:* 17.21 feet
Installed By: Vironex
Logged By: DH *Checked By:* DH *Depth of Well:* 22.81 feet bgs

SUBSURFACE PROFILE			SAMPLE					
Depth (ft / m)	USCS Symbol	Description	Sample Interval	Type	% Recovery	PID Field Screen (ppm 250 500 750) / OVA Field Screen (ppm 250 500 750)	Lab Sample Depth	Well Data
		Ground Surface						
0	SM	Brown, silty fine sand with organic material						
1	SM	Brown, silty fine sand with gravel fill material		MC	100			
3	SM	Tan, silty fine sand						
4	SC	Tan, clayey fine sand (wet)		MC	100			
6	SM	Tan, silty fine sand						
7	SM	Tan, silty fine sand		MC	100			
10	GM	Tan, silty fine sand with <1/2 inch dia. gravel						
12	CL	Tan, plastic and dense clay		MC	100			
13	SM	Tan, silty fine sand						
16	SM	Tan, silty fine sand with slightly more clay		MC	100			
17	SC	Tan, clayey fine sand						
18	CL	Bluish grey sandy clay		MC	100			
20		Boring terminated at 24 feet bgs.						
24								

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APPENDIX IV

BORING ADVANCEMENT AND GROUNDWATER SAMPLING

SAMPLE COLLECTION DETAILS BUILDING 1419
INDIAN HEAD
ESTCP PROJECT NO. CU-0248
SOLUTIONS-IES PROJECT NO. 3030.04A2.ESTC

Soil Sampling and Monitoring Well Installation – Solutions-IES personnel or a subcontracted Geoprobe® drilling contractor will provide soil collection services. During the pre-demonstration work, a mechanical pile driver will be used to install borings in the mudflats. One of the objectives of this work is to gain a knowledge of the hydrogeology, and geochemistry in the mudflats at Indian Head The mechanical pile driver will be used to drive a Geoprobe® Large Bore Sampler or split-spoon sampler into the mudflats located southeast of the source area. The borings will likely be advanced to a depth of approximately 11 ft bgs approximately 2 feet above the clay layer that has been previously identified at the site. Soil samples will be collected from the upper and lower portion of the boring. If possible, a number of the borings will be converted to a temporary monitoring well by inserting a 1-inch diameter PVC slotted well screen and casing into a shorter outer casing that will be used to keep the boring open while the well screen is inserted into the boring. A bentonite seal will be placed within the borehole around the well screen. A 2-foot well screen will be used in the well construction. During the demonstration set-up, a number of the temporary wells may be converted to permanent monitoring wells for use in the technical demonstration. Selected temporary wells will be abandoned with a bentonite-grout mix by a licensed well contractor.

Groundwater Sampling- Groundwater samples will be collected via a temporary monitoring well or a Geoprobe®.Screen Point Sampler. If a groundwater sample is collected from a temporary monitoring well, plastic tubing will be placed in the temporary well and pumped with a peristaltic pump at a low flow rate collecting groundwater sample while minimizing disturbance to the dissolved oxygen concentration. Hand bailers will be available, if necessary.

If a groundwater sample is collected via a Geoprobe®.Screen Point Sampler, the sampler will be driven to the appropriate depth. The sleeve of the sampler will be retracted to expose the screen, and the groundwater sample will be collected using a peristaltic pump as described above.

During the pre-demonstration work, and performance monitoring, groundwater samples will be analyzed for those parameters outlined in Section 3.5.3 and Section 3.6.7 of the Technical Demonstration Plan.

Specific Capacity Tests - Specific capacity tests will be performed on several new shallow and deep wells. The specific capacity test, as described by Wilson *et al.* (1997), will be performed by inserting a ¼

inch polyethylene tube to a known depth beneath the water surface. The depth of the intake tube is determined by attaching a water level gauge to the side of the tube. When the exact known depth is reached below the static water table, a peristaltic pump will be switched-on at full flow. When the drawdown is stabilized, as witnessed by the occurrence of bubbles in the tubing, a graduated cylinder will be filled. The time to fill the cylinder, volume of the cylinder, and depth of the intake is entered into a spreadsheet formula to estimate the hydraulic conductivity. A minimum of three tests will be performed in at each location so that an average can be determined.

APPENDIX V

UPDATED SITE-SPECIFIC HEALTH AND SAFETY PLAN

SITE-SPECIFIC HEALTH AND SAFETY PLAN: BUILDING 1419, IHDIV

ESTCP PROJECT NO. ER-0428
SOLUTIONS-IES PROJECT NO. 3030.04A2.ESTC

A. General Information

Site Name: Building 1419, Indian Head Division, Naval Surface Warfare Center (IHDIV)

Site Contact: Mr. Randall Cramer

Contact Address: Indian Head Division, Naval Surface Warfare Center
101 Strauss Avenue, Indian Head, Maryland, 20640

Contract Office Phone # (301) 744-2578

Site Location: The site is on the southeast side of IHDIV near Indian Head, MD.

Date(s) of Reconnaissance/Assessment: SSWP activities are planned for "DATE"..

Nature of Visit (check all that apply**):**

On-Site Reconnaissance	
Boring Advancement	**X**
Monitoring Well Installation	**X**
Groundwater Sampling	**X**
Remediation Overview	

Site Investigation Team: **All site personnel have read the site-specific Health and Safety Plan and are familiar with its provisions.**

Personnel	**Responsibilities**	**Signature**
	Well Installation, Groundwater Sampling, and Permeability Tests	
	Groundwater Sampling, and Permeability Tests	

Site Health and Safety Officer: _____ _____

Plan Prepared by: Sheri L. Knox, P.E. _____

Plan Reviewed by: Walt Beckwith, P.G. _____

B. Site Characterization

Site Description: The Building 1419 Site is located approximately 30 miles south of Washington, DC. Building 1419 is also referred to as the Hog-out Building. The study area includes approximately 2 acres of grassy area containing a drum storage building, a concrete block with a manhole cover, and numerous groundwater monitoring, injection, and extraction wells. The area is bordered to the southeast by Mattawoman Creek, a large tributary to the Potomac River.

History of the Site: Building 1419 is used to clean out or "hog out" solid propellant containing ammonium perchlorate from various devices, including rockets and ejection seat motors, that have exceeded their useful life span. The hog-out process and former waste handling methods have impacted the groundwater near Building 1419.

Unusual Conditions or Features on Site (ponds, chemical lines, terrain, etc.) The land surface in the immediate site vicinity of the perchlorate plume appears to be relatively flat and open. The south edge of the site is bordered by a wooded area just prior to the shore of Mattawoman Creek, which is a tributary to the Potomac River. Small saplings or low lying branches may require clearing in the wooded area. Mudflats lie to the southeast of the shore. Slippery conditions as well as standing water may exist in the mudflats.

Prevailing Weather Conditions: Local forecasts should be reviewed prior to mobilization to help identify the weather conditions prior to site work.

C. Work Plan Instruction

Work Schedule / Visit Objectives:

The site-specific objective is to better define the perchlorate contaminant plume, obtain additional information concerning the hydrogeology, and obtain updated monitoring data which will aid Solutions-IES in locating permanent monitoring wells associated with the technology demonstration. Field work may include any of the following: collecting groundwater samples using a peristaltic pump or bailer and/or soil samples using a split spoon sampler or MacroCore® sampler, and installing permanent/temporary monitoring wells using standard well drilling techniques, direct push technology or pile driver, installing *insitu* columns, collecting groundwater samples from new and existing monitoring wells, and performing permeability tests in selected wells. The work will be performed in the spring of 2006.

Groundwater will be recovered from wells for sample analysis. Investigative derived waste will be containerized in drums and disposed of in coordination with IHDIV. See Section 3.6.4 of the Technical Demonstration Plan for details concerning investigative derived waste. IHDIV personnel are aware of the amount and kind of waste that may be generated. IHDIV will dispose of all IDW.

Map: Maps are attached to the Site-Specific Work Plan (Attached Figures).

D. Site Waste Characterization: The primary contaminants of concern are

Waste Type(s):

X	Liquid	X	Solid		Sludge		Gas

Characteristics: Perchlorate is the only contaminant identified in groundwater in the vicinity of Building 1419. It is a highly soluble, inorganic anion that results from the disassociation of the ammonium perchlorate. It possesses none of the characteristics listed below.

	Corrosive		Ignitable		Radioactive		Volatile
	Toxic		Reactive		Other		

.

Personal Protection Equipment (PPE):

The level of protection at the site is Level D PPE. Level D PPE will consist of standard work clothes (including tyvek overalls, as needed), steel-toed work boots, safety glasses, and nitrile gloves. A hard hat and hearing protection must be worn during drilling or Geoprobe activities. To avoid overexposure to the weather, appropriate winter gear will be worn when necessary.

Decontamination Procedures

X Level D If Level D personal protection contacts contaminated soil or groundwater, boot soles and safety glasses will be washed and rinsed, nitrile gloves will be removed. When necessary, standard work clothes will be removed and replaced with dry items.

Emergency Precautions: The greatest hazard is anticipated to be skin contact with contaminated soil or groundwater from contaminants that may be present in the groundwater.

Possible Exposure Route/First Aid: Perchlorate is the only contaminant of concern known to be in soil and groundwater at this site. However, because it is an industrial site, there is some potential that other undocumented contaminants are present, as well. The following information summarizes the first aid that will implemented as a result of minor exposure via the listed exposure routes. The exposure method identified is based on the possibility of encountering unknown contaminants in the vicinity of Building 1419 since it is located in industrialized portion of the Indian Head Site.

