M00263.AR.000708
MCRD PARRIS ISLAND
5090.3a

INVESTIGATION WORK PLAN FOR SITE 45 FIELD VALIDATION OF TIER 2 SCREENING CRITERIA AND TIER 3 FIELD PROCEDURES FOR EVALUATION OF VAPOR INTRUSION

MCRD PARRIS ISLAND SC

5/18/2009

GSI ENVIRONMENTAL INC

INVESTIGATION WORK PLAN: SITE 45, PARRIS ISLAND

Field Validation of Tier 2 Screening Criteria and Tier 3 Field Procedures for Evaluation of Vapor Intrusion

ESTCP Project ER-0707

May 18, 2009

Issued by GSI Environmental Inc.
Houston, Texas
Job No. G-3213

Table of Contents

1.0 INTRODUCTION 1
1.2 OBJECTIVE OF THE DEMONSTRATION 1
1.2 TECHNOLOGY DESCRIPTION 2

2.0 WORK PLAN FOR SITE 45 INVESTIGATION 3
2.1 CONCEPTUAL EXPERIMENTAL DESIGN 3
2.1.1 Tier 2 Screening Criteria Based on Soil Conditions 3
2.1.2 Streamlined Tier 3 Evaluation Based on Building Foundation Permeability 4
2.2 BASELINE CHARACTERIZATION ACTIVITIES 7
2.3 DESIGN AND LAYOUT OF TECHNOLOGY COMPONENTS 7
2.3.1 Installation of Sampling Points for Evaluation of Tier 2 Screening Procedure 7
2.3.2 Installation of Sampling Points for Validation of Tier 3 Investigation Program 10
2.4 FIELD TESTING 11
2.4.2 Field Testing for Evaluation of Tier 2 Screening Procedure 12
2.4.1 Field Testing of Tier 3 Evaluation Procedure 12
2.5 SAMPLING PLAN 13
2.5.1 Sampling Plan for Validation of Tier 2 Screening Procedure 13
2.5.2 Sampling Plan for Validation of Tier 3 Evaluation Procedure 14
2.5.3 Quality Assurance Procedures 16
2.6 DATA ANALYSES AND REPORTING 17

Tables

Table 2.1.1: Summary of Tier 2 Evaluation Sampling Program
Table 2.1.2: Summary of Tier 3 Evaluation Sampling Program
Table 2.5.1: Analytical Methods to be used for Sample Analysis

Figures

Figure 2.1.1: Conceptual plan for field validation of soil type and moisture content as basis for selection of Tier 2 vapor intrusion screening values.
Figure 2.1.2: Field Schedule for Tier 2 Demonstration Program
Figure 2.1.3: Conceptual basis for measurement of foundation permeability as part of expedited Tier 3 evaluation of vapor intrusion.
Figure 2.1.4: Tier 3 Field Testing Schedule
Figure 2.3.1: Example Construction Specifications for Monitoring Wells and Soil Gas Sample Points.
Figure 2.3.2: Proposed Sample Point Cluster Locations for Tier 2 Field Program.
Figure 3.1: Wire Diagram of Project Management

Photos

Photo 2.3.1: Example Sub Slab Sample Point
Photo 2.4.1: Pressure transducer installation.
Photo 2.5.1: SF6 Tracer Gas Release System.

Table of Contents

Acronyms

bgs	Below ground surface
BTEX	Benzene, Toluene, Ethylbenzene and Xylenes
COC	Chemical of Concern
HVAC	Heating, Ventilating, and Air Conditioning
PCE	Tetrachloroethene
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance / Quality Control
QAPP	Quality Assurance Project Plan
SF6	Sulfur Hexafluoride
TCE	Trichloroethene
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
VI	Vapor Intrusion
VOC	Volatile Organic Compound

1.0 INTRODUCTION

Site 45 at Marine Corps Recruit Depo, Parris Island, SC has been selected as one of 8 sites for field validation of proposed Tier 2 screening procedures and one of 8 sites for field validation of proposed Tier 3 field investigation procedures for the evaluation of vapor intrusion. We are conducting this field validation as part of research project ER-0707 funded by the Environmental Security Technology Certification Program (ESTCP). This work plan described the investigation locations and procedures to be used for the Site 45 field program.

