Interim Remedial Measure Work Plan

Bay Shore Former Manufactured Gas Plant Site
Operable Unit No. 4
Former Cesspool Area

Bay Shore, New York

Submitted to:
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January 13, 2005

Project 982482-15-2501

Table of Contents

Table of Contents (cont.)

Figures

Appendices

J:\WPROC\Project\KEYSPAN\Bay Shore\OU-4 Cesspool\Comment Response\Comment Response 1-13-05\BayShore OU-4 WP.doc

1. Introduction

KeySpan Corporation is performing an Interim Remedial Measure (IRM) at a portion of Operable Unit No. 4 (OU-4) of the former Bay Shore Manufactured Gas Plant (MGP) site located in Bay Shore, New York. An Area Location Map and Site Plan are provided as Figures 1 and 2, respectively. This IRM Work Plan (Work Plan) has been prepared by GEI Consultants, Inc. on behalf of KeySpan, and will address areas within OU-4 and on the adjacent 22 Oak Street parcel where Manufactured Gas Plant (MGP)-related constituents from the former industrial cesspool have been delineated. The delineation and extent of MGP-related impacts are presented in the Pre-IRM Investigation Report for the 22 Oak Street parcel that was submitted to the NYSDEC on September 23, 2003. This IRM is one phase of the overall environmental improvements being implemented at the Bay Shore/Brightwaters Former MGP site in conformance with an Administrative Order on Consent (ACO) with the New York State Department of Environmental Conservation (NYSDEC), Index No. DI-0001-98-11.

For purposes of the ACO, the Bay Shore/Brightwaters Former MGP Site OU-4 includes the historic cesspool located along Oak Street and the assumed headwaters portion of Crum's Brook (a.k.a. Watchogue Creek) flowing beneath the parking lot at the Long Island Railroad (LIRR) train station south to its intersection with Mechanicville Road. This IRM focuses on the portion of OU-4 that leaves the MGP site and ends to the northern LIRR right of way adjacent to the Town of Islip parking lot.

OU-4 is remote from the former main operations area of the MGP. MGP-related constituents are present in soil and groundwater at OU-4 due to the historic discharge of treated MGP wastewater to an industrial cesspool. The 22 Oak Street parcel abuts the property where the cesspool is located and where investigations identified MGP-related constituents in soil and groundwater near and downgradient from the cesspool.

This Work Plan describes the techniques to be used for the excavation, material handling, waste characterization, processing, transportation, and disposal of MGP-related constituents and impacted media. This effort will be performed under the approval and oversight of the NYSDEC and the New York State Department of Health (NYSDOH).

1.1 Project Objective

The objectives of the Work Plan are removal by excavation of MGP-related contaminated material from the former industrial cesspool, removal of the cesspool structure and an adjacent stormwater catch basin, removal of a portion of a former wastewater discharge pump associated with the former MGP operations, removal of contaminated soils proximate to these structures and treatment of other soils with an oxidation process to reduce the concentration of MGP-related constituents in them.

KeySpan will remove via excavation, the former cesspool, its contents, the adjacent stormwater catch basin located on Oak Street, the surrounding soils containing MGP-related constituents (identified as part of Area A on Figure 2), and the former wastewater discharge pipe located along Oak Street. The discharge pipe was previously cut and sealed at the intersection of Fifth Avenue and Oak Street. Therefore, this IRM will only involve the excavation and removal of the section of pipe that extends from the intersection of Fifth Avenue and Oak Street to the cesspool/catch basin area (identified as Area B on Figure 2).

KeySpan proposes to use in-situ chemical oxidation (ISCO) to address subsurface areas containing MGP-related constituents in the vicinity of and downgradient to the excavated areas. The soils to be treated represent residual impacts (blebs, sheen, staining) or thin lenses of tar-saturated soils. In addition, the ISCO will treat the shallow petroleum-impacted soils not related to the former MGP, which are located within the boundaries of this IRM. The MGP- related constituents are located under the existing structure on the 22 Oak Street parcel and in the western portion of the Town of Islip property below the water table (also identified as part of Area A on Figure 2). Depth to groundwater in the excavation areas has varied historically between 3-6 feet below ground surface (bgs).

A two-phased approach is proposed to address MGP-related constituents in the vicinity of the former cesspool and the historic wastewater discharge pipe along Oak Street. The first phase of remediation will be the removal of significant sources of contamination via excavation. The second phase will be the utilization of ISCO to treat residual levels of MGP-related constituents and deeper sources not readily accessible via excavation as depicted on Figure 3.

Using the aforementioned technologies, the objectives of the IRM are to:

- Remove significant sources of contamination from the IRM area
- Use ISCO technology to mitigate residual MGP-related constituents located in subsurface soils and groundwater
- Monitor and document the success of the IRM activities based on post ISCO soil sampling and groundwater monitoring

For the purposes of this IRM, source contamination is defined as soil observed to be heavily impacted by MGP-related constituents to the extent of saturation. Minor staining, odors, or elevated air monitoring readings are not indicative of source material to be removed for the purposes of this work. The excavation activities are only one part of a two-phased approach to remedy MGP-related constituents associated with the site. If additional source material is observed in the unsaturated zone during the IRM outside of the defined areas, it will be removed via excavation and managed accordingly. Any lesser degree of contamination in the IRM area, or source material not readily accessible via excavation, will be remedied during the second phase of the IRM in-situ.

In sum, the remedial goals of the IRM will be to remove and/or treat where practicable, sources of groundwater contamination and prevent, to the extent practicable, the migration of chemicals from source areas to the groundwater within and downgradient of the operable unit.

1.2 Work Site Location and Description

The Site Plan is depicted on Figure 2. Area A is part of a Town of Islip commuter parking lot for the adjacent LIRR Montauk Line Bay Shore Station. Area A also includes a portion of the 22 Oak Street parcel that abuts the former industrial cesspool area. Area B consists of the southern sidewalk and roadway shoulder of Oak Street beginning at Fifth Avenue and continuing east to Area A. To the immediate north of the site are primarily residential lots; to the west of the 22 Oak Street parcel is a dry cleaner, Fifth Avenue, and then the Bay Shore Former MGP site; to the east is the rest of the LIRR parking lot and then small mixed residential/commercial properties; to the south is the LIRR Montauk Line and then primarily residential lots.

1.3 Work Site History

During part of its operational history, the Bay Shore MGP discharged stormwater drainage and treated process wastewater from a skimming basin overflow through a pipe that ran east along Oak Street to a basin (former industrial cesspool). This pipe has been previously cut and capped at the MGP property line. The location of the former cesspool is near the northwestern corner of the LIRR parking lot adjacent to the northeastern corner of an inactive oil terminal (the former Standard Oil Distribution Station – 22 Oak Street property). The 22 Oak Street property is currently used for office space, automotive repairs, and miscellaneous indoor and outdoor storage.

It is believed that this cesspool overflowed to a stormwater drainage culvert. The drainage culvert ran south, beneath the Town of Islip parking lot, adjacent to the LIRR Bay Shore Station, crossed under the LIRR right of way and discharged to the open brook south of the

LIRR tracks. This area is considered to be the headwaters of Crum's Brook. Based on a review of historic Sanborn maps, a pond once existed in this area as depicted on maps dated 1915, 1925, 1949, and 1969. It is unclear exactly when, but sometime between the 1940s-1960s, the pond was filled in and only a drainage ditch, or open creek channel, exists today.

From the former pond area the open brook channel extends southward under Union Boulevard and continues adjacent to the South Wind Village Development, paralleling Smith Avenue. This section of the brook was remedied in 2000 as part of a previous IRM. The restored brook channel runs south from Union Boulevard to Mechanicville Road and continues under it. Crum's Brook eventually flows into Great South Bay.

1.4 Project Organizational Structure and Responsibility

KeySpan will work with NYSDEC, NYSDOH, and other regulatory agencies to conduct the IRM. Approval of this Work Plan by the NYSDEC and NYSDOH will be obtained prior to site preparation. It is anticipated that the NYSDEC will have a representative at the site during the IRM for purposes of general oversight.

GEI will be responsible for engineering design, project management, contractor oversight, work plan compliance, determination of corrective measures when needed, monitoring for health and safety, perimeter-air monitoring activities, collection of soil and groundwater samples, maintenance of site sampling and monitoring logs, and preparation of an IRM completion report. GEI also serves as the Site Health and Safety Officer for KeySpan, and ensures all approved site-specific health and safety plans are adhered to.

The Contractor(s) will be responsible for all on-site construction activities to include, but not be limited to, compliance with all applicable OSHA health and safety regulations, construction personnel health and safety, implementation of appropriate emission control measures (as necessary), traffic control, site security, excavation and material handling activities associated with the IRM, and any other specified tasks outlined in this Work Plan.

NYSDEC's representative will be invited to attend all regular job progress meetings, including pre-construction meetings.

1.5 Work Plan Organization

- Section 1, the introduction, describes the purpose and objectives of the IRM. It also includes a site description and historical information relative to MGP operations.
- Section 2 presents a general overview of the scope of work to be performed as part of the IRM.
- Section 3 presents the key components of the Site-specific HASP.

- Section 4 presents the site management plan.
- Section 5 includes the waste management practices for the IRM.
- Section 6 discusses the IRM Summary Report to be prepared following completion of the IRM.
- Section 7 presents the proposed schedule for implementation of the IRM.
- Section 8 presents pertinent documents referenced for developing the IRM.
- Appendix A includes the Site-Specific HASP.
- Appendix B includes the Quality Assurance Program Plan.
- Appendix C includes the Field Sampling Plan.
- Appendix D includes Technical Specifications for Rusmar Foam – an odor suppressant.

2. Scope of Work

This section provides a general overview of the activities necessary to complete the IRM. A two-phased approach is proposed to address MGP related impacts in the vicinity of the former cesspool and the historic wastewater discharge pipe along Oak Street. The first phase of remediation will be the removal of significant sources of contamination and former structures via excavation. The second phase will use ISCO to chemically treat residual impacts and deeper sources not readily accessible via excavation.

2.1 Execution of the IRM

The proposed IRM to be conducted for the removal of former MGP related structures, piping, and the surrounding impacted soil involves excavation and off-site disposal of impacted materials. Dewatering activities are assumed to be unnecessary for the limited amount of excavation activities taking place below the water table because MGP-related constituents in the saturated zone will be treated in-situ via ISCO. Vapor mitigation methods such as covering excavation areas with plastic sheeting and/or the use of vapor suppressing foam may be required during the IRM and are discussed in subsection 2.4. Following removal of the impacted materials and MGP-related structures, the excavation will be backfilled with clean fill and the site will be restored to pre-excavation conditions. ISCO operations will take place on a separate schedule and actual injections will not commence until the excavation is complete.

Site work will take place during normal business hours Monday through Friday with no heavy truck traffic until 0800 hrs. During working hours, the Contractor will make every effort to minimize potential community nuisance impacts. These include, but are not limited to, noise and traffic concerns associated with the execution of the IRM. Site work will not be conducted on weekends without prior approval of KeySpan and other parties granting access for the work.

2.2 Mobilization and Site Access

Prior to mobilization, the selected Contractor(s) will prepare and submit all required documents for review and approval by GEI, KeySpan, and the NYSDEC. GEI will review final Contractor submittals to ensure conformance with this IRM Work Plan.

The Contractor will apply for and obtain all necessary Federal, State, and local permits associated with the IRM scope of work. These permits may include, but are not limited to, traffic routing, road opening and/or closure, construction/zoning, noise, etc. KeySpan will obtain the appropriate access agreements for conducting the IRM.

The Contractor will be responsible for contacting the New York City – Long Island One Call Center to request that all utilities within the work area be located and marked, and all potential conflicts will be resolved. Underground utility protection will be the responsibility of the selected Contractor. When all utilities have been verified/confirmed/protected, then intrusive activities may be initiated.

GEI will conduct a pre-construction site meeting, after the project is awarded, with the Contractor, KeySpan, and NYSDEC prior to the commencement of IRM implementation. The meeting will be conducted to review specified construction requirements and schedules, as well as to review the responsibilities of the Contractor, GEI, and KeySpan with respect to the IRM implementation.

The Contractor will mobilize all necessary labor, equipment, supplies and materials to complete the IRM upon approval by KeySpan and GEI. Lay down areas for equipment, supplies, and materials; and the appropriate exclusion zone(s) and support area(s) will be identified by the Contractor and approved by GEI to conduct the planned activities safely and effectively.

The Contractor is responsible for restricting parking in the vicinity of each day's work area and coordinating approval of parking closure and any necessary traffic control measures with the town.

2.3 Site Preparation

Site preparation activities necessary to provide support for the work include the establishment of work zones, support facilities, decontamination facilities, and installation of temporary fencing around the work area(s). The Contractor may utilize the Bay Shore Former MGP property (OU-1) for additional offsite storage and staging for IRM activities as needed. For additional details on the decontamination pad see Subsection 5.6. Also, due to excavation activities taking place in close proximity to a two story brick and masonry building located at 22 Oak Street, a pre-construction building and facilities inspection will take place prior to commencing intrusive activities in order to document the existing conditions of the property.

2.4 Excavation Activities

2.4.1 Excavation Limits

Two excavation areas are proposed as part of this work. The primary excavation area is Area A, which consists of a former industrial cesspool and an adjacent catch basin. The secondary area, Area B, consists of excavating a trench to uncover and removed historic piping associated with former MGP operations. The excavation limits are defined in detail in the following sections. Dewatering activities are not anticipated for either area, but the catch basin located in Area A is in use during precipitation events, therefore some water management by the Contractor will be necessary to bypass this area until the structure is replaced.

2.4.1.1 Area A (Former Industrial Cesspool and Catch Basin)

The Contractor will remove via excavation the former cesspool, its contents, the adjacent stormwater catch basin located on Oak Street, and the surrounding soils containing MGP-related constituents to the limits indicated on Figure 3. The approximate excavation area is twenty feet by forty feet, with an average depth of six feet. The average depth of six feet is based on the anticipated depth of the historic structures, and to be protective of existing adjacent structures. The catch basin immediate area and the former cesspool immediate area will be as deep as necessary to remove the structures. The purpose of the excavation is to remove historic structures and an area determined by previous investigations as containing source contamination.

For the purposes of this IRM, source contamination is defined as soil observed to be heavily impacted by MGP-related constituents to the extent of saturation. Minor staining, odors, or elevated air monitoring readings are not indicative of source material to be removed for the purposes of this work. The excavation activities are only one part of a two-phased approach to remedy MGP-related constituents associated with the site. If additional source material is observed in the unsaturated zone during the IRM outside of the defined areas, it will be removed via excavation and managed accordingly. If field observations cause the excavation area to expand, the Contractor will not expand the western/southwestern limits of excavation beyond those detailed in the Work Plan to be protective of existing structures (walls, foundations, etc). All excavations will be completed with a trench box or other suitable means of shoring designed and sealed by the Contractor's New York-licensed Professional Engineer, and the concept approved by GEI and KeySpan. Any lesser degree of contamination in the IRM area, or source material not readily accessible via excavation, will be remedied during the second phase of the IRM in-situ.

The Contractor will expose an existing gas main located beneath the southern sidewalk along Oak Street that transects the excavation area. The Contractor will be responsible for safeguarding any utilities and structures located within and adjacent to the excavation area. The Contractor will be responsible for any saw cutting necessary to remove the basin and portions of the roadway and sidewalk.

2.4.1.2 Area B (Historic Piping Removal)

The Contractor will also remove via excavation the former wastewater discharge pipe located along Oak Street. The anticipated depth of the pipe is approximately 2 feet below grade, but portions of the pipe may have been removed when the existing gas main was installed. If the former pipe is not discovered at a particular section, excavation activities will cease at approximately four feet below grade. The discharge pipe was previously cut at the intersection of Fifth Avenue and Oak Street and sealed. Therefore, this IRM will only involve the excavation and removal of the section of pipe that extends from the intersection of Fifth Avenue and Oak Street to the cesspool/catch basin area. The Contractor will expose the existing gas main located beneath the southern sidewalk along Oak Street that runs parallel with the historic piping. The estimated dimensions of the trench will be 370 feet long, by three feet wide, by four feet deep.

The Contractor will be responsible for safeguarding any utilities and structures located within and adjacent to the excavation area. The Contractor will be responsible for any saw cutting necessary to penetrate portions of the roadway and sidewalk. The Contractor will also be responsible for managing vehicular and personnel traffic around the work area.

Impacted soils encountered within the planned trench limits will be removed for treatment and/or disposal. If environmental impacts are observed that appear to continue outside of the proposed trench, then the impacted soils immediately adjacent to the trench will also be removed for treatment and/or disposal. If the impacts appear to continue under the roadway or onto private property, then the observations will be documented and the area will be marked for further investigation via subsurface soil sampling.

2.4.2 Odor Control

To minimize the potential for the generation of odors during the work, the opened excavation area will be kept as small as practicable. Excavated material stockpiles and containers will be covered with plastic sheeting as appropriate during the work. The Contractor will also provide a backup odor suppressant system consisting of chemical foam (e.g., Rusmar™ foam) or other approved method. The material will be stored near the excavation and will be mobile.

2.4.3 Product Recovery

It is assumed no construction dewatering will be necessary for this project. The limited amount of excavation activities taking place in the saturated zone will be worked wet. Depth to groundwater in the excavation areas has varied historically between 3-6 feet bgs. Floating product that may accumulate in an open excavation prior to backfill operations will be collected using a Contractor-provided vacuum truck or other equipment.

2.4.4 Backfill

The Subcontractor shall backfill the excavated area with clean fill and compact the backfill material in twelve inch lifts to 90 percent Proctor Density until the base of the existing surface material is reached. The backfill material shall be clean, granular sand and gravel, free from organic material, rubbish, clay, frozen or other deleterious substances and conform to the following gradations: 100% passing 3/8 inch sieve, 80-100% No. 8, 60-20% No. 50, and 0-5% No. 100 sieve. The remaining volume will be completed with the same surface as was pre-existing (asphalt/concrete/topsoil). The new surface shall tie in with the existing surface so as not to alter preexisting drainage patterns.

2.5 Material Handling

To minimize adverse operational impacts on Oak Street and the Town of Islip parking lot, IRM excavation activities will consist of either a direct load out of excavated materials for transport and disposal, or excavated materials could be temporarily stockpiled prior to ultimate transport and disposal. All trucks or containers used for transport and disposal will be watertight, lined with plastic, with the load covered with plastic and a secured tarp. Waste transport vehicles will be loaded while parked over plastic sheeting. Once a truck is filled, it will be decontaminated with dry brushes/brooms as necessary. Following decontamination, the truck will proceed directly to the designated thermal treatment facility.

The Contractor may segregate material excavated prior to direct load as space allows. Lined and covered roll-off bins will be staged at the Bay Shore Former MGP site whenever feasible to contain construction debris and bulk waste for waste classification and appropriate disposal. No more than one roll-off bin at a time may be stored in the Town of Islip parking lot to minimize disturbance to normal daily operations. Roll offs containing contaminated soils or debris will be secured in the IRM area, or relocated to the secure Bay Shore Former MGP site, at the end of each workday.

Based on previous investigation results, no hazardous materials are anticipated during this work. If necessary, suspect materials encountered during excavation that may exhibit hazardous characteristics will be segregated, stored off-site at the Bay Shore former MGP site, sampled, characterized, and disposed of appropriately.

2.6 Chemical Oxidation

In order to remove residual impacts and potentially deeper sources not readily accessible via excavation, KeySpan proposes ISCO treatment, more specifically, ISCO via the injection of activated persulfate. A bench scale treatability study has been completed for the OU-1 portion of the Bay Shore former MGP site for this technology. This portion of the IRM Work Plan is intended to outline the general scope and process to be followed during a full-scale implementation of ISCO for the former cesspool area of OU-4. Upon completion of a pilot test on the OU-1 parcel, a revised and detailed chemical oxidation design and implementation plan will be submitted to the NYSDEC prior to mobilization for this task.

2.6.1 Remedial Technology Process Description

Chemical oxidation is a process by which a chemical oxidant mineralizes organic compounds, in this case PAHs, leaving behind CO2 and water. ISCO is a proven remedial technology and has been successfully applied at many sites. The application of ISCO to MGP sites is relatively new, with several full-scale applications over the past few years. These applications, together with the bench-scale testing performed for OU-1 and bench-scale testing performed on other MGP sites, demonstrate the effectiveness of the technology on PAHs. The high permeability of the site soils provides an ideal setting for ISCO and the distribution of oxidants in the subsurface. In addition, the in situ treatment will have little disruption to 22 Oak and LIRR parking lot operations, and the persistence of the persulfate will allow greater well spacing so that minimal intrusive activities will need to take place within the 22 Oak building. Furthermore, the application of ISCO will eliminate the necessity of excavation near or under the building thereby protecting the integrity of the structure.

Pre-, during-, and post-treatment monitoring is an integral component of the ISCO process. The monitoring program documents the progress and effectiveness of the treatment and assures that the remedial objectives are met.
The persulfate anion ($S_2O_8^{2-}$) is the most powerful oxidant of the peroxygen family of compounds, and is among the strongest oxidants commonly used for water and wastewater treatment. Sodium persulfate can be catalyzed (i.e., activated) by transition metal ions such as naturally occurring or externally supplemented ferrous iron (Fe^{2+}) to produce a powerful oxidant known as the sulfate free radical ($SO_4\bullet$). The stoichiometric reaction between persulfate and ferrous iron is shown in the following equations:

$$2Fe^{2+} + S_2O_8{}^{2-} \Rightarrow 2Fe^{3+} + 2SO_4{}^{2-} \quad \text{..........} (1)$$

Through the steps:

$$2Fe^{2+} + S_2O_8^{\ 2-} \Rightarrow 2Fe^{3+} + SO_4^{\ 2-} + SO_4 \bullet \ldots\ldots (2)$$

$$SO_4 \bullet + Fe^{2+} \Rightarrow Fe^{3+} + SO_4^{\ 2-} \ldots\ldots (3)$$

With a standard reduction potential of 2.6 volts (V), the sulfate free radical ($SO_4\bullet$) produced is a very powerful oxidant, and is capable of oxidizing a wide array of organic compounds.

2.6.2 Summary of Bench-Scale Study Results/Field Pilot Test Plan

Xpert Design and Diagnostics, LLC (XDD) has evaluated the applicability of ISCO to treat site soils containing PAH and BTEX compounds in a bench scale study. The chemical oxidation bench-scale treatability study consisted of numerous setups and oxidant loading ratios applied to soils collected from OU-1 of the Bay Shore site. Each sample setup consisted of site soils and groundwater placed in a flask with a mixture of persulfate and reagents. The flasks were held at a constant temperature and at specific time intervals they were “sacrificed” for analysis of contaminants of concern (COCs). The COCs include BTEX and PAH compounds. Additionally, the samples were monitored for off-gassing and stable by-products formation.

Persulfate achieved greater than 90% remediation of COCs from soils with concentrations up to the 4,000 milligram per kilogram (mg/kg) range. The most optimal bench-scale oxidant loading rate for persulfate was 58 grams per gram of COCs. No stable hazardous by-products of significance were produced with respect to the COCs.

The conceptual approach for a full-scale application at the site is currently projected to involve oxidant injection using an array of temporary vertical injection wells throughout the target area. The oxidant and catalyst would be injected into target zones using short injection well screens over a relatively short period of time. After the oxidant is injected, the oxidant would migrate due to density advection, dispersion and groundwater movement. Post-injection monitoring would be used to determine the effectiveness of the treatment and provide insight into areas targeted for additional injections as necessary.

A field pilot test of activated persulfate for the remediation of the residual MGP-related constituents is proposed at OU-1. The work plan for the field pilot test is currently being finalized. The proposed field pilot test is designed to answer the following questions:

- What are the achievable levels of COC oxidation and COC mass flux reduction under field conditions?

- What injection well spacing, injection pressure and flow rate will be required to dose the target soil volume with the oxidant?
- What oxidant volume (or number of doses) or what oxidant/COC mass ratio is required to remediate the COCs in the target volume?
- What is the expected time required for the oxidation process to be complete?
- What amount of groundwater monitoring is required during the oxidation process?

2.6.3 ISCO Full Scale Program Implementation

Utilizing the pilot test results, a final design submittal will be prepared for the application of ISCO at the OU-4 area. In general, a series of injection wells will be installed across the target area to provide an efficient distribution of the oxidant for contact with the targeted subsurface soils. A draft ISCO injection well layout for the site is depicted on Figure 3. It is currently proposed that the ISCO process will be applied at 10 injection locations (ISCO 1 through 10) spaced 35 feet apart perpendicular to the groundwater flow direction (south, south westerly) and spaced 70 feet apart along the direction of groundwater flow. At each injection well location, 2-foot-diameter PVC nested wells will be installed to address specific 10-foot vertical intervals of soils targeted from the investigation phase. A total of 26 vertical well intervals are proposed at the injection locations and are presented in Table 2-6. To clarify, the shallow injection interval labeled as the 0 to 10 foot zone in Table 2-6, will actually receive oxidant injection from approximate current depth of groundwater (varies from 3 to 6 feet) to 10 feet below grade. Soil samples will not be collected from 0 to 4 foot intervals because significant MGP-related impacts have not been observed outside of excavation areas in this interval based on results of the remedial investigation or subsequent supplemental investigation activities. BTEX and PAHs were present in shallow soils (2 to 4 feet), but concentrations were below TAGM levels.

The proposed nested wells provide versatility in operation, allowing for either the injection of oxidant or reagent from either well and more uniform dosing across the interval than one well would provide. The ultimate injection well design will be finalized based on the pilot test results. The oxidant solution will be prepared on-site and pumped into the injection wells. The mass of the applied oxidant injected into each well will be reflective of the mass of COCs identified within the influence of the injection well and other naturally occurring oxidant demands in the subsurface. The injection system will be operated until monitoring results indicate remediation has been completed. Soil sampling will be conducted to verify the status of the remediation. Performance monitoring locations are depicted on Figure 4, and further details of IRM monitoring can be found in Subsection 2.9. A general process schematic for Persulfate is presented in Figure 5.

Table 2-6 Chemical Oxidation Injection Locations

Injection Well	Injection Interval (Feet Below Grade)			
	0-10	10-20	20-30	Injections per Location
ISCO-1	X	X	X	3
ISCO-2	X	X	X	3
ISCO-3	X	X	X	3
ISCO-4	X	X	X	3
ISCO-5	X	X		2
ISCO-6	X	X		2
ISCO-7	X	X	X	3
ISCO-8	X	X	X	3
ISCO-9	X	X		2
ISCO-10	X	X		2

*Additional injection locations will be added as needed based on observations made during excavation/trenching activities and the results of the Field Pilot Test.

2.7 Restoration

At the completion of IRM activities, the Contractor will restore the site to Pre-IRM conditions. This will include, but may not be limited to:

- Replace/repair surfaces on the Town of Islip asphalt parking area and the 22 Oak Street parcel disturbed during excavation and ISCO
- Restore the portions of Oak Street, the sidewalk, and curb disturbed during the wastewater discharge pipe excavation
- Replace the catch basin and associated piping located in Oak Street with a concrete structure of similar dimensions

All restoration construction will be identical to pre-existing conditions with the exception of the catch basin, which will be upgraded, and the former cesspool, which will be abandoned. This includes similar material type, thickness, compaction rate, and traffic line painting as necessary. KeySpan will present any substitutes to the respective property owner for approval prior to commencing restoration activities.

2.8 Demobilization

Once all site restoration activities are complete, IRM demobilization activities will take place. This includes the removal of all temporary facilities, including decontamination areas, removal of unused materials, and general housekeeping.

2.9 Monitoring IRM Performance

Figure 4, IRM Performance Monitoring Locations Map, presents planned soil and soil gas sample locations and existing monitoring wells that will be used to obtain data to quantify the performance of the IRM. An additional monitoring well, WCMW-09S, I, I2, will be installed in the vicinity of soil boring WCSB-46 per NYSDEC letter dated January 4, 2005. This well will confirm that groundwater in the area is not significantly impacted by MGP-related contaminants and monitor the effectiveness of the proposed IRM. Soil samples will be obtained via direct push methods on a 25-foot grid system over the ISCO injection area ninety days after ISCO injections are completed. As indicated in our October 20, 2004 letter, we will collect a soil sample, GPI-10, in the vicinity of WCSB-37 to assess the need for and practicability of further action. Soil samples will be obtained from the depths listed in Table 2-8. All samples will be analyzed for BTEX and PAHs via United States Environmental Protection Agency (EPA) Methods 8260 and 8270, respectively. Soil gas sampling will take place via Summa® canister in accordance with the Field Sampling Plan (Appendix C) before implementation of ISCO to establish a baseline data set. The same three locations will be sampled for soil gas weekly during implementation of ISCO and quarterly for one year after completion of the IRM using the same sample methods. Groundwater monitoring data will be obtained from the on-going OU-4 Quarterly Program.

Table 2-8 Post In-Situ Chemical Oxidation Injection Soil Sampling

Sample Location	Sample Interval (FT Bgs)	Sample Location	Sample Interval (FT Bgs)
GPI-1	8-12, 16-20	GPI-18	8-12, 16-20, 24-28
GPI-2	4-6, 8-12, 16-20, 24-28	GPI-19	4-6, 8-12, 16-20, 24-28
GPI-3	12-16, 20-24	GPI-20	4-6, 12-16, 20-24
GPI-4	8-12, 16-20, 24-28	GPI-21	4-6, 8-12, 16-20, 24-28
GPI-5	4-6, 12-16, 20-24	GPI-22	12-16, 20-24
GPI-6	8-12, 16-20, 24-28	GPI-23	8-12, 16-20, 24-28
GPI-7	12-16, 20-24	GPI-24	12-16, 20-24
GPI-8	8-12, 16-20, 24-28	GPI-25	12-16, 20-24
GPI-9	12-16, 20-24	GPI-26	8-12, 16-20, 24-28
GPI-10	4-6, 8-12, 16-20, 24-28	GPI-27	12-16, 20-24
GPI-11	4-6, 12-16, 20-24	GPI-28	8-12, 16-20, 24-28
GPI-12	8-12, 16-20, 24-28	GPI-29	12-16, 20-24
GPI-13	12-16, 20-24	GPI-30	12-16, 20-24
GPI-14	8-12, 16-20, 24-28	GPI-31	8-12, 16-20, 24-28
GPI-15	4-6, 12-16, 20-24	GPI-32	12-16, 20-24
GPI-16	4-6, 8-12, 16-20, 24-28	GPI-33	8-12, 16-20, 24-28
GPI-17	12-16, 20-24		

All monitoring wells in the OU-4 vicinity are currently sampled quarterly as part of the Bay Shore Former MGP site groundwater monitoring program. These wells will also be sampled monthly beginning at the completion of each ISCO injection series (as needed), and continue for three consecutive months.

After three rounds of monthly groundwater sampling, the analytical results will be evaluated in conjunction with the soil sampling results, and a status report will be submitted to the NYSDEC. This report will address whether an additional round of ISCO will be required.

3. Health and Safety Plan

This section summarizes the health and safety guidelines that will be followed during the execution of the IRM activities at the site. A complete copy of the HASP is provided as Appendix A of this Work Plan. The HASP establishes the requirements for the project in compliance with 29 CFR 1926 and other applicable standards as well as client requirements. The project-specific HASP:

- Incorporates health and safety standards established for the project
- Addresses project-specific physical and chemical hazards
- Includes Activity Hazard Analysis (AHA) for critical tasks
- Includes a project-specific community air-monitoring plan (CAMP)

Modifications may be required to address previously unanticipated hazards. These changes will be made after review and approval by a certified health and safety professional.

3.1 Health and Safety Guidelines

All work will be performed in accordance with all OSHA, state, and industry safety standards. All on-site personnel performing activities associated with this IRM will have the requisite 1910.120 OSHA Hazardous Waste Operations and Emergency Response (HAZWOPER) training as well as site-specific training prior to intrusive activities. Personal protective equipment will be used as needed, in combination with applicable engineering controls, during all phases of the work. Daily safety meetings will be held with field oversight personnel and construction personnel working on the site. Attendance will be recorded along with topics covered concerning the safe performance of the required tasks.

3.1.1 Training Requirements

All personnel performing work associated with this IRM will be required to have both general and site-specific training. The general training includes all applicable OSHA and state required training, such as 40-hour Hazardous Waste Operations and Emergency Response and the 8-hour Refresher Training. Supervisory personnel will also have Supervisory Training. All personnel will be in a medical surveillance program. Also, site-specific training will be given to all personnel performing fieldwork at the site. This site-specific training will include site hazards, required personal protective equipment (PPE), and site warning and evacuation procedures.

3.1.2 Emergency Response

The HASP includes an emergency response plan. All personnel receive training prior to performing work on site, and will be familiar with the hazards present. Each worker will be aware of the appropriate emergency response for hazard conditions. Because there will be no office trailer at the work location, the vehicle of field oversight manager will be equipped with a map and directions to the nearest hospital if medical attention is required, in addition to a full copy of the IRM Work Plan and HASP for this work.

3.1.3 Record Keeping

Record keeping will be ongoing from the onset through the closure of the project. This effort will include but not be limited to personnel medical and training records, on-site logs, weekly/monthly health and safety reports, health and safety logbooks, hazard communication program documents and Material Safety Data Sheets (MSDS), and work permits.

4. Community Health and Safety Measures

4.1 Community Relations

Maintaining good community relations is of utmost importance for this IRM. Any inquiries from the public as to the work being performed will be directed to KeySpan, via the on-site field oversight personnel. Contact information will be available for distribution by field oversight personnel to address any inquiries.

All field activities shall be conducted in an efficient and professional manner, with the minimum practical impact to the site. All field personnel will provide assistance in maintaining a positive relationship with the surrounding community, local authorities and state agency personnel.

4.2 Special Material Handling

As part of the Hazard Communication Program identified in the HASP, all Material Safety Data Sheets (MSDSs) for all applicable chemicals utilized for this IRM will be stored at the project site. The intent of the Hazard Communication Program is to provide information regarding the potential health hazards from exposure to workplace chemicals in accordance with the OSHA Hazard Communication. Typically an MSDS includes important information such as the properties of a chemical, details on handling, special safety precautions, and actions to take in the event of a release or exposure. For the ISCO portion of work for this IRM, a chemical called Sodium Persulfate will be transported in accordance with United States Department of Transportation (DOT) regulations and stored in bulk on the Bay Shore former MGP site and smaller quantities will be distributed daily to the work area for use in remediation activities. Sodium Persulfate is a white crystal powder with no odor.

The potential hazards identified for Sodium Persulfate are:

- It is a strong oxidizer, which may release oxygen and promote the combustion of flammable material. *(The product itself is non-combustible, but it can release oxygen, which will intensify an existing fire).*

- Sensitization may occur from the inhalation and skin contact of this product. Direct contact may cause irritation of the eyes, skin, and respiratory tract.

In order to mitigate these potential hazards to the community and site workers, the Persulfate will be stored in bulk on the Bay Shore former MGP away from any residences, structures, or flammable materials. It will be transported to the work area in accordance with DOT regulations, and handled by workers utilizing eye and skin protection. All handling will take place in well-ventilated areas, if ventilation becomes limited, respiratory protection will be used. The work zones defined in the HASP will prevent anyone other than site workers from coming in direct contact with the product.

5. Site Management

The objective of site management is to provide safe, controlled, and efficient operations that comply with the access rules and guidelines, that accomplish the technical requirements of the IRM, and that comply with sound construction, environmental, waste management, field sampling, quality assurance, and health and safety practices.

5.1 Site Access

Access to the work zones and areas of construction will be restricted by the use of warning tape and/or temporary high-visibility plastic barricade fencing or similar types of demarcation. An exclusion zone for work involving potentially contaminated materials will also be similarly set up as necessary, and as detailed in the HASP. Access to these areas will be restricted to Contractor personnel, authorized KeySpan representatives, other technical personnel, and personnel representing NYSDEC and local authorities as necessary.

5.2 Construction Oversight

Field oversight will be conducted by GEI to monitor and manage daily construction activities. Construction activities, as well as associated health and safety issues, will be discussed during “tailgate” meetings to be held before commencing work at the site.

5.3 Communication

Field oversight personnel will be equipped with a mobile cell phone for communication with off-site project personnel and emergency notifications.

5.4 Orientation/Briefings

Prior to the performance of construction activities, a site-specific health and safety orientation for appropriate personnel will be conducted. A pre-construction meeting will be held on-site with all oversight and construction field personnel prior to initiation of on-site activities to review site history, layout and field procedures. All personnel will provide training records and medical surveillance program records as required in the site-specific HASP prior to mobilization. As indicated previously, a daily Health and Safety briefing will be conducted prior to the start of each day’s activities, led by on-site field oversight personnel.

5.5 Erosion and Sediment Control Plan

The objectives of the erosion and sediment control plan at the Site are to mitigate erosion and sedimentation from the site through the best available technology. The plan includes a description of the construction activities, identification of potential areas of erosion and sedimentation, the implementation of erosion control measures, and final restoration.

5.5.1 Description of Construction Activities

Excavation depths will vary between approximately 2 feet and 6 feet bgs. Dewatering of the excavation will not be required during this project. It is anticipated that groundwater varies from 3 to 6 feet bgs. Open excavation areas will be kept as small as practical, and will be backfilled each day when possible. If daily backfilling is not possible, all stormwater runoff from the exterior of open excavation areas will be routed to bypass the affect area and discharged into the storm sewer system prior to any soil contact. A portion of the excavation areas includes removing an active stormwater catch basin. The Contractor will route stormwater as necessary to bypass this structure until it can be replaced.

5.5.2 Potential Areas for Erosion and Sedimentation

The site is relatively flat and is generally covered with asphalt or concrete. One small area will be excavated from a grass area, but the excavation equipment will be working from an adjacent asphalt area. Little potential exists for erosion or sedimentation issues during this IRM.

5.5.3 Implementation of Erosion Control Measures

Decontamination stations will act as anti-tracking pads thereby removing all soil and sediment from all trucks/equipment wheels and bodies that are exiting the site onto public streets.

The Contractor shall install and maintain erosion control measures such as fencing around the perimeter of any excavation area not completely backfilled at the end of each workday. Additional erosion control measures may be needed due to unforeseen conditions. The Contractor shall install additional measures as necessary as directed by GEI.

5.6 Decontamination Procedures

All personnel, tools, equipment, and vehicles coming in contact with contaminated soils and/or groundwater will be decontaminated as detailed in the HASP. The Contractor will establish decontamination areas for the following activities.

- Personnel decontamination
- Equipment decontamination

5.6.1 On-site Personnel Decontamination

A personnel decontamination station where workers can drop equipment and remove PPE will be set up at the boundary work zone within the work zone. It will be equipped with basins for water and detergent, and trash bags or cans for containing disposable PPE and discarded materials. Once personnel have decontaminated at this station and taken off their PPE, they will proceed to a final basin where they will wash themselves as a secondary means of personal hygiene (e.g., hands, face, etc.).

The specific decontamination procedures and requirements for the disposal of decontamination wastewater are outlined in the HASP.

5.6.2 On-Site Equipment Decontamination

Equipment decontamination will take place on plastic lined, bermed, temporary decontamination pads. During the preliminary site visit, the location of the decontamination area(s) will be chosen.

Drilling equipment, hand tools, and miscellaneous small equipment that come in contact with excavated soils or impacted groundwater will be decontaminated on a temporary decontamination pad in buckets of water and detergent.

Vehicles and other large equipment which come in contact with excavated soils or impacted groundwater will be thoroughly dry brushed clean while on plastic sheeting, the potentially contaminated portions of the equipment will be wrapped in plastic, and the equipment will be transported to the Bay Shore OU-1 site for off-site decontamination with steam cleaning equipment. All wastes will be managed accordance with Section 6.

Any generated wastes will be drummed/containerized and transported to the OU-1 site at the end of each workday for bulk storage until characterization and ultimate disposal.

5.6.3 Off-Site Equipment Decontamination

A decontamination area will be established by the Contractor at the OU-1 site area to steam clean equipment in accordance with the HASP. Potable water is not believed to be available to certain portions of the site; consequently potable water for decontamination will need to be staged at the site in close vicinity to the decontamination area. Drilling equipment (e.g., drill rods and auger flights) from the hollow stem auger drill rig and the bucket from the backhoe equipment will need to be steam cleaned with a pressure washer within the established off-site decontamination area. The decontamination pad will be sufficiently sized to ensure that the largest piece of Contractor equipment can be adequately decontaminated. Provisions will be made to control overspray at the decontamination pad.

All equipment leaving the site will be decontaminated per these guidelines. In addition, any equipment previously utilized to excavate impacted material will be decontaminated prior to use in backfilling (e.g., excavator bucket).

Wastewaters produced during decontamination will be collected from the decontamination pad and placed into USDOT/UN-approved drums, labeled and stored at the established waste storage area at the site. The drums will be characterized and properly disposed of by KeySpan. Disposal of the wastewater will be handled in accordance with the Waste Management Plan (Section 6).

Soils collected from the decontamination pads will be bulked with the excavated material and disposed of in accordance with the Waste Management Plan (Section 6).

5.6.4 Decontamination Equipment

The Contractor will be responsible for maintaining a sufficient supply of equipment required to implement decontamination procedures, including, but not limited to, the following items:

- Plastic trash barrels
- Liners for trash barrels
- Wash basins
- Alconox™ detergent concentrate
- Hand pump sprayers
- Long handled soft bristle brushes
- Large sponges
- Cleaning wipes for respirators
- Bench or stool(s)
- Stepladder(s)
- Stream generator
- Liquid detergent and paper towels
- Plastic trash bags
- Supplies/equipment to construct the decontamination pads
- All necessary hosing, connections, etc to collect and transport decontamination fluids

5.7 Equipment and Material Staging and Storage Areas

Areas within the Bay Shore Former MGP site will be used for construction material and equipment storage and excavated material staging as needed. The areas serve as the central receiving locations for any materials, equipment, and expendables that will be utilized in the execution of the project. Temporary daily storage at the worksite is permitted.

5.8 Traffic Control Plan

The objectives of the traffic plan at the Site are to describe the traffic objectives and concerns and indicate the traffic routes to and from the site for trucking soil and bulky waste off site, importing clean fill to the site, liquid waste hauler off loading dewatered liquids if necessary, Contractor access, parking, equipment access, and storage. Although portions of the LIRR parking lot will be out of service for periods of time during the IRM activities, there are adequate spaces to accommodate the work without inconveniencing people or limiting parking availability.

Figure 6, shows the proposed traffic routing pattern to the work area on Oak Street and to the Bay Shore former MGP site for bulk storage and staging. Vehicles for hauling of contaminated, fill materials, and supplies shall enter Bay Shore from the Sunrise Highway (RT 27) at the 5th Avenue (CR13) Exit. The vehicles shall follow 5th Avenue south to where it becomes Clinton Avenue and shall continue south on Clinton Avenue.

Vehicles shall make a left hand turn through the gate on Clinton Avenue to access to the Bay Shore former MGP site for equipment storage, laydown, etc. Vehicles exiting the Bay Shore site will exit via the Clinton Avenue gate and make a left turn onto Clinton Avenue. Vehicles will continue on Clinton Avenue to the intersection of Clinton Avenue and Union Boulevard. Vehicles shall make a left turn onto Union Boulevard followed by a left turn onto 5th Avenue. Vehicles shall then retrace the site entry route to exit Bay Shore or make a right hand turn on Oak Street to access the work area.

The Contractor shall provide traffic control personnel when all trucks are exiting onto Clinton Avenue from the Bay Shore site, and onto 5th Avenue from Oak Street. Traffic control personnel shall also direct traffic as needed upon delivery of equipment, trailers, excavation support materials, etc.

5.9 Security

The work zones will be secured at the end of each day's activities. The Contractor will attempt to work in small enough excavation cells so as to limit the existence of open trenches at the end of the workday. If it is not feasible to complete an excavation area before daily work stoppage, then open trenches will be covered with heavy plywood sheeting, or steel plate and barricaded as necessary based on location. Uncompleted monitoring wells or other construction will be protected with high visibility cones, warning tape, or other similar barricades.

5.9.1 Perimeter Security

All work will take place on non-KeySpan owned property. Each day, a temporary fence or barricade system will be erected around the perimeter of the IRM work area. Each day’s work area will be kept small enough for the Contractor to safely and efficiently manage the excavation and work areas in regards to personnel and vehicular traffic. The fence will extend around all work areas to include waste handing equipment and storage areas. The safe distance around each work area will be determined by the GEI oversight manager in accordance with the site specific HASP. The Contractor will provide additional security, as necessary, to satisfy any local traffic permits to complete the IRM activities.

5.9.2 Equipment Security

At the end of each working day, all vehicles and/or equipment must be secured within a fenced in area. No vehicles or equipment may be left overnight in an unsecured location. It is the responsibility of the Contractor to ensure that all non-essential equipment is de-energized when left on site and not in use to prevent electrical/fire/explosive hazards. Essential equipment that must run overnight and/or on non-working days will be designed and managed with appropriate automatic shutoffs and/or alarms to prevent unsafe operation.

6. Waste Management Plan

The objectives of the waste management plan are to identify the waste streams to be generated and outline the management/disposal guidelines. All waste materials generated as a result of the IRM will be properly disposed of in accordance with all applicable laws and regulations. The Contractor is responsible for management and disposal of all general construction generated wastes. Excavated soils and liquid wastes will be characterized, transported, and disposed of by KeySpan. The Contractor is responsible for management of these wastes up to and including load-out for final transport and disposal/treatment. KeySpan will prepare and submit to the disposal/treatment facility a generator profile of soils and wastes generated at the site. KeySpan will provide a transporter for excavated soils and liquid wastes and coordinate load out/pick up with the Contractor.

6.1 Disposal Record Keeping

All manifests and/or bills of lading for all shipments will be submitted to the Engineer (GEI) prior to any vehicle departing the site. All manifests and/or bills of lading will be reviewed by the Engineer and signed by a KeySpan representative or designee.

A log of all shipments and copies of all manifests and/or bills of lading will be maintained by the Engineer on-site for reference. Upon completion of the IRM, KeySpan will receive all logs and manifests and/or bills of lading.

6.2 Material Management Procedures

All material transportation vehicles must be watertight and will be decontaminated prior to departing the site.

Individual waste streams will be managed as follows.

6.2.1 Soils and Bulky Waste

Excavated soils will be handled as previously detailed in Subsection 2.5 and Section 5. Bulky waste (i.e., large debris) encountered during the IRM may include the excavated miscellaneous material from former subsurface structures. The debris will be evaluated with regard to its disposition. If the debris is constructed of material that is impervious to contamination infiltration, it will be steam cleaned to remove gross contamination and then disposed of as general construction debris. If the debris is of a porous nature, a gross decontamination effort will be performed and it will be disposed of as contaminated debris along with the excavated soils.

6.2.2 Liquid Wastes

Liquid wastes (e.g., decontamination waters) may be potentially contaminated with BTEX and PAHs and other chemical constituents from site sources. The presence of any contaminants in the wastewater is expected to be dilute; therefore, the wastewaters are not expected to be classified as hazardous waste. Moreover, site history does not indicate the presence of listed hazardous wastes at the site. Therefore, the wastewaters are not likely to contain hazardous waste pursuant to the EPA's "contained-in policy" (i.e., environmental media which contain a listed hazardous waste are to be managed as a hazardous waste). It is anticipated that liquid wastes will be placed in bulk containers, 55-gallon drums or similar containers, for off-site disposal as non-hazardous waste by KeySpan. The Contractor will be responsible for properly storing, labeling, and providing a representative liquid waste sample to KeySpan for characterization to coordinate transport and disposal.

If a vacuum truck is used for collecting product pooling in open excavations, a sample will be immediately obtained for characterization, and the Contractor will transport the liquid waste to a KeySpan provided disposal facility.

7. IRM Summary Report

Following completion of the IRM, an IRM Summary Report will be prepared and stamped by an engineer licensed to practice in the State of New York. The IRM Summary Report will include a summary of IRM activities, document any changes to the work plan, document the final disposal of wastes, and contain a statement that the work was performed in accordance with the IRM Work Plan, contract drawings, and any approved changes to those documents. The report will also contain an assessment of the degree to which the remedial activities met the remedial objectives. Specific components of the IRM Summary Report will include:

- Record drawings, addenda, and approved changes
- The actual volumes of excavated material and disposed wastewater
- Other plans and figures (if required), photographs, data summary tables and appendices that will provide KeySpan with an accurate account of the remedial measures implemented at the site
- Approved permits
- Summary of construction work, meetings, and changes in work scope

8. IRM Implementation Schedule

A milestone schedule for implementation of the IRM activities is presented in the table below. It is important to note that the schedule may be affected by regulatory review time periods, contractor response timeframes, timeframes necessary to negotiate access agreements with property owners, community issues, permit review and approval timeframes, or other unknown factors. Every effort, however, will be made to keep the project on the anticipated schedule.

The schedule includes review of the IRM Work Plan by NYSDEC, procurement of a Construction Contractor, IRM field activities, and preparation and submittal of the IRM Summary Report for NYSDEC Approval. The overall OU-4 schedule will be revised and submitted to the NYSDEC after incorporating the selected Contractor's IRM execution schedule.

Milestone	Target Completion Date
Work Plan Submission	April 20, 2004
NYSDEC/NYSDOH Approval	January 4, 2005
Updated Work Plan Submission	January 14, 2005
Excavation Contractor Retained	February/March, 2005
Excavation Activities	March/April, 2005
ISCO Contractor Retained	April, 2005
ISCO Injection Begins	May, 2005
ISCO Injection Ends	August, 2005
Post Injection Quarterly Monitoring	September, 2006
IRM Summary Report	December, 2006

References

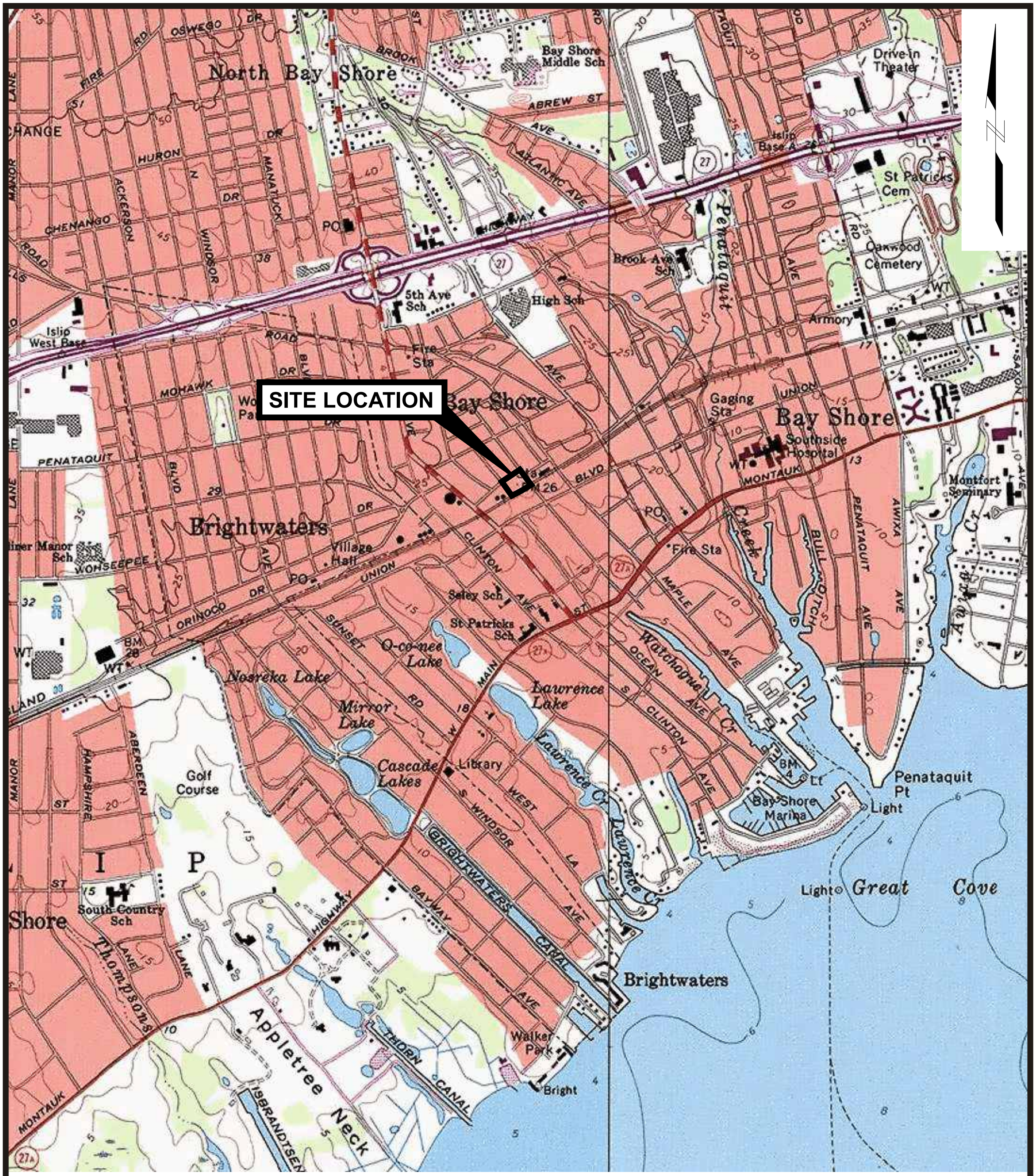
GEI Consultants, September, 2003. *Pre-Interim Remedial Measure Investigation Report, 22 Oak Street Parcel Adjacent to Operable Unit 4 – Cesspool Area, Bay Shore Former Manufactured Gas Plant Site, Bay Shore, New York.*

Dvirka and Bartilucci Consulting Engineers, January, 2003. *Final Remedial Investigation Report, Bay Shore/Brightwaters Former MGP Site.*

New York State Department of Environmental Conservation, December 2002. Draft DER-10 Technical Guidance for Site Investigation and Remediation.

Dvirka and Bartilucci Consulting Engineers, April, 2002. *Remedial Investigation Report, Bay Shore/Brightwaters Former MGP Site.*

Figures



SOURCE: Map created with TOPO! ® ©2001 National Geographic (www.nationalgeographic.com/topo)

OU4 CESSPOOL IRM
BAY SHORE FORMER MGP SITE
BAY SHORE, NEW YORK

KEYSPAN CORPORATION

GEI Consultants

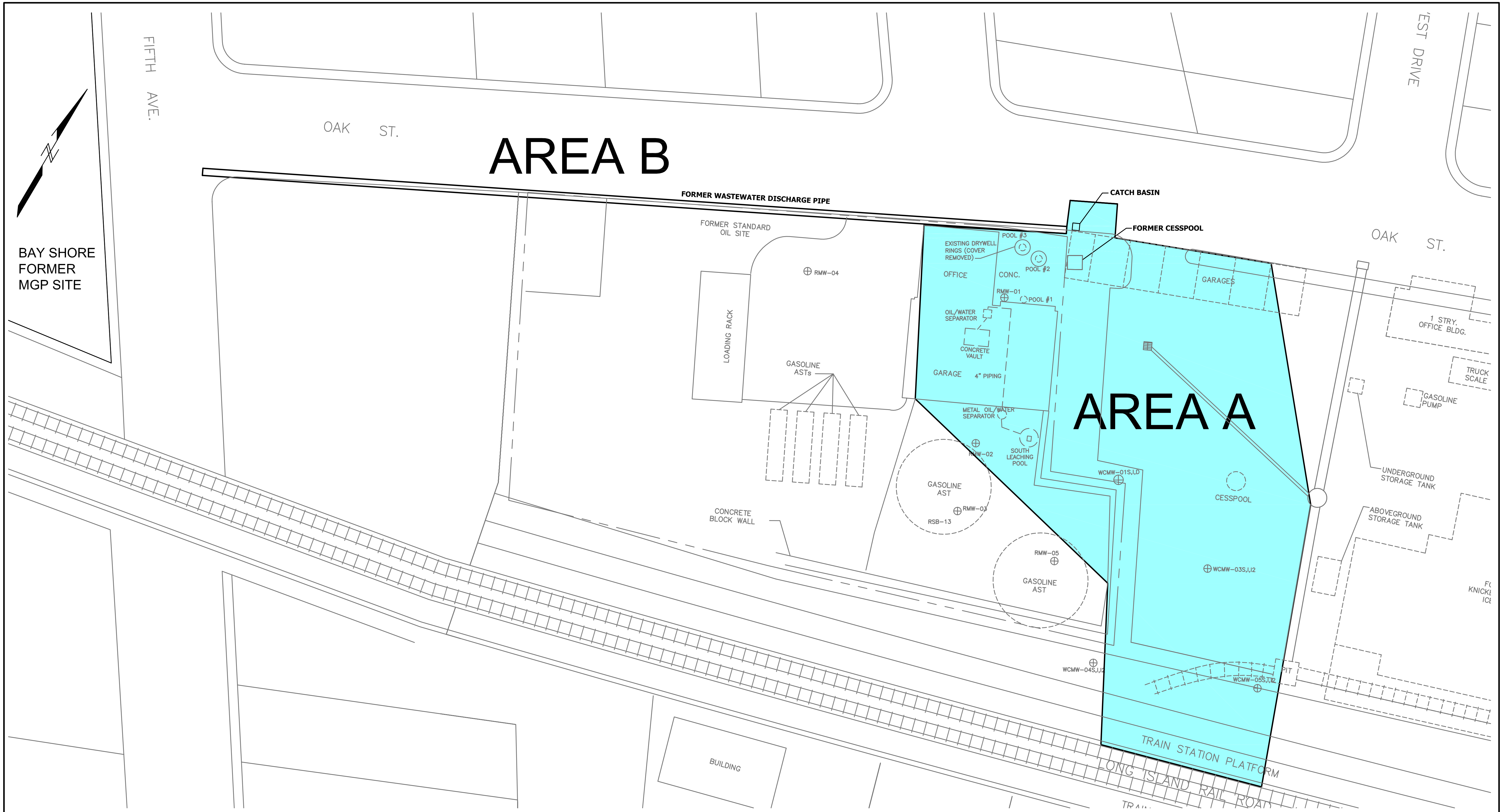
PROJECT 982492-15-2501

SITE LOCATION MAP

January 2005

Figure 1

KEYSPAN\BAYSHORE\OU-4\CESSPOOL IRM\BAYOU4-LOC.CDR



Sources: Town of Islip Engineering Department dated May 1965, Long Island Lighting Co. dated Dec 1947, Long Island Lighting Co. Rev. dated Apr 1973, interpretation of an Apr 94 aerial photograph, Berninger Environmental, Inc. dated Jun 02.

Note: Site survey data shown on this map is for KeySpan use only and is not to be relied upon by others.

0 40 80

SCALE, FEET

OU4 CESSPOOL IRM
BAY SHORE FORMER MGP SITE
BAY SHORE, NEW YORK

KEYSPAN CORPORATION

GEI Consultants

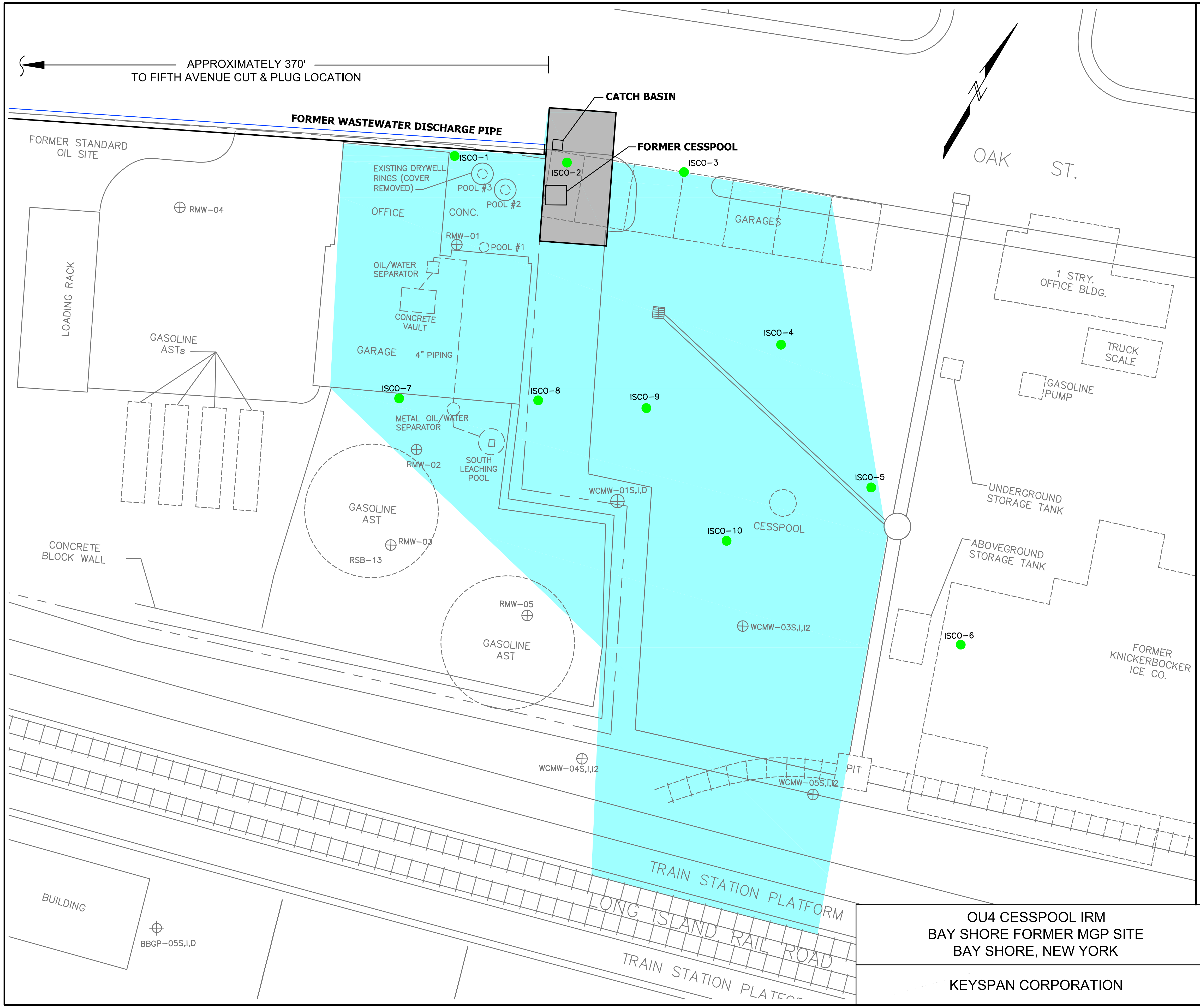
Project 982482-15-2501

SITE PLAN

January 2005

Figure 2

KEYSPAN\BAYSHORE\OU4\CESSPOOL IRM\FIGURE 2



LEGEND

- ▨ SOURCE REMOVAL EXCAVATION
- ☐ FORMER DISCHARGE PIPE EXCAVATION
- ● ISCO INJECTION LOCATION
- 🟦 IRM AREA A

Sources: Town of Islip Engineering Department dated May 1965, Long Island Lighting Co. dated Dec 1947, Long Island Lighting Co. Rev. Dated Apr 1973, interpretation of an Apr 94 aerial photograph, Berninger Environmental, Inc. dated Jun 02.

Note: Site survey data shown on this map is for KeySpan use only and is not to be relied upon by others.

0 30 60

SCALE, FEET

OU4 CESSPOOL IRM
BAY SHORE FORMER MGP SITE
BAY SHORE, NEW YORK

KEYSPAN CORPORATION

GEI Consultants

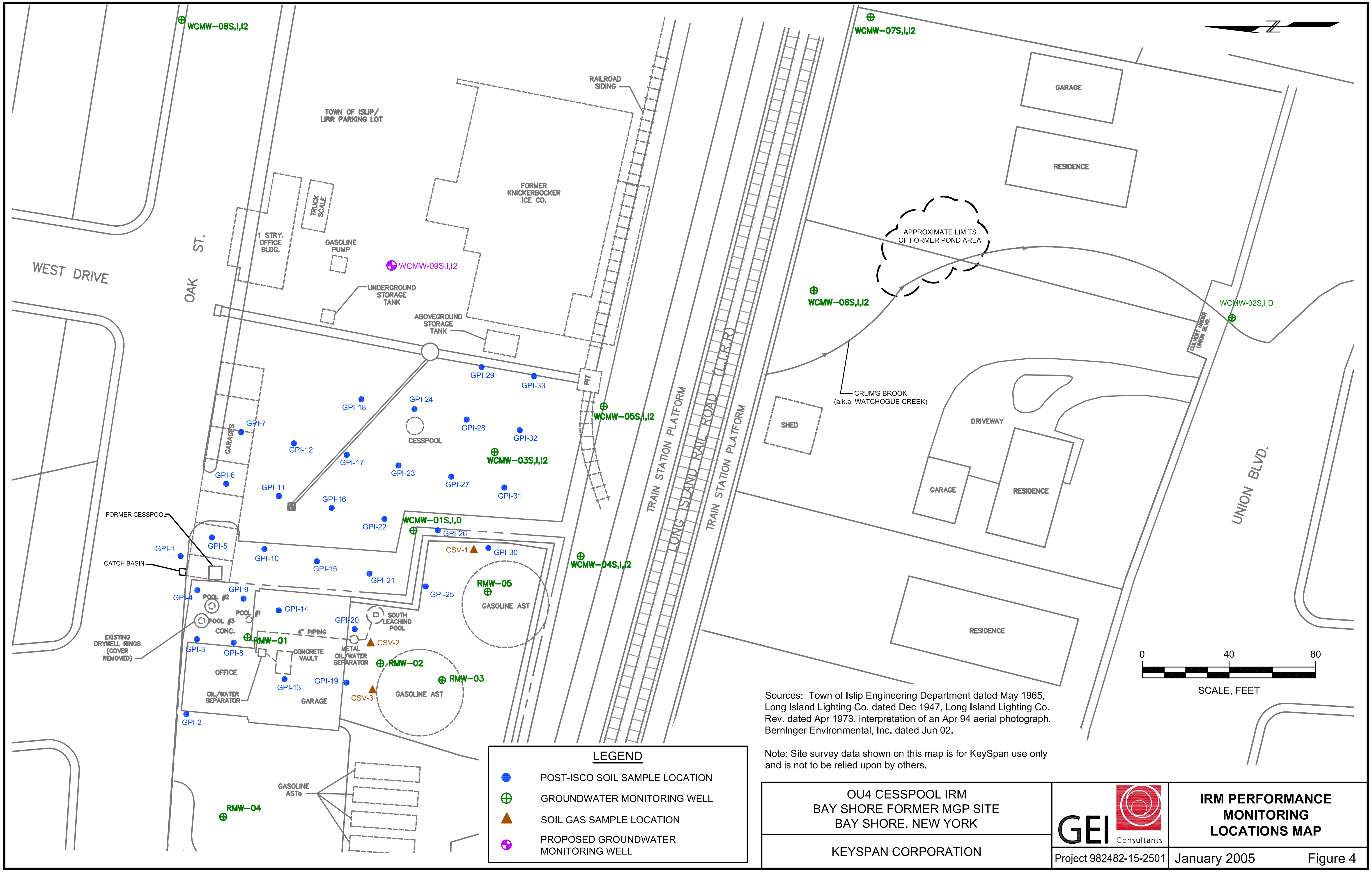
Project 982482-15-2501

REMEDIAL CONCEPT PLAN

January 2005

Figure 3

KEYSPAN\BAYSHORE\OU4\CESSPOOL IRM\FIGURE 3



LEGEND

● POST-ISCO SOIL SAMPLE LOCATION

⊕ GROUNDWATER MONITORING WELL

▲ SOIL GAS SAMPLE LOCATION

⊕ PROPOSED GROUNDWATER MONITORING WELL

Sources: Town of Islip Engineering Department dated May 1965, Long Island Lighting Co. dated Dec 1947, Long Island Lighting Co. Rev. dated Apr 1973, interpretation of an Apr 94 aerial photograph, Berninger Environmental, Inc. dated Jun 02.

Note: Site survey data shown on this map is for KeySpan use only and is not to be relied upon by others.