Exposure Route		Exposure Method		First Aid
Eyes		Yes, Splash		Flush with clean water for at least 15 minutes.
Skin		Yes, Splash, Contact with Soil		Wash with copious amounts of water.
Inhalation		Yes, Possibility of unknown volatiles present in the Groundwater.		Move upwind from the area of concern.
Ingestion		Yes, Splash, Contact with Soil		Flush the mouth with copious amount of clean water

Note: With any exposure route, inform the site contact if prolonged or unusual symptoms occur.

E. Hazard Evaluation

Previous investigations showed that perchlorate has been handled in the vicinity of Building 1419 (Table within Attachment A of the Health & Safety Plan). Contaminants are expected to be dilute in groundwater. However, the area in the vicinity of Building 1419 is highly industrialized, so there is a possibility that other unknown contaminants are present at that location.

Other hazards include slips, trips and falls, hypothermia, and operation of vehicles on wet and muddy surfaces. To address these concerns, the “buddy system” will be employed in muddy areas, the work area will be kept in order, and rain gear will be available on-site. Depending on work area, sampling activities may occur from a floating vessel or platform. When working in these conditions the “buddy system” will be used, and a life preserver, life saving ring, and/or life pole may be necessary, and will be positioned in close proximity to the work area as conditions warrant.

In addition, biting insects and ticks may be present during site work, so insect repellent will be available if needed. Snakes may also be present in the vicinity of the work area. Care will be taken to avoid snakes and their habitats.

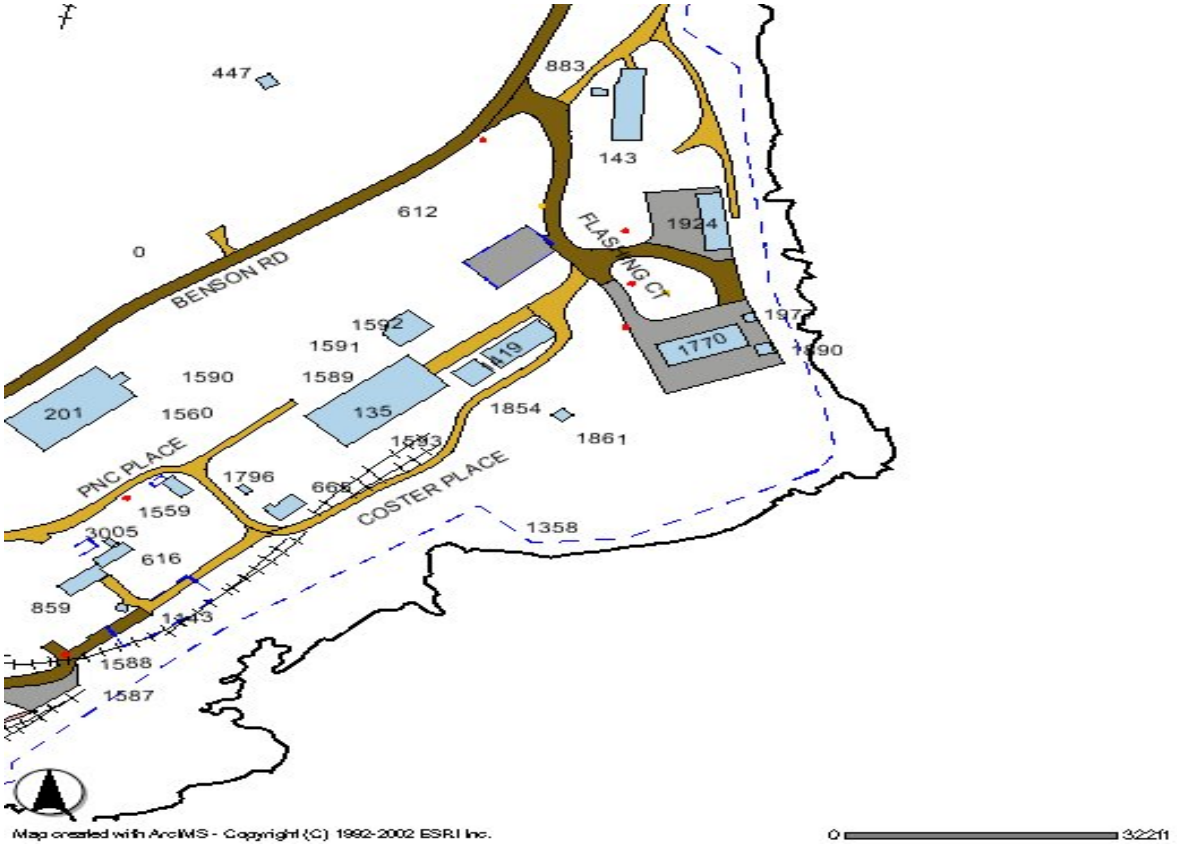
Air Monitoring:

Although there is a minimal chance of airborne contamination, air monitoring will be conducted during boring advancement by Solutions-IES personnel. During soil sampling activities, a Photoionization Detector (PID) or Organic Vapor Analyzer (OVA) will be used to monitor the air. Periodic air monitoring will be performed in the worker's breathing zone and at point sources (at the top of casing, soil piles etc.). The breathing zone is defined as the area within a 2-foot sphere around the worker's head. Background readings will be taken before work starts. If concentrations greater than 5 ppm above background concentrations are detected in the worker's breathing zone, work will stop, and air monitoring will be performed 5, 15 and 30 minutes after stopping to evaluate the conditions. If air concentrations in the breathing zone do not return to background levels in 30 minutes, reevaluate the situation with the Health and Safety Coordinator. Engineering controls may be required to continue work.

Unless there is evidence of airborne contamination during boring advancement and soil sampling, air monitoring will not be required during the groundwater sampling event, but will be available on site during groundwater sampling

F. Emergency Contacts

Location of Nearest Phone: Cell phones cannot be used on site. Phones are located at the fire box stations marked in red shown in following illustration. The closest firebox is located near Building 1770. At the fire box location, **dial 4333 to reach assistance.**



Hospital Address: Civista Medical Center, 701 Charles St, La Plata, MD

Hospital Phone Number: 301-609-4000

Emergency Transportation Systems (Phone Numbers): At Fire Box location **dial 4333** and the call will be routed to IHDIV Security.

Cell Phones: Dial IHDIV Security Direct: **(228) 688-3636**

Verify emergency response procedures required by the facility before starting work.

Emergency Route to Hospital:

Maneuvers

Distance Maps

Reverse Route | **Avoid Highways** | **Revise Route**

Total Est. Time: 24 minutes **Total Est. Distance:** 13.44 miles

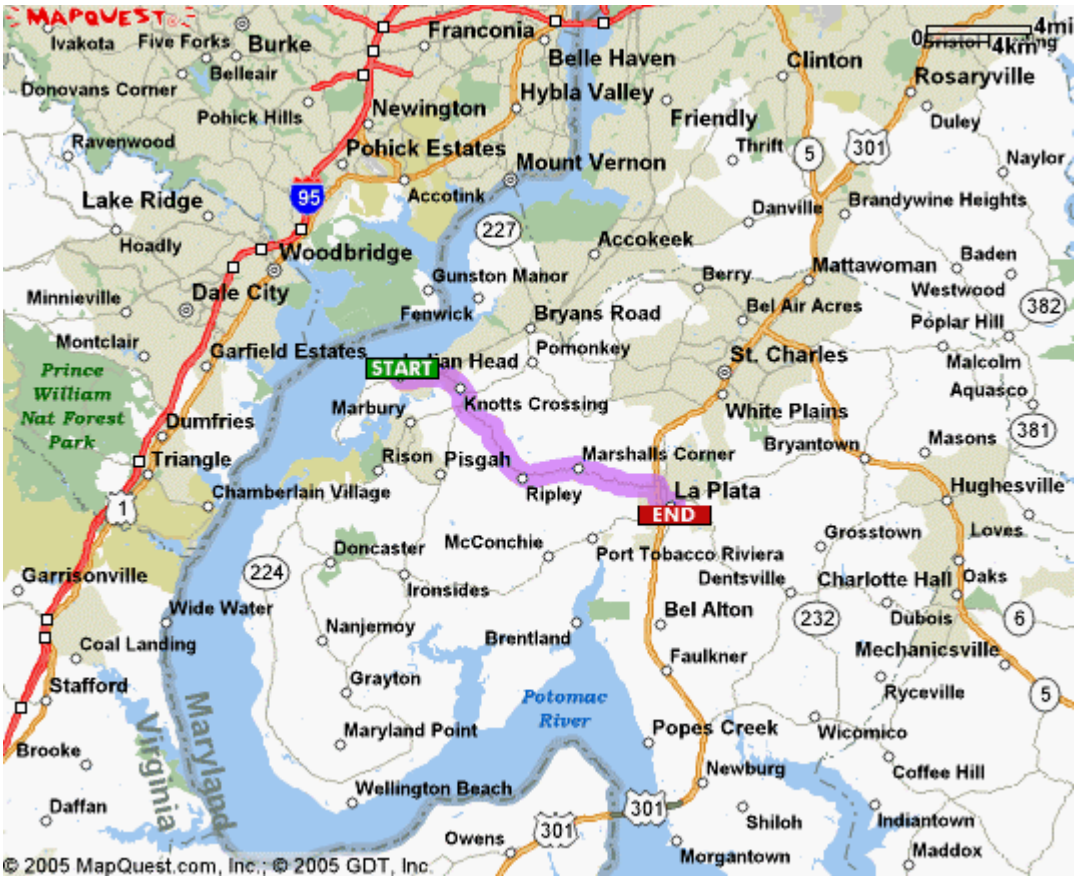
START 1: Start out going EAST on INDIAN HEAD HWY/MD-210 N toward N PROSPECT AVE. 1.5 miles Map

2: Turn RIGHT onto MD-225/HAWTHORNE RD. 10.5 miles Map

SOUTH 301 3: Turn RIGHT onto CRAIN HWY/US-301 S/BLUE STAR MEMORIAL HWY. 0.7 miles Map

4: Turn LEFT onto MD-6. 0.5 miles Map

END 5: End at **Civista Medical Ctr** 301-609-4000
701 Charles St, La Plata, MD 20646 US



TABLE

Table-Attachment A
Toxicological Characteristics of Chemical Constituent

CHEMICAL (CAS NO.)	OSHA PEL ACGIH TLV ACGIH STEL NIOSH IDLH	CHARACTERISTICS	ROUTE OF EXPOSURE	SYMPTOMS OF EXPOSURE
Perchlorate	NA	Appearance and properties vary with specific compound	ING	Evidence of long term exposure may include interference with iodine uptake in the production of hormones in the human thyroid.