1.2 OBJECTIVE OF THE DEMONSTRATION

The overall objective of research project ER-0707 is to develop simple procedures for i) Tier 2-level site-specific evaluation and screening and ii) limited Tier 3 field investigation of the vapor intrusion pathway. These procedures will utilize easily obtained site-specific information to support a realistic site-specific pathway assessment involving significantly less effort than is currently required. The specific project objectives are as follows:

- Evaluate soil grain size and moisture content as factors affecting vapor intrusion attenuation factors.
- Develop Tier 2 screening procedures and criteria that incorporate the effect of grain size and moisture content on VOC attenuation.
- Evaluate building foundation permeability and building pressure as factors affecting vapor intrusion attenuation factors.
- Develop Tier 3 focused field investigation procedures for the evaluation of vapor intrusion based measurement of foundation permeability and building pressure.
- Validate the Tier 2 screening procedures and Tier 3 focused field investigations by application at well characterized vapor intrusion sites.

The progress and results of this demonstration are being documented in a series of reports as follows:

1) *Proposed Tier 2 Screening Criteria And Tier 3 Field Procedures For Evaluation Of Vapor Intrusion (Issued February 2008; Revised August 2008)*: Documents results of literature review and survey and presents Tier 2 and Tier 3 vapor intrusion evaluation procedures for field validation.

2) *Demonstration Plan for Field Validation Program (Issued March 2008; Revised October 2008)*: Provides detailed design of field validation program for Tier 2 and Tier 3 vapor intrusion evaluation procedures.

3) *Interim and Final Reports (Due October 2009 to April 2011)*: Presents interim and final results from 16 field demonstration sites.

1.2 TECHNOLOGY DESCRIPTION

This technology demonstration project will develop and validate i) a Tier 2 vapor intrusion screening procedure based on easily measured site-specific characteristics and ii) a streamlined Tier 3 evaluation procedure to determine the presence or absence of a vapor intrusion impact to a specific building. The screening procedures can be used individually or together to provide maximum flexibility for cost-effective evaluation of vapor intrusion at each site.

Tier 2 Screening Procedures: The groundwater-soil gas interface and the vadose zone soils are key targets for site-specific evaluation because: i) transport across these zones varies significantly (>100x) between sites making the Tier 1 default very conservative for a large proportion of sites evaluated, and ii) easily obtained site-specific data can be used to support a less conservative evaluation. At either the groundwater-soil gas interface or within the vadose zone, a high moisture content, fine-grained soil layer serves as a significant barrier to the vertical migration of VOCs towards buildings. As a result, VOC attenuation along the vapor intrusion pathway at sites with these soil layers can be much higher than at sites where these barriers to vertical diffusion are absent.

For this demonstration, we will measure VOC attenuation from shallow groundwater through the soil column at up to eight sites exhibiting a variety of soil-type characteristics. Sample collection and analysis will be conducted in a consistent manner across the sites, providing a comparable data set for accurate assessment of the differences in VOC attenuation between these sites. The results of this demonstration will serve to document the higher VOC attenuation that occurs at sites with high moisture, fine-grained soils. This, in turn, will validate the use of higher Tier 2 screening criteria at sites with these documented soil conditions.

Streamlined Tier 3 Evaluation: Although building foundation permeability has been identified as an important site characteristic for vapor intrusion, the peer-reviewed literature and regulatory guidance do not provide accepted methods for the evaluation of foundation permeability. Currently, some state regulatory guidance documents recommend multiple indoor sampling events or building sampling only during specific weather conditions (i.e., during the heating seasons) in order to characterize "worst case" vapor intrusion conditions.

For buildings with concrete foundations, our streamlined building sampling procedure will combine VOC sampling with building pressure measurements and manipulation of building pressure to i) evaluate building foundation permeability, and ii) measure attenuation factors under a range of building pressure conditions. During a single sampling event, this streamlined evaluation procedure documents the potential for vapor intrusion under a range of building operating conditions and will serve to document the role of building foundation permeability in preventing or facilitating a vapor intrusion impact.

Comment [EPA2]: A less conservative evaluation may increase, or make more significant, the need to evaluate seasonally throughout a year. Otherwise, for this data to suffice for site-specific evaluation of Site45 VI analysis, data/documentation should be submitted which shows soil moisture content, as well as other VI variables, at Site 45 do not vary during the year.

Comment [EPA3]: Has the study considered what difference the variability in source concentrations may have on this study? Are you comparing sites which may have reasonably low, but above the screening criteria, COCs in GW at 50 feet bgs with Sites which have DNAPL in the vadose zone at 6 feet? Will it not make a difference? Please explain your controls.