OU4 CESSPOOL IRM
BAY SHORE FORMER MGP SITE
BAY SHORE, NEW YORK

KEYSPAN CORPORATION

GEI Consultants

Project 982482-15-2501

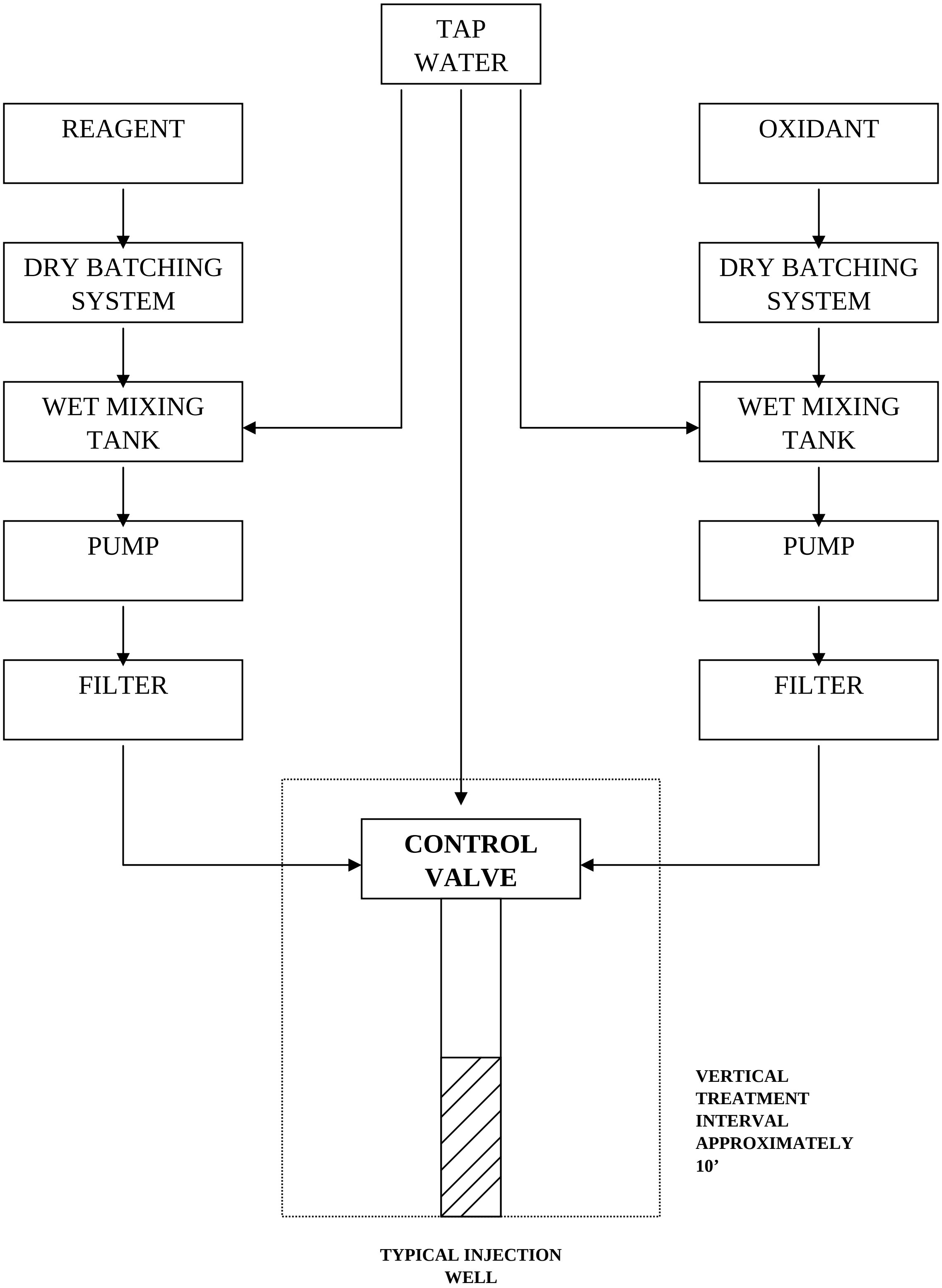
IRM PERFORMANCE MONITORING LOCATIONS MAP

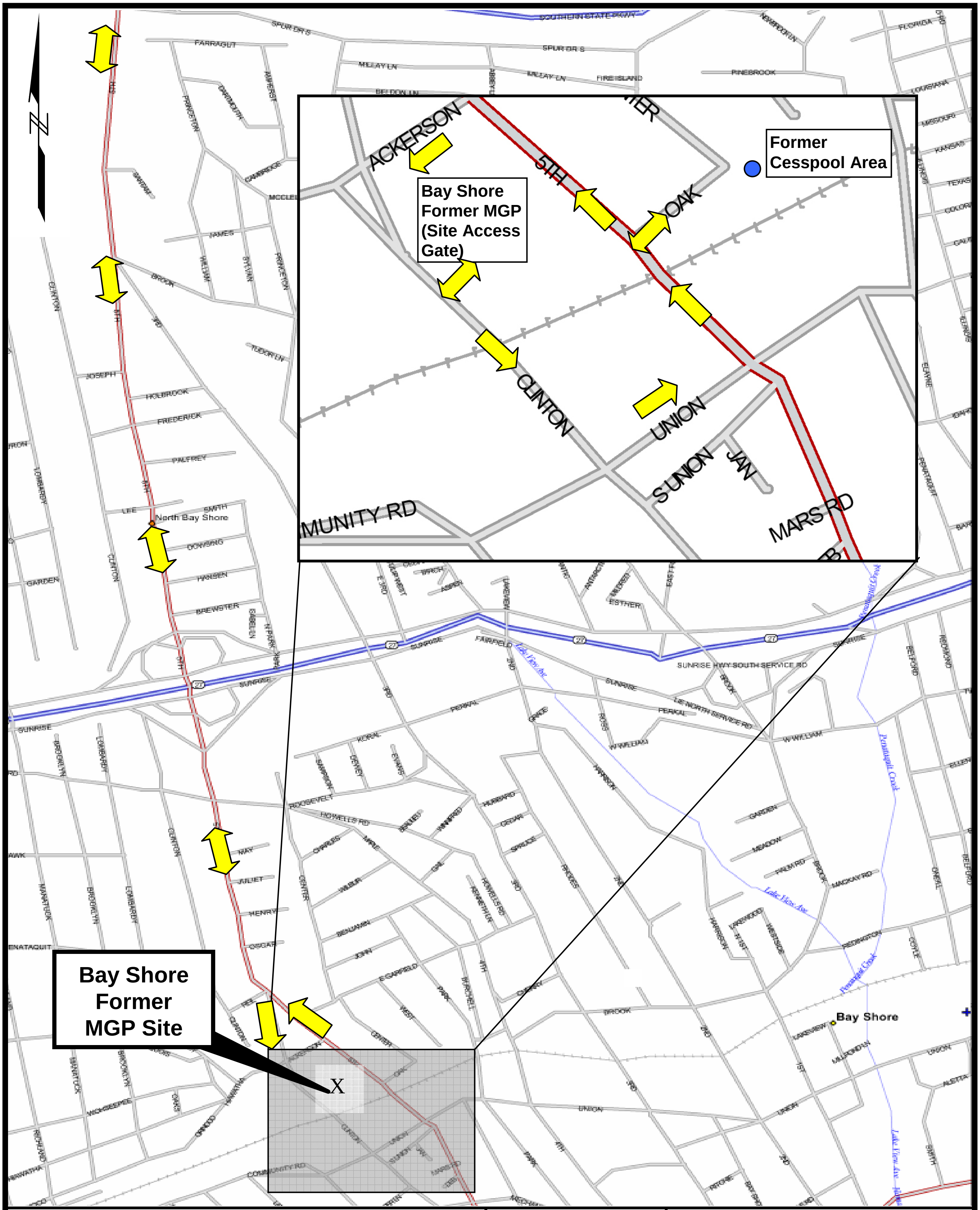
January 2005

Figure 4

KEYSPAN\BAYSHORE\OU-4\DRAFT CESSPOOL IRM\BAY-PERF

FIGURE 5 - ISCO PROCESS SCHEMATIC





OU4 CESSPOOL IRM
BAY SHORE FORMER MGP SITE
BAY SHORE, NEW YORK

KEYSPAN CORPORATION

GEI Consultants

Project 982482-15-2501

TRAFFIC CONTROL PLAN

January 2005

Figure 6

KEYSPAN\BAYSHORE\OU4\CESSPOOL IRM\BAY-TRAFFIC.PPT

Appendices

Appendix A Site Specific Health and Safety Plan

(Electronic Version Only)

Appendix B Quality Assurance Program Plan

(Electronic Version Only)

Appendix C Field Sampling Plan

(Electronic Version Only)

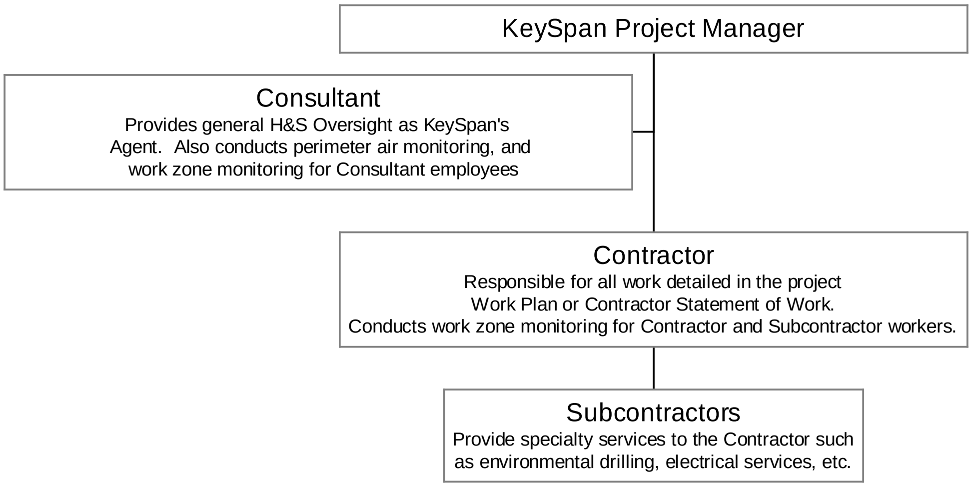
Appendix D Rusmar Foam Technology Technical Memorandum

(Electronic Version Only)

The following example Health and Safety Plan (HASP) is provided to KeySpan environmental contractors to aid in preparation of a Contractor/Subcontractor Site-Specific HASP. This document shall be used as a foundation for HASP development by a certified health and safety professional to meet the requirements of 29 CFR 1910 and 1926. It is the Contractor's responsibility to identify project specific hazards and mitigation methods to protect Contractor employees (and Subcontractor employees under Contractor direction), and to augment this example HASP as necessary to meet these requirements.

The format of the example HASP follows the average project structure utilized by KeySpan for remedial investigation, and remedial construction activities at KeySpan former Manufactured Gas Plant sites.

This structure is typically as follows:



Typical responsibilities are listed in Section 2.0 of the example HASP. The Contractor will confirm with the KeySpan Project Manager the exact structure to be utilized for this specific project.

The example HASP appendices provided are to demonstrate the level of detail KeySpan requires from its Contractors and Subcontractors. The Contractor is required to provide similar appendices to elaborate on key aspects of the Contractor's corporate health and safety program.

GENERIC HEALTH AND SAFETY PLAN (HASP)

Site(s):	**KEYSPAN CORPORATION BAY SHORE FORMER MANUFACTURED GAS PLANT (MGP) SITE AND ASSOCIATED OFF-SITE AREAS**
Location:	**BAY SHORE, NEW YORK**
Date Prepared:	**MARCH 2004**
Revision:	**0**
Project Description:	**Construction, Excavation, Trenching, Soil and Groundwater Sampling**
Waste types:	Impacted Soils and Groundwater
Characteristics:	Volatile, Toxic
Unusual Site Features:	None
Status:	Industrial (Off-site areas are residential)
Background Review:	Site Investigations have been performed
Overall Hazard:	Low

KEYSPAN CORPORATION, KEYSPAN CORPORATION CONTRACTORS AND SUBCONTRACTORS DO NOT GUARANTEE THE HEALTH OR SAFETY OF ANY PERSON ENTERING THIS SITE. DUE TO THE NATURE OF THIS SITE AND THE ACTIVITY OCCURRING THEREON, IT IS NOT POSSIBLE TO DISCOVER, EVALUATE, AND PROVIDE PROTECTION FOR ALL POSSIBLE HAZARDS THAT MAY BE ENCOUNTERED. STRICT ADHERENCE TO THE HEALTH AND SAFETY GUIDELINES SET FORTH HEREIN WILL REDUCE, BUT NOT ELIMINATE, THE POTENTIAL FOR INJURY AT THIS SITE. THE HEALTH AND SAFETY GUIDANCE IN THIS PLAN WAS PREPARED TO SERVE AS AN EXAMPLE TO POTENTIAL CONTRACTORS AND SUBCONTRACTORS THAT MAY WORK AT THIS SITE AND SHOULD NOT BE USED ON ANY SPECIFIC PROJECT WITHOUT PRIOR RESEARCH AND EVALUATION BY TRAINED HEALTH AND SAFETY SPECIALISTS.

CONTRACTOR APPROVALS

By their signature, the undersigned hereby certify that this HASP has been reviewed and approved for use at the KeySpan Corporation (KeySpan) Bay Shore, New York site.

PROJECT MANAGER	DATE
PROJECT ENVIRONMENTAL HEALTH AND SAFETY MANAGER	DATE

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1.0 INTRODUCTION

1.1 Purpose

This Health and Safety Plan (HASP) addresses the health and safety practices that will be employed by workers participating in investigation and remediation activities at the site that are under the direction of **CONSULTANT**. This work will be performed at the KeySpan Corporation (KeySpan) Former Manufactured Gas Plant (MGP) Bay Shore, NY site (Site). The HASP takes into account the specific hazards inherent to the Site, and presents procedures to be followed by **CONSULTANT**, **CONTRACTOR**, **SUBCONTRACTORS**, and all site visitors in order to avoid and if necessary, protect against health and/or safety hazards. Activities performed under this HASP will comply with applicable parts of OSHA Regulations, primarily 29 CFR Parts 1910 and 1926 and attached KeySpan policies and procedures. A copy this HASP will be maintained on-site for the duration of work.

All workers who may participate in activities at the Site that are under the direction of **CONSULTANT** are required to comply with the provisions specified in this HASP. All site visitors who enter designated work zones must also comply with this HASP. Refusal or failure to comply with the HASP or violation of any safety procedures by field personnel and/or subcontractors performing work covered by this HASP may result in immediate removal from the site following consultation with **CONTRACTOR**.

1.2 Scope

This HASP has been developed to address the health and safety concerns during site investigation and remedial actions at the Site that are under the direction of **CONSULTANT**. Although the HASP addresses all activities listed below, work at the individual locations may include all, or only some of these tasks.

The HASP addresses the following activities:

Mobilization/Demobilization
- Mobilization/Demobilization of Equipment and Supplies
- Establishment of Site Security, Work Zones and Staging Areas

Pre Construction, Excavation, and Trenching Activities
- Locate All Utilities to and from the Site
- Locate All Active Utility Lines on Site

Construction Activities

- Utility Connections (Water, Sewer, Electrical)
- Excavation and Trenching (see Excavation and Trenching Activities)

Excavation and Trenching Activities

- Excavate Overburden Material
- Stockpile and Segregate Overburden Material
- Confined Space Entry/Trench Box Use
- Dewater Excavation
- Trenching
- Break Lines
- Cut, Fill and Cap Lines
- Backfill Excavation
- Site Restoration

Other Remediation Activities

- Installation of Injection Wells
- Injection of Chemical Oxidants
- Operation and Maintenance Tasks

Soil and Groundwater Sampling Activities

- Soil Borings and Soil Sampling
- Monitoring Well Installation, Development, and Sampling

1.3 Application

The HASP applies to all personnel involved in the above tasks, that are under the direction of **CONSULTANT**, who wish to gain access to active work areas, including but not limited to:

- KeySpan representatives, contractors, and subcontractors performing tasks under the direction of the **CONSULTANT;**
- Federal, State or local representatives;
- **CONSULTANT** Employees; and
- **CONSULTANT** Subcontractors.

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

This section specifies the **CONTRACTOR** Project Organization.

2.1 Project Manager (PM)

The Project Manager is ______________________. The PM responsibilities include the following:

- Ensures implementation of this program;
- Conducts periodic inspections;
- Participates in incident investigations;
- Ensures the HASP has all of the required approvals before any site work is conducted;
- Ensures that the Site Manager is informed of project changes which require modifications of the site safety plan; and
- Has overall project responsibility for Project Health and Safety.

2.2 Site Manager (SM)

The Site Manager is ________________________. The SM responsibilities include the following:

- Ensures that the HASP is implemented and that all health and safety activities identified in site safety plans are conducted and/or implemented;
- Ensures that field work is scheduled with adequate personnel and equipment resources to complete the job safely and enforce site health and safety rules;
- Ensures that adequate communication between field crews and emergency response personnel is maintained;
- Ensures that field site personnel are adequately trained and qualified to work at the site and that proper personal protective equipment is utilized by field teams;
- Investigate and report all accidents/incidents to the PM;
- Conducts and documents daily safety briefings;
- Stop work if necessary;
- Acts as the primary point of contact with KeySpan for site related activities and coordination with non-project related site operations;
- Identifies operational changes which require modifications to health and safety procedures and site safety plans, and ensures that the procedure modifications are implemented and documented through changes to the HASP, with CESM approval;
- Direct and coordinate health and safety monitoring activities;
- Determines upgrades or downgrades of personal protective equipment (PPE) based on site conditions and/or real-time monitoring results;
- Ensures that monitoring instruments are calibrated; and
- Reports to the CESM to provide summaries of field operations and progress.

2.3 Corporate Environmental and Safety Manager (CESM)

The CESM is an individual certified by the American Board of Industrial Hygiene as a Certified Industrial Hygienist (CIH) or by the Board of Certified Safety Professionals as a Certified Safety Professional (CSP) with experience in hazardous waste site remediation activities. The CESM is ______________________________. The CESM responsibilities include the following:

- Provides for the development and approval of the HASP;
- Serves as the primary contact to review health and safety matters that may arise;
- Approves revised or new safety protocols for field operations;
- Coordinates revisions of this HASP with field personnel;
- Coordinates upgrading or downgrading of personal protective equipment with the SM; and
- Assists in the investigation of all accidents/incidents;

2.4 Site Supervisor

The Site Supervisor is ______________________________. The Site Supervisor responsibilities include the following:

- Provide for the necessary training of field crews in accordance with OSHA regulations and provides proof of training to the SM prior to entering the site;
- Conduct routine safety inspections of their work areas;
- Conduct incident investigations and together with the SM, prepares appropriate reports;
- Enforces health and safety rules and compliance with the HASP; and
- Plans field work using appropriate safe procedures and equipment.

2.5 Site Personnel

The Site Personnel responsibilities include the following:

- Report any unsafe or potentially hazardous conditions to the SM;
- Maintain knowledge of the information, instructions and emergency response actions contained in the HASP;
- Comply with rules, regulations and procedures as set forth in this HASP and any revisions;
- Prevent admittance to work sites by unauthorized personnel; and
- Inspect all tools and equipment, including PPE, prior to use.

3.0 SITE HISTORY AND PROJECT DESCRIPTION

3.1 Location

The KeySpan Bay Shore Site is located in Suffolk County, Long Island, within the State of New York. See the Site-Specific Information provided in Appendix A for the Site Location Map.

3.2 Background and Site Description

The Bay Shore MGP opened as a gas plant in 1889 under the ownership of the Mutual Gas and Light Company. The Suffolk Gas and Electric Light Company owned and operated the site from 1889 to 1917. In 1918, the Long Island Lighting Company (LILCO) became the legal owner. Gas manufacturing occurred at the site between 1889 and approximately 1973. The plant was demolished in the mid-1970's. In 1918, LILCO began operating a carbureted water gas MGP. Later in the life of the plant, it was converted to an oil-gas MGP. Manufacturing operations were conducted on the Bay Shore Property, while the Brightwaters Yard was used to support gas manufacturing and distribution operations. Further description of the site history can be found in the Final Remedial Investigation Report for the Bay Shore/Brightwaters Former MGP Site (January 2003).

In an effort to manage the remediation of the Bay Shore/Brightwaters former MGP site, the site has been divided into four operable units (OUs), including:

- **Operable Unit 1** - Bay Shore Site, Bay Shore West Parcel and Adjacent Off-site Areas north of Union Boulevard.
- **Operable Unit 2** - Bay Shore Site Groundwater Plume.
- **Operable Unit 3** - Brightwaters Yard and Groundwater Plume.
- **Operable Unit 4** - Watchogue Creek/Crum's Brook.

The geographic boundaries of each operable unit are shown on Figures provided in Appendix A. Work covered by this HASP may be performed within or near any of these operable units.

4.0 POTENTIAL HAZARDS AT THE SITE

This section presents an assessment of the chemical, biological, and physical hazards that may be encountered during the tasks specified under HASP Section 1.2. A Hazard Communication Program is included in Appendix B. The Hazard Communication Program describes procedures for: 1) determining chemical hazards, 2) providing training on chemical hazards, 3) and transmitting chemical hazard information.

4.1 Properties of Chemical Contamination

The characteristics of compounds at the Site are discussed below for information purposes. Adherence to the safety and health guidelines in this HASP should reduce the potential for exposure to the compounds discussed below. Extensive analytical testing has been done within each Site OU and known chemical hazards within each OU are different so personnel should familiarize themselves with the know hazards of each area. Table 4-1 presents chemical data regarding exposure and monitoring for the chemical types listed below.

Polyaromatic hydrocarbons (PAHs) are present at the Site in impacted soil and groundwater and as a dense nonaqueous phase liquid (DNAPL) by-product of gas production. These compounds generally have a depressant effect on the central nervous system (CNS), may cause chronic liver and kidney damage, and some are suspected human carcinogens. Acute exposure may include headache, dizziness, nausea, and skin and eye irritation.

Volatile organic chemicals (VOCs), such as benzene, toluene, ethyl benzene, and xylene (BTEX) may be present as soil and groundwater contaminants and in some cases as free product in abandoned pipelines. These compounds generally have a depressant effect on the CNS, may cause chronic liver and kidney damage, and some are suspected human carcinogens. Benzene is a known human carcinogen. Acute exposure may include headache, dizziness, nausea, and skin and eye irritation.

Polychlorinated Biphenyls (PCBs) have also been detected at the Site in certain areas. The primary routes of exposure for PCBs are inhalation, absorption, ingestion, and contact. This compound causes eye irritation, liver damage and an acne-like skin rash (chloracne).

The Site potentially contains elevated levels of lead and arsenic. The primary routes of this exposure for these compounds are inhalation and ingestion. Exposure to lead may cause acute symptoms such as eye irritation, weakness, weight loss, abdominal pain, and anemia. Chronic exposure to lead may result in kidney disease, effects to the reproductive system, blood forming organs, and CNS. Acute exposure to arsenic may cause dermatitis, GI disturbances and respiratory irritation. Chronic exposure to arsenic has resulted in lung cancer in humans.

The Site potentially contains asbestos containing materials (ACM) in the forms of ACM pipe insulation and asbestos cement pipe. The primary route of exposure for asbestos is inhalation. Chronic exposure to asbestos may cause asbestosis and mesothelioma.

Cyanide compounds are common by-products of manufactured gas production. Analysis of soils from the Site did not indicate elevated levels of cyanides.

4.1.1 Other Chemical Hazards

Chemicals not identified in this HASP may be used during investigation and remediation activities. Prior to the initiation of these tasks, Material Safety Data Sheets will be obtained for each of the chemicals to be used and all site workers and visitors who may potentially be exposed will be made aware of these hazards.

If the CESM determines that monitoring will be required to determine if these chemicals are potentially migrating off-site, a monitoring program will be established that is consistent with the provisions stated in Section 7.

4.2 Biological Hazards

During the course of the project, there is a potential for workers to come into contact with biological hazards such as animals, insects and plants. Workers will be instructed in hazard recognition, health hazards, and control measures during site-specific training.

4.2.1 Animals

During the conduct of site operations, wild animals such as stray dogs or cats, raccoons, and mice may be encountered. Workers shall use discretion and avoid all contact with wild animals. If these animals present a problem, efforts will be made to remove these animals from the site by contacting a licensed animal control technician.

4.2.2 Insects

Insects, including bees, wasps, hornets, and spiders, may be present at the Site making the chance of a bite possible. Some individuals may have a severe allergic reaction to an insect bite or sting that can result in a life threatening condition; any individuals who have been bitten or stung by an insect should notify the SM. The following is a list of preventive measures:

- Apply insect repellent prior to performing any field work and as often as needed throughout the work shift.
- Wear proper protective clothing (work boots, socks and light colored pants).
- When walking in wooded areas, avoid contact with bushes, tall grass, or brush as much as possible.
- Field personnel who may have insect allergies shall have bee sting allergy medication on site and should provide this information to the SM prior to commencing work.

Table 4-1
Chemical Data

Compound	CAS #	ACGIH TLV	OSHA PEL	Route of Exposure	Symptoms of Exposure	Target Organs	Physical Data
Benzene	71-43-2	0.5 ppm (skin)	1 ppm TWA 5 ppm STEL	Inhalation Skin Absorption Ingestion Skin Contact	Irrit eyes, skin, nose, resp system, nausea; potential carcinogen	Eyes, skin, CNS, bone marrow, blood	FP: 12° F IP: 9.24 eV LEL: 1.2% UEL: 7.8% VP: 75 mm
Ethylbenzene	100-41-4	100 ppm	100 ppm	Inhalation Ingestion Skin Contact	Eye, skin, mucous membrane irritation; headache; dermatitis, narcosis; coma	Eyes, skin, respiratory system, CNS	FP: 55° F IP: 8.76 eV LEL: 0.8% UEL: 6.7% VP: 7 mm
Toluene	108-88-3	50 ppm	200 ppm	Inhalation Skin Absorption Ingestion Skin Contact	Eye, nose irritation; fatigue, weakness, confusion, euphoria, dizziness, headache; dilated pupils, lacrimation; nervousness, muscle fatigue, insomnia, tingling in limbs; dermatitis	Eyes, skin, resp system, CNS, liver, kidneys	FP: 40° F IP: 8.82 eV LEL: 1.1% UEL: 7.1% VP: 21 mm
Xylene	1330-20-7	100 ppm	100 ppm	Inhalation Skin Absorption Ingestion Skin Contact	Eye, skin, nose, throat irritation; dizziness, excitement, drowsiness; incoordination, staggering gait; corneal damage; appetite loss, nausea, vomiting, abdominal pain; dermatitis	Eyes, skin, resp system	FP: 90° F IP: 8.56 eV LEL: 0.9% UEL: 6.7% VP: 9 mm
Arsenic	7440-38-2	0.01 mg/m^3	0.01 mg/m^3	Inhalation Skin Absorption Ingestion Skin Contact	Ulceration of nasal septum, derm, GI disturbances, peripheral neuropathy, resp irrt, hyperpig of skin, potential carcinogen	Liver, kidneys, skin, lungs, lymphatic system	Metal: Silver-gray or tin-white, brittle, odorless solid FP: NA IP: NA LEL: NA UEL: NA VP: 0 mm
Asbestos	1332-21-4	0.1 f/cc	0.1 f/cc	Inhalation Ingestion Skin Contact	Asbestosis (chronic exposure); mesothelioma, breathing difficulty, interstital fibrosis' restricted pulmonary function, finger clubbing; irritate eyes	Respiratory system, eyes	White, greenish, blue, or gray-green fibrous solids FP: NA IP: NA LEL: NA UEL NA VP: 0 mm

Table 4-1
Chemical Data

Compound	CAS #	ACGIH TLV	OSHA PEL	Route of Exposure	Symptoms of Exposure	Target Organs	Physical Data
Lead	7439-92-1	0.050 mg/m^3	0.05 mg/m^3	Inhalation Ingestion Skin Contact	Weak, lass, insom; facial pallor; pal eye, anor, low-wgt, malnut; constip, abdom pain, colic; anemia; gingival lead line; tremor; para wrist, ankles; irrit eyes	Eyes, GI tract, CNS, kidneys, blood, gingival tissue	A heavy, ductile, soft, gray solid. FP: NA IP: NA LEL: NA UEL: NA VP: 0 mm
PAH's as Coal tar pitch Volatiles (CTPV)	65996-93-2	0.2 mg/m3	0.2 mg/m3	Inhalation Skin contact Ingestion	Irritant to eyes, swelling, acne contact dermatitis, chronic bronchitis	Respiratory system, CNS, liver, kidneys, skin, bladder, carc	Black or dark brown amorphous residue.
PCBs	11097-69-1	0.5 mg/m^3 (Skin)	0.5 mg/m^3 (Skin)	Inhalation Skin Absorption Ingestion Skin Contact	Irritate eyes; chloracne; liver damage;	Skin, eyes, liver, reproductive system	Colorless liquid or solid with a mild, hydro-carbon odor VP = 0.00006 mm
Hydrogen cyanide	74-90-8	4.7 ppm (5 mg/m^3) STEL [skin]	10 ppm (11 mg/m^3) [skin]	Inhalation Ingestion Absorption Skin/Eye Contact	Asphyxia; weakness, headache, confusion; nausea, vomiting; increased rate and depth of respiration or respiration slow and gasping; thyroid, blood changes	CNS, CVS, thyroid, blood	Colorless or pale-blue liquid or gas (above 78°F) with a bitter, almond-like odor. VP: 630 mmHg IP: 13.60 eV
Hydrogen sulfide	7783-06-4	10 ppm TWA, 15 ppm STEL	20 ppm C, 50 ppm [10-min. Maximum peak]	Inhalation Skin/Eye Contact	Irritation eyes, respiratory system; apnea, coma, convulsions; conjunctivitis, eye pain, lacrimation (discharge of tears), photophobia (abnormal visual intolerance to light), corneal vesiculation; dizziness, headache, fatigue, irritability, insomnia; gastrointestinal disturbance; liquid: frostbite	Eyes, respiratory system, CNS	Colorless gas with a strong odor of rotten eggs. VP: 17.6 atm IP: 10.46 eV

Abbreviations

C = ceiling limit, not to be exceeded	LEL = Lower explosive limit

Table 4-1
Chemical Data

Compound	CAS #	ACGIH TLV	OSHA PEL	Route of Exposure	Symptoms of Exposure	Target Organs	Physical Data

CNS = Central Nervous System	mm = millimeter
CVS = Cardiovascular System	ppm = parts per million
eV = electron volt	Skin = significant route of exposure
FP = Flash point	STEL = Short-term exposure limit (15 minutes)
IP = Ionization Potential	TWA = Time-weighted average (8 hours)
GI = Gastro-intestinal	UEL = Upper explosive limit
	VP = vapor pressure approximately 68° F in mm Hg (mercury)

4.2.2.1 Lyme Disease

Lyme disease is caused by infection from a deer tick that carries a spirochete. During the painless tick bite, the spirochete may be transmitted into the bloodstream that could lead to the worker contracting Lyme disease.

Lyme disease may cause a variety of medical conditions including arthritis, which can be treated successfully if the symptoms are recognized early and medical attention is received. Treatment with antibodies has been successful in preventing more serious symptoms from developing. Early signs may include a flu-like illness, an expanding skin rash and joint pain. If left untreated, Lyme disease can cause serious nerve or heart problems as well as a disabling type of arthritis.

Symptoms can include a stiff neck, chills, fever, sore throat, headache, fatigue and joint pain. This flu-like illness is out of season, commonly happening between May and October when ticks are most active. A large expanding skin rash usually develops around the area of the bite. More than one rash may occur. The rash may feel hot to the touch and may be painful. Rashes vary in size, shape, and color, but often look like a red ring with a clear center. The outer edges expand in size. It's easy to miss the rash and the connection between the rash and a tick bite. The rash develops from three days to as long as a month after the tick bite. Almost one third of those with Lyme disease never get the rash.

Joint or muscle pain may be an early sign of Lyme disease. These aches and pains may be easy to confuse with the pain that comes with other types of arthritis. However, unlike many other types of arthritis, this pain seems to move or travel from joint to joint.

Lyme disease can affect the nervous system. Symptoms include stiff neck, severe headache, and fatigue usually linked to meningitis. Symptoms may also include pain and drooping of the muscles on the face, called Bell's Palsy. Lyme disease may also mimic symptoms of multiple sclerosis or other types of paralysis.

The disease can also cause serious but reversible heart problems, such as irregular heartbeat. Finally, Lyme disease can result in a disabling, chronic type of arthritis that most often affects the knees. Treatment is more difficult and less successful in later stages. Often, the effects of Lyme disease may be confused with other medical problems.

It is recommended that personnel check themselves when in areas that could harbor deer ticks, wear light color clothing and visually check themselves and their buddy when coming from wooded or vegetated areas. If a tick is found biting an individual, the SM should be contacted immediately. The tick can be removed by pulling gently at the head with tweezers. The affected area should then be disinfected with an antiseptic wipe. The employee will be offered the option for medical treatment by a physician, which typically involves prophylactic antibiotics. If personnel feel sick or have signs similar to those above, they should notify the SM immediately.

4.2.3 Plants

The potential for contact with poisonous plants exists when performing field work in undeveloped and wooded areas. Poison ivy, sumac, and oak may be present on site. Poison ivy can be found as vines on tree trunks or as upright bushes. Poison ivy consists of three leaflets with notched edges. Two leaflets form a pair on opposite sides of the stalk, and the third leaflet stands by itself at the tip. Poison ivy is red in the early spring and turns shiny green later in the spring. Poison sumac can be present in the form of a flat-topped shrub or tree. It has fern-like leaves, which are velvety dark green on top and pale underneath. The branches of immature trees have a velvety "down." Poison sumac has white, "hairy" berry clusters. Poison oak can be present as a sparingly branched shrub. Poison oak is similar to poison ivy in that it has the same leaflet configuration, however, the leaves have slightly deeper notches. Prophylactic application of Tecnu may prevent the occurrence of exposure symptoms. Post exposure over the counter products are available and should be identified at the local pharmacist. Susceptible individuals should be identified by the SM.

Contact with poison ivy, sumac, or oak may lead to a skin rash, characterized by reddened, itchy, blistering skin which needs first aid treatment. If you believe you have contacted one of these plants, immediately wash skin thoroughly with soap and water, taking care not to touch your face or other body parts.

4.3 Physical Hazards

Physical hazards will be addressed as necessary. More detailed safety procedures are provided as appendices where applicable.

4.3.1 Cold Stress

At certain times of the year, workers may be exposed to the hazards of working in cold environments. Potential hazards in cold environments include frostbite, trench foot or immersion foot, hypothermia as well as slippery surfaces, brittle equipment, poor judgment and unauthorized procedural changes. The procedures to be followed are found in Appendix C, the Cold Stress Program.

4.3.2 Heat Stress

Heat stress is a significant potential hazard, which is greatly exacerbated with the use of PPE in hot environments. The potential hazards of working in hot environments include dehydration, cramps, heat rash, heat exhaustion, and heat stroke. A heat stress prevention program will be implemented when ambient temperatures exceed 70ºF for personnel wearing impermeable clothing. The procedures to be followed are found in Appendix D, the Heat Stress Program.

4.3.3 Noise

Noise is a potential hazard associated with the operation of heavy equipment, power tools, pumps and generators. Site workers who will perform suspected high noise tasks and operations for short durations (less than 1-hour) will be provided with earplugs. If deemed necessary by the SM, the CESM will be consulted on the need for additional hearing protection and the need to monitor sound levels for site activities.

4.3.4 Hand and Power Tools

In order to complete the various tasks for the project, personnel will utilize hand and power tools. The use of hand and power tools can present a variety of hazards, including physical harm from being struck by flying objects, being cut or struck by the tool, fire, and electrocution. Work gloves, safety glasses, and hard hats will be worn by the operating personnel at all times when utilizing hand and power tools and GFI-equipped circuits will be used for all power tools.

4.3.5 Slips, Trips, and Falls

Working in and around the site will pose slip, trip and fall hazards due to slippery surfaces that may be oil covered, or from surfaces that are wet from rain or ice. Excavation at the sites will cause uneven footing in the trenches and around the spoil piles.

4.3.6 Fire and Explosion

When conducting excavating activities, the opportunity of encountering fire and explosion hazards exists from contamination in the soil and the possibility of free product in the underground pipelines. This will be especially hazardous when pipelines are sawed or broken to grout the ends. Additionally, the use of a diesel engine on excavating equipment could present the possibility of encountering fire and explosion hazards.

4.3.7 Manual Lifting

Manual lifting of heavy objects such as sections of pipe may be required. Failure to follow proper lifting technique can result in back injuries and strains. Site workers will be instructed to use power equipment to lift heavy loads when ever possible and to evaluate loads before trying to lift them (i.e. they should be able to easily tip the load and then return it to its original position). Carrying heavy loads with a buddy and proper lifting techniques, 1) make sure footing is solid, 2) make back straight with no curving or slouching, 3) center body over feet, 4) grasp the object firmly and as close to your body as possible, 5) lift with legs, and 6) turn with your feet, don't twist, will be stressed. Back injuries are a serious concern as they are the most common workplace injury, often resulting in lost or restricted work time, and long treatment and recovery periods. In addition, hand digging for pipes may present lifting/ergonomic hazards.

4.3.8 Steam, Heat, Splashing

Exposure to steam/heat/splashing hazards can occur during steam cleaning activities. Exposure to steam/heat/splashing can result in scalding/burns, eye injury, and puncture wounds. Proper PPE will be worn during all steam cleaning activities including rain gear or tyvek, hardhat equipped with splashguard, and water resistant gloves and boots.

5.0 PROCESS SAFETY MANAGEMENT

Process Safety Management is a systematic way of identifying the potential health and safety hazards associated with major phases of work on the project and the methods to avoid, control and mitigate those hazards. Process Safety Management Program guidance can be found in Appendix E. Process Safety Management guidelines will be developed for all activities as necessary, prior to start-up. Process Safety Management will be used to train work crews in proper safety procedures during phase preparatory meetings.

Mobilization/Demobilization

- Mobilization/Demobilization of Equipment and Supplies
- Establishment of Site Security, Work Zones and Staging Areas

Pre Construction, Excavation, and Trenching Activities

- Locate All Utilities to and from the Site
- Locate All Active Utility Lines on Site

Construction Activities

- Utility Connections (Water, Sewer, Electrical)
- Excavation and Trenching (see Excavation and Trenching Activities

Excavation and Trenching Activities

- Excavate Overburden Material
- Stockpile and Segregate Overburden Material
- Confined Space Entry/Trench Box Use
- Dewater Excavation
- Trenching
- Break Lines
- Cut, Fill and Cap Lines
- Backfill Excavation
- Site Restoration

Other Remediation Activities

- Installation of Injection Wells
- Injection of Chemical Oxidants
- Operation and Maintenance Tasks

Soil and Groundwater Sampling Activities

- Soil Borings and Soil Sampling
- Monitoring Well Installation, Development, and Sampling

6.0 PERSONAL PROTECTIVE EQUIPMENT

The personal protective equipment (PPE) specified in Table 6-1 represents the hazard analysis and PPE selection required by 29 CFR 1910.132. Specific information on the selection rationale for each activity can be found under Section 4.0 and Appendix F - Personal Protective Equipment (PPE): Selection and Use. For the purposes of PPE selection, the CESM and SM (if they have completed the 8-hour OSHA Site Supervisor Training) are considered competent persons. The signatures on the front of the HASP constitute certification of the hazard assessment. For activities not covered by Table 6-1, the SM will conduct the hazard assessment and select the PPE using the information provided in Appendix F. PPE selection will be made in consultation with the CESM.

Modifications for initial PPE selection may also be made by the SM in consultation with the CESM using the same form. A written justification for major downgrades will be provided to the CESM for approval on a field change request form.

Table 6-1 describes the anticipated task-specific PPE.

6.1 PPE Abbreviations

HEAD PROTECTION HH = Hard Hat HEARING PROTECTION EP = ear plugs EM = ear muffs	EYE/FACE PROTECTION APR = Full Face Air Purifying Respirator MFS = Mesh Face shield PFS =Plastic Face shield SG = ANSI approved safety glasses with side shields	FOOT PROTECTION Neo = Neoprene OB = Overboot Poly = polyethylene coated boot Rub = rubber slush boots STB = Leather work boots with steel toe.
HAND PROTECTION Cot = cotton But = Butyl LWG = Leather Work Gloves Neo = Neoprene Nit = Nitrile Sur = Surgical Nit Sur - Nitrile Surgical	BODY PROTECTION Cot Cov = Cotton Coveralls Poly = Polyethylene coated tyvek coveralls Saran = Saranex coated tyvek coveralls Tyvek = Uncoated paper tyvek coveralls WC = Work clothes	RESPIRATORY PROTECTION Level D = No respiratory protection required Level C = Full face air purifying respirator with approved cartridges Level B = Full face air supplied respirator with escape bottle

TABLE 6-1

PERSONAL PROTECTIVE EQUIPMENT SELECTION

TASK	HEAD	EYE/FACE	FEET	HANDS	BODY	HEARING	RESPIRATOR
Mobilization/Demobilization							
Mobilization/ demobilization of equipment and supplies	HH	SG	STB	LWG as needed	WC	EP as needed	Level D
Establishment of site security, work zones and staging area	HH	SG	STB	LWG as needed	WC	EP as needed	Level D
Pre Construction, Excavation, and Trenching Activities							
Locate all utilities to and from the site	HH	SG	STB	LWG as needed	WC	EP as needed	Level D
Locate all active utility lines on site	HH	SG	STB	LWG as needed	WC	EP as needed	Level D
Construction Activities							
Utility Connections	HH	SG	STB	LWG as needed	WC	EP as needed	Level D
Excavation and Trenching Activities							
Excavate overburden material	HH	SG, APR as needed	STB, OB	Nit Sur, LWG	WC, tyvek or Poly as needed	EP as needed	Level D initially, Level C as needed
Segregate overburden material	HH	SG, APR as needed	STB, OB	Nit Sur, LWG	WC, tyvek or Poly as needed	EP as needed	Level D initially, Level C as needed
Confined space entry/ trench box use	HH	SG, APR as needed	STB, OB	Nit Sur, LWG	WC, tyvek or Poly as needed	EP as needed	Level D initially, Level C as needed
Dewater excavation	HH	SG, APR as needed	STB, OB	Nit Sur, LWG	WC, tyvek or Poly as needed	EP as needed	Level D initially, Level C as needed

TASK	HEAD	EYE/FACE	FEET	HANDS	BODY	HEARING	RESPIRATOR
Break lines	HH	SG, APR as needed	STB, OB	Nit Sur, LWG	WC, tyvek or Poly as needed	EP as needed	Level D initially, Level C as needed
Cut, fill and cap lines	HH	SG, APR as needed	STB, OB	Nit Sur, LWG	WC, tyvek or Poly as needed	EP as needed	Level D initially, Level C as needed
Backfill excavation	HH	SG	STB, OB	LWG as needed	WC, tyvek or Poly as needed	EP as needed	Level D
Trenching	HH	SG	STB STB + OB for entry	LWG Nit + Sur for entry	WC WC + Tyvek for entry	EP or EM Note: EM may not be worn over hardhat liner	As required based upon real-time monitoring results as compared to action levels in Table 7-2.
Site Restoration	HH	SG	STB	LWG as needed	WC	EP as needed	Level D
Heavy equipment decontamination	HH	SG, PFS	STB, OB	Sur, Nit	WC, Poly	EP as needed	Level D
Other Remediation Activities							
Installation of Injection Wells	HH	SG	STB	Nit Sur, LWG	WC	EP as needed	Level D
Injection of Chemical Oxidants	HH	SG	STB	Nit Sur, LWG, need for additional gloves will be evaluated	WC	EP as needed	Level D
Operation and Maintenance Task	HH	SG	STB	Nit Sur, LWG	WC	EP as needed	Level D
Soil and Groundwater Sampling Activities							
Soil Borings and Soil Sampling	HH	SG	STB	Nit Sur, LWG	WC	EP as needed	Level D
Monitoring Well Installation, Development, and Sampling	HH	SG	STB	Nit Sur, LWG	WC	EP as needed	Level D

6.2 OSHA Requirements for Personal Protective Equipment

All personal protective equipment used during the course of this field investigation must meet the following OSHA standards:

Type of Protection	Regulation	Source
Eye and Face	29 CFR 1910.133	ANSI Z87.1-1968
Respiratory	29 CFR 1910.134	ANSI Z88.1-1980
Head	29 CFR 1910.135	ANSI Z89.1-1969
Foot	29 CFR 1910.136	ANSI Z41.1-1967

ANSI = American National Standards Institute

Any on-site personnel who have the potential to don a respirator must have a valid fit test certification and documentation of medical clearance. The CESM will maintain such information on file for **CONTRACTOR** personnel. The SM will obtain such information from the subcontractor's site supervisor prior to the initiation of any such work. Both the respirator and cartridges specified for use in Level C protection must be fit-tested prior to use in accordance with OSHA regulations (29 CFR 1910.1025; 29 CFR 1910.134). Air purifying respirators cannot be worn under the following conditions:

- Oxygen deficiency;
- IDLH concentrations; and
- If contaminant levels exceed designated use concentrations.

SECTION 7.0 - MONITORING

7.1 Monitoring Requirements

Environmental Health and Safety Monitoring will be performed by ______________ in accordance with this section.

7.1.1 On-site Monitoring

The following monitoring instruments will be available for use during field operation as necessary:

- Photoionization Detector (PID), Photovac Microtip with 10.6 eV lamp or equivalent; or
- Flame Ionization Detector (FID), Foxboro OVA model 128 or equivalent; and
- Dust Meter, MIE Miniram model PDM-3 or equivalent; and
- Combustible Gas Indicator (CGI)/Oxygen (O2) / H2S / HCN meter, MSA model 361 or equivalent; and
- Sound Level Meter if deemed necessary by the SM and CESM, type to be appropriate to the activities performed.

All air monitoring equipment will be calibrated and maintained in accordance with manufacturer's requirements and the Monitoring Instruments: Use, Care, and Calibration program included in Appendix G.

Organic vapor concentrations shall be measured using the PID and/or FID during excavating and other intrusive activities. During intrusive operations, organic vapor concentrations shall be measured continuously; during other activities, readings shall be taken at least once every hour. Organic vapor concentrations shall be measured upwind of the work site(s) to determine background concentrations at least twice a day, (once in the morning and once in the afternoon). The SM will interpret monitoring results using professional judgment.

A dust meter shall be used to measure airborne particulate matter during intrusive activities. Monitoring will be continuous and readings will be averaged over a 15-minute period for comparison with the action levels. Monitoring personnel will make a best effort to collect dust monitoring data from downwind of the intrusive activity. If off-site sources are considered to be the source of the measured dust, upwind readings will also be collected.

A CGI/O2 meter shall be used to monitor for combustible gases and oxygen content in the trenches and surrounding areas and elsewhere as necessary. The CGI will also be equipped with a hydrogen sulfide sensor and hydrogen cyanide sensor. H2S monitoring will be completed every fifteen minutes, or if a sulfur odor is present, monitoring will be continuous. HCN monitoring will be completed every fifteen minutes, or if an almond odor is detected, monitoring will be continuous.

All trenches will be monitored before entry at the beginning of each shift.

Guidelines have been established by the National Institute for Occupational Safety and Health (NIOSH) concerning the action levels for work in a potentially explosive environment. These guidelines are as follows: 10% LEL- Limit all activities to those which do not generate sparks, 20% LEL- Cease all activities in order to allow time for the combustible gases to vent.

TABLE 7-1

REAL TIME AIR MONITORING ACTION LEVELS

Air Monitoring Instrument	Monitoring Location	Action Level	Site Action	Reason
PID/FID	Breathing Zone	0.5 ppm	Use detector tube for benzene	1/2 of PEL for benzene
PID/FID	Breathing Zone	0 - 10 ppm	No respiratory protection is required	
		10 - 250 ppm	Level C	
		> 250 ppm	Stop work, withdraw from work area; notify CESM	
Oxygen meter	Breathing Zone	< 19.5%	Stop work; withdraw from work area; notify CESM.	Low oxygen
		> 22%	Stop work; withdraw from work area; notify CESM.	Oxygen enriched atmosphere; explosion hazard
H2S meter	Breathing Zone	<5 ppm	No respiratory protection is required	
		>5 ppm	Stop work, cover excavation, notify CESM	
HCN meter	Breathing Zone	<2.5 ppm	No respiratory protection is required	
		>2.5 ppm	Stop work, cover excavation, notify CESM	
CGI	Excavation	< 10 % LEL	Investigate possible causes, allow excavation to ventilate; use caution during procedures.	Increasing potential for ignition of vapors
		> 10% LEL	Stop work; allow excavation, borehole to ventilate to < 10% LEL; if ventilation does not result in a decrease to < 10% LEL, withdraw from work area; notify CESM.	Potential for ignition of vapors
Dust Meter	Excavation	> 1.5 mg/m^3	Implement work practices to reduce/minimize airborne dust generation, e.g., spray/misting of soil with water	Potential inhalation source for airborne contaminants adhering to dust
		> 2.5 mg/m^3	Upgrade to Level C PPE	1/2 PEL for respirable dust

7.2 Community Air Monitoring Plan

This community air monitoring plan has been designed to conform with the guidelines presented by the New York State Department of Health in Appendix 1A of the Draft New York State Department of Conservation DER-10 Technical Guidance for Site Investigation and Remediation. Real-time air monitoring for volatile compounds at the perimeter of the exclusion zone will be conducted. If particulates become a concern at the site, possibly as a result of excavating activities or wind erosion of soils, this community plan will be modified accordingly. Contaminants on-site are not anticipated to pose a problem as particulates because of the anticipated high moisture content of the soil during field activities. The following procedures will be implemented during field activities as appropriate:

- Volatile organic compounds will be monitored at the downwind perimeter of the exclusion zone on a continuous basis. If 15-minute average total organic vapor levels exceed 5 ppm (or 5 ppm above background as determined at an upwind location), excavating activities will be temporarily halted and monitoring continued until total organic vapor levels drop below the action level. If the organic vapor level is above 25 ppm at the perimeter of the exclusion area, activities must be shut down. Monitoring will continue and the CESM will be consulted regarding a proper course of action. All 15-minute average readings must be recorded and be available for regulatory personnel to review.

- Particulates will become a concern if visible dust emissions occur from site investigation activities or wind erosion or if intrusive activities are performed. When particulates become a concern, the following protocol will be followed. PM10 particulate levels will be continuously monitored downwind at the perimeter of the exclusion zone with a portable real-time PM10 particulate monitor that will have an alarm set at 100 ug/m3. If downwind particulate levels integrated over a period of 15 minutes exceed 100 ug/m3, then particulate levels upwind of the exclusion zone will be measured. If the downwind particulate level is more than 100 ug/m3 greater than the upwind particulate level, dust suppression techniques (e.g. spraying water, covering exposed soils with poly sheeting) will be employed. If after implementation of dust suppression techniques, the downwind PM10 particulate level exceeds the upwind PM10 particulate level by greater than 150 ug/m3, activities will be halted and the CESM will be consulted. All readings will be recorded and be available for regulatory personnel to review. These action levels can be modified if particulates are better characterized and identified.

7.2.1 Vapor Emission Response Plan

If the ambient air concentration of organic vapors exceeds 5 ppm above background levels at the perimeter of the exclusion zone, excavating activities will cease and monitoring continued. If the organic vapor level decreases below 5 ppm (above background), excavating activities may resume. If the organic vapor levels are greater than 5 ppm, but less than 5 ppm over background at the perimeter of the work area, activities may resume provided:

- The organic vapor level 200 feet downwind of the exclusion zone or half the distance to

the nearest residence or commercial structure, whichever is less, is below 5 ppm over background, and
- More frequent intervals of monitoring, as directed by the SM in consultation with the CESM, are conducted.

If the organic vapor level is above 5 ppm over background at the perimeter of the exclusion zone, work activities will halt and odor control contingencies will be implemented. Exposed soils will be covered with poly sheeting or a biodegradable, surfactant-based foam concentrate, will then be sprayed onto the excavated soils to control the fugitive vapors. When work shutdown occurs, downwind air monitoring will be implemented to ensure that vapor emissions do not impact the nearest residential or commercial structure.

If organic vapor levels greater than 5 ppm over background are identified 200 feet downwind from the exclusion zone, or half the distance to the nearest residential or commercial property line, whichever is less, all work must cease. Following cessation of work activities and implementation of odor control contingencies, if organic vapor levels persist above 5 ppm above background 200 feet downwind or half the distance to the nearest residential or commercial property from the exclusion zone, then air quality must be monitored within 20 feet of the perimeter of the nearest residential/commercial structure (the “20 foot zone”).

If organic vapor levels approach 5 ppm above background within the “20 foot zone” for a period of more than 30 minutes, or organic vapor levels greater than 10 ppm above background for any time period occur within the “20 foot zone”, then the following steps will be taken:

- Frequent air monitoring will be conducted at 30-minute intervals within the 20-foot zone. If two successive readings below action levels are measured, air monitoring within the 20 foot zone may be halted and the perimeter reduced back to the exclusion zone perimeter, or as determined by the SM.

7.3 Data Quality Assurance

7.3.1 Calibration

Instrument calibration shall be documented and included in a dedicated safety and health logbook or on separate calibration pages. All instruments shall be calibrated before and after each shift. Calibration checks may be used during the day to confirm instrument accuracy. Duplicate readings may be taken to confirm individual instrument response.

7.3.2 Operations

All instruments shall be operated in accordance with the manufacturer's specifications. Manufacturers' literature, including an operations manual for each piece of monitoring equipment will be maintained on-site by the SM for reference.

7.4 Noise Monitoring

Work areas or tasks that pose an exposure risk greater than 85 dBA will require hearing protection. If there is a reasonable possibility that workers may be exposed to an 8-hour time-weighted average exceeding 85 dBA, noise monitoring will be conducted.

8.0 ZONES, PROTECTION, AND COMMUNICATION

8.1 Site Control

Site zones are intended to control the potential spread of contamination and to assure that only authorized individuals are permitted into potentially hazardous areas. A three-zone approach will be utilized. It shall include an Exclusion Zone (EZ), Contamination Reduction Zone (CRZ) and a Support Zone (SZ). Specific zones shall be established on the work site when operations begin for each task requiring such delineation (i.e. construction, excavation, trenching in impacted areas of the site). Maps will be available at the Site and used during initial site-specific training.

This project is being conducted under the requirements of 29 CFR 1910.120, and any personnel working in an area where the potential for exposure to site contaminants exists, will only be allowed access after proper training and medical documentation as required by KeySpan. These records are maintained by the CESM, and copies are provided to the SM prior to mobilization for project activities.

The following shall be used for guidance in revising these preliminary zone designations, if necessary.

Support Zone - The SZ is an uncontaminated area that will be the field support area for most operations. The SZ provides for field team communications and staging for emergency response. Appropriate sanitary facilities and safety equipment will be located in this zone. Potentially contaminated personnel/materials are not allowed in this zone. The only exception will be appropriately packaged/decontaminated and labeled samples.

Contamination Reduction Zone - The CRZ is established between the EZ and the SZ. The CRZ contains the contamination reduction corridor and provides an area for decontamination of personnel and portable hand-held equipment, tools and heavy equipment. A personnel decontamination area will be prepared at each exclusion zone. The CRZ will be used for Exclusion Zone entry and egress in addition to access for heavy equipment and emergency support services.

Exclusion Zone - All activities which may involve exposure to site contaminants, hazardous materials and/or conditions should be considered an exclusion zone. This zone will be clearly delineated by cones, tapes or other means. The SM may establish more than one EZ where different levels of protection may be employed or different hazards exist. The size of the EZ shall be determined by the site SM allowing adequate space for the activity to be completed, field members and emergency equipment.

8.2 Contamination Control

8.2.1 Personnel Decontamination Station

Personnel hygiene, coupled with diligent decontamination, will significantly reduce the potential for exposure.

8.2.2 Minimization of Contact With Contaminants

During completion of all site activities, personnel should attempt to minimize the degree of contact with contaminated materials. This involves a conscientious effort to keep "clean" during site activities. All personnel should minimize kneeling, splash generation, and other physical contact with contamination. This may ultimately minimize the degree of decontamination required and the generation of waste materials from site operations.

Field procedures will be developed to control over spray and runoff and to ensure that unprotected personnel working nearby are not affected.

8.2.3 Personnel Decontamination Sequence

Consideration will be given to prevailing wind directions so that the decontamination line, the support zone, and contamination reduction zone exit is upwind from the exclusion zone and the first station of the decontamination line. Decontamination will be performed by removing all PPE used in EZ and placing in drums/trash cans at CRZ. Baby wipes shall be available for wiping hands and face.

8.2.4 Emergency Decontamination

If circumstances dictate that contaminated clothing cannot be readily removed, then remove gross contamination, wrap injured personnel with clean garments/blankets to avoid contaminating other personnel or transporting equipment.

If the injured person can be moved, he/she will be moved to the exclusion zone boundary and decontaminated by site personnel as described above before emergency responders handle the victim. If the person cannot be moved because of the extent of the injury (a back or neck injury) provisions shall be made to ensure that emergency response personnel will be able to respond to victim without being exposed to potentially hazardous atmospheric conditions. If the potential for inhalation hazards exist, such as with open excavation, this area will be covered with poly to eliminate any potential inhalation hazards. All emergency personnel are to be immediately informed of the injured person's condition, potential contaminants, and provided with all pertinent chemical data.

8.2.5 Hand Held Equipment Decontamination

Hand held equipment includes all monitoring instruments, samples, hand tools, and notebooks. The hand held equipment is dropped at the first decontamination station to be decontaminated by one of the decontamination team members. These items must be decontaminated or discarded as waste prior to removal from the exclusion zone.

To aid in decontamination, monitoring instruments can be sealed in plastic bags or wrapped in polyethylene. This will also protect the instruments against contaminants. The instruments will be wiped clean using wipes or paper towels if contamination is visually evident.

Decontamination procedures for sampling equipment, hand tools, etc., shall include the use of steam cleaning or a detergent wash, as appropriate for the site conditions.

8.2.6 Heavy Equipment Decontamination

Decontamination of chemically contaminated heavy equipment will be accomplished using high -pressure steam or dry decon with brushes and shovels. Decontamination shall take place on a decontamination pad and all liquids used in the decontamination procedure will be collected. Vehicles or equipment brought into an exclusion zone will be treated as contaminated, and will be decontaminated prior to removal. All liquids used in the decontamination procedure will be collected, stored and disposed of in accordance with federal, state and local regulations. Personnel performing this task will wear the proper PPE as prescribed in Table 6-1.

8.3 Communications

The following communications equipment shall be specified as appropriate:

- Telephones - A cellular telephone will be located in the SZ for communication with emergency support services/facilities and the home office. Personnel in the EZ can carry cellular telephones for communication as well if Level D PPE has been determined to be appropriate.
- Hand Signals - Hand signals shall be used by field teams along with the buddy system. They shall be known by the entire field team before operations commence and their use covered during site-specific training. Typical hand signals are the following:

Signal	Meaning
Hand gripping throat	Out of air, can't breathe
Grip on a partner's wrist or placement of both hands around a partner's waist	Leave area immediately, no debate
Hands on top of head	Need assistance
Thumbs up	Okay, I'm all right, I understand.
Thumbs down	No, negative.

9.0 MEDICAL SURVEILLANCE PROCEDURES

All personnel performing field work where potential exposure to contaminants exists at the site are required to have passed a complete medical surveillance examination in accordance with 29 CFR 1910.120(f) and, where applicable, expanded health standards.

9.1 Medical Surveillance Requirements

A physician's medical release for work will be confirmed by the SM before a worker can enter the exclusion zone. The examination will be taken annually at a minimum and upon termination of hazardous waste site work if the last examination was not taken within the previous six months. Additional medical testing may be required by the CESM in consultation with the SM if an over-exposure or accident occurs, if an employee exhibits symptoms of exposure, or if other site conditions warrant further medical surveillance.

10.0 SAFETY CONSIDERATIONS

10.1 High Loss Potential Hazards

Activities to be conducted at the site may involve operations that have the potential for a serious injury to occur, to included the following:

- Lockout/Tagout
- Heavy Equipment Operation
- Excavation and Trenching
- Confined Space Entry
- Line Breaking

10.1.1 Lockout-Tagout

Site personnel will assume that all electrical equipment at surface and overhead locations is energized, until the equipment has been designated as de-energized by a KeySpan representative. If the equipment cannot de-energized, work will stop and the SM will consult with the PM and CESM. **CONTRACTOR** will notify KeySpan prior to working adjacent to this equipment, and will verify that the equipment is energized or de-energized in the vicinity of the excavation location. The Control of Hazardous Energy Program "Lock Out/Tag Out" is included in Appendix H.

All power lines which have been indicated by KeySpan to be de-energized must be locked out, such that the lines cannot be energized when personnel are working near them. The lines shall not be unlocked and re-energized until **CONTRACTOR** notifies KeySpan that they have completed work in the area and that all personnel are clear of the area. KeySpan representatives will thoroughly familiarize **CONTRACTOR** personnel with site-specific lockout/tagout procedures during the site orientation. The lockout procedures must be equivalent in effectiveness to those found in Appendix H.

If power lines cannot be de-energized, the SM will consult with Long Island Power Authority (LIPA) safety personnel to determine the safe working distance from the energized line. Work tasks will only commence after determination that a safe working distance can be maintained and all personnel working in the area have been informed of the limitation.

10.1.3 Heavy Equipment Operation

Heavy equipment will be operated under the following conditions:

- The operation of heavy equipment will be limited to authorized personnel specifically trained in its operation. The subcontractor site supervisors must provide this information to the SM.
- The operator will use the safety devices provided with the equipment, including seat belts. Backup warning indicates and horns will be operable at all times.
- While in operation, all personnel not directly required in the area will keep a safe distance from the equipment.

- Personnel directly involved in activity will avoid moving in the path of operating equipment or any portion thereof. Areas blinded from the operator's vision will be avoided. Spotters will be used when personnel may be in areas where the operator's view is obstructed.
- Additional riders will not be allowed on equipment unless it is specifically designed for that purpose.

10.1.4 Excavation and Trenching

The safety requirements for each excavation must be determined by a competent person who is capable of identifying existing and predictable hazards and work conditions that are unsanitary, hazardous, or dangerous to employees. The competent person must also have the authorization to take prompt corrective measures to eliminate unsatisfactory conditions.

The following are general requirements for work activities in and around excavations:

- Prior to initiation of any excavation activity, the location of underground installations will be determined. The New York State one-call center will be contacted by the excavation subcontractor a minimum of 72 hours prior to excavation activities.
- All excavations will be inspected daily by the competent person prior to commencement of work activities. Evidence of cave-ins, slides, sloughing, or surface cracks or excavations will be cause for work to cease until necessary precautions are taken to safeguard employees.
- Excavated and other materials or equipment that could fall or roll into the excavation shall be placed at least 5 feet from the edge of the excavation.

10.1.5 Confined Space Entry

All trenches and excavations deeper than five feet will be considered potential Permit Required Confined Spaces. All trenches deeper than 5 feet will be monitored for oxygen content, combustible gases, and toxic gases and vapors if entry is required. All trenches which contain hazardous atmospheres at concentrations above the action levels found in Table 7-1 will be classified as Permit Required Confined Spaces. All entry into these trenches will be performed in accordance with the Confined Space/Hot Work Permitting Procedure which is found in Appendix I.

10.1.6 Line Breaking

During line breaking activities, the potential exists for exposure to suspect asbestos containing materials (ACM). If suspect ACM is encountered, work will stop and will not resume until involved personnel have been upgraded to gray tyvek and Level C respiratory protection, and water is available to keep the work area and the suspect ACM wetted. Workers are to have completed asbestos awareness training prior to working with suspect ACM. The PM and CESM are to be notified if suspect ACM is encountered.

11.0 DISPOSAL PROCEDURES

All discarded materials, waste materials or other objects shall be handled in such a way as to preclude the potential for spreading contamination, creating a sanitary hazard or causing litter to be left on site. All potentially contaminated materials, e.g., clothing, gloves, etc., will be bagged or drummed as necessary, labeled and segregated for disposal. All non-contaminated materials shall be collected and bagged for appropriate disposal as non-hazardous solid waste. The waste management procedures as specified in the Field Sampling Plan and the applicable work plan for activities being performed, shall be complied with.

12.0 EMERGENCY RESPONSE / CONTINGENCY PLAN

This section establishes procedures and provides information for use during a project emergency. Emergencies happen unexpectedly and quickly, and require an immediate response; therefore, contingency planning and advanced training of staff are essential. Specific elements of emergency support procedures which are addressed in the following subsections include communications, local emergency support units, preparation for medical emergencies, first aid for injuries incurred on-site, record keeping, and emergency site evacuation procedures.

12.1 Responsibilities

12.1.1 Corporate Environmental and Safety Manager (CESM)

The CESM oversees and approves the Emergency Response/Contingency Plan and performs audits to determine that the plan is in effect and that all pre-emergency requirements are met. The CESM acts as a liaison to applicable regulatory agencies and notifies OSHA of reportable accidents.

12.1.2 Site Manager (SM)

The SM is responsible for ensuring that all personnel are evacuated safely and that machinery and processes are shut down or stabilized in the event of a stop work order or evacuation. The SM is required to immediately notify the PM and CESM of any fatalities or catastrophes (three or more workers injured and hospitalized) so that the CESM can notify OSHA within the required time frame. The CESM will be notified of all OSHA recordable injuries, fires, spills, releases or equipment damage in excess of $500 within 24 hours. The SM also serves as the Alternate Emergency Coordinator.

12.1.3 Emergency Coordinator

In the event of an emergency, the Emergency Coordinator, with KeySpan representatives, shall make contact with Local Emergency Response personnel. In these contacts, the Emergency Coordinator will inform response personnel about the nature of work on the Site, the type of contaminants and associated health or safety effects, and the nature of the emergency, particularly if it is related to exposure to contaminants.

The Emergency Coordinator shall review this plan and verify emergency phone numbers and identify hospital routes prior to beginning work on Site. The Emergency Coordinator shall make necessary arrangements to be prepared for any emergencies that could occur.

The Emergency Coordinator shall implement the Emergency Response/Contingency Plan whenever conditions at the Site warrant such action.

12.1.4 Site Personnel

Site personnel are responsible for knowing the Emergency Response/Contingency Plan and the procedures contained herein. Personnel are expected to notify the Emergency Coordinator of situations that could constitute a Site emergency.

12.2 Communications

A variety of communication systems may be utilized during emergency situations. These are discussed in the following sections.

The primary form of communication during an emergency between field groups in the exclusion zone and the Emergency Coordinator will be verbal communications. During an emergency situation, the lines will be kept clear so that instructions can be received by all field teams.

12.2.1 Telephone Communications

A cellular telephone will be available on-site.

12.2.2 Hand Signals

Hand signals will be employed by downrange field teams where necessary for communication during emergency situations. Hand signals are found in Section 8.3.

12.3 Pre-Emergency Planning

Before the field activities begin, the local emergency response personnel may be notified by KeySpan of the schedule for field activities and about the materials that are thought to exist on the site so that they will be able to respond quickly and effectively in the event of a fire, explosion, or other emergency.

In order to be able to deal with any emergency that might occur during remedial activities at the Site, emergency telephone numbers will be readily available in the SM vehicle or Construction Office. These telephone numbers are presented in the Site Specific Appendix A to this Health and Safety Plan. Hospital route maps will also be readily available in the SM vehicle and/or Construction Office. The Emergency phone numbers listed are preliminary. Immediately prior to mobilization the SM shall verify all numbers, and document any changes in the Site Logbook.

12.4 Emergency Medical Treatment

The procedures and rules in this HASP are designed to prevent employee injury. However, should an injury occur, no matter how slight, it will be reported to the SM immediately. First-aid equipment will be available on-site.

During the site safety briefing, project personnel will be informed of the location of the first aid station(s) that have been set up. Unless they are in immediate danger, severely injured persons will not be moved until paramedics can attend to them. Some injuries, such as severe cuts and lacerations or burns, may require immediate treatment. Any first aid instructions that can be obtained from doctors or paramedics, before an emergency-response squad arrives at the site or before the injured person can be transported to the hospital, will be followed closely.

12.5 Emergency Site Evacuation Routes and Procedures

In the event of a Site Emergency that would require the evacuation of personnel, the Emergency Coordinator will immediately contact the project-specific dedicated KeySpan Corporation contact (this person may or may not be on-site).

All project personnel will be instructed on proper emergency response procedures and locations of emergency telephone numbers during the initial site safety meeting. If an emergency occurs at the work area, including but not limited to fire, explosion or significant release of toxic gas into the atmosphere, immediate evacuation of all personnel is necessary due to an immediate or impending danger. All heavy equipment will be shut down and all personnel will evacuate the work areas and assemble at a pre-determined location.

If any task covered under this HASP has the potential for significant hazards, evacuation drills will be performed as deemed necessary by the SM and CESM.

12.6 Fire Prevention and Protection

In the event of a fire or explosion, procedures will include immediately evacuating the work area, the Emergency Coordinator will immediately notify the local fire and police departments. No personnel will fight a fire beyond the stage where it can be put out with a portable extinguisher (incipient stage).

Fires will be prevented by adhering to the following precautions:

- Good housekeeping and storage of materials
- Storage of flammable liquids and gases away from oxidizers
- No smoking in the exclusion zone or any work area
- No hot work without a properly executed hot work permit
- Shutting off engines to refuel
- Grounding and bonding metal containers during transfer of flammable liquids
- Use of UL approved flammable storage cans
- Fire extinguishers rated at least 10 pounds ABC located on all heavy equipment, in all trailers and near all hot work activities
- Monthly inspections of all fire extinguishers

The person responsible for the maintenance of fire prevention and/or control equipment is the Site Supervisor. The person responsible for the control of fuel source hazards is the Site Manager.

12.7 Overt Chemical Exposure

The following are standard procedures to treat chemical exposures. Other, specific procedures detailed on the Material Safety Data Sheet will be followed as necessary. If first aid or emergency medical treatment is necessary the Emergency Coordinator will contact the appropriate emergency facilities.

SKIN AND EYE CONTACT:	Use copious amounts of soap and water. Wash/rinse affected areas thoroughly, then provide appropriate medical attention. Eyes should be rinsed for 15 minutes upon chemical contamination. Skin should also be rinsed for 15 minutes if contact with caustics, acids or hydrogen peroxide occurs.
INHALATION:	Move to fresh air. Decontaminate and transport to hospital or local medical provider.
INGESTION:	Decontaminate and transport to emergency medical facility.
PUNCTURE WOUND OR LACERATION:	Decontaminate and transport to emergency medical facility.

12.8 Decontamination During Medical Emergencies

If emergency life-saving first aid and/or medical treatment is required, normal decontamination procedures may need to be abbreviated or postponed. The SM or designee will accompany contaminated victims to the medical facility to advise on matters involving decontamination, when necessary. The outer garments can be removed if they do not cause delays, interfere with treatment or aggravate the problem. Respiratory equipment must always be removed. Protective clothing can be cut away. If the outer contaminated garments cannot be safely removed on site, a plastic barrier between the injured individual and clean surfaces should be used to help prevent contamination of the inside of ambulances and/or medical personnel. Outer garments may then be removed at the medical facility. No attempt will be made to wash or rinse the victim if his/her injuries are life threatening, unless it is known that the individual has been contaminated with an extremely toxic or corrosive material which could also cause severe injury or loss of life to emergency response personnel. For minor medical problems or injuries, the normal decontamination procedures will be followed.

12.9 Accident/Incident Reporting

Incident reporting will be done following the guidelines established in the Incident Reporting Program presented in Appendix J.

Written confirmation of verbal reports are to be submitted within 24 hours. The accident/incident report is found in Appendix J.

In addition to the incident reporting procedures and actions described in the HASP, the SM will coordinate with KeySpan relative to reporting and notification for all environmental, safety, and other incidents.

If necessary, a site safety briefing will be held to discuss accidents/incidents and any findings from the investigation of the incident. The HASP will be modified if deemed necessary by the CESM.

12.10 Adverse Weather Conditions

In the event of adverse weather conditions, the SM will determine if work can continue without potentially risking the safety of all field workers. Some of the items to be considered prior to determining if work should continue are:

- Potential for heat stress and heat-related injuries
- Potential for cold stress and cold-related injuries
- Treacherous weather-related working conditions (hail, rain, snow, ice, high winds)
- Limited visibility (fog)
- Potential for electrical storms
- Earthquakes
- Other major incidents

Site activities will be limited to daylight hours, or when suitable artificial light is provided, and acceptable weather conditions prevail. The SM will determine the need to cease field operations or observe daily weather reports and evacuate, if necessary, in case of severe inclement weather conditions.

12.11 Spill Control and Response

All small hazardous spills/environmental releases shall be contained as close to the source as possible. Whenever possible, the MSDS will be consulted to assist in determining the best means of containment and cleanup. For small spills, absorbent materials such as sand, sawdust or commercial sorbents should be placed directly on the substance to contain the spill and aid recovery. Any acid spills should be diluted or neutralized carefully prior to attempting recovery. Berms of earthen or sorbent materials can be used to contain the leading edge of the spills. Drains or drainage areas should be blocked. All spill containment materials will be properly disposed. An exclusion zone of 50-100 feet around the spill area should be established depending on the size and type of the spill.

The following steps should be taken by the Emergency Coordinator:

1. Determine the nature, identity and amounts of major spill components;
2. Make sure all unnecessary persons are removed from the spill area;
3. Notify appropriate response teams and authorities;
4. Use proper PPE in consultation with the SM;
5. If a flammable liquid, gas or vapor is involved, remove all ignition sources and use nonsparking and/or explosive proof equipment to contain or clean up the spill (diesel only vehicles, air operated pumps, etc.);
6. If possible, try to stop the leak with appropriate material; and,
7. Remove all surrounding materials that can react or compound with the spill.
8. Notify the Project-Specific KeySpan Corporation Dedicated Contact.

12.12 Emergency Equipment

The following minimum emergency equipment shall be kept and maintained on-site.