NA = Not available
ING = Ingestion

APPENDIX VI

QUALITY ASSURANCE PROJECT PLAN

Quality Assurance Project Plan

Evaluation of Potential for Monitored Natural Attenuation of Perchlorate in Groundwater

Technology Demonstration Plan
for
Building 1419 Site, Naval Surface Warfare Center,
Indian Head, MD
ESTCP Project No. ER-0428

Prepared by:

Solutions IES, Inc.
1101 Nowell Road
Raleigh, NC 27607

February 2006

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Figure

Figure 1 Organizational Chart

QAPP Preparation

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2/15/06

Solutions-IES Senior Engineer | Date

Reviewed and Approved by: M. Tony Lieberman

2/15/06

Solutions-IES Project Manager and Co-Principal Investigator | Date

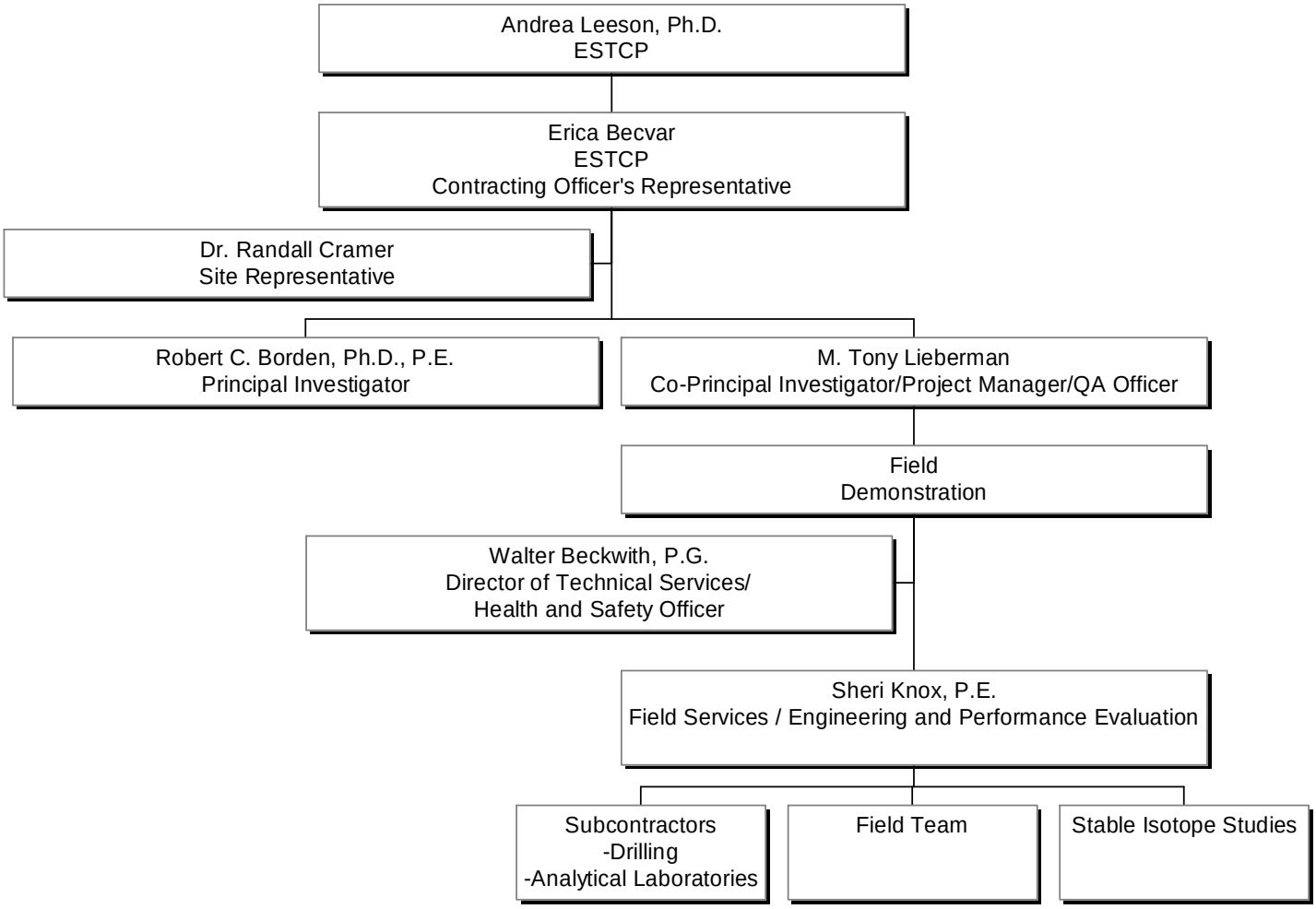
1.0 Purpose and Scope

The purpose of this Quality Assurance Project Plan (QAPP) is to provide guidelines that, when followed, will optimize the potential to obtain high quality field and laboratory data during the technology demonstration project. This QAPP describes methodologies for sampling and analysis of environmental media, proper record keeping protocols, data quality objectives, and procedures for data review. The overall objective of the QA program is to obtain and evaluate project-specific data that are accurate, precise, complete, adequately documented, and representative of actual field conditions to allow verification of the performance of monitored natural attenuation of perchlorate in groundwater.

2.0 Quality Assurance Responsibilities

Figure 1 provides the organizational chart for the technology demonstration project. The roles and responsibilities of relevant project personnel are summarized below.

Figure 1
Organizational Chart



Principal Investigator:	Responsible for providing overall project direction, coordination with ESTCP, site representatives, and regulatory agencies, and final review and approval of reports.
Project Manager:	Responsible for project coordination, scheduling, budget management, technical oversight, and report preparation.
QA Officer:	Responsible for ongoing review, monitoring, auditing, and evaluation of the field and laboratory QA/QC program.
Field Services/Eng:	Responsible for implementation of field QA/QC procedures, oversight of field team, and coordination with subcontractors.

3.0 Data Quality Objectives

The overall quality assurance objective is to ensure that data of known and acceptable quality are produced during the demonstration. Proper execution of each task will yield reliable data that are representative of media and conditions measured and are useful for meeting the intended project objectives. Data Quality Objectives (DQOs) are statements of the level of uncertainty that a decision maker is willing to accept in results derived from environmental data. These are developed for specific projects.

3.1 Objectives for Water-Level Measurements

Water-level measurement is a critical aspect of any groundwater evaluation. Water-level measurements are required during the course of the demonstration project to evaluate the groundwater flow direction. Water levels will be measured by sampling team personnel during all sampling events. Water levels will be measured with an electronic measuring device. Water-level measurements will be recorded to the nearest one-hundredth (0.01) of a foot, and the data will be referenced to surveyed top-of-casing data to determine groundwater elevations.

3.2 Objectives for Field Measurements in Aqueous Media

Field analyses will be performed on aqueous samples collected from monitoring wells in accordance with the Technology Demonstration Plan. Measurements of pH, temperature, and specific conductance will be collected to assure that an adequate purge has been achieved prior to actual sample collection and to evaluate changes in aquifer conditions during the course of the project. Quality assurance objectives for these parameters are presented as follows:

- pH – Measurements remain constant within 0.1 standard units.
- Specific Conductance - Measurements vary by no more than 10 percent.
- Temperature - Measurements remain constant for at least three successive readings.

Descriptions of the calibration and measuring procedures for these field instruments are provided in Section 4.1.

3.3 Objectives for Ambient Air and Volatile Gas Monitoring

Field analyses of ambient air quality will be performed as part of the site-specific health and safety program. It should be noted that perchlorate is the only contaminant identified in groundwater at this site and perchlorate is not detected by headspace monitoring. Nonetheless, monitoring for volatile organic compounds (VOCs) in the headspace of soil samples may be performed on samples as a screening step during boring and well installation activities. Field measurements will be performed either with a Photoionization Detector (PID) or an Organic Vapor Analyzer (OVA) with a Flame Ionization Detector (FID). The calibration and measurement procedures for these instruments are described in Section 4.1.

As a general rule, the PID should not be used to monitor for low molecular weight hydrocarbon compounds whose structures contain only single bonds (methane, ethane, pentane, hexane, heptane, carbon tetrachloride, and hydrogen sulfide). The PID should be used to detect: aromatics such as benzene, toluene and styrene; aliphatic amines such as dimethylamine; and chlorinated unsaturated compounds such as vinyl chloride and trichloroethene.

The OVA uses a hydrogen FID as its detection principle. This detector allows the monitor to respond to a wide variety of organic compounds, but limits its sensitivity to around 10 ppm under ideal circumstances. The OVA's best response is to single –bonded hydrocarbons such as methane and dichloroethane.

3.4 Objectives for Media Sample Analyses

The analytical level is appropriate for the following data uses that are applicable to this project:

- Site characterization;
- Engineering design;
- Monitoring during implementation.

The QA objectives for precision and accuracy established by contract laboratories are available upon request.