Comment [EPA4]: Which screening criteria are you proposing to replace? Table 2a?, 2b? 2c? 3a-SG?, 3b-SG?, 3c-SG, 3a-GW?, 3b-GW?, 3c-GW? Or all of the above?

Comment [EPA5]: EPA understands that "worst case" scenarios are to be determined site-specifically. For example, at Site 45, August may be determined to be the warmest month and February to be the coldest month. However, if an exposed building has a positive pressure HVAC system which runs pretty much full time in summer and winter, but not as much in spring or fall, then August may not necessarily indicate a worst case scenario. Again, this further supports seasonal sampling to determine site-specific conditions and risk.

Comment [EPA6]: It appears your study attempts to address this by manipulating building pressures in a single event, but there may be more seasonal variation impacts than just building pressure (i.e. temperature, soil moisture content, depth of water table, etc.), which may impact soil gas concentrations available for intrusion and therefore cause different results at different times of the year. So this may not relieve the need for season sampling.

2.0 WORK PLAN FOR SITE 45 INVESTIGATION

Comment [EPA7]: EPA does not typically comment on the technical aspects of an ESTCP research design. However, since it is being proposed to use this data for Site 45 VI Analysis, most of EPA Region 4's comments will be made from this perspective. I am also consulting with Mr. Schuver to see if he cares to comment (which may include more technical comments on the study.)

2.1 CONCEPTUAL EXPERIMENTAL DESIGN

The purpose of this field demonstration is to validate i) confining layers and high moisture content fine-grained soil layers in the vadose zone as site specific criteria that support use of higher Tier 2 screening criteria for the vapor intrusion pathway and ii) the use of building pressure gradient measurements and control of building pressure in a streamlined Tier 3 evaluation of vapor intrusion. Validation of the Tier 2 screening procedures and criteria will require measurement of VOC attenuation at a number of sites with and without the defining characteristics (i.e., an aquifer confining layer or a high moisture content fine-grained soil layer) to demonstrate a difference in VOC attenuation between these types of sites. Validation of the streamlined Tier 3 evaluation methods will require application of the method at a number of buildings to demonstrate that the investigation methods provide a clear determination of vapor intrusion conditions for buildings of different size, design, and foundation characteristics.

2.1.1 Tier 2 Screening Criteria Based on Soil Conditions

As illustrated in Figure 2.1.1, the impact of an aquifer confining layer or high moisture content fine-grained soil layer on VOC attenuation will be validated through the measurement of aquifer confining conditions, soil parameters, and VOC concentrations at eight demonstration sites. The demonstration sites will represent a range of confined and unconfined aquifer conditions in order to clearly document the differences in VOC attenuation between sites. Three clusters of eight sample points will be installed at each demonstration site. The sampling program for the validation of the Tier 2 screening procedure is summarized in Table 2.1.1 and the field schedule is provided in Figure 2.1.2.

At Site 45, groundwater is located at a depth of 5 to 10 ft bgs and the shallow geology is characterized by sand and silty sand with discontinuous layers of silty clay. Within the investigation area for the Tier 2 field program, the vadose zone is characterized by sand and silty sand. As a result, Site 45 will serve as a without a confining layer or high moisture content fine-grained soil layer in the vadose zone.

Comment [EPA8]: Since this is a site which is considered to NOT have a confining layer or high moisture fine grained soil in the vadose zone, the Navy will need to justify why the attenuation results obtained at the sample locations over the hottest parts of the plume should apply to evaluations for the facilities which are greater than 100feet from these sample locations. See comments on sample location figure for more detail.

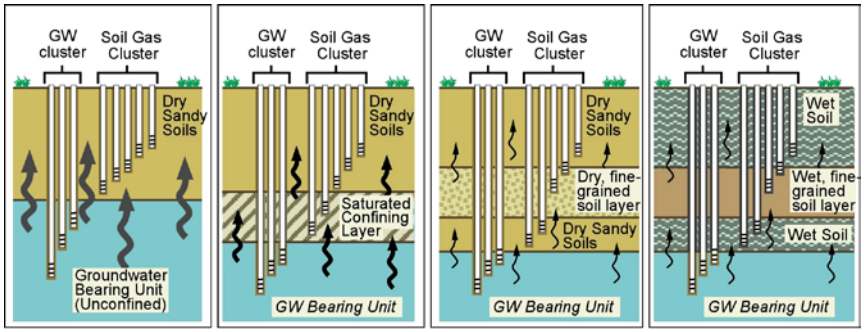