- Industrial first aid kit
- Portable eye washes
- Fire extinguishers (one per vehicle and heavy equipment)
- Absorbent material

12.13 Postings

The following information shall be posted or be readily visible and available at conspicuous locations throughout the site:

- Emergency telephone numbers
- Hospital Route Map

12.14 Restoration and Salvage

After an emergency, prompt restoration of utilities, fire protection equipment, medical supplies and other equipment will reduce the possibility of further losses. Some of the items that may need to be addressed are:

- Refilling fire extinguishers;
- Refilling medical supplies;
- Recharging eyewashes and/or showers
- Replenishing spill control supplies
- Replacing used air horns

13.0 TRAINING

13.1 General Health and Safety Training

In accordance with 29 CFR 1910.120, hazardous waste site workers shall, at the time of job assignment, have received a minimum of 40 hours of initial health and safety training for hazardous waste site operations unless otherwise noted in the above reference. At a minimum, the training shall have consisted of instruction in the topics outlined in the standard. Personnel who have not met the requirements for initial training shall not be allowed to work in any site activities in which they may be exposed to hazards (chemical or physical). Proof of training shall be submitted to the SM prior to the start of field activities.

13.2 Annual Eight-Hour Refresher Training

Annual eight-hour refresher training will be required of all hazardous waste site field personnel in order to maintain their qualifications for fieldwork. The training will cover a review of 29 CFR 1910.120 requirements and related company programs and procedures.

13.3 Supervisor Training

Personnel acting in a supervisory capacity shall have received 8 hours of instruction in addition to the initial 40 hours training.

13.4 Site-Specific Training

Prior to commencement of field activities, all field personnel assigned to the project will have completed training that will specifically address the activities, procedures, monitoring, and equipment used in the site operations. It will include site and facility layout, hazards and emergency services at the site and will highlight all provisions contained within this HASP. This training will also allow field workers to clarify anything they do not understand and to reinforce their responsibilities regarding safety and operations for their particular activity. Personnel that have not received site-specific training will not be allowed on-site.

13.5 On-Site Safety Briefings

Project personnel and visitors will be given health and safety briefings daily by the SM to assist site personnel in safely conducting their work activities. The briefings will include information on new operations to be conducted, changes in work practices or changes in the site's environmental conditions, as well as periodic reinforcement of previously discussed topics. The briefings will also provide a forum to facilitate conformance with safety requirements and to identify performance deficiencies related to safety during daily activities or as a result of safety inspections. The meetings will also be an opportunity to periodically update the crews on monitoring results.

13.6 First Aid and CPR

The SM will identify those individuals requiring first aid and CPR training in order to ensure that emergency medical treatment is available during field activities. The training will be consistent with the requirements of the American Red Cross Association and will include training on bloodborne pathogens.

13.7 Hazard Communication

Hazard communication training will be provided in accordance with the requirements contained in the Health and Safety Hazard Communication Program in Appendix B.

14.0 LOGS, REPORTS, AND RECORD KEEPING

The following is a summary of required health and safety logs, reports, and record keeping.

14.1 Medical and Training Records

Copies or verification of training (40 hour, 8 hour, supervisor, and site-specific training) and medical clearance for hazardous waste site work and respirator use will be maintained by the CESM and copies provided to the SM prior to the initiation of work on-site.

14.2 On-Site Log

A log of personnel on-site each day will be kept by the SM in a field logbook.

14.3 Exposure Records

All personal monitoring results, laboratory reports, calculations and air sampling data sheets will be maintained by the SM during site work. At the end of the project they may be maintained in employee files if deemed necessary by the CESM.

14.4 Accident/Incident Reports

The incident reporting and investigation during site work will follow the Incident Reporting Program in Appendix J.

14.5 OSHA Form 300

An OSHA Form 300 will be kept on-site by the SM. All recordable injuries or illnesses will be recorded on this form. The incident report form referenced in Section 12.11 meets the requirements of the OSHA Form 101(supplemental record) and must be maintained with the OSHA Form 300 for all recordable injuries or illnesses.

14.6 Hazard Communication Program/MSDS

Material Safety Data Sheets (MSDSs) will be obtained for applicable substances and included in the site hazard communication file. The hazard communication program will be maintained onsite in accordance with 29 CFR 1910.1200 and the Hazard Communication Program in Appendix B.

14.7 Work Permits

All work permits, including confined space entry, hot work, lockout/tagout, and line breaking permits will be maintained in the project files. Copies of the work permits shall also be provided to the SM, and the Project-Specific KeySpan Corporation Dedicated Contact.

15.0 FIELD PERSONNEL REVIEW

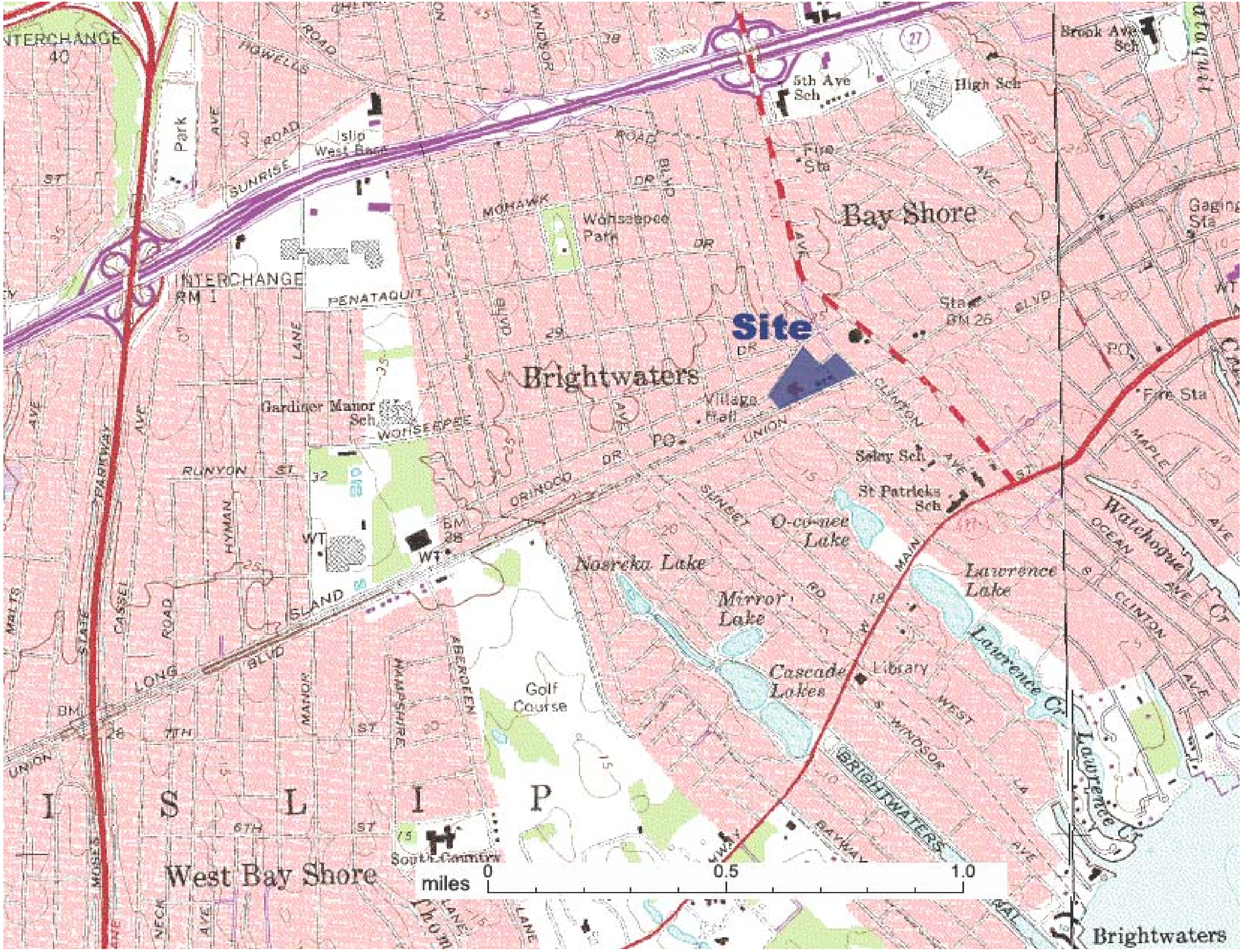
This form serves as documentation that field personnel have read, or have been informed of, and understand the provisions of this HASP for the Bay Shore Site. It is maintained on-site by the SM as a project record. Each field team member shall sign this section after training in the contents of this HASP has been completed. Site workers must sign this form after site-specific training is completed and before being permitted to work on-site.

I have read, or have been informed of, the Health and Safety Plan and understand the information presented. I have also completed site-specific training for the work detailed in the project Work Plan. I will comply with the provisions contained therein.

NAME (PRINT AND SIGN)	DATE

APPENDIX A

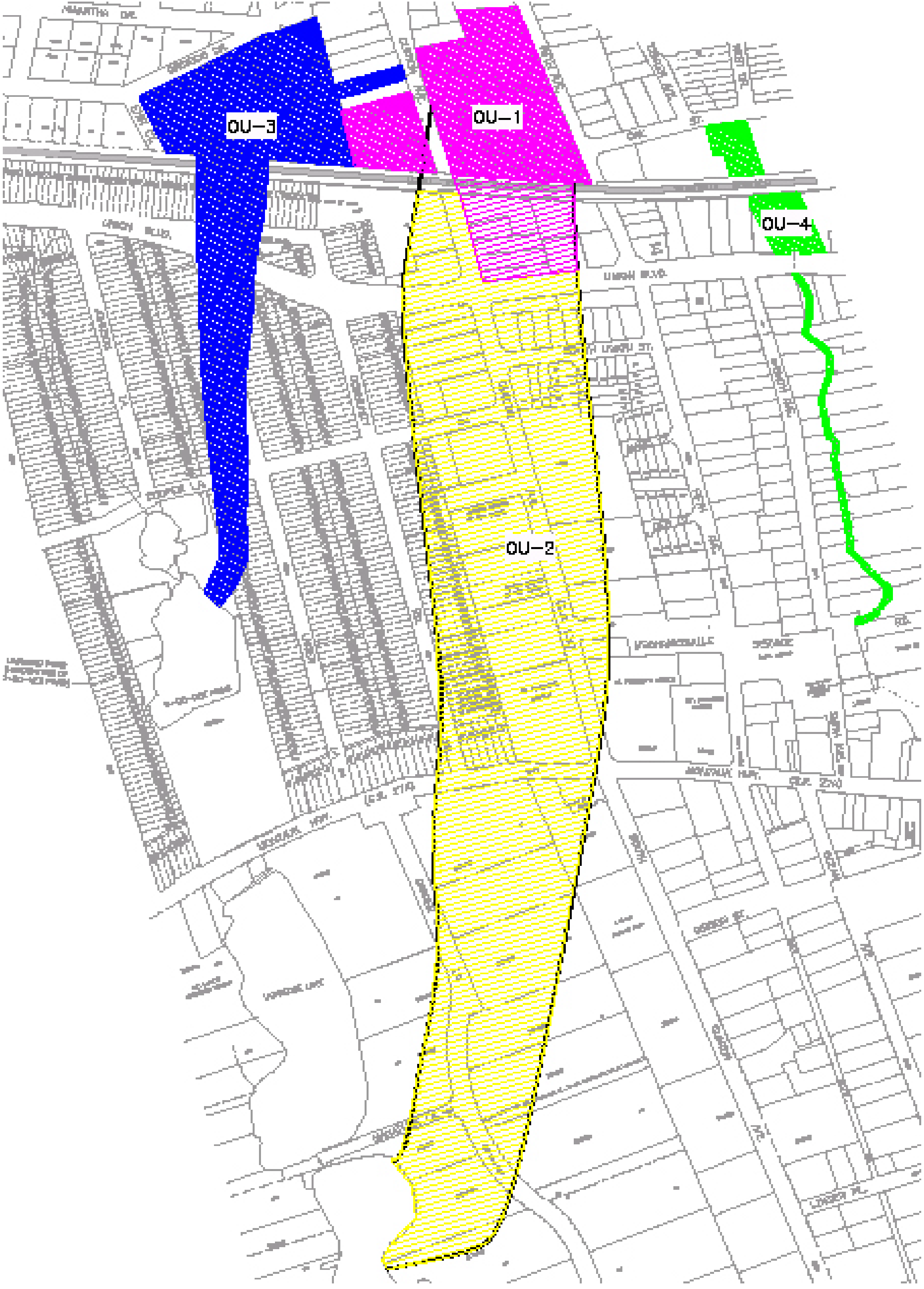
SITE SPECIFIC INFORMATION



SITE LOCATION MAP

BayShore / Brightwaters Former Manufactured Gas Plant

Bay Shore, New York



Site Plan with Operable Units

BayShore / Brightwaters Former Manufactured Gas Plant

Bay Shore, New York

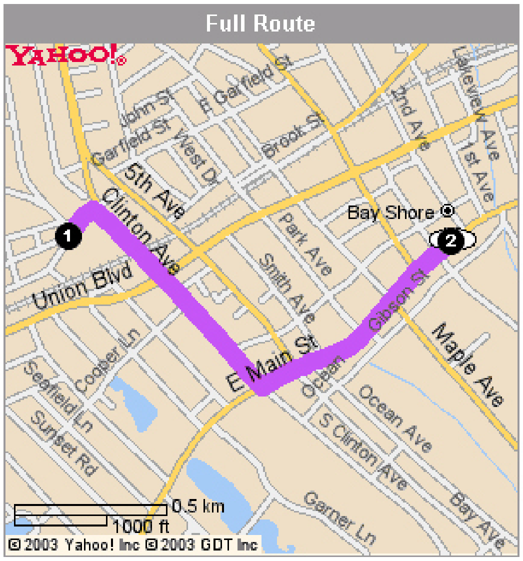
HOSPITAL MAP TO:
North Shore University Hospital - South Side
301 E. Main Street

BAY SHORE, NY 11706-8458

631-968-3000

Starting from:	❶ 1 orinoco drive, Bay Shore, NY 11706-7110		
Arriving at:	❷ 301 E. Main Street, Bay Shore, NY 11706-8408		
Distance:	1.1 miles	**Approximate Travel Time:**	1 mins

Full Route



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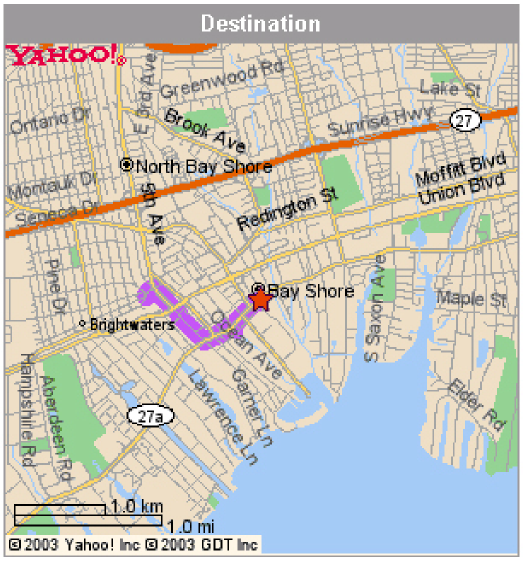
Destination



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Directions		Miles	
1.	Start on **ORINCO DR/ORINOCO DR**	0.0	↑
2.	Continue on **ORINOCO DR**	0.0	↑
3.	Continue on **ACKERSON ST**	0.0	↗
4.	Turn Right on **RAMP**	0.1	↱
5.	Continue on **CLINTON AVE**	0.4	↗
6.	Turn Left on **E MAIN ST**	0.5	↰

Distance: 1.1 miles **Approximate Travel Time:** 1 mins

APPENDIX B

HAZARD COMMUNICATION PROGRAM

1.0 INTRODUCTION

The intent of the Hazard Communication Program is to provide employees with information about the potential health hazards from exposure to workplace chemicals in accordance with the OSHA Hazard Communication Standard promulgated on August 24, 1987. In order to accomplish its goal of transmitting this information to its employees, a written hazard communication program specifying how this goal will be achieved has been formulated. This document represents **CONTRACTOR'S** Hazard Communication Program (HCP).

Employee participation is the key ingredient to the HCP. It is extremely important that employees not only follow the procedures, but also understand the reasoning. The Hazard Communication Program is an integral part of **CONTRACTOR'S** effort to provide its employees with a healthy and safe workplace.

Although most **CONTRACTOR** field projects do not involve the use of hazardous substances, it is imperative that all hazardous materials be managed in accordance with this program. This applies to any usage of hazardous materials regardless of volume.

2.0 PURPOSE

To make information available to employees concerning chemical hazards known to be present in the workplace under normal conditions, or in a foreseeable emergency.

3.0 SCOPE

This Hazard Communication Program (HCP) applies to any chemical obtained in excess of retail amounts known to be present in the workplace that employees may be exposed to under normal conditions of use, or may be exposed to in a foreseeable emergency. The HCP describes procedures for: determining chemical hazards in operations; providing training on chemical hazards to employees; and transmitting chemical hazard information through proper labeling and Material Safety Data Sheets (MSDSs). Field staff are responsible for keeping MSDSs for work performed at each job site.

4.0 RESPONSIBILITIES

The following individuals and groups are responsible for implementing the Hazard Communication Program (HCP).

1. Health and Safety Assessment Division

    a. Provide general training to all new and existing employees as appropriate under the HCP. This training will include hazardous material monitoring and recognition, emergency response and understanding labels.

    b. Maintain documentation for HCP training, inform division/section managers of annual training requirements.

    c. Periodically update and review Hazard Communication Program.

    d. Maintain file of current MSDSs and arrange for retention of all obsolete MSDSs.

    e. Review operations with division/section managers to determine what jobs require HCP training.

    f. Obtain all missing MSDSs.

    g. Audit job sites and work areas for compliance with the HCP.

    h. Annually audit chemical listing to ensure that the most current MSDSs are on file and maintain a complete chemical inventory of chemicals in use.

    i. Act as liaison to outside authorities responding to chemical emergencies or conducting inspections to verify compliance with the HCP.

2. Department/Section Manager

    a. Inventory and compile listing of chemicals used in Department/Section annually and each job site.

    b. Provide specific training as appropriate for Department/Section/Client location.

    c. Notify H&S Division of any changes in operations that could affect the way hazardous chemicals are handled.
    d. Identify all jobs requiring the use or handling of hazardous chemicals.

    e. Notify H&S Division of employees requiring hazard specific training.

    f. Notify H&S Division when new hazards are presented.

    g. Ensure proper labeling procedures and MSDS review is being followed.

3. Employee

    a. Follow HCP procedures.

    b. Use PPE as instructed by training procedures.

    c. Inform division/section manager or H&S Division of:

        - Any symptoms of overexposure that may be related to handling hazardous chemicals.

        - Missing or inappropriate labels.

- Missing or unavailable MSDSs.

- Malfunctioning or unavailable safety equipment.

- Read, understand and comply with information on labels and MSDSs.

- Leave labels affixed to containers.

- Use only approved containers for hazardous chemicals.

- Know the location of emergency equipment on site and in the facility (if applicable).

- Know your role in contingency plans.

- Understand all changes in chemical handling and procedures.

- Attend training sessions as scheduled.

4. Purchasing Department

   a. Request Material Safety Data Sheets (MSDS) from suppliers on each order of a chemical subject to this Program.

   b. Document the request for an MSDS on the purchase order.

5.0 TRAINING

1. General Training: Training on this program will be part of **CONTRACTOR** annual refresher training or supplied on an as-needed basis.

   General training will consist of the following items:

   a. Requirement of OSHA HCS (29 CFR 1910.1200)

   b. Details of **CONTRACTOR**'s HCP including:

      - Labeling
      - MSDSs
      - How employees can obtain and use appropriate hazard information.

   c. Detailed explanation on how to read and interpret an MSDS including:

      - Description

- Sections
- Explanations of each section
- Usefulness of each section
- Applicability of each section

2. Specific Training

a. Listing of hazardous materials in each department/location/site.

b. Location of MSDSs in each department/site.

c. Methods and observations to detect hazardous materials in the workplace, including:

- Exposure monitoring
- Continuous monitoring
- Visual inspection
- Odor
- Other physical or unusual appearances

d. Physical and health hazards of chemicals present in the workplace.

e. Protection measures and procedures:

- Appropriate work practices
- Emergency procedures
- PPE

f. Field operations where hazardous chemicals are present.

5.1 Nonroutine Tasks

CONTRACTOR typically uses low quantities of hazardous materials on job sites and in the laboratory. **CONTRACTOR** projects that involve large quantities of hazardous materials, extremely hazardous substances or exposure to a client's hazardous materials that are not on **CONTRACTOR**'s inventory are to be reviewed on a case by case basis to determine the necessary training to safely work with these materials. Clients regulated under the Process Safety Management program require affected employees to attend the Client's site-specific safety training program before being allowed access to the site. The **CONTRACTOR** Safety Department will provide training to employees when client training is not provided. All training will be documented and repeated as necessary. For example, **CONTRACTOR** does provide task specific training to DOT regulated employees for General Awareness, Shipping and Driving for workers involved in the shipping of hazardous materials and this training is provided every three years. Project Managers will notify the Safety Department when conducting non-routine tasks or when working with extremely hazardous substances in order to properly train employees before the project commences.

6.0 TRAINING DOCUMENTATION

a. Record names of attendee(s).
b. Request that employees initial by their names.
c. Complete training documentation form.
d. Submit copies to H&S Coordinator for employee training file.

7.0 MATERIAL SAFETY DATA SHEETS (MSDSs)

1. MSDS Requirements

   a. An MSDS must be available for each hazardous material used in the workplace. Field staff are responsible for keeping MSDSs for work performed at each job site. The Windsor MSDSs are located at the entrance to the laboratory where all chemicals are stored. Copies of MSDSs can be obtained by contacting the Safety Department. MSDSs for each office should be located near the area where hazardous materials are stored.

   b. The H&S Assessment Division will ensure that all MSDSs are complete, legible and in English. Employees that cannot read or understand English will be provided training as needed in a manner that the employee can understand.

   c. A file containing appropriate MSDSs for each **CONTRACTOR** facility will be readily available to all employees.

   d. A cover sheet will identify all MSDSs in the file – Appendix B.
   e. The H&S Assessment Division will audit the file.

   f. The Facility Manager will keep a master list of chemicals by department and listed alphabetically, by division.

   g. The H&S Assessment Division will distribute, to each department, new or updated MSDSs as they become available and make changes in the master list.

   h. Old MSDSs will remain on file permanently.

   i. MSDSs must be capable of being cross-referenced to their container labels, where appropriate.

   j. Where a process or group of hazardous chemicals presents a health hazard greater than or not indicated by the individual MSDSs, written operating procedures will also be provided or readily accessible. Standard operating procedures by the manufacturer, job descriptions, etc. may be useful for this information.

2. Procedure for Obtaining MSDSs

   a. The Purchasing Department will make an initial request for an MSDS from the manufacturer, either by phone, facsimile or mail. A copy of the request will be maintained with the name of the individual contacted and the date and included in the purchase order.

   b. Employees who are working at a manufacturing location should request a MSDS from the site contact for both raw materials and finished product.

   c. If MSDSs are not received within a reasonable time, approximately 30 days, the H&S Assessment Division or Facility Manager will send a second request to the manufacturer via certified mail, with a return receipt requested.

   d. If, after the second request, no MSDS is sent, the H&S Assessment Division will contact the appropriate local OSHA area office by telephone, informing them of **CONTRACTOR**'s inability to obtain an MSDS from the manufacturer.

   e. The H&S Assessment Division will document the following information: date; name; title of OSHA contact; and, summary of conversation.

   f. A copy of this information will be placed in the master file with the H&S Division for a 30-day period.

   g. If the MSDS is not received or OSHA does not contact the H&S Assessment Division within 30 days, H&S Assessment Division will contact the local OSHA area office again.

   h. If the MSDS is not received within 60 days, the H&S Assessment Division will contact the regional OSHA office.

3. Labeling

   a. All manufacturers' labels will be left on containers.

   b. All container labels will be legible, prominently displayed, and in English as well as any other prevalent language. **CONTRACTOR** will provide interpretation to employees who do not read or understand English when necessary.

   c. Minimum label contents include chemical identity; appropriate hazard warnings; and the name and address of the manufacturer.

   d. **CONTRACTOR** has generated a label for use when portable containers are poured off from the original container to a compatible unlabeled container for field, laboratory or facility use. This label should also be sued for samples and mixtures suspected of containing hazardous materials. The appropriate MSDS will be referenced in order to complete the "Hazard Warning" portion of the label and determine if the chemical is compatible with the container in which it is being stored.

e. **CONTRACTOR** uses the International Air Transport Association/Department of Transportation Hazard Classification System for labeling hazardous material shipments by **CONTRACTOR**. Each office that ships hazardous materials must obtain appropriate labels for the shipment and transport of hazardous materials.

4. Outside Contractors

a. Unless required by the nature of services to be provided, **CONTRACTOR** will attempt to restrict contractors from contact with hazardous chemicals on **CONTRACTOR** property or projects.

b. The Office Manager will notify the H&S Coordinator of all outside contractors on **CONTRACTOR** property or subcontracted to perform on **CONTRACTOR** projects.

c. The Project Manager will review the work and determine all hazardous chemicals to which the outside contractor's employees may be exposed.

d. The Project Manager will provide to the contractor a list of hazardous chemicals to which their employees may be exposed, and copies of corresponding MSDSs.

e. The Project Manager will inform the contractor of precautionary measures contained within the MSDS.

f. The Project Manager will inform the contractor of the labeling system used in the location of the contractor's work.

g. Records will be retained permanently with the H&S Coordinator.

References:

1. 29 CFR 1910.1200, Hazard Communication.

2. OSHA Instruction CPL 2-2.38A, CH-1, July 18, 1986.

3. ACGIH, Threshold Limit Values and Biological Exposure Indices for 1991-92, 1991.

4. Genium Publishing Corporation, MSDS Pocket Dictionary, August, 1988.

5. National Institute of Occupational Safety and Health, Pocket Guide to Chemical Hazards, June, 1990.

6. United States Department of Agriculture, Hazard Communication: A Program Guide for Federal Agencies; August, 1987.

APPENDIX C

COLD STRESS PROGRAM

1.0 PURPOSE & INTRODUCTION

The purpose of this document is to educate the employee about exposure to cold environments and the effects of hypothermia and other cold-related injuries. Through proper use of Personal Protective Equipment (PPE), engineering and administrative controls; and education, cold injury, both to the extremities and the body's core temperature, can be prevented.

2.0 SCOPE

This program is intended for use by employees engaged in work with the potential for exposure to cold environments. This program will be reviewed annually by the Health and Safety Division. Training will be provided annually to all those potentially affected, and will include this written program.

3.0 WORKING IN COLD ENVIRONMENTS

1. Metabolic Responses

The human body is designed to function best at a rectal temperature of 99-100F. The body maintains this temperature in two ways: by gaining heat from food and muscular work; or, by losing it through radiation and sweating. By constricting blood vessels of the skin and/or shivering, the body uses its first line of cold defense.

Temperature control of the body is better understood by dividing the body into two main parts: the shell; and, the core. The shell is comprised of the skin, capillaries, nerves, muscles and fat. Other internal organs such as the heart, lungs, brain and kidneys make up the core.

During exposure to cold, the skin is first affected. Blood in the peripheral capillaries is cooled, sending a signal to a portion of the brain called the hypothalamus. Regulating body temperature is one of the many basic body functions of the hypothalamus. Acting like a thermostat, adjustments are performed in order to maintain normal body temperatures. When a chill signal is received, two processes are begun by the hypothalamus: conserve heat already in the body; and, generate new heat.

Heat conservation is performed through constriction of the blood vessels in the skin (shell), thus reducing heat loss from the shell and acting as an insulator for the core. Sweat glands are also inhibited, thus preventing heat loss by evaporation.

Additional fuel for the body is provided in the form of glucose. Glucose causes the heart to beat faster, sending oxygen and glucose-rich blood to the tissue where needed. In an attempt to produce heat, the muscles rapidly contract. This process is better known as "shivering", and generates heat similarly to that created by strenuous activity, raising the body's metabolic rate.

During physical activity and fatigue, the body is more prone to heat loss. As exhaustion approaches, blood vessels can suddenly enlarge, resulting in rapid loss of heat. Exposure to extreme cold causes nerve pulses to be slowed, resulting in fumbling, sluggish and clumsy reactions.

4.0 COLD INJURIES

Cold injuries are classified into two categories: local; or, general. Local injuries include frostbite, frostnip, chilblain and trenchfoot. General injuries include hypothermia and blood vessel abnormalities (genetically or chemically induced). Major factors contributing to cold injury are exposure to humidity and high winds; contact with wetness or metal; inadequate clothing; age; and, general health. Allergies, vascular disease, excessive smoking and/or drinking, and certain drugs and medicines are physical conditions that can compound the effects of exposure to a cold environment.

1. Hypothermia

Hypothermia is a condition of reduced body temperature. Most cases develop in air temperatures between 30-50°F, not taking wind-chill factor in consideration.

Symptoms of hypothermia are uncontrolled shivering and the sensation of cold. The heartbeat slows and sometimes becomes irregular, weakening the pulse and changing blood pressure. Changes in the body chemistry cause severe shaking or rigid muscles; vague or slow slurred speech; memory lapses; incoherence; and, drowsiness. Cool skin, slow irregular breathing, low blood pressure, apparent exhaustion, and fatigue after rest can be seen before complete collapse.

As the core temperature drops, the victim can become listless, confused, and make little or no effort to keep warm. Pain in the extremities can be the first warning of dangerous exposure to cold. Severe shivering must be taken as a sign of danger. At a core body temperature of about 85°F, serious problems develop due to significant drops in blood pressure, pulse rate and respiration. In some cases, the victim may die.

Sedative drugs and alcohol increase the risk of hypothermia. Sedative drugs interfere with the transmission of impulses to the brain. Alcohol dilates blood vessels near the skin's surface, increasing heat loss and lowering body temperature.

Table I provides information on the onset of hypothermia and metabolic responses at different body temperatures.

2. Raynaud's Phenomenon

Raynaud's Phenomenon is the abnormal constriction of the blood vessels of the fingers on exposure to cold temperatures, resulting in blanching of the ends of the fingers. Numbness, itching, tingling or a burning sensation may occur during related attacks. The disease is also associated with the use of vibrating hand tools in a condition sometimes called White Finger Disease. Persistent cold sensitivity, ulceration and amputations can occur in severe cases.

3. Acrocyanosis

Acrocyanosis is caused by exposure to the cold and reduces the level of hemoglobin in the blood, resulting in a slightly blue, purple or gray coloring of the hands and/or feet.

4. <u>Thromboangitis Obliterans</u>

Thromboangitis obliterans is clotting of the arteries due to inflammation and fibrosis of connective tissue surrounding medium-sized arteries and veins. This is one of the many disabling diseases that can also result from tobacco use. Gangrene of the affected limb often requires amputation.

5. <u>Frostbite</u>

Frostbite is the freezing of the body tissues due to exposure to extremely low temperatures, resulting in damage to and loss of tissue. Frostbite occurs because of inadequate circulation and/or insulation, resulting in freezing of fluids around the cells of the body tissues. Most vulnerable parts of the body are the nose, cheeks, ears, fingers and toes.

Frostbite can affect outer layers of skin or can include the tissues beneath. Damage can be serious, with permanent loss of movement in the affected parts, scarring, necrotic tissue, and amputation are all possibilities. Skin and nails that slough off can grow back.

The freezing point of the skin is about 30F. As wind velocity increases, heat loss is greater and frostbite will set in more rapidly.

There are three (3) degrees of frostbite: first degree, freezing without blistering and peeling; second degree, freezing with blistering and peeling; and, third degree, freezing with death of skin tissues and possibly the deeper tissues.

The following are symptoms of frostbite:

a. Skin changes color to white or grayish-yellow, progresses to reddish-violet, and finally turns black as the tissue dies;

b. Pain may be felt at first, but subsides;

c. Blisters may appear;

d. Affected part is cold and numb.

The first symptom of frostbite is usually an uncomfortable sensation of coldness followed by numbness. Tingling, stinging, cramping and aching feelings will be experienced by the victim. Frostbite of the outer layer of the skin has a waxy or whitish look and is firm to the touch. Cases of deep frostbite cause severe injury. The tissues are cold, pale and solid. The victim is often unaware of the frostbite until someone else observes these symptoms. It is therefore important to use the "buddy system" when working in cold environments, so that any symptoms of overexposure can be noted.

Table II describes the cooling power of wind on exposed flesh. This information can be used as a guide for determining equivalent chill temperatures when the wind is present in cold environments.

6. Trench Foot and Chilblains

Trench foot is swelling of the foot caused by long, continuous exposure to cold without freezing, combined with persistent dampness or immersion in water. Edema (swelling), tingling, itching and severe pain occurs, followed by blistering, necrotic tissue and ulcerations. Chilblains have similar symptoms as trench foot, except that other areas of the body are affected.

7. Frostnip

Frostnip occurs when the face or extremities are exposed to a cold wind, causing the skin to turn white.

5.0 PREVENTION OF COLD STRESS

Cold Stress can be prevented through a combination of various factors: acclimation; water and salt displacement; medical screening, proper clothing selection; and, training and education. Through the use of engineering controls, work practices, work/rest schedules, environmental monitoring and consideration of the wind-chill temperature, the employee can be protected.

1. Acclimation

Acclimation can be achieved to some degree. Sufficient exposure to cold causes the body to undergo changes to increase comfort and reduce the risk of injury. But, these changes are minor and require repeated exposure to cold and uncomfortable temperatures to induce them.

2. Dehydration

The dryness of cold air causes the body to lose a significant amount of water through the skin and lungs. It is essential that caffeine-free, non-alcoholic beverages be available at the worksite for fluid replacement. Dehydration also increases the risk of injury due to cold and affects blood flow to the extremities.

3. Diet

A well-balanced diet is important for employees working in cold environments. Diets restricted only to certain foods may not provide the necessary elements for the body to withstand cold stress, leaving the worker vulnerable.

4. Control Measures

When the windchill factor results in an equivalent temperature of -26F, continuous exposure of the skin will not be permitted. Any worker exposed to temperatures of 36F or less who becomes immersed in water will be given dry clothing immediately and treated for hypothermia at the local hospital if any symptoms of hyperthermia are present. Notification of this incident will be provided to the Health and Safety Division immediately after sending the worker to the hospital.

5. Engineering Controls

The following are some ways that environmental controls can be used to reduce the effects of a cold environment:

a. General or spot heating should be used to increase temperature in certain areas in the workplace;

b. Warm air jets, radiant heaters or contact warm plates can be used to warm the worker's hands if fine work is to be performed with bare hands for 10 to 20 minutes or more;

c. Shield the work area if air velocity at the work site is increased by wind, draft or ventilating equipment;

d. Metal handles of tools and control bars should be covered with thermal insulating material at temperatures below 30F;

e. Unprotected metal chair seats will not be used in cold environments;

f. When appropriate and feasible, equipment and processes will be substituted, isolated, relocated, or redesigned;

g. Power tools, hoists, cranes or lifting aids will be used to reduce the metabolic workload;

h. Heated warming shelters will be made available for continuous work being performed in an equivalent temperature of 20F or below. Workers will be encouraged to use the shelters regularly.

6. Administrative Work Practice Controls

Work practices and guidelines can be designed and developed to reduce exposure to cold stress. Some of these may include:

a. Work-rest schedules to reduce the peak of cold stress;

b. Enforce scheduled breaks;

c. Enforce intake of caffeine-free, non-alcoholic beverages;

d. Schedule work that has potential exposure to cold stress for the warmest part of the day;

e. Move work to warmer areas, whenever possible;

f. Assign extra workers for high-demand tasks;

g. Provide relief workers for other workers needing breaks;

h. Teach basic principles of recognizing and preventing cold stress;

i. Use the buddy system for work at 10F or below, and keep within eyeshot;

j. Allow new employees to adjust to the conditions before they work full-time in cold environments;

k. Minimize sitting and standing in one place for long periods of time;

l. Include weight and bulkiness of clothing when estimating work performance requirements and weights to be lifted;

Table III provides a work/warm-up schedule for cold environments, with wind chill taken into account.

7. <u>Special Considerations</u>

Older workers and workers with circulatory problems should be extra careful in cold environments. Sufficient sleep and good nutrition are important preventive measures for maintenance tolerance to the cold. Double shifts and overtime work should be avoided when working in cold environments.

If any of the following symptoms are observed on site, the affected worker will immediately go to warm shelter:

- Onset of heavy shivering;
- Frostnip;
- Feeling of excessive fatigue;
- Drowsiness;
- Euphoria.

After entering the warm shelter, the outer layer of clothing should be removed. If the clothing is wet from sweat and perspiration, dry clothing should be provided. If this is not feasible, then the clothing should be loosened to allow sweat to evaporate.

Anyone working in cold environments and on prescribed medication should consult their physician concerning any possible side effects due to cold stress. Those individuals suffering from diseases and/or taking medication that interferes with normal body temperature regulation or reduces the tolerance to cold will not be allowed to work in temperatures of 30F or below.

6.0 PERSONAL PROTECTIVE EQUIPMENT (PPE)

In choosing PPE for cold environments, it is important to maintain airspace between the body and outer layer of clothing to retain body heat. The more air pockets, the better the insulation. The clothing should also allow for the evaporation of sweat if the skin is wet.

The most important parts of the body to protect are the feet, hands, head and face. Hands and feet become cooled most easily, because of their distance from the heart. Keeping the head covered is equally important. As much as 40% of body heat loss is through the head when it is exposed.

Ideal clothing for exposure to cold environments is made of cotton. Cotton picks up sweat off the body and brings it to the surface. Loosely fitted clothing also aids in sweat evaporation. Recommended clothing may include the following:

a. Polypropylene under shirt and shorts under thermal underwear (preferably two-piece);

b. Wool socks;

c. Wool or thermal pants, lapped over boot tops to keep out snow and water;

d. Suspenders (belts can constrict and reduce circulation);

e. Insulated work boots, preferably waterproof. Safety toe, if necessary;

f. Wool or cotton shirt;

g. Parka;

h. Knit cap/hard hat liner;

i. Wool mittens or gloves (depending on the dexterity required);

j. Face mask or scarf.

Dirty or greasy clothing loses much of its insulation value. Dirty clothing crushes air pockets, allowing air to escape more easily. Also, denim is not a good protective fabric. It is loosely woven and allows water to penetrate and wind to blow away body heat.

TABLE I
Progressive Clinical Presentation of Hypothermia*

Core Temperature Deg. C	Deg. F	Clinical Signs
37.6	99.6	"Normal" rectal temperature.
37	98.6	"Normal" oral temperature.
36	96.8	Metabolic rate increases in an attempt to compensate for heat loss.
35	95.0	Maximum shivering.
34	93.2	Victim conscious and responsive, with normal blood pressure.
33	91.4	Severe hypothermia below this temperature.
32	89.6	Consciousness clouded; blood pressure becomes difficult to obtain;
31	87.8	pupils dilated but react to light; shivering ceases.
30	86.0	Progressive loss of consciousness; muscular rigidity increases;
29	84.2	pulse and blood pressure difficult to obtain; respiratory rate decreases.
28	82.4	Ventricular fibrillation possible with myocardial irritability.
27	80.6	Voluntary motion ceases; pupils non-reactive to light; deep tendon and superficial reflexes absent.
26	78.8	Victim seldom conscious.
25	77.0	Ventricular fibrillation may occur spontaneously.
24	75.2	Pulmonary edema.
22	71.6	Maximum risk of ventricular fibrillation.
20	68.0	Cardiac standstill.
18	64.4	Lowest accidental hypothermia victim to recover.
17	62.6	Isoelectric electroencephalogram.
9	48.2	Lowest artificially cooled hypothermia patient to recover.

* Presentations approximately related to core temperature. Reprinted from the January 1982 issue of American Family Physician, published by the American Academy of Family Physicians.

TABLE II
Cooling Power of Wind on Exposed Flesh as Equivalent Temperature (under calm conditions)*

{PRIVATE } **Estimated Wind Speed (mph)**	**Actual Temperature Reading (Degrees Fahrenheit)**											
	50	**40**	**30**	**20**	**10**	**0**	**-10**	**-20**	**-30**	**-40**	**-50**	**-60**
	Equivalent Chill Temperature (F)											
Calm	50	40	30	20	10	0	-10	-20	-30	-40	-50	-60
5	48	37	27	16	6	-5	-15	-26	-36	-47	-57	-68
10	40	28	16	4	-9	-24	-33	-46	-58	-70	-83	-95
15	36	22	9	-5	-18	-32	-45	-58	-72	-85	-99	-112
20	32	18	4	-10	-25	-39	-53	-67	-82	-96	-110	-121
25	30	16	0	-15	-29	-44	-59	-74	-88	-104	-118	-133
30	28	13	-2	-18	-33	-48	-63	-79	-94	-109	-125	-140
35	27	11	-4	-20	-35	-51	-67	-82	-98	-113	-129	-145
40	26	10	-6	-21	-37	-53	-69	-85	-100	-116	-132	-148
(Wind speeds greater than 40 mph have little additional effect).	LITTLE DANGER In < hr with dry skin. Maximum danger of false sense of security.				INCREASING DANGER Danger from freezing of exposed flesh within one minute.			GREAT DANGER Flesh may freeze within 30 seconds.				
	Trenchfoot and immersion foot may occur at any point on this chart.											

* Developed by the U.S. Army Research Institute of Environmental Medicine, Natick, MA

Note #1: Wind speeds greater than 40 mph have little additional effect.

Note #2: Trenchfoot and immersion foot may occur at any point on this chart

TABLE III

Threshold Limit Values Work/Warm-up Schedule for 4 Hour Shift (*)

Air Temp.-Sunny Sky		**No Noticeable Wind**		**5 mph Wind**		**10 mph Wind**		**15 mph Wind**		**20 mph Wind**	
˚C (approx)	**˚F (approx)**	**Max. Work Period**	**No. of Breaks**	**Max. Work PERIOD**	**No. of Breaks**	**Max. Work Period**	**No. of Breaks**	**Max. Work Period**	**No. of Breaks**	**Max. Work Period**	**No. of Breaks**
-26° to -28°	-15° to -19°	(Norm. Breaks) 1		(Norm.Breaks) 1		75 min.	2	55 min.	3	40 min.	4
-29° to -31°	-20° to -24°	(Norm. Breaks) 1		75 min	2	55 min.	3	40 min.	4	30 min.	5
-32° to -34°	-25° to -29°	75 min	2	55 min.	3	40 min.	4	30 min.	5	Non-emergency work should cease	
-35° to -37°	-30° to -34°	55 min.	3	40 min.	4	30 min.	5	Non-emergency work should cease			
-38° to -39°	-35° to -39°	40 min.	4	30 min.	5	Non-emergency work should cease					
-40° to -42°	-40° to -44°	30 min.	5	Non-emergency work should cease							
-43° & below	-45° & below	Non-emergency work should cease									

Notes for TABLE III:

1. Schedule applies to moderate to heavy work activity with warm-up breaks of 10 minutes in a warm location. For light to moderate work (limited physical motion), apply the schedule one step lower. For example, at -30F with no noticeable wind (step 4, a worker at a job with little physical movement should have a maximum work period of 40 minutes with 4 breaks in a 4 hour period.

2. The following is suggested as a guide for estimating wind velocity if accurate information is not available: 5 mph, light flag moves; 10 mph, light flag fully extended; 15 mph, raises newspaper sheet; 20 mph, blowing drifting snow.
3. If only the wind-chill cooling rate is available, a rough rule of thumb for applying it rather than the temperature and wind velocity factors given above would be: 1) special warm-up breaks should be initiated at a wind-chill cooling rate of about 17 W/m2; 2) all non-emergency work should have ceased at or before a wind-chill of 2250 W/m2. In general the warm-up schedule provided above slightly under-compensates for the wind at the warmer temperatures, assuming acclimatization and clothing appropriate for winter work. On the other hand, the chart over-compensates for the actual temperatures in the colder ranges, since windy conditions prevail at extremely low temperatures.

4. TLVs apply only for workers in dry clothing.

* Adapted from Occupational Health and Safety Division, Saskatchewan Department of Labour.

APPENDIX D

HEAT STRESS PROGRAM

1.0 INTRODUCTION

Heat stress is one of the most common (and potentially serious) illnesses at job sites. Although it is caused by a number of interacting factors, the wearing of PPE puts the worker at a much higher risk during warmer environmental conditions. The results of heat stress range from fatigue to serious illness or death. Through regular fluid replacement and other preventive measures, heat stress can be controlled, leading to increased efficiency and a higher level of safety on the job.

2.0 PURPOSE

To create an awareness among employees concerning the body's physiologic responses to heat; different types of heat stress that can affect the body; recognition of signs and symptoms; first aid treatment; and, preventive measures.

3.0 SOURCES OF HEAT

There are two sources of heat that are important to anyone working in a hot environment:

- Internally generated metabolic heat;
- Externally imposed environmental heat.

4.0 PHYSIOLOGIC RESPONSES TO HEAT

The human body maintains a fairly constant internal temperature, even though it is exposed to varying environmental temperatures. To keep internal body temperatures within safe limits, the body must get rid of its excess heat, primarily through varying the rate and amount of blood circulation through the skin and the release of fluid onto the skin by the sweat glands. These automatic responses usually occur when the temperature of the blood exceeds 98.6°F and are kept in balance and controlled by the brain. In this process of lowering internal body temperature, the heart begins to pump more blood, blood vessels expand to accommodate the increased flow, and the microscopic blood vessels (capillaries) which thread through the upper layers of the skin begin to fill with blood. The blood circulates closer to the surface of the skin, and the excess heat is lost to the cooler environment.

If the heat loss from increased blood circulation through the skin is not adequate, the brain continues to sense overheating and signals the sweat glands in the skin to release large quantities of sweat onto the skin surface. Evaporation of sweat cools the skin, eliminating large quantities of heat from the body.

As environmental temperatures approach normal skin temperature, cooling of the body becomes more difficult. If air temperature is as warm as or warmer than the skin, blood brought to the body surface cannot lose its heat. Under these conditions, the heart continues to pump blood to the body surface, the sweat gland pour liquids containing electrolytes onto the surface of the skin, and the evaporation of the sweat becomes the principal effective means of maintaining a constant body temperature. Sweating does not cool the body unless the moisture is removed from the skin by evaporation. In high humidity, the evaporation of sweat from the skin is decreased and the body's efforts to maintain an acceptable body temperature may be significantly impaired. These conditions adversely affect an individual's ability to work in the hot environment. With so much blood going to the external surface of the body, relatively less goes to the active muscles, the brain, and other internal organs; strength declines; and fatigue occurs sooner than it would otherwise. Alertness and mental capacity also may be affected. Workers who must perform delicate or detailed work may find their accuracy suffering, and others may find their comprehension and retention of information lowered.

When temperature differences exist between two or more bodies, heat can be transferred. Net heat transfer is always from the body (or object) of higher temperature to that of lower temperature and occurs by one or more of the following mechanisms:

> **Conduction**. The transfer of heat from one point to another within the body, or from one body to another when both bodies are in physical contact. Conduction can be a localized source of discomfort from direct physical contact with a hot or cold surface, it is normally not a significant factor to total heat stress.
>
> **Convection**. The transfer of heat from one place to another by moving gas or liquid. Natural convection results from differences in density caused by temperature differences. Thus warm air is less dense than cool air.
>
> **Radiation**. The process by which energy, electromagnetic (visible and infrared), is transmitted through space without the presence or movement of matter in or through this space.

5.0 PREDISPOSING FACTORS TO HEAT STRESS

Factors that may predispose an individual to heat stress vary according to the individual. These factors include:

- Lack of physical fitness;
- Lack of acclimatization;
- Age;
- Dehydration;
- Obesity;
- Drug/alcohol abuse;
- Infection;
- Sunburn;
- Diarrhea;
- Chronic disease.

Predisposing factors and an increased risk of excessive heat stress are both directly influenced by the type and amount of PPE worn. PPE adds weight and bulk, reduces the body's access to normal heat exchange mechanisms (evaporation, convection and radiation) and increases energy expenditure.

6.0 FORMS OF HEAT STRESS AND FIRST AID

(The following excerpts were taken from NIOSH Publication No. 86-112, Working in Hot Environments):

"Excessive exposure to a hot work environment can bring about a variety of heat-induced disorders. Among the most common are heat stroke, heat exhaustion, heat cramps, fainting and heat rash.

Heat Stroke

Heat Stroke is the most serious of health problems associated with working in hot environments. It occurs when the body's temperature regulatory system fails and sweating becomes inadequate. The body's only effective means of removing excess heat is compromised with little warning to the victim that a crisis stage has been reached.

A heat stroke victim's skin is hot, usually dry, red or spotted. Body temperature is usually 105°F or higher, and the victim is mentally confused, delirious perhaps in convulsions, or unconscious. Unless the victim receives quick and appropriate treatment, death can occur.

Individuals with signs or symptoms of heat stroke require immediate hospitalization. First aid should be immediately administered. This includes removing the victim to a cool area, thoroughly soaking the clothing with water, and vigorously fanning the body to increase cooling. Further treatment, at a medical facility, should be directed to the continuation of the cooling process and the monitoring of complications which often accompany heat stroke. Early recognition and treatment are the only means of preventing permanent brain damage or death.

Heat Exhaustion

Heat Exhaustion includes several clinical disorders having symptoms which may resemble the early symptoms of heat stroke. Heat exhaustion is caused by the loss of large amounts of fluid by sweating, sometimes with excessive loss of salt. A worker suffering from heat exhaustion still sweats but experiences weakness or fatigue, giddiness, nausea or headache. In more serious cases, the victim may vomit or lose consciousness. The skin is clammy and moist, the complexion is pale or flushed, and the body temperature is normal or only slightly elevated.

In most cases, treatment involves having the victim rest in a cool place and drink plenty of liquids. Victims with mild cases of heat exhaustion usually recover spontaneously with this treatment. Those with severe cases may require extended care for several days. There are no known permanent effects.

Heat Cramps

Heat cramps are painful spasms of the muscles that occur among those who sweat profusely in heat, drink large quantities of water, but do not adequately replace the body's salt loss. The drinking of large amounts of water tends to dilute the body's fluids, while the body continues to lose salt. Shortly after, the low salt level in the muscles causes painful cramps. The affected muscles may be part of the arms, legs, or abdomen; but tired muscles (those used in performing the work) are usually the ones most susceptible to cramps. Cramps may occur during or after work hours and may be relieved by taking salted liquids by mouth.

Fainting

Fainting occurs in workers not accustomed to hot environments and who stand erect and immobile in the heat.

With enlarged blood vessels in the skin and in the lower part of the body due to the body's attempts to control internal temperature, blood may pool there rather than return to the heart to be pumped to the brain. Upon lying down, the worker should soon recover. By moving around, and thereby preventing blood from pooling, the patient can prevent further fainting.

Heat Rash (Prickly Heat)

Heat rash, also known as prickly heat, is likely to occur in hot, humid environments where sweat is not as easily removed from the surface of the skin by evaporation and the skin remains wet most of the time. The sweat ducts become plugged, and a skin rash soon appears. When the rash is extensive or when it is complicated by infection, prickly heat can be very uncomfortable and may reduce a worker's performance. The worker can prevent this condition by resting in a cool place part of each day and by regularly bathing and drying the skin."

7.0 SELECTION OF PERSONAL PROTECTIVE EQUIPMENT (PPE)

During work periods where the increased risk of heat stress exists, each item's benefit will be carefully evaluated. Once the PPE is chosen, safe work durations/rest periods will be determined based on the following conditions:

- Anticipated work rate;
- Ambient temperature and humidity;
- Level of protection.

8.0 PREVENTION OF HEAT STRESS

Prevention of heat stress will be addressed in the following manner:

1. Adjustment of work schedules.

    a. Modify work/rest schedules.
    b. Enforce work slowdowns, as needed.
    c. Rotate personnel to minimize overstress or overexertion.
    d. When possible, work will be scheduled and performed during cooler hours.

1. Provide shelter or shaded areas to protect personnel during rest periods.

2. Maintain worker's body fluids at normal levels.

    a. Drink approximately 12 to 16 ounces of non-caffeinated liquid (preferably water, Gatorade or equivalent) prior to the start of work. Caffeinated fluids act to dehydrate the worker.

    b. Workers will be urged to drink a cup or two every 15 to 20 minutes, or at each break. A total of 1 to 1.5 gallons of water per individual per day are recommended for fluid replacement under heat stress conditions, but more may be required.

3. Encourage physical fitness among the workers.

    Gradually acclimatize workers on site to help build up an "immunity" to the conditions.

    - Heat acclimatization can usually be induced in 5 to 7 days of exposure at a hot job. For workers with previous experience with the job, acclimatization will include exposures of 50% for day 1, 60% for day 2, 80% for day 3, and 100% for the remaining additional days.

4. Provide cooling devices during prolonged work or severe heat exposure.

    a. Supply field showers or hose down areas.

    b. Supply personnel with cooling jackets, vests, and suits.

5. Train workers in recognition and treatment of heat stress.

6. Use of the buddy system that depends on the recognition of signs and symptoms of heat stress.

7. Identification of heat-intolerant individuals through medical screening.

APPENDIX E

PROCESS SAFETY MANAGEMENT

1.0 PROCESS SAFETY INTRODUCTION

The OSHA Process Safety Management (PSM) Standard applies to users of extremely hazardous substances and flammable substances that exceed certain thresholds. The regulation requires users of these substances to conduct a thorough comprehensive analysis of processes that use these hazardous materials. The EPA Risk Management Program regulations are closely related to the OSHA Standard. Many **CONTRACTOR** clients must comply with PSM/RMP and it is **CONTRACTOR**'s responsibility to meet the Client's requirements as a vendor to the client. The purpose of the OSHA PSM and EPA RMP regulations is to minimize the impact of catastrophic releases of extremely hazardous materials. These substances include toxic, reactive, flammable and explosive substances. **CONTRACTOR** employees are required to be properly trained and informed when working at sites regulated under the PSM/RMP rule.

2.0 PROCESS HAZARD ANALYSIS

Regulated facilities are required to conduct a Process Hazard Analysis of all regulated processes. All **CONTRACTOR** project managers are required to discuss the applicability of the Process Hazard Analysis to **CONTRACTOR**'s work. Copies of the Process Hazard Analysis (PHA) should be obtained if available prior to starting the work. The PHAs applicable to **CONTRACTOR**'s work will be identified and provided to **CONTRACTOR**'s affected employees. Each employee will be familiar with the hazards related to **CONTRACTOR**'s work and the proper response in the event of an emergency. This response could include evacuation, sheltering in place or the use of emergency escape equipment. The escape routes must be known before beginning work. **CONTRACTOR** staff should meet with the Client's Safety Department whenever possible to review safety issues associated with **CONTRACTOR**'s work.

3.0 TRAINING

All **CONTRACTOR** employees will receive site-specific training prior to working at a site regulated by the Process Safety Standard. Training will review the known potential fire, explosion, and toxic hazards present on site. Most clients provide this training as part of the site admissions process. Varying levels of training may be needed depending on the type of access and proximity to regulated processes. Only documented trained **CONTRACTOR** employees will be allowed to work at a site regulated by the Process Safety Standard. Records of the training will be maintained in each employee's personnel record.

4.0 SITE SPECIFIC EMERGENCY ACTION PLAN

4.1 Emergency Action Plan

Emergency Action Plans are required by all facilities. The plan will be reviewed by **CONTRACTOR** staff before beginning work on site. Exit routes, gathering locations and shelters in place will be reviewed relative to **CONTRACTOR**'s work. The review of the plan will be part of **CONTRACTOR**'s daily toolbox safety meeting.

4.2 Response Procedures

CONTRACTOR will be familiar with the alarms or other notification systems used by the client. CONTRACTOR will place all equipment in a neutral state, if possible, before leaving the work area during an emergency. **CONTRACTOR** employees should remain together and identify themselves to the response coordinator. Re-access to the work area will not take place until permission has been obtained and the emergency mitigated.

4.3 Material Safety Data Sheets

CONTRACTOR will maintain on-site a compilation of MSDSs for chemicals used by **CONTRACTOR**. **CONTRACTOR** will obtain from the client MSDSs for facility chemicals that could be encountered by **CONTRACTOR** employees during this work. **CONTRACTOR** will review **CONTRACTOR**'s work with the client including the chemical usage to determine if there will be significant impact with the client's processes.

4.4. Accidents/Incidents

Accidents and near-miss incidents will be investigated in accordance with client and **CONTRACTOR** Corporate Health and Safety requirements.

5.0 TRADE SECRETS

All **CONTRACTOR** employees have an obligation to keep client information confidential and are not allowed to discuss the client's processes with outside personnel. All communication with regulatory personnel or other observers of **CONTRACTOR**'s work is to be directed to the client unless written permission has been obtained from the client. The results of all data collected by **CONTRACTOR** is also considered confidential and must not be discussed without client permission.

6.0 SAFE WORK PRACTICES

CONTRACTOR's work is typically non-intrusive and should not interfere with the clients operation. Unique hazards associated with **CONTRACTOR**'s work should be identified and reviewed with the client. Special procedures that may need to be followed could include lockout/tagout, confined space entry, hot work, or other operational issues that may need to be addressed. **CONTRACTOR** will review **CONTRACTOR**'s work with the Client to determine if **CONTRACTOR**'s work will create unique hazards or interfere with the client's operation.

6.1 Hot-work and Lockout/tagout

CONTRACTOR will adhere to client's requirements for lockout/tagout procedures. Hot work permits may be necessary in certain situations and **CONTRACTOR** will discuss these permit conditions with the client before starting work.

APPENDIX F

PERSONAL PROTECTIVE EQUIPMENT (PPE) PROGRAM: SELECTION AND USE

1.0 PURPOSE

This program has been written to help the worker choose the correct Personal Protective Equipment (PPE) for the job. Familiarity with the different levels of protection (A, B, C and D) will help speed up the selection process. Careful selection and use of adequate PPE should protect the respiratory system, skin, eyes, face, hands, feet, head, body and hearing. **CONTRACTOR** employees may work at a variety of job sites and locations which may require different types of protective equipment. Client specific requirements will always be adhered to. **CONTRACTOR** will supply all PPE or reimburse the employee for the costs of PPE if the PPE is required as part of the project.

2.0 SCOPE

This program establishes criteria for the selection, use, donning and doffing, inspection, maintenance, storage, decontamination of PPE, and evaluation. This information is general, and specific PPE use should be included in the site-specific health and safety plan prepared for each project.

3.0 OSHA REQUIREMENTS (29 CFR 1910.120)

A written personal protective equipment program, which is part of the employer's safety and health program and also part of the site-specific health and safety plan shall be established. The PPE program shall address the elements listed below.

- PPE selection based upon site hazards;
- PPE use and limitations of the equipment;
- Work mission duration;
- PPE Maintenance and storage;
- PPE decontamination and disposal;
- PPE training and proper fitting;
- PPE donning and doffing procedures;
- PPE inspection procedures prior to, during and after use;
- Evaluation of the effectiveness of the PPE program; and
- Limitations during temperature extremes, heat stress, and other appropriate medical considerations.

OSHA Standard 29 CFR 1910.132 requires employers to assess the employer's workplace and determine if hazards are present that necessitate the use of personal protective equipment (PPE). This assessment must be certified in writing and documented.

Due to the variety of job sites and situations that **CONTRACTOR** personnel may be involved in, it is important that **CONTRACTOR** maintain a consistent approach in complying with health and safety procedures. The project manager and/or site supervisor are responsible for ensuring that all personnel wear the appropriate PPE. Failure to comply with these requirements may result in disciplinary action. Employee safety is a paramount concern for all **CONTRACTOR** managers and employees. We all must make every effort to protect ourselves and each other from harm. These procedures will now require the following:

1. Protective footwear must be worn by all field personnel working in the field. Footwear must at a minimum include steel toe and shank protection. **CONTRACTOR** will reimburse employees up to $90 for the purchase of protective footwear which must be dedicated for work. Protective footwear must meet ANSI Z41-1991. Additionally, chemical protective footwear may also be required if the potential for contaminated materials exists. This type of protection will be required on a site-specific basis.

2. Eye protection must be worn by all field personnel during all sampling activities, stack sampling, and inside manufacturing facilities. Eye protection must include side shields. Prescription lenses worn as eye protection and other protective eyewear must meet ANSI Z87.1-1989.

3. Hardhats are to be worn by all field personnel when in the field. New hardhats must meet ANSI Z89-1986.

4. Hand protection is to be worn on a site-specific basis. The hand protection must be selected based on the chemical hazards expected to be encountered. **CONTRACTOR** maintains a stock of a variety of gloves including:

   Best: Nitrile N-Dey
   PVC
   Latex
   Vinyl
   Solvex, Nitrile
   Leather Work Gloves

   These gloves are available from the Windsor office on a project specific basis.

   Additionally, nitrile coated Kevlar gloves or other types of puncture resistant gloves are to be worn by all personnel working with or cleaning glass impingers. Manufacturers that supply these gloves include Ansell Edmont, Jomac and Wells Lamont. Insulated electrical gloves with outer leather gloves is required when working around high-voltage systems.
   CONTRACTOR is responsible for supplying all personal protective equipment required for **CONTRACTOR**'s projects.

4.0 WORK MISSION DURATION

Before donning any PPE ensembles, workers will estimate their anticipated work duration. There are several limiting factors that affect the length of work time. These factors must be addressed:

- Air supply consumption
- Permeation and penetration of the Chemical Protective Clothing/ensemble;
- Ambient temperature; and
- Coolant supply (ice or chilled area to keep the worker's body temperature at a normal temperature).

5.0 LEVEL OF PROTECTION

The following section describes the different levels of protection (A through D). Each level is described in the following manner: the protection provided; when this particular level of protection should be used; recommended and optional equipment; and, any limiting criteria.

1. Level A

   a. Protection provided:

      - Level A provides the highest available level of respiratory, skin and eye protection.

   b. Should be used when:

      - The chemical substance has been identified and requires the highest level of protection for skin, eyes, and the respiratory system based on any of the following circumstances;

      - Measured (or potential for) high concentration of atmospheric vapors, gases or particulates;

      - Site operations and work functions involving a high potential for splash, immersion, or exposure to unexpected vapors, gases or particulates of materials that are harmful to skin or capable of being absorbed through intact skin;

      - Substances with a high degree of hazard to the skin are known or suspected to be present, and skin contact is possible;

      - The Operations must be conducted in confined, poorly ventilated areas until absence of conditions requiring Level A protection is determined.

   c. Recommended equipment:

- Pressure-demand, full facepiece SCBA or pressure-demand supplied-air respirator with escape SCBA;

- Fully-encapsulating, chemical-resistant suit (pressure-tested immediately before use);

- Inner chemical-resistant suit;

- Inner chemical-resistant gloves;

- Chemical-resistant safety boots/shoes; and

- Two-way radio communications.

d. Optional equipment:

- Cooling unit;
- Coveralls;
- Long cotton underwear;
- Hard hat; and
- Disposable gloves and boot covers.

e. Limiting criteria:

- Fully encapsulating suit material must be compatible with the substances involved.

2. Level B

a. Protection provided:

- The same level of respiratory protection, but less skin protection than Level A.

b. Should be used when:

- The type and atmospheric concentration of substances have been identified and require a high level of respiratory protection, but less skin protection. This involves atmospheres with IDLH concentrations of specific substances that do not represent a severe skin hazard, or that do not meet the criteria for use of air purifying respirators;

- Atmospheres contain less than 19.5% oxygen; and

- Presence of incompletely identified vapors or gases indicated by direct-reading organic vapor detection instrument, but vapors and gases are not suspected of containing high levels of chemicals harmful to skin or capable of being absorbed through the intact skin.

c. Recommended equipment:

- Pressure-demand, full facepiece SCBA or pressure-demand supplied-air respirator with escape SCBA;

- Chemical-resistant clothing (overalls and long-sleeved jacket; hooded, one- or two-piece chemical splash suit; disposable chemical-resistant one-piece suit);

- Inner and outer chemical-resistant gloves;

- Chemical-resistant safety boots/shoes;

- Hard hat; and

- Two-way radio communications.

d. Optional equipment:

- Coveralls;
- Disposable boot covers;
- Face shield; and
- Long cotton underwear.

e. Limiting criteria:

- Use only when the vapors or gases present are not suspected of containing high concentrations of chemicals that are harmful to skin or capable of being absorbed through the intact skin.

- Use only when it is highly unlikely that the work being done will generate either high concentrations of vapors, gases or splashes of material that will affect the exposed skin.

3. Level C

a. Protection provided:

- Level C provides the same level of skin protection as Level B, but a lower level of respiratory protection.

b. Should be used when:

- The atmospheric contaminants, liquid splashes, or other direct contact will not adversely affect any exposed skin;

- The types of air contaminants have been identified, concentrations measured, and a canister/ cartridge is available that can remove the contaminant; and

- All criteria for the use of air-purifying respirators are met.

c. Recommended equipment:

- Full facepiece or half facepiece air-purifying negative pressure respirator;
- Chemical-resistant clothing;
- Inner and outer chemical-resistant gloves;
- Chemical-resistant safety boots and shoes;
- Disposable boot covers;
- Hard hat; and
- Two-way radio communications.

d. Optional equipment:

- Coveralls;
- Face shield;
- Escape bottle; and
- Long cotton underwear.

e. Limiting criteria:

- Atmospheric concentration of chemicals must not exceed IDLH levels; and
- The atmosphere must contain at least 19.5% oxygen.

4. Level D

a. Protection provided:

- No respirator protection and minimal skin protection.

b. Should be used when:

- The atmosphere contains no known hazard; and

- Work functions preclude splashes, immersion, or the potential for unexpected inhalation of or contact with hazardous levels of any chemicals.

c. Recommended equipment:

- Coveralls;
- Safety boots/shoes;

- Safety glasses or chemical splash goggles; and
- Hardhat.

d. Optional equipment:

- Gloves;
- Escape bottle; and
- Face shield.

e. Limiting criteria:

- This level should not be worn in the exclusion zone; and
- The atmosphere must contain at least 19.5% oxygen.

6.0 LEVEL OF PROTECTION UTILIZED BY CONTRACTOR PERSONNEL

Due to the nature of our work, it can be reasonably expected that personnel will not be performing any work that will require the use of Level A protection. **CONTRACTOR** will not directly undertake assignments and **CONTRACTOR** does not generally train or equip its personnel to handle circumstances involving Level A protection. If **CONTRACTOR** is working on a site and Level A is deemed necessary, the work will be subcontracted to a qualified firm. **CONTRACTOR** personnel should not directly undertake these tasks.

Sites where **CONTRACTOR** is working often require the use of Level C or D, with Level B equipment available on-site for emergency rescue. Any questions concerning the level of protection necessary to complete a certain task will be directed to the Health and Safety Assessment Division before setting up the job.

7.0 TYPES OF PPE OWNED AND UTILIZED BY CONTRACTOR

The following list contains all types of PPE owned by **CONTRACTOR** and their uses on the job, as they may apply to a specific site.

1. Respiratory Equipment:

a. SCBAs:

- Used for emergency rescue and exposures greater than maximum use concentration limits set for canister/cartridge type negative pressure respirators.

b. Supplied-air respirators:

- MSA Premaire system.

c. Negative pressure respirators:

  - Half face and full face, used for exposure to certain types of acid gases, organic vapors and particulates not greater than the canister/cartridge maximum use concentration limit.

2. Chemical protective apparel suits:

   a. Polycoated Tyvek, Saranex, Chemrel and Tyvek (porous). Provide protection against certain liquid chemicals.

      - Tyvek provides protection against particulates only.

   b. Fire/flame retardant coveralls:

      - Provide protection against flash fires.

3. Insulated clothing (Provides protection against exposure to the cold:

   a. Chemical resistant gloves:

      - Provide protection for the hands against chemical splashes.

   b. Disposable boot covers:

      - Protect safety boots from contamination and feet from contact with chemicals.

4. Eye protection:

   a. Safety glasses and chemical splash goggles.

      - Safety glasses protect the eyes against large particles and projectiles.
      - Chemical splash goggles protect the eyes against vaporized chemicals, splashes, large particles, and projectiles.

   b. Vented goggles do not provide protection against vapors and are not adequate for splashes, as material may seep inside the goggles.

5. Hard hat:

   - Provides protection against blows to the head. When worn with a liner, provides protection against the cold.

6. Construction safety boots:

   - Steel-toe and shank construction boots with chemically resistant soles protect the feet from heavy and sharp objects, and contact with chemicals.

7. Safety harnesses and lifelines:

    - Enable the individual to work in elevated areas or enter confined spaces to prevent falls and aid in rescue.

8. Hearing protection:

    - Provides protection against physiological damage and psychological effects.

9. Canvas work gloves:

    - Provide protection for the hands against abrasions and slivers.

8.0 SELECTION OF CHEMICALLY PROTECTIVE CLOTHING

1. Chemically-protective clothing (CPC) will be chosen in the following manner:

    a. Determine what chemicals are present on the site.

    b. CPC chosen must be resistant to permeation, degradation and penetration of the chemical(s).

        - Permeation - Process by which a chemical dissolves in and/or moves through a protective clothing material on a molecular level.

        - Degradation - The loss of or change in the fabric's chemical resistance or physical properties due to exposure to chemicals, use or ambient conditions (e.g., sunlight).

        - Penetration - The movement of chemicals through zippers, stitched seams or imperfections (e.g., pinholes) in CPC.

    c. Review manufacturer's permeation data to determine the performance characteristics of the material to the specific chemical. See Appendix A for "Permeation Guides".

    d. Select CPC that protects against the greatest range of chemicals on the site and has the longest breakthrough time.

    e. Discuss choice of CPC with the Health and Safety division prior to setting up the job.

9.0 DONNING AND DOFFING PROCEDURES

The following procedures will be used by **CONTRACTOR** employees for donning and doffing PPE at protection Levels B and C. Donning and doffing will be performed with the assistance of an individual(s) located in the Support Zone and Contamination Reduction Zone, respectively. This individual will help the worker tape up and adjust PPE for proper fit, as well as remove PPE after decontamination.

1. Donning PPE

- Inspect the clothing and respirator before donning.
- Unzip the suit.
- Step into the legs of the suit, slipping the feet through the legs. Push arms through the sleeves.
- Pull leg cuffs over the feet.
- Put on chemical-resistant safety boots over the feet. Tape the leg cuff over the tops of the boots.
- Pull over chemical-resistant boot covers and tape over the leg cuff.
- If suit contains protective feet, wear chemical-resistant safety boots inside the suit with chemical-resistant boot covers over the suit and taped securely to the leg.
- If wearing a SCBA, don the facepiece and adjust it to be secure, but comfortable. Do not connect the breathing hose. Open valve on the air tank.
- If wearing a negative pressure respirator, pull hood over the head and perform positive and negative pressure facepiece seal test.
- Pull on chemical protective inner gloves.
- Pull on chemical protective outer gloves and tape securely to the sleeve of the suit.
- Securely tape the suit to protect all exposed skin around the neck area, and if wearing a full facepiece, tape around the edge of the hood-to-facepiece junction.
- Put on hardhat, if needed, and tape securely on top of head so that the hard hat does not slide off.