4.0 Calibration, QC Checks, and Corrective Action

4.1 Instrument Calibration Procedures and Frequency

Calibration of field equipment, such as pH meters, DO meters, ORP meters, specific conductance meters, PIDs and OVAs will be performed according to the procedures outlined in the equipment instruction manuals. Calibration of field equipment will be conducted each day the equipment is used in the field prior to use. The calibration procedures and calibration frequency employed by the contracted laboratories are described in their QA/QC Plans.

4.2 Field Quality Assurance and Quality Control Checks

Solutions-IES will collect field quality control (QC) samples during implementation of field activities to assess the quality of field procedures, preservation reagents, and sample bottles and the reliability of sample shipping and storage procedures.

As part of the overall project QA program, field replicate samples, method confirmation samples, and equipment rinsate blank samples will be collected for selected constituents. These field QC samples will be collected at the same time as the field samples and in the same type of containers. The QC samples will be handled in an identical manner as the field samples and shipped to the laboratory for analysis of the same constituents by the same analytical procedures as the field samples.

Field QC samples will include one of more of the following:

- Field Replicates – Sample aliquots taken from the same sampling device (bailer, hand auger, etc.) and sent to the same analytical laboratory for identical analyses. Field Replicates will be prepared at a frequency of <u>one per 20 samples per media-type sampled</u>.

- Method Confirmation Samples –Approximately 10% of the total samples collected during performance monitoring for perchlorate analysis by Method 314 will be sent to a certified laboratory for confirmatory analysis of perchlorate by Method 330.

- Equipment Rinsate Blanks – Organic-free, deionized water prepared in the laboratory that is placed in contact with cleaned sampling devices. The water is collected in appropriately labeled and preserved containers and sent for analysis. These samples will verify that field sampling equipment was properly cleaned. Rinsate blanks will be prepared at a frequency of <u>one per 20 samples per media type sampled</u>.

- Field QC samples will be labeled accordingly:
    - Field Replicates – REP- (1,2,3…)
    - Equipment Rinsate Blanks – RB –(1,2,3…)

4.3 Laboratory Quality Assurance and Quality Control Checks

The contract laboratories will demonstrate the ability to produce acceptable results using the procedures recommended by the analytical method. The data will be evaluated by the laboratory based on the following criteria (as appropriate for organic and inorganic chemical analyses):

- Method performance is evaluated using the following QC checks:
    - Calibration curve linearity
    - Blank contamination
    - Initial and continuing calibration standards
    - Spike recoveries (matrix and surrogate)
    - Relative Percent Differences (RPDs) between matrix spikes and matrix spike duplicates, samples and laboratory duplicates
    - Recoveries of laboratory control samples and independent QC check samples

- Percent recovery of internal standards
- Percent recovery of surrogate compounds
- Adequacy of detection limits obtained
- Precision of replicate analyses

Specific QA/QC procedures are included in the laboratory's QA/QC Plan, which is available upon request.

4.4 Performance and System Audits

Performance audits monitor the accuracy and precision of the analytical systems through the submission and analysis of control samples. System audits assess how closely the QAPP is adhered to during all phases of field data collection, sample collection, sample shipping, sample analyses, and data reduction and reporting. Performance and system audits for sampling and analysis operations consist of on-site review of field and laboratory procedures and QA systems and on-site review of equipment for sampling, calibration, and measurement.

4.4.1 Field System Audit

Solutions-IES field team leader may evaluate the performance of field personnel and general field operations in progress. The auditor will compare the performance of the field team during field activities (such as water-level measurements and sample collection) with the procedures specified in the QAPP.

4.4.2 Performance Evaluation Audits

A performance evaluation (PE) audit evaluates a laboratory's ability to obtain an accurate and precise answer in the analysis of a known check sample by a specific analytical method. Following the analytical data validation, a PE audit of the laboratory may be requested and conducted by Solutions-IES. This audit may be conducted if it is determined that the QA data provided in the analytical data package is outside acceptance criteria control limits. These PE audits may include a review of all raw data developed by the laboratory and not reported (laboratory non-reportables) and the submission of blind spike check samples for the analysis of the parameters in question. These check samples may be submitted disguised as field samples, in which case the laboratory will not know the purpose of the samples, or the samples may be obvious (known) check samples (USEPA or NIST traceable).

PE audits also may be conducted by reviewing the laboratory's results from "round-robin" certification testing and/or USEPA CLP evaluation samples. An additional component of PE audits includes the review and evaluation of raw data generated from the analysis of PE samples and actual field samples that may be in question.

4.5 Instrument Preventive Maintenance

4.5.1 Field Equipment

Records of calibration and preventive maintenance performed while collecting samples will be documented in field notebook during sampling.

4.5.2 Laboratory Equipment

Each contract laboratory will ensure that instruments are operating properly, and that rigorous maintenance and trouble-shooting procedures are followed. Specific preventative maintenance procedures followed by each contract laboratory is included in their respective QA/QC Plans.

4.6 Assessment of Data Precision, Accuracy, and Completeness

Brief descriptions of protocols that will be used to assess the precision, accuracy and completeness of the analytical data are provided below. Detailed methods used to assess precision and accuracy of data by the analytical laboratories are provided in their QA/QC Plans.

4.6.1 Precision

Precision is an estimate of the reproducibility of a method, and it may be estimated by several statistical tests, including the coefficient of variation and the relative percent difference (RPD) between replicate (or duplicate) samples. For the field sampling activities, precision will be evaluated by calculating the RPD for laboratory duplicate and field replicate samples. The calculated RPD then will be compared to the precision criteria established by the laboratory for analysis of laboratory duplicates.

4.6.2 Accuracy

The accuracy of a method is an estimate of the difference between the true value and the determined mean value. Certain QC samples, such as laboratory control samples, reagent water spike samples, QC check samples, matrix spike samples, and surrogate spike samples, have known concentrations prior to analysis. By comparing the percent recovery of the analysis of these samples to the known true value, it is possible to measure the accuracy of the analysis.

The laboratory collects recovery data for each of these parameters from approximately 30 analytical batches during routine analysis. The percent recovery data are averaged and the standard deviation of the percent recoveries is calculated. Ranges are established as practical control limits based on the desired level of confidence. Control charts are constructed, and the calculated range becomes the practical control limits used by the laboratory until another set of data is developed and new control limits are calculated.

4.6.3 Completeness

Data completeness will be expressed both as the percentage of total tests conducted that are deemed valid and as the percentage of the total tests required in the scope of work that are

deemed valid. Completeness will be calculated by Solutions-IES as part of the data validation process.

4.7 Data Reduction and Validation

The contract laboratories will utilize USEPA precision and accuracy criteria as guidance for data validation. Specific objectives for accuracy (percent recovery) and precision (relative percent difference) of the analytical measurements are presented in the laboratories QA/QC Plans. Additional documentation of analytical QA data will be available upon request to the laboratory to support validation conclusions and data usability determinations if increased defensibility of laboratory report data is required.

4.7.1 Validation of Field Data Package

The field data package will be reviewed by Solutions-IES for completeness and accuracy. The field data package includes all of the field records and measurements developed by the sampling team personnel. Failure in any of these areas may result in data being invalidated. The field data package validation procedures will consist of:

- A review of field data contained in the sampling logs for accuracy and completeness.
- A verification that samples, field replicates, field splits, and equipment blanks were properly prepared, preserved, and identified.
- A check of field analyses for equipment calibration and instrument condition.
- A review of the chain-of-custody forms for proper completion, signatures of field personnel, and the laboratory sample custodian and dates.

4.7.2 Validation of the Analytical Data Package

Validation of the analytical data package will be performed after completing the validation of the field data package. The validation steps will be performed by applying, where appropriate, the most current USEPA Laboratory Data Validation Functional Guidelines For Evaluating Inorganics Analyses (USEPA 2/94) and Organic Analyses (USEPA 12/94), and the precision and accuracy statements specified in the laboratory QA/QC Plan.

The analytical data package validation procedure will include:

- A comparison of the data package to the reporting level requirement to ensure completeness in the analytical data package.
- A comparison of sampling dates, sample extraction dates, and analysis dates to check that samples were extracted and/or analyzed within proper holding times.
- A review of the field and laboratory blanks to evaluate possible contamination sources.

- A review of QC check sample spike results and expected values (initial and continuing calibration verification standards) for inorganics analysis, to ensure that the recoveries are within the established control limits specified in the Laboratory QA/QC Plan.

- A review of the field replicate sample data, to check the precision of the chemical analyses and field sample collection techniques. Laboratory duplicates for solid and water matrices, if available, will also be reviewed.

- A review of the surrogate spike results and expected values for organic analyses to ensure that recoveries are within the control limits specified in the Laboratory QA/QC Plan.

4.8 Corrective Action

4.8.1 Field Conditions

Field personnel are responsible for ensuring that field instruments are functioning properly, that work progresses satisfactorily, and that work is performed in compliance with this QAPP. If a problem is detected by the field personnel, the Solutions-IES Project Manager shall be notified immediately by the Field Services Manager, at which time the problem will be investigated further and corrective action will begin.

4.8.2 Laboratory Corrective Action

Data evaluations necessary to verify proper analytical function must be performed by the contracting lab as early as possible in the analysis program within the time constraints imposed by individual analysis procedures.

A preliminary check of standard curve linearity, precision, and sensitivity should be performed when practical either before the analysis of the samples is begun (manual procedures) or while the first samples are being analyzed (automated procedures). The results are compared to QA/QC limits established by the contracting laboratory and the USEPA. Any analysis not conforming to control limits for precision, accuracy, detection limit, or linearity will be halted until the problem is identified and corrected. Laboratory batch sheets and control charts will document data evaluations and will contain all information necessary for assessment of the data quality, including: (1) information regarding indices of sensitivity, (2) precision, (3) detection limit, and (4) accuracy achieved during that run or batch.