2. Doffing PPE

- Doffing of PPE will not take place until the individual has been properly decontaminated by a suitably attired assistant. Both the worker and assistant will make every effort to avoid any direct contact with the outside of the suit.

- If the individual is wearing a SCBA, the hose connection to the diaphragm will be disconnected, leaving the facepiece on the wearer. The remainder of the unit will be removed and decontaminated before proceeding further.

- If the individual is wearing a half-face or full-face negative pressure respirator, she/he will be instructed to leave it on until the doffing procedure is complete.

NOTE: Decontamination is to be performed in accordance with the Site-Specific Health and Safety Plan for the site.

10.0 DECONTAMINATION OF PPE

Whenever possible, disposable PPE will be used on-site. Disposable PPE includes the following:

- Chemical protective suits;
- Gloves; and
- Chemical protective boot covers.

After decontaminating the worker, PPE is disposed of on-site in labeled disposal containers.

11.0 INSPECTION OF PPE

PPE will be inspected prior to, during and after each use according to the procedure outlined below.

1. Prior to use (Reusable and Disposable PPE):

   a. Through reviewing available literature, determine that the clothing material is correct for the task.

   b. Visually inspect for:

      - Imperfect seams;
      - Non-uniform coatings;
      - Tears or holes; and
      - Malfunctioning closures.

   c. Hold up to the light and check for pinholes (inflate gloves and check for leaks).

   d. Flex and check for:

      - Cracks; and

- Shelf deterioration.

e. If previously used, check for:

- Discoloration;
- Swelling;
- Stiffness and cracking; and
- Holes and tears.

2. During use (Reusable and Disposable PPE), check for:

   a. Evidence of chemical attack.
   b. Discoloration, swelling, stiffening, softening and/or cracking.
   c. Tears.
   d. Punctures.
   e. Seam discontinuities.

   Note: Report any sense of breakthrough to the Health and Safety Assessment Division. Medical monitoring may be necessary to determine the extent of exposure.

3. After use (Reusable PPE), check for:

   a. Malfunctioning parts.
   b. Evidence of chemical attack.
   c. Punctures.
   d. Tears.
   e. Cracks.

12.0 MAINTENANCE AND STORAGE OF PPE

PPE, other than respiratory equipment, will be maintained and stored in accordance with the manufacturer's recommendations at a minimum to prevent damage due to exposure to dust, moisture, sunlight, chemicals, temperature extremes and sudden impact.

Employees are given Field Operations Equipment bags prior to working on any **CONTRACTOR** sites. PPE that is given to the individual solely for his/her use will be stored in this bag. Before and after each use, the PPE will be inspected to determine whether or not it is still "field worthy". Any PPE found to be defective will be reported to the Health and Safety Assessment Division and either discarded or repaired, as appropriate. Under no circumstances will defective PPE be used in the field.

8. The Health and Safety Assessment Division will periodically inspect PPE issued for individual use.

   a. Unless the equipment can be repaired, any PPE found to be defective will be removed from service and discarded immediately.

b. Repairable PPE will be tagged, returned to the Facility Manager and sent out for repair.

13.0 EVALUATION OF PPE PROGRAM

CONTRACTOR's Personal Protection Equipment Program will be reviewed annually by the Health and Safety Assessment Division. Any program deficiencies that are identified by a **CONTRACTOR** employee will be reported to the Health and Safety Assessment Division, so that changes will be made immediately. All employees affected by the change(s) will be notified in writing.

Review of the PPE Program will include, but not be limited to, the following:

- Accident and illness experience on various job sites.
- Type and degree of exposure.
- Adequacy of equipment selection process.
- Degree of fulfillment of program objectives.
- Employee acceptance.
- Coordination with overall health and safety program elements.
- Recommendations for program improvements and modifications.
- Adequacy of program records.

APPENDIX G

MONITORING INSTRUMENTS: USE, CARE, AND CALIBRATION

1.0 INTRODUCTION

Prior to beginning any work at **CONTRACTOR** sites, a preliminary site evaluation must be conducted to identify the hazards or suspected hazards of the site. Through area and personal monitoring with direct-reading instruments and personal sampling pumps, hazardous conditions can be evaluated, and the proper level of protection chosen for the specific type of work activity. Monitoring equipment used by **CONTRACTOR** personnel includes the following: Oxygen/Combustible Gas Meters (CGM); Organic Vapor Analyzers (OVA); Photoionization Detectors (PID); Personal Sampling Pumps; and, Colorimetric Tubes. This program contains a description of each type of monitoring equipment; hazards for which it can be used to monitor; Applications; Care and Maintenance; Limitations; and, Calibration.

2.0 SCOPE

This program covers the use, application, care and maintenance, limitations and calibration of CGMs, OVAs, PIDs, Personal Sampling Pumps and Colorimetric Tubes used by **CONTRACTOR** employees in hazardous materials operations. **CONTRACTOR** employees engaged in activities involving hazardous materials includes the Hazardous Waste Division and the Air Division.

3.0 INSTRUMENTATION

1. Photoionization Detectors (PIDs)

<u>Introduction</u>

PIDs measure a variety of gases in many industrial, as well as hazardous material, operations. These analyzers employ the principle of photoionization, which is the absorption of ultraviolet light by molecules, for detection.

The sensor consists of a sealed ultraviolet light. The energy ionizes many trace species (particularly organics) but does not ionize the major components of air, such as O_2, N_2, CO, CO_2, or H_2O. A chamber adjacent to the ultraviolet source contains a pair of electrodes. When a positive potential is applied to one electrode, the field created drives any ions, which are formed by absorption of the UV light, to the collector electrode, where the current (proportional to the concentration) is measured.

To minimize absorption of various sample gases, the ion chamber is made up of an inert fluorocarbon material, located at the sampling point, and a rapid flow of sampling gas is maintained through the small ion chamber volume.

The analyzer will operate either from a rechargeable battery for up to 10 hours, or continuously from the AC battery charger.

The useful linear range of the instrument is from a fraction of a part per million to about 2000 PPM.

Theory

CONTRACTOR utilizes the HNu meter as its PID. The HNu is a portable, non-specific vapor/gas detector. The HNu employs the principle of photoionization to detect a variety of chemical compounds, both organic and inorganic.

The HNu contains an ultraviolet light source within its sensor chamber. Ambient air is drawn into the chamber with the aid of a small fan (PI-101) or positive displacement pump (HW-101). If the ionization potential (IP) of any contaminant present in the ambient air is equal to or lower than the energy of the UV light source, ionization will take place, causing a deflection in the meter.

Response time for the HNu is approximately 90% at 3 seconds. The meter reading is expressed in parts per million (PPM) relative to the calibration gas. All readings must be stated as equivalent readings that depend on the calibration gas being used to calibrate the HNu. The calibration gas used is Isobutylene. Formerly, benzene was used as the calibration gas, but due to its hazard it is no longer used. Isobutylene, used as an equivalent in place of benzene, allows the instrument to provide results in benzene equivalents.

A list of IPs for various gases is provided in the latest edition of the NIOSH Pocket Guide to Chemical Hazards.

Basic Operation of the HNu

A sample of air is drawn through a chamber and an ultraviolet light causes certain contaminants present to be broken apart into positive and negative charged particles. These charged particles are passed between electrodes and converted into an electrical impulse displayed on the readout.

Checkout and Use Procedures

Attach the probe to the readout assembly. Be sure pins and "slot/key" are properly aligned. DO NOT FORCE CONNECTION INTO THE RECEPTACLE. Turn the connector clockwise until it snaps into place with a clicking noise, which will be both heard and felt.

Turn the function switch to "BATT". The needle should deflect to the right ("BATT CHK"). Listen for the humming of the fan or the pump. Look briefly into the probe and check to see if the lamp is on (look for a purple glow). Do not use the probe extension. Do not look into the lamp for more than a brief moment to see if the lamp is on. Prolonged exposure to the ultraviolet light rays of the lamp will cause eye damage.

Turn the function switch to "STANDBY". The fan will stay on, but the light will go out. Check the readout, which will read close to 0, and adjust the "ZERO" control knob. Check the "SPAN", which should be 9.8 for the 10.2 eV lamp. The lock should be on and should not be touched unless the unit is being calibrated.

Turn the function switch to "0-20". Check the unit with a magic marker, lighter (unlit), etc. to make sure it is working properly. Turn the function switch to 0-200, 0-2000 or 0-20 to sample, as necessary.

Field Applications/Limitations

a. The HNu will only detect organic materials with an ionization potential less than 10.2eV.

b. It is a non-specific detection device, but provides continuous information on airborne concentrations.

c. It will not respond equally to all contaminants, and does not detect methane.

d. High humidity will cause the instrument to give lower readings than the actual airborne concentration.

e. Transfer of the instrument from a cold to a warm environment may cause condensation to form on the UV light source window, causing erroneous results.

f. The readout may also be affected by electrical power lines or power transformers.

g. Total concentrations are relative to the calibration gas used (isobutylene). Therefore, true concentrations cannot be identified. And, while the instrument scale reads 0-2000 ppm, response is linear (to isobutylene) from 0-600 ppm.

h. Wind speeds of greater than 3 mph may affect the fan speed on the PI-101 and readings, depending on the position of the probe relative to wind direction.

Calibration Procedure

Calibration Checklist: HNu Meter (Probe and box); Span gas (HNu Manufactured); Regulator; Tygon tubing.

Cleaning and Calibration Checklist: Same materials as above; HNu cleaning compound; Fine screwdrivers, flat and Phillips head; Sonnicator; Drying/Toaster oven.

Inventory Items: Battery; Lamp; ION chamber; O-Rings; Screws.

a. Obtain calibration gas, Isobutylene at Span 9.8 with 10.2 eV, manufactured by HNu.

b. Connect the calibration gas to the end of the probe extension. Open the gas flow valve.

c. Turn the selection knob to the 0-200 range and observe the meter needle. The concentration should read the same as that listed on the cylinder. If not, the span should be adjusted until the meter reads accurately.

d. The above procedure can be used until the span reading is approximately 5. At this time, the meter needs to be cleaned and internally calibrated. See Step 5.

e. For cleaning and internal calibration:

- Disassemble the probe, carefully removing the lamp.
- Clean the lamp.
- Clean the ION chamber and probe extension.
- Remove the instrument from its housing to expose the calibration screw, located on the side of the instrument.
- Once the probe parts have cooled (assuming it has been used), assemble the probe and connect it to the instrument.
- Connect the calibration gas to the end of the probe extension and open the gas flow.
- Turn the selection knob to the 0-200 range and observe the needle. The concentration should read the same as the concentration listed on the cylinder. If not, then the calibration screw must be adjusted with a fine screwdriver.

Maintenance and Calibration Records

a. Protect the instrument from excessive abuse, such as moisture, shock, vibration, etc.

b. Maintenance and calibration records will be recorded in a logbook specific to the HNu meter.

Troubleshooting

Below are some points that should be considered if the instrument is not running appropriately:

a. Check the battery condition. Recharge it if necessary.

b. If unstable readings are obtained, a faulty probe cable or electrical connection could be the problem. To check this, hold the probe normally and flex the cable firmly. Watch the meter needle for fluctuations as the cable is flexed. Individual wires in the readout can be checked in a similar way.

c. Check the coaxial connector on the amplifier board in the probe for any separation.

d. Determine whether or not the meter is being used in close proximity to AC power lines or power transformers. This can cause the instrument to read erroneously. To check for this interference, zero the instrument in an electrically quiet area in the standby position, and then move the instrument into the area in question. If AC pick-up is a problem in the area, then the meter will indicate the magnitude of the problem.

e. No response on any setting may mean that the meter movement is broken. Tip the instrument from side-to-side. The needle should move freely and return to zero.

f. No response may mean that the electrical connection to the meter is broken. Check all wires leading to the meter and clean the contacts of the quick-disconnects.

g. No response may mean that the battery is completely dead. Disconnect the battery and check the voltage with a volt-ohm meter. Also check the 2-amp fuse.

h. If the meter responds in the BATT CHK mode, but reads zero or near zero for all other modes, the power supply may be defective.

- Replace the power supply.
- Check the input signal connection, which may be broken in the probe or readout.
- Check the input connector on the printed circuit board inside the probe. It should be firmly pressed down.
- Check the components on the backside of the circuit board. All connections should be solid and no wires should touch any other object.
- Check all wires in the readout for solid connections.

i. When the instrument responds appropriately in the "BATT CHK" and "STANDBY" positions, but not in the measuring mode, check to see that the light source is on.

j. If the instrument responds correctly in all settings, but the signal is lower than expected:

- ▪ Check the span setting.
- ▪ Clean the window of the light source.
- ▪ Check the fan for proper insertion.

k. If the instrument response is slow and/or not reproducible, either the fan is operating improperly (check the fan voltage), or the instrument needs to be recalibrated.

l. A low battery indication comes on if the battery charge is low. It will also come on if the ionization voltage is too high.

2. Organic Vapor Analyzer

Introduction

The OVA 128 is a sensitive instrument designed to measure trace quantities of organic materials in air. It is essentially a flame ionization detector such as that utilized in laboratory gas chromatographs and has similar analytical capabilities. The Flame Ionization Detector (FID) is an almost universal detector for organic compounds with the sensitivity to measure in parts per million range in the presence of atmospheric moisture, nitrogen oxides, carbon monoxide and carbon dioxide.

The instrument has broad application since it has a chemically resistant air sampling system and can be readily calibrated to measure almost all organic vapors. It has a single linearly scaled readout from 0 ppm to 10 ppm with a X1, X10, X100 range switch. This range expansion feature provides accurate readings across a wide concentration range with either the 10, 100, or 1000 ppm full-scale deflection. Designed for use as a portable survey instrument, it can also be readily adapted to fixed remote monitoring or mobile installations. It is ideal for the determination of many organic air pollutants and for monitoring the air in potentially contaminated areas.

The OVA 128 is certified by Factory Mutual Research Corporation for use in Class 1, Groups A, B, C and D Division 1 hazardous locations. Similar foreign certifications have been obtained, including BASEEFA. This requirement is especially significant in industries where volatile flammable petroleum or chemical products are manufactured or used and for instruments which are used in portable surveying or for analyzing concentrations of gases and vapors. Such instruments must not be capable, under normal or abnormal conditions, of causing ignition of hazardous mixtures in the air. In order to maintain the certified safety, it is important that the precautions outlined in this manual be practiced and that no modifications be made to these instruments.

Theory

The OVA 128 analyzer is designed to detect and measure hazardous organic vapors and gases found in most industries. It has broad application since it has a chemically resistant sampling system and can be calibrated to almost all organic vapors. It can provide accurate indication of gas concentration in one of three ranges: 0-10 ppm, 0-100 ppm, 0-1000 ppm. While designed as a lightweight portable instrument, it can be permanently installed to monitor a fixed point.

The instrument utilizes the principle of hydrogen flame ionization for detection and measurement of organic vapors. The instrument measures organic vapor concentration by producing a response to an unknown sample, which can be related to a gas of known composition to which the instrument has previously been calibrated. During normal survey mode operation, a continuous sample is drawn into the probe and transmitted to the detector chamber by an internal pumping system.

The sample stream is metered and passed through particle filters before reaching the detector chamber. Inside the detector chamber, the sample is exposed to a hydrogen flame which ionizes the organic vapors. When most organic vapors burn, they leave positively charged carbon-containing ions. An electric field drives the ions to a collecting electrode. As the positive ions are collected, a current corresponding to the collection rate is generated. This current is measured with a linear electrometer preamplifier which has an output signal proportional to the ionization current. A signal-conditioning amplifier is used to amplify the signal from the pre-amp and to condition it for subsequent meter or external recorder display. The display is an integral part of the probe/readout assembly and has 270-degree scale deflection.

In general, the hydrogen flame ionization detector is more sensitive for hydrocarbons than any other class of organic compounds. The response of the OVA varies from compound to compound, but gives repeatable results with all types of hydrocarbons, i.e. saturated hydrocarbons (alkanes), unsaturated hydrocarbons (alkenes and alkynes) and aromatic hydrocarbons.

Applications

a. Measurement of most toxic organic vapors present in industry for compliance with OSHA requirements.

b. Evaluation and monitoring applications in the air pollution field.

c. Source identification and measurement for fugitive emissions (leaks) as defined by the EPA.

d. Forensic science applications.

e. Controlling and monitoring atmospheres in manufacturing and packaging operations.

f. Leak detection related to volatile fuel handling equipment.

g. Monitoring the background level of organic vapors at hazardous waste sites.

h. Quality control procedures geared to leak checking, pressurized system checks, combustion efficiency checks, etc.

Limitations

a. The OVA will not detect any inorganic compounds.

b. The OVA will see methane, which is explosive, but relatively non-toxic in other than high concentrations. The user should determine if the contaminant involved is or is not methane.

c. DOT shipping regulations are strict for the OVA when shipping pressurized oxygen.

d. A relative humidity greater than 95% will cause inaccurate and unstable responses.

e. A temperature of less than 40 deg. F will cause poor and slow response.

f. Actual contaminant concentrations are measured relative to the calibration gas used. Therefore, specific contaminants and their quantities cannot be easily identified.

Battery Charging

a. Plug charging connector into mating connector on battery cover and insert AC plug into 115V AC wall outlet.

b. Move the battery charger switch to the ON position. The lamp above the switch button should illuminate.

c. Battery charge condition is indicated by the meter on the front panel of the charger; meter will deflect to the left when charging. When fully charged, the pointer will be in line with "CHARGED" marker above the scale.

d. Approximately 1 hour of charging time is required for each hour of operation. However, an overnight charge is highly recommended. The charger can be left on indefinitely without damaging the battery. When finished, move the battery charger switch to "OFF" and disconnect from the SIDE PACK ASSEMBLY.

Calibration

The OVA 128 is capable of responding to nearly all organic compounds. At the time of manufacture, the analyzer is calibrated to mixtures of methane in air.

The instrument is calibrated by using a mixture of a specific vapor in air, with a known concentration. After the instrument is in operation and the normal background is zeroed, draw a sample of the calibration gas into the instrument. The GAS SELECT knob on the panel is then used to set the readout meter indication to correspond to the concentration of the calibration gas mixture.

The instrument has now been calibrated to the vapor mixture being used. After this adjustment, the setting on the DIGIDIAL should be recorded for that particular organic vapor compound. This exercise can be performed for a variety of compounds, thereby generating a library which can be used for future reference without need for additional calibration standards.

To read a particular compound, the GAS SELECT control is turned to the predetermined setting for the compound. Calibration on any one range automatically calibrates the other 2 ranges.

Startup Procedure

a. Connect the Probe/Readout Assembly to the Sidepack Assembly by attaching the sample line first, then connect electronic jack to the side pack.

b. Select the desired sample probe (close area sampler or telescoping probe) and connect the probe handle. Before tightening the knurled nut, check that the probe accessory is firmly seated against the flat seals in the probe handle and in the tip of the telescoping probe.

c. Move the instrument/BATT switch to the test position. The meter needle should move to a point beyond the white line, indicating that the integral battery has more than four (4) hours of operating life before recharging is necessary.

d. Move the instrument/BATT switch to the "ON" position and allow a five (5) minute warm-up.

e. Move PUMP switch to "ON" position, then place instrument panel in vertical position and check SAMPLE FLOW RATE indication. The normal range is 1.5 - 2.5 units. If less, check filters.

f. Perform a leak test. (See "Sampling Fixtures")

g. Activate audible alarm:

- Use the CALIBRATE ADJUST knob to set the meter needle to the level desired for activating the audible alarm. If this alarm level is other than zero, the CALIBRATE SWITCH must be set to the appropriate range.

- Turn the VOLUME knob fully clockwise.

- Using the ALARM LEVEL ADJUST knob, turn the knob until the audible alarm is activated.

h. Move the CALIBRATION SWITCH to X1 and adjust the meter reading to zero using the CALIBRATE ADJUST (zero knob).

i. Open the Hydrogen TANK VALVE one or two turns and observe the reading on the HYDROGEN TANK PRESSURE INDICATOR. Approximately 150 psi of pressure is required for each hour of operation.

j. Open the HYDROGEN SUPPLY VALVE one or two turns and observe the reading on the HYDROGEN SUPPLY PRESSURE INDICATOR. The reading should be between 8 and 12 psi.

k. After approximately 10 seconds, depress the IGNITER BUTTON until the hydrogen flame lights. The meter needle will travel upscale and begin to read "TOTAL ORGANIC VAPORS".

CAUTION: Do not depress the igniter for more than 6 seconds. If the flame does not ignite, wait one minute and try again.

l. Calibrate instrument (see "Calibration").

m. The instrument is ready for use.

NOTE: If the ambient background organic vapors are "zeroed out" using the CALIBRATE ADJUST KNOB, the meter may move off scale in the negative direction when the OVA is moved to a location with lower background levels. If the OVA are to be used in the 0-10 ppm range, it should be "zeroed" in an area with very low background.

Shut Down Procedure

a. Close the HYDROGEN SUPPLY VALVE.

b. Close the HYDROGEN TANK VALVE.

c. Move the INSTR switch and PUMP switch to OFF.

d. Instrument is now in the shut down configuration.

Operation Procedure

Set the CALIBRATE switch to the desired range. Survey the areas of interest while observing the meter and/or listening for the audible alarm indicator. For ease of operation, carry the SIDE PACK ASSEMBLY positioned on the side opposite the hand which holds the PROBE/READOUT ASSEMBLY. For broad surveys outdoors, the pick-up fixture should be positioned several feet above ground level. When making quantitative readings or pinpointing, the pick-up fixture should be positioned at the point of interest.

When organic vapors are detected, the meter pointer will move upscale. If the audible alarm is utilized, it will sound when the set point is exceeded. The frequency of the alarm will increase as the detection level increases.

If a flameout occurs, check that the pump is running, then press the igniter button. Under normal conditions, flameout results from sampling a gas mixture that is above the Lower Explosion Limit (LEL) which causes the hydrogen flame to extinguish. If this is the case, re-ignition is all that is required to resume monitoring. Another possible cause for flameout is restriction of the sample flow line which would not allow sufficient air into the chamber to support combustion. The normal cause for such restriction is a clogged particle filter.

It should be noted that the chamber exhaust port is on the bottom of the case and blocking this port with the hand will cause fluctuations and/or flameout.

Maintenance and Troubleshooting

IMPORTANT NOTE: This section describes a routine maintenance procedures for troubleshooting instrument malfunctions. Maintenance personnel should be thoroughly familiar with instrument operation before performing maintenance. All written portions of this section must be thoroughly understood relating to safety of operation, servicing and maintenance. There should be no potential ignition sources in the area when filling, emptying or purging the hydrogen system and the instrument should be turned off.

Replacement parts that are specified by Foxboro must be used for repair. No modifications are permitted. Disassembly of the instrument must take place in a non-hazardous atmosphere only.

Primary Filter Cleaning

This filter is located behind the sample inlet connector (fitting assembly) on the SIDE PACK ASSEMBLY and is removed for cleaning by using a 7/16" thin screwdriver to unscrew the fitting assembly. The filter cup, "O" ring and loading spring will then come out. The porous stainless filter cup can be cleaned by blowing out. Reassemble in reverse order, ensuring that the "O" ring seal on the fitting assembly is intact.

Secondary Filter Cleaning

A particle filter is located in each pick-up fixture. One of these filters must be in the sample line whenever the instrument is in use. The OVA 128 uses a porous metal filter which can be replaced and cleaned.

Mixer/Burner Assembly Filter

A porous metal particle filter is incorporated in the Mixer/Burner Assembly, which screws into the Pre-Amp Assembly. This filter is used as the sample mixer and inlet flame arrestor in the chamber. The filter should not become contaminated under normal conditions but can be cleaned or the assembly replaced, if necessary.

Access to this filter or output surface does not require removing the instrument from the case. For access, remove the safety cover using a hex key wrench (supplied) then unscrew the exhaust port. The Filter Assembly can now be seen on the side of the chamber (Pre-Amp Assembly) and can be cleaned with a small wire brush.

Exhaust Flame Arrestor

A porous metal flame arrestor is located in the exhaust port of the detector chamber (Pre-Amp Assembly). It acts as a particle filter on the chamber output and restricts foreign matter from entering the chamber. This filter may be cleaned by removing the exhaust port. For access, see Mixer/Burner section above. Note that the filter is captive to the exhaust port.

Sampling Fixtures

Sampling fixtures should be periodically cleaned with an air hose and/or detergent solution to eliminate foreign particle matter.

The OVA is equipped with a flow gauge that provides a method to check for air leaks. Assemble the pick-up probe selected for use to the readout assembly and then position the side pack vertically so the flow gauge may be observed. Cover the end of the pick-up probe with your finger and observe that the ball in the flow gauge goes to the bottom, indicating no air flow (If the ball has a slight chatter while on the bottom, this is acceptable). Cover the center of the chamber exhaust port with your thumb and again observe the ball going to the bottom. Another simple check is to expose the pick-up probe to cigarette smoke or a light vapor (butane) and observe that the meter responds in approximately 2 seconds. It should be noted that the slow meter response might also indicate restriction in the air sampling.

Failure of the ball to go to the bottom when the inlet is blocked indicates a leak in the system between the probe and the pump inlet or the inlet check valve. To isolate the problem, remove the parts, one at a time, and again block off the air inlet. Remove the pick-up probes and cover the air inlet at the readout assembly. If the ball goes to the bottom, check that the "readout to probe" seal washer is in place and replace the probes, holding them back against this seal while tightening the nut. Recheck, and if leakage is still present, it is probably in the probe (pick-up fixture), which should be repaired or replaced.

If leakage is indicated as being past the readout handle when the connection to the sidepack is tight, disconnect the sample line at the fitting on the sidepack and cover this inlet with your finger. If the flow gauge ball goes to the bottom, the problem should be a leak in the umbilical cord/readout assembly. which should be investigated and repaired. There is also the possibility of a leaking check valve in the pump which would not show up on this test. If the leakage is not found in the umbilical cord, it is most likely in the pump check valve. If the ball does not go to the bottom following these corrective actions, contact the manufacturer for further instructions, and do not use the instrument.

Using Empirical Data

Relative response data can be used to estimate the concentration of a vapor without need to recalibrate the analyzer. With the instrument calibrated to methane, obtain the concentration reading for a calibration sample of the test vapor. The response factor (**R**) in percent for that vapor is:

$$\mathbf{R} = \frac{\text{Actual Conc.}}{\text{Measured Conc.}}$$

To determine the concentration of an unknown sample of that vapor, multiply the measured concentration by **R.** See the alphabetical list of compounds and Relative Response values in Appendix B.

3. Colorimetric Indicator Tubes

Colorimetric indicator tubes are used to measure concentrations of specific gases and vapors, both organic and inorganic. When used appropriately, an indicator tube specific to a certain compound will produce a stain in the tube. The length of the stain (or color change) is proportional to the compound's concentration. Minimal operator training and expertise is required to operate this type of sampling instrument.

Limitations

Colorimetric indicator tubes are cross-sensitive, meaning that other compounds may trigger a similar response, which will give the user a false reading. The user must take this fact into account when he/she dealing with a situation containing unknowns.

Other limitations include individual interpretation concerning the length of the stain, the limited accuracy of the tube, and use in high humidity. The greatest sources of error occur in different interpretations that are obtained between individuals as to how far the stain has gone on the tube, and the tubes limited accuracy. Users must remember that the tubes are **25% accurate**. A simple calculation will tell the user the range in which the correct reading could possibly occur.

With this in mind, any discoloration on the tube should alert the user as to the appropriate protection required for the site. High humidity also affects the readings. Use in humid environments tends to clog the filtering medium, not allowing the gases or vapors to be drawn properly through the tube.

Maintenance and Calibration

CONTRACTOR utilizes the Draeger Model 31 Bellows-type pump for colorimetric tube sampling. General maintenance for this type of instrument includes: avoiding rough handling which may cause channeling; performing a leakage test before sampling each day (including documentation); calibrating the unit at least quarterly; providing an inventory of tubes, with expiration dates; and, appropriate storing.

Rough handling of this instrument may cause erroneous results due to channeling (leakage). Therefore, the unit must be handled carefully and not be stored outside of its protective carrying case when not in use.

It may be necessary to clean the rubber bung (tube holder) if a large number of tubes have been taken with the pump. A mild soap and water solution can be used.

Leak Test

Before each day's use, the user will perform a leak test on the instrument. This is a simple test and includes the following:

a. Squeeze the bellows of the pump and insert an unopened detector tube, attempting to draw 100 ml of air.

b. After a few minutes, examine the bellows for any expansion. Document the findings in the Site Monitoring Log Book. If the pump does not pass the leak test, it will be removed from service immediately and returned to the Facility Manager, to be sent out for repair.

Calibration Test

At least quarterly, the instrument will be calibrated for proper volume measurement. Equipment needed for the calibration test is: 100 ml burette and ring stand; stopwatch; soap solution; detector tube with both ends broken off; and, tygon tubing.

The calibration test is performed as follows:

a. Break both ends of a colorimetric tube and connect it in-line with the pump.

b. Connect the instrument directly to a bubble burette, and create a bubble inside the burette by touching the bottom of the burette to the soap solution.

c. Squeeze the bellows to exhaust all the air out of the unit.

d. Release the bellows and wait 5 minutes for the full volume of air to be drawn into the bellows. The bubble should stop between the 95 and 105 cc marks. Errors of 5% are permissible; if the error is greater than 5%, return the pump to the Facility Manager, to be sent out for repair.

Inventory and Storage Requirements

To inventory the tubes, check the expiration date marked on the storage container. No tubes will be allowed for use past the manufacturer's expiration date. A listing of tubes that are readily available will be maintained by the Health and Safety Coordinator. This list will contain the name of the tube and the expiration date of those available. The list will be updated monthly and provided to the Facility Manager and each Field Division. All colorimetric tubes will be stored in the refrigerator in the Chemical Storage Area. Refrigeration helps to maintain shelf life. Any tubes that have been previously opened and inadvertently stored in the refrigerator will not be used in the field. Colorimetric tubes are not reusable, and any reuse will result in erroneous results.

4. Personal Monitoring Pumps

Personal monitoring involves the collection of an air sample by a sampling device worn by the worker. The sampling device is worn as close as possible to the breathing zone of the individual so that the data collected closely approximates the concentration inhaled. Personal monitoring pumps are used when it is necessary to monitor the workers' exposure to air contaminants.

Personal monitoring pumps can be classified into three basic categories:

a. Low-Flow Pumps (0.5 - 500 ml/min);

b. High-Flow Pumps (500 - 4500 ml/min);

c. Dual Range Pumps.

Low-flow pumps are used for gas and vapor sampling. For example, the common flow rate for organic vapors is 200 ml/min.

High-flow pumps are used for particulate sampling as well as gas and vapor sampling. A common flow rate for fumes or dust sampling (i.e. zinc fume or asbestos) is 2 L/min.

Limitations

The major disadvantage in personal monitoring is the lag time between sampling and obtaining analysis results, which may take weeks, days or months if a remote laboratory is used. If a situation requires an immediate decision concerning worker safety, this can be a serious problem. Therefore, personal monitoring is rarely used for site characterization. Its main purpose is to assure effectiveness of work practice and engineering controls.

A second disadvantage is that multiple exposures may require the use of a variety of sampling media. Unfortunately, workers cannot carry multiple sampling media because of the added strain. Also, it is not usually possible to draw air through different sampling media using a single, portable battery operated pump. Several days may be required to measure the exposure of a specific individual to the variety of chemicals on site. Alternatively, if workers are in teams, a different monitoring device can be assigned to each team member.

Calibration

The following procedure will be used for calibration with a primary calibration source for all personal monitoring pumps used by **CONTRACTOR**. It has been taken from OSHA Instruction CPL 2-2.20B, Appendix 1-C, Manual Bubble Meter Technique.

Electronic bubble meters are also used as primary calibration sources. These meters have a digital read-out and the ability to give a printed copy for documentation of the pump flow rate. **CONTRACTOR** uses a Spectrex Model BFM-4000 for this purpose.

NOTE:
When calibrating with a bubble meter (either manual or electronic), the use of adapters can cause moderate to severe pressure drop in the sampling train, which will affect the calibration result. If adapters are used for sampling, then they should be used when calibrating.

a. Connect the collection device, tubing, pump and calibration apparatus.

b. Conduct a visual inspection on all tygon tubing connections.

c. Wet the inside of a one-liter burette with a soap solution.

d. Turn on the pump and adjust the pump rotameter to the appropriate flow rate setting.

e. Momentarily submerge the opening of the burette in order to catch a film of soap.

f. Draw 2 or 3 bubbles up to the burette in order to insure that the bubbles will complete their run.

g. Visually capture a single bubble and time the bubble from 0 - 1000 ml for high flow pumps or 0 - 100 ml for low flow pumps.

h. The timing accuracy must be within 1 second of the time corresponding to the desired flow rate.

i. If the time is not within the range of accuracy, adjust the flow rate and repeat steps g and h until the correct flow rate is achieved.

j. While the pump is running, mark the pump or record on the air sampling worksheet the position of the center of the float in the pump rotameter as a reference.

k. Repeat bubble timing for 3 times. Calculate the average time given by these measurements.

l. Calculate the flow rate as follows:
(NOTE: 1L = 1000 ml)

$$\frac{\text{Measured Volume (L)}}{\text{Average Seconds}} \times \frac{\text{60 Seconds}}{\text{1 Min}} = \text{L/min}$$

For Example:

$$\frac{\text{1 L}}{\text{38 sec}} \times \frac{\text{60 Sec}}{\text{min}} = \text{1.6 L/min}$$

(round to m)
2 digits)

Repeat the procedures for all pumps to be used for all calibrations involving the same sampling method.

Different contaminants have different sampling protocols, which may result in different calibration protocol. Contact the **CONTRACTOR** Certified Industrial Hygienist or Health and Safety Coordinator for chemical-specific calibration protocols.

Checklist for Using Personal Monitoring Pumps

a. Look at measurement method in NIOSH Pocket Guide to Chemical Hazards (Latest edition).

b. Calibrate with a primary calibration source, as described in the calibration procedures.

c. Record information of air sampling worksheet and calibration logbook.

d. Make sure battery is fully charged. Air pumps have NiCd battery, which creates a memory. Care needs to be used so as to not recharge a battery that has been used for only a few hours. Recharge a battery only if it has been used for at least 8 hours. There are chargers which will completely discharge a battery before recharging; or, the pumps can be left running until the battery is rundown completely and then recharged to eliminate this memory, also.

e. Check sample requirement sheet or NIOSH method to see the minimum time/volume for the sample. An 8-hour sample period would allow for the best measure, giving an 8-hour TWA exposure.

5. Combination Oxygen and Combustible Gas Meter

Combination meters measure the concentration of combustible gas or vapor present in an area, as well as the oxygen content. The concentration is reported as a percent, with 1% equal to 10,000 ppm. Although it is an easy instrument to operate, its effective use requires that the operator understand the operating principles and procedures behind the instrument. Certain atmospheres may cause erroneous readings or damage to the instrument. Typically, the instrument can be used as long as the battery lasts, or for the recommended interval between calibrations.

Maintenance

Maintenance of combination meters is fairly simple. Batteries must be recharged at the end of a continuous day's use. Occasionally, the rechargeable battery must be replaced. Most batteries last for approximately 2 years of continued use. Also, oxygen and combustible gas sensors will need to be replaced periodically. These sensors last approximately 6 months with continued use. Sensors that can no longer be calibrated within the manufacturers' acceptable range indicate the need for replacement.

If, after an attempted calibration, the instrument cannot be calibrated due to problems other than the need for battery or sensor replacement, the problem must be reported to the Facility Manager immediately, so that the instrument can be sent out for repair.

Detection Method

The instrument contains 2 analyzers: 1 for combustible gases and vapors; and 1 for oxygen content. The combustible gas analyzer contains a battery operated electrical circuit called a Wheatstone Bridge. Basically, the Wheatstone Bridge is a filament, usually made of platinum, that is exposed to the air in the instrument. When heated by a burning combustible gas or vapor, the increase in heat over the filament is measured as electrical resistance. Another part of the bridge contains similar filaments, but it has been sealed. They are heated in the same fashion, but not directly in the air stream. Thus, this filament is not capable of causing combustion of the gas or vapor, because it is sealed. The net effect of the change in resistance to the electrical current flow in the air stream is due only to the presence of a combustible gas. These changes in electrical current are registered as "percent LEL" (Lower Explosion Limit) on the instrument.

The oxygen analyzer senses oxygen concentration by a galvanic cell. The cell contains 1 gold and 1 lead electrode, and is encapsulated in inert plastic. Oxygen diffusing through the plastic initiates a redox reaction, which generates a small electrical current that is proportional to the oxygen partial pressure. The instrument contains a temperature-compensated electronic circuit that converts the electrical current to a proportional voltage. This voltage is displayed on the instrument as the concentration of oxygen.

Limitations

The combination meter contains some inherent limitations. Knowledge of these limitations will help the user make an educated decision regarding the accuracy of the instrument.

Accuracy of the instrument depends, in part, on the difference between the calibration and sampling temperatures. Differences in temperature may cause a lack of sensitivity in the instrument when brought from a warm to a cold environment.

Another aspect of sensitivity of the instrument is a function of the differences in the chemical and physical properties between the calibration gas (pentane) and the gas being sampled. The chemical and physical properties of the calibration gas are slightly different from those being sampled, so all gases being sampled are compared to the combustion of pentane. In order to get a true reading of the LEL, the gas that is present must also be used as the calibration gas.

The filament can be damaged by certain compounds such as silicones, halides, tetraethyl lead, and oxygen enriched atmospheres. Each manufacturer's instrument handbook should contain a listing of compounds that should not be sampled with this instrument, or serious damage could result.

Under oxygen deficient atmospheres, the oxygen analyzer must be read first. Otherwise, the CGM analyzer may not provide a valid reading and give the user a false sense of security.

APPENDIX H

CONTROL OF HAZARDOUS ENERGY PROGRAM "LOCK OUT/TAG OUT"

1.0 INTRODUCTION

The Lock Out/Tag Out Standard, 29 CFR 1910.147, is believed to prevent about 120 deaths and 60,000 injuries per year, according to OSHA officials. Although this standard is aimed at the industrial community, in environmental engineering applications, it is very important that employees understand and implement these procedures when working with and around energized equipment. Under this standard, **CONTRACTOR** is required to establish a program that utilizes procedures for locking out and/or tagging to isolate and disable the equipment to prevent accidental start-up or release of stored energy. **CONTRACTOR** employees will identify, locate and control these energy sources, as necessary.

2.0 PURPOSE

To establish procedures for locking out and/or tagging to isolate and disable equipment to prevent accidental startup or release of stored energy, and possible injury to employees.

3.0 SCOPE

This procedure applies to all field/facility operations that require all operative energy sources, including line breaking, in the work area to be shut down, locked out and tagged, so that **CONTRACTOR** employees may safely perform their job. Contractors and subcontractors performing work on **CONTRACTOR** projects will be required to comply with these requirements if their employer does not have a comparable lock out/tag out program already in place.

4.0 PROCEDURE

1. The authorized employee will evaluate the scope of work and all equipment, machines or industrial processes in the area that require the use of stored energy. Energized equipment that may cause a safety hazard will be shut down to eliminate the potential for injury.

2. Prior to beginning the work, the authorized employee will be sure that appropriate lock out/tag out equipment is available to isolate the energy source.

3. The authorized employee will ensure that all affected employees have been advised of the following topics:

   a. Scope of Work.

   b. Energy sources.

   c. Energy isolation devices.

   d. Lock out devices.

   e. Tags.

   f. Test procedures.

   g. Authorized personnel. Those individuals charged with the responsibility for deenergizing and reenergizing energy sources).

4. The safety meeting will be documented and placed in the job folder for future reference. All employees will sign the Lockout Worksheet prior to starting the work. See Appendix A for a copy of the Lockout Worksheet.

5. All energized equipment will be shut down before **CONTRACTOR** personnel or its contractors/subcontractors begin work on site. Shut down will take place in the following manner:

   a. The authorized employee will inform the client's representative of the need to shut down the equipment.

   b. The authorized employee, with assistance from the client's representative, will locate all power sources on the process or equipment.

   c. All power sources will be shut down and verified as such by the authorized employee.

   d. When possible, a lockout device will be applied by both parties to isolate each source.

   e. Any necessary testing of equipment will be conducted to ensure that the process or equipment is free of energy.

   f. The authorized employee will attempt to operate the machine to be sure that it remains inoperative. All activation controls will be returned to the "off" position after testing.

   g. The authorized employee will apply a tag that bears the following warning, "DANGER - EQUIPMENT LOCKOUT" along with the authorized employee's name, the date, and the time of the lockout.

   h. The authorized employee will complete the Lockout Worksheet.

   i. Equipment may now be released for work by the authorized employee. No release will be given until all required inspections and testing are performed.

6. Residual energy, i.e. pneumatic/hydraulic power, spring compression, and residual electrical energy in transformers are examples of residual energy that, when unsuspected, may present a greater hazard to the employee. These sources of energy will be identified, located and controlled in the following manner:

   a. Residual electrical energy can be controlled through grounding.

   b. Pneumatic/hydraulic line pressure can be released, allowing the weight to come to a rest.

   c. Spring tensions can be relieved.

   d. Product lines will be double blocked (panned) and bled to prevent product from being released.

   e. A lockout device and tag will be applied and secured by the authorized employee for the duration of the job to prevent residual energy from reaccumulating and creating a hazard to employees.

   f. The lockout/tagout will be documented by the authorized employee on the Lockout Worksheet.

7. After all work is completed, the authorized employee will perform the following:

   a. The authorized employee will inform everyone that the job is complete.

   b. The Lockout Worksheet will be reviewed by the authorized employee with all employees to make sure that all employees are accounted for before re-energizing the equipment.

   c. The authorized employee will be sure that all tools, debris or other material that could be placed into motion are removed before the equipment or process is re-energized. All employees will be instructed to stay clear of movable parts of the equipment or process.

   d. All residual energy controls will be removed by the authorized employee, as well as all energy isolation lockouts and tags.

   e. In the presence of the client's representative, energy will be restored to the equipment or process.

   f. All lockout equipment removal will be documented on the Lockout Worksheet by the authorized employee. The Lockout Sheet will be placed in the job file at the end of the shift.

8. All employees must be accounted for before re-energizing equipment. When employees that have worked on the job are absent from the final inspection before re-energizing the equipment, the authorized employee will initiate the following:

   a. The lockout sheet will be checked to account for all employees.

   b. The authorized employee will obtain a Lockout/Tagout Absent Employee form (See Appendix B).

   c. The authorized employee will appoint employees to look for the individual, paying special attention to high hazard areas where physical harm could result from the start-up of the equipment or process.

d. After a complete search of the equipment or process, and it has been determined by the authorized employee that the employee is not present, all outlying areas surrounding the site will be searched.

e. The area surrounding the site will be guarded to prevent the absent employee from inadvertently entering a hazardous situation.

f. The equipment or process will be cleared for re-energization only by the authorized employee once all of the above conditions are met.

g. A copy of the completed Absent Employee form will be posted conspicuously in the work area, and not removed until the employee has been located. The client's representative will be notified of the situation so that the absent employee does not endanger himself/herself by entering an energized process or equipment.

9. When appropriate, contractors and subcontractors working under **CONTRACTOR**'s direction will be informed of their responsibilities, under the Lockout/Tagout Standard, to provide protection against hazardous energy.

   a. When necessary within the scope of work, contractors and subcontractors without such a program, at the discretion of **CONTRACTOR**, will be disqualified from bidding on these projects.

   b. Contractors and subcontractors with such a program will submit their program to the Health and Safety Division for review. The contractor or subcontractor program must be comparable or more strict than **CONTRACTOR**'s program.

      - Programs found to be insufficient in some areas will be returned, with the requested changes to be made before the program is acceptable for implementation.

      - The copy of the program will be returned to the contractor or subcontractor, and will not be duplicated by **CONTRACTOR** or any of its employees.

10. All affected employees will be given training in these procedures prior to performing any lockout/tagout work. This training will be documented and maintained in the employees' training file with the Health and Safety Division.

11. This procedure will be reviewed annually by the Health and Safety Division to ensure that it is relevant to **CONTRACTOR** operations.

DEFINITIONS

Affected Employee: An employee whose job requires operation/use of equipment or machines on which servicing or maintenance is being performed under lockout or tagout, or whose job requires him/her to work in an area in which such servicing or maintenance is being performed. All **CONTRACTOR** personnel or subcontractors working in these circumstances are "affected employees".

Authorized Employee: A person who locks out or implements a tagout system procedure on machines or equipment in connection with the servicing or maintenance on that machine or equipment. An authorized person and an affected employee may be the same person when the affected employee's duties also include performing a lock out or tag out on a machine or equipment.

Capable of being Locked Out: An energy isolating device will be considered to be capable of being locked out either if it designed with a hasp or other attachment or integral part to which, or through which, a lock can be affixed, or if it has a locking mechanism built into it. Other energy isolating devices will also be considered to be capable of being locked out, if lockout can be achieved without the need to dismantle, rebuild, or replace the energy isolating device or permanently alter its energy control capability.

Energized: Connected to an energy source or containing residual or stored energy.

Energy Isolating Device: A mechanical device that physically prevents the transmission or release of energy, including but not limited to the following: a manually operated electrical circuit breaker; a disconnect switch; a manually operated switch by which the conductors of a circuit can be disconnected from all ungrounded supply conductors, and, in addition, no pole can be operated independently; a slide gate; a slip blind; a line valve; a block; and, any similar device used to block or isolate energy. The term does not include a push button, selector switch, and other control circuit type devices.

Energy Source: Any source of electrical, mechanical, hydraulic, pneumatic, chemical, thermal, or other energy.

Lockout: The placement of a lockout device on an energy isolating device, in accordance with an established procedure, ensuring that the energy isolating device and the equipment being controlled cannot be operated until the lockout device is removed.

Lockout Device: A device that utilizes a positive means such as a lock, either key or combination type, to hold an energy isolating device in the safe position and prevent the energizing of a machine or equipment.

Tagout: The placement of a tagout device on an energy isolating device, in accordance with an established procedure, to indicate that the energy isolating device and the equipment being controlled may not be operated until the tagout device is removed.

Tagout Device: A prominent warning device, such as a tag and a means of attachment, which can be securely fastened to an energy isolating device in accordance with an established procedure, to indicate that the energy isolating device and the equipment being controlled may not be operated until the tagout device is removed.

APPENDIX A

LOCKOUT WORKSHEET

LOCKOUT WORKSHEET

Job Location: ___________________ Project Manager: _______________________________________

Date: _______________________ Time: ____ a.m./p.m.

Description of Lockout to be Performed: ____

Energy Source(s): _

Pre-Work Safety Meeting Minutes: ____

Lockout Hardware Used: ____

Energy Restoration (Check each as you Progress):

		Time Completed
___	All personnel accounted for and in the clear.	____________________
___	Point(s) of operation free of tools and debris.	____________________
___	Points of operation restraints removed.	____________________
___	Lockout hardware removed.	____________________
___	Personnel clear of points of operation.	____________________
___	Energy restored.	____________________
___	Equipment operation verified, client's rep on site.	____________________
___	Lockout terminated.	____________________

Employees' Signatures: ____

APPENDIX B

LOCKOUT/TAGOUT ABSENT EMPLOYEE FORM

LOCKOUT/TAGOUT ABSENT EMPLOYEE FORM

NOTICE

Upon completion of work performed under lockout/tagout conditions, the following employee(s) listed below could not be located or accounted for:

____

____

____

All attempts have been made to locate this employee at the jobsite. It has been verified that this employee is not in the vicinity of the hazardous energy source and will not be affected by the startup of equipment which was under lockout conditions.

____ __________________________________
Signature of Authorized Employee Date

APPENDIX I

CONFINED SPACE/HOT WORK PERMITTING PROCEDURE

1.0 INTRODUCTION

Welding, cutting, brazing and other hot work operations are a necessary part of the industrial world, both in manufacturing and construction. Too often, the people who hire, use, or supervise the use of these processes don't understand the hazards behind them, which can result in loss of life, property, or both, by fire and explosion.

Any material that is combustible or flammable is susceptible to ignition by heat-producing activity. Common materials such as floors, partitions, roofs, wooden members, paper, textiles, plastics, chemicals, flammable liquids and gases, and grass or brush are very likely to become involved in fire during hot work operations if adequate precautions are not taken.

Hot work is any work that requires the use of tools/equipment that have the potential to produce temperatures which could reasonably be expected to ignite flammable/combustible material or atmospheres in the vicinity of the work area. These tools/equipment have the capability of producing sparks, open flames, heat, or an electrical arc during use. Hot work is not limited to just welding, cutting and brazing, but also grinding, sawing (metal to metal) and chipping operations.

Confined spaces are spaces that can be bodily entered but are not meant for human occupancy. Confined space hazards exist if the potential for hazardous or explosive atmospheres and/or oxygen deficient hazards exist. Other hazards that could exist include mechanical sources and falls. Two types of confined spaces exist: permit required and non-permit required.

2.0 PURPOSE

To provide **CONTRACTOR** employees, who oversee hot work performed and confined space entry on projects, with a standard permitting and safety procedure to prevent injury or loss of life and property. To be used as a reference in instances where hot work/confined space entry is performed and as a permit procedure in instances where one is not available.

3.0 SCOPE

This procedure will apply to all **CONTRACTOR** employees who oversee hot work on projects utilizing welding, cutting, brazing, grinding, chipping, portable heaters, and other potential heat-producing equipment for field/facility activities. This procedure is also to be followed for all confined space entry situations. This procedure will apply to all contractors or subcontractors working under **CONTRACTOR** that do not have an adequate Permitting Procedure in place with the company in which they are currently employed. All **CONTRACTOR** employees involved with confined space entry will be properly trained for the role and duties performed. Training will consist of hands-on training with **CONTRACTOR**'s confined space entry equipment including harnesses, retrieval equipment, air-line respirators and monitoring equipment. Certification that the training was satisfactorily complete will be provided and documentation maintained.

4.0 PROCEDURE

1. Hazard Identification

a. The Project Manager will identify all work that requires tools, equipment, or operations that may produce sparks or temperatures that are sufficient to ignite flammable/combustible materials or atmospheres.

b. The Project Manager will determine if a confined space entry is required and determine if the entry requires a permit. Any situation that has the potential to produce hazardous atmospheres or deplete oxygen will require a permit.

c. This information will be included in the Site Specific Health and Safety Plan to be reviewed with the Health and Safety Division prior to starting the project.

d. The Project Manager will determine if the work can be performed without the use of hot work, i.e. alternative method to reduce the hazard.

e. The Project Manager should consult the Health and Safety Division if the Project Manager has questions on hazard determination. The Project Manager will act as the Entry Supervisor.

f. The Safety Director will review entry with the Project Manager and review this program at least annually to make sure the Program is effective and enforced. Copies of completed permits will be retained for at least one year.

g. The permit program will be reviewed to determine if it is adequate for the projects conducted. Incident reports will be reviewed, employee issues raised and entries reviewed. The permit program will be evaluated to determine if all hazards were adequately identified and evaluated. Additional protective equipment will be purchased, if necessary, for future entries if the review process shows that all hazards were not properly controlled. This review will be part of annual confined space training.

2. Area Preparation

a. The following preparation for the work area will be made once it is determined that hot work is necessary:

- All flammable/combustible materials will be relocated at least 35 feet away from the work area.

- All combustible materials that cannot be reasonably removed from the area will be covered with a fire blanket.

- An appropriate fully charged fire extinguisher and/or charged fire hose will be available at the work area before, during and 1/2 hour after hot work procedures have ended.

- All safety equipment will be on-site and functional.

The confined space entry area will be appropriately marked and barricaded to prevent impact from external hazards and vehicles. Ground level entries will be ringed with a toe board to prevent objects from inadvertently being dropped into the space.

3. Pre-Work Safety Meeting

a. The Project Manager will assure that a pre-work safety meeting has been provided to the crew prior to any hot work/confined space entry being performed. Individuals involved with confined space entry will be identified as the authorized entrant(s), attendant and the entry supervisor. Additional individuals may be designated to conduct monitoring for multiple entries. This meeting will include, but not be limited to:

- Permitting conditions (environmental conditions, type of work to be performed). This would include reviewing the results of the initial monitoring of the test results, ventilation requirements, potential hazards and continuous testing procedures.

- Personnel authorized to sign-off on the permit. All personnel involved with the confined space entry must sign the permit and acknowledge the hazards expected to be encountered.

- Location of the permit. (Must be conspicuously posted.)

- Type of monitoring required. Employees involved with the entry may request additional monitoring or increasing monitoring frequency at any time.

- Designation of attendant and discussion of duties.

- Returning completed permit to Project Manager or client when work is complete and project has concluded.

b. During the pre-work safety meeting the authorized entrants will be identified and the entry procedure reviewed. The attendant will be specified and the monitoring and communication procedures reviewed. The entry will be reviewed with the designated entry supervisor before entry. The attendant will be responsible for conducting the air monitoring during the entry and providing results to the entrants and entry supervisor. The designated positions will be posted on the entry permit.

c. The entry supervisor will be responsible for meeting with the client prior to entry to identify if other contractors or client personnel will be working in close proximity to the confined space entry. The entry supervisor will coordinate entry activities in order to make sure the other work does not impact the entry or endanger entry personnel. The entry supervisor will attend scheduled project meetings with the client and other contractor representatives in order to properly coordinate the entry with other projects.

d Initial air-monitoring results will be reviewed with the entry supervisor and the authorized entrants prior to entry. Air-monitoring procedures and alarm levels will also be reviewed. Ventilation of the space will be initiated before entry and periodic monitoring conducted prior to entry to verify the ventilation is adequate. Monitoring will be performed throughout entry by the attendant and entrants will wear dosimeters with alarms to conduct monitoring during the entry.

e The Project Manager will meet with the client to arrange for adequate rescue services from the client, if available, or from outside rescue operations. The Project Manager will discuss rescue procedures with representatives of the rescue operation and allow the rescue team to examine the area, practice the rescue and decline to act as the rescue team if they feel they are not adequately staffed or equipped. The entry cannot be conducted until adequate rescue services are provided.

f The Project Manager will meet with the client to discuss other projects or contractors that could interfere with **CONTRACTOR**'s confined space work. **CONTRACTOR** will coordinate the entry to have minimal impact on other contractors in the area and to make sure **CONTRACTOR** personnel are not endangered by other contractors work.

4. Permit Completion

The Confined Space Work Permit (see Appendix A) will be completed by the Project Manager prior to beginning work each day. The permit will not be considered valid until all personnel involved with the entry have reviewed and signed the entry permit. The entry supervisor will review each permit at the completion of the entry to determine if monitoring and safety procedures are adequate for this project. The permit will be modified if appropriate. The permit will be conspicuously posted at the site of the work.

5. Attendant

A designated Attendant will be present to observe the hot work/confined space operation. The Attendant will maintain contact with personnel and conduct air monitoring. The Attendant will oversee safety retrieval systems and initiate the alarm if rescue is necessary. The Attendant will not perform entry rescue or enter the confined space unless relieved of duty by another authorized Attendant and is equipped with maximum respirator protection. The Attendant will monitor only one confined space entry at one time.

6. Entrant

Entrants will be identified on the permit and instructed on the purpose for the entry of the confined space. Entrants are responsible for adhering to the permit requirements and communicating with the Attendant. Once work tasks are completed the Entrant is responsible for removing equipment, sampling devices and exiting the confined space safely.

7. Atmospheric Monitoring

a. When cutting, grinding, heating or welding surfaces coated with epoxy finishes or paint, or when cutting certain metals with a welding torch, toxic fumes or vapors can be emitted in the process. In these instances, monitoring may be required under the OSHA Standard. Therefore, it is the responsibility of the Project Manager to notify the Health and Safety Coordinator of these coatings and have them sampled (if unknown) to determine what type of monitoring will be required.

b. Occasionally, a "liner" will be adhered to the inside of a metal duct or tank. When hot work will be performed on such material, the liner will be removed at least 4 inches to each side of the cut to prevent toxic vapors from being emitted, or fire from occurring.

c. After moving all flammable materials out of the work area, the area will be monitored with a Combustible Gas Meter immediately before hot work takes place. LEL readings at or above 5% will necessitate that the area be ventilated before hot work operations begin. **Hot work should not proceed if readings of five percent or below cannot be achieved.**

d. All area monitoring must be performed a minimum of once every 10 minutes when the hot work area is located in a low lying area down slope from a storage area containing flammable and/or combustible liquids.

e. Hot work performed in confined spaces requires that contaminant specific air monitoring be performed. Contact the Health and Safety Division to determine the type of air monitoring required for the contaminant.

f. Hot work performed on containers that previously contained flammable liquids (i.e. underground storage tanks) will not be performed until the Health and Safety Division has been contacted and has approved the work to be performed. **CONTRACTOR**'s Site Specific Health and Safety Plan for Flammable and Combustible Underground Storage Tank Removals contains detailed procedures for cleaning, inerting and cutting these types of containers.

g. Entrants and the attendant will continuously evaluate the permit-required space to determine if additional monitoring or more frequent monitoring is necessary. The permit may be revoked or modified accordingly. All entrants will leave the space if unsafe conditions are observed or measured. The permit will be invalidated and reviewed with the supervisor before re-entry is allowed. Additional monitoring will be performed at the request of employees or attendants.

8. Prohibitive Circumstances

a. Hot work will be prohibited if any of the following conditions exist:

- Oxygen levels greater than 21%.
- LEL greater than 5%.

- Organic vapor concentration greater than Permissible Exposure Limits depending on contaminant (ventilation may reduce this hazard).

- Confined space entry will not be permitted if oxygen levels are below 19.5% or if the LEL is >10%. Individual hazardous constituents will be monitored and appropriate levels of respiratory protection will be issued.

9. Conditions of Permit Validity

   a. A permit is not valid unless all necessary inspections and air monitoring (if required) have been performed and all required signatures appear on the permit.

   b. Work permits will be judged as valid for the following time durations:

      - Shift or significant change in personnel.

      - Duration of the hot work.

      - When atmospheric changes dictate ceasing the operation, abate the hazard and reinspect the work area before completing another permit.

   c. Permits are valid up to one day and new permits must be completed each day or whenever the permit conditions change.

   d. The local Fire Department or client emergency services will be contacted prior to entry into confined spaces. They will be notified of the reason for entry and be requested to be available for rescue and administrating first aid. If emergency rescue cannot be provided within three minutes **CONTRACTOR** will not conduct the entry. The permit program will be reviewed to determine if it is adequate for the projects conducted. Incident reports will be reviewed, employee issues raised and entries reviewed. The permit program will be evaluated to determine if all hazards were adequately identified and evaluated. Additional protective equipment will be purchased, if necessary, for future entries if the review process shows that all hazards were not properly controlled. This review will be part of annual confined space training.

   e. **CONTRACTOR** will coordinate the entry with client and/or other contractors present at the job site. Work will be evaluated to determine the impact by non-**CONTRACTOR** staff on the work being conducted.

   f. If conditions change and **CONTRACTOR** employees are at risk the permit will be considered invalid.

   g. The permit will be canceled once the project is complete or conditions change that warrant leaving the site. A new permit will be issued for future entries once a permit has been canceled.

10. Training and Program Review

All workers involved with confined space entry will receive training relative to their role on the project. Since **CONTRACTOR** conducts confined space entry infrequently training will be conducted prior to each project in order to refresh **CONTRACTOR** employees on the use of the equipment, monitoring procedures and the confined space entry program. The program will be reviewed annually or when new equipment is acquired. All completed permits will be reviewed and critiqued at the completion of each entry. The entrants and attendants will be interviewed after entry to determine if there were significant problems or concerns.

DEFINITIONS

Fire Blanket: Blanket made of fire-resistant material, such as NOMEX or KEVLAR (**not asbestos**), or treated wool, which can be used to cover combustible materials to prevent their ignition from sparks, flames or heat during hot work.

Attendant: Person who observes the confined space activities/hot work to ensure that ignition of the surrounding material does not occur. The Attendant will be equipped with a fully charged, suitable fire extinguisher and/or charged fire hose at the work area at the time of the hot work. The Attendant will not be assigned to any other duties.

Confined Space: Confined spaces are spaces that can be bodily entered but are not meant for human occupancy.

Entrant: Person who is trained and authorized to enter a confined space. Entrants are required to review air-monitoring data prior to entry into a PRCS and understand the hazards.

APPENDIX A

CONFINED SPACE PERMIT

CONTRACTOR

Confined Space Entry Permit

- Location of Confined Space ________________ Date/time ______________________
  Purpose of entry __________________________ Duration ______________________

AUTHORIZED BY________________ **EXPIRES ON**_________________

Attendant ____
Authorized Entrants ____

Measures for Isolating Equipment	**YES**	**NO**	Measures for Isolating Equipment	**YES**	**NO**
LOTO			Protective clothing		
Lines capped			Communications equipment		
Purging			Hot work permit needed		
Ventilation			Other PPE		
Secure area			Special conditions		
Harness and retrieval system					
Fire extinguishers					
Air line system					
SCBAs					
Other Respirators					

Atmospheric Monitoring

Tests to be Taken	yes	no	Acceptable Entry Conditions	Test # Date: Time:	1	2	3	4	5	6	7	8	9	10
Oxygen			19.5-23.5%											
LEL			<10%											
CO			<25 ppm											
H_2S			<5 ppm											
Other														

Individual conducting test:____
Supervisor authorizing entry____

Instruments used:

Instrument(s) name	Type	Serial #

Standby persons:____
Emergency and rescue contact:____

Entry supervisor approval to conduct entry______________________ Date/time_________

APPENDIX J

INCIDENT REPORTING

1.0 ACCIDENT AND INCIDENT REPORTING

It is important that all accidents and incidents that result in injury, illness, or medical treatment be reported immediately. Reporting consists of calling the Teleclaim Center and providing information on the injury. The Teleclaim Center will complete the first report of injury and file it accordingly. Copies will be sent to the Safety Director. Supervisors are required to complete the Supervisor's Report of Accident included in this section. It is **CONTRACTOR**'s responsibility to investigate each incident, file appropriate paperwork and conduct a follow-up analysis of each incident.

2.0 REPORTING PHONE NUMBERS

Safety and Health Director: XXX-XXX-XXXX
Human Resources Director: XXX-XXX-XXXX

3.0 FIRST AID AND MEDICAL TREATMENT

CONTRACTOR provides a First Aid Kit on each site and in each Company vehicle. It is there for use in the treatment of minor scratches, burns, headaches, nausea, etc. Each employee should verify the location of the nearest first aid kit and should make use of it whenever needed. Each kit is fully stocked and restocked monthly by an outside vendor. The kit includes bandages, over the counter medications, disinfecting supplies and topical ointments. The user of each kit is responsible for contacting the vendor to replace items used or submitting the kit to **CONTRACTOR** for replacement. Kits are to be inventoried by the Project Manager before being sent in the field. Only completely stocked kits are to be brought into the field. The kits are maintained in a weatherproof container and in accordance with ANSI Standard Z308.1-1998. The first aid supplies in each kit are included in Appendix A.

Any work related injury or illnesses that requires professional medical assistance should be reported immediately. Failure to promptly notify of a work related injury could make the claim questionable and subject to stricter review. The nearest medical center or hospital will be identified for each project. The phone number and location for this center will be determined before commencing field activities and be included in the Health and Safety Plan. The phone numbers will be posted by Health and Safety Director or the Project Manager and available to all employees in order to provide prompt response to all injuries. The Project Manager will contact the nearest medical facility to determine the facility's capabilities and verify that the facility is willing to provide emergency medical services.

4.0 FIRST AID

Each **CONTRACTOR** project will have at least one certified CPR/first aid trained person on site at all times. All Project Managers and anyone acting as the on-site Health and Safety Officer must be current in First Aid/CPR. First aid training sponsored by the American Red Cross is acceptable and must be renewed every three years. CPR training must be renewed annually. Other first aid training will be reviewed to see if it is comparable to the Red Cross training.

1. Minor First Aid Treatment

First aid kits are stored in each company vehicle. If an injury is sustained or results in minor first aid treatment:

a. Inform your supervisor.
b. Administer first aid treatment to the injury or wound.
c. If a first aid kit is used, indicate usage on the accident investigation report.
d. Access to a first aid kit is not intended to be a substitute for medical attention.
e. Provide details for the completion of the accident investigation report.

2. Non-Emergency Medical Treatment

For non-emergency work-related injuries requiring professional medical assistance, management must first authorize treatment. If you sustain an injury requiring treatment other than first aid:

a. Inform your supervisor.

b. Proceed to the posted medical facility. Your supervisor will assist with transportation, if necessary.

c. Provide details for the completion of the accident investigation report.

3. Emergency Medical Treatment

If you sustain a severe injury requiring emergency treatment:

a. Call for help and seek assistance from a co-worker.

b. Use the emergency telephone numbers and instructions posted next to the telephone in your work area to request assistance and transportation to the local hospital emergency room.

c. Provide details for the completion of the accident investigation report.

d. The Project Manager will identify an ER provider for each long-term project for emergency medical services. The phone number will be posted at each job site.

4. First Aid Training

Each employee will receive training and instructions from his or her supervisor on our first aid procedures.

5. Wounds

a. Minor - Cuts, lacerations, abrasions, or punctures

- Wash the wound using soap and water; rinse it well.
- Cover the wound using clean dressing.

b. Major - Large, deep and bleeding

- Stop the bleeding by pressing directly on the wound, using a bandage or cloth.
- Keep pressure on the wound until medical help arrives.

6. Broken Bones

a. Do not move the victim unless it is absolutely necessary.

b. If the victim must be moved, "splint" the injured area. Use a board, cardboard, or rolled newspaper as a splint.

7. Burns

a. Thermal (Heat)

- Rinse the burned area, without scrubbing it, and immerse it in cold water; do not use ice water.

- Blot dry the area and cover it using sterile gauze or a clean cloth.

c. Chemical

- Flush the exposed area with cool water immediately for 15 to 20 minutes.

8. Eye Injury

a. Small particles

- Do not rub your eyes.

- Use the corner of a soft clean cloth to draw particles out, or hold the eyelids open and flush the eyes continuously with water.

b. Large or stuck particles

- If a particle is stuck in the eye, do not attempt to remove it.
- Cover both eyes with bandage.

c. Chemical

- Immediately irrigate the eyes and under the eyelids, with water, for 30 minutes.

9. Neck And Spine Injury

If the victim appears to have injured his or her neck or spine, or is unable to move his or her arm or leg, do not attempt to move the victim unless it is absolutely necessary.

10. Heat Exhaustion

a. Loosen the victim's tight clothing.
b. Give the victim "sips" of cool water.
c. Make the victim lie down in a cooler place with the feet raised.

5.0 WORKERS' COMPENSATION

Every state has a Workers' Compensation Law to provide benefits to employees for lost wages and medical bills resulting from a work related injury or illness. You are covered under Workers' Compensation. You may request Workers' Compensation benefits from your supervisor. Qualification for benefits is determined by the state, not **CONTRACTOR**. Employees are responsible for keeping appointments, following doctors' instructions on and off the job, maintaining good communication with your supervisor, and to fully cooperating with all instructions given.

Workers' Compensation provides wages at a <u>lower pay scale</u> than what you may earn by working.

1. <u>Employee Safety Rights</u>

Employees have several important rights concerning safety, which are protected by federal, state and local laws that you should be aware of. They are:

a. The right to a safe work-place free from recognized hazards.

b. The right to request information on safety and health hazards in the workplace, precautions that may be taken, and procedures to be followed if an employee is injured or exposed to toxic substances.

c. The right to know about the hazards associated with the chemicals you work with, and the safety procedures.

d. The right to question any instruction which may violate a safety rule, which puts someone in unnecessary danger of serious injury.

e. The right of freedom from retaliation for demanding safety rights.

2. Safety Responsibilities

Employees also have some important responsibilities concerning safety. These are:

a. The responsibility of reporting all injuries and illnesses to your supervisor, no matter how small.

b. The responsibility of always following the safety rules for every task performed.

c. The responsibility of reporting any hazards seen.

d. The responsibility of helping co-workers recognize unsafe actions or conditions.

e. The responsibility of asking about the safety rules.

3. Employee Safety Rules

It is impossible to list or include all safety rules for all the possible tasks. But the following rules have been prepared to help the employee avoid hazards, which may cause injury while doing some of the more common tasks. Failure to follow safety rules and /or safe practices will result in disciplinary action, up to and including termination.

6.0 GENERAL SAFETY RULES

a. Read and follow the safety notices and other information that is posted.

b. Observe and follow all safety instructions, signs, and operation procedures.

c. Help your fellow employee when they ask for assistance or when needed for their safety.

d. Never participate in "horseplay". Horseplay that results in injury is often not covered by Workers' Compensation.

e. Clean up spills immediately.

f. Report all unsafe conditions, hazards, or equipment immediately. Make sure other people are warned of the problem so that they may avoid it.

g. Wear personal protective equipment as required to reduce injury potential. Use gloves, safety glasses, back support belts, etc., as necessary.

h. Never stand on chairs, furniture, or anything other than an approved ladder or step stool.

i. Never use intoxicating beverages or controlled drugs before or during work. Prescription medication should only be used at work with your Doctor's approval.

1. Fire Safety

a. Report all fire hazards to your supervisor immediately.

b. Fire fighting equipment shall be used only for fire fighting purposes.

c. Smoking is not permitted at any time in the areas where "No Smoking" signs are posted.

d. Do not block off access to fire fighting equipment.

e. Keep doors, aisles, fire escapes and stairways completely unobstructed at all times.

f. In the case of a fire, your first consideration must be the safety of all persons, then attention should be directed to the protection of property.

g. Change clothes immediately if they are soaked with oil, gasoline, paint thinner or any other flammable liquid.

h. Know how to report a fire and how to turn on a fire alarm.

i. Know the location of all fire extinguishers, and how to use them.

j. Know the fire exits to be used in an emergency.

7.0 HAND TOOL SAFETY

a. Wear protective equipment necessary for the job you are performing. Discuss any required safety equipment with your supervisor as changes occur.

b. Defective tools must not be used.

c. Do not carry sharp hand tools in clothing.

d. Check all wiring on electric hand tools for proper insulation and 3-prong plug grounding.

e. **Hammers:** Use eye protection at all times!

f. **Screwdrivers:** Use the right size and type of screwdriver for the job. Do not use a screwdriver as a chisel.

g. **Wrenches:** In using any wrench, it is better to pull than to push. If you have to push, use your open palm. Use the proper wrench for the job.

h. **Handsaws:** Saws that are sharp and rust free are less likely to bind or jump. Insure the object being cut is secured tightly to a flat surface.

8.0 PROTECTIVE EQUIPMENT

a. Approved eye protection (safety glasses with side shields, goggles, etc.) must be worn at all times when assigned any certain job classifications. It is important to check with your supervisor to assure compliance.

b. Moccasins and shoes with open toes or high heels are not permitted.

c. Wear protective clothing and equipment as required by your job classification to protect against hazards at hand. These include, but are not limited to, hard hats, steel-toed shoes, gloves, fall safety harnesses, earplugs, etc.

9.0 MATERIAL HANDLING SAFETY RULES

a. When lifting, lift properly. Keep the back straight, stand close to the load, and use your leg muscles to do the lifting, keeping the load close to the body. Never twist your upper body while carrying a load.

b. When lifting heavy objects, utilize a two-wheeled dolly, or, ask for assistance from another employee.

c. Inspect the object you are going to lift for sharp corners, nails, black widow spiders, or other things that may cause injury.

d. Use gloves when handling rough or sharp materials.

10.0 HOUSEKEEPING

a. Do not place materials in aisles, stairways, or any designated path of travel.

b. Stack material at a safe height so that material will not fall if bumped. Insure heavy loads have proper support, and make sure there is no overhanging or irregular stacking of material.

c. Place all trash or scrap in places provided. Clean up all spills immediately.

d. Report worn or broken flooring, stair treads, handrails, furniture, or other office equipment.

e. Smoking is permitted only in designated areas. Use ashtrays for disposing of butts. Do not throw butts on the floor.

Supervisor's Report of Accident

Supervisor's Name: ____

Basic Rules for Accident Investigation

- Find the cause to prevent future accidents - Use an unbiased approach during investigation
- Interview witnesses & injured employees at the scene - conduct a walkthrough of the accident
- Conduct interviews in private - Interview one witness at a time.
- Get signed statements from all involved.
- Take photos or make a sketch of the accident scene.
- What hazards are present - what unsafe acts contributed to accident
- Ensure hazardous conditions are corrected immediately.

Date & Time		**Location**	
Tasks performed		**Witnesses**	
Resulted in	**__ Injury __ Fatality** **__Property Damage**	**Property Damage**	
Injured		**Injured**	
Describe Accident Facts & Events			

Supervisor's Root Cause Analysis		*Check ALL that apply to this accident*	
Unsafe Acts		**Unsafe Conditions**	
Improper work technique		Poor Workstation design	
Safety rule violation		Unsafe Operation Method	
Improper PPE or PPE not used		Improper Maintenance	
Operating without authority		Lack of direct supervision	
Failure to warn or secure		Insufficient Training	
Operating at improper speeds		Lack of experience	
By-passing safety devices		Insufficient knowledge of job	
Protective equipment not in use		Slippery conditions	
Improper loading or placement		Excessive noise	
Improper lifting		Inadequate guarding of hazards	
Servicing machinery in motion		Defective tools/equipment	

Horseplay		Poor housekeeping	
Drug or alcohol use		Insufficient lighting	
Unsafe Acts require a written warning and re-training <u>before</u> the Employee resumes work			
Date		**Date**	
Re-Training Assigned		Unsafe Condition Guarded	
Re-Training Completed		Unsafe Condition Corrected	
Supervisor Signature		**Supervisor Signature**	

Accident Report Review

Supervisor ____ Date _______________

Department Superintendent __________________________ Date _______________

Safety Manager ___________________________________ Date _______________

Plant Manager ____________________________________ Date _______________

APPENDIX A

First Aid Kits

Each first aid kit is in a weather proof container and contains the following:

Item	Amount
Ear Plugs	2 pair
Band-aids	2 boxes
Sterile pads	5 2”x2”
Oval eye pads	2
Tylenol	10
Burn cream	1 tube
Tweezers	1 each
Scissors	1 each
Triangular bandage	1
Antiseptic wipes	1 box
Ammonia inhalants	1 box
Flexible gauze	1 roll
First aid guide	
Latex gloves	2 pair

KeySpan Corporation
Quality Assurance/Quality Control Program Plan

Bay Shore / Brightwaters Yard Former MGP Site
Bay Shore, New York

MARCH 2004

TABLE OF CONTENTS

SECTION **PAGE**

TABLE OF CONTENTS

PAGE

LIST OF TABLES

TABLE **PAGE**

1.0 INTRODUCTION

This Quality Assurance/Quality Control Program Plan presents the organization, objectives, planned activities, and specific quality assurance/quality control (QA/QC) procedures associated with investigation and remediation Work Plans for the Bay Shore Former MGP Site project in Bay Shore, New York. Task-specific addenda to this plan may be provided for future investigations or remediation elements at these sites as needed.

The plan describes specific protocols for field sampling, sample handling and storage, chain-of-custody, laboratory analysis, and data handling and management. Preparation of the plan was based on US EPA Quality Assurance Project Plan (QAPP) and New York State Department of Environmental Conservation (NYSDEC) guidance documents, including:

- *US EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations (EPA QA/R-5, October 1998), and*
- *Guidance for Quality Assurance Project Plans (EPA QA/G-5, February 1998)*, and
- *Draft DER-10, Technical Guidance for Site Investigation and Remediation (NYSDEC, December, 2002).*

Task-specific plan addendum may accompany a task-specific work plan if this document does not completely cover the tasks in the work plan. The addendum will provide a description of the site and will list the project quality objectives and outline the proposed samples and analytical parameters. The data generated from the analysis of samples will be used to determine the extent of contamination, identify impacted targets, and to compare the results of the remedial actions to site-specific cleanup goals. A list of the potential parameters to be analyzed, including their respective quantitation limits (QLs), and data quality levels (DQLs), is shown in Tables 1a and 1b.

2.0 PROJECT ORGANIZATION AND RESPONSIBILITY

CONSULTANT will coordinate and manage with KeySpan, Bay Shore Former MGP Site Operable Units (OU) OU-1, OU-2, OU-3 and OU-4 sampling and analysis program, data reduction, QA/QC, data validation, analysis, and reporting. **CONSULTANT** will direct the sampling activities and coordinate laboratory and drilling activities.

CONSULTANT's Quality Assurance Officer (QAO) will insure that the QA/QC plan is implemented and will oversee data validation. They will provide oversight and technical support for the sampling and analytical procedures followed in this project. The oversight personnel have the broad authority to approve or disapprove project plans, specific analyses, and final reports. They are independent from the data generation activities. In general, the QA personnel will be responsible for reviewing and advising on all QA/QC aspects of this program.

The QAO will have qualifications that meet the minimum requirements as specified in the NYSDEC guidance document DER-10, Appendix 2A. Specifically:

- The project QAO will not have another position on the project, such as a project or task manager, that involves project productivity or profitability as a job performance criteria;
- The project QAO must have a minimum of a bachelors degree in chemistry or natural science with a minimum of 20 hours in chemistry;
- The project QAO must be proficient in analytical methodology, data interpretation and validation, the development of sampling plans, quality control procedures, and auditing techniques; and
- The project QAO will assist the project manager in the development of the sampling and analytical portion of the QAPP. The QAO or their designee shall conduct periodic field and sampling audits, interface with the analytical laboratory to make requests and resolve problems, interface with the data validator and develop a project specific data usability report. Because on-site work may be necessary, verification of completion of the 40-hour OSHA safety training course and 8-hour refresher is required.

The laboratory will be H2M Labs, Inc. of Melville, New York. H2M is a New York State Department of Health ELAP certified laboratory. The laboratory will communicate directly with **CONSULTANT** regarding the analytical results and reporting. H2M will be responsible for providing all labels, sample jars, field blank water, trip blanks, shipping coolers, and laboratory documentation.

3.0 QA OBJECTIVES FOR DATA MANAGEMENT

All analytical data will be provided by the laboratory using the New York State Analytical Services Protocol (ASP) Category B deliverable format.

All analytical measurements will be made so that the results are representative of the media sampled (soil, groundwater and waste characterization) and the conditions measured. Data will be reported in consistent dry weight units for solid samples (i.e mg/kg) and in µg/L or mg/L for aqueous samples. Table 2 presents the proposed samples, sampling and analytical parameters, analytical methods, sample preservation requirements and containers for the Bay Shore Former MGP Site project.

Quantitation Limits (QLs) are laboratory-specific and reflect those values achievable by the laboratory performing the analyses. Data Quality Levels (DQLs) are those reporting limits required to meet the objectives of the program (i.e., program action levels, cleanup standards, etc.). Data Quality Objectives (DQOs) define the quality of data and documentation required to support decisions made in the various phases of the data collection activities. The DQOs are dependent on the end uses of the data to be collected and are also expressed in terms of objectives for precision, accuracy, representativeness, completeness, and comparability.

The analytical methods to be used at this site provide the highest level of data quality and can be used for purposes of risk assessment, evaluation of remedial alternatives and verification that cleanup standards have been met. However, in order to ensure that the analytical methodologies are capable of achieving the DQOs, measurement performance criteria have been set for the analytical measurements in terms of accuracy, precision, and completeness.

The overall QA objective is to develop and implement procedures for field sampling, chain-of-custody, laboratory analysis, and reporting which will provide results that are scientifically valid, and the levels of which are sufficient to meet DQOs. Specific procedures for sampling, chain of custody, laboratory instruments calibration, laboratory analysis, reporting of data, internal quality control, and corrective action are described in other sections of this Plan.

Tables 3a and 3b present the precision and accuracy requirements for each parameter to be analyzed. For quantitation limits for soil parameters, the laboratory will be required to attempt to meet or surpass the parameter-specific limits listed in the STARS and/or TAGM guidance, whichever is lower. Note, however, that NYSDEC is in the process of consolidating the STARS and TAGM guidance levels into one guidance document that largely reflects the TAGM standards. Given this development, **CONSULTANT** intends to interpret the analytical results primarily using the TAGM criteria.

In certain instances, if the STARS or TAGM criteria are not achievable due to analytical limitations, the laboratory will report the lowest possible quantitation limit (See Table 1a for affected analytes). For quantitation limits for groundwater parameters, the laboratory will be required to attempt to meet or surpass the parameter-specific limits for groundwater from the Division of Water Technical and Operational Guidance Series (1.1.1), June 1998 (TOGS) Ambient Water Quality Standards and Guidance Values or the TAGM Recommended Groundwater Standards/Criteria. It should be noted that the TOGS standards were first used to develop DQLs for groundwater. When TOGS standards did not exist for an analyte of interest, the TAGM groundwater standards were used. In certain instances, if the TOGS or TAGM criteria are not achievable due to analytical limitations, the laboratory will report the lowest possible quantitation limit (See Table 1b for affected analytes). The QA objectives are defined as follows:

- ***Accuracy*** is the closeness of agreement between an observed value and an accepted reference value. The difference between the observed value and the reference value includes components of both systematic error (bias) and random error.

  Accuracy in the field is assessed through the adherence to all field instrument calibration procedures, sample handling, preservation, and holding time requirements, and through the collection of equipment blanks prior to the collection of samples for each type of equipment being used (e.g., split spoons, groundwater sampling pumps).

  The laboratory will assess the overall accuracy of their instruments and analytical methods (independent of sample or matrix effects) through the measurement of "standards," materials of accepted reference value. Accuracy will vary from analysis to analysis because of individual sample and matrix effects. In an individual analysis, accuracy will be measured in terms of blank results, the percent recovery (%R) of surrogate compounds in organic analyses, or %R of spiked compounds in matrix spikes (MSs), matrix spike duplicates (MSDs) and/or laboratory control samples (LCSs). This gives an indication of expected recovery for analytes tending to behave chemically like the spiked or surrogate compounds. Tables 4a and 4b summarize the laboratory accuracy requirements.

- ***Precision*** is the agreement among a set of replicate measurements without consideration of the "true" or accurate value: i.e., variability between measurements of the same material for the same analyte. Precision is measured in a variety of ways including statistically, such as calculating variance or standard deviation.

  Precision in the field is assessed through the collection and measurement of field duplicates (one extra sample in addition to the original field sample). Field duplicates will be collected at a frequency of one per twenty investigative samples per matrix per analytical parameter, with the exception of the TCLP parameters. Precision will be measured through the calculation of relative percent differences (RPDs). The resulting information will be used to assess sampling and analytical variability. Field duplicate RPDs must be less than 50% for soil samples and less than 30% for aqueous samples. These criteria apply only if the sample and/or duplicate results are >5x the quantitation limit; if both results are <5x the quantitation limit, the criterion will be doubled.

  Precision in the laboratory is assessed through the calculation of RPD for duplicate samples. For organic analyses, laboratory precision will be assessed through the analysis of MS/MSD samples and field duplicates. For the inorganic analyses, laboratory precision will be assessed through the analysis of matrix duplicate pairs and field duplicate pairs. MS/MSD samples or matrix duplicate pairs will be performed at a frequency of one per twenty investigative samples per matrix per parameter. Tables 4a and 4b summarize the laboratory precision requirements.

- ***Completeness*** is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions. "Normal conditions" are defined as the conditions expected if the sampling plan was implemented as planned.

  Field completeness is a measure of the amount of (1) valid measurements obtained from all the measurements taken in the project and (2) valid samples collected. The field completeness objective is greater than 90 percent.

  Laboratory completeness is a measure of the amount of valid measurements obtained from all valid samples submitted to the laboratory. The laboratory completeness objective is greater than 95 percent.

- ***Representativeness*** is a qualitative parameter that expresses the degree to which data accurately and precisely represent either a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition within a defined spatial and/or temporal boundary. To ensure representativeness, the sampling locations have been selected to provide coverage over a wide area and to highlight potential trends in the data.

  Representativeness is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the Work Plans and Plan are followed and that proper sampling, sample handling, and sample preservation techniques are used.

  Representativeness in the laboratory is ensured by using the proper analytical procedures, appropriate methods, and meeting sample-holding times.

- ***Comparability*** expresses the confidence with which one data set can be compared to another. Comparability is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the Work Plans and Plan are followed and that proper sampling techniques are used. Maximization of comparability with previous data sets is expected because the sampling design and field protocols are consistent with those previously used.

  Comparability is dependent on the use of recognized EPA or equivalent analytical methods and the reporting of data in standardized units. Laboratory procedures are consistent with those used for previous sampling efforts.

Table 1a
Chemical Parameters, Quantitation Limits and Data Quality Levels for Soil Samples
Bay Shore Former MGP Site Program

Parameter	QL	DQL[1]
Volatile Organic Compounds (mg/kg) –STARS/TAGM[3]		
Acetone	0.005	0.2
Benzene	0.002	0.06
2-Butanone	0.005	0.3
Carbon Disulfide	0.005	2.7
Carbon Tetrachloride	0.005	0.6
Chlorobenzene	0.005	1.7
Chloroethane	0.005	1.9
Chloroform	0.005	0.3
Dibromochloromethane	0.005	NS
1,2-Dichlorobenzene	0.005	7.9
1,3-Dichlorobenzene	0.005	1.6
1,4-Dichlorobenzene	0.005	8.5
1,1-Dichloroethane	0.005	0.2
1,2-Dichloroethane	0.005	0.1
1,1-Dichloroethene	0.005	0.4
trans-1,2-Dichloroethene	0.005	0.3
1,3-Dichloropropane	0.005	0.3
Ethylbenzene	0.005	5.5
Freon 113	0.005	6.0
Methylene chloride	0.005	0.1
4-Methyl-2-pentanone	0.005	1.0
Tetrachloroethene	0.005	1.4
1,1,1-Trichloroethane	0.005	0.8
1,1,2,2-Tetrachloroethane	0.005	0.6
1,2,3-Trichloropropane	0.005	0.4
1,2,4-Trichlorobenzene	0.005	3.4
Toluene	0.005	1.5
Trichloroethene	0.005	0.7
Vinyl chloride	0.005	0.2
Xylenes	0.005	1.2
Isopropylbenzene	0.005	5.0
n-Propylbenzene	0.005	14
p-Isopropyltoluene	0.005	11
1,2,4-Trimethylbenzene	0.005	13
1,3,5-Trimethylbenzene	0.005	3.3
n-Butylbenzene	0.005	18
sec-Butylbenzene	0.005	25
t-Butylbenzene	0.005	0.1[2]
MTBE	0.005	0.12

Table 1a
Chemical Parameters, Quantitation Limits and Data Quality Levels for Soil Samples
Bay Shore Former MGP Site Program

Parameter	QL	DQL[1]
Polynuclear Aromatic Hydrocarbons (mg/kg) –STARS/TAGM		
Acenaphthene	0.066	50
Acenaphthylene	0.066	41
Anthracene	0.066	50
Benzo(a)anthracene	0.066	0.224
Benzo(a)pyrene	**0.066**	**0.061**
Benzo(b)fluoranthene	0.066	1.1
Benzo(g,h,i)perylene	0.066	50
Benzo(k)fluoranthene	0.066	1.1
Chrysene	0.066	0.4
Dibenzo(a,h)anthracene	**0.066**	**0.014**
Fluoranthene	0.066	50
Fluorene	0.066	50
Indeno(1,2,3-cd)pyrene	0.066	3.2
2-Methylnaphthalene	0.066	36.4
Naphthalene	0.066	13
Phenanthrene	0.066	50
Pyrene	0.066	50
Semivolatile Organic Compounds (mg/kg) –STARS/TAGM		
Acenaphthene	0.066	50
Acenaphthylene	0.066	41
Aniline	0.066	0.1
Anthracene	0.066	50
Benzo(a)anthracene	0.066	0.224
Benzo(a)pyrene	**0.066**	**0.061**
Benzo(b)fluoranthene	0.066	1.1
Benzo(g,h,i)perylene	0.066	50
Benzo(k)fluoranthene	0.066	1.1
Bis(2-ethylhexyl)phthalate	0.066	50
Butylbenzylphthalate	0.066	50
Chrysene	0.066	0.4
4-Chloroaniline	0.16	0.22
4-Chloro-3-methylphenol	0.16	0.24
2-Chlorophenol	0.16	0.8
Dibenzofuran	0.066	6.2
Dibenz(a,h)anthracene	**0.066**	**0.014**
3,3’-Dichlorobenzidine	0.16	NS
2,4-Dichlorophenol	0.16	0.4
2,4-Dinitrophenol	**0.66**	**0.2**
2,6-Dinitrotoluene	0.66	1
Diethylphthalate	0.66	7.1

Table 1a
Chemical Parameters, Quantitation Limits and Data Quality Levels for Soil Samples
Bay Shore Former MGP Site Program

Parameter	QL	DQL[1]
Dimethylphthalate	0.066	2
Di-n-butylphthalate	0.066	8.1
Di-n-octylphthalate	0.066	50
Fluoranthene	0.066	50
Fluorene	0.066	50
Hexachlorobenzene	0.066	0.41
Indeno(1,2,3-cd)pyrene	0.066	3.2
Isophorone	0.066	4.4
2-Methylnaphthalene	0.066	36.4
2-Methylphenol	**0.16**	**0.1**
4-Methylphenol	0.16	0.9
Naphthalene	0.066	13
Nitrobenzene	0.066	0.2
2-Nitroaniline	0.16	0.43
2-Nitrophenol	0.16	0.33
4-Nitrophenol	**0.66**	**0.1**
3-Nitroaniline	0.16	0.5
Pentachlorophenol	0.66	1
Phenanthrene	0.066	50
Phenol	**0.16**	**0.03**
Pyrene	0.066	50
2,4,5-Trichlorophenol	**0.16**	**0.1**
Metals (mg/kg) – TAGM		
Aluminum	20	NS
Antimony	1.0	NS
Arsenic	1.0	8.0
Barium	20	300
Beryllium	**0.5**	**0.16**
Cadmium	0.5	1.0
Calcium	500	NS
Chromium	1.0	10
Cobalt	5.0	30
Copper	2.5	25
Iron	10	2000
Lead	1.0	NS (background)
Magnesium	500	NS
Manganese	1.5	NS
Mercury	0.04	0.1
Nickel	4	13
Potassium	500	NS
Selenium	1	2

Table 1a
Chemical Parameters, Quantitation Limits and Data Quality Levels for Soil Samples
Bay Shore Former MGP Site Program

Parameter	QL	DQL[1]
Silver	1	NS
Sodium	500	NS
Thallium	1	NS
Vanadium	5	150
Zinc	2	20
PCBs (mg/kg)[4]		
Aroclor 1016	0.330	1 Surface/ 10 Subsurface
Aroclor 1221	0.330	1 Surface/ 10 Subsurface
Aroclor 1232	0.330	1 Surface/ 10 Subsurface
Aroclor 1242	0.330	1 Surface/ 10 Subsurface
Aroclor 1248	0.330	1 Surface/ 10 Subsurface
Aroclor 1254	0.330	1 Surface/ 10 Subsurface
Aroclor 1260	0.330	1 Surface/ 10 Subsurface
TCLP VOCs (µg/L) – STARS/TAGM[7]		
Benzene	**5**	**0.7[5]**
2-Butanone	25	200,000[6]
Carbon Tetrachloride	5	500[6]
Chlorobenzene	10	100,000[6]
Chloroform	25	6000[6]
1,4-Dichlorobenzene	25	7500[6]
1,2-Dichloroethane	10	500[6]
1,1-Dichloroethene	10	700[6]
Ethylbenzene	5	5[5]
Tetrachloroethene	5	700[6]
Toluene	5	5[5]
Trichloroethene	5	500[6]
Vinyl chloride	5	200[6]
Xylenes	**25**	**5[5]**
Isopropylbenzene	**10**	**5[5]**
n-Propylbenzene	**25**	**5[5]**
p-Isopropyltoluene	**25**	**5[5]**
1,2,4-Trimethylbenzene	**25**	**5[5]**
1,3,5-Trimethylbenzene	**25**	**5[5]**
n-Butylbenzene	**25**	**5[5]**
sec-Butylbenzene	**25**	**5[5]**
t-Butylbenzene	**25**	**5[5]**
MTBE	5	50[5]
TCLP PAHs (µg/L) – STARS/TAGM[7]		
Acenaphthene	2	20[5]
Anthracene	2	50[5]

Table 1a
Chemical Parameters, Quantitation Limits and Data Quality Levels for Soil Samples
Bay Shore Former MGP Site Program

Parameter	QL	DQL[1]
Benzo(a)anthracene	**2**	**0.002[5]**
Benzo(a)pyrene	**2**	**0.002[5]**
Benzo(b)fluoranthene	**2**	**0.002[5]**
Benzo(g,h,i)perylene	**2**	**0.002[5]**
Benzo(k)fluoranthene	**2**	**0.002[5]**
Chrysene	**2**	**0.002[5]**
Dibenzo(a,h)anthracene	2	50[5]
Fluoranthene	2	50[5]
Fluorene	2	50[5]
Indeno(1,2,3-cd)pyrene	**2**	**0.002[5]**
Naphthalene	2	10[5]
Phenanthrene	2	50[5]
Pyrene	2	50[5]
TCLP Metals (µg/L) –PP[8]		
Arsenic	5	5,000[6]
Barium	200	100,000[6]
Cadmium	4	1,000[6]
Chromium	10	5,000[6]
Lead	3	5,000[6]
Mercury	0.2	200[6]
Selenium	5	1,000[6]
Silver	10	5,000[6]

[1] DQL based on TAGM Recommended Soil Cleanup Objectives (January 24, 1994) unless otherwise specified
[2] DQL based on STARS TCLP Alternative Guidance Values (August 1992)
[3] Includes QLs and DQLs for BTEX and MTBE when required individually for a particular sample
[4] DQL listed is for total PCBs
[5] DQL based on STARS TCLP Extraction Guidance Values (August 1992)
[6] DQL based on TCLP standards (SW-846 Chapter 7, Table 7-1)
[7] Analyte list based on STARS/TAGM compounds but only those compounds which exhibit TCLP standards based on the STARS document or SW-846
[8] Analyte list based on PP metals and barium but only for those metals which exhibit TCLP standards based on SW-846
QL=Quantitation Limit
DQL=Data Quality Level
NS = None specified
Compounds which will not achieve the DQL are highlighted.

Table 1b
Chemical Parameters, Quantitation Limits and Data Quality Levels for Groundwater Samples
Bay Shore Former MGP Site Program

Parameter	QL	DQL[1]
Volatile Organic Compounds (µg/L) –STARS/TAGM[2]		
Acetone	5	50
Benzene	1	1
2-Butanone	5	50
Carbon Disulfide	5	50[3]
Carbon Tetrachloride	1	5
Chlorobenzene	2	5
Chloroethane	5	5
Chloroform	5	7
Dibromochloromethane	5	50
1,2-Dichlorobenzene	2	3
1,3-Dichlorobenzene	2	3
1,4-Dichlorobenzene	2	3
1,1-Dichloroethane	5	5
1,2-Dichloroethane	**2**	**0.6**
1,1-Dichloroethene	2	5
trans-1,2-Dichloroethene	5	5
1,3-Dichloropropane	5	5
Ethylbenzene	1	5
Freon 113	5	5
Methylene chloride	2	5
4-Methyl-2-pentanone	5	50[3]
Tetrachloroethene	1	5
1,1,1-Trichloroethane	5	5
1,1,2,2-Tetrachloroethane	2	5
1,2,3-Trichloropropane	**5**	**0.04**
1,2,4-Trichlorobenzene	5	5
Toluene	1	5
Trichloroethene	1	5
Vinyl chloride	1	2
Xylenes	5	5
Isopropylbenzene	2	5
n-Propylbenzene	5	5
p-Isopropyltoluene	5	5
1,2,4-Trimethylbenzene	5	5
1,3,5-Trimethylbenzene	5	5
n-Butylbenzene	5	5
sec-Butylbenzene	5	5

Table 1b
Chemical Parameters, Quantitation Limits and Data Quality Levels for Groundwater Samples
Bay Shore Former MGP Site Program

Parameter	QL	DQL[1]
t-Butylbenzene	5	5
MTBE	1	10
Polynuclear Aromatic Hydrocarbons (μg/L) –STARS/TAGM		
Acenaphthene	2	20
Acenaphthylene	2	20[3]
Anthracene	2	50
Benzo(a)anthracene	**2**	**0.002**
Benzo(a)pyrene	2	ND
Benzo(b)fluoranthene	**2**	**0.002**
Benzo(g,h,i)perylene	2	5[3]
Benzo(k)fluoranthene	**2**	**0.002**
Chrysene	**2**	**0.002**
Dibenzo(a,h)anthracene	2	50[3]
Fluoranthene	2	50
Fluorene	2	50
Indeno(1,2,3-cd)pyrene	**2**	**0.002**
2-Methylnaphthalene	2	4.7
Naphthalene	2	10
Phenanthrene	2	50
Pyrene	2	50
Pesticides (μg/L) - TAGM		
Aldrin	0.02	ND
alpha-BHC	**0.02**	**0.01**
beta-BHC	0.02	0.04
delta-BHC	0.02	0.04
Chlordane	**0.5**	**0.05**
4,4’-DDD	0.02	0.3
4,4’-DDE	0.02	0.2
4,4’-DDT	0.02	0.2
Dieldrin	**0.02**	**0.004**
Endosulfan I	0.02	0.1[3]
Endosulfan II	0.02	0.1[3]
Endosulfan sulfate	0.02	0.1[3]
Endrin	0.02	ND
Endrin ketone	0.05	5
gamma-BHC (Lindane)	0.02	0.05
gamma-Chlordane	0.02	0.1[3]
Heptachlor	0.02	0.04
Heptachlor epoxide	0.02	0.03
Methoxychlor	0.05	35

Table 1b
Chemical Parameters, Quantitation Limits and Data Quality Levels for Groundwater Samples
Bay Shore Former MGP Site Program

Parameter	QL	DQL[1]
2,4'-DDD	0.02	NS
Semivolatile Organic Compounds (µg/L) –STARS/TAGM		
Acenaphthene	2	20
Acenaphthylene	2	20[3]
Aniline	2	5
Anthracene	2	50
Benzo(a)anthracene	**2**	**0.002**
Benzo(a)pyrene	2	ND
Benzo(b)fluoranthene	**2**	**0.002**
Benzo(g,h,i)perylene	2	5[3]
Benzo(k)fluoranthene	**2**	**0.002**
Bis(2-ethylhexyl)phthalate	2	5
Butylbenzylphthalate	2	50
Chrysene	**2**	**0.002**
4-Chloroaniline	5	5
4-Chloro-3-methylphenol	**5**	**1**
2-Chlorophenol	**5**	**1**
Dibenzofuran	5	5[3]
Dibenz(a,h)anthracene	2	50[3]
3,3'-Dichlorobenzidine	5	5
2,4-Dichlorophenol	5	5
2,4-Dinitrophenol	**20**	**10**
2,6-Dinitrotoluene	2	5
Diethylphthalate	2	50
Dimethylphthalate	2	50
Di-n-butylphthalate	2	50
Di-n-octylphthalate	2	50
Fluoranthene	2	50
Fluorene	2	50
Hexachlorobenzene	**2**	**0.04**
Indeno(1,2,3-cd)pyrene	**2**	**0.002**
Isophorone	2	50
2-Methylnaphthalene	2	50[3]
2-Methylphenol	**5**	**1**
4-Methylphenol	**5**	**1**
Naphthalene	2	10
Nitrobenzene	**2**	**0.4**
2-Nitroaniline	5	5
2-Nitrophenol	**5**	**1**
4-Nitrophenol	**20**	**1**

Table 1b
Chemical Parameters, Quantitation Limits and Data Quality Levels for Groundwater Samples
Bay Shore Former MGP Site Program

Parameter	QL	DQL[1]
3-Nitroaniline	5	5
Pentachlorophenol	**20**	**1**
Phenanthrene	2	50
Phenol	**5**	**1**
Pyrene	2	50
2,4,5-Trichlorophenol	**5**	**1**
Metals (µg/L) – TAGM		
Aluminum	200	NS
Antimony	**5**	**3**
Arsenic	5	25
Barium	200	1000
Beryllium	3	3
Cadmium	4	5
Calcium	5000	NS
Chromium	10	50
Cobalt	50	NS
Copper	25	200
Iron	100	300
Lead	3	25
Magnesium	5000	35,000
Manganese	15	300
Mercury	0.2	0.7
Nickel	40	100
Potassium	5000	NS
Selenium	5	10
Silver	10	50
Sodium	5000	20,000
Thallium	**5**	**0.5**
Vanadium	50	NS
Zinc	20	2000
PCBs (µg/L)[4]		
Aroclor 1016	**0.5**	**0.09**
Aroclor 1221	**0.5**	**0.09**
Aroclor 1232	**0.5**	**0.09**
Aroclor 1242	**0.5**	**0.09**
Aroclor 1248	**0.5**	**0.09**
Aroclor 1254	**0.5**	**0.09**
Aroclor 1260	**0.5**	**0.09**

Table 1b
Chemical Parameters, Quantitation Limits and Data Quality Levels for Groundwater Samples
Bay Shore Former MGP Site Program

Parameter	QL	DQL[1]
Wet Chemistry (µg/L)		
Ammonia	100	2000
Nitrate	100	10,000
Nitrite	10	10,000
Carbonate	5000	NS
Bicarbonate	5000	NS
Sulfate	20,000	250,000
Cyanide	10	200
Total Dissolved Solids	10,000	NS
Chloride	20,000	250,000

[1] DQL based on TOGS Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations (June, 1998) unless otherwise specified
[2] Includes QLs and DQLs for BTEX and MTBE when required individually for a particular sample
[3] DQL based on TAGM Recommended Groundwater Standards/Criteria (January 24, 1994)
[4] DQL listed is for total PCBs
QL=Quantitation Limit
DQL=Data Quality Level
NS = None specified
ND = Not detected when analyzed by method listed in Table 2
Compounds which will not achieve the DQL are highlighted.

Table 2
Analytical Parameters, Methods, Preservation and Container Requirements
Bay Shore Former MGP Site Program

Sample Matrix	Analytical Parameter	Sample Type[1]	No. of Samples[2]	EPA Analytical Method	Sample Preservation	Holding Time[3]	Sample Container[4,5]
Soil/Solid Waste	VOCs (TCL or STARS/TAGM)	Grab	TBD	SW 846 Method 8260B	Cool to 4^0 C; no headspace	14 days to analysis	(2) 2-oz. glass jars
Soil	BTEX	Grab	TBD	SW-846 Method 8260B	Cool to 4^0 C; no headspace	14 days to analysis	(2) 2-oz. glass jars
Soil	BTEX/MTBE	Grab	TBD	SW-846 Method 8260B	Cool to 4^0 C; no headspace	14 days to analysis	(2) 2-oz. glass jars
Soil/Solid Waste	PCBs	Grab	TBD	SW 846 Method 8082	Cool to 4^0 C	14 days to extraction; 40 days from extraction to analysis	(1) 300 mL amber glass jar
Solid Waste	Pesticides (TCL)	Grab	TBD	SW-846 Method 8081A	Cool to 4^0 C	14 days to extraction; 40 days from extraction to analysis	(1) 300 mL amber glass jar
Solid Waste	SVOCs (TCL)	Grab	TBD	SW-846 Method 8270C	Cool to 4^0 C	14 days to extraction; 40 days from extraction to analysis	(1) 300 mL amber glass jar
Soil	PAHs or SVOCs (STARS/TAGM)	Grab	TBD	SW 846 Method 8270C	Cool to 4^0 C	14 days to extraction; 40 days from extraction to analysis	(1) 300 mL amber glass jar
Soil	Lead	Grab	TBD	SW 846 Method 6010B	Cool to 4^0 C	6 months to analysis	(1) 300 mL amber glass jar
Soil	Metals (TAGM)	Grab	TBD	SW-846 Method 6010B/7000 Series	Cool to 4^0 C	28 days to analysis for Hg; 6 months to analysis for other metals	(1) 300 mL amber glass jar
Solid Waste	Metals (PP)	Grab	TBD	SW-846 Method 6010B/7000 Series	Cool to 4^0 C	28 days to analysis for Hg; 6 months to analysis for other metals	(1) 300 mL amber glass jar

Table 2
Analytical Parameters, Methods, Preservation and Container Requirements
Bay Shore Former MGP Site Program

Sample Matrix	Analytical Parameter	Sample Type[1]	No. of Samples[2]	EPA Analytical Method	Sample Preservation	Holding Time[3]	Sample Container[4,5]
Soil	GRO	Grab	TBD	SW-846 Method 8015B	Cool to 4^0 C; no headspace	14 days to analysis	(2) 2-oz. glass jars
Soil	DRO	Grab	TBD	SW-846 Method 8015B	Cool to 4^0 C	14 days to extraction; 40 days from extraction to analysis	(1) 300 mL amber glass jar
Soil/Solid Waste/Liquid Waste	TCLP VOC (STARS/TAGM or RCRA)	Grab	TBD	SW 846 Methods 1311/8260B	Cool to 4^0 C; no headspace	14 days to TCLP extraction; 14 days from TCLP extraction to analysis	(1) 60 ml VOC vial
Soil/Solid Waste	TCLP SVOC or PAHs (STARS/TAGM or RCRA)	Grab	TBD	SW 846 Methods 1311/ 8270C	Cool to 4^0 C	14 days to TCLP extraction; 7 days from TCLP extraction to SVOC extraction; 40 days from SVOC extraction to analysis	(1) 950 mL amber glass jar
Liquid Waste	TCLP SVOC (RCRA)	Grab	TBD	SW 846 Methods 1311/ 8270C	Cool to 4^0 C	7 days to TCLP extraction; 7 days from TCLP extraction to SVOC extraction; 40 days from SVOC extraction to analysis	(1) 950 mL amber glass jar
Solid Waste	TCLP Pesticides (RCRA)	Grab	TBD	SW-846 Methods 1311/8081A	Cool to 4ºC	14 days to TCLP extraction; 7 days from TCLP extraction to pesticide extraction; 40 days from pesticide extraction to analysis	(1) 950 mL amber glass jar

Table 2
Analytical Parameters, Methods, Preservation and Container Requirements
Bay Shore Former MGP Site Program

Sample Matrix	Analytical Parameter	Sample Type[1]	No. of Samples[2]	EPA Analytical Method	Sample Preservation	Holding Time[3]	Sample Container[4,5]
Liquid Waste	TCLP Pesticides (RCRA)	Grab	TBD	SW-846 Methods 1311/8081A	Cool to 4ºC	7 days to TCLP extraction; 7 days from TCLP extraction to pesticide extraction; 40 days from pesticide extraction to analysis	(1) 950 mL amber glass jar
Solid Waste	TCLP Herbicides (RCRA)	Grab	TBD	SW-846 Methods 1311/8151A	Cool to 4ºC	14 days to TCLP extraction; 7 days from TCLP extraction to herbicide extraction; 40 days from herbicide extraction to analysis	(1) 950 mL amber glass jar
Liquid Waste	TCLP Herbicides (RCRA)	Grab	TBD	SW-846 Methods 1311/8151A	Cool to 4ºC	7 days to TCLP extraction; 7 days from TCLP extraction to herbicide extraction; 40 days from herbicide extraction to analysis	(1) 950 mL amber glass jar
Soil/Solid Waste/Liquid Waste	TCLP Metals (PP or RCRA)	Grab	TBD	SW 846 Methods 1311/ 6010B/7000 Series	Cool to 4^0 C	Hg: 28 days to TCLP extraction; 28 days from TCLP extraction to analysis Other Metals: 6 months to TCLP extraction; 6 months from TCLP extraction to analysis	(1) 500 mL amber glass jar
Soil	TCLP Lead	Grab	TBD	SW 846 Methods 1311/ 6010B	Cool to 4^0 C	6 months to TCLP extraction; 6 months from TCLP extraction to analysis	(1) 500 mL amber glass jar

Table 2
Analytical Parameters, Methods, Preservation and Container Requirements
Bay Shore Former MGP Site Program

Sample Matrix	Analytical Parameter	Sample Type[1]	No. of Samples[2]	EPA Analytical Method	Sample Preservation	Holding Time[3]	Sample Container[4,5]
Soil/Solid Waste/Liquid Waste	Ignitability	Grab	TBD	SW-846 Method 1010	Cool to 4^0 C	None specified	(1) 500 mL amber glass jar
Soil/Solid Waste/Liquid Waste	Corrosivity	Grab	TBD	SW-846 Method 9045C	Cool to 4^0 C	As soon as possible (within 3 days of collection)	(1) 500 mL amber glass jar
Soil/Solid Waste/Liquid Waste	Reactive cyanide	Grab	TBD	SW-846 Chapter 7, Section 7.3.3	Cool to 4^0 C; no headspace	As soon as possible (within 3 days of collection)	(1) 500 mL amber glass jar
Soil/Solid Waste/Liquid Waste	Reactive sulfide	Grab	TBD	SW-846 Chapter 7, Section 7.3.4	Cool to 4^0 C; no headspace	As soon as possible (within 3 days of collection)	(1) 500 mL amber glass jar
Groundwater	VOCs (STARS/TAGM)	Grab	TBD	SW-846 Method 8260B	pH<2 with HCl Cool to 4^0 C; no headspace	14 days to analysis	(2) 40 mL VOA vials
Groundwater	BTEX	Grab	TBD	SW-846 Method 8260B	pH<2 with HCl Cool to 4^0 C; no headspace	14 days to analysis	(2) 40 mL VOA vials
Groundwater	BTEX/MTBE	Grab	TBD	SW-846 Method 8260B	pH<2 with HCl Cool to 4^0 C; no headspace	14 days to analysis	(2) 40 mL VOA vials
Groundwater	PCBs	Grab	TBD	SW-846 Method 8082	Cool to 4^0 C; no headspace	7 days to extraction; 40 days from extraction to analysis	(2) 1 L amber glass jar

Table 2
Analytical Parameters, Methods, Preservation and Container Requirements
Bay Shore Former MGP Site Program

Sample Matrix	Analytical Parameter	Sample Type[1]	No. of Samples[2]	EPA Analytical Method	Sample Preservation	Holding Time[3]	Sample Container[4,5]
Groundwater	PAHs (STARS/TAGM)	Grab	TBD	SW-846 Method 8270C	Cool to 4^0 C; no headspace	7 days to extraction; 40 days from extraction to analysis	(2) 1 L amber glass jar
Groundwater	SVOCs (STARS/TAGM)	Grab	TBD	SW-846 Method 8270C	Cool to 4^0 C; no headspace	7 days to extraction; 40 days from extraction to analysis	(2) 1 L amber glass jar
Groundwater	Pesticides (TAGM)	Grab	TBD	SW-846 Method 8081A	Cool to 4^0 C; no headspace	7 days to extraction; 40 days from extraction to analysis	(2) 1 L amber glass jar
Groundwater	Lead	Grab	TBD	SW-846 Method 6010B	pH<2 with HNO_3; Cool to 4^0 C	6 months to analysis	(1) 1L polyethylene container
Groundwater	Metals (TAGM)	Grab	TBD	SW-846 Method 6010B/7000 Series	pH<2 with HNO_3; Cool to 4^0 C	28 days to analysis for Hg; 6 months to analysis for other metals	(1) 1L polyethylene container
Groundwater	Ammonia	Grab	TBD	EPA Method 350.1 (350.2 for distillation)	pH<2 with H_2SO_4; Cool to 4^0 C	28 days to analysis	(1) 250 mL polyethylene container
Groundwater	Nitrate	Grab	TBD	EPA Method 353.2/SM 4500-NO_2B (18th edition)	pH<2 with H_2SO_4; Cool to 4^0 C	28 days to analysis	(1) 100 mL polyethylene container
Groundwater	Nitrite	Grab	TBD	SM 4500-NO_2B (18th edition)	Cool to 4^0 C	48 hours to analysis	(1) 100 mL polyethylene container
Groundwater	Sulfate	Grab	TBD	SW-846 9056	Cool to 4^0 C	As soon as possible (within 3 days of collection)	(1) 100 mL polyethylene container
Groundwater	Carbonate	Grab	TBD	SM 4500-CO_2D (18th edition)	Cool to 4^0 C	14 days to analysis	(1) 250 mL polyethylene container

Table 2
Analytical Parameters, Methods, Preservation and Container Requirements
Bay Shore Former MGP Site Program

Sample Matrix	Analytical Parameter	Sample Type[1]	No. of Samples[2]	EPA Analytical Method	Sample Preservation	Holding Time[3]	Sample Container[4,5]
Groundwater	Bicarbonate	Grab	TBD	SM 4500-CO_2D (18th edition)	Cool to 4^0 C	14 days to analysis	(1) 250 mL polyethylene container
Groundwater	Total Cyanide	Grab	TBD	EPA Method 335.3	pH>12 with NaOH; Cool to 4ºC	14 days to analysis	(1) 250 mL polyethylene container
Groundwater	Total Dissolved Solids	Grab	TBD	EPA Method 160.1	Cool to 4ºC	7 days to analysis	(1) 100 mL polyethylene container
Groundwater	Chloride	Grab	TBD	EPA Method 300.0	Cool to 4ºC	28 days to analysis	(1) 100 mL polyethylene container

[1] For soil samples, a six-inch sampling interval is the preferred sample size; however, sample volume recovery, analytical method requirements, and field conditions can affect the actual sample interval size. For these reasons, the actual sampling interval may change in order to obtain adequate volume.

[2] Actual number of samples may vary depending on field conditions, sample material availability, and field observations

[3] From date of sample collection

[4] I-Chem Series 300 bottles

[5] MS/MSDs require duplicate volume for all parameters for solid matrices; MS/MSDs require triplicate volume for organic parameters for aqueous matrices and duplicate volume for inorganic parameters for aqueous matrices

TBD = To Be Determined

Table 3a
Data Quality Objectives: Precision and Accuracy: Soil and Solid Waste Samples
Bay Shore Former MGP Site Program

Parameter	Method	Matrix	Accuracy Control Limits		Accuracy Frequency Requirements	Precision (RPD) Control Limits		Precision Frequency Requirements
VOCs (TCL or STARS/TAGM)	SW-846 Method 8260B	Soil/Solid Waste	Surrogates	% Rec.	Surrogates: All samples, standards, QC samples	Field Duplicates		Field Duplicates: One per 20 per soils
			1,2-Dichloroethane-d4	54-129				
			4-Bromofluorobenzene	58-137		RPD ≤50		
			Dibromofluoromethane	55-132				
			Toluene-d8	65-133				
			Matrix Spikes		Matrix Spikes: One per 20 per matrix type	MS/MSDs	RPD	MS/MSDs: One per 20 per matrix type
			1,1-Dichloroethene	60-130		1,1-Dichloroethene	19	
			Trichloroethene	59-146		Trichloroethene	18	
			Benzene	64-132		Benzene	15	
			Toluene	48-145		Toluene	16	
			Chlorobenzene	56-137		Chlorobenzene	17	
BTEX and BTEX/MTBE	SW-846 Method 8260B	Soil	Surrogates	% Rec.	Surrogates: All samples, standards, QC samples	Field Duplicates		Field Duplicates: One per 20
			1,2-Dichloroethane-d4	54-129				
			4-Bromofluorobenzene	58-137		RPD ≤50		
			Dibromofluoromethane	55-132				
			Toluene-d8	65-133				
			Matrix Spikes		Matrix Spikes: One per 20	MS/MSDs	RPD	MS/MSDs: One per 20
			Benzene	64-132		Benzene	15	
			Toluene	48-145		Toluene	16	
			Ethyl Benzene	49-143		Ethyl Benzene	20	
			Xylenes (total)	45-146		Xylenes (total)	17	
			MTBE	60-132		MTBE	15	

Table 3a
Data Quality Objectives: Precision and Accuracy: Soil and Solid Waste Samples
Bay Shore Former MGP Site Program

Parameter	Method	Matrix	Accuracy Control Limits		Accuracy Frequency Requirements	Precision (RPD) Control Limits		Precision Frequency Requirements
PCBs	SW-846 Method 8082	Soil/Solid Waste	Surrogates	% Rec.	Surrogates: All samples, standards, QC samples	Field Duplicates		Field Duplicates: One per 20 per soils
			Decachlorobiphenyl	23-149				
			Tetrachloro-m-xylene	26-126		RPD ≤50		
			Matrix Spikes		Matrix Spikes: One per 20 per matrix type	MS/MSDs	RPD	MS/MSDs: One per 20 per matrix type
			Aroclor 1016	60-130		Aroclor 1016	26	
			Aroclor 1260	40-146		Aroclor 1260	27	
PAHs (STARS/TAGM)	SW-846 Method 8270C	Soil	Surrogates	% Rec.	Surrogates: All samples, standards, QC samples	Field Duplicates		Field Duplicates: One per 20
			Nitrobenzene-d5	27-124				
			2-Fluorobiphenyl	27-127		RPD ≤50		
			Terphenyl-d14	29-157				
			Matrix Spikes		Matrix Spikes: One per 20	MS/MSDs	RPD	MS/MSDs: One per 20
			Naphthalene	30-120		Naphthalene	28	
			2-Methylnaphthalene	36-126		2-Methylnaphthalene	28	
			Acenaphthylene	38-110		Acenaphthylene	31	
			Acenaphthene	32-122		Acenaphthene	30	
			Fluorene	31-133		Fluorene	29	
			Fluoranthene	35-128		Fluoranthene	27	
			Pyrene	25-139		Pyrene	33	
			Phenanthrene	24-135		Phenanthrene	29	
			Anthracene	28-132		Anthracene	29	
			Benzo(a)anthracene	32-129		Benzo(a)anthracene	24	
			Chrysene	29-128		Chrysene	30	
			Benzo(b)fluoranthene	34-139		Benzo(b)fluoranthene	31	
			Benzo(k)fluoranthene	24-137		Benzo(k)fluoranthene	30	
			Benzo(a)pyrene	35-126		Benzo(a)pyrene	29	
			Indeno(1,2,3-cd)pyrene	12-133		Indeno(1,2,3-cd)pyrene	35	
			Dibenzo(a,h)anthracene	18-139		Dibenzo(a,h)anthracene	33	
			Benzo(g,h,i)perylene	10-135		Benzo(g,h,i)perylene	33	

Table 3a
Data Quality Objectives: Precision and Accuracy: Soil and Solid Waste Samples
Bay Shore Former MGP Site Program

Parameter	Method	Matrix	Accuracy Control Limits	Accuracy Frequency Requirements	Precision (RPD) Control Limits	Precision Frequency Requirements
SVOCs (TCL or STARS/TAGM)	SW-846 Method 8270C	Solid Waste	Surrogates % Rec.	Surrogates: All samples, standards, QC samples		
			Phenol-d5 24-123			
			2-Fluorophenol 21-127			
			2,4,6-Tribromophenol 14-156			
			Nitrobenzene-d5 27-124			
			2-Fluorobiphenyl 27-127			
			Terphenyl-d14 29-157			
			Matrix Spikes	Matrix Spikes: One per 20 per matrix type	MS/MSDs RPD	MS/MSDs: One per 20 per matrix type
			Phenol 22-115		Phenol 28	
			n-Nitroso-di-n-propylamine 34-122		n-Nitroso-di-n-propylamine 27	
			2-Chlorophenol 29-114		2-Chlorophenol 26	
			4-Chloro-3-methylphenol 36-121		4-Chloro-3-methylphenol 22	
			Acenaphthene 32-122		Acenaphthene 30	
			4-Nitrophenol 13-136		4-Nitrophenol 34	
			Pentachlorophenol 17-136		Pentachlorophenol 23	
			Pyrene 25-139		Pyrene 33	
			2,4-Dinitrotoluene 13-130		2,4-Dinitrotoluene 33	
Pesticides (TCL)	SW-846 Method 8081A	Solid Waste	Surrogates % Rec.	Surrogates: All samples, standards, QC samples		
			Decachlorobiphenyl 27-158			
			Tetrachloro-m-xylene 35-145			
			Matrix Spikes	Matrix Spikes: One per 20 per matrix type	MS/MSDs RPD	MS/MSDs: One per 20 per matrix type
			gamma-BHC 42-157		Gamma-BHC 31	
			Heptachlor 46-157		Heptachlor 30	
			Aldrin 46-158		Aldrin 32	
			Dieldrin 43-158		Dieldrin 31	
			Endrin 55-158		Endrin 35	
			4,4’-DDT 37-158		4,4’-DDT 35	

Table 3a
Data Quality Objectives: Precision and Accuracy: Soil and Solid Waste Samples
Bay Shore Former MGP Site Program

Parameter	Method	Matrix	Accuracy Control Limits	Accuracy Frequency Requirements	Precision (RPD) Control Limits	Precision Frequency Requirements
GRO	SW-846 Method 8015B	Soil	Surrogates % Rec. ααα-Trifluorotoluene 42-147	Surrogates: All samples, standards, QC samples	Field Duplicates RPD ≤50	Field Duplicates: One per 20
			Matrix Spikes GRO (C_6-C_{10}) 18-139	Matrix Spikes: One per 20	MS/MSDs RPD GRO (C_6-C_{10}) 15	MS/MSDs: One per 20
DRO	SW-846 Method 8015B	Soil	Surrogates % Rec. 0-Terphenyl 33-145 Tetracosane-d50 42-145 52-Androstane 32-141	Surrogates: All samples, standards, QC samples	Field Duplicates RPD ≤50	Field Duplicates: One per 20
			Matrix Spikes DRO 28-149	Matrix Spikes: One per 20	MS/MSDs RPD DRO 20	MS/MSDs: One per 20
Metals (PP or TAGM)	SW-846 Methods 6010B/7000 Series	Soil/Solid Waste			Field Duplicates RPD ≤50	Field Duplicates: One per 20 per soils
			Matrix Spikes 75-125% recovery	Matrix Spikes: One per 20 per matrix type	Matrix Duplicates RPD ≤20	Matrix Duplicates: One per 20 per matrix type

Table 3a
Data Quality Objectives: Precision and Accuracy: Soil and Solid Waste Samples
Bay Shore Former MGP Site Program

Parameter	Method	Matrix	Accuracy Control Limits		Accuracy Frequency Requirements	Precision (RPD) Control Limits		Precision Frequency Requirements
TCLP VOCs (STARS/TAGM)	SW-846 Methods 1311/ 8260B	Soil	Surrogates	% Rec.	Surrogates: All samples, standards, QC samples			
			1,2-Dichloroethane-d4	68-124				
			4-Bromofluorobenzene	75-127				
			Dibromofluoromethane	81-118				
			Toluene-d8	85-119				
			Matrix Spikes		Matrix Spikes: One per 20 per matrix type	MS/MSDs	RPD	MS/MSDs: One per 20 per matrix type
			1,1-Dichloroethene	72-134		1,1-Dichloroethene	17	
			Trichloroethene	77-132		Trichloroethene	13	
			Benzene	61-138		Benzene	11	
			Toluene	55-147		Toluene	12	
			Chlorobenzene	83-124		Chlorobenzene	12	
TCLP VOCs (RCRA)	SW-846 Methods 1311/8260B	Solid Waste	Surrogates	% Rec.	Surrogates: All samples, standards, QC samples			
			1,2-Dichloroethane-d4	68-124				
			4-Bromofluorobenzene	75-127				
			Dibromofluoromethane	81-118				
			Toluene-d8	85-119				
			Matrix Spikes		Matrix Spikes: One per 20 per matrix type	MS/MSDs	RPD	MS/MSDs: One per 20 per matrix type
			1,1-Dichloroethene	72-134		1,1-Dichloroethene	17	
			1,2-Dichloroethane	67-138		1,2-Dichloroethane	12	
			2-Butanone	41-141		2-Butanone	29	
			Chloroform	76-128		Chloroform	12	
			Carbon Tetrachloride	69-143		Carbon Tetrachloride	17	
			Benzene	61-138		Benzene	11	
			Trichloroethene	77-132		Trichloroethene	13	
			Tetrachloroethene	55-149		Tetrachloroethene	13	
			Chlorobenzene	83-124		Chlorobenzene	12	
			Vinyl chloride	63-138		Vinyl chloride	18	
			1,4-Dichlorobenzene	75-121		1,4-Dichlorobenzene	13	

Table 3a
Data Quality Objectives: Precision and Accuracy: Soil and Solid Waste Samples
Bay Shore Former MGP Site Program

Parameter	Method	Matrix	Accuracy Control Limits		Accuracy Frequency Requirements	Precision (RPD) Control Limits		Precision Frequency Requirements
TCLP PAHs (STARS/TAGM)	SW-846 Methods 1311/ 8270C	Soil	Surrogates	% Rec.	Surrogates: All samples, standards, QC samples			
			Nitrobenzene-d5	42-127				
			2-Fluorobiphenyl	38-131				
			Terphenyl-d14	22-153				
			Matrix Spikes		Matrix Spikes: One per 20 per matrix type	MS/MSDs	RPD	MS/MSDs: One per 20 per matrix type
			Naphthalene	47-116		Naphthalene	16	
			Acenaphthene	51-116		Acenaphthene	15	
			Fluorene	47-129		Fluorene	16	
			Fluoranthene	54-125		Fluoranthene	18	
			Pyrene	53-124		Pyrene	17	
			Phenanthrene	52-119		Phenanthrene	16	
			Anthracene	51-122		Anthracene	17	
			Benzo(a)anthracene	55-121		Benzo(a)anthracene	16	
			Chrysene	53-119		Chrysene	16	
			Benzo(b)fluoranthene	52-133		Benzo(b)fluoranthene	25	
			Benzo(k)fluoranthene	47-123		Benzo(k)fluoranthene	24	
			Benzo(a)pyrene	52-122		Benzo(a)pyrene	17	
			Indeno(1,2,3-cd)pyrene	42-134		Indeno(1,2,3-cd)pyrene	25	
			Dibenzo(a,h)anthracene	51-135		Dibenzo(a,h)anthracene	20	
			Benzo(g,h,i)perylene	49-128		Benzo(g,h,i)perylene	24	

Table 3a
Data Quality Objectives: Precision and Accuracy: Soil and Solid Waste Samples
Bay Shore Former MGP Site Program

Parameter	Method	Matrix	Accuracy Control Limits		Accuracy Frequency Requirements	Precision (RPD) Control Limits		Precision Frequency Requirements
TCLP SVOCs (RCRA)	SW-846 Methods 1311/8270C	Solid Waste	Surrogates	% Rec.	Surrogates: All samples, standards, QC samples			
			Phenol-d5	10-93				
			2-Fluorophenol	10-112				
			2,4,6-Tribromophenol	37-159				
			Nitrobenzene-d5	42-127				
			2-Fluorobiphenyl	38-131				
			Terphenyl-d14	22-153				
			Matrix Spikes		Matrix Spikes: One per 20 per matrix type	MS/MSDs	RPD	MS/MSDs: One per 20 per matrix type
			Hexachloroethane	41-120		Hexachloroethane	19	
			Nitrobenzene	52-107		Nitrobenzene	17	
			Hexachlorobutadiene	46-128		Hexachlorobutadiene	18	
			2,4,6-Trichlorophenol	45-129		2,4,6-Trichlorophenol	15	
			2,4,5-Trichlorophenol	40-126		2,4,5-Trichlorophenol	16	
			2,4-Dinitrotoluene	52-114		2,4-Dinitrotoluene	17	
			Hexachlorobenzene	54-119		Hexachlorobenzene	18	
			Pentachlorophenol	33-139		Pentachlorophenol	19	
			Pyridine	25-97		Pyridine	27	
			2-Methylphenol	24-118		2-Methylphenol	15	
			3&4-Methylphenol	32-120		3&4-Methylphenol	16	
TCLP Pesticides	SW-846 Methods 1311/8081A	Solid Waste	Surrogates	% Rec.	Surrogates: All samples, standards, QC samples			
			Decachlorobiphenyl	22-147				
			Tetrachloro-m-xylene	48-136				
			Matrix Spikes		Matrix Spikes: One per 20 per matrix type	MS/MSDs	RPD	MS/MSDs: One per 20 per matrix type
			gamma-BHC	55-144		Gamma-BHC	35	
			Heptachlor	31-164		Heptachlor	35	
			Heptachlor epoxide	46-158		Heptachlor epoxide	28	
			Endrin	73-156		Endrin	34	
			Methoxychlor	55-166		Methoxychlor	35	
			Technical Chlordane	50-150		Chlordane		
			Toxaphene	50-150		Toxaphene		

Table 3a
Data Quality Objectives: Precision and Accuracy: Soil and Solid Waste Samples
Bay Shore Former MGP Site Program

Parameter	Method	Matrix	Accuracy Control Limits	Accuracy Frequency Requirements	Precision (RPD) Control Limits	Precision Frequency Requirements
TCLP Herbicides	SW-846 Methods 1311/8151A	Solid Waste	<u>Surrogates</u> <u>% Rec.</u> 2,4-DCAA 57-158 <u>Matrix Spikes</u> 2,4-D 48-123 2,4,5-TP 54-143	Surrogates: All samples, standards, QC samples Matrix Spikes: One per 20 per matrix type	<u>MS/MSDs</u> <u>RPD</u> 2,4-D 21 2,4,5-TP 20	MS/MSDs: One per 20 per matrix type
TCLP Metals	SW-846 Methods 1311/ 6010B/7000 Series	Soil/Solid Waste	<u>Matrix Spikes</u> 75-125% recovery	Matrix Spikes: One per 20 per matrix type	<u>Matrix Duplicates</u> RPD ≤20	Matrix Duplicates: One per 20 per matrix type
Ignitability	SW-846 Method 1010	Soil/Solid Waste	<u>Not Applicable</u>	Not Applicable	<u>Matrix Duplicates</u> RPD ≤20	Matrix Duplicates: One per 20 per matrix type
Corrosivity	SW-846 Method 9045C	Soil/Solid Waste	<u>Not Applicable</u>	Not Applicable	<u>Matrix Duplicates</u> RPD ≤5	Matrix Duplicates: One per 20 per matrix type
Reactive cyanide	SW-846 Chapter 7, Section 7.3.3	Soil/Solid Waste	<u>Not Applicable</u>	Not Applicable	<u>Matrix Duplicates</u> RPD ≤20	Matrix Duplicates: One per 20 per matrix type
Reactive sulfide	SW-846 Chapter 7, Section 7.3.4	Soil/Solid Waste	<u>Not Applicable</u>	Not Applicable	<u>Matrix Duplicates</u> RPD ≤20	Matrix Duplicates: One per 20 per matrix type

Recovery criteria for laboratory control samples must be at least as stringent as MS/MSD criteria.
Laboratory control limits are periodically updated. The latest control limits will be utilized at the time of sample analysis.

Table 3b
Data Quality Objectives: Precision and Accuracy: Groundwater Samples
Bay Shore Former MGP Site Program

Parameter	Method	Matrix	Accuracy Control Limits	Accuracy Frequency Requirements	Precision (RPD) Control Limits	Precision Frequency Requirements
VOCs (STARS/TAGM)	SW-846 Method 8260B	Groundwater	Surrogates % Rec. 1,2-Dichloroethane-d4 68-124 4-Bromofluorobenzene 75-127 Dibromofluoromethane 81-118 Toluene-d8 85-119	Surrogates: All samples, standards, QC samples	Field Duplicates RPD ≤30	Field Duplicates: One per 20
			Matrix Spikes 1,1-Dichloroethene 72-134 Trichloroethene 77-132 Benzene 61-138 Toluene 55-147 Chlorobenzene 83-124	Matrix Spikes: One per 20	MS/MSDs RPD 1,1-Dichloroethene 17 Trichloroethene 13 Benzene 11 Toluene 12 Chlorobenzene 12	MS/MSDs: One per 20
BTEX and BTEX/MTBE	SW-846 Method 8260B	Groundwater	Surrogates % Rec. 1,2-Dichloroethane-d4 68-124 4-Bromofluorobenzene 75-127 Dibromofluoromethane 81-118 Toluene-d8 85-119	Surrogates: All samples, standards, QC samples	Field Duplicates RPD ≤30	Field Duplicates: One per 20
			Matrix Spikes Benzene 61-138 Toluene 55-147 Ethyl Benzene 68-139 Xylenes (total) 57-146 MTBE 35-151	Matrix Spikes: One per 20	MS/MSDs RPD Benzene 11 Toluene 12 Ethyl Benzene 12 Xylenes (total) 12 MTBE 11	MS/MSDs: One per 20

Table 3b
Data Quality Objectives: Precision and Accuracy: Groundwater Samples
Bay Shore Former MGP Site Program

Parameter	Method	Matrix	Accuracy Control Limits		Accuracy Frequency Requirements	Precision (RPD) Control Limits		Precision Frequency Requirements
Pesticides (TAGM)	SW-846 Method 8081A	Groundwater	Surrogates	% Rec.	Surrogates: All samples, standards, QC samples	Field Duplicates		Field Duplicates: One per 20
			Decachlorobiphenyl	22-147				
			Tetrachloro-m-xylene	48-136		RPD ≤30		
			Matrix Spikes		Matrix Spikes: One per 20	MS/MSDs	RPD	MS/MSDs: One per 20
			gamma-BHC	55-144		gamma-BHC	35	
			Heptachlor	31-164		Heptachlor	35	
			Aldrin	32-158		Aldrin	35	
			Dieldrin	48-167		Dieldrin	35	
			Endrin	73-156		Endrin	34	
			4,4’-DDT	46-163		4,4’-DDT	35	
PCBs	SW-846 Method 8082	Groundwater	Surrogates	% Rec.	Surrogates: All samples, standards, QC samples	Field Duplicates		Field Duplicates: One per 20
			Decachlorobiphenyl	14-150				
			Tetrachloro-m-xylene	25-134		RPD ≤30		
			Matrix Spikes		Matrix Spikes: One per 20	MS/MSDs	RPD	MS/MSDs: One per 20
			Aroclor 1016	49-138		Aroclor 1016	21	
			Aroclor 1260	25-133		Aroclor 1260	35	

Table 3b
Data Quality Objectives: Precision and Accuracy: Groundwater Samples
Bay Shore Former MGP Site Program

Parameter	Method	Matrix	Accuracy Control Limits	Accuracy Frequency Requirements	Precision (RPD) Control Limits	Precision Frequency Requirements
SVOCs (STARS/TAGM)	SW-846 Method 8270C	Groundwater	<u>Surrogates</u> <u>% Rec.</u> Phenol-d5 10-93 2-Fluorophenol 10-112 2,4,6-Tribromophenol 37-159 Nitrobenzene-d5 42-127 2-Fluorobiphenyl 38-131 Terphenyl-d14 22-153	Surrogates: All samples, standards, QC samples	<u>Field Duplicates</u> RPD ≤30	Field Duplicates: One per 20
			<u>Matrix Spikes</u> Phenol 10-126 2-Chlorophenol 44-105 n-Nitroso-di-n-propylamine 50-120 4-Chloro-3-methylphenol 45-116 Acenaphthene 51-116 4-Nitrophenol 28-131 2,4-Dinitrotoluene 52-114 Pentachlorophenol 33-139 Pyrene 53-124	Matrix Spikes: One per 20	<u>MS/MSDs</u> <u>RPD</u> Phenol 16 2-Chlorophenol 13 n-Nitroso-di-n-propylamine 16 4-Chloro-3-methylphenol 14 Acenaphthene 15 4-Nitrophenol 25 2,4-Dinitrotoluene 17 Pentachlorophenol 19 Pyrene 17	MS/MSDs: One per 20

Table 3b
Data Quality Objectives: Precision and Accuracy: Groundwater Samples
Bay Shore Former MGP Site Program

Parameter	Method	Matrix	Accuracy Control Limits		Accuracy Frequency Requirements	Precision (RPD) Control Limits		Precision Frequency Requirements
PAHs (STARS/TAGM)	SW-846 Method 8270C	Groundwater	Surrogates	% Rec.	Surrogates: All samples, standards, QC samples	Field Duplicates		Field Duplicates: One per 20
			Nitrobenzene-d5	42-127				
			2-Fluorobiphenyl	38-131		RPD ≤30		
			Terphenyl-d14	22-153				
			Matrix Spikes		Matrix Spikes: One per 20	MS/MSDs	RPD	MS/MSDs: One per 20
			Naphthalene	47-116		Naphthalene	16	
			2-Methylnaphthalene	47-125		2-Methylnaphthalene	18	
			Acenaphthylene	53-108		Acenaphthylene	16	
			Acenaphthene	51-116		Acenaphthene	15	
			Fluorene	47-129		Fluorene	16	
			Fluoranthene	54-125		Fluoranthene	18	
			Pyrene	53-124		Pyrene	17	
			Phenanthrene	52-119		Phenanthrene	16	
			Anthracene	51-122		Anthracene	17	
			Benzo(a)anthracene	55-121		Benzo(a)anthracene	16	
			Chrysene	53-119		Chrysene	16	
			Benzo(b)fluoranthene	52-133		Benzo(b)fluoranthene	25	
			Benzo(k)fluoranthene	47-123		Benzo(k)fluoranthene	24	
			Benzo(a)pyrene	52-122		Benzo(a)pyrene	17	
			Indeno(1,2,3-cd)pyrene	42-134		Indeno(1,2,3-cd)pyrene	25	
			Dibenzo(a,h)anthracene	51-135		Dibenzo(a,h)anthracene	20	
			Benzo(g,h,i)perylene	49-128		Benzo(g,h,i)perylene	24	
Metals (TAGM)	SW-846 Methods 6010B/7000 Series	Groundwater	Matrix Spikes		Matrix Spikes: One per 20	Field Duplicates		Field Duplicates: One per 20
			75-125% recovery			RPD ≤30		
						Matrix Duplicates		Matrix Duplicates: One per 20
						RPD ≤20		

Table 3b
Data Quality Objectives: Precision and Accuracy: Groundwater Samples
Bay Shore Former MGP Site Program

Parameter	Method	Matrix	Accuracy Control Limits	Accuracy Frequency Requirements	Precision (RPD) Control Limits	Precision Frequency Requirements
Ammonia	EPA Method 350.1 (350.2 for distillation)	Groundwater	Matrix Spikes 60-134% recovery	Matrix Spikes: One per 20	Field Duplicates RPD ≤30 Matrix Duplicates RPD ≤24	Field Duplicates: One per 20 Matrix Duplicates: One per 20
Nitrate	EPA Method 353.2/SM 4500-NO_2B (18th edition)	Groundwater	Matrix Spikes 56-129% recovery	Matrix Spikes: One per 20	Field Duplicates RPD ≤30 Matrix Duplicates RPD ≤6	Field Duplicates: One per 20 Matrix Duplicates: One per 20
Nitrite	SM 4500-NO_2B (18th edition)	Groundwater	Matrix Spikes 71-122% recovery	Matrix Spikes: One per 20	Field Duplicates RPD ≤30 Matrix Duplicates RPD ≤20	Field Duplicates: One per 20 Matrix Duplicates: One per 20
Sulfate	SW-846 9056	Groundwater	Matrix Spikes 80-120% recovery	Matrix Spikes: One per 20	Field Duplicates RPD ≤30 Matrix Duplicates RPD ≤20	Field Duplicates: One per 20 Matrix Duplicates: One per 20

Table 3b
Data Quality Objectives: Precision and Accuracy: Groundwater Samples
Bay Shore Former MGP Site Program

Parameter	Method	Matrix	Accuracy Control Limits	Accuracy Frequency Requirements	Precision (RPD) Control Limits	Precision Frequency Requirements
Carbonate	SM 4500-CO_2D (18th edition)	Groundwater	Matrix Spikes 80-120% recovery	Matrix Spikes: One per 20	Field Duplicates RPD ≤30 Matrix Duplicates RPD ≤20	Field Duplicates: One per 20 Matrix Duplicates: One per 20
Bicarbonate	SM 4500-CO_2D (18th edition)	Groundwater	Matrix Spikes 80-120% recovery	Matrix Spikes: One per 20	Field Duplicates RPD ≤30 Matrix Duplicates RPD ≤11	Field Duplicates: One per 20 Matrix Duplicates: One per 20
Cyanide	EPA Method 335.3	Groundwater	Matrix Spikes 75-125% recovery	Matrix Spikes: One per 20	Field Duplicates RPD ≤30 Matrix Duplicates RPD ≤20	Field Duplicates: One per 20 Matrix Duplicates: One per 20
Total Dissolved Solids	EPA Method 160.1	Groundwater	Not Applicable	Not Applicable	Field Duplicates RPD ≤30 Matrix Duplicates RPD ≤18	Field Duplicates: One per 20 Matrix Duplicates: One per 20

Table 3b
Data Quality Objectives: Precision and Accuracy: Groundwater Samples
Bay Shore Former MGP Site Program

Parameter	Method	Matrix	Accuracy Control Limits	Accuracy Frequency Requirements	Precision (RPD) Control Limits	Precision Frequency Requirements
Chloride	EPA Method 300.0	Groundwater	Matrix Spikes 80-120% recovery	Matrix Spikes: One per 20	Field Duplicates RPD ≤30 Matrix Duplicates RPD ≤20	Field Duplicates: One per 20 Matrix Duplicates: One per 20
Recovery criteria for laboratory control samples must be at least as stringent as MS/MSD criteria. Laboratory control limits are periodically updated. The latest control limits will be utilized at the time of sample analysis.						

4.0 SAMPLING PLAN

Environmental sampling for the Bay Shore Former MGP Site Project will include soil, soil vapor, groundwater, and waste characterization sampling. Direct push drilling (GeoProbe) and hollow-stem auger drilling will be the preferred methods for obtaining subsurface soil and groundwater samples; however, other drilling methods including mud rotary and drive and wash and rotosonic drilling methods may also be used if warranted by site conditions. Performing grab or composite sampling by appropriate hand-held sampling equipment will be the preferred method for waste characterization sampling.

4.1 Grab/Composite Sampling

Grab soil/solid samples will be collected from the material or interval in question by retrieving a volume for analysis using a clean stainless steel, aluminum, plastic, or mild steel scoop, trowel, spoon, or bucket auger. Samples may be collected from a discrete interval or by placing the soil in a cleaned stainless steel pan for homogenization before inserting into the sample container. The method of sampled collection for analytical parameters other than volatiles will be specified in the project Work Plan. Samples for volatile organics analysis will be placed directly into the sample container. Composite samples will be collected in the same manner described above, except that the discrete sample volumes will be placed in a clean stainless steel pan and mixed to form the composite. Composites for volatile organics analysis will have the discrete sample volumes placed directly into the sample container without mixing.