Out-of-control incidents shall be documented concerning the nature of the incident and the corrective action taken to set the system back in control. A corrective action report (CAR), to be signed by the laboratory director and the laboratory QA officer, will be prepared and reported in the narrative summary of the laboratory report. Specific situations requiring the preparation of a CAR are described in the laboratory QA/QC Plan.

4.8.3 Reporting of Corrective Actions

A written report describing the nature of a corrective action case with an evaluation of the cause, if known, and the action taken, will be prepared by the Solutions-IES Field Services or Project Manager. The report will be distributed to the Solutions-IES Project Manager (if not preparing the report) and Principal Investigator.

All corrective actions taken by the contracted laboratories will be reported to the Solutions-IES Project Manager. The laboratory will include in each data package a discussion of the problems encountered and corrective actions taken. In addition, the laboratories will maintain a file for Solutions-IES' review that documents all corrective actions taken regardless of whether the actions performed were pertinent to the analysis of sample from Solutions-IES' project.

5.0 Demonstration Procedures

The Technology Demonstration Plan outlines the procedures for setting up and starting the demonstration. Materials such as monitoring well supplies will be routinely inspected to ensure proper function, and faulty materials will be discarded. Equipment used in the *in situ* columns will be inspected prior to installation. Equipment malfunctions will be recorded in the field logbook.

6.0 Equipment Decontamination Procedures

The cleaning procedures specified in this section are to be used by sampling personnel to decontaminate sampling and other field equipment prior to field use. Downhole drilling equipment (augers, tag lines, etc.) will be steam cleaned prior to and between each location to minimize the potential for cross-contamination. Split-spoon, hand-auger and other soil sampling devices and non-dedicated groundwater purging and sampling equipment will be scrubbed with laboratory-grade detergent, rinsed with tap water, and double rinsed with organic-free, deionized water prior to and between each use.

All liquids resulting from equipment decontamination will be containerized and properly disposed.

7.0 Sample Custody, Handling, and Shipment

7.1 Field Records

The key aspect of documenting sample custody is thorough record keeping. Daily records will be completed in the field logbook during field activities to document the collection of samples. All documents will be completed in ink, dated, and signed by the field person conducting the work.

7.2 Sample Labeling

Samples collected for chemical analysis will be fully labeled at the time of collection. At a minimum, the sample label information will include the sample identification, the date and time of collection, the analyses requested, the preservatives used, and the initials of the personnel collecting the sample. The sample collection data and the information contained on the label will be recorded in the field logbook as the samples are collected.

7.3 Sample Container Custody

All sample containers to be provided by the subcontract laboratories for this project will be new, pre-cleaned, and pre-baked according to the procedures specified in the analytical methods. All containers will be shipped from the laboratories to the designated location by common carrier in sealed coolers.

7.4 Sample Custody, Shipment, and Laboratory Receipt

All samples will be maintained in the custody of the sampling personnel. At the end of each sampling day prior to the transfer of the samples off-site, chain-of-custody entries will be made for all samples using the standard chain-of-custody form. All information on the chain-of-custody form and the sample container labels will be checked against the sample field log entries and samples will be recounted before leaving the sampling site. Upon transfer of custody, the chain-of-custody form will be signed and dated by the sample team leader. Because common carriers (Federal Express, Airborne Express, etc.) will not sign chain-of-custody forms, the forms will be sealed in the cooler prior to shipping. The tracking number of the express shipping label will be included in the comments section of the chain-of-custody form. All chain-of-custody forms sent to the laboratory must be signed and dated by the sample team member shipping the samples.

Upon receipt of the samples at the laboratory, the laboratory sample custodian will note the condition of each sample received as well as any questions or observations concerning sample integrity. The laboratory custodian will also measure the temperature of the samples. The temperature will be recorded on the chain-of-custody form. The laboratory sample custodian also will maintain a sample-tracking record that will follow each sample through all stages of laboratory processing. The sample tracking records will document sample removal from storage as well as the date of sample extraction or preparation and sample analysis. These records will be used to determine compliance with handling and holding time requirements. Samples will be stored by the laboratory in their original containers in walk-in refrigerators designated by the contracted laboratories..

8.0 Sample Collection and Preservation

8.1 Groundwater Samples

Groundwater sample collection will be accomplished in three steps: (1) measurement of the water level in the well, (2) evacuation of standing water; and (3) collection of samples for analysis. Evacuation of water will be performed with a peristaltic pump, an electric submersible groundwater pump, or a bailer. The well will be purged until three well volumes have been removed or until field measurements of pH, temperature, and conductivity have stabilized. Field measurements will be recorded in the logbook. After an adequate purge is achieved, the groundwater samples will be collected in the appropriate laboratory-prepared sample containers. Certain samples must be preserved at the time of sampling. The sample bottles will have the appropriate preservative added to the bottle by the laboratory prior to shipment to the site. Care will be taken to prevent water to fill bottles and overflow to minimize potential dilution of preservatives. Immediately after collection, the sample containers will be placed on ice in an insulated cooler at 4 °C for shipment to the laboratory.

9.0 Handling and Disposal of Investigation-Derived Waste

Because the groundwater is being treated by natural attenuation, it will not be removed from the subsurface for treatment, and will not require disposal. However, it is anticipated that several types of investigation-derived waste (IDW) will be generated on this site, including:

- Personnel protective equipment (PPE).
- Disposable equipment, such as plastic ground and equipment covers, aluminum foil, tubing, bailers, discarded or unused sample containers, boxes, etc.
- Soil cuttings/drilling muds/cores from well installation.
- Groundwater obtained through well development or well purging.
- Cleaning fluids such as detergents, spent solvents and wash water.
- Packing and shipping materials.

Based on generator knowledge, IDW anticipated at the site will be classified as non-hazardous. At the time of generation, soil cuttings/cores will be spread on site in the grassy area south of the drum storage building.

Contaminated groundwater and decontamination fluids derived from well sampling, and equipment decontamination will also be disposed of in the grassy area south of the drum storage building. Solid IDW waste, such as PPE, bailers, tubing, in-line filters, etc., will be double-bagged and deposited in a dumpster for transport to a municipal landfill.

10.0 References

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APPENDIX VII

LABORATORY ANALYTICAL RESULTS FROM PRE-DEMONSTRATION SAMPLING (NOVEMBER 2005)

COLUMBIA ANALYTICAL SERVICES, INC.

Analytical Report

Client : Environmental Solutions Inc.
Project Name : ESTCP-NSWC Indian Head, MD
Project Number : 3030.04A2.ESTC
Sample Matrix : WATER

Service Request : K0505983
Date Collected : 11/15-17/05
Date Received : 11/18/05

Perchlorate

Units : ug/L (ppb)
Basis : NA

Analysis Method 314.0
Test Notes :

Sample Name	Lab Code	MRL	Dilution Factor	Date Analyzed	Result	Result Notes
MW-1	K0505983-001	4000	2000	12/04/05	24200	
MW-2	K0505983-002	2.0	1	12/04/05	16.4	
MW-3	K0505983-003	2000	1000	12/04/05	9240	
MW-4	K0505983-004	4000	2000	12/04/05	26400	
MW-5	K0505983-005	2000	1000	12/04/05	16500	
SGP-1D	K0505983-006	400	200	12/04/05	2660	
SGP-1S	K0505983-007	400	200	12/04/05	2610	
SGP-2S	K0505983-008	2000	1000	12/04/05	12800	
SGP-2D	K0505983-009	2000	1000	12/04/05	12300	
SGP-5D	K0505983-010	40	20	12/04/05	316	
SGP-3D	K0505983-011	10	5	12/04/05	80	
SGP-3S	K0505983-012	4.0	2	12/04/05	22.8	
SGP-7S	K0505983-013	10	5	12/04/05	40	
SGP-7D	K0505983-014	10	5	12/04/05	41	
SGP-5S	K0505983-015	40	20	12/05/05	231	
SGP-4S	K0505983-016	40	20	12/05/05	346	
SGP-4D	K0505983-017	1000	500	12/04/05	5730	
SGP-6S	K0505983-018	2000	1000	12/05/05	17800	
SGP-6D	K0505983-019	2000	1000	12/04/05	16900	
SGP-8D	K0505983-020	4000	2000	12/04/05	26800	
SGP-8S	K0505983-021	4000	2000	12/04/05	27900	
DUP-1-Filtered	K0505983-022	4000	2000	12/04/05	16600	
DUP-1-Unfiltered	K0505983-023	2000	1000	12/04/05	10900	
Method Blank	K0505983-MB	2.0	1	12/04/05	ND	
Method Blank	K0505983-MB	2.0	1	12/04/05	ND	

Report By: Agreer

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client : Environmental Solutions Inc.
Project Name : ESTCP-NSWC Indian Head, MD
Project Number : 3030.04A2.ESTC
Sample Matrix : WATER

Service Request : K0505983
Date Collected : 11/16/05
Date Received : 11/18/05
Date Prepared : NA
Date Analyzed : 12/04/05

Duplicate Summary
Inorganic Parameters

Sample Name : SGP-5D
Lab Code : K0505983-010DUP
Test Notes :

Units : ug/L (ppb)
Basis : NA

Analyte	Analysis Method	MRL	Sample Result	Duplicate Sample Result	Average	Relative Percent Difference	Result Notes
Perchlorate	314.0	40	316	325	321	3	

Report By: Agreer

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client : Environmental Solutions Inc.
Project Name : ESTCP-NSWC Indian Head, MD
Project Number : 3030.04A2.ESTC
Sample Matrix : WATER

Service Request : K0505983
Date Collected : 11/16/05
Date Received : 11/18/05
Date Prepared : NA
Date Analyzed : 12/04/05

Matrix Spike Summary
Inorganic Parameters

Sample Name : SGP-5D
Lab Code : K0505983-010MS
Test Notes :

Units : ug/L (ppb)
Basis : NA

Analyte	Prep Method	Analysis Method	MRL	Spike Level	Sample Result	Spiked Sample Result	Percent Recovery	CAS Percent Recovery Acceptance Limits	Result Notes
Perchlorate	None	314.0	100	500	316	807	98	80-120	

Report By:MFirth

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client : Environmental Solutions Inc.
Project Name : ESTCP-NSWC Indian Head, MD
Project Number : 3030.04A2.ESTC
Sample Matrix : WATER

Service Request : K0505983
Date Collected : 11/16/05
Date Received : 11/18/05
Date Prepared : NA
Date Analyzed : 12/04/05

Duplicate Summary
Inorganic Parameters

Sample Name : SGP-3D
Lab Code : K0505983-011DUP
Test Notes :

Units : ug/L (ppb)
Basis : NA

Analyte	Analysis Method	MRL	Sample Result	Duplicate Sample Result	Average	Relative Percent Difference	Result Notes
Perchlorate	314.0	10	80	81	81	1	

Report By: Agreer

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client : Environmental Solutions Inc.
Project Name : ESTCP-NSWC Indian Head, MD
Project Number : 3030.04A2.ESTC
Sample Matrix : WATER

Service Request : K0505983
Date Collected : 11/16/05
Date Received : 11/18/05
Date Prepared : NA
Date Analyzed : 12/04/05

Matrix Spike Summary
Inorganic Parameters

Sample Name : SGP-3D
Lab Code : K0505983-011MS
Test Notes :

Units : ug/L (ppb)
Basis : NA

Analyte	Prep Method	Analysis Method	MRL	Spike Level	Sample Result	Spiked Sample Result	Percent Recovery	CAS Percent Recovery Acceptance Limits	Result Notes
Perchlorate	None	314.0	20	100	80	173	93	80-120	

Report By:MFirth

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client :	Environmental Solutions Inc.	**Service Request :**	K0505983
Project Name :	ESTCP-NSWC Indian Head, MD	**Date Collected :**	NA
Project Number :	3030.04A2.ESTC	**Date Received :**	NA
Sample Matrix :	WATER	**Date Prepared :**	NA
		Date Analyzed :	12/04/05

Laboratory Control Sample Summary
Inorganic Parameters

Sample Name :	Laboratory Control Sample	Units :	ug/L (ppb)
Lab Code :	K0505983-LCS1	Basis :	NA
Test Notes :			

Analyte	Prep Method	Analysis Method	True Value	Result	Percent Recovery	CAS Percent Recovery Acceptance Limits	Result Notes
Perchlorate	None	314.0	17.6	17.1	97	85-115	

Report By: Agreer

COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

Client :	Environmental Solutions Inc.	**Service Request :**	K0505983
Project Name :	ESTCP-NSWC Indian Head, MD	**Date Collected :**	NA
Project Number :	3030.04A2.ESTC	**Date Received :**	NA
Sample Matrix :	WATER	**Date Prepared :**	NA
		Date Analyzed :	12/04/05

Laboratory Control Sample Summary
Inorganic Parameters

Sample Name :	Laboratory Control Sample	Units :	ug/L (ppb)
Lab Code :	K0505983-LCS2	Basis :	NA
Test Notes :			

Analyte	Prep Method	Analysis Method	True Value	Result	Percent Recovery	CAS Percent Recovery Acceptance Limits	Result Notes
Perchlorate	None	314.0	17.6	16.4	93	85-115	

Report By: Agreer

ENVIRONMENTAL
SCIENCE CORP.

12065 Lebanon Rd.
Mt. Juliet, TN 37122
(615) 758-5858
1-800-767-5859
Fax (615) 758-5859

Tax I.D. 62-0814289

Est. 1970

REPORT OF ANALYSIS

Ms. Sheri Knox
Solutions-IES
1101 Nowell Road
Raleigh, NC 27607

November 28, 2005

ESC Sample # : L223086-01

Date Received : November 18, 2005
Description : ESTCP - Indian Head, MD

Site ID : Indian Head Division,

Sample ID : SGP-5S

Project # : 3030.04A2.ESTC

Collected By : Kevin Buchanan
Collection Date : 11/17/05 08:15

Parameter	Result	Det. Limit	Units	Method	Date	Dil.
Methane	BDL	0.010	ppm	8015M	11/22/05	1
TOC (Total Organic Carbon)	2.6	1.0	mg/l	9060	11/23/05	1

Jimmy Hunt
Jimmy Hunt, ESC Representative

BDL - Below Detection Limit
Det. Limit - Practical Quantitation Limit(PQL)

Laboratory Certification Numbers:
AIHA - 100789, AL - 40660, CA - I-2327, CT- PH-0197, FL - E87487, GA - 923, IN - C-TN-01
KY - 90010, KYUST - 0016, NC - ENV375,DW21704, ND - R-140, SC - 84004, TN - 2006, VA - 00109, WV - 233
AZ -0612, MN - 047-999-395, NY - 11742, NJ - 81002, WI - 998093910

Note:
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REPORT OF ANALYSIS

Ms. Sheri Knox
Solutions-IES
1101 Nowell Road
Raleigh, NC 27607

November 28, 2005

ESC Sample # : L223086-02

Date Received : November 18, 2005
Description : ESTCP - Indian Head, MD

Site ID : Indian Head Division,

Sample ID : SGP-4S

Project # : 3030.04A2.ESTC

Collected By : Kevin Buchanan
Collection Date : 11/17/05 08:55

Parameter	Result	Det. Limit	Units	Method	Date	Dil.
Methane	BDL	0.010	ppm	8015M	11/22/05	1
TOC (Total Organic Carbon)	15.	1.0	mg/l	9060	11/23/05	1

Jimmy Hunt
Jimmy Hunt, ESC Representative

BDL - Below Detection Limit
Det. Limit - Practical Quantitation Limit(PQL)

Laboratory Certification Numbers:
AIHA - 100789, AL - 40660, CA - I-2327, CT- PH-0197, FL - E87487, GA - 923, IN - C-TN-01
KY - 90010, KYUST - 0016, NC - ENV375,DW21704, ND - R-140, SC - 84004, TN - 2006, VA - 00109, WV - 233
AZ -0612, MN - 047-999-395, NY - 11742, NJ - 81002, WI - 998093910

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REPORT OF ANALYSIS

Ms. Sheri Knox
Solutions-IES
1101 Nowell Road
Raleigh, NC 27607

November 28, 2005

ESC Sample # : L223086-03

Date Received : November 18, 2005
Description : ESTCP - Indian Head, MD

Site ID : Indian Head Division,

Sample ID : SGP-4D

Project # : 3030.04A2.ESTC

Collected By : Kevin Buchanan
Collection Date : 11/17/05 09:35

Parameter	Result	Det. Limit	Units	Method	Date	Dil.
Methane	BDL	0.010	ppm	8015M	11/22/05	1
TOC (Total Organic Carbon)	2.2	1.0	mg/l	9060	11/23/05	1

Jimmy Hunt
Jimmy Hunt, ESC Representative

BDL - Below Detection Limit
Det. Limit - Practical Quantitation Limit(PQL)

Laboratory Certification Numbers:
AIHA - 100789, AL - 40660, CA - I-2327, CT- PH-0197, FL - E87487, GA - 923, IN - C-TN-01
KY - 90010, KYUST - 0016, NC - ENV375,DW21704, ND - R-140, SC - 84004, TN - 2006, VA - 00109, WV - 233
AZ -0612, MN - 047-999-395, NY - 11742, NJ - 81002, WI - 998093910

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REPORT OF ANALYSIS

Ms. Sheri Knox
Solutions-IES
1101 Nowell Road
Raleigh, NC 27607

November 28, 2005

ESC Sample # : L223086-04

Date Received : November 18, 2005
Description : ESTCP - Indian Head, MD

Site ID : Indian Head Division,

Sample ID : SGP-6S

Project # : 3030.04A2.ESTC

Collected By : Kevin Buchanan
Collection Date : 11/17/05 10:50

Parameter	Result	Det. Limit	Units	Method	Date	Dil.
Methane	0.083	0.010	ppm	8015M	11/22/05	1
TOC (Total Organic Carbon)	3.1	1.0	mg/l	9060	11/26/05	1

Jimmy Hunt
Jimmy Hunt, ESC Representative

BDL - Below Detection Limit
Det. Limit - Practical Quantitation Limit(PQL)

Laboratory Certification Numbers:
AIHA - 100789, AL - 40660, CA - I-2327, CT- PH-0197, FL - E87487, GA - 923, IN - C-TN-01
KY - 90010, KYUST - 0016, NC - ENV375,DW21704, ND - R-140, SC - 84004, TN - 2006, VA - 00109, WV - 233
AZ -0612, MN - 047-999-395, NY - 11742, NJ - 81002, WI - 998093910

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REPORT OF ANALYSIS

Ms. Sheri Knox
Solutions-IES
1101 Nowell Road
Raleigh, NC 27607

November 28, 2005

ESC Sample # : L223086-05

Date Received : November 18, 2005
Description : ESTCP - Indian Head, MD

Site ID : Indian Head Division,

Sample ID : SGP-6D

Project # : 3030.04A2.ESTC

Collected By : Kevin Buchanan
Collection Date : 11/17/05 11:25

Parameter	Result	Det. Limit	Units	Method	Date	Dil.
Methane	1.1	0.010	ppm	8015M	11/22/05	10
TOC (Total Organic Carbon)	29.	1.0	mg/l	9060	11/26/05	1

Jimmy Hunt
Jimmy Hunt, ESC Representative

BDL - Below Detection Limit
Det. Limit - Practical Quantitation Limit(PQL)