4.2 Soil Sampling (Direct Push Drilling)

Sampling will be performed using four-foot-long acetate sleeves that will be advanced continuously to the desired depth below the surface. Soil samples from each sleeve will be screened using an organic vapor monitor (OVM), a photoionization instrument, to detect possible organic vapors. Organic vapor screening will be performed by slicing open the acetate sleeve, making a small slice in the soil column with a clean knife or sampling tool, inserting the OVM probe. The sampler will then cover the open slice with the OVM probe tip inserted with their gloved hand and monitoring the soil for approximately 5 to 10 seconds. This procedure will be repeated at a minimum of 0.5-foot intervals along the soil column.

The samples will be examined for staining, discoloration, odors, and debris indicative of contamination (ash, coal fragments, wood chips, cinders, petroleum staining, etc.). Samples for laboratory analysis will be collected from the six-inch interval most likely to be contaminated, based on OVM readings, discoloration, staining, and the field geologist's judgment (field conditions may require a section longer than six inches to make sufficient sample; however this decision will be field-based). The samples will be collected by either removing a discrete interval or by cutting the soil in two places with a decontaminated steel, stainless steel, or aluminum trowel, spoon, or knife and homogenized in a decontaminated stainless steel pan before being placed in the sample bottles. VOC samples will go directly into the sample containers without homogenization. Samplers will wear phthalate-free gloves such as nitrile (no latex will be used) and will avoid contact of the gloves with the sample. Only clean metal instruments will be allowed to touch the sample. If there is insufficient soil volume in the spoon, then this will be made up by attempting a second direct push sleeve at the same depth, or by using the next immediate sample interval above or below this depth, if appropriate. If there is no recovery, then the sample from this depth will be skipped, and drilling will progress to the next four-foot depth.

4.3 Soil Sampling (Hollow-Stem Auger)

Soil samples will be collected continuously utilizing 2-inch-diameter by 2-foot-long split spoon samplers driven ahead of a hollow stem auger. Three-inch-diameter split spoon samplers may also be used. Augers with a minimum inside diameter of 4¼ inches shall be used for drilling where wells are proposed. If soil sampling below the groundwater table is required, augers will be equipped with center plugs and/or inert "knock out" plates to control sub-water table sediments from rising inside the auger flights and hampering collection of representative soil samples.

Each split spoon sample will be screened using an OVM to detect possible organic vapors. Organic vapor screening will be performed by opening the split spoon, making a small slice in the soil column with a clean knife or sampling tool, inserting the OVM probe and pushing the slice closed, and monitoring the soil for approximately 5 to 10 seconds. This procedure will be repeated at intervals along the split spoon soil column at the field geologist's discretion.

The split spoons will be examined for staining, discoloration, odors, and debris indicative of contamination (ash, coal fragments, wood chips, cinders, petroleum staining, etc.). One sample will be collected from each split spoon, from the six-inch interval most likely to be contaminated, based on OVM readings, discoloration, staining, and the field geologist's judgment. Note that due to sample recovery or field conditions, sample intervals other than six inches may be necessary to collect sufficient sample.

The samples will be collected by either collecting a discrete interval or by cutting the soil in two places with a decontaminated steel, stainless steel, or aluminum trowel, spoon, or knife and homogenizing in a decontaminated stainless steel pan before being placed in the sample bottles (refer to Table 2). VOC and GRO samples will go directly into the sample containers without homogenization. Samplers will wear phthalate-free gloves such as nitrile (no latex will be used) and will avoid contact of the gloves with the sample. Only clean metal instruments will be allowed to touch the sample. If there is no recovery, then the sample from this depth will be skipped, and drilling will progress to the next sampling interval.

4.4 Drive and Wash/Mud Rotary

Borings will be advanced vertically by driving 4-inch-diameter steel casing with a 300-pound hammer falling freely for 24 inches. The casing will be cleaned with water using a tri-cone roller bit and/or chopping bit. A 2-inch-diameter by 2-foot-long split spoon sampler will be driven ahead of the tri-cone roller bit and samples will be collected as described in Section 4.3. Any drilling fluids used to advance the drill bit will be contained within a steel trough and re-circulated into the drill hole. Uncontaminated drilling fluids containing drilling mud will be mixed with cement to form a grout that will be used to backfill the borehole where required; otherwise the mud will be pumped into 55-gallon drums for on-site storage and subsequent off-site disposal. In Drive and Wash drilling where only potable water will be used as the drilling fluid, the water will be allowed to diffuse into the borehole. Samples will be collected in the same manner as with hollow stem auger drilling. Where drilling mud is necessary, bentonite and/or Revert® will be used. Every effort will be made to collect samples for soil analysis before the addition of drilling mud. Only bentonite mixed with cement will be used to prepare grout for sealing the borehole.

4.5 Groundwater Sampling (Direct Push)

Groundwater samples will be collected utilizing dedicated screen point samplers, which utilize a screen with a slot size and length appropriate for the subsurface conditions. Polyethylene tubing, equipped with a check valve, is attached to the screen point sampler for retrieval of a groundwater sample to the surface. The screen point sampler is threaded onto a probe rod driven to the desired sampling interval. An O-ring on the screen head maintains a seal at the top of the screen during installation of the sampling unit. After reaching the desired sampling depth, the tubing and check valve will be introduced into the screen-point sampler and a tool string is inserted into the probe rod and retracted to open the screen point sampler. A peristaltic or vacuum pump attached to the polyethylene tubing is then utilized to collect a representative groundwater sample.

Field parameters which will be monitored include temperature, conductivity, pH, dissolved oxygen (DO), and turbidity. Field parameters should generally be within 10 percent for two consecutive readings, one minute apart, so that it may be determined when the parameters stabilize.

4.6 Groundwater Sampling (Permanent Well)

Groundwater sampling of permanent monitoring wells is described according to the following distinct phases of this work: well installation/construction, well development, well purging, and well sampling.

4.6.1 Well Installation/Construction

To collect representative groundwater samples, previously installed soil borings will be converted into permanent two-inch or four-inch diameter monitoring wells. Groundwater monitoring wells will be constructed of threaded two-inch or four-inch-diameter PVC well casing and 20-slot well screen, such that the well screen extends approximately 8 feet below the water table. A minimum of one foot of well screen will be installed above the water table, depth to water and surface elevation permitting; however, optimally, two to three feet of well screen will remain above the water table. Clean silica sand, Morie No. 2, or equivalent, shall be placed in the annular space around the well to a minimum of one foot above the top of the well screen, two feet being optimal. For a two-inch diameter well, the annular space for the filter pack should be between 2 to 4 inches thick. (The 4 ¼ inside diameter hollow stem augers will have to be retracted as the filter pack is installed to yield the required annular space.) A two-foot bentonite seal shall then be placed above the sand pack and wetted with potable water for a minimum of 15 minutes before backfilling the remaining space with a cement-bentonite grout. If warranted by depth, backfilling will be completed using a tremie pipe placed below the surface of the grout. Solid PVC riser, attached to the well screen, will extend approximately to grade. A flush-mount protective casing with a locking water-tight well cap will then be installed and a measuring point marked on each PVC well riser. Well construction diagrams will be prepared for each well. Modifications to the well installation/construction procedures may be warranted if subsurface conditions (presence of finer grained materials or DNAPL) indicate that they may be necessary. Any modifications must be approved by the Project Manager and KeySpan.

4.6.2 Well Development

Following their installation, the groundwater monitoring wells will be developed, using a two-inch diameter Grunfos submersible pump(s) (or equivalent) until the water is reasonably free of turbidity and field readings (pH, conductivity, temperature, and dissolved oxygen) sufficiently stabilize. Fifty nephelometric turbidity units (NTUs) or less will be the turbidity goal but not an absolute value. To minimize suspended material, the wells will be developed very carefully using low-flow submersible pump techniques. The wells will be developed gently at low pumping rates, on the order of 0.5 to one gpm. Bailers will not be used for developing these wells (nor will bailers be used for sampling except for VOC compounds). The wells will be allowed to equilibrate for 14 days prior to sampling. The volume of water removed, the well development time, and field instrument readings will be recorded in the logbook

4.6.3 Well Purging

The objective is to purge monitoring wells until turbidity stabilizes to a level as low as possible and this parameter will be given the greatest weight in determining when groundwater sampling may begin. The samples should have an absolute minimum amount of suspended material. This is to be achieved by slow and steady pumping. Fifty NTUs or less is the well purging goal, but not an absolute value before sampling. Other field parameters including temperature, conductivity, pH, and DO will also be monitored. As practical, all field measurements will be taken from the flow cell and will be recorded during and after purging, and before sampling. Field parameters should generally be within ±10 percent for two consecutive readings, one minute apart, so that it may be determined when the parameters stabilize.

Upon opening each monitoring well and point, the concentration of VOCs in the headspace will be measured using an OVM and water level measurements will be recorded using an electronic oil-water interface probe. The depth to product (if present), depth to water, and the total depth will be measured from the top of the marked PVC casings. Water level and free product (none anticipated) measurements will first be made and the volume of water in the well determined. The volume of water in the well will be calculated so that the number of well volumes purged and an estimate of the time required to purge the well can be made. Before sampling, the wells will be purged utilizing a low-flow submersible stainless steel pump (or equivalent pump able to achieve low-flow sampling rates) using dedicated polypropylene, tygon, and/or Teflon tubing connected to a flow cell. Very low purging rates are proposed, on the order of 100 ml/minute to 500 ml/minute, so as to minimize suspension of particulate matter in the well.

Purging will be done with the pump placed near the top of the water column to insure that all stagnant water in the well is removed, while not stirring sediment that may have accumulated on the bottom of the well. Equipment will be lowered into the well very carefully so as to prevent suspension of bottom sediment and subsequent entrainment onto sampling equipment. Surging will be avoided. Pumps must be carefully cleaned between wells according to the procedures specified in Section 4.10. It is anticipated that no more than three well volumes will be purged in order for turbidity to reach a minimum and the other parameters to stabilize. During purging, **CONSULTANT** will actively monitor and track the volume of water purged and the field parameter readings. Data will be recorded in the field logbook. For example, **CONSULTANT** will record the running total volume purged from each well and note the readings for the corresponding field parameters.

4.6.4 Well Sampling

Once groundwater conditions have stabilized and groundwater levels have recovered, all samples except those slated for VOC analysis will be collected from the flow cell outlet (connected to the low-flow submersible pump). Samples for VOC analysis will be sampled using a micro stainless steel and/or Teflon bailer or some other appropriate VOC sampling method. All sampling equipment will be cleaned according to the procedures specified in Section 4.8.

Sampling will be performed by suspending the bottom of the pump and/or bailer a minimum of 15 inches above the bottom of the well and a minimum of 0.5 feet from the top of the water level, in order to minimize the amount of suspended sediment in the sample. Pumping rates for withdrawing the samples will be similar to those followed for well purging, 100 ml/minute to 500 ml/minute.

The samples will be collected in sample bottles (pre-preserved, if appropriate), placed in iced coolers and removed from light immediately after collection. In addition, all samples bottles must be filled to the top so that no aeration of the samples occurs during transport. All bottles will be filled so as to avoid cascading and aeration of the samples, the goal being to minimize any precipitation of colloidal matter.

4.7 Waste Classification Sampling

Waste classification sampling will be conducted for the purpose of characterizing a waste for its proper off-site disposal. Specific methods for sampling liquid and solid wastes are listed in Table 4 and briefly discussed below.

4.7.1 Solid Waste

As indicated by Table 4, solid sampling methods include utilizing dedicated stainless steel or Teflon scoops/shovels, triers, and thiefs. Scoops and shovels is the preferred method for sampling solids from piles or containers. Stainless steel triers are similar to a scoop and are used for the collection of a core sample of a solid material. Thiefs are long hollow tubes, with an inner tube, and are used for sampling of dry free running solids (e.g. pile of fine sand). To sample solid material at varying depths, a hollow stem auger or a core sampler in conjunction with an auger can be utilized (See Soil Sampling Section).

4.7.2 Liquid Waste

As indicated by Table 4, liquid sampling methods include utilizing dedicated dippers, glass tube samplers, pump and tubing, kemmerer bottles, and Bacon Bomb samplers. Dippers are used to collect samples from the surface of the liquid, and are appropriate for wastes that are homogeneous. Glass tube samplers consist of glass tubes of varying length and diameter used to collect a full-depth liquid sample from a drum or similar container. Pump and tubing (e.g. bladder pump or peristaltic pump) are used to collect liquid samples from a depth (up to approximately 20 feet below grade), and are typically relied upon for sampling subsurface structures, such as underground storage tanks. To minimize the loss of volatile organic components in the liquid, the lowest achievable flow rate is utilized for collecting the sample by this method. Kemmerer bottles and Bacon Bomb samplers are discrete-depth samplers. These samplers are lowered into the liquid and opened to collect a sample at a desired depth.

Table 4
Sampling Methods Summary For Waste Characterization
Bay Shore Former MGP Site

	1	2	3	4	5	6	7	8	9	10	11
Waste Type/Unit Type	**Scoops/ Shovels**	**Triers**	**Thief**	**Sample Core**	**Auger**	**Core Sampler***	**Glass Tubes**	**Dipper**	**Pump/ Tubing**	**Kemmerer Bottle**	**Bacon Bomb**
Solid Wastes											
Waste Piles	X	X	X	X	X						
Drums	X		X	X							
Sacks/Bags	X	X	X								
Trucks	X	X	X			X					
Sludge Wastes											
Waste Piles	X	X		X		X					
Drums	X					X	X				
Tanks	X							X			
Surface Impoundment	X							X			
Trucks	X	X				X		X			
Liquid Wastes											
Drums							X	X	X		
Tanks									X	X	X
Surface Impoundment								X	X	X	X
Trucks								X	X	X	X

* Core sampler modified to serve as air-tight container for retention of volatile fraction

4.7.3 Grab versus Composite Sampling

Waste characterization of a liquid or a solid can involve grab or composite sampling depending upon the homogeneity and the volume of the waste. Grab sampling consists of collecting discrete sample or samples of a material, and submitting each sample for separate analysis. Grab sampling is appropriate for characterizing small quantities of waste as well as waste streams of varying content (e.g. drums of different contents). Composite sampling consists of taking discrete grab samples of a material and combining them into a smaller number of samples for analysis. Composite sampling generally is appropriate for large volumes of a homogenous waste material, such a pile of soil or construction debris. The specific number of composite and grab samples largely will depend upon the size and nature of the waste pile (i.e. cubic yards) as well as the analysis required for characterization of the waste.

4.8 QC Sample Collection

QC samples will include equipment blanks, trip blanks, field duplicates and MS/MSDs.

Equipment blanks will consist of distilled water and will be used to check for potential contamination of the equipment which may cause sample contamination. Equipment blanks will be collected by routing the distilled water through the sampling equipment prior to sample collection. Equipment blanks will be submitted to the laboratory at a frequency of one per 20 samples per matrix per type of equipment being used per parameter, with the exception of TCLP parameters; equipment blanks will not be submitted for the TCLP parameters.

Trip blanks will consist of distilled water (supplied by the laboratory) and will be used to assess the potential for volatile organic compound contamination of groundwater samples due to contaminant migration during sample shipment and storage. Trip blanks will be transported to the site unopened, stored with the investigative samples, and kept closed until analyzed by the laboratory. Trip blanks will be submitted to the laboratory at a frequency of one per cooler which contains VOC groundwater samples.

Field duplicates are an additional aliquot of the same sample submitted for the same parameters as the original sample. Field duplicates will be used to assess the sampling and analytical reproducibility. Field duplicates will be collected by alternately filling sample bottles from the source being sampled. Field duplicates will be submitted at a frequency of one per 20 samples for all matrices and all parameters, with the exception of TCLP parameters; field duplicates will not be submitted for the TCLP parameters.

MSs and MSDs are two additional aliquots of the same sample submitted for the same parameters as the original sample. However, the additional aliquots are spiked with the compounds of concern. Matrix spikes provide information about the effect of the sample matrix on the measurement methodology. MS/MSDs will be submitted at a frequency of one per 20 investigative samples per matrix for organic parameters. MSs will be submitted at a frequency of one per 20 investigative samples per matrix for inorganic parameters.

Refer to Table 5 for a summary of QC sample preservation and container requirements.

4.9 Sample Preservation and Containerization

The analytical laboratory will supply the sample containers for the chemical samples. These containers will be cleaned by the manufacturer to meet or exceed all analyte specifications established in the latest US EPA's Specifications and Guidance for Contaminant-Free Sample Containers. Certificates of analysis are provided with each bottle lot and maintained on file to document conformance to EPA specifications. The containers will be pre-preserved, where appropriate (See Table 2).

4.10 Equipment Decontamination

4.10.1 Sampling Equipment

Re-usable Teflon, stainless steel, and aluminum sampling equipment shall be cleaned between each use in the following manner:

- Wash/scrub with a biodegradable degreaser ("Simple Green") if there is oily residue on equipment surface
- Tap water rinse
- Wash and scrub with Alconox and water mixture
- Tap water rinse
- 10 percent HNO3 rinse for non-dedicated groundwater sampling equipment for metals analysis only (excludes submersible pump and flow cell)
- Hexane rinse (optional, only if required to remove heavy petroleum coating)
- Distilled/deionized water rinse
- Air dry

Cleaned equipment shall be wrapped in aluminum foil if not used immediately after air-drying.

Groundwater sampling pumps will be cleaned by washing and scrubbing with an Alconox/water mixture, rinsing with tap water and irrigating with deionized water.

Table 5
QC Sample Preservation and Container Requirements
Bay Shore Former MGP Site

Sample Matrix	Analytical Parameter	Sample Type	No. of Samples	EPA Analytical Method	Sample Preservation	Holding Time[1]	Sample Container[2,3]
Soil	VOCs (TCL or STARS/TAGM)	Field Duplicate	TBD	SW-846 Method 8260B	Cool to 4^0 C; no headspace	14 days to analysis	(2) 2-oz. glass jars
Soil	BTEX/MTBE	Field Duplicate	TBD	SW-846 Method 8260B	Cool to 4^0 C; no headspace	14 days to analysis	(2) 2-oz. glass jars
Soil	PCBs	Field Duplicate	TBD	SW-846 Method 8082	Cool to 4^0 C	14 days to extraction; 40 days from extraction to analysis	(1) 300 mL amber glass jar
Soil	PAHs or SVOCs (STARS/TAGM)	Field Duplicate	TBD	SW-846 Method 8270C	Cool to 4^0 C	14 days to extraction; 40 days from extraction to analysis	(1) 300 mL amber glass jar
Soil	Lead	Field Duplicate	TBD	SW-846 Method 6010B	Cool to 4^0 C	6 months to analysis	(1) 300 mL amber glass jar
Soil	Metals (TAGM)	Field Duplicate	TBD	SW-846 Method 6010B/7000 Series	Cool to 4^0 C	28 days to analysis for Hg; 6 months to analysis for other metals	(1) 300 mL amber glass jar
Soil	GRO	Field Duplicate	TBD	SW-846 Method 8015B	Cool to 4^0 C; no headspace	14 days to analysis	(2) 2-oz. glass jars
Soil	DRO	Field Duplicate	TBD	SW-846 Method 8015B	Cool to 4^0 C	14 days to extraction; 40 days from extraction to analysis	(1) 300 mL amber glass jar
Groundwater	VOCs (STARS/TAGM)	Field Duplicate	TBD	SW-846 Method 8260B	pH<2 with HCl Cool to 4^0 C; no headspace	14 days to analysis	(2) 40 mL VOA vials
Groundwater	BTEX/MTBE	Field Duplicate	TBD	SW-846 Method 8260B	pH<2 with HCl Cool to 4^0 C; no headspace	14 days to analysis	(2) 40 mL VOA vials

Table 5
QC Sample Preservation and Container Requirements
Bay Shore Former MGP Site

Sample Matrix	Analytical Parameter	Sample Type	No. of Samples	EPA Analytical Method	Sample Preservation	Holding Time[1]	Sample Container[2,3]
Groundwater	Pesticides (TAGM)	Field Duplicate	TBD	SW-846 Method 8081A	Cool to 4^0 C	7 days to extraction; 40 days from extraction to analysis	(2) 1 L amber glass jars
Groundwater	PCBs	Field Duplicate	TBD	SW-846 Method 8082	Cool to 4^0 C	7 days to extraction; 40 days from extraction to analysis	(2) 1 L amber glass jars
Groundwater	SVOCs (STARS/TAGM)	Field Duplicate	TBD	SW-846 Method 8270C	Cool to 4^0 C	7 days to extraction; 40 days from extraction to analysis	(2) 1 L amber glass jars
Groundwater	PAHs (STARS/TAGM)	Field Duplicate	TBD	SW-846 Method 8270C	Cool to 4^0 C	7 days to extraction; 40 days from extraction to analysis	(2) 1 L amber glass jars
Groundwater	Lead	Field Duplicate	TBD	SW-846 Method 6010B	pH<2 with HNO_3; Cool to 4^0 C	6 months to analysis	(1) 1L polyethylene container
Groundwater	Metals (TAGM)	Field Duplicate	TBD	SW-846 Method 6010B/7000 Series	pH<2 with HNO_3; Cool to 4^0 C	28 days to analysis for Hg; 6 months to analysis for other metals	(1) 1L polyethylene container
Groundwater	Ammonia	Field Duplicate	TBD	EPA Method 350.1 (350.2 for distillation)	pH<2 with H_2SO_4; Cool to 4^0 C	28 days to analysis	(1) 250 mL polyethylene container
Groundwater	Nitrate	Field Duplicate	TBD	EPA Method 353.2/SM 4500-NO_2B (18th edition)	pH<2 with H_2SO_4; Cool to 4^0 C	28 days to analysis	(1) 100 mL polyethylene container
Groundwater	Nitrite	Field Duplicate	TBD	SM 4500-NO_2B (18th edition)	Cool to 4^0 C	48 hours to analysis	(1) 100 mL polyethylene container
Groundwater	Sulfate	Field Duplicate	TBD	SW-846 9056	Cool to 4^0 C	As soon as possible (within 3 days of collection)	(1) 100 mL polyethylene container

Table 5
QC Sample Preservation and Container Requirements
Bay Shore Former MGP Site

Sample Matrix	Analytical Parameter	Sample Type	No. of Samples	EPA Analytical Method	Sample Preservation	Holding Time[1]	Sample Container[2,3]
Groundwater	Carbonate	Field Duplicate	TBD	SM 4500-CO_2D (18th edition)	Cool to 4^0 C	14 days to analysis	(1) 250 mL polyethylene container
Groundwater	Bicarbonate	Field Duplicate	TBD	SM 4500-CO_2D (18th edition)	Cool to 4^0 C	14 days to analysis	(1) 250 mL polyethylene container
Groundwater	Cyanide	Field Duplicate	TBD	EPA Method 335.3	pH>12 with NaOH; Cool to 4ºC	14 days to analysis	(1) 250 mL polyethylene container
Groundwater	Chloride	Field Duplicate	TBD	EPA Method 300.0	Cool to 4ºC	28 days to analysis	(1) 100 mL polyethylene container
Groundwater	Total Dissolved Solids	Field Duplicate	TBD	EPA Method 160.1	Cool to 4ºC	7 days to analysis	(1) 100 mL polyethylene container
Aqueous	Ammonia	Equipment Blank	TBD	EPA Method 350.1 (350.2 for distillation)	pH<2 with H_2SO_4; Cool to 4^0 C	28 days to analysis	(1) 250 mL polyethylene container
Aqueous	Nitrate	Equipment Blank	TBD	EPA Method 353.2/SM 4500-NO_2B (18th edition)	pH<2 with H_2SO_4; Cool to 4^0 C	28 days to analysis	(1) 100 mL polyethylene container
Aqueous	Nitrite	Equipment Blank	TBD	SM 4500-NO_2B (18th edition)	Cool to 4^0 C	48 hours to analysis	(1) 100 mL polyethylene container
Aqueous	Sulfate	Equipment Blank	TBD	SW-846 9056	Cool to 4^0 C	As soon as possible (within 3 days of collection)	(1) 100 mL polyethylene container
Aqueous	Carbonate	Equipment Blank	TBD	SM 4500-CO_2D (18th edition)	Cool to 4^0 C	14 days to analysis	(1) 250 mL polyethylene container

Table 5
QC Sample Preservation and Container Requirements
Bay Shore Former MGP Site

Sample Matrix	Analytical Parameter	Sample Type	No. of Samples	EPA Analytical Method	Sample Preservation	Holding Time[1]	Sample Container[2,3]
Aqueous	Bicarbonate	Equipment Blank	TBD	SM 4500-CO_2D (18th edition)	Cool to 4^0 C	14 days to analysis	(1) 250 mL polyethylene container
Aqueous	Cyanide	Equipment Blank	TBD	SW-846 Method 9010B	pH>12 with NaOH; Cool to 4ºC	14 days to analysis	(1) 250 mL polyethylene container
Aqueous	Chloride	Equipment Blank	TBD	SW-846 Method 9250	Cool to 4ºC	28 days to analysis	(1) 100 mL polyethylene container
Aqueous	Total Dissolved Solids	Equipment Blank	TBD	EPA Method 160.1	Cool to 4ºC	7 days to analysis	(1) 100 mL polyethylene container
Aqueous	VOCs (TCL or STARS/TAGM)	Equipment Blank	TBD	SW-846 Method 8260B	pH<2 with HCl Cool to 4^0 C; no headspace	14 days to analysis	(2) 40 mL VOA vials
Aqueous	BTEX/MTBE	Equipment Blank	TBD	SW-846 Method 8260B	pH<2 with HCl Cool to 4^0 C; no headspace	14 days to analysis	(2) 40 mL VOA vials
Aqueous	Pesticides (TAGM)	Equipment Blank	TBD	SW-846 Method 8081A	Cool to 4^0 C	7 days to extraction; 40 days from extraction to analysis	(2) 1 L amber glass jars
Aqueous	PCBs	Equipment Blank	TBD	SW-846 Method 8082	Cool to 4^0 C	7 days to extraction; 40 days from extraction to analysis	(2) 1 L amber glass jars
Aqueous	SVOCs (STARS/TAGM)	Equipment Blank	TBD	SW-846 Method 8270C	Cool to 4^0 C	7 days to extraction; 40 days from extraction to analysis	(2) 1 L amber glass jars

Table 5
QC Sample Preservation and Container Requirements
Bay Shore Former MGP Site

Sample Matrix	Analytical Parameter	Sample Type	No. of Samples	EPA Analytical Method	Sample Preservation	Holding Time[1]	Sample Container[2,3]
Aqueous	PAHs (STARS/TAGM)	Equipment Blank	TBD	SW-846 Method 8270C	Cool to 4^0 C	7 days to extraction; 40 days from extraction to analysis	(2) 1 L amber glass jars
Aqueous	Lead	Equipment Blank	TBD	SW-846 Method 6010B	pH<2 with HNO_3; Cool to 4^0 C	6 months to analysis	(1) 1L polyethylene container
Aqueous	Metals (TAGM)	Equipment Blank	TBD	SW-846 Method 6010B/7000 Series	pH<2 with HNO_3; Cool to 4^0 C	28 days to analysis for Hg; 6 months to analysis for other metals	(1) 1L polyethylene container
Aqueous	GRO	Equipment Blank	TBD	SW-846 Method 8015B	pH<2 with HCl; Cool to 4^0 C; no headspace	14 days to analysis	(2) 40 mL VOA vials
Aqueous	DRO	Equipment Blank	TBD	SW-846 Method 8015B	Cool to 4^0 C	7 days to extraction; 40 days from extraction to analysis	(2) 1L amber glass bottles
Aqueous	VOCs (TCL or STARS/TAGM)	Trip Blank	TBD	SW-846 Method 8260B	pH<2 with HCl Cool to 4^0 C; no headspace	14 days to analysis	(2) 40 mL VOA vials
Aqueous	BTEX/MTBE	Trip Blank	TBD	SW-846 Method 8260B	pH<2 with HCl Cool to 4^0 C; no headspace	14 days to analysis	(2) 40 mL VOA vials

[1] From date of sample collection

[2] I-Chem Series 300 bottles

[3] MS/MSDs require duplicate volume for all parameters for solid matrices; MS/MSDs require triplicate volume for organic parameters for aqueous matrices and duplicate volume for inorganic parameters for aqueous matrices

TBD = To Be Determined

5.0 DOCUMENTATION AND CHAIN-OF-CUSTODY

5.1 Sample Collection Documentation

5.1.1 Field Notes

Field team members will keep a field logbook to document all field activities. Field logbooks will provide the means of recording the chronology of data collection activities performed during the investigation. As such, entries will be described in as much detail as possible so that a particular situation could be reconstructed without reliance on memory.

The logbook will be a bound notebook with water-resistant pages. Logbook entries will be dated, legible, and contain accurate and inclusive documentation of the activity. The title page of each logbook will contain the following:

- Person to whom the logbook is assigned,
- The logbook number,
- Project name and number,
- Site name and location,
- Project start date, and
- End date.

Entries into the logbook will contain a variety of information. At the beginning of each entry, the date, start time, weather, and names of all sampling team members present will be entered. Each page of the logbook will be signed and dated by the person making the entry. All entries will be made in permanent ink, signed, and dated and no erasures or obliterations will be made. If an incorrect entry is made, the information will be crossed out with a single strike mark which is signed and dated by the sampler. The correction shall be written adjacent to the error.

Field activities will be fully documented. Information included in the logbook will include, but may not be limited to the following:

- Chronology of activities, including entry and exit times,
- Names of all people involved in sampling activities,
- Level of personal protection used,
- Any changes made to planned protocol,
- Names of visitors to the site during sampling and reason for their visit,
- Sample location and identification,
- Changes in weather conditions,
- Dates (month/day/year) and times (military) of sample collection,
- Measurement equipment identification (model/manufacturer) and calibration information,
- Sample collection methods and equipment,
- Sample depths,
- Whether grab or composite sample collected,
- How sample composited, if applicable,
- Sample description (color, odor, texture, etc.)
- Sample identification code.

- Tests or analyses to be performed,
- Sample preservation and storage conditions,
- Equipment decontamination procedures,
- QC sample collection,
- Unusual observations,
- Record of photographs,
- Sketches or diagrams, and
- Signature of person recording the information

Field logbooks will be reviewed on a daily basis by the Field Team Leader. Logbooks will be supported by standardized forms.

5.1.2 Chain-of-Custody Records

Sample custody is discussed in detail in Section 5.2 of this Plan. Chain-of-custody records are initiated by the samplers in the field. The field portion of the custody documentation should include: (1) the project name; (2) signatures of samplers; (3) the sample number, date and time of collection, and whether the sample is grab or composite; (4) signatures of individuals involved in sampling; and (5) if applicable, air bill or other shipping number. Sample receipt and log-in procedures at the laboratory are described in Section 5.2.2 of this Plan.

On a regular basis (daily or on such a basis that all holding times will be met), samples will be transferred to the custody of the respective laboratories, via third-party commercial carriers or via laboratory courier service. Sample packaging and shipping procedures, and field chain-of-custody procedures are described in Section 5.2.1 of this Plan.

5.1.3 Sample Labeling

Immediately upon collection, each sample will be labeled with a pre-printed adhesive label, which includes the date and time of collection, sampler's initials, tests to be performed, preservative (if applicable), and a unique identifier. The following identification scheme will be used:

A. The sample ID number will include the soil sampling, soil boring, or monitoring well location, along with the sample depth, sample interval, and the depth interval at which it was collected.

Example:

Sample "BS-B22, 5.0 - 5.5' indicates the sample was taken at the Bay Shore boring location B-22, from the 6-inch interval in the spoon beginning at 5.0 feet below grade and ending at 5.5 feet below grade. Duplicate samples will be labeled as blind duplicates by giving them sample numbers indistinguishable from a normal sample.

Blanks should be spelled out and identify the associated matrix, e.g. Equipment Blank, Soil

MS/MSDs will be noted in the Comments column of the COC.

B. The job number will be the number assigned to the particular site.

Example: 28410-KB03-2210T

C. The analysis required will be indicated for each sample.

Example: SVOC

D. Date taken will be the date the sample was collected, using the format: MM-DD-YY.

Example: 3-22-01

E. Time will be the time the sample was collected, using military time.

Example: 1335

F. The sampler's name will be printed in the "Sampled By" section.

G. Other information relevant to the sample.

Example: Equipment Blank

An example sample label is presented below:

Job No:	28410-KB03-2210T
Client:	KEYSPAN
Sample No:	"BS-22, 5.0 - 5.5'
Matrix:	Soil
Date Taken:	3/22/04
Time Taken:	14:30
Sampler:	M. Burke
Analysis:	SVOC

Job No. ____________________
Client: ____________________
Sample Number ____________________
Date ____________________ Sample Time ____________________
Sample Matrix ____________________
Grab or Composite (explain) ____________________
Preservatives ____________________
Analyses ____________________
Sampler Signature____________________

This sample label contains the authoritative information for the sample. Inconsistencies with other documents will be settled in favor of the vial or container label unless otherwise corrected in writing from the field personnel collecting samples or the **CONSULTANT** Project QA Officer.

5.2 Sample Custody

Custody is one of several factors that are necessary for the admissibility of environmental data as evidence in a court of law. Custody procedures help to satisfy the two major requirements for admissibility: relevance and authenticity. Sample custody is addressed in three parts: field sample collection, laboratory analysis, and final evidence files.

A sample or evidence file is considered to be under a person's custody if

- the item is in the actual possession of a person;
- the item is in the view of the person after being in actual possession of the person;
- the item was in the actual physical possession of the person but is locked up to prevent tampering;
- the item is in a designated and identified secure area.

5.2.1 Field Custody Procedures

Samples will be collected following the sampling procedures documented in Section 4.0 of this Plan. Documentation of sample collection is described in Section 5.1 of this Plan. Sample chain-of-custody and packaging procedures are summarized below. These procedures will ensure that the samples will arrive at the laboratory with the chain-of-custody intact.

- The field sampler is personally responsible for the care and custody of the samples until they are transferred or dispatched properly. Field procedures have been designed such that as few people as possible will handle the samples.
- All bottles will be identified by the use of sample labels with sample numbers, sampling locations, date/time of collection, and type of analysis. The sample numbering system is presented in Section 5.1.3 of this Plan.
- Sample labels will be completed for each sample using waterproof ink unless prohibited by weather conditions. For example, a logbook notation would explain that a pencil was used to fill out the sample label because the pen would not function in wet weather.
- Samples will be accompanied by a properly completed chain-of-custody form. The sample numbers and locations will be listed on the chain-of-custody form. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the record. This record documents the transfer of custody of samples from the sampler to another person, to a mobile laboratory, to the permanent laboratory, or to/from a secure storage location.
- All shipments will be accompanied by the chain-of-custody record identifying the contents. The original record will accompany the shipment, and copies will be retained by the sampler and placed in the project files.
- Samples will be properly packaged for shipment and dispatched to the appropriate laboratory for analysis, with a separate signed custody record enclosed in and secured to the inside top of each sample box or cooler. Shipping containers will be secured with strapping tape and custody seals for shipment to the laboratory. The custody seals will be attached to the front right and back left of the cooler and

covered with clear plastic tape after being signed by field personnel. The cooler will be strapped shut with strapping tape in at least two locations.
- If the samples are sent by common carrier, the air bill will be used. Air bills will be retained as part of the permanent documentation. Commercial carriers are not required to sign off on the custody forms since the custody forms will be sealed inside the sample cooler and the custody seals will remain intact.
- Samples remain in the custody of the sampler until transfer of custody is completed. This consists of delivery of samples to the laboratory sample custodian, and signature of the laboratory sample custodian on chain-of-custody document as receiving the samples and signature of sampler as relinquishing samples.

5.2.2 Laboratory Custody Procedures

Samples will be received and logged in by a designated sample custodian or his/her designee. Upon sample receipt, the sample custodian will

- Examine the shipping containers to verify that the custody tape is intact,
- Examine all sample containers for damage,
- Determine if the temperature required for the requested testing program has been maintained during shipment and document the temperature on the chain-of-custody records,
- Compare samples received against those listed on the chain-of-custody,
- Verify that sample holding times have not been exceeded,
- Examine all shipping records for accuracy and completeness,
- Determine sample pH (if applicable) and record on chain-of-custody forms,
- Sign and date the chain-of-custody immediately (if shipment is accepted) and attach the air bill,
- Note any problems associated with the coolers and/or samples on the cooler receipt form and notify the Laboratory Project Manager, who will be responsible for contacting the **CONSULTANT** Project QA Officer,
- Attach laboratory sample container labels with unique laboratory identification and test, and
- Place the samples in the proper laboratory storage.

Following receipt, samples will be logged in according to the following procedure:

- The samples will be entered into the laboratory tracking system. At a minimum, the following information will be entered: project name or identification, unique sample numbers (both client and internal laboratory), type of sample, required tests, date and time of laboratory receipt of samples, and field ID provided by field personnel.
- The Laboratory Project Manager will be notified of sample arrival.
- The completed chain-of-custody, air bills, and any additional documentation will be placed in the final evidence file.

6.0 CALIBRATION PROCEDURES

6.1 Field Instruments

Field instruments will be calibrated according to the manufacturer's specifications. All calibration procedures performed will be documented in the field logbook and will include the date/time of calibration, name of person performing the calibration, reference standard used, temperature at which the readings were taken, and the readings.

6.2 Laboratory Instruments

Calibration procedures for a specific laboratory instrument will consist of initial calibrations, initial calibration verifications, and/or continuing calibration verification. Detailed descriptions of the calibration procedures for a specific laboratory instrument are included in the laboratory's standard operating procedures (SOPs), which describe the calibration procedures, their frequency, acceptance criteria, and the conditions that will require recalibration. These procedures are as required in the respective analytical methodologies (summarized in Table 2 of this Plan). The initial calibration associated with all analyses must contain a low-level calibration standard which is less than or equal to the quantitation limit.

7.0 SAMPLE PREPARATION AND ANALYTICAL PROCEDURES

No field analyses are anticipated for the Bay Shore Former MGP Site project Work Plan. If site conditions were to warrant field analysis, **CONSULTANT** will prepare an addendum establishing the field analytical procedures. Analyses of all soil, groundwater and waste classification samples will be performed by H2M Labs, Inc, Melleville, New York. Table 2 summarizes the analytical methods to be used during this investigation.

8.0 DATA REDUCTION, VALIDATION, AND REPORTING

Appropriate QC measures will be used to ensure the generation of reliable data from sampling and analysis activities. Proper collection and organization of accurate information followed by clear and concise reporting of the data is a primary goal in this project. Complete data packages suitable for data validation to support the generation of a Data Usability Summary Report (DUSR) according to NYSDEC requirements will be provided by the analytical laboratory.

For all analyses, the laboratory will report results which are below the laboratory's reporting limit; these results will be qualified as estimated (J) by the laboratory. The laboratory may be required to report tentatively identified compounds (TICs) for the VOC and SVOC analyses; this will be requested by CONSULTANT on an as-needed basis.

8.1 Data Evaluation/Validation

8.1.1 Field Data Evaluation

Measurements and sample collection information will be transcribed directly into the field logbook or onto standardized forms. If errors are made, results will be legibly crossed out, initialed and dated by the person recording the data, and corrected in a space adjacent to the original (erroneous) entry. Daily reviews of the field records by the Field Team Leader will ensure that:

- Logbooks and standardized forms have been filled out completely and that the information recorded accurately reflects the activities that were performed.
- Records are legible and in accordance with good record keeping procedures, i.e., entries are signed and dated, data are not obliterated, changes are initialed, dated, and explained.
- Sample collection, handling, preservation, and storage procedures were conducted in accordance with the protocols described in the Plan, and that any deviations were documented and approved by the appropriate personnel.

8.1.2 Analytical Data Validation

CONSULTANT will be responsible for performing an independent validation of the analytical data. Project-specific procedures will be used to validate analytical laboratory data. The basis for the validation will be the USEPA CLP National Functional Guidelines for Organic Data Review (October 1999) and the USEPA CLP National Functional Guidelines for Inorganic Data Review (February 1994), modified to accommodate the criteria in the analytical methods used in this program, and Region II Standard Operating Procedures (SOPs) for CLP Organic Data review (Revision 11, June 1996) and Evaluation of Metals for the CLP Program (Revision 11, January 1992). Tables 1, 2, 3a, 3b and 5 highlight the QC criteria and holding time requirements for all analyses conducted under this program. These criteria will be used to evaluate and qualify the data during validation.

CONSULTANT will validate an appropriate number of soil samples collected for the purpose of characterizing the subsurface and/or delineating impacted areas to ensure that verifiable data are used to support decision making and endpoint documentation. Likewise, an appropriate number of groundwater samples will be validated to ensure that cleanup criteria have been achieved. Samples collected for waste classification will not be validated. Validation will include all technical holding times, as well as QC sample results (blanks, surrogate spikes, laboratory duplicates, MS/MSDs, and LCSs), tunes, internal standards, calibrations, target compound identification, and results calculations.

The overall completeness of the data package will also be evaluated by the data validator. Completeness checks will be administered on all data to determine whether full data deliverables were provided. The reviewer will determine whether all required items are present and request copies of missing deliverables.

Upon completion of the validation, a report will be prepared. This report will summarize the samples reviewed, elements reviewed, any nonconformances with the established criteria, and validation actions. Data qualifiers will be consistent with EPA National Functional Guidelines. This report will be in a format consistent with NYSDEC's Data Usability Summary Report (DUSR),

8.2 Identification and Treatment of Outliers

Any data point which deviates markedly from others in its set of measurements will be investigated; however, the suspected outlier will be recorded and retained in the data set. One or both of the following tests will be used to identify outliers.

Dixon's test for extreme observations is an easily computed procedure for determining whether a single very large or very small value is consistent with the remaining data. The one-tailed t-test for difference may also be used in this case. It should be noted that these tests are designed for testing a single value. If more than one outlier is suspected in the same data set, other statistical sources may be consulted and the most appropriate test of hypothesis will be used and documented, if warranted.

Since an outlier may result from unique circumstances at the time of sample analysis or data collection, those persons involved in the analysis and data reduction will be consulted. This may provide an experimental reason for the outlier. Further statistical analysis may be performed with and without the outlier to determine its effect on the conclusions. In many cases, two data sets may be reported, one including, and one excluding the outlier.

In summary, every effort will be made to include the outlying values in the reported data. If the value is rejected, it will be identified as an outlier, reported with its data set and its omission noted.

9.0 INTERNAL QUALITY CONTROL

The subcontracting laboratory Quality Assurance Project Plan will identify the supplemental internal analytical quality control procedures to be used. At a minimum, this will include:

- Matrix spike and/or matrix spike duplicate samples
- Matrix duplicate analyses
- Laboratory control spike samples
- Instrument calibrations
- Instrument tunes for SW-846 8260B and 8270C analyses
- Method and/or instrument blanks
- Surrogate spikes for organic analyses
- Internal standard spikes for SW-846 8260B and 8270C analyses
- Detection limit determination and confirmation by analysis of low-level calibration standard

Field quality control samples will include:

- Equipment blanks as outlined in Table 5
- Field duplicate samples as outlined in Table 5
- Trip blanks as outlined in Table 5
- MS/MSDs described in Section 4.8

10.0 CORRECTIVE ACTION

The entire sampling program will be under the direction of **CONSULTANT**'s Project QA officer. The emphasis in this program is on preventing problems by identifying potential errors, discrepancies, and gaps in the data-collection-laboratory-analysis-interpretation process. Any problems identified will be promptly resolved. Likewise, follow-up corrective action is always an option in the event that preventative corrective actions are not totally effective.

The acceptance limits for the sampling and analyses to be conducted in this program will be those stated in the method or defined by other means in the Plan. Corrective actions are likely to be immediate in nature and most often will be implemented by the contracted laboratory analyst or the **CONSULTANT** Program Manager. The corrective action will usually involve recalculation, reanalysis, or repeating a sample run.

10.1 Immediate Corrective Action

Corrective action in the field may be needed when the sample network is changed (i.e., more/less samples, sampling locations other than those specified in the Plan), or when sampling procedures and/or field analytical procedures require modification, etc. due to unexpected conditions. The field team may identify the need for corrective action. The Field Team Leader will approve the corrective action and notify the **CONSULTANT** Program Manager. The **CONSULTANT** Program Manager will approve the corrective measure. The Field Team Leader will ensure that the corrective measure is implemented by the field team.

Corrective actions will be implemented and documented in the field record book. Documentation will include:

- A description of the circumstances that initiated the corrective action,
- The action taken in response,
- The final resolution, and
- Any necessary approvals.

No staff member will initiate corrective action without prior communication of findings through the proper channels.

Corrective action in the laboratory may occur prior to, during, and after initial analyses. A number of conditions such as broken sample containers, omissions or discrepancies with chain-of-custody documentation, low/high pH readings, and potentially high concentration samples may be identified during sample log-in or just prior to analysis. Following consultation with laboratory analysts and Laboratory Section Leaders, it may be necessary for the Laboratory QA Manager to approve the implementation of corrective action. The laboratory SOPs specify some conditions during or after analysis that may automatically trigger corrective action or optional procedures. These conditions may include dilution of samples, additional sample extract cleanup, automatic reinjection/reanalysis when certain QC criteria are not met, loss of sample through breakage or spillage, etc.

The analyst may identify the need for corrective action. The Laboratory Section Leader, in consultation with the staff, will approve the required corrective action to be implemented by the laboratory staff. The Laboratory QA Manager will ensure implementation and documentation of the corrective action. If the nonconformance causes project objectives not to be achieved, the **CONSULTANT** Project QA Officer will be notified. The **CONSULTANT** Project QA Officer will notify the **CONSULTANT** Program Manager, who in turn will contact all levels of project management for concurrence with the proposed corrective action.

These corrective actions are performed prior to release of the data from the laboratory. The corrective action will be documented in both the laboratory's corrective action files, and the narrative data report sent from the laboratory to the **CONSULTANT** Program Manager. If the corrective action does not rectify the situation, the laboratory will contact the **CONSULTANT** Program Manager, who will determine the action to be taken and inform the appropriate personnel.

If potential problems are not solved as an immediate corrective action, the contractor will apply formalized long-term corrective action if necessary.

KEYSPAN CORPORATION

FIELD SAMPLING PLAN

FOR

SITE INVESTIGATIONS

AT

MANUFACTURED GAS PLANTS

MARCH 2004

FIELD SAMPLING PLAN
TABLE OF CONTENTS

Figures

Attachments

1.0 INTRODUCTION

This Field Sampling Plan (FSP) has been prepared to specify procedures to be used during the various types of environmental sampling activities that may be utilized during implementation of Site Characterization and/or Remedial Investigations, Interim Remedial Measures, Feasibility Studies, Remedial Designs, and/or Remedial Actions at MGP sites. The numbers and types of environmental samples to be collected are identified in the respective detailed Site-Specific Work Plans to which this document is appended.

In the event of conflict between the FSP and the Site Work Plan, including suggested record keeping requirements and designations of responsible personnel, the provisions of the Site Work Plan will prevail. The KeySpan Project Manager will be kept informed of the planned activities, and will in turn keep the KeySpan Facility Manager informed.

During the conduct of any investigation, references in all work products to dense nonaqueous phase liquids (DNAPL) and/or other MGP impacted media (i.e. soil, water, sediments, etc.) will be made using the terminology and descriptions presented in the USEPA document entitled ***Ground Water Issue - Dense Nonaqueous Phase Liquids*** (Huling and Weaver; March 1991) and included as Attachment A

2.0 GENERAL FIELD GUIDELINES

2.1 Underground Utilities

All underground utilities, including electric, telephone, cable TV, sewers, water, natural gas, etc., will be identified prior to any drilling and subsurface sampling. KeySpan will provide underground utility locations on KeySpan property. Public and privately owned utilities will be located by contacting responsible agencies by phone at least 48 hours prior to field activities so their underground utilities can be marked at the project site. Other potential on-site hazards such as sharp objects, known subsurface structures, overhead power lines, and building hazards will be identified during the Site reconnaissance visit.

2.2 Sample Identification

Each sample will be given a unique identification and field duplicates will be denoted so that no two samples will have the same label. Labels or tags identified will be attached to each sample container.

2.3 Sampling Equipment

The following is a general list of equipment necessary for sample collection:

- Stainless steel spoons and bowls for mixing soil and sediment samples;
- Appropriate sample containers provided by the laboratory;
- Sample bottles (kept closed and in the laboratory-shipped coolers until the samples are collected);
- Reagent-grade preservatives or pre-preserved sample containers for aqueous samples;
- Chain-of-Custody labels, tags, seals, and record forms;
- Surgical Gloves;
- Logbook, field sampling records, and indelible ink markers;
- Laboratory grade decontamination soaps (such as Alconox), reagent-grade solvents, and deionized, organic-free water to be used for decontaminating equipment between sampling stations;
- Squirt Bottles;
- Ruler and measuring tape;
- Garbage bags;
- Paper towels and/or baby wipes;
- Buckets, wash basins, and scrub brushes to be used for decontaminating equipment;
- Digital camera or camera and film to document sampling procedures and sample locations;
- Stakes and flagging tape and/or spray paint to identify sampling locations;
- Shipping labels and forms;
- Knife;
- Vermiculite or other packing/shipping material for sample bottles;
- Strapping tape;

- Clear plastic tape;
- Duct tape;
- Aluminum Foil;
- Resealable plastic bags;
- Ice;
- Portable field instruments, including a multi-parameter water quality meter with flow through cell, photoionization detector (PID), and water/product level indicator;
- Poly-sheeting;
- Driller’s jars (for archiving samples);
- Polypropylene or stainless steel bailers;
- Poly propylene rope and/or Teflon line; and
- Submersible, whale, peristaltic and/or centrifugal pump and associated tubing.

Other sampling materials and equipment may be utilized as warranted by field conditions encountered at time of sampling and media to be sampled. Appropriate health and safety equipment and PPE, as per the Health and Safety Plan (HASP) will be used.

2.4 Field Records

The Project Manager (PM) or delegated task lead will control all field logbooks. Field logbooks will be maintained by the Field Operations Lead (FOL) and other team members to provide a daily record of significant events, observations, and measurements during the field investigation. All entries will be signed and dated at the bottom of each page.

Information pertinent to the field investigation and/or sampling activities will be recorded in the logbooks. The logbooks will be bound with consecutively numbered pages. Entries in the logbook will include, but not limited to, the following information:

- Name and title of author, date and time of entry, and physical/environmental/weather conditions during field activity;
- Purpose of sampling activity;
- Location of sampling activity;
- Name and title of field crew members;
- Name and title of any Site visitors;
- Sample media (soil, sediment, groundwater, etc.);
- Sample collection method;
- Number and volume of sample(s) collected;
- Description of sampling point(s);
- Approximate volume of groundwater removed before sampling;
- Preservatives used;
- Date and time of collection;
- Sample identification number(s);
- Sample distribution (e.g., laboratory);

- Field observations;
- Any field measurements made, such as pH, temperature, turbidity, conductivity, water level, etc.;
- References for all maps and photographs of the sampling site(s); and
- Information pertaining to sample documentation such as:
    - Bottle lot numbers;
    - Dates and method of sample shipments;
    - Chain-of-Custody Record numbers; and
    - Overnight Shipping Air Bill Number.

All original data recorded in Field Logbooks, Sample Tags, and Chain-of-Custody records will be written with waterproof ink. None of these accountable, serialized documents will be destroyed.

If an error is made on an accountable document assigned to one individual, that individual will make all corrections simply by crossing a single line through the error and entering the correct information. The erroneous information will not be erased. The person who made the entry will correct any subsequent error discovered on an accountable document. All subsequent corrections will be initialed and dated.

3.0 EQUIPMENT DECONTAMINATION

Equipment will be decontaminated in accordance with procedures specified in the Site Work Plan and as set forth below.

3.1 Drill Rig and Backhoe Decontamination

A decontamination pad will be constructed of high density polyethylene sheeting on a prepared surface sloped to a sump. If possible, the decontamination pad will be constructed onsite, even if work is to be performed offsite. If contaminated soils are encountered offsite, the need for an offsite decontamination pad will need to be evaluated.

The sump must be lined and of sufficient volume to contain at least 20 gallons of decontamination water. The size of the pad shall be sufficient to drive the drill rig on without tearing the sides or bottom of the plastic sheet. Sides of the pad will be bermed so that all decontamination water is contained. Upon completion of all field activities, the decontamination pad will be properly decommissioned. To accomplish decommissioning, all free liquids will be removed from the surface of the High Density Polyethylene (HDPE) sheeting, including the sump area, and allowed to air dry. The HDPE sheeting will then be cut to manageable size, folded or rolled, and placed in the waste container (roll-off container or 55-gallon drum). The earthen material or wood timbers used to construct the containment berm will be inspected to ascertain if the material has come in contact with decontamination liquids during use. If they have, the materials will be disposed in the waste container for subsequent disposal at an appropriate facility. If the materials have not been in contact with decontamination liquids, they may be reused.

All equipment used in intrusive work including backhoe, drilling rig, augers, bits, tools, split-spoon samplers, macro-tube samplers, and tremie pipe will be cleaned with a high-pressure hot water or steam cleaning unit. The equipment will be scrubbed with a wire brush to remove dirt, grease, and oil before beginning fieldwork and before leaving the project Site upon completion of the last sampling activity. Tools, drill rods, and augers will be placed on sawhorses or polyethylene plastic sheets following steam cleaning. Direct contact with the ground will be avoided. The back of the drill rig and all augers, rods, and tools will be decontaminated between each drilling location according to the above procedures. The backhoe bucket, arm, and any other part of the equipment, which may have contacted excavated soil, will be decontaminated between each test pit location. Tools, augers, and rods will be decontaminated between drilling monitoring wells. Decontamination water will be containerized on-site prior to disposal.

Unless sealed in manufacturers packaging, monitoring well casing and screens will be steam cleaned immediately before installation. The screen and casing shall then be wrapped in polyethylene plastic and transported from the designated decontamination area to the well location.

3.2 Sampling Equipment Decontamination

Prior to sampling, all non-dedicated equipment (i.e., bowls, spoons, augers, bailers, and filtering equipment) will be washed with potable water and a detergent (such as Alconox). Decontamination may take place at the sampling location as long as all liquids are contained in pails, buckets, 55-gallon drums, etc. The sampling equipment will then be rinsed with deionized water. Additionally, all equipment used to collect samples for metals analysis will receive a nitric acid rinse followed by a deionized water rinse. At no time will decontaminated equipment be placed directly on the ground. Equipment will be wrapped in polyethylene plastic or aluminum foil for storage or transportation from the designated decontamination area to the sampling location, where appropriate.

4.0 SITE SCREENING

The following practices, procedures and methods will be utilized in carrying out all field activities if specified for in the Site Work Plan.

4.1 Utility Clearance

At a minimum of 72 hours prior to the initiation of intrusive activities, the Contractor responsible for the performance of the work will contact the New York State One Call Center (718-631-6700). Utility maps will be obtained from all entities that may have utilities located within the work area. A private utility locator will be used to clear the area of intrusive work or to identify possible utility interferences and to mark out the utilities in the work area.

4.2 Metal Detector Survey

A metal detector and/or magnetometer survey may be conducted prior to intrusive activity. If there is no indication of buried utilities, drums, or tanks, then subsurface sampling will proceed. However, if the locator indicates the presence of a buried object, activities will not proceed in that location until the type of buried object is determined. If the object cannot be identified from surface or shallow digging, a test pit may be required to determine the identity of the buried object. If a test pit is required, the procedure and scope will be reviewed with the KeySpan PM prior to conducting the work.

The KeySpan PM will keep the property owner or company representative informed of planned Site activities.

5.0 SUBSURFACE BORING PROTOCOL

5.1 Drilling Methods and Sample Collection

Overburden

Soil borings will usually be drilled with geoprobe direct push methods, rotary hollow-stem auger methods, or rotosonic methods. Alternative methods may be used at the geologist's discretion with the authorization of KeySpan and NYSDEC. For geoprobe direct push methods, an assembled Geoprobe Macro-Core® open-tube soil sampler will be driven one sampling interval (approximately 4 feet) into the subsurface then retrieved using a Geoprobe® soil probing machine. The collected soil core will be removed from the sampler along with the liner. After decontamination, the Macro-Core sampler will be reassembled using a new liner. For rotary hollow-stem auger methods, split-spoon sampling will be conducted in accordance with ASTM Specification D-1586-84 for standard penetration test and split barrel sampling, unless otherwise authorized by the field geologist. Split-spoons will be decontaminated after each sample is collected. For rotosonic methods, core samples will be taken directly from the core barrel by extruding it into a plastic baggie-like sleeve, stainless steel tray, or retained in a clear plastic liner. The core barrel will be decontaminated following each use. The field geologist will classify and sample the soil located within the liner. Upon completion the excess soil will be placed into a 55-gallon drum for disposal and the inner liner properly disposed. The clean sampler will then be advanced back down the same borehole to collect the next soil core interval.

Procedures for geologic logging and field classification will be as presented in Section 5.3.

Plastic sheet, plywood sheet, or other suitable cover will be placed around the auger area during drilling, if needed, to contain soil cuttings. Soil cuttings will be placed in a 55-gallon steel drum or a roll-off container for subsequent sampling and disposal. Decontamination water and drilling water will be placed in tanks and/or 55-gallon steel drums for proper disposal.

Sample descriptions, PID readings, and drilling locations will be recorded in the field logbook.

Shelby Tube Sampling

Shelby tube samples will be collected in accordance with the latest revision of ASTM D/587. When the desired sampling depth is reached, the hollow-stem auger or casing will be cleaned out using whatever method is preferred so as not to disturb the material to be sampled. The Shelby tube will be lowered to the bottom of the borehole, then advanced (pushed) via pressure without rotation by a continuous relatively rapid motion until 24 inches of penetration is achieved. At the discretion of the field geologist, a period of approximately 10 minutes, measured from the time of insertion, will be allowed to provide for sample adhesion to the tube walls. Prior to removal, the tube may be rotated two complete revolutions to shear the bottom of the sample from the native material.

Upon removal, the field geologist will log the tops and bottoms of the sample for soil classification. Samples recovered via Shelby tube will be preserved in conformance with the latest revision of ASTM D 4220. To preserve the natural moisture content of the samples, the tube ends will be sealed with a minimum of 0.50 inch of paraffin wax. Plastic slip caps will be applied at the ends of the sample tube, taped, then dipped and sealed in wax.

Rock Coring

Conventional or wire-line HX coring will be used if rock drilling is specified in the Site Work Plan. Prior to drilling at such locations, a minimum 4-inch diameter, temporary steel casing will be socketed into the top of bedrock. Rock coring will be conducted in accordance with the latest version of ASTM D2113. Upon retrieval, the core will be placed in a core box labeled as follows:

Outer Core Box and/or End Panels

1) Project/Site name
2) Site location
3) Boring/well number
4) Box number
5) Core run number and footage interval
6) Date

Inside Core Box Cover (in columns)

1) Boring/well number
2) Run number
3) Depth interval
4) Actual recovery
5) Rock quality degree (RQD) in percent
6) PID screening results where applicable
7) Comments

In addition, a geologist will be on-site during the drilling operations to fully describe each core, including:

1) Color
2) Thickness of bedding
3) Rock type
4) Additional petrographic information
5) Texture
6) Weathering state
7) Structure
8) Detailed description of discontinuities and fillings
9) Formation name
10) Detailed description of visible impacts
11) Miscellaneous observations

Sample descriptions, PID readings, and drilling locations will be recorded in the field logbook.

5.2 Boring Completion Methods

All soil borings will be completed by adding neat cement grout or cement/bentonite grout via tremie pipe from the bottom of the borehole up to the ground surface as the augers are withdrawn. The neat cement grout will be mixed in accordance with the manufacturers recommendations. The bentonite/cement grout will be mixed in the following relative proportions: 30 gallons of water to three 94-pound bags of cement to 25 pounds granular bentonite.

5.3 Geologic Logging, Soil Classification and Documentation

The field geologist will log borehole geology in the field logbook. All samples collected from the borehole will be classified in accordance with ASTM standards D2487 *Standard Method for Classification of Soils for Engineering Purposes* and D2488 *Standard Practice for Description and Identification of Soils*. The field geologist will be on-site during the drilling operations to classify/log each sample in the field logbook and/or field forms including and to enter data items that may include, but not limited to:

- Site;
- Boring number;
- Interval sampled;
- Date;
- Initials of sampling personnel;
- Drilling Company's Name;
- Soil type;
- Color;
- Feet/Inches of recovery;
- Moisture content;
- Texture;
- Grain size and shape;
- Relative density;
- Consistency;
- Visible evidence of residues; and
- Miscellaneous observations (including organic vapor readings).

Figure 1 presents an example of a log of boring form to be completed. If this form is not utilized, the form used should be approved by the KeySpan Project Manager.

6.0 MONITORING WELL INSTALLATION AND DEVELOPMENT

Monitoring wells will be installed at the locations identified in the Site Work Plan. After the completion of drilling and monitoring well installation, all wells will be developed prior to the collection of groundwater samples. The following procedures will be used to install and develop all monitoring wells.

6.1 Monitoring Well Specifications

Monitoring wells installed in unconsolidated deposits that do not penetrate a presumed confining layer will be constructed according to the following specifications:

- PVC 4-inch or 2-inch diameter threaded, flush-joint casing and screens will be installed;
- Wells will be screened in the unconsolidated deposits. Screens will be range in length from 5 to 20 feet, and slot openings will be 0.010 inch. Alternatives may be used at the discretion of the field geologist, based on site-specific geologic conditions;
- If appropriate, a sump, 2 feet in length, may be attached to the bottom of the screen to collect dense nonaqueous phase liquids (DNAPLs);
- The top of the casing will extend to approximately 2 feet above ground surface where possible, given site-specific considerations. Otherwise, flush-mount casings will be used;
- Where appropriate, the annulus around the screens will be backfilled with #0 Morie silica sand (based on Site-specific geologic conditions and screen slot size) to a minimum height of 1 feet above the top of the screen;
- Neat cement grout, a bentonite pellet seal, or a bentonite slurry (30 gallons water to 25 to 30 pounds bentonite, or relative proportions) will be placed above the sand pack. If a pellet seal is used, it will be allowed to hydrate for at least 30 minutes before placement of grout above the seal. Where possible, the bentonite pellet seal will be a minimum of 24-inches in depth, except in those instances where the top of the well screen is in close proximity to the ground surface. In these instances, the well will be completed in accordance with specifications provided by the field geologist who will incorporate an adequate surface seal into the well design;
- A fine sand pack approximately 1-foot thick will be placed above and below the bentonite seal to isolate it and to prevent mixing of components;
- The remainder of the annular space will be filled with a cement grout up to the ground surface. The grout will be pumped from the bottom up. The grout will be mixed in the following relative proportions: 30 gallons of water to three 94-pound bags of cement to 25 pounds granular bentonite. The grout will be allowed to set for a minimum of 48 hours before wells are developed;
- Each monitoring well will have a vented cap and a 4-inch diameter, steel casing with a hinged, locking cap placed over the monitoring well. The protective casing will extend at least 2 feet below ground surface and cemented in place. In some areas, it may be necessary to provide flush mounted casings. All wells will have keyed-alike

locks;

- A concrete surface pad (2 ft x 2 ft x 6-inch) will be sloped to channel water away from the well casing;
- A weep hole will be drilled at the base of the protective standpipe casing to allow any water between the inner and outer casing to drain;
- The top of the PVC well casing will be marked and surveyed to 0.01 foot, and elevations will be determined relative to a fixed benchmark or datum. The measuring point on all wells will be on the innermost PVC casing; and
- Each outer casing will be permanently labeled using a steel hand stamp (i.e. MW-4).

Characteristics of each newly installed well will be recorded on a well installation checklist (Figure 2). Figure 3 shows details of an overburden monitoring well construction diagram for wells installed in unconsolidated material.

Figure 4 shows details of a typical double-cased monitoring well construction diagram for wells installed in unconsolidated soils that penetrate a presumed confining layer. The decision to install double-cased wells will be made on a boring-specific basis by the field geologist. Double-cased wells will be installed when the boring for the monitoring well penetrates a presumed confining layer. The confining layer shall be defined as a minimum five (5) foot thick, predominantly clay unit that has been shown to be laterally continuous across the Site. In the event the field geologist, KeySpan, and NYSDEC PMs decide a reasonable possibility exists for contamination to be deposited in deeper, clean zones during the drilling and installation of a monitoring well, the well will be double-cased. The purpose of the steel protective casing will be to minimize the possibility that residual contamination is deposited at the depth of the screened interval during the drilling process.

Monitoring wells that penetrate confining layers will be installed according to the following specifications:

- 6-inch inner diameter (ID) steel outer casings will be installed to a depth of at least 2 feet below the lower limit of observed or measured contamination and/or the confining layer. This casing will be grouted in place with cement to inhibit downward migration of contamination.
- The 6-inch casing will be installed through 6.25-inch ID hollow-stem augers. The augers will be filled with grout prior to their removal to ensure the integrity of the borehole and the grout seal. Then, the 6-inch casing will be installed into the grout and hydraulically pushed approximately 1-foot beyond the bottom of the boring. Potable water will be tremied to the bottom of the inside of the casing to dilute the grout, thereby allowing the grout to be more easily pumped out of the casing. The grout pumped out of the casing will be drummed and staged with other investigation-derived waste (IDW).
- The cement-bentonite grout remaining in the annulus between the casing and the formation will be allowed to set for at least 24 hours before drilling is continued. The drilling will then continue using a 4-inch diameter flush-joint spin casing and potable water. All lubricant water will be containerized.

- The well will be constructed of 2-inch diameter PVC or stainless steel riser pipe and screen, sand pack, bentonite seal, grout, and surface casing as specified for single cased monitoring wells and in accordance with NYSDEC requirements. The bentonite seal may consist of pellets or a mixture of bentonite slurry in proportions relative to 30 gallons of water to 25-30 pounds of bentonite. The grout mix will consist of 30 gallons water to three 94-pound bags cement and 25 pounds granular bentonite.

Monitoring wells to be installed as open holes in bedrock will be installed according to the following specifications:

- Advance each boring to the top of the bedrock surface. Borehole advancement will be conducted using 6¼-inch ID continuous flight hollow-stem augers in 2-foot intervals, to permit the continuous collection of subsurface soil samples with carbon steel split-spoon samplers in accordance with Section 5.1. Confirmation of the bedrock surface depth will be based upon split-spoon refusal.
- Overbore the borehole to a 12-inch diameter borehole, in which to install a temporary 10-inch carbon steel overburden casing to bedrock, utilizing an appropriately sized tri-cone roller bit.
- Subsequent to temporary casing installation, continue borehole advancement into the bedrock to a depth of 5 feet below the bedrock surface, first using the rock coring method for logging (see Section 5.1) and then overboring with a 9-inch outer diameter (OD) tri-cone roller bit via the water rotary method.
- Set a permanent 6-inch carbon steel casing 5-feet into the competent bedrock by the spin casing method.
- Backfill the annular space around the well casing with bentonite/cement slurry to the surface. The ratio of cement to bentonite for grouting will be approximately 30 gallons of water to three 94 pound bags of cement to every 25 pounds of granular bentonite.
- Remove the 10-inch temporary casing during pressure grouting. Allow grout to cure for at least 24 hours.
- Continue coring and then drilling in the borehole to the maximum anticipated total depth (i.e. 10 feet below the point where groundwater was encountered) and/or the depth where fracture zones indicate sufficient yield, first using the rock coring method and then overboring utilizing the water rotary method and a 5-inch OD tri-cone roller bit.
- Complete the open hole monitoring well with a protective locking stick-up or flush mount box installed in a concrete pad as per Section 6.1.
- If the borehole extends to a depth greater than 25 feet below the bottom of the surface casing (due to depth and/or yield of groundwater), construct the monitoring well using 10 feet of 2-inch diameter Schedule 40 PVC or Schedule 5 stainless steel wire wound screen (0.010-inch slot or a slot size appropriate to the formation) and 2-inch diameter Schedule 40 PVC or Schedule 5 stainless steel riser pipe. For non-flushmounted wells, at least 2 to 3 feet of riser pipe must extend above the ground

surface. Flushmounted wells will only be installed in high traffic areas, such as roadways, sidewalks, etc.

- Backfill the annular space to a minimum height of 2 feet above the top of screen with a sand pack. The sand pack shall be Morie #0 silica sand (based on site-specific geologic conditions and screen slot size). The remaining annular space will be filled with bentonite/cement grout up to the ground surface. The ratio of cement to bentonite for grouting will be approximately 30 gallons of water to three 94 pound bags of cement to every 25 pounds of granular bentonite.
- Complete the constructed monitoring well as described with a protective locking stickup or flush mount box installed in a concrete pad as per Section 6.1.

Characteristics of each newly installed well will be recorded on the well installation checklist (Figure 2). Each well will be identified with a well number placed on the inside of the well cap and on the outside of the protective casing or outside flush-mount cover. Each separate source of potable water used for the drilling process will be sampled once for TCL/TAL compounds.

6.2 Monitoring Well Development

After a minimum of 48 hours after completion, one or a combination of the following techniques will be used in the monitoring well development:

- Surging;
- Bailing;
- Using a centrifugal pump and dedicated polyethylene tubing;
- Positive displacement pumps and dedicated polyethylene tubing; and/or
- Other methods recommended by the field geologist and approved by the KeySpan PM.

Development water will initially be monitored for organic vapors with a PID. In addition, the development water will be observed for the presence of non-aqueous phase liquids (NAPLs) or sheens. The development water will be contained in a tank and/or 55-gallon steel drums on-site. The purge water will be disposed of in accordance with NYSDEC requirements. The wells will be developed until the water in the well is reasonably free of visible sediment (<50 NTU if possible or until pH, temperature and specific conductivity stabilize as judged suitable by the field geologist). In no case will well development exceed 8 hours per well. Following development, wells will be allowed to recover for at least one week before groundwater is purged and sampled. All monitoring well development will be overseen by a field geologist and recorded in the field logbook.

6.3 In-Situ Hydraulic Conductivity Testing

In-situ hydraulic conductivity testing may be performed on selected monitoring wells as indicated in the Site Work Plan to obtain estimates of groundwater velocities and potential groundwater recovery rates for the aquifer. The objective of the hydrogeologic testing is to determine the hydraulic properties of the aquifer in the vicinity of the Site.

Slug tests may be conducted in selected monitoring wells utilizing the rising or falling head slug test technique. Rising head tests can be performed in unconfined and confined aquifers. Falling head tests should only be performed in confined aquifers. The slug tests will be performed by subjecting water-bearing units in the screened interval to a stress caused by the sudden displacement of the water level within the well. The rising head tests will be conducted as follows:

- Slugs and other downhole equipment will be decontaminated before and after each test by methods described in Section 3.2.
- Prior to conducting each slug test, the static water level in the well will be measured to the nearest 0.01 foot. Water levels will be measured during the test with an electronic water level indicator and with pressure transducers attached to a data logger, thereby providing water level measurements by two independent devices.
- A weighted slug of known volume will be inserted gently into the well below the water table. The water level will be measured until the water level returns to static conditions.
- The slug will be suddenly withdrawn from the well and the water level recovery will be monitored at appropriate intervals until recovery is complete and stabilized.
- Wells that were bailed dry during development may not be able to provide meaningful data through slug tests. Tests will be terminated in wells that do not recover significantly (>80% of static level) within one hour. These wells will be bailed dry and their recovery measured with an electronic water level indicator.