Laboratory Certification Numbers:
AIHA - 100789, AL - 40660, CA - I-2327, CT- PH-0197, FL - E87487, GA - 923, IN - C-TN-01
KY - 90010, KYUST - 0016, NC - ENV375,DW21704, ND - R-140, SC - 84004, TN - 2006, VA - 00109, WV - 233
AZ -0612, MN - 047-999-395, NY - 11742, NJ - 81002, WI - 998093910

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REPORT OF ANALYSIS

Ms. Sheri Knox
Solutions-IES
1101 Nowell Road
Raleigh, NC 27607

November 28, 2005

ESC Sample # : L223086-06

Date Received : November 18, 2005
Description : ESTCP - Indian Head, MD

Site ID : Indian Head Division,

Sample ID : SGP-8D

Project # : 3030.04A2.ESTC

Collected By : Kevin Buchanan
Collection Date : 11/17/05 12:00

Parameter	Result	Det. Limit	Units	Method	Date	Dil.
Methane	BDL	0.010	ppm	8015M	11/22/05	1
TOC (Total Organic Carbon)	3.4	1.0	mg/l	9060	11/26/05	1

Jimmy Hunt
Jimmy Hunt, ESC Representative

BDL - Below Detection Limit
Det. Limit - Practical Quantitation Limit(PQL)

Laboratory Certification Numbers:
AIHA - 100789, AL - 40660, CA - I-2327, CT- PH-0197, FL - E87487, GA - 923, IN - C-TN-01
KY - 90010, KYUST - 0016, NC - ENV375,DW21704, ND - R-140, SC - 84004, TN - 2006, VA - 00109, WV - 233
AZ -0612, MN - 047-999-395, NY - 11742, NJ - 81002, WI - 998093910

Note:
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REPORT OF ANALYSIS

Ms. Sheri Knox
Solutions-IES
1101 Nowell Road
Raleigh, NC 27607

November 28, 2005

ESC Sample # : L223086-07

Date Received : November 18, 2005
Description : ESTCP - Indian Head, MD

Site ID : Indian Head Division,

Sample ID : SGP-8S

Project # : 3030.04A2.ESTC

Collected By : Kevin Buchanan
Collection Date : 11/17/05 12:30

Parameter	Result	Det. Limit	Units	Method	Date	Dil.
Methane	0.011	0.010	ppm	8015M	11/22/05	1
TOC (Total Organic Carbon)	2.1	1.0	mg/l	9060	11/26/05	1

Jimmy Hunt
Jimmy Hunt, ESC Representative

BDL - Below Detection Limit
Det. Limit - Practical Quantitation Limit(PQL)

Laboratory Certification Numbers:
AIHA - 100789, AL - 40660, CA - I-2327, CT- PH-0197, FL - E87487, GA - 923, IN - C-TN-01
KY - 90010, KYUST - 0016, NC - ENV375,DW21704, ND - R-140, SC - 84004, TN - 2006, VA - 00109, WV - 233
AZ -0612, MN - 047-999-395, NY - 11742, NJ - 81002, WI - 998093910

Note:
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REPORT OF ANALYSIS

Ms. Sheri Knox
Solutions-IES
1101 Nowell Road
Raleigh, NC 27607

November 28, 2005

ESC Sample # : L223086-08

Date Received : November 18, 2005
Description : ESTCP - Indian Head, MD

Site ID : Indian Head Division,

Sample ID : DUP-1

Project # : 3030.04A2.ESTC

Collected By : Kevin Buchanan
Collection Date : 11/17/05 10:50

Parameter	Result	Det. Limit	Units	Method	Date	Dil.
TOC (Total Organic Carbon)	3.3	1.0	mg/l	9060	11/26/05	1

Jimmy Hunt
Jimmy Hunt, ESC Representative

BDL - Below Detection Limit
Det. Limit - Practical Quantitation Limit(PQL)

Laboratory Certification Numbers:
AIHA - 100789, AL - 40660, CA - I-2327, CT- PH-0197, FL - E87487, GA - 923, IN - C-TN-01
KY - 90010, KYUST - 0016, NC - ENV375,DW21704, ND - R-140, SC - 84004, TN - 2006, VA - 00109, WV - 233
AZ -0612, MN - 047-999-395, NY - 11742, NJ - 81002, WI - 998093910

Note:
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Reported: 11/28/05 13:46 Printed: 11/28/05 13:47

Attachment A
List of Analytes with QC Qualifiers

Sample #	Analyte	Qualifier
L223086-04	TOC (Total Organic Carbon)	K
L223086-05	TOC (Total Organic Carbon)	K
L223086-06	TOC (Total Organic Carbon)	K
L223086-07	TOC (Total Organic Carbon)	K
L223086-08	TOC (Total Organic Carbon)	K

Attachment B
Explanation of QC Qualifier Codes

Qualifier	Meaning
K	REX(EPA)- Re-prepared: The indicated analytical results were generated from a re-extraction or preparation of the sample.

Qualifier Report Information

ESC utilizes sample and result qualifiers as set forth by the EPA Contract Laboratory Program and as required by most certifying bodies including NELAC. In addition to the EPA qualifiers adopted by ESC, we have implemented ESC qualifiers to provide more information pertaining to our analytical results. Each qualifier is designated in the qualifier explanation as either EPA or ESC. Data qualifiers are intended to provide the ESC client with more detailed information concerning the potential bias of reported data. Because of the wide range of constituents and variety of matrices incorporated by most EPA methods,it is common for some compounds to fall outside of established ranges. These exceptions are evaluated and all reported data is valid and useable unless qualified as 'R' (Rejected).

Definitions

Accuracy - The relationship of the observed value of a known sample to the true value of a known sample. Represented by percent recovery and relevant to samples such as: control samples, matrix spike recoveries, surrogate recoveries, etc.

Precision - The agreement between a set of samples or between duplicate samples. Relates to how close together the results are and is represented by Relative Percent Differrence.

Surrogate - Organic compounds that are similar in chemical composition, extraction, and chromotography to analytes of interest. The surrogates are used to determine the probable response of the group of analytes that are chemically related to the surrogate compound. Surrogates are added to the sample and carried through all stages of preparation and analyses.

	Control Limits				(AQ)	(SS)
2-Fluorophenol	31-119	Nitrobenzene-d5	43-118	Dibromfluoromethane	68-128	64-125
Phenol-d5	12-134	2-Fluorobiphenyl	45-128	Toluene-d8	76-115	69-118
2,4,6-Tribromophenol	51-141	Terphenyl-d14	43-137	4-Bromofluorobenzene	79-127	61-134

TIC - Tentatively Identified Compound: Compounds detected in samples that are not target compounds, internal standards, system monitoring compounds, or surrogates.

Summary of Remarks For Samples Printed
11/28/05 at 13:47:02

TSR Signing Reports: 350
R5 - Desired TAT

Sample: L223086-01 Account: SOLINDRNC Received: 11/18/05 11:00 Due Date: 11/28/05 00:00 RPT Date: 11/28/05 13:46
Added QC2 - jeh 11/22/05
Sample: L223086-02 Account: SOLINDRNC Received: 11/18/05 11:00 Due Date: 11/28/05 00:00 RPT Date: 11/28/05 13:46
Added QC2 - jeh 11/22/05
Sample: L223086-03 Account: SOLINDRNC Received: 11/18/05 11:00 Due Date: 11/28/05 00:00 RPT Date: 11/28/05 13:46
Added QC2 - jeh 11/22/05
Sample: L223086-04 Account: SOLINDRNC Received: 11/18/05 11:00 Due Date: 11/28/05 00:00 RPT Date: 11/28/05 13:46
Added QC2 - jeh 11/22/05
Sample: L223086-05 Account: SOLINDRNC Received: 11/18/05 11:00 Due Date: 11/28/05 00:00 RPT Date: 11/28/05 13:46
Added QC2 - jeh 11/22/05
Sample: L223086-06 Account: SOLINDRNC Received: 11/18/05 11:00 Due Date: 11/28/05 00:00 RPT Date: 11/28/05 13:46
Added QC2 - jeh 11/22/05
Sample: L223086-07 Account: SOLINDRNC Received: 11/18/05 11:00 Due Date: 11/28/05 00:00 RPT Date: 11/28/05 13:46
Added QC2 - jeh 11/22/05
Sample: L223086-08 Account: SOLINDRNC Received: 11/18/05 11:00 Due Date: 11/28/05 00:00 RPT Date: 11/28/05 13:46
Added QC2 - jeh 11/22/05

Solutions-IES

1101 Nowell Road
Raleigh,NC 27607

Alternate billing information:

Chain of Custody
Page 1 of 2

Prepared by:
ENVIRONMENTAL SCIENCE CORP.
12065 Lebanon Road
Mt. Juliet, TN 37122
Phone (800) 767-5859
FAX (615) 758-5859

Report to: Ms. Sheri Knox
Email: sknox@solutions-ies.com
Project Description: ESTCP - Indian Head, MD
City/State Collected
Phone: (919) 873-1060
FAX: (919) 873-1074
Client Project #: 3030.04A2. ESTC
Lab Project #: SOLINDRNC-3030.04A2.
Collected by (print): Kevin Buchanan
Site/Facility ID#: Indian Head Division, Bl
P.O.#:
Collected by (signature):
Packed on Ice N (Y)
Rush? (Lab MUST Be Notified)
___Same Day 200%
___ Next Day.....100%
___ Two Day 50%
Date Results Needed
Email? __No __Yes
FAX? No Yes

Acctnum: SOLINDRNC (lab use only)
Template/Prelogin T33685/ P160153
Cooler #: 1/9 05 GA
Shipped Via: FedEX Ground