The falling head tests will be conducted as follows:

- Slugs and other downhole equipment will be decontaminated before and after each test by methods described in Section 3.2.
- Prior to conducting each slug test, the static water level in the well will be measured to the nearest 0.01 foot. Water levels will be measured during the test with an electronic water level indicator and with pressure transducers attached to a data logger, thereby providing water level measurements by two independent devices.
- A weighted slug of known volume will be quickly inserted into the well below the water table. The water level will be measured until the water level returns to static conditions.
- The test will be terminated in wells that do not recover significantly (>80% of static level) within one hour.

The slug test data will be analyzed using either the Cooper, Bredehoeft, and Papadopulos (1967) type curve method or the Bouwer and Rice (1976, 1989) method. The Cooper et al. analysis assumes that the well penetrates a confined aquifer, and the Bouwer and Rice method applies where unconfined conditions are prevalent.

6.4 Well Abandonment

Unconsolidated monitoring wells will be abandoned in the following manner:

- Remove the protective casing and concrete pad;
- Overdrill the well casing using hollow-stem augers or casing to at least one foot below the depth of the boring/well as indicated in the soil boring log;

- Remove the well casing from the hole. If the casing cannot be removed while the augers are in place, cut off the casing at least two feet, and if possible five feet, below the ground surface;
- Add cement/bentonite grout via tremie pipe from the bottom of the augers as the augers are withdrawn.
- If the well casing cannot be overdrilled and removed, the well casing will be filled with grout from the bottom up using a tremie pipe. The grout mixture will be as specified for the well installation (see Section 6.1); and
- Add grout to the point where the casing was cut off. From that point up to ground surface, backfill with native soil material surrounding the boring/well.

Consolidated (bedrock) monitoring wells or open holes will be abandoned in the following manner:

- Remove the protective casing and concrete pad;
- Add cement/bentonite grout via tremie pipe from the bottom of the well up to the ground surface. The grout mixture will be as specified for the well installation (see Section 6.1); and
- Add grout to the point where the casing was cut off. From that point up to ground surface, backfill with native soil material surrounding the boring/well.

7.0 TEST PIT EXCAVATIONS

When specified in the Site Work Plan, test pits will be excavated using a rubber-tired backhoe. In the event deep excavations are required, a track hoe will be utilized. Locations of test pits will be finalized in the field, based on the location of potential source areas and existing underground utilities. If the prospective test pit location is covered by asphalt or concrete, the area will be saw cut prior to excavation. During excavation activities, personnel will stand upwind of the excavation area to the extent possible. Air monitoring will be conducted in accordance with the HASP. Test pit materials will be visually described, as well as photographed for future reference. Material removed from the test pit will be placed on polyethylene sheeting. Should sampling of excavated material be performed, samples will be collected from the stockpiled material and/or the backhoe bucket. Upon completion, the materials from the test pit will be placed back in the excavation in the reverse order in which it was excavated.

Visually clean soils, such as surface soils, will be segregated from soils that may be impacted. The visually clean soils will be used to cover the impacted soils/source materials when placed back in the excavation. Test pits will be backfilled as soon as possible after completion. No test pit excavation will remain open overnight. For gravel roadways and parking areas, the backfill will be tamped down in 18-inch lifts. A six (6) inch layer of clean run of crushed gravel will be tamped in-place as the final lift. For test pits located in asphalt-covered areas, the surface will be replaced with cold or hot asphalt mix, compacted by rolling, and trimmed flush with the adjoining surface. Test pits located in grassed areas will be reseeded. Following restoration of the excavation, the test pit will be staked to facilitate subsequent location by surveying crews, if necessary.

If during test pit activities a pipe or other buried utility is encountered, excavation will cease, the orientation and dimensions will be recorded, the test pit backfilled and a new test pit attempted in the general vicinity of the initial location. If a pipe or underground utility is accidentally severed, the owner of the utility, then KeySpan, will immediately be notified. Liquid flows or electricity will be shut off immediately and appropriate repairs initiated as soon as possible. If a release of liquid occurs, the Consultant/Contractor PM will notify KeySpan who will then notify NYSDEC. Appropriate response actions will be implemented.

8.0 GROUNDWATER SAMPLING

The following is a step-by-step sampling procedure to be used to collect groundwater samples from the monitoring wells. Well sampling procedures will be recorded on the form shown as Attachment B. Sample management is detailed in the QAPP.

- Groundwater samples will not be collected until at minimum, one week following well development.
- Prior to sampling, a round of groundwater elevation measurements will be collected. The measurements will be made from the surveyed well elevation mark on the top of the inner PVC casing with a decontaminated electric water/product level probe. The measurements will be made in as short a time frame as practical to minimize temporal fluctuations in hydraulic conditions. When appropriate, the elevation of nearby surface water bodies will also be recorded using bulkheads, culverts, or other convenient structures as reference points in which the elevation is known. These relative measurements will be used to aid with interpreting the relationship between observed surface water and groundwater fluctuations. The time, date, and measurement to nearest 0.01 foot will be recorded in the field logbook;
- Decontaminate the probe;
- Place a plastic sheet on the ground to prevent contamination of the bailer rope and/or the tubing associated with the purging (pump) equipment;
- Purge the well by removing a minimum of 3 well volumes, or at least one volume of saturated sand pack, whichever is greater, or use the low flow sampling procedures below. Purging will be conducted with a Teflon, stainless steel or disposable polyethylene bailer, or a centrifugal, submersible, peristaltic, or whale pump and dedicated polyethylene tubing, or other methods at the discretion of the field geologist, and with the prior approval of KeySpan and NYSDEC. If the well goes dry before the required volumes are removed, the well may be sampled when it recovers sufficiently;
- Collect volatile organic analyte (VOA) or BTEX samples with a Teflon, stainless steel or dedicated polyethylene bailer lowered by a dedicated polypropylene and/or Teflon line or other methods as indicated. TCL SVOCs, PAHs, pesticide/PCBs, TAL metals, natural attenuation parameters, and other non-conventional parameters may be collected with a Teflon, stainless steel, or dedicated polyethylene bailer or a submersible, or peristaltic pump using the low-flow sampling technique. Low-flow sampling procedures may be utilized to collect samples for metals analysis if sample turbidity is excessive. Modified low flow sampling procedures may also be utilized to collect samples to facilitate groundwater field parameter measurement using a flow through cell. Low-flow sampling procedures are presented in the April 1996 USEPA Ground Water issue publication EPA/540/S-95/504. The pump should be capable of throttling to a low flow rate suitable for sampling;
- Measure temperature, pH, turbidity, DO, and conductivity, at 3 to 5 minute intervals. When the parameters stabilize over 3 consecutive readings, sampling may commence. Record results in the field logbook prior to sample collection;

- Fill sample containers for VOCs or BTEX first. Sample containers for SVOCs and other analytes are then filled.
- After all samples are collected, dispose of polypropylene line and bailer, or other dedicated disposable sampling equipment.

9.0 SURFACE WATER SAMPLING

Surface water samples will be collected at the locations indicated in the Site Work Plan. Sample management is detailed in the QAPP. A decontaminated stainless steel or glass cup may be used to collect the water for these samples or the sample bottles may be directly dipped into the water. The sample should be collected from mid-depth by submersing the sampling device or sample container to a mid-depth position and opening the container and allowing it to fill. The stainless steel glass cup will be decontaminated following the procedures outlined in Section 3.2. Surface water samples will be collected downstream first, progressing upstream. If sediment sampling is to be performed in conjunction with surface water sampling at corresponding locations, the surface water sample will be collected prior to the sediment sample.

Surface water flow will be measured using a temporary weir or flume and an open channel flow meter consistent described in the Stevens Water Resources Data Book (3rd ed., Leupold & Stevens, Inc., 1978).

Field data will be recorded in the logbook.

10.0 SURFACE SOIL SAMPLING

Surface soil samples will be collected at the locations indicated in the Site Work Plan. Sample management is detailed in the QAPP. Samples will be collected using decontaminated stainless steel equipment. If the selected sampling location is in a vegetated area, the vegetation will be removed over a one square foot area prior to sample collection. The sample will be collected from within the top two (2) inches of the exposed ground surface. Samples will be collected by digging into the soil with a pre-cleaned stainless steel trowel. All samples selected for laboratory analysis will be placed in the appropriate containers provided by the laboratory. Sample containers for volatile organic analysis will be filled first. Next, a sufficient amount of the remaining soil will be homogenized by mixing the sample in a decontaminated stainless steel bowl with a decontaminated steel trowel or disposable scoop. This composite sample will be analyzed for all remaining parameters identified in the Site Work Plan.

All samples collected for analysis will be placed immediately into laboratory sample jars and properly stored in a cooler with ice to 4^{o}C before transport to the laboratory.

Duplicate samples will be collected at the frequency detailed in the QAPP by alternately filling two sets of sample containers. Composite samples may be required to obtain a sufficient soil volume.

In addition, the surface soil sample will be described including:

- Site;
- Location number;
- Interval sampled;
- Date;
- Initials of sampling personnel;
- Soil type;
- Color;
- Moisture content;
- Texture;
- Grain size and shape;
- Relative density;
- Consistency;
- Visible evidence of residues; and
- Miscellaneous observations (including organic vapor readings).

11.0 SUBSURFACE SOIL SAMPLING

11.1 Samples for Laboratory Analysis

Samples selected for laboratory analysis will be obtained from macro-tube samplers, split-spoon samplers, or rotosonic cores and placed in the appropriate containers provided by the laboratory. Sample containers for volatile organic analysis will be filled first. Samples for volatile analysis will be collected from that portion of the sampler that exhibits the highest PID reading or as otherwise detailed in the Site Work Plan. Samples for all remaining parameters will be collected from a discrete interval within the core if required by the Site Work Plan. If a composite sample across a prescribed interval is required, a sufficient amount of the remaining soil will be homogenized by mixing the sample in a decontaminated stainless steel bowl with a decontaminated stainless steel trowel or disposable scoop. This composite sample will be analyzed for all remaining parameters identified in the Site Work Plan.

All samples collected for analysis will immediately be placed into sampling containers provided by the laboratory and properly stored on ice to 4^{o}C before transport to the laboratory. In addition, a geologist will be on-site during the drilling operations to fully describe each sample, which may include but is not limited to the following items:

- Soil type and sorting;
- Color;
- Feet/inches of recovery;
- Moisture content;
- Texture;
- Grain size and shape;
- Relative density;
- Consistency;
- Visible evidence of residues; and
- Miscellaneous observations.

Duplicate samples will be collected at the frequency detailed in the QAPP by alternately filling two sets of sample containers.

If sufficient soil remains after collecting analytical samples, representative portions of each soil sample will be placed in a one-pint glass jar, labeled, and stored on-site. Each container will be labeled with:

- Site;
- Boring number;
- Interval sampled;
- Date; and
- Initials of sampling personnel.

Soil sampling will be described using ASTM procedure D2488 or alternate appropriate method with the approval of the site manager.

11.2 Geotechnical Testing

When identified in the Site Work Plan, laboratory geotechnical testing will be performed on selected soil samples in accordance with appropriate ASTM standards. Geotechnical analysis will be performed on soil samples collected in Shelby tubes or in glass sampling containers including, but not limited to, the following tests: grain size and sieve analysis, total organic carbon, permeability, specific gravity, Atterberg Limits, porosity, moisture content, and bulk density.

12.0 SEDIMENT SAMPLING

Proposed sediment sampling locations are identified in the Site Work Plan. Sample management is detailed in the QAPP. Sample locations in surface waterways will be marked along the bank prior to sampling. For all sample locations, the distance from the waterline to the sample location will be measured and recorded in the field logbook. Sediment samples will be collected from the furthest downstream point, progressing toward the furthest upstream sampling location.

12.1 Shallow Sediment Samples

Shallow sediment samples collected in shallow water will be collected with a Wildco core sampler, clam shell, lexane tubes, hand auger, vibracore or split-spoon sampler. Where possible, rocks and vegetative material will be discarded, and care will be taken to retain fine materials, which tend to disperse when disturbed. Sampling personnel will stand downstream of the sampling point to minimize disturbance of the bottom sediments during collection. Equipment will be decontaminated between samples following procedures outlined in Section 3.2. Field data will be recorded in the field logbook. Surface sediment samples will be collected from a depth interval of 0 to 6 inches (0 to 15 cm) using these same procedures as outlined above.

12.2 Deep Water Sediment Samples

Sediment sampling in deeper water and samples requiring retrieval from deeper depths will be obtained using a barge-mounted drilling system or similar watercraft. Either a tripod and cat-head or a Vibracore will be used on the barge to advance the sampling apparatus into the bottom sediments. The tripod and cat-head assembly will be equipped either with a five-foot long "California" split-spoon sampler or a standard 2-foot long split-spoon sampler for sample collection. To keep the hole open for subsequent samples and to minimize cross-contamination, 3-inch spin casing will be advanced into the sediment. The spin casing will be advanced in 2-foot increments prior to sampling. The sampler will then be pushed into the sediments within the spin casing. The spin casing will be pumped free of sediment after each sample is collected. When the casing is free of sediment, it will be advanced 2 additional feet in preparation for the next sample collection.

The Vibracore uses a vibrating motion to advance a barrel and flexible plastic liner to achieve sample collection. A “core catcher” retains the sediment sample upon retrieval. Samples will be obtained by cutting the plastic liner longitudinally using a knife, and then the sediment samples will be placed in sampling jars, based on sampling interval compensating for compression.

Sediment samples will be visually classified for texture and screened for the evolution of organic vapors with a PID before being placed in sampling jars. Visible staining or contamination will be noted in the field logbook.

13.0 SOIL GAS SAMPLING

13.1 Method of Soil Gas Sampling

Using a hand operated slide hammer, each soil vapor sample will be collected by driving a decontaminated stainless steel soil gas probe approximately 2 to 3 feet bgs. The soil gas probes will then be purged using a PID with an integrated vacuum pump (PhotoVac 2020). After purging each probe until stable PID readings are recorded or five minutes have passed, whichever occurs first, the probe will be capped and soil gas will be allowed to stabilize for a period of five minutes. Following the stabilization period, each probe will be connected to a laboratory-supplied Summa® canister. Summa® canisters are passivated stainless steel vessels that have been cleaned and certified contaminant-free by the contract laboratory. Each Summa® canister will be shipped to the sampling site under a high vacuum (<1 m Torr) to ensure that the canister remains free of contaminants prior to use. After connecting the Summa® canister to the soil gas probe, a regulator valve on the canister will be opened and the vacuum will slowly draw the sample into the canister over a period of 30 minutes. After collecting the gas sample, the valve will be closed and disconnected from the soil gas probe.

13.2 Analysis of the Soil Gas Samples

The samples will be shipped overnight to a New York ELAP certified laboratory for Modified TO-14A analysis. Modified T0-14A (with specific three-point calibration) is an EPA method that increases resolution and identification of potential contaminants identified in the draft New York Department of Department of Health *Volatilization Study of Manufactured Gas Plant Waste and Petroleum Fuels* (August 8, 2003). The method includes further resolution of n-nonane, p-isopropyltoluene, and 1,2,3-trimethylbenzene. In addition, indane and indene will be searched as tentatively identified compounds.

14.0 AIR MONITORING AND SAMPLING

14.1 Ambient Air Monitoring

Air monitoring will be conducted with a calibrated photoionization detector (PID) during all drilling and sampling activities. The PID will be used to monitor for organic vapors in the breathing zone, borehole, and to screen the samples for analysis. PID readings will be recorded in the field logbook. Action levels are identified in the HASP. The PID will be calibrated at least once each day and more frequently, if needed, with the manufacturer specified calibration gas. The detailed procedure for the PID operation and calibration are included in the HASP.

14.2 Air Sampling

Perimeter air monitoring and sampling may be required during field activities at the Site. Air sampling may be required during test pit excavation and/or during soil excavation/removal associated with remedial activities. The basis for such sampling will be outlined in the Site Work Plan.

Air monitoring will be conducted using a mini-ram digital particulate meter, and air sampling will be conducted with a Summa Canister as set forth in the Site Work Plan to fulfill the requirements for baseline measurement in building sumps or basements immediately downgradient of the LIRR ROW, and to fulfill the community monitoring plan requirements if applicable. The mini-ram will be calibrated at least once each day in accordance with the manufacturer’s specifications or otherwise quality assured. The Summa Canister will be sent to an analytical laboratory to be analyzed for volatile organic compounds and naphthalene by EPA Method TO-14.

The air monitoring results will be recorded in the field logbook.

15.0 FIELD INSTRUMENTS

All field analytical equipment will be calibrated immediately prior to each day's use and more frequently if required. Further details on calibration, precision, accuracy, etc. are provided in the QAPP. The calibration procedures will conform to manufacturer's standard instructions. This calibration will ensure that the equipment is functioning within the allowable tolerances established by the manufacturer and required by the project. Records of all instrument calibration will be maintained by the Field Operations Leader (FOL) and will be subject to audit by the Project Quality Assurance Manager (PQAM). Copies of all of the instrument manuals will be maintained on-site by the FOL. The field instruments will include a PID, Horiba multi-parameter water quality meter with flow through cell, electronic water/product level indicator, and possible other instruments such as a mini-ram digital particulate meter, combustible gas indicator (CGI), downwell pH meter, downwell conductivity meter, and a downwell DO meter. Select examples of instrument specific procedures are provided below.

15.1 Portable Photoionization Detector

The photoionization detector (PID) will be equipped with a minimum 10.6 eV lamp. The PID should be capable of ionizing and detecting compounds with an ionization potential of less than 10.6 eV. This accounts for up to 73% of the volatile organic compounds on the NYSDEC ASP Target Compound List. Calibration will be performed at the beginning of each day of use with a standard calibration gas specified by the manufacturer. If the unit experiences abnormal perturbation or erratic readings, additional calibration will be required. All calibration data will be recorded in field logbooks and/or on calibration log sheets to be maintained on-site by the FOL.

15.2 pH Meter

Calibration of the pH meter will be performed at the start of each day of use, and after very high or low readings. National Institute of Standards and Technology-traceable standard buffer solutions, which bracket the expected pH range, will be used. The standards will most likely be pH of 7.0 and 10.0 standard units. The use of the pH calibration and slope knobs will be used to set the meter to display the value of the standard being checked. All calibration data will be recorded in field logbooks and/or on calibration log sheets to be maintained on-site by the FOL.

15.3 Specific Conductivity Meter

Calibration checks using the conductivity standard will be performed at the start of each day of use, after five to ten readings or after very high or low readings. The portable conductivity meter will be calibrated on a daily basis using a reference solution specified by the manufacturer. Readings must be within 5 percent to be acceptable. The thermometer of the meter will be calibrated against the field laboratory thermometer on a weekly basis.

15.4 Turbidity Meter

Calibration using a turbidity standard will be performed at the start of each day of use and after very high or low readings. The portable turbidity meter will be calibrated using a reference solution specified by the manufacturer. The turbidity reading must be within ±2 NTU of the standard to be acceptable.

15.5 DO Meter

Calibration using a DO standard will be performed at the start of each day of use. The portable DO meter will be calibrated using a calibration solution specified by the manufacturer. The DO reading must be within 5% of the standard to be acceptable.

15.6 Combustible Gas Indicator

Calibration of the CGI will conform to the procedures prescribed in the HASP. Calibration will occur at the start of each day of use. All calibration data will be recorded in field logbooks and/or on calibration log sheets to be maintained on-site by the FOL.

16.0 MANAGEMENT OF INVESTIGATION DERIVED WASTE

During the implementation of field activities, investigation derived wastes (IDW) will be generated at the Site. These IDWs will include the following: soil drilling cuttings and water, development and purge water, decontamination wash water, PPE, polysheeting, spent decontamination fluids, etc. Following the generation of these IDWs, they will be properly containerized in 55-gallon drums, frac tanks, and/or roll-off containers. PPE will be bagged and placed in 55-gallon drums. The containers will be properly labeled with the Site name, client name and address, contents of the containers, etc. The containers will be secured at the end of each day at the Site. The containers will be segregated on-site.

Upon completion of the field activities, the containers will be sampled for disposal characteristics as required by the disposal facility. The program manager will coordinate disposal of IDW with KeySpan including the determination that the selected disposal facility is properly permitted to dispose of the IDW.

17.0 REFERENCES:

Atlas of Community Water System Sources

Bouwer and Rice, 1976: A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells, Water Resources Research, v. 12, pp. 423-428.

Cooper, Bredehoeft, and Papadopulos, 1967: Response of a Finite Diameter Well to an Instantaneous Charge of Water. Water Resources Research, vol. 3, no. 1, pp. 263-269.

Haling and Weaver, 1991: Dense Nonaqueous Phase Liquids, EPA Groundwater Issue. March, 1991.

Leupold & Stevens, Inc. 1978: Stevens Water Resources Data Book, 3rd Edition.

USEPA, 1998: Low-Flow (Minimal Drawdown) Ground Water Sampling Procedures. 540/5-95/504.

FIGURES

Figure 1
Boring Log Data Form

Boring Log Data Form

Boring No.: ______________________ Location/Operable Unit: ____

Depth (feet)	**Recovery (inches)**	**Blow Counts**	**Soil Description**	**Samples**

Notes:

Figure 2

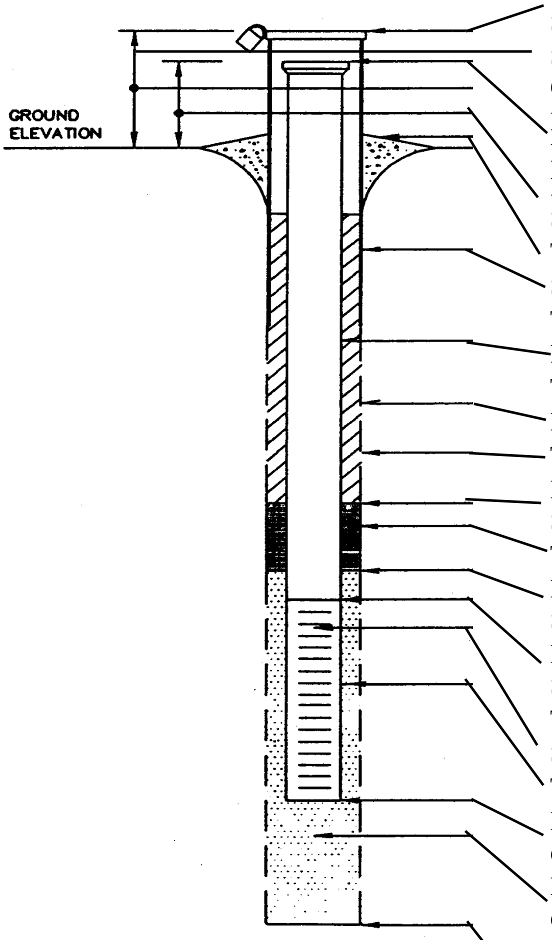
WELL INSTALLATION CHECKLIST

Project Name		Drilling Co.		Boring No.	
Project Number		Drillers		Date Started	
Project Location		TRC Inspector		Date Completed	
Site Location					

Final depth of boring and bore hole diameter	
Depth bottom of sand pack and sand used (e.g. Morie #0)	
Type of casing (e.g. 2-in SCH 40 PVC)	
Depth bottom of screen and screen type (e.g. 10-slot)	
Depth top of screen	
Depth top of sand pack	
Depth top of seal and type of seal (e.g. cement/bentonite grout)	
Type of surface seal	
Well completion (e.g. stickup or flush mount)	

Figure 3
Overburden Monitoring Well Construction Diagram

Project		Driller	
Project No.		Drilling Method	
Date		Development Method	
Elevation		Boring No.	
Field Geologist		Well No.	

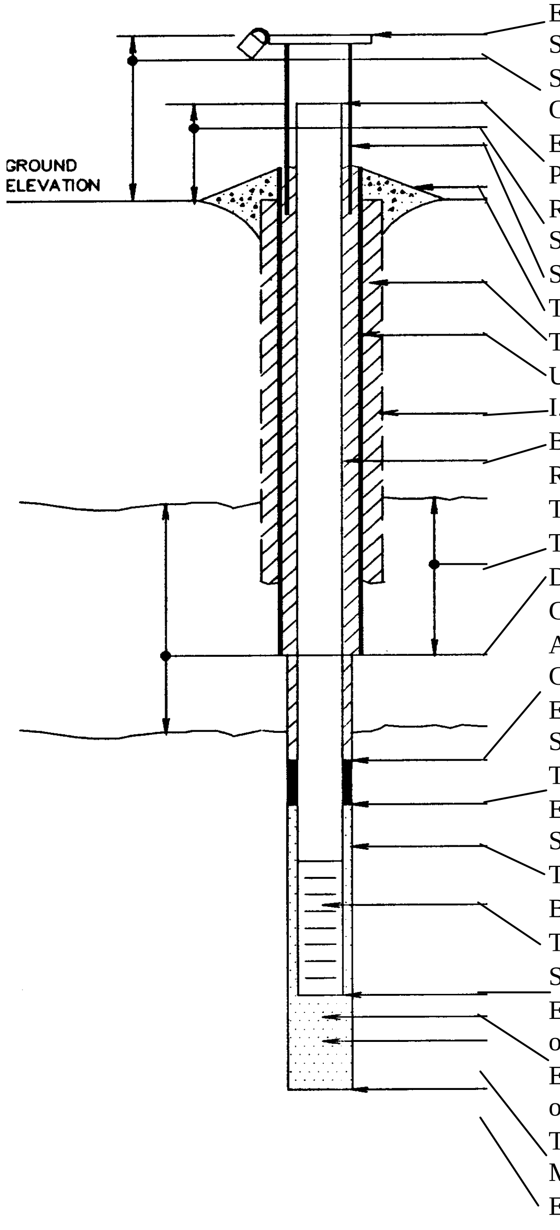


Elevation of Top of Surface Casing	
Stick Up Casing Above Ground Surface	
Elevation of Top of Riser Pipe	
Riser Pipe Above Ground Surface	
Type of Surface Seal	
Surface Casing I.D.	
Type of Surface Casing	
Riser Pipe I.D.	
Type of Riser Pipe	
Borehole Diameter	
Type of Backfill	
Elevation/Depth Top of Seal	
Type of Seal	
Elevation/Depth Top of Sand Pack	
Elevation/Depth Top of Screen	
Type of Screen	
Slot Size and Length	
Type of Sand Pack	
Elevation/Depth Bottom of Screen	
Elevation/Depth Bottom of Sand Pack	
Type of Backfill Below Monitoring Well	
Elevation/Depth of Hole	

NOT TO SCALE

Figure 4
Double Cased Monitoring Well Construction Diagram

Project		Driller	
Project No.		Drilling Method	
Date		Development Method	
Elevation		Boring No.	
Field Geologist		Well No.	



Elevation of Top of Surface Casing	
Stick Up Casing Above Ground Surface	
Elevation of Top of Riser Pipe	
Riser Pipe Above Ground Surface	
Surface Casing I.D.	
Type of Surface Seal	
Type of Surface Casing	
Upper Aquifer Casing I.D.	
Borehole Diameter/Depth	
Riser Pipe I.D.	
Type of Riser Pipe	
Type of Backfill	
Depth Casing is Set In	
Confining Layer	
Approximate Thickness Confining Layer	
Elevation/Depth Top of Seal	
Type of Seal	
Elevation/Depth Top of Sand Pack	
Type of Sand Pack	
Borehole Diameter/Depth	
Type of Screen	
Slot Size and Length	
Elevation/Depth Bottom of Screen	
Elevation/Depth Bottom of Sand Pack	
Type of Backfill Below Monitoring Well	
Elevation/Depth of Hole	

NOT TO SCALE

ATTACHMENTS

ATTACHMENT A

United States
Environmental Protection
Agency

Office of
Research and
Development

Office of Solid Waste
and Emergency
Response

EPA/540/4-91-002
March 1991

Ground Water Issue

DENSE NONAQUEOUS PHASE LIQUIDS

Scott G. Huling* and James W. Weaver**

Background

The Regional Superfund Ground Water Forum is a group of EPA professionals representing EPA's Regional Superfund Offices, committed to the identification and the resolution of ground water issues impacting the remediation of Superfund sites. The Forum is supported by and advises the Superfund Technical Support Project. Dense nonaqueous phase liquids is an issue identified by the Forum as a concern of Superfund decision-makers. For further information contact Scott G. Huling (FTS:743-2313), Jim Weaver (FTS:743-2420), or Randall R. Ross (FTS: 743-2355).

Introduction

Dense nonaqueous phase liquids (DNAPLs) are present at numerous hazardous waste sites and are suspected to exist at many more. Due to the numerous variables influencing DNAPL transport and fate in the subsurface, and consequently, the ensuing complexity, DNAPLs are largely undetected and yet are likely to be a significant limiting factor in site remediation. This issue paper is a literature evaluation focusing on DNAPLs and provides an overview from a conceptual fate and transport point of view of DNAPL phase distribution, monitoring, site characterization, remediation, and modeling.

A nonaqueous phase liquid (NAPL) is a term used to describe the physical and chemical differences between a hydrocarbon liquid and water which result in a physical interface between a mixture of the two liquids. The interface is a physical dividing surface between the bulk phases of the two liquids, but compounds found in the NAPL are not prevented from solubilizing into the ground water. Immiscibility is typically determined based on the visual observation of a physical interface in a water- hydrocarbon mixture. There are numerous methods, however, which are used to quantify the physical and chemical properties of hydrocarbon liquids (31).

Nonaqueous phase liquids have typically been divided into two general categories, dense and light. These terms describe the specific gravity, or the weight of the nonaqueous phase liquid relative to water. Correspondingly, the dense nonaqueous phase liquids have a specific gravity greater than water, and the light nonaqueous phase liquids (LNAPL) have a specific gravity less than water.

Several of the most common compounds associated with DNAPLs found at Superfund sites are included in Table 1. These compounds are a partial list of a larger list identified by a national screening of the most prevalent compounds found at Superfund sites (65). The general chemical categories are halogenated/non-halogenated semi-volatiles and halogenated volatiles. These compounds are typically found in the following wastes and waste-producing processes: solvents, wood preserving wastes (creosote, pentachlorophenol), coal tars, and pesticides. The most frequently cited group of these contaminants to date are the chlorinated solvents.

DNAPL Transport and Fate - Conceptual Approach

Fate and transport of DNAPLs in the subsurface will be presented from a conceptual point of view. Figures have been selected for various spill scenarios which illustrate the general behavior of DNAPL in the subsurface. Following the conceptual approach, detailed information will be presented explaining the specific mechanisms, processes, and variables which influence DNAPL fate and transport. This includes DNAPL characteristics, subsurface media characteristics, and saturation dependent parameters.

Unsaturated Zone

Figure 1 indicates the general scenario of a release of DNAPL into the soil which subsequently migrates vertically under both the forces of gravity and soil capillarity. Soil capillarity is also responsible for the lateral migration of DNAPL. A point is reached at which the DNAPL no longer holds together as a continuous phase, but rather is present as isolated residual globules. The fraction of the hydrocarbon that is retained by capillary forces in the porous media is

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Director

Table 1. Most prevalent chemical compounds at U.S. Superfund Sites (65) with a specific gravity greater than one.

Compound	Density [1]	Dynamic[2] Viscosity	Kinematic Viscosity[3]	Water[4] Solub.	Henry's Law Constant[5]	Vapor[6] Pressure
Halogenated Semi-volatiles						
1,4-Dichlorobenzene	1.2475	1.2580	1.008	8. 0 E+01	1.58 E-03	6 E-01
1,2-Dichlorobenzene	1.3060	1.3020	0.997	1. 0 E+02	1.88 E-03	9.6 E-01
Aroclor 1242	1.3850			4.5 E-01	3.4 E-04	4.06 E-04
Aroclor 1260	1.4400			2.7 E-03	3.4 E-04	4.05 E-05
Aroclor 1254	1.5380			1.2 E-02	2.8 E-04	7.71 E-05
Chlordane	1.6	1.1040	0.69	5.6 E-02	2.2 E-04	1 E-05
Dieldrin	1.7500			1.86 E-01	9.7 E-06	1.78 E-07
2,3,4,6-Tetrachlorophenol	1.8390			1. 0 E+03		
Pentachlorophenol	1.9780			1.4 E+01	2.8 E-06	1.1 E-04
Halogenated Volatiles						
Chlorobenzene	1.1060	0.7560	0.683	4.9 E+02	3.46 E-03	8.8 E+00
1,2-Dichloropropane	1.1580	0.8400	0.72	2.7 E+03	3.6 E-03	3.95 E+01
1,1-Dichloroethane	1.1750	0.3770	0.321	5.5 E+03	5.45 E-04	1.82 E+02
1,1-Dichloroethylene	1.2140	0.3300	0.27	4. 0 E+02	1.49 E-03	5 E+02
1,2-Dichloroethane	1.2530	0.8400	0.67	8.69 E+03	1.1 E-03	6.37 E+01
Trans-1,2-Dichloroethylene	1.2570	0.4040	0.321	6.3 E+03	5.32 E-03	2.65 E+02
Cis-1,2-Dichloroethylene	1.2480	0.4670	0.364	3.5 E+03	7.5 E-03	2 E+02
1,1,1-Trichloroethane	1.3250	0.8580	0.647	9.5 E+02	4.08 E-03	1 E+02
Methylene Chloride	1.3250	0.4300	0.324	1.32 E+04	2.57 E-03	3.5 E+02
1,1,2-Trichloroethane	1.4436	0.1190	0.824	4.5 E+03	1.17 E-03	1.88 E+01
Trichloroethylene	1.4620	0.5700	0.390	1. 0 E+03	8.92 E-03	5.87 E+01
Chloroform	1.4850	0.5630	0.379	8.22 E+03	3.75 E-03	1.6 E+02
Carbon Tetrachloride	1.5947	0.9650	0.605	8.0 E+02	2. 0 E-02	9.13 E+01
1,1,2,2-Tetrachloroethane	1.6	1.7700	1.10	2.9 E+03	5. 0 E-04	4.9 E+00
Tetrachloroethylene	1.6250	0.8900	0.54	1.5 E+02	2.27 E-02	1.4 E+01
Ethylene Dibromide	2.1720	1.6760	0.79	3.4 E+03	3.18 E-04	1.1 E+01
Non-halogenated Semi-volatiles						
2-Methyl Napthalene	1.0058			2.54 E+01	5.06 E-02	6.80 E-02
o-Cresol	1.0273			3.1 E+04	4.7 E-05	2.45 E-01
p-Cresol	1.0347			2.4 E+04	3.5 E-04	1.08 E-01
2,4-Dimethylphenol	1.0360			6.2 E+03	2.5 E-06	9.8 E-02
m-Cresol	1.0380	21. 0	20	2.35 E+04	3.8 E-05	1.53 E-01
Phenol	1.0576		3.87	8.4 E+04	7.8 E-07	5.293E-01
Naphthalene	1.1620			3.1 E+01	1.27 E-03	2.336E-01
Benzo(a)Anthracene	1.1740			1.4 E-02	4.5 E-06	1.16 E-09
Flourene	1.2030			1.9 E+00	7.65 E-05	6.67 E-04
Acenaphthene	1.2250			3.88 E+00	1.2 E-03	2.31 E-02
Anthracene	1.2500			7.5 E-02	3.38 E-05	1.08 E-05
Dibenz(a,h)Anthracene	1.2520			2.5 E-03	7.33 E-08	1 E-10
Fluoranthene	1.2520			2.65 E-01	6.5 E-06	E-02 E-06
Pyrene	1.2710			1.48 E-01	1.2 E-05	6.67 E-06
Chrysene	1.2740			6. 0 E-03	1.05 E-06	6.3 E-09
2,4-Dinitrophenol	1.6800			6. 0 E+03	6.45 E-10	1.49 E-05
Miscellaneous						
Coal Tar	1.028(7)	18.98(7)				
Creosote	1.05	1.08(8)				

[1] g/cc

[2] centipoise (cp), water has a dynamic viscosity of 1 cp at 20°C.

[3] centistokes (cs)

[4] mg/l

[5] atm-m^3/mol

[6] mm Hg

[7] 45° F (70)

[8] 15.5°C, varies with creosote mix (62)

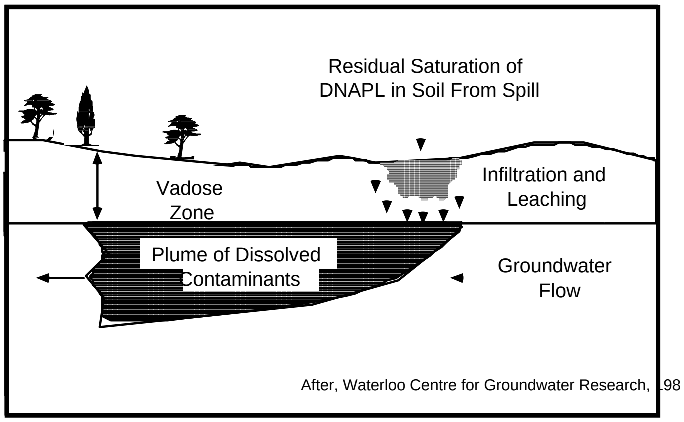

Figure 1. **The entire volume of DNAPL is exhausted by residual saturation in the vadose zone prior to DNAPL reaching the water table. Soluble phase compounds may be leached from the DNAPL residual saturation and contaminate the ground water.**

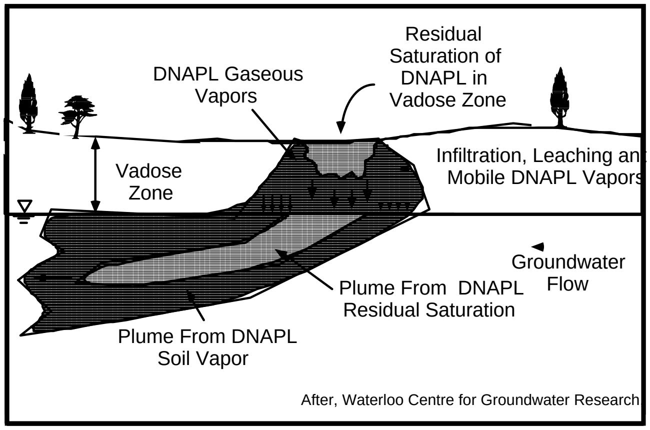

Figure 2. Migration of DNAPL vapors from the spill area and subsequent contamination of the soils and ground water.

referred to as residual saturation. In this spill scenario, the residual saturation in the unsaturated zone exhausted the volume of DNAPL, preventing it from reaching the water table. This figure also shows the subsequent leaching (solubilization) of the DNAPL residual saturation by water percolating through the unsaturated zone (vadose zone). The leachate reaching the saturated zone results in ground-water contamination by the soluble phase components of the hydrocarbon. Additionally, the residual saturation at or near the water table is also subjected to leaching from the rise and fall of the water table (seasonal, sea level, etc.).

Increasing information is drawing attention to the importance of the possibility that gaseous-phase vapors from NAPL in the unsaturated zone are responsible for contaminating the ground water and soil (18,47). It is reported that the greater “relative vapor density” of gaseous vapors to air will be affected by gravity and will tend to sink. In subsurface systems where lateral spreading is not restricted, spreading of the vapors may occur as indicated in Figure 2. The result is that a greater amount of soils and ground water will be exposed to the DNAPL vapors and may result in further contamination. The extent of contamination will depend largely on the partitioning of the DNAPL vapor phase between the aqueous and solid phases.

DNAPL Phase Distribution - Four Phase System

It is apparent from Figures 1 and 2 that the DNAPL may be present in the subsurface in various physical states or what is referred to as phases. As illustrated in Figure 3, there are four possible phases: gaseous, solid, water, and immiscible hydrocarbon (DNAPL) in the unsaturated zone. Contaminants associated with the release of DNAPL can, therefore, occur in four phases described as follows:

1. Air phase - contaminants may be present as vapors;
2. Solid phase - contaminants may adsorb or partition onto the soil or aquifer material;
3. Water phase - contaminants may dissolve into the water according to their solubility; and
4. Immiscible phase - contaminants may be present as dense nonaqueous phase liquids.

The four phase system is the most complex scenario because there are four phases and the contaminant can partition between any one or all four of these phases, as illustrated in Figure 4. For example, TCE introduced into the subsurface as a DNAPL may partition onto the soil phase, volatilize into the soil gas, and solubilize into the water phase resulting in contamination in all four phases. TCE can also partition between the water and soil, water and air, and between the soil and air. There are six pathways of phase distribution in the unsaturated zone. The distribution of a contaminant between these phases can be represented by empirical relationships referred to as partition coefficients. The partition coefficients, or the distribution of the DNAPL between the four phases, is highly site-specific and highly dependent on the characteristics of both the soil/aquifer matrix and the DNAPL. Therefore, the distribution between phases may change with time and/or location at the same site and during different stages of site remediation.

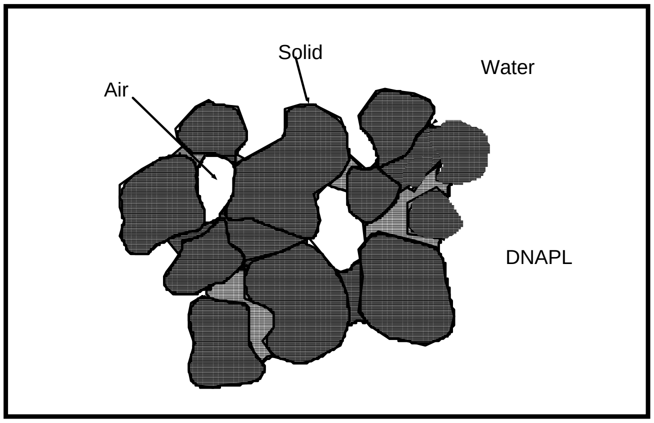

Figure 3. A DNAPL contaminated unsaturated zone has four physical states or phases (air, solid, water, immiscible). The contaminant may be present in any one, or all four phases.

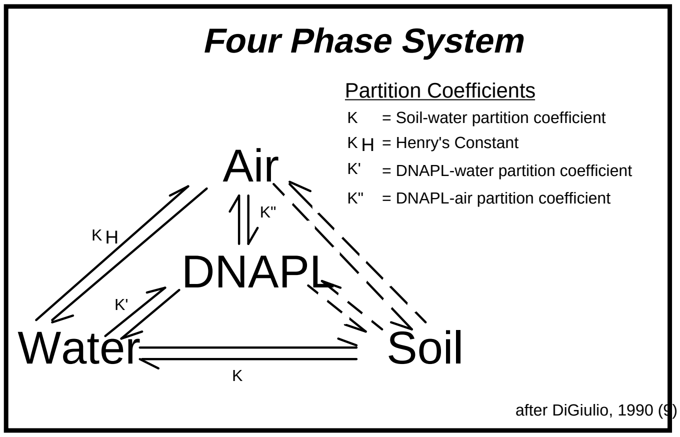

Figure 4. Distribution of DNAPL between the four phases found in the vadose zone.

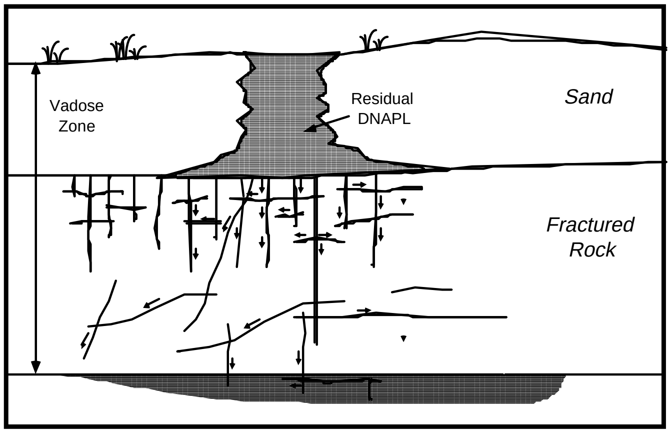

Figure 5. DNAPL spilled into fractured rock systems may follow a complex distribution of the preferential pathways.

The concept of phase distribution is critical in decision-making. Understanding the phase distribution of a DNAPL introduced into the subsurface provides significant insight in determining which tools are viable options with respect to site characterization and remediation.

DNAPL represented by residual saturation in the four phase diagram is largely immobile under the usual subsurface pressure conditions and can migrate further only: 1) in water according to its solubility; or 2) in the gas phase of the unsaturated zone (47). DNAPL components adsorbed onto the soil are also considered immobile. The mobile phases are, therefore, the soluble and volatile components of the DNAPL in the water and air, respectively.

The pore space in the unsaturated zone may be filled with one or all three fluid phases (gaseous, aqueous, immiscible). The presence of DNAPL as a continuous immiscible phase has the potential to be mobile. The mobility of DNAPL in the subsurface must be evaluated on a case by case basis. The maximum number of potentially mobile fluid phases is three. Simultaneous flow of the three phases (air, water, and immiscible) is considerably more complicated than two-phase flow (46). The mobility of three phase flow in a four-phase system is complex, poorly understood, and is beyond the scope of this DNAPL overview. The relative mobility of the two phases, water and DNAPL, in a three-phase system is presented below in the section entitled “Relative Permeability.”

Generally, rock aquifers contain a myriad of cracks (fractures) of various lengths, widths, and apertures (32). Fractured rock systems have been described as rock blocks bounded by discrete discontinuities comprised of fractures, joints, and shear zones which may be open, mineral-filled, deformed, or any combination thereof (61). The unsaturated zone overlying these fractured rock systems also contain the myriad of preferential pathways. DNAPL introduced into such formations (Figure 5) follow complex pathways due to the heterogeneous distribution of the cracks, conduits, and fractures’, i.e., preferential pathways. Transport of DNAPL may follow non-Darcian flow in the open fractures and/or Darcian flow in the porous media filled fractures. Relatively small volumes of NAPL may move deep, quickly into the rock because the retention capacity offered by the dead-end fractures and the immobile fragments and globules in the larger fractures is so small (32). Currently, the capability to collect the detailed information for a complete description of a contaminated fractured rock system is regarded as neither technically possible nor economically feasible (61).

Low permeability stratigraphic units such as high clay content formations may also contain a heterogeneous distribution of preferential pathways. As illustrated in Figure 6, DNAPL transport in these preferential pathways is correspondingly complex. Typically, it is assumed that high clay content formations are impervious to DNAPL. However, as DNAPL spreads out on low permeable formations it tends to seek out zones of higher permeability. As a result, preferential pathways allow the DNAPL to migrate further into the low permeable formation, or through it to underlying stratigraphic units. It is apparent from Figures 5 and 6 that the complexity of DNAPL transport may be significant prior to reaching the water table.

Saturated Zone

The second general scenario is one in which the volume of DNAPL is sufficient to overcome the fraction depleted by the residual saturation in the vadose zone, as illustrated in Figure 7. Consequently, the DNAPL reaches the water table and contaminates the ground water directly. The specific gravity of DNAPL is greater than water, therefore, the DNAPL migrates into the saturated zone. In this scenario, DNAPL continues the vertical migration through the saturated zone until the volume is eventually exhausted by the residual saturation process or until it is intercepted by a low permeable formation where it begins to migrate laterally.

DNAPL Phase Distribution - Three Phase System

Due to the lack of the gaseous phase, the saturated zone containing DNAPL is considered a three-phase system consisting of the solid, water, and immiscible hydrocarbon (Figure 8). Contaminant distribution in the three-phase

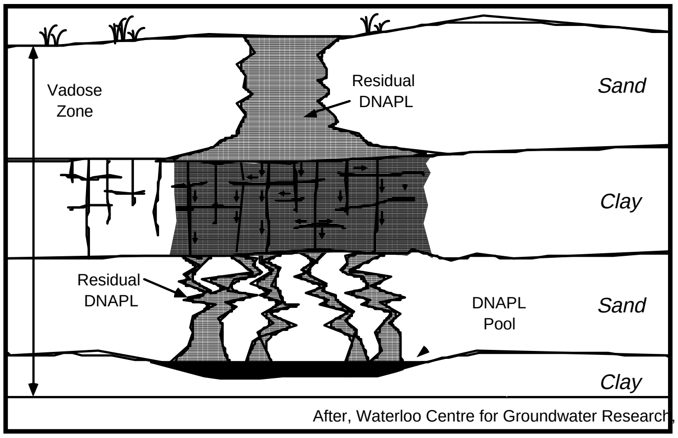

Figure 6. DNAPL spilled into a low permeable formation may follow a complex distribution of preferential pathways. The volume of DNAPL is exhausted in the vadose zone prior to reaching the water table.

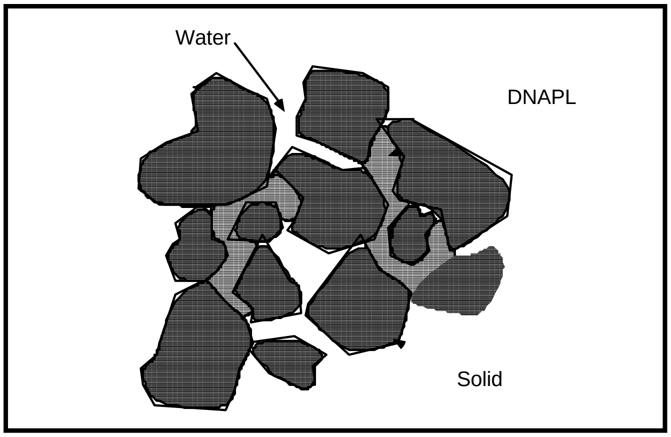

Figure 8. A DNAPL contaminated saturated zone has three phases (solid, water, immiscible). The contaminant may be present in any one, or all three phases.

system is less complex than the four-phase system. Again, this is highly dependent on the characteristics of both the aquifer matrix and the DNAPL. Figure 9 indicates the three phases and the transfer of the mass of contaminant between the phases. In this scenario, there are only three pathways of phase distribution in the saturated zone.

Note that when the DNAPL is represented by residual saturation in the three-phase system, the mobile phase of the contaminant is the water soluble components of the DNAPL and the immobile phases are the residual saturation and the adsorbed components of the DNAPL associated with the aquifer material. The main mobilization mechanism of the residual saturation is removal of soluble phase components into the ground water. When the DNAPL is present as a continuous immiscible phase, it too is considered one of the mobile phases of the contaminant. While the continuous phase DNAPL has the potential to be mobile, immobile continuous phase DNAPL may also exist in the subsurface. Although the saturated zone is considered a three-phase system, gaseous vapors from DNAPL in the unsaturated zone does have the potential to affect ground-water quality, as was indicated earlier in Figure 2.

Assuming the residual saturation in the saturated zone does not deplete the entire volume of the DNAPL, the DNAPL will continue migrating vertically until it encounters a zone or stratigraphic unit of lower permeability. Upon reaching the zone of lower permeability, the DNAPL will begin to migrate laterally. The hydraulic conductivity in the vertical direction is typically less than in the horizontal direction. It is not uncommon to find vertical conductivity that is one-fifth or one-tenth the horizontal value (4). It is expected that DNAPL spilled into the subsurface will have a significant potential to migrate laterally. If the lower permeable boundary is “bowl shaped”, the DNAPL will pond as a reservoir (refer to Figure 10). As illustrated in Figure 11, it is not uncommon to observe a perched DNAPL reservoir where a discontinuous impermeable layer; i.e., silt or clay lens, intercepts the vertical migration of DNAPL. When a sufficient volume of

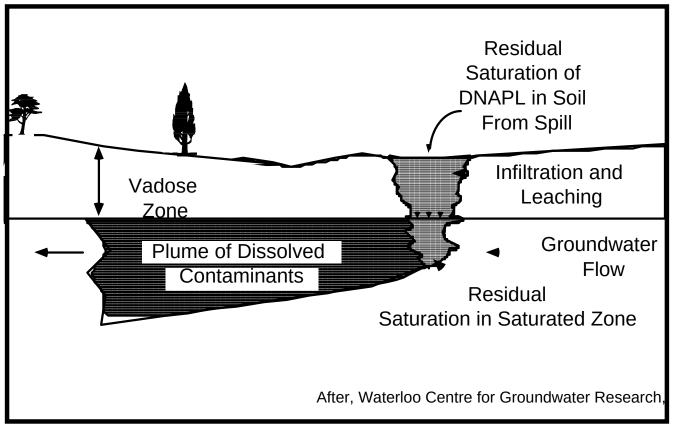

Figure 7. The volume of DNAPL is sufficient to overcome the residual saturation in the vadose zone and consequently penetrates the water table.

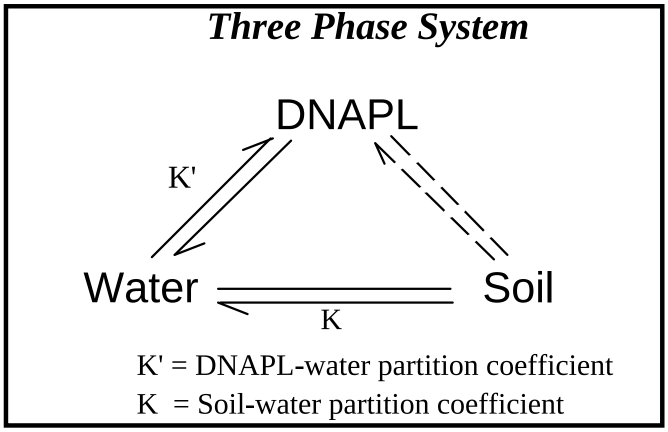

Figure 9. Distribution of DNAPL between the three phases found in the saturated zone.

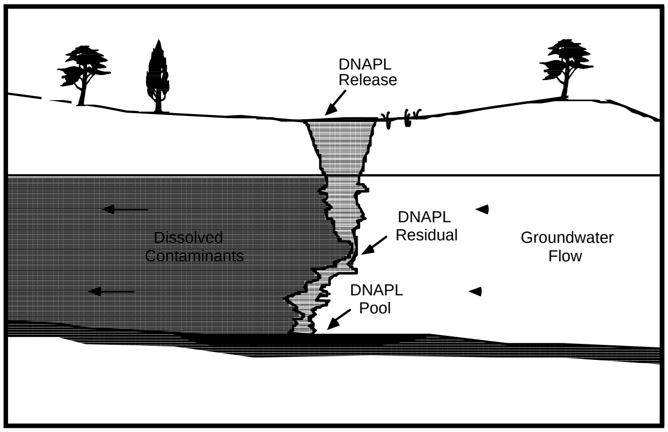

Figure 10. Migration of DNAPL through the vadose zone to an impermeable boundary.

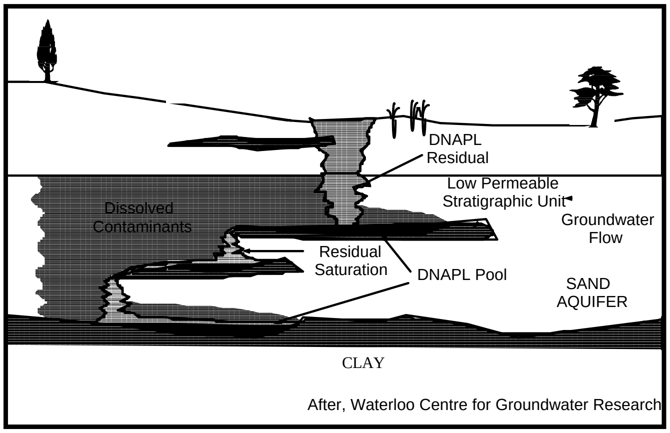

Figure 12. Perched and deep DNAPL reservoirs.

DNAPL has been released and multiple discontinuous impermeable layers exist, the DNAPL may be present in several perched reservoirs as well as a deep reservoir (refer to Figure 12). Lateral migration continues until either the residual saturation depletes the DNAPL or an impermeable depression immobilizes the DNAPL in a reservoir type scenario. Soluble-phase components of the DNAPL will partition into the ground water from both the residual saturation or DNAPL pools. The migration of DNAPL vertically through the aquifer results in the release of soluble-phase components of the DNAPL across the entire thickness of the aquifer. Note, that ground water becomes contaminated as it flows through, and around, the DNAPL contaminated zone.

As indicated earlier, DNAPL will migrate laterally upon reaching a stratigraphic unit of lower permeability. Transport of DNAPL will therefore be largely dependent on the gradient of the stratigraphy. Occasionally, the directional gradient of an impermeable stratigraphic unit may be different than the direction of ground-water flow as illustrated in Figure 13a. This may result in the migration of the continuous phase DNAPL in a direction different from the ground-water flow. Nonhorizontal stratigraphic units with varying hydraulic conductivity may also convey DNAPL in a different direction than ground-water flow, and at different rates (refer to Figure 13b). Determination of the direction of impermeable stratigraphic units will therefore provide useful information concerning the direction of DNAPL transport.

Similar to the unsaturated zone, the saturated zone also contains a complex distribution of preferential pathways from cracks, fractures, joints, etc. DNAPL introduced into such formations correspondingly follow the complex network of pathways through an otherwise relatively impermeable rock material. Other pathways which may behave as vertical conduits for DNAPL include root holes, stratigraphic windows, disposal wells, unsealed geotechnical boreholes, improperly sealed hydrogeological investigation sampling holes and monitoring wells, and old uncased/unsealed water supply wells (72). Transport of the DNAPL may migrate very rapidly in these open conduits or follow Darcian flow in the surrounding porous media or porous media filled fractures. A relatively small volume of DNAPL can move deep into a fractured system due to the low retentive capacity of the fractured system. Consequently, fractured clay or rock stratigraphic units, which are often considered lower DNAPL

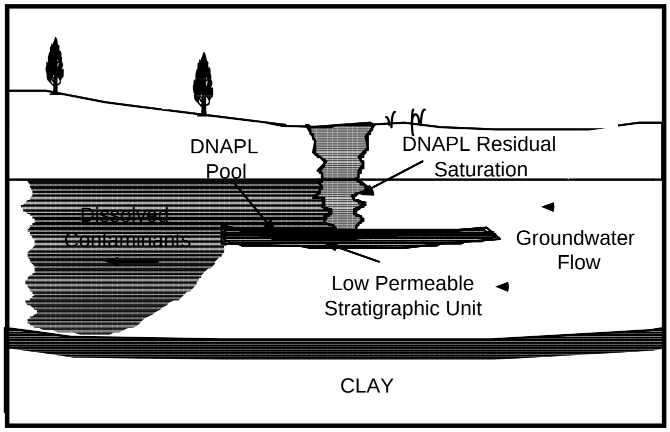

Figure 11. Perched DNAPL reservoir.

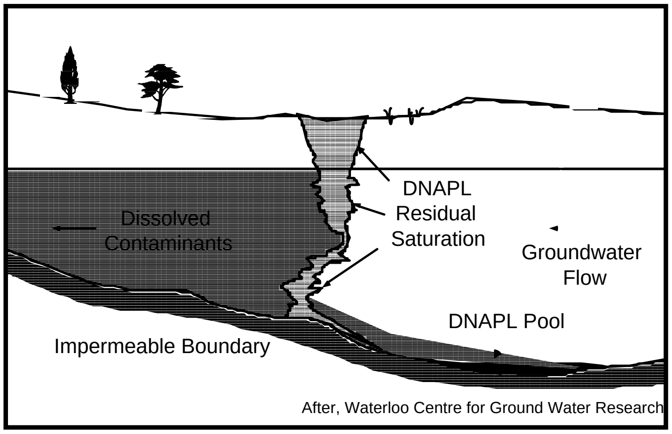

Figure 13a. Stratigraphic gradient different from ground water gradient results in a different direction of flow of the ground water and continuous phase DNAPL.

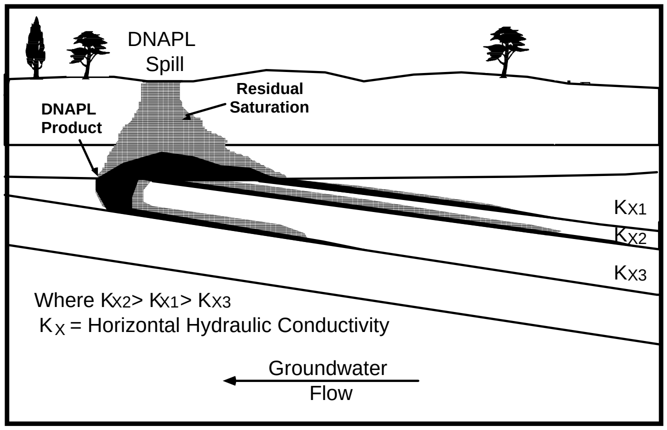

Figure 13b. Non-horizontal stratigraphic units with variable hydraulic conductivity may convey DNAPL in a different direction than the ground water flow direction.

boundary conditions, may have preferential pathways leading to lower formations, as depicted in Figure 14. Careful inspection of soil cores at one Superfund site indicated that DNAPL flow mainly occurred through preferential pathways and was not uniformly distributed throughout the soil mass (8). Due to the complex distribution of preferential pathways, characterization of the volume distribution of the DNAPL is difficult.

Important DNAPL Transport and Fate Parameters

There are several characteristics associated with both the subsurface media and the DNAPL which largely determine the fate and transport of the DNAPL. A brief discussion of these parameters is included to help identify the specific details of DNAPL transport mechanisms. Several of the distinctive DNAPL phenomena observed on the field-scale relates back to phenomena at the pore-scale. Therefore, it is important to understand the principles from the pore-scale level to develop an understanding of field-scale observations, which is the scale at which much of the Superfund work occurs. A more complete and comprehensive review of these parameters is available (2,36,71).

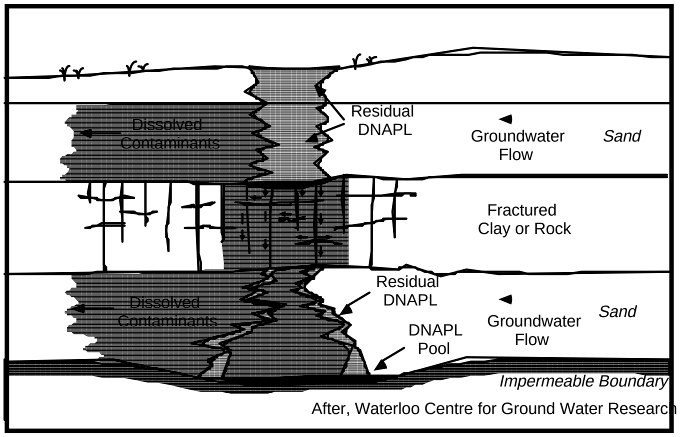

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Figure 14. DNAPL transport in fracture and porous media stratigraphic units.

DNAPL Characteristics

Density

Fluid density is defined as the mass of fluid per unit volume, i.e. g/cm^3 . Density of an immiscible hydrocarbon fluid is the parameter which delineates LNAPL's from DNAPL's. The property varies not only with molecular weight but also molecular interaction and structure. In general, the density varies with temperature and pressure (2). Equivalent methods of expressing density are specific weight and specific gravity. The specific weight is defined as the weight of fluid per unit volume, i.e. lb/ft^3. The specific gravity (S.G.) or the relative density of a fluid is defined as the ratio of the weight of a given volume of substance at a specified temperature to the weight of the same volume of water at a given temperature (31). The S.G. is a relative indicator which ultimately determines whether the fluid will float (S.G.< 1.0) on, or penetrate into (S.G.>1.0) the water table. Table 1 contains a list of compounds with a density greater than one that are considered DNAPL's. Note, however, that while the specific gravity of pentachlorophenol and the non-halogenated semi-volatiles is greater than 1.00, these compounds are a solid at room temperature and would not be expected to be found as an immiscible phase liquid at wood preserving sites but are commonly found as contaminants. Pentachlorophenol is commonly used as a wood preservant and is typically dissolved (4-7%) in No. 2 or 3 fuel oil.

Viscosity

The viscosity of a fluid is a measure of its resistance to flow. Molecular cohesion is the main cause of viscosity. As the temperature increases in a liquid, the cohesive forces decrease and the absolute viscosity decreases. The lower the viscosity, the more readily a fluid will penetrate a porous media. The hydraulic conductivity of porous media is a function of both the density and viscosity of the fluid as indicated in equation [1]. It is apparent from this equation that fluids with either a viscosity less than water or fluids with a density greater than water have the potential to be more mobile in the subsurface, than water.

$$K = \frac{k \rho g}{\mu} \qquad [1]$$

where,
K = hydraulic conductivity
k = intrinsic permeability
ρ = fluid mass density
g = gravity
μ = dynamic (absolute) viscosity

Results from laboratory experiments indicated that several chlorinated hydrocarbons which have low viscosity (methylene chloride, perchloroethylene, 1,1,1-TCA, TCE) will infiltrate into soil notably faster than will water (47). The relative value of NAPL viscosity and density, to water, indicates how fast it will flow in porous media (100% saturated) with respect to water. For example, several low viscosity chlorinated hydrocarbons (TCE, tetrachloroethylene, 1,1,1-TCA, Methylene Chloride, Chloroform, Carbon Tetrachloride, refer to Table 1) will flow 1.5-3.0 times as fast as water and higher viscosity compounds including light heating oil, diesel fuel, jet fuel, and crude oil (i.e. LNAPL's) will flow 2-10 times slower than water (45). Both coal tar and creosote typically have a specific gravity greater than one and a viscosity greater than water. It is interesting to note that the viscosity of NAPL may change with time (36). As fresh crude oils lose the lighter volatile components from evaporation, the oils become more viscous as the heavier components compose a larger fraction of the oily mixture resulting in an increase in viscosity.

Solubility

When an organic chemical is in physical contact with water, the organic chemical will partition into the aqueous phase. The equilibrium concentration of the organic chemical in the aqueous phase is referred to as its solubility. Table 1 presents the solubility of several of the most commonly found DNAPL's at EPA Superfund Sites. The solubility of organic compounds varies considerably from the infinitely miscible compounds, including alcohols (ethanol, methanol) to extremely low solubility compounds such as polynuclear aromatic compounds.

Numerous variables influence the solubility of organic compounds. The pH may affect the solubility of some organic compounds. Organic acids may be expected to increase in solubility with increasing pH, while organic bases may act in the opposite way (31). For example, pentachlorophenol is an acid which is ionized at higher pH's. In the ionized form, pentachlorophenol would be more soluble in water (59). Solubility in water is a function of the temperature, but the strength and direction of this function varies. The presence of dissolved salts or minerals in water leads to moderate decreases in solubility (31). In a mixed solvent system, consisting of water and one or more water-miscible compounds, as the fraction of the cosolvent in the mixture increases, the solubility of the organic chemical increases exponentially (12). In general, the greater the molecular weight and structural complexity of the organic compound, the lower the solubility.

Organic compounds are only rarely found in ground water at concentrations approaching their solubility limits, even when organic liquid phases are known or suspected to be present. The observed concentrations are usually more than a factor of 10 lower than the solubility presumably due to diffusional limitations of dissolution and the dilution of the dissolved organic contaminants by dispersion (74). This has also been attributed to: reduced solubility due to the presence of other soluble compounds, the heterogeneous distribution of DNAPL in the subsurface, and dilution from monitoring wells with long intake lengths (10). Detection of DNAPL components in the subsurface below the solubility should clearly not be interpreted as a negative indicator for the presence of DNAPL.

In a DNAPL spill scenario where the DNAPL or its vapors are in contact with the ground water, the concentration of the soluble phase components may range from non-detectable up to the solubility of the compound. The rate of dissolution has been expressed as a function of the properties of the DNAPL components (solubility), ground water flow conditions, differential between the actual and solubility concentration, and the contact area between the DNAPL and the ground water (10). The contact area is expected to be heterogeneous and difficult to quantify. Additionally, as the time of contact increases between the DNAPL and the water, the concentration in the aqueous phase increases.

Vapor Pressure

The vapor pressure is that characteristic of the organic chemical which determines how readily vapors volatilize or evaporate from the pure phase liquid. Specifically, the partial pressure exerted at the surface by these free molecules is known as the vapor pressure (30). Molecular activity in a liquid tends to free some surface molecules and this tendency towards vaporization is mainly dependent on temperature. The vapor pressure of DNAPL's can actually be greater than the vapor pressure of volatile organic compounds. For example, at 20 C, the ratio of the vapor pressures of TCE and benzene is 1.4 (1).

Volatility

The volatility of a compound is a measure of the transfer of the compound from the aqueous phase to the gaseous phase. The transfer process from the water to the atmosphere is dependent on the chemical and physical properties of the compound, the presence of other compounds, and the physical properties (velocity, turbulence, depth) of the water body and atmosphere above it. The factors that control volatilization are the solubility, molecular weight, vapor pressure, and the nature of the air-water interface through which it must pass (31). The Henry's constant is a valuable parameter which can be used to help evaluate the propensity of an organic compound to volatilize from the water. The Henry's law constant is defined as the vapor pressure divided by the aqueous solubility. Therefore, the greater the Henry's law constant, the greater the tendency to volatilize from the aqueous phase, refer to Table 1.

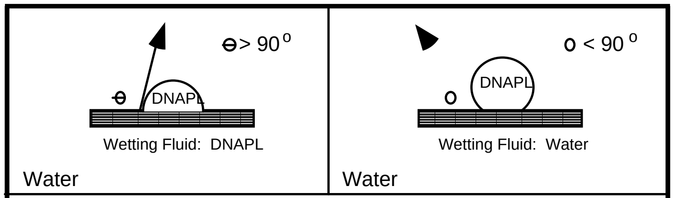
Interfacial Tension

The unique behavior of DNAPLs in porous media is largely attributed to the interfacial tension which exists between DNAPL and water, and between DNAPL and air. These interfacial tensions, result in distinct interfaces between these fluids at the pore-scale. When two immiscible liquids are in contact, there is an interfacial energy which exists between the fluids resulting in a physical interface. The interfacial energy arises from the difference between the inward attraction of the molecules in the interior of each phase and those at the surface of contact (2). The greater the interfacial tension between two immiscible liquids; the less likely emulsions will form; emulsions will be more stable if formed, and the better the phase separation after mixing. The magnitude of the interfacial tension is less than the larger of the surface tension values for the pure liquids, because the mutual attraction of unlike molecules at the interface reduces the large imbalance of forces (31). Interfacial tension decreases with increasing temperature, and may be affected by pH, surfactants, and gases in solution (36). When this force is encountered between a liquid and a gaseous phase, the same force is called the surface tension (66).

The displacement of water by DNAPL and the displacement of DNAPL by water in porous media often involves a phenomena referred to as immiscible fingering. The lower the interfacial tension between immiscible fluids, the greater the instability of the water:DNAPL interface and thus the greater the immiscible fingering (27). The distribution of the fingering effects in porous media has been reported to be a function of the density, viscosity, surface tension (27) and the displacement velocity (13) of the fluids involved as well as the porous media heterogeneity (28).

Wettability

Wettability refers to the relative affinity of the soil for the various fluids - water, air, and the organic phase. On a solid surface, exposed to two different fluids, the wettability can be inferred from the contact angle (66), also referred to as the wetting angle, refer to Figure 15. In general, if the wetting angle is less than 90 degrees, the fluid is said to be the wetting fluid. In this scenario, water will preferentially occupy the smaller pores and will be found on solid surfaces (14). When the wetting angle is near 90 degrees, neither fluid is preferentially attracted to the solid surfaces. If the wetting angle is greater than 90 degrees, the DNAPL is said to be the wetting fluid. The wetting angle is an indicator used to determine whether the porous material will be preferentially wetted by either the hydrocarbon or the aqueous phase (71). Wettability, therefore, describes the preferential spreading of one fluid over solid surfaces in a two-fluid system. The wetting angle, which is a measure of wettability, is a solid-liquid interaction and can actually be defined in terms of interfacial tensions (71). Several methods have been developed to measure the wetting angle (36,71). In most natural systems, water is the wetting fluid, and the immiscible fluid is the non-wetting fluid. Coal tar may be the exception (i.e. contact angle greater than 90 degrees), which is mainly attributed to the presence of surfactants (70). The wetting fluid will tend to coat the surface of grains and occupy smaller spaces (i.e. pore throats) in porous media, the non-wetting fluid will tend to be restricted to the largest openings (47).



Fluid Relationships:

System	Wetting Fluid	Non-Wetting Fluid
air:water	water	air
air: DNAPL	DNAPL	air
water:DNAPL	water	DNAPL
air:DNAPL:water	water>organic>air (1)	

(1) Wetting fluid order

After, Waterloo Centre for Groundwater Research, 1989.

Figure 15. Wetting angle and typical wetting fluid relationships.

The wetting angle depends on the character of the solid surface on which the test is conducted. The test is conducted on flat plates composed of minerals which are believed representative of the media, or on glass. Contact angle measurements for crude oil indicates that the wetting angles vary widely depending on the mineral surface (53). Soil and aquifer material are not composed of homogeneous mineral composition nor flat surfaces. The measured wetting angle can only be viewed as a qualitative indicator of wetting behavior.

The reader is recommended to refer to reference No. 31 for review of the basic principles and for various techniques to measure the following DNAPL parameters: density, viscosity, interfacial tension, solubility, vapor pressure, and volatility.

Subsurface Media Characteristics

Capillary Force/Pressure

Capillary pressure is important in DNAPL transport because it largely determines the magnitude of the residual saturation that is left behind after a spill incident. The greater the capillary pressure, the greater the potential for residual saturation. In general, the capillary force increases in the following order; sand, silt, clay. Correspondingly, the residual saturation increases in the same order. Capillary pressure is a measure of the tendency of a porous medium to suck in the wetting fluid phase or to repel the nonwetting phase (2). Capillary forces are closely related to the wettability of the porous media. The preferential attraction of the wetting fluid to the solid surfaces cause that fluid to be drawn into the porous media. Capillary forces are due to both adhesion forces (the attractive force of liquid for the solids on the walls of the channels through which it moves) and cohesion forces (the attraction forces between the molecules of the liquid) (32). The capillary pressure depends on the geometry of the void space, the nature of solids and liquids, the degree of saturation (2) and in general, in-creases with a decrease in the wetting angle and in pore size, and with an increase in the interfacial tension (71). All pores have some value of capillary pressure. Before a nonwetting fluid can enter porous media, the capillary pressure of the largest pores (smallest capillary pressure) must be exceeded. This minimum capillary pressure is called the entry pressure.

In the unsaturated zone, pore space may be occupied by water, air (vapors), or immiscible hydrocarbon. In this scenario, capillary pressure retains the water (wetting phase) mainly in the smaller pores where the capillary pressure is greatest. This restricts the migration of the DNAPL (non-wetting phase) through the larger pores unoccupied by water. Typically, DNAPL does not displace the pore water from the smaller pores. It is interesting to note that the migration of DNAPL through fine material (high capillary pressure) will be impeded upon reaching coarser material (low capillary pressure).

The capillary fringe will obstruct the entry of the DNAPL into the saturated zone. When a sufficient volume of DNAPL has been released and the “DNAPL pressure head” exceeds the water capillary pressure at the capillary fringe (entry pressure), the DNAPL will penetrate the water table. This is why DNAPL is sometimes observed to temporarily flatten out on top of the water table. Similarly, laboratory experiments have been conducted in which DNAPL (tetrachloroethylene) infiltrating through porous media was found to flow laterally and cascade off lenses too fine to penetrate (28), (refer to Figure 11). This was attributed to the inability of the DNAPL to overcome the high capillary pressure associated with the lenses. Logically, when “DNAPL pressure head” exceeds the capillary pressure, the DNAPL will penetrate into the smaller pores. These laboratory experiments are important because they illustrate that small differences in the capillary characteristics of porous media can induce significant lateral flow of non-wetting fluids.

A comprehensive investigation of capillary trapping and multiphase flow of organic liquids in unconsolidated porous media revealed many intricacies of this process in the vadose and saturated zone (66). An important note is that while capillary pressure is rarely measured at hazardous waste sites, the soil texture (sand, silt, clay) is usually recorded during drilling operations and soil surveys. This information, along with soil core analyses will help to delineate the stratigraphy and the volume distribution of NAPL.

Pore Size Distribution/Initial Moisture Content

In natural porous media, the geometry of the pore space is extremely irregular and complex (2). The heterogeneity of the subsurface environment i.e. the variability of the pore size distribution, directly affects the distribution of the capillary pressures along the interfaces between the aqueous and immiscible phases (50). In saturated column experiments, it was observed that NAPL preferentially traveled through strings of macropores, almost completely by-passing the water filled micropores (66). In the same study, a heterogeneous distribution of coarse and fine porous material was simulated. Most of the incoming organic liquid preferentially traveled through the coarse lens material.

In short term column drainage experiments, results indicated that the particle grain size is of primary importance in controlling the residual saturation of a gasoline hydrocarbon (19). Fine and coarse sands (dry) were found to have 55% and 14% residual saturation, respectively. The finer the sand, the greater the residual saturation. During these experiments, the residual saturation was reduced 20-30% in a medium sand and 60% in a fine sand when the sands were initially wet. Soil pore water held tightly by capillary forces in the small pores will limit the NAPL to the larger pores, and thus, result in lower residual saturation. In a similar laboratory (unsaturated) column study, the smaller the grain size used in the experiment, the greater the residual saturation of the NAPL (74). The residual saturation in the saturated column experiments was found to be greater than the unsaturated columns and was independent of the particle size distribution.

These observations follow traditional capillary force theory. Residual saturation resulting from a DNAPL spill in the unsaturated zone is highly dependent on the antecedent moisture content in the porous media. When the moisture content is low, the strong capillary forces in the smaller pores will tenaciously draw in and hold the DNAPL. When the moisture content is high, the capillary forces in the smaller pores will retain the soil pore water, and DNAPL residual saturation will mainly occur in the larger pores. Therefore, greater residual saturation can be expected in dryer soils. Correspondingly, NAPL will migrate further in a wetter soil, and displacement of NAPL from small pores is expected to be more difficult than from large pores.

Stratigraphic Gradient

DNAPL migrating vertically will likely encounter a zone or stratigraphic unit of lower vertical permeability. A reduction in the vertical permeability of the porous media will induce lateral flow of the DNAPL. The gradient of the lower permeable stratigraphic unit will largely determine the direction in which the DNAPL will flow. This is applicable to both the saturated and unsaturated zones. As depicted in Figures 13a and 13b, the lateral direction of DNAPL flow may be in a different direction than ground-water flow.

Ground Water Flow Velocity

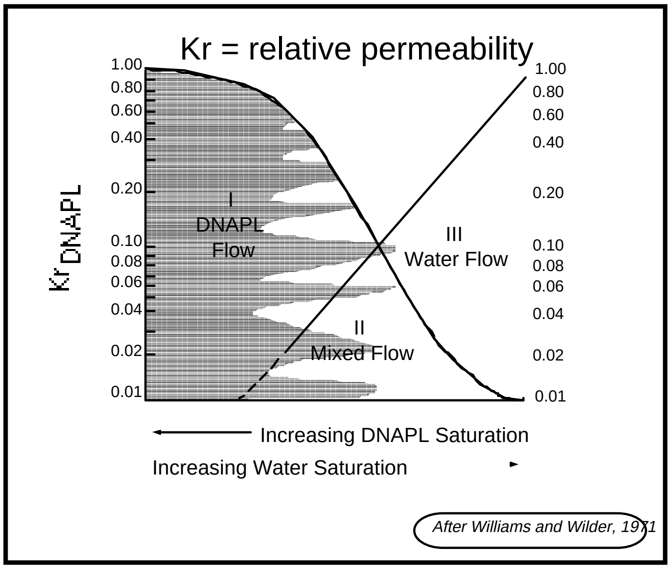
The ground water flow velocity is a dynamic stress parameter which tends to mobilize the hydrocarbon (39). As the ground water velocity increases, the dynamic pressure and viscous forces increase. Mobilization of DNAPL occurs when the viscous forces of the ground water acting on the DNAPL, exceeds the porous media capillary forces retaining the DNAPL.

Saturation Dependent Functions

Residual Saturation

Residual saturation is defined as the volume of hydrocarbon trapped in the pores relative to the total volume of pores (38) and therefore is measured as such (74). Residual saturation has also been described as the saturation at which NAPL becomes discontinuous and is immobilized by capillary forces (36). The values of residual saturation vary from as low as 0.75 - 1.25% for light oil in highly permeable media to as much as 20% for heavy oil (50). Residual saturation values have also been reported to range from 10% to 50% of the total pore space (39,74). Other researchers reported that residual saturation values appear to be relatively insensitive to fluid properties and very sensitive to soil properties (and heterogeneities) (66). Laboratory studies conducted to predict the residual saturation in soils with similar texture and grain size distribution yielded significantly different values. It was concluded that minor amounts of clay or silt in a soil may play a significant role in the observed values.

In the unsaturated zone during low moisture conditions, the DNAPL residual saturation will wet the grains in a pendular state (a ring of liquid wrapped around the contact point of a pair of adjacent grains). During high moisture conditions, the wetting fluid, which is typically water, will preferentially occupy the pendular area of adjacent grains and the hydrocarbon will occupy other available pore space, possibly as isolated droplets. In the saturated zone, the DNAPL residual saturation will be present as isolated drops in the open pores (47). Furthermore, results of laboratory experimentation indicated that residual saturation increased with decreasing hydraulic conductivity in both the saturated and unsaturated zones and that the residual saturation is greatest in the saturated zone. Laboratory experiments indicated that vadose zone residual saturation was roughly one third of the residual saturation in the saturated zone (66). The increase in residual saturation in the saturated zone is due to the following: [1] the fluid density ratio (DNAPL:air versus DNAPL:water above and below the water table, respectively) favors greater drainage in the vadose zone; [2] as the non-wetting fluid in most saturated media, NAPL is trapped in the larger pores; and, [3] as the wetting fluid in the vadose zone, NAPL tends to spread into adjacent pores and leave a lower residual content behind, a process that is inhibited in the saturated zone (36). Thus, the capacity for retention of DNAPLs in the unsaturated zone is less than the saturated zone.

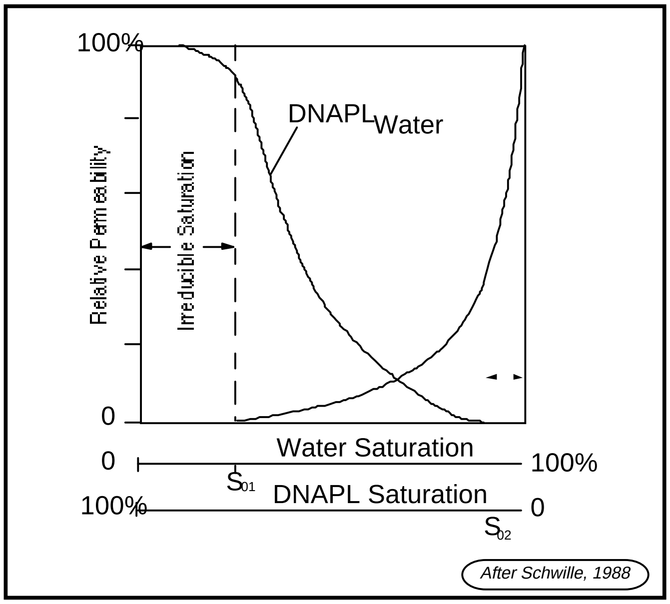


After Williams and Wilder, 1971

Figure 16. Relative permeability graph.

Relative Permeability

Relative permeability is defined as the ratio of the permeability of a fluid at a given saturation to its permeability at 100% saturation. Thus it can have a value between 0 and 1 (71). Figure 16 illustrates a relative permeability graph for a two fluid phase system showing the relationship between the observed permeability of each fluid for various saturations to that of the observed permeability if the sample were 100% saturated with that fluid (73). The three regions of this graph are explained as follows (71): Region I has a high saturation of DNAPL and is considered a continuous phase while the water is a discontinuous phase, therefore, water permeability is low. Assuming the DNAPL is the non-wetting fluid, water would fill the smaller capillaries and flow through small irregular pores. In Region II, both water and DNAPL are continuous phases although not necessarily in the same pores. Both water and NAPL flow simultaneously. However, as saturation of either phase increases, the relative permeability of the other phase correspondingly decreases. Region III exhibits a high saturation of water while the DNAPL phase is mainly discontinuous. Water flow dominates



After Schwille, 1988

Figure 17. The relative permeability curves for water and a DNAPL in a porous medium as a function of the pore space saturation.

Site Characterization for DNAPL

Characterization of the subsurface environment at hazardous waste sites containing DNAPL is complex and will likely be expensive. Specific details associated with the volume and timing of the DNAPL release are usually poor or are not available and subsurface heterogeneity is responsible for the complicated and unpredictable migration pathway of subsurface DNAPL transport. As discussed previously, slight changes in vertical permeability may induce a significant horizontal component to DNAPL migration.

Site characterization typically involves a significant investment in ground-water analyses. Although analysis of ground water provides useful information on the distribution of the soluble components of the DNAPL, the presence of other phases of the DNAPL may go unrecognized. The investigation must, therefore, be more detailed to obtain information concerning the phase distribution of the DNAPL at a site. Site characterization may require analyses on all four phases (aqueous, gaseous, solid, immiscible) to yield the appropriate information (refer to Table 2). In brief, data collected on the various phases must be compiled, evaluated and used to help identify: where the contaminant is presently located; where it has been; what phases it occurs in; and what direction the mobile phases may be going. A comprehensive review of site characterization for subsurface investigations is available (68). Development of monitoring and remediation strategies can be focused more effectively and efficiently after a clear definition of the phase distribution has been completed.

Ground Water

Ground water analyses for organic compounds, in conjunction with ground water flow direction data, has repeatedly been used to: delineate the extent of ground

Table 2 - Phase Distribution of DNAPL in the Subsurface

MATRIX	PHASE
1. ground water	aqueous - soluble components of DNAPL
2. soil/aquifer material	solid - adsorbed components of DNAPL on solid phase material
3. DNAPL	immiscible - continuous phase (mobile), residual saturation (immobile)
4. soil gas	gaseous - volatile components

water contamination from DNAPL; determine the direction of plume migration; and to identify probable DNAPL source area(s). While this approach has been used successfully to characterize the distribution of contaminants in the subsurface, there are limitations. For example, since DNAPL and ground water may flow in different directions, as indicated in Figures 13a and 13b, ground water analyses may not necessarily identify the direction of DNAPL migration.

Ground water analyses may be useful to identify probable DNAPL source areas, but, estimating the volume of DNAPL in the subsurface is limited using this approach. Soluble phase components of DNAPL are rarely found in excess of 10% of the solubility even when organic liquids are known or suspected to be present. The concentration of soluble DNAPL components in the ground water is not only a function of the amount of DNAPL present, but also the chemical and physical characteristics of the DNAPL, the contact area and time between the ground water and DNAPL, and numerous transport and fate parameters (retardation, biodegradation, dispersion, etc.). One technique has been developed using chemical ratios in the ground water as a means of source identification and contaminant fate prediction (18).

Soil/Aquifer Material

Exploratory Borings

Physical and chemical analyses of soil and aquifer material (drill cuttings, cores) from exploratory borings will provide useful information in the delineation of the horizontal and vertical mass distribution of DNAPL. While simple visual examination for physical presence or absence of contamination might seem like a worthwhile technique, it can be deceiving and does nothing to sort out the various liquid phases and their relationship to each other (71). A quantitative approach is necessary to determine DNAPL distribution.

Drill cuttings or core material brought to the surface from exploratory borings can be screened initially to help delineate the depth at which volatile components from the various phases of the hydrocarbon exists. The organic vapor analyzer and the HNU are small portable instruments that can detect certain volatile compounds in the air. These methods are used to initially screen subsurface materials for volatile components of DNAPL. Identification of individual compounds and their concentrations may be confirmed by other, more precise, analyses.

Analysis of the soil or aquifer material by more accurate means, such as gas chromatography or high pressure liquid chromatography, will take longer but will provide more specific information on a larger group of organic compounds, i.e., volatile/non-volatile, and on specific compounds. This information is necessary to help fix the horizontal and vertical mass distribution of the contaminant and to help delineate the phase distribution. These analyses do not distinguish between soluble, sorbed or free-phase hydrocarbon, however; a low relative concentration indicates that the contaminant may mainly be present in the gaseous or aqueous phases; and a high relative concentration indicates the presence of sorbed contaminant or free phase liquid either as continuous-phase or residual saturation. A more rigorous set of analyses is required to distinguish between the various phases.

Additional tests to identify the presence of NAPL in soil or aquifer core sample are currently undeveloped and research in this area is warranted. Squeezing and immiscible displacement techniques have been used to obtain the pore water from cores (40). Other methods of phase separation involving vacuum or centrifugation may also be developed for this use. A paint filter test was proposed in one Superfund DNAPL field investigation where aquifer cores were placed in a filter/funnel apparatus, water was added, and the filtrate was examined for separate phases. These core analysis techniques have potential to provide valuable field data to characterize NAPL distribution.

Cone Penetrometer

The cone penetrometer (ASTM D3441-86)(69) has been used for some time to supply data on the engineering properties of soils. Recently, the application of this technology has made the leap to the hazardous waste arena. The resistance of the formation is measured by the cone penetrometer as it is driven vertically into the subsurface. The resistance is interpreted as a measure of pore pressure, and thus provides information on the relative stratigraphic nature of the subsurface. Petroleum and chlorinated hydrocarbon plumes can be detected most effectively when the cone penetrometer is used in conjunction with in-situ sensing technologies (48). Features of the cone penetrometer include: a continuous reading of the stratigraphy/permeability; in-situ measurement; immediate results are available; time requirements are minimal; vertical accuracy of stratigraphic composition is high; ground-water samples can be collected in-situ; and the cost is relatively low.

Data from the cone penetrometer can be used to delineate probable pathways of DNAPL transport. This is accomplished by identifying permeability profiles in the subsurface. A zone of low permeability underlying a more permeable stratigraphic unit will likely impede vertical transport of the DNAPL. Where such a scenario is found, a collection of DNAPL is probable and further steps can be implemented to more accurately and economically investigate and confirm such an occurrence. This general approach has successfully been implemented at one Superfund site (8).

DNAPL

Well Level Measurements

In an effort to delineate the horizontal and vertical extent of the DNAPL at a spill site, it is important to determine the elevation of DNAPL in the subsurface. Monitoring DNAPL elevation over time will indicate the mobility of the DNAPL. There are several methods that can be used to determine the presence of DNAPL in a monitoring well. One method relies on the difference in electrical conductivity between the DNAPL and water. A conductivity or resistivity sensor is lowered into the well and a profile is measured. The interface of the DNAPL is accurately determined when the difference in conductivity is detected between the two fluids. This instrument may also be used to delineate LNAPL. A transparent, bottom-loading bailer can also be used to measure the thickness (and to sample) of DNAPL in a well (36). The transparent bailer is raised to the surface and the thickness of the DNAPL is made by visual measurement.

Several laboratory and field studies have been performed which investigate the anomaly between the actual and measured LNAPL levels in ground-water wells (15,16,24,25). The anomaly between actual and measured NAPL thickness in the subsurface is also applicable to DNAPL, but for different reasons. The location of the screening interval is the key to understanding both scenarios. First, if the well screen interval is situated entirely in the DNAPL layer, and the hydrostatic head (water) in the well is reduced by pumping or bailing, then to maintain hydrostatic equilibrium, the DNAPL will rise in the well (36,44,71) (refer to Figure 18). Secondly, if the well screen extends into the barrier layer, the DNAPL measured thickness will exceed that in the formation by the length of the well below the barrier surface (36) (refer to Figure 19). Both of these scenarios will result in a greater DNAPL thickness in the well and thus a false indication (overestimate) of the actual DNAPL thickness will result. One of the main purposes of the monitoring well in a DNAPL investigation is to provide information on the thickness of the DNAPL in the aquifer. Therefore, construction of the well screen should intercept the ground water:DNAPL interface and the lower end of the screen should be placed as close as possible to the impermeable stratigraphic unit.

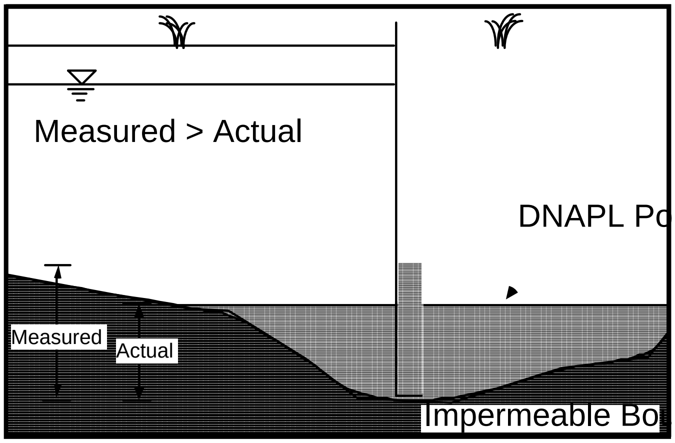


Figure 18. A well screened only in the DNAPL in conjunction with lower hydrostatic head (i.e. water) in the well may result in an overestimation of DNAPL thickness.

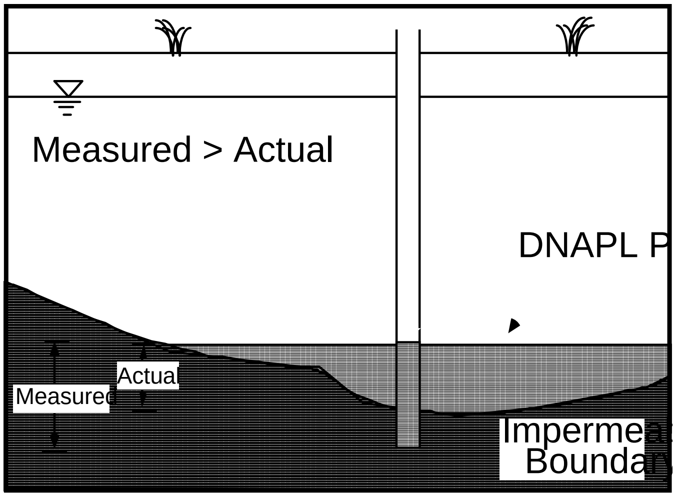


Figure 19. A well screened into an impermeable boundary may result in an over-estimation of the DNAPL thickness.

DNAPL Sampling

Sampling of DNAPL from a well is necessary to perform chemical and physical analyses on the sample. Two of the most common methods used to retrieve a DNAPL sample from a monitoring well are the peristaltic pump and the bailer. A peristaltic pump can be used to collect a sample if the DNAPL is not beyond the effective reach of the pump, which is typically less than 25 feet. The best method to sample DNAPL is to use a double check valve bailer. The key to sample collection is controlled, slow lowering (and raising) of the bailer to the bottom of the well (57). The dense phase should be collected prior to purging activities.

Soil-Gas Surveys

A soil-gas survey refers to the analysis of the soil air phase as a means to delineate underground contamination from volatile organic chemicals and several techniques have been developed (34,52). This investigative tool is mainly used as a preliminary screening procedure to delineate the areal extent of volatile organic compounds in the soil and ground water. This method is quick, less expensive than drilling wells and can provide greater plume resolution (33).

Data from a soil-gas survey is a valuable aid in the development of a more detailed subsurface investigation where ground water monitoring wells and exploratory borings are strategically located for further site characterization. There are limitations to soil-gas surveys (26,52) and data interpretation must be performed carefully (35,49). Soil-gas investigations have mainly been conducted to identify the location of the organic contaminants in ground water. At the time of this publication, the scientific literature did not contain information specifically applicable to the delineation of DNAPL from soil-gas survey data. However, it is surmisable that soil- gas surveys can be used to help delineate DNAPL residual saturation in the unsaturated zone or the location of perched DNAPL reservoirs.

Miscellaneous

The vertical migration of DNAPL in the saturated zone will eventually be challenged by a low permeability stratigraphic unit. According to the principles of capillary pressure, the lower permeability unit will exhibit a greater capillary pressure. Displacement of water by DNAPL requires that the hydrostatic force from the mounding DNAPL exceed the capillary force of the low permeability unit. The Hobson formula is used to compute the critical height calculation to overcome the capillary pressure under different pore size conditions (70).

In an effort to minimize further DNAPL contamination as a result of drilling investigations, precautionary steps should be taken. Penetration of DNAPL reservoirs in the subsurface during drilling activities offers a conduit for the DNAPL to migrate vertically into previously uncontaminated areas. It is very easy to unknowingly drill through a DNAPL pool and the bed it sits on, causing the pool to drain down the hole into a deeper part of the aquifer or into a different aquifer (32). Special attention to grouting and sealing details during and after drilling operations will help prevent cross-contamination.

Precautionary efforts should also be considered when a DNAPL reservoir is encountered during drilling operations. The recommended approach is to cease drilling operations and install a well screen over the DNAPL zone and cease further drilling activities in the well. If it is necessary to drill deeper, construction of an adjacent well is recommended. Alternatively, if it is not necessary to screen off that interval, it is recommended to carefully seal off the DNAPL zone prior to drilling deeper.

Well construction material compatibility with DNAPL should be investigated to minimize downhole material failure. A construction material compatibility review and possible testing will prevent the costly failure of well construction material. The manufacturers of well construction material are likely to have the most extensive compatibility data and information available.

Remediation

Remediation of DNAPL mainly involves physical removal by either pumping or trench-drainline systems. Removal of DNAPL early in the remediation process will eliminate the main source of contaminants. This step will substantially improve the overall recovery efficiency of the various DNAPL phases including the long term pump and treat remediation efforts for soluble components. Remediation technologies such as vacuum extraction, biodegradation, ground water pumping, and soil flushing is mainly directed at the immobile DNAPL and the various phases in which its components occur. Physical barriers can be used in an effort to minimize further migration of the DNAPL.

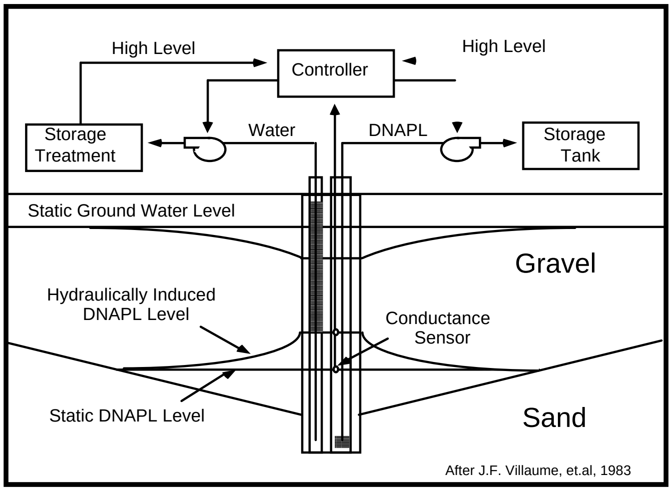
Clean-up of DNAPL can involve sizable expenditures: they are difficult to extract and the technology for their removal is just evolving (43). Historically, field recovery efforts usually proceed with a poor understanding of the volume distribution of the DNAPL. This reflects the difficulties involved in adequate site characterization, poor documentation of the release, and the complexity associated with the DNAPL transport in the subsurface.

Pumping Systems

Pumping represents an important measure to stop the mobile DNAPL from migrating as a separate phase by creating a hydraulic containment and by removal of DNAPL (44). Very simply, DNAPL recovery is highly dependent on whether the DNAPL can be located in the subsurface. The best recovery scenario is one in which the DNAPL is continuous and has collected as a reservoir in a shallow, impermeable subsurface depression. Once the DNAPL has been located and recovery wells are properly installed, pumping of pure phase DNAPL is a possible option but depends largely on site specific conditions which include, but are not limited to: DNAPL thickness, viscosity, and permeability.

Many DNAPL reservoirs in the subsurface are of limited volume and areal extent. Therefore, it can be expected that both the level of DNAPL (saturated thickness) in the well will decline from the prepumping position and the percentage of DNAPL in the DNAPL:water mixture will decrease rather rapidly. Correspondingly, DNAPL recovery efficiency decreases. Field results indicate that recovery wells screened only in the DNAPL layer will maintain maximum DNAPL:water ratios (44). Well diameter was not found to influence long term DNAPL recovery; however, large diameter wells allow high volume pumping for short durations; and small diameter wells result in lower DNAPL:water mixtures and greater drawdown.

An enhanced DNAPL recovery scheme may be used to improve recovery efficiency. An additional well is constructed with a screen interval in the ground water zone located vertically upward from the DNAPL screen intake. Ground



After J.F. Villaume, et.al, 1983

Figure 20. A DNAPL recovery system where deliberate upwelling of the static coal-tar surface is used to increase the flow of product into the recovery wells.

water is withdrawn from the upper screen which results in an upwelling of the DNAPL (70), refer to Figure 20. The upwelling of the DNAPL, coal tar in this case, improved the rate (twofold) at which the coal tar was recovered resulting in a more efficient operation. The ground water withdrawal rate must be carefully determined; too much will result in the coal tar from rising excessively and being either mixed (emulsions) with or suppressed by the higher water velocity above; too low will not caused upwelling. An estimate of this upwelling can be calculated using the simplified Ghyben-Herzberg Principle under ideal conditions (4). Laboratory studies indicated that dimethyl phthalate (1.19 g/cc) recovery rate was doubled or tripled over the conventional, non-upconing, recovery scheme (75). A similar application of this technique was used to increase the level of DNAPL (solvents) in a sandstone bedrock formation (11). Other enhanced DNAPL recovery techniques were implemented utilizing both water flooding and wellbore vacuum. Essentially, this minimized drawdown, allowing a maximum pumping rate of the DNAPL:water mixture. Both techniques offered significant advantages in terms of the rate and potential degree of DNAPL removal (8).

The highly corrosive nature of some DNAPL's may increase maintenance problems associated with the recovery system. A design consideration during any DNAPL recovery program should include a material compatibility review to minimize downhole failures. This is applicable to the well construction material and the various appurtenances of the recovery system. Manufacturers of the construction material would most likely have the best compatibility information available.

While most scientists agree that the residual saturation of immiscible hydrocarbon droplets in porous media are immobile, researchers have investigated the mobility of residual saturation in porous media for enhanced oil recovery and for NAPL remediation at spill sites. Specifically, this includes a complex interplay between four forces (viscous, gravity, capillary, buoyancy). These forces are dependent on both the chemical and physical characteristics of the DNAPL and porous media. The mobilization of residual saturation mainly hinges on either increasing the ground water velocity which increases the viscous forces between the residual saturation and the ground water, or decreasing the interfacial tension between the residual saturation and the ground water which decreases the capillary forces.

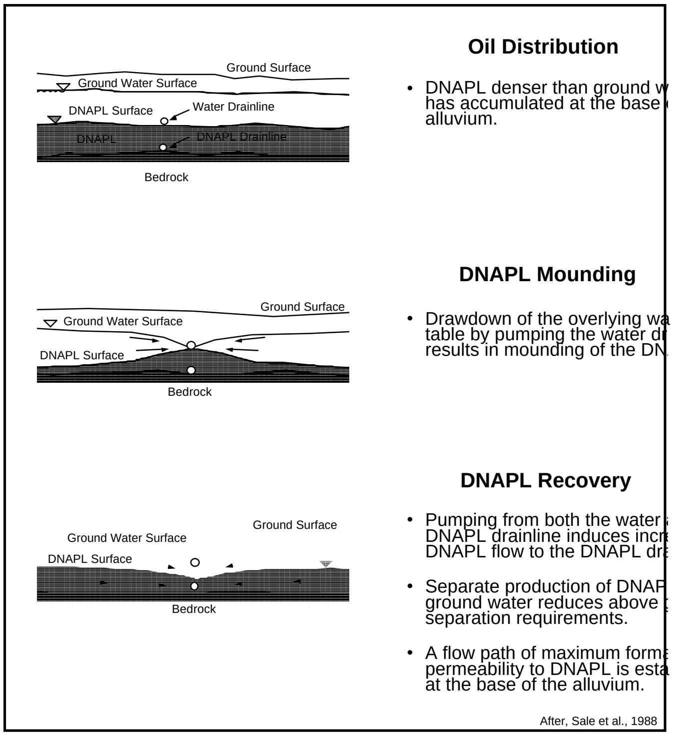
The capillary number is an empirical relationship which measures the ratio between the controlling dynamic stresses (absolute viscosity and ground water velocity) and static stresses (interfacial tension) of the residual saturation (39). The former are the viscous stresses and the dynamic pressure in the water which tend to move the oil. The latter are the capillary stresses in the curved water/oil interfaces which tend to hold the oil in place. As the capillary number is increased, the mobility of the residual saturation increases. In a laboratory column study, the capillary number had to be increased two orders of magnitude from when motion was initiated to complete displacement of the hydrocarbon in a sandstone core (74). In a glass bead packed column, only one order of magnitude increase was required. However, a higher capillary number was required to initiate mobility. The difference in mobility between the two columns was attributed to the pore geometry, i.e. size, shape.

There are limitations to residual saturation mobilization. The ground water gradient (dh/dl) necessary to obtain the critical capillary number to initiate blob mobilization would be 0.24. To obtain complete NAPL removal would require a gradient of 18 (3). Ground water gradients of this magnitude are unrealistic. Another estimate of the gradient necessary to mobilize carbon tetrachloride in a fine gravel and medium sand was 0.09 and 9.0 respectively (74). The former gradient is steep but not unreasonable and the latter gradient is very steep and impractical to achieve in the field. The same researchers concluded from more recent, comprehensive studies, that the earlier predictions were optimistic, and that the gradient necessary to mobilize residual organic liquid is clearly impractical (66). Another limitation is that along with residual saturation mobilization, the NAPL blobs disperse into smaller blobs and that the blob distribution was dependent on the resulting capillary number (6). Recovery of the NAPL residual saturation by pumping ground water may be more feasible where the porous media is coarse and capillary forces are low, i.e. coarse sands and gravel. However, even in this scenario, it is expected that the radius of residual saturation mobilization would be narrow.

It is held in petroleum engineering theory that the only practical means of raising the capillary number dramatically is by lowering the interfacial tension (39) and that this can be achieved by using surfactants (66). Surfactants reduce the interfacial tension between two liquids, and therefore, are injected into the subsurface for enhanced recovery of immiscible hydrocarbons. In laboratory experiments, surfactant flushing solutions produced dramatic gains in flushing even after substantial water flushing had taken place (54). Unfortunately, surfactants can be quite expensive and cost prohibitive in NAPL recovery operations. Surfactants are usually polymeric in nature and a surfactant residue may be left behind in the porous media which may not be environmentally acceptable. Additionally, surfactants may be alkaline and thus affect the pH of the subsurface environment. It has been suggested that such a surfactant may inhibit bacterial metabolism and thus preclude subsequent use of biological technologies at the site. Significant research in this area is currently underway which may uncover information improving the economics and feasibility of this promising technology.

In summary, practical considerations and recommendations concerning the mobilization and recovery of residual saturation include the following: greater effectiveness in very coarse porous media i.e. coarse sands and gravel; recovery wells should be installed close to the source to minimize flow path distance; a large volume of water will require treatment/ disposal at the surface; compounds with high interfacial tension or viscosity will be difficult to mobilize; and implementation of linear one-dimensional sweeps through the zones of residual saturation (74) and surfactants will optimize recovery.

Pumping the soluble components (aqueous phase) of DNAPL from the immiscible (continuous and residual saturation), solid (sorbed), and gaseous phases has been perhaps one of the most effective means to date to both recover DNAPL from the subsurface and to prevent plume migration. Recovery of soluble components quite often has been the only remediation means available. This is largely



After, Sale et al., 1988

Figure 21. **Trench recovery system of DNAPL utilizing the dual drainline concept.**

attributed to the inability to locate DNAPL pools and due to low, DNAPL yielding formations. The basic principles and theory of pump and treat technology and the successes and failures have been summarized in other publications (64,67) and is beyond the scope of this publication.

Pumping solubilized DNAPL components from fractured rock aquifers historically has been plagued with a poor recovery efficiency. Although the rock matrix has a relatively small intergranular porosity, it is commonly large enough to allow dissolved contaminants from the fractures to enter the matrix by diffusion and be stored there by adsorption (32). The release of these components is expected to be a slow diffusion dominated process. This is because little or no water flushes through dead-end fracture segments or through the porous, impervious rock matrix. Therefore, clean-up potential is estimated to be less than that expected for sand and gravel aquifers.

Trench Systems

Trench systems have also been used successfully to recover DNAPL and are used when the reservoir is located near the ground surface. Trench systems are also effective when the DNAPL is of limited thickness. Recovery lines are placed horizontally on top of the impermeable stratigraphic unit. DNAPL flows into the collection trenches and seep into the recovery lines. The lines usually drain to a collection sump where the DNAPL is pumped to the surface. Similar to the pumping system, an enhanced DNAPL recovery scheme may be implemented using drain lines to improve recovery efficiency. This "dual drain line system" (41) utilizes a drain line located in the ground water vertically upward from the DNAPL line. Ground water is withdrawn from the upper screen which results in an upwelling of the DNAPL which is collected in the lower line, refer to Figure 21. This increases the hydrostatic head of the DNAPL. Excessive pumping of either single or dual drain line systems may result in the ground water "pinching off" the flow of DNAPL to the drain line. An advantage of the dual drain system is that the oil:water separation requirements at the surface are reduced.

Vacuum Extraction

Soil vacuum extraction (SVE) is a remediation technology which involves applying a vacuum to unsaturated subsurface strata to induce air flow. Figure 22 illustrates that the volatile contaminants present in the contaminated strata will evaporate and the vapors are recovered at the surface and treated. Common methods of treatment include granular activated carbon, catalytic oxidation, and direct combustion. SVE can effectively remove DNAPL present as residual saturation or its soluble phase components in the unsaturated zone. In general, vacuum extraction is expected to be more applicable for the chlorinated solvents (PCE, TCE, DCE) than the polycyclic aromatic compounds (wood preserving wastes, coal tars, etc.). When DNAPL is present in perched pools (Figure 12) it is more effective to remove the continuous phase DNAPL prior to the implementation of SVE. The same strategy is applicable in the saturated zone where DNAPL removal by SVE is attempted concomitantly with lowering the water table. Upon lowering the water table, SVE can be used to remove the remnant volatile wastes not previously recovered. Often, the precise location of the DNAPL is unknown; therefore, SVE can be used to remediate the general areas where the presence of DNAPL is suspected. Removal of DNAPL by SVE is not expected to be as rapid as direct removal of the pure phase compound. One advantage of SVE however, is that the precise location of the DNAPL need not be known.

Important parameters influencing the efficacy of SVE concern both the DNAPL and porous media. Porous media specific parameters include: soil permeability, porosity, organic carbon, moisture, structure, and particle size distribution. DNAPL specific parameters include: vapor pressure, Henry's constant, solubility, adsorption equilibrium, density, and viscosity (20). These parameters and their relationships must be evaluated on a site specific basis when considering the feasibility of vacuum extraction and a practical approach to the design, construction, and operation of venting systems (22). Additionally, soil gas surveys which delineate vapor concentration as a function of depth is critical in locating the contaminant source and designing an SVE system.

Historically, SVE has been used to remove volatile compounds from the soil. Recently it has been observed that SVE enhances the biodegradation of volatile and semivolatile organic compounds in the subsurface. While SVE removes volatile components from the subsurface, it also aids in supplying oxygen to biological degradation processes in the unsaturated zone. Prior to soil venting, it was believed that biodegradation in the unsaturated zone was limited due to inadequate concentrations of oxygen (17). In a field study where soil venting was used to recover jet fuel, it was

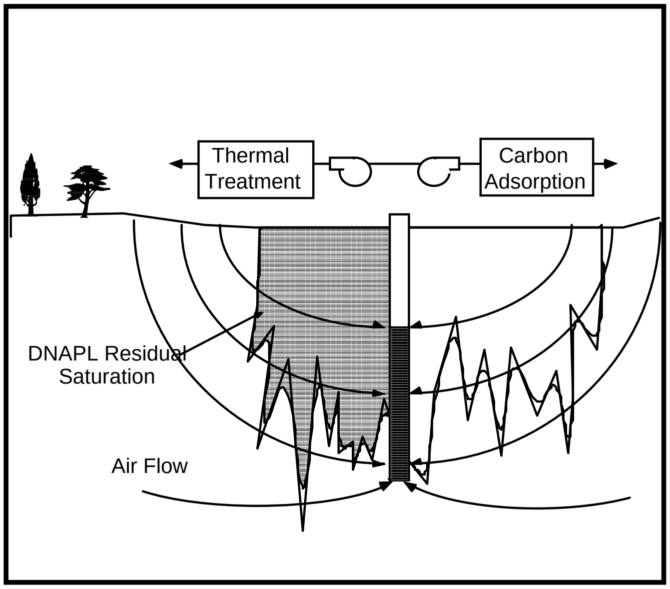


Figure 22. Vacuum extraction of DNAPL volatile components in the unsaturated zone. As shown here, vapors are treated by thermal combustion or carbon adsorption and the air is discharged to the atmosphere.

observed that approximately 15% of the contaminant removal was from the result of microbial degradation. Enhanced aerobic biodegradation during SVE increases the cost effectiveness of the technology due to the reduction in the required above ground treatment.

Vacuum extraction is one form of pump and treat which occurs in the saturated zone where the fluid is a gas mixture. Therefore, many of the same limitations to ground water pump and treat are also applicable to vacuum extraction. While the application of vacuum extraction is conceptually simple, its success depends on understanding complex subsurface chemical, physical, and biological processes which provide insight into factors limiting its performance (9).

Biodegradation

The potential for biodegradation of immiscible hydrocarbon is highly limited for several reasons. First, pure phase hydrocarbon liquid is a highly hostile environment to the survival of most microorganisms. Secondly, the basic requirements for microbiological proliferation (nutrients, electron acceptor, pH, moisture, osmotic potential, etc.) is difficult if not impossible to deliver or maintain in the DNAPL. A major limitation to aerobic bioremediation of high concentrations of hydrocarbon is the inability to deliver sufficient oxygen. A feasible remediation approach at sites where immiscible hydrocarbon is present is a phased technology approach. Initial efforts should focus on pure phase hydrocarbon recovery to minimize further migration and to decrease the volume of NAPL requiring remediation. Following NAPL recovery, other technologies could be phased into the remediation effort. Bioremediation may be one such technology that could be utilized to further reduce the mass of contaminants at the site. NAPL recovery preceding bioremediation will improve bioremediation feasibility by reducing the toxicity, time, resources, and labor.

Similar to other remediation technologies, a comprehensive feasibility study evaluating the potential effectiveness of bioremediation is critical and must be evaluated on a site specific basis. A comprehensive review of biodegradation of surface soils, ground water, and subsoils of wood preserving wastes, i.e. PAH's (29,37,51,62,63) are available. A comprehensive review of microbial decomposition of chlorinated aromatic compounds is also available (58).

Soil Flushing

Soil flushing utilizing surfactants is a technology that was developed years ago as a method to enhance oil recovery in the petroleum industry. This technology is new to the hazardous waste arena and available information has mainly been generated from laboratory studies. Surfactant soil flushing can proceed on two distinctly different mechanistic levels: enhanced dissolution of adsorbed and dissolved phase contaminants, and displacement of free-phase nonaqueous contaminants. These two mechanisms may occur simultaneously during soil flushing (42).

Surfactants, alkalis, and polymers are chemicals used to modify the pore-level physical forces responsible for immobilizing DNAPL. In brief, surfactants and alkalis reduce the surface tension between the DNAPL and water which increases the mobility. Polymers are added to increase the viscosity of the flushing fluid to minimize the fingering effects and to maintain hydraulic control and improve flushing efficiency. Based on successful laboratory optimization studies where an alkali-polymer-surfactant mixture was used, field studies were conducted on DNAPL (creosote) which resulted in recovery of 94% of the original DNAPL (42). Laboratory research has also been conducted which indicated that aqueous surfactants resulted in orders of magnitude greater removal efficiency of adsorbed and dissolved phase contaminants than water flushing (55).

Depth to contamination, DNAPL distribution, permeability, heterogeneities, soil/water incompatibility, permeability reduction, and chemical retention are important factors when considering soil flushing (42). Prior to this technology being cost effective in the field, surfactant recycling will be necessary to optimize surfactant use (55). Soil flushing is complex from a physical and chemical point of view; is relatively untested in the field; and will likely be challenged regulatorily. Considerable research currently being conducted in this area may result in the increased use of this technology to improve DNAPL recovery in the future.

Thermal methods of soil flushing involve injecting hot water or steam in an effort to mobilize the NAPL. The elevated temperature increases volatilization and solubilization and decreases viscosity and density. A cold-water cap is used to prevent volatilization. The mobile phases of the DNAPL are then recovered using a secondary approach, i.e. pumping, vacuum extraction etc. This approach (Contained Recovery of Oily Wastes) to enhance recovery of DNAPL is currently under EPA's Superfund Innovative Technology Evaluation Program and a pilot-scale demonstration is forthcoming (21). A limitation in the use of thermal methods is that the DNAPL may be converted to LNAPL due to density changes (36). The adverse effects from this are that the DNAPL, existing as a thin layer, becomes buoyant and mobilizes vertically resulting in a wider dispersal of the contaminant. Other limitations involve the high energy costs associated with the elevated water temperature and the heat loss in the formation (36).

Physical Barriers

Physical barriers may be used to prevent the migration of DNAPL's in the subsurface and are typically used in conjunction with other recovery means. One feature of physical barriers is the hydraulic control it offers providing the opportunity to focus remediation strategies in treatment cells. Unfortunately, physical barriers, while satisfactory in terms of ground water control and containment of dissolved-phase plumes, may contain small gaps or discontinuities which could permit escape of DNAPL (7). Chemical compatibility between physical barriers and construction material must agree to insure the physical integrity of the barrier. The history of the performance of these containment technologies is poorly documented and is mainly offered here for completeness of review. A more complete review of these physical barriers is available (5,56).

Sheet piling involves driving lengths of steel that connect together into the ground to form an impermeable barrier to lateral migration of DNAPL. Ideally, the bottom of the sheet pile should be partially driven into an impermeable layer to complete the seal. Slurry walls involve construction of a trench which is backfilled with an impermeable slurry (bentonite) mixture. Grouting is a process where an impermeable mixture is either injected into the ground or is pumped into a series of interconnected boreholes which together form an impermeable boundary. Again, the main feature of these techniques is to physically isolate the DNAPL.

In summary, site characterization and remediation options for sites containing DNAPL are limited. Field data from site characterization and remediation efforts are also limited. This is largely due to the complexity of DNAPL transport and fate in the subsurface, poorly developed techniques currently available to observe and predict DNAPL in the subsurface, and to the fact that this issue has not been widely recognized until recently. Clearly, there is a growing realization within the scientific and regulatory community that DNAPL is a significant factor in limiting site remediation. Correspondingly, current research efforts within the private, industrial, and public sectors are focusing on both the fundamentals and applications aspects of DNAPL behavior in subsurface systems. Additionally, the number of field investigations reflecting an increased awareness of DNAPLs, is growing.

DNAPL Modeling

A modeling overview report identified nineteen (numeric and analytic) multiphase flow models which are currently available (60). Most of these models were developed for salt water intrusion, LNAPL transport, and heat flow. Four models are qualitatively described as immiscible flow models but do not specifically indicate DNAPL. A more recent model has been developed which simulates density driven, three phase flow, that is capable of modeling DNAPL transport (23). Presently, very little information is available on DNAPL modeling in the scientific literature.

Multiphase flow modeling involves modeling systems where more than one continuous fluid phase (NAPL, water, gaseous) is present. Modeling any subsurface system requires a conceptual understanding of the chemical, physical, and biological processes occurring at the site. Modeling of simultaneous flow of more than one fluid phase requires a conceptual understanding of the fluids and the relationship between the fluid phases. The significance of multiphase flow over single phase flow is the increased complexity of fluid flow and the additional data requirements necessary for modeling. As presented earlier, numerous variables strongly influence DNAPL transport and fate, and consequently, the mathematical relationship of these variables is complex. Therefore, it follows that DNAPL modeling presents paramount technical challenges.

Presently, it is exceedingly difficult to obtain accurate field data which quantitatively describes DNAPL transport and fate variables within reasonable economic constraints. DNAPL transport is highly sensitive to subsurface heterogeneities (8,27,28) which compounds the complexity of modeling. Heterogeneities are, by nature, difficult to identify and quantify and models are not well equipped to accommodate the influence of heterogeneities. Additionally, relative permeability and capillary pressure functions must be quantified to identify the relationship between fluids and between the fluids and the porous media. Unfortunately, these parameters are very difficult to measure, particularly in three phase systems. Prior to an investment of time and money to model a given site, a careful evaluation of the specific objectives and the confidence of the input and anticipated output data should be performed. This will help illuminate the costs, benefits, and therefore, the relative value of modeling in the Superfund decision making process.

In summary, DNAPL modeling at Superfund sites is presently of limited use. This is mainly due to: the fact that very little information is available in the scientific literature to evaluate previous work; accurate and quantitative input data is expected to be costly; the sensitivity of DNAPL transport to subsurface heterogeneities; and, the difficulty in defining the heterogeneities in the field and reflecting those in a model. However, multiphase flow models are valuable as learning tools.

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ATTACHMENT B

Groundwater Sample Log Sheet

Client: __KeySpan Brightwaters OU3 GW Sampling____________________ Well Identification: _______________

Project Number: __37641.0430.00001______________________________ Date: _______________

Site Name / Location: __Brightwaters OU3 GW Sampling__Brightwaters, NY Depth to Water (ftbtoc): _______________

Weather: ____

Headspace PID (ppm) ________________________ Well PID (ppm): _________________

Purging Information

Time	pH	Specific Cond. (mS/m)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Temp. (ºC)	TDS	ORP (Eh) (mV)	Purge Rate (lpm)	Comments (color, odor, etc.)
3@3-5 m.	+/- 0.1	3%	10%	10%	3%		+/- 10 mV		

Approximate Purge Volume: ______________________

Sampling Information TRC Personnel: ________________________________

Containers					Sample Collection	
Analysis	Number	Size	Type	Preserv.	Sample Name:	Time:
BTEX	1	1 L	Amber	None		
PAH	2	40 mL	VOA Vial	HCl		

Notes:

Only 1-1L bottle and 2-40mL VOA Vials collected per well unless duplicate or MS/MSD collected from well.

Collect sample after 3 readings (collected every 3-5 minutes) have stabilized.

RUSMAR
FOAM TECHNOLOGY

TECHNICAL MEMORANDUM

EVALUATION OF VOLATILE ORGANIC COMPOUND EMISSION CONTROL OF RUSMAR AC-900L AND AC-900 FOAM USING THE SURFACE EMISSION ISOLATION FLUX CHAMBER

Prepared For:
Dr. Paul Kittle
Rusmar, Inc.
216 Garfield Street
West Chester, PA 19380

Prepared By:
Dr. C.E. Schmidt
Environmental Consultant
19200 Live Oak Road
Red Bluff, California 96080

November 4, 1991

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

Emission rate testing of volatile and some semi-volatile compounds (VOC/SVOC) from contaminated soil was conducted at a licensed commercial hazardous waste landfill on August 6, 7, and 14, 1991. Emission rate measurements were made using the EPA recommended surface isolation flux chamber. Hydrocarbon samples were collected in evacuated stainless steel canisters and analyzed off-site by gas chromatography and mass spectrometry (GC/MS) following EPA Method TO-14.

The primary objective of this testing effort was to determine the efficiency of two Rusmar foam products for controlling emissions of VOC/SVOCs from soil contaminated with petroleum fuel (aviation fuel). EPA Method TO-14 provides for the speciation of a listed 39 air toxic compounds, some of which were routinely identified in these samples. However, most of the sample compounds were aliphatic hydrocarbons and were accounted for by the summation of total non-methane hydrocarbon compounds (TNMHCs). In addition, the analysis included the listing of up to the ten highest tentatively identified compounds found in each sample. As such, improvements in this sample collection and analytical technique, as compared to historical testing, have provided additional test data for this evaluation.

Three test pads were constructed of contaminated soil. Testing included uncontrolled emission rate testing, application of foam products, and retesting of fugitive TNMHC emissions. VOC\SVOC emission control data were calculated by dividing controlled TNMHC emission rate data by pad specific uncontrolled TNMHC emission rate data, subtracting this quotient from one, and multiplying this result by 100 (percent control). Test data were not corrected for foam baseline emissions. Rusmar AC-900L foam demonstrated a 98 percent control efficiency for foam applied immediately after application (replicate test). Likewise, Rusmar AC-900 foam had a 99 percent control efficiency immediately after application (single test). These control efficiencies were also calculated by dividing controlled emission rate data by the average of all uncontrolled emission

rate data. This normalized uncontrolled emission rate accounts for waste heterogeneity. These results show a 99 percent control efficiency for AC-900L and a 98 percent control efficiency for AC-900.

Time-weighted control efficiency data for test pad #1 showed TNMHC emission control efficiencies (calculated using pad specific uncontrolled rate data) for time T=2 hours, T=6 hours, T=24 hours, and T=7 days of 98, 99, 94, and 97 percent, respectively. Time-weighted test data for the other two test pads were of limited use. Control efficiency data for some compounds were calculated for comparison purposes and are provided. These data, along with other compound data, are useful for evaluating other aspects of VOC/SVOC control efficiency.

INTRODUCTION

This technical memorandum describes the field testing that was conducted in order to establish the VOC\SVOC emission control efficiency of Rusmar AC-900L and AC-900 foams for petroleum hydrocarbon wastes. The objective of this testing was to determine the emission rates of organic compounds (VOCs/SVOCs) from uncontrolled waste and then from wastes with representative layers of foams applied to the waste for purposes of emission control. This testing was conducted by Dr. CE Schmidt on August 6, 7, and 14, 1991.

The testing protocol that was used for this program has been used in the past to establish the control efficiency of other foam products developed for the same purpose, namely to control VOC/SVOC emissions from waste/hazardous waste materials. The testing protocol included the use of the EPA recommended surface emission isolation flux chamber technology and the EPA Method TO-14 canister sample collection and GC/MS analytical technique. The testing consisted of constructing test pads of contaminated soils approximately one foot thick and at least six feet in diameter. Uncontrolled emission rate testing was conducted within minutes of shaping the test pads. After uncontrolled testing, a selected foam product was applied (approximately 1-to-3 minutes post application) to a given pad and controlled emission rate testing was conducted. Foam was applied using Rusmar foam application equipment with coverage of about 2-to-3 inches of foam as per recommended vendor application or usage. Foam was applied to the top and all sides of the test pads so that hydrocarbons could not escape from the pad except through the foam layer. Repeat emission rate testing was conducted over time with most of the testing focused on test pad (pad #1). In total, three test pads were constructed and tested; pad #1 and pad #2 were covered with foam product AC-900L and pad #3 was covered with foam product AC-900. The testing included: uncontrolled emission rate testing, controlled emission rate testing as a function of time up to a time period of 7 days, uncontrolled emission rate testing of the pads after the controlled testing with the foam layers removed, system blank quality control testing,

replicated sample analysis, replicate sample testing, foam baseline testing, and other standard analytical quality control testing.

The sections that follow include a discussion of the testing methodology, quality control procedures, the results of this testing effort, and a discussion of these results.

TEST METHODOLOGY

Testing was conducted using the EPA recommended Surface Isolation Flux Chamber (flux chamber) as the emission assessment tool to collect emissions data. The primary reference for this section is the document entitled "Measurement of Gaseous Emission Rates From Land Surfaces Using an Emission Isolation Flux Chamber, Users Guide." EPA Environmental Monitoring Systems Laboratory, Las Vegas, Nevada, EPA Contract No. 68-02-3889, Work Assignment No. 18, February 1986.

The operation of the flux chamber is given below:

1) Flux chamber, sweep air, sample collection equipment, and field documents were located on-site and at the test location.

2) The site information, location information, equipment information, name of sampler, date, and proposed time of testing were documented on the Emissions Measurement Field Data Sheet.

3) The exact test location was selected and the chamber was placed on the testing surface (uncontrolled waste, foam, waste controlled with foam layer). The thermocouples were placed in order to monitor soil/air temperature inside and outside of the chamber. The chamber was suspended from a portable tripod when used on foam layers to prevent disturbance of the foam layer.

4) The sweep air flow rate was initiated and the rotometer was set at 5.0 liters per minute. Constant sweep air flow rate was maintained throughout the measurement.

5) The chamber was operated at 5.0 liters per minute sweep air flow rate, and data were recorded every residence time (6 minutes) for five residence times or 30 minutes. The sample line was continually purged by withdrawing exhaust gas and monitoring with an Organic Vapor Analyzer.

6) At steady-state (5 residence times or more), gas samples were collected. Sample collection rate of 2.5 liters per minute was not exceeded at any time. This prevented unwanted entraining of ambient air.

7) After sample collection, all samples were labeled and documented on the data sheet.

8) After labeling, all samples were properly stored in shipping boxes.

9) Sample collection was documented on the chain-of-custody sheet.

10) After sampling, the flux measurement was discontinued by shutting off the sweep air, removing the chamber, and securing the equipment.

11) Where contact was made with the surface, the chamber was decontaminated using appropriate cleaning supplies.

12) Sample equipment was then relocated to the next test location and steps 1) through 12) were repeated.

Gas samples were collected from the exhaust of the flux chamber in evacuated stainless steel canisters and analyzed by GC/MS following EPA Method TO-14. These samples were analyzed off-site by an accredited, California laboratory.

QUALITY CONTROL

Quality control procedures are described below. The application and frequency of these procedures were developed to meet the program objectives and the data quality objectives.

- **<u>Field Notebook</u> -- A field notebook with data forms was maintained for the testing program.**

- **<u>Laboratory Blank</u> -- A total of five laboratory blank samples were analyzed for the program. No compounds were detected in any of these samples at or above 1.0 ppbv per species or 0.10 ppmv TNMHC. These data indicate acceptable laboratory blank performance.**

- **<u>Blank Sample</u> -- Blank samples were obtained by placing the clean chamber on a clean surface (away from areas of known contamination on the test site). The chamber was operated as described and blank samples were collected prior to and after testing. Blank sample testing frequency was about 5 percent. The blank sample concentrations of compounds were acceptable. Only one compound, 1,2,4-trimethylbenzene at 2.6 ppbv, was detected. Method detection limit for this method was 1.0 ppbv per species and 0.13 ppmv for TNMHC. This results in a system blank test emission estimate of <21 ug/m2,min-1.**

- **<u>Replicate Analysis</u> -- Two canisters were analyzed in replicate (about 10 percent). Six-to-eight compounds were identified per sample and the relative percent difference (RPD) for these replicate analyses ranged from 4.8 to 15 (average of 9.8) for one and 0.0 to 8.9 (average of 3.7) for the other. These data represent acceptable precision as compared to a criteria of 30 percent RPD.**

- **<u>Replicate Sample</u> -- A replicate canister was collected immediately after collection of an initial canister sample during a measurement at one location. Replicate frequency was about 5 percent. The relative percent difference of the duplicate emission test per one location ranged from 14 to 23 for all six compounds detected (average of 19). These data indicate**

acceptable sampling and analytical precision as compared to acceptance criteria of 50 percent.

- **<u>Chain-of-Custody</u> -- Sample labels and sample custody forms were completed and samples were executed as follows: canisters - avoid heat and light, package for shipping, ship priority mail, analysis within 30 days.**

- **<u>Laboratory Quality Control Data</u> -- Laboratory quality control data for canister samples are available upon request. Laboratory surrogate recovery data and matrix sample recovery data are included with sample results. Three matrix samples were analyzed and average recoveries for the TO-14 compounds were 85, 97, and 105 percent for an overall average recovery of 96 percent. These data indicate acceptable performance as compared to recovery criteria 80 to 120 percent.**

RESULTS

Emission rate data for TNMHC are summarized in Table 1 as well as percent control data. In addition to TNMHC, four species were selected and used to calculate percent control efficiency including benzene, toluene, xylenes, and ethylbenzene. These data are reported in Table 2. Other species emission rate data were not summarized or used in this data presentation but are available upon request.

Emission rate data were calculated using measured data. Emission rate data are calculated by multiplying chamber concentration (ug/m3) by sweep air flow rate (5.0 l/min), dividing by chamber surface area (0.13 m2), and converting these data to the appropriate units resulting in emission rate data in ug/m2, min-1.

DISCUSSION

The primary objective of this testing was to determine the control efficiency of two Rusmar foam products for application on soils contaminated with hydrocarbon products. The standard test for foam evaluation was used, namely TNMHC emission measurement from soils contaminated with hydrocarbons, immediate application of the foam to the soil/waste, and controlled TNMHC emission rate measurement on the foam.

These data are presented in Tables 1 and 2 and indicate that AC-900L had a 98 percent control efficiency for TNMHC after immediate application (both test pads #1 and #2), and AC-900 had a 99 percent control efficiency for TNMHC after immediate application. If all uncontrolled waste emission rate data are averaged and used for this calculation of control efficiency (as opposed to per pad uncontrolled emissions), pad #1 and #2 had a 99 percent control efficiency and pad #3 had a 98 percent control efficiency. This normalized uncontrolled waste emission rate (ie., average 1300 ppmv chamber concentration or 210 mg/m2, min-1) may better represent emissions from these waste materials given the heterogeneity of the waste.

Time-weighted control efficiency data are given showing control efficiency of these products up to 7 days after application. Speciation data are also presented for these tests indicating control efficiency for benzene, toluene, o,m,p-xylenes, and ethylbenzene. Specific comment about these data are summarized below.

- **Time-dependent emission rate testing on pad #1 for AC-900L indicate that this product demonstrated a control efficiency of 94 to 98 percent over a 7 day time period with an average control efficiency of 97 percent. Uncontrolled emission rate testing on test pad #1 indicated that these contaminants had been contained by the foam layer. Individual species control efficiencies (Table 2) supported these findings with most species data reflecting these TNMHC control efficiencies.**

- **These foam products have a baseline emissions of hydrocarbon species which compose the foam. Speciation data indicate that there are a variety of generally high molecular weight baseline hydrocarbon emissions from the foam products including aliphatic, aromatic, oxygenated, and chlorinated species.**

- Baseline emissions were not subtracted from these control efficiency tests. It appears that the foam baseline emissions is consistent and is usually less than 10 mg/m2,min-1. These baseline emissions influence the percent control efficiency expression. For instance, both pad #1 (AC-900L) and pad #3 (AC-900) had about the same controlled emission rate (18 and 21 mg/m2, min-1, respectively), however, the control efficiency for AC-900 was reported at 99 percent and AC-900L at 98 percent. This is because both products are effectively controlling emissions and had approximately the same baseline or foam emissions, but the uncontrolled emissions for pad #3 was about twice that of pad #1 (300 versus 120 mg/m2, min-1). The greater denominator (300 versus 120 mg/m2, min-1) in the calculation of AC-900 control efficiency was responsible for the 99 percent expression.

- Test pad #2 showed break-through of TO-14 compounds (xylenes, ethylbenzene, trimethylbenzenes) and TNMHC at T=21 and T=22 hours. Field observations indicated that the texture of the foam under the flux chamber was different than that of the foam around the test area. The chamber was placed exactly on the same area initially tested for exact repeat testing. This foam texture appeared to have a coarse, open-pore structure that was unlike the other foam surfaces. It is likely that the foam was affected by the flux chamber test disturbing the formation of the cell structure and surface as compared to areas not enclosed by the chamber. These test results for pad #2 after T= 0 are considered suspect.

- The uncontrolled emissions from the contaminated soils after the foam layers were removed indicated that the emission rates for two of the three test pads (#l and# 2) were higher after the containment experience than before. There is no explanation for this observation except that the waste may have not been at equilibrium for the initial uncontrolled test and the time spent under the foam layer allowed the soil/soil vapor to come to equilibration. Since the purpose of these tests is to demonstrate that the foam contained the contaminants, time-dependent testing conducted on these test pads is considered acceptable. Further, if the uncontrolled emissions were in fact higher than the initial uncontrolled results, these control efficiency data are conservative and the control efficiencies are probably higher than reported. These post-foam data suggest the use of average uncontrolled rate data as opposed to pad specific uncontrolled emission rate data for the control efficiency evaluation.

Test pad #3 showed lower uncontrolled emissions indicating VOC/SVOC loss, however, the T= 0 hour control efficiency was 99 percent. With the 53 percent TNMHC residual emissions after foam removal, the 100 percent control estimate at T= 6 days for TNMHC control is suspect (ie., VOC/SVOC escaped and the uncontrolled emissions and the control efficiency estimate are lower).

TABLE 1. SUMMARY OF TOTAL NON-METHANE HYDROCARBON (TNMHC) EMISSIONS AND PERCENT CONTROL DATA

		TNMHC		PERCENT
SAMPLE I.D.	TEST	(ppmv)	(mg/m2,min-1)	CONTROL
A001	SYSTEM BLANK	<0.13	<0.021	NA
A002	AC-900L	33	5.2	NA
A003	AC-900L, REPLICATE	17	2.7	NA
A004	PAD #1, UNCONTROLLED	740	120	NA
A004	LAB REPLICATE	640	100	NA
A005	PAD #1, UNCONTROLLED REPLICATE	790	120	NA
NA	**PAD #1 UNCONTROLLED AVERAGE**	**740**	**120**	**NA**
A006	PAD #1 : AC-900L, T = 0 HOUR	18	2.8	98
A007	**PAD #2, UNCONTROLLED**	**900**	**140**	**NA**
A008	PAD #2, AC-900L, T= 0 HOUR	19	3.0	98
A009	PAD #1, AC-900L, T= 2 HOUR	18	2.8	98
A010	PAD #I, AC-900L, T= 6 HOUR	6.4	1.0	99
A011	PAD #1 AC-900L, T= 24 HOUR	41	6.5	94
A012	PAD #2: AC-900L, T= 21 HOUR	360	57	60
A012	LAB REPLICATE	350	55	61
A013	PAD #2 AC-900L, T= 22 HOUR	600	95	33
A014	PAD #I: AC-900L, T= 24 HOUR	42	6.6	94
A015	**PAD #3, UNCONTROLLED**	**1,900**	**300**	**NA**
A016	PAD #3, AC-900, T = 0 HOUR	21	3.3	99
A017	PAD #3, AC-900, T = 6 DAYS	0.47	0.074	100[a]
A018	PAD #3, UNCONTROLLED, POST-FOAM	1,000	160	53[b]
A019	PAD #2, AC-900L, T = 7 DAYS	82	13	91
A019	LAB REPLICATE	88	14	90
A020	PAD #2 UNCONTROLLED, POST-FOAM	1,900	300	210[b]
A021	PAD #1: AC-900L, T = 7 DAYS	23	3.6	97
A022	PAD #1, UNCONTROLLED, POST-FOAM	1,400	220	190[b]

NA - NOT APPLICABLE

[a] LESS VOC EMISSIONS FOUND AFTER FOAM REMOVED AS COMPARED TO UNCONTROLLED TEST

[b] PERCENT VOC EMISSIONS REMAINING AFTER FOAM REMOVED COMPARED TO INITIAL UNCONTROLLED TEST (POST-FOAM TEST)

NOTE:PERCENT CONTROL CALCULATED USING PAD SPECIFIC UNCONTROLLED EMISSION RATE DATA.

TABLE 2. SUMMARY OF PERCENT CONTROL DATA FOR BENZENE, XYLENES (o, m, p), ETHYLBENZENE, AND TNMHC

COMPOUNDS	P#l T=0	P#l T=2	P#l T=6	P#l T=24	P#l D=7	P#2 T=O	P#2 T=21	P#2 D=7	P#3 T=0	P#3 D=6
BENZENE	NC	NC	ND	ND	ND	55	81/82	77	87	100[a]
TOLUENE	68	95	96	93/93	99	68	81/77	98	94	100[a]
XYLENES (o,m,p)	99	98	98	95/95	98	94	84/76	97	97	100[a]
ETHYLBENZENE	99	98	98	96/95	98	93	83/76	96	97	100[a]
TNMHC	98	98	99	94/94	97	98	61/33	91/90	99	100[a]

P#- Pad Number   T= Time in Hours   D= Days

NC - CANNOT CALCULATE; COMPOUND NOT DETECTED IN UNCONTROLLED TEST

[a] LOW RECOVERY FOR POST-FOAM TEST

NOTES:
- TWO DATA POINTS REPRESENT REPLICATE TESTING
- PAD #1 AND #2 TESTED AC-900L
- PAD #3 TESTED AC-900
- PAD #2 EMISSIONS TEST MAY HAVE ADVERSELY AFFECTED CONTROL EFFICIENCY
- PERCENT CONTROL CALCULATED USING PAD SPECIFIC UNCONTROLLED EMISSION RATE DATA.

Case Histories

MANUFACTURED GAS PLANT
COAL TAR CONTAMINATION
ODOR & VOC CONTROL

Products used:

AC-645 Long Duration Foam
AC-904 Long Duration Foam
Pneumatic Foam Unit 400/25

Application Summary

Rusmar Long Duration Foam products have been used at numerous manufactured gas plant facilities. Often, tanks containing coal tar were filled with soil and other debris from the site before being abandoned.

Old manufactured gas plants are usually located in the center of the town near residential and industrial facilities. Therefore, the control of odors and VOCs, particularly benzene, is very important. The excavation plans usually require that the soil be stabilized prior to being shipped off site for disposal. Rusmar Long Duration Foam is used to control both the odors and VOCs.

During periods of warm weather,when there are emission problems during the stabilization process, AC-645 is applied over the top layer of contaminated soil during active excavations to control emissions. The worst emission problems occur when the contaminated soil is allowed to sit dormant for an extended period of time, particularly overnight. Rusmar AC-645 Long Duration Foam is applied over the top layer of contaminated soil to control emissions when control requirements do not exceed eighteen (18) hours.

If the emission control requirements exceed eighteen (18) hours, such as on weekend or holiday shutdowns, AC-904 Long Duration Foam is applied over the contaminated soil. The AC-904 Long Duration Foam provides superior emission control for up to ten (10) days.

The Pneumatic Foam Unit 400/25 can be used to apply both foam products. The unit is self contained and simple to operate.

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Company Profile | Emissions Control | Alternate Daily Cover | Case Histories
Superfund References | Equipment (PFU's) | Specialty Equipment | MSDS & Reports