Analysis/Container/Preservative

Sample ID	Comp/Grab	Matrix*	Depth	Date	Time	No. of Cntrs JC	METHANE 40mlAmb-NoPres	TOC 250mlAmb-Septa-HCl						Remarks/Contaminant	Sample # (lab only)
MW-1	G	GW		11/15/05	0945	3	X	X						L222930-01	
MW-2	G	GW		11/15/05	1025	3	X	X						-02	
MW-3	G	GW		11/15/05	1145	3	X	X						-03	
MW-4	G	GW		11/15/05	1225	3	X	X						-04	
MW-5	G	GW		11/15/05	1255	3	X	X						-05	
~~MW-6~~ SGP-1D	G	GW		11/16/05	0955	3	X	X						-06	
~~DUP-1~~ SGP-1S	G	GW		11/16/05	0950	3		X						-07	
~~SGP-1~~ SGP-2S	G	GW		11/16/05	1140	3	X	X						-08	
~~SGP-2~~ SGP-2D	G	GW		11/16/05	1210	3	X	X						-09	

*Matrix: SS - Soil GW - Groundwater WW - WasteWater DW - Drinking Water OT - Other_____

pH _____ Temp _____

Flow _____ Other _____

Remarks:
FedEx AirBill # 8454 1148 3573

Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Samples returned via: ☐ UPS ☒ FedEx ☐ Courier ☐	Condition: (lab use only)	
Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Temp: 2.4°C Bottles Received: 42+TB		
Relinquished by: (Signature)	Date:	Time:	Received for lab by: (Signature)	Date: 11-17-05 Time: 0811:00	pH Checked: <2	NCF: ✓

Solutions-IES

1101 Nowell Road
Raleigh,NC 27607

Alternate billing information:

Analysis/Container/Preservative

Chain of Custody
Page 2 of 2

Prepared by:

ENVIRONMENTAL SCIENCE CORP.
12065 Lebanon Road
Mt. Juliet, TN 37122
Phone (800) 767-5859
FAX (615) 758-5859

Report to: Ms. Sheri Knox

Email: sknox@solutions-ies.com

Project Description: ESTCP - Indian Head, MD

City/State Collected

Phone: (919) 873-1060
FAX: (919) 873-1074

Client Project #: 3030.04A2. ESTC

Lab Project #: SOLINDRNC-3030.04A2.

Collected by (print): Kevin Buchanan

Site/Facility ID#: Indian Head Division, Bl

P.O.#:

Collected by (signature):

Rush? (Lab MUST Be Notified)
___Same Day 200%
___ Next Day 100%
___ Two Day 50%

Date Results Needed

Email? __No __Yes
FAX? No Yes

Packed on Ice N (Y)

Acctnum: SOLINDRNC (lab use only)
Template/Prelogin: T33685/ P160153
Cooler #: 11905 BA
Shipped Via: FedEX Ground

Sample ID	Comp/Grab	Matrix*	Depth	Date	Time	No. of Cntrs	METHANE 40mlAmb-NoPres	TOC 250mlAmb-Septa-HCl						Remarks/Contaminant	Sample # (lab only)
~~SGP-3~~ SGP-5D	G	GW		11/16/05	1330	3	X	X						L222930 -10	
~~SGP-4~~ SGP-3D	G	GW		11/16/05	1405	3	X	X						-11	
~~SGP-5~~ SGP-3S	G	GW		11/16/05	1430	3	X	X						-12	
~~SGP-6~~ SGP-7S	G	GW		11/16/05	1505	3	X	X						-13	
~~SGP-7~~ SGP-7D	G	GW		11/16/05	1535	3	X	X						-14	
~~SGP-8~~		~~GW~~				~~3~~	~~X~~	~~X~~							
~~SGP-9~~		~~GW~~				~~3~~	~~X~~	~~X~~							
~~SGP-10~~		~~GW~~				~~3~~	~~X~~	~~X~~							
~~SGP-11~~		~~GW~~				~~3~~	~~X~~	~~X~~							

*Matrix: SS - Soil GW - Groundwater WW - WasteWater DW - Drinking Water OT - Other_____

pH _____ Temp _____

Flow _____ Other _____

Remarks:

FedEx AirBill# 8454 1148 3573

Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Samples returned via: ☐ UPS ☑ FedEx ☐ Courier ☐	Condition: (lab use only)
Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Temp: 2.4°C Bottles Received: 42+TB	
Relinquished by: (Signature)	Date:	Time:	Received for lab by: (Signature)	Date: 11-17-05 Time: 11:00	pH Checked: C2 NCF: ✓

Solutions-IES

1101 Nowell Road
Raleigh,NC 27607

Alternate billing information:

Analysis/Container/Preservative

Chain of Custody
Page 1 of 1

Prepared by:

ENVIRONMENTAL SCIENCE CORP.
12065 Lebanon Road
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Phone (800) 767-5859
FAX (615) 758-5859

Report to: Ms. Sheri Knox

Email: sknox@solutions-ies.com

Project Description: ESTCP - Indian Head, MD

City/State Collected

Phone: (919) 873-1060
FAX: (919) 873-1074

Client Project #: 3030.04A2. ESTC

Lab Project #: SOLINDRNC-3030.04A2.

Collected by (print): Kevin Buchanan

Site/Facility ID#: Indian Head Division, Bl

P.O.#:

Collected by (signature):

Rush? (Lab MUST Be Notified)
___Same Day 200%
___ Next Day.....100%
___ Two Day 50%

Date Results Needed

Email? __No __Yes
FAX? No Yes

Packed on Ice N (Y)

Acctnum: SOLINDRNC (lab use only)
Template/Prelogin: T33685/ P160153
Cooler #: 11-9-05 GP
Shipped Via: FedEX Ground

Sample ID	Comp/Grab	Matrix*	Depth	Date	Time	No. of Cntrs	METHANE 40mlAmb-NoPres	TOC 250mlAmb-Septa-HCl							Remarks/Contaminant	Sample # (lab only)
~~SGP-12~~ SGP-5S		GW			0815	3	X	X								L1223086-01
~~SGP-13~~ SGP-4S		GW			0855	3	X	X								-02
~~SGP-14~~ SGP-4D		GW			0935	3	X	X								-03
~~SGP-15~~ SGP-6S		GW			1050	3	X	X								-04
~~SGP-16~~ SGP-6D		GW			1125	3	X	X								-05
~~SGP-17~~ SGP-8D		GW			1200	3	X	X								-06
~~SGP-18~~ SGP-8S		GW			1230	3	X	X								-07
~~SGP-19~~ DUP-1		GW			1050	1		X							TOC ANALYSIS ONLY	-08
~~SGP-20~~		GW				3	X	X								

*Matrix: SS - Soil GW - Groundwater WW - WasteWater DW - Drinking Water OT - Other_____

pH _____ Temp _____

Flow _____ Other _____

Remarks: Fedex Air Bill # 8454 1148 3562
8454 1148 3562

Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Samples returned via: ☐ UPS ☒ FedEx ☐ Courier ☐	Condition: (lab use only)
	11/17/05		Fedex		
Relinquished by: (Signature)	Date:	Time:	Received by: (Signature)	Temp: 2.5°C Bottles Received: 22+TB	
Relinquished by: (Signature)	Date:	Time:	Received for lab by: (Signature)	Date: 11-18-05 Time: 11:00	pH Checked: C2 NCF:

IC Analysis-Solutions IES
NSWC-Indian Head, MD

Date Sampled: 11/15-17/05
Date Received: 11/28/05
Date Analyzed: 12/15/05

N. C. State University
Environmental Engineering Laboratory

David C. Black

Quality Control Information

Certified Standard from AccuStandard Inc.

Sample ID	Chloride	Nitrite	Bromide	Nitrate	Phosphate	Sulfate
Certified Standard	19.9	18.1	19.6	18.7	20.3	19.6
% Recovery	**99.5%**	**90.5%**	**98.0%**	**93.5%**	**101.5%**	**98.0%**
Blank	<0.5	<0.5	<1	<0.5	<1	<0.5

Sample Information: (Samples labeled a and b are lab replicates)

All units are mg/L

Sample ID	Chloride	Nitrite	Bromide	Nitrate	Phosphate	Sulfate
MW-1	16.2	<0.5	<1	136.2	<1	40.5
MW-2	1.8	<0.5	<1	3.4	<1	62.9
MW-3	4.7	<0.5	<1	0.8	<1	57.1
MW-4a	2.0	<0.5	<1	1.6	<1	56.2
MW-4b	2.1	<0.5	<1	1.6	<1	57.3
MW-5	2.3	<0.5	<1	2.4	<1	96.1
SGP-1D	5.2	<0.5	<1	0.9	<1	80.0
SGP-2D	9.7	<0.5	<1	<0.5	<1	77.5
SGP-3D	2.3	<0.5	<1	<0.5	<1	59.8
SGP-4Da	2.4	<0.5	<1	1.4	<1	43.4
SGP-4Db	2.6	<0.5	<1	1.4	<1	46.5
SGP-5D	10.7	<0.5	<1	2.0	<1	168.2
SGP-6D	10.9	<0.5	<1	<0.5	<1	76.7
SGP-7D	4.4	<0.5	<1	<0.5	<1	79.8
SGP-8D	10.4	<0.5	<1	4.9	<1	62.7
SGP-1Sa	2.5	<0.5	<1	<0.5	<1	57.4
SGP-1Sb	2.6	<0.5	<1	<0.5	<1	57.4
SGP-2S	11.3	<0.5	<1	0.8	<1	127.4
SGP-3S	4.8	<0.5	<1	<0.5	<1	54.6
SGP-4S	6.4	<0.5	<1	6.0	<1	16.4
SGP-5S	5.3	<0.5	<1	1.1	<1	100.2
SGP-6Sa	9.9	<0.5	<1	2.5	<1	92.8
SGP-6Sb	11.3	<0.5	<1	2.8	<1	109.2
SGP-7S	3.8	<0.5	<1	2.6	<1	62.1
SGP-8S	15.0	<0.5	<1	7.7	<1	78.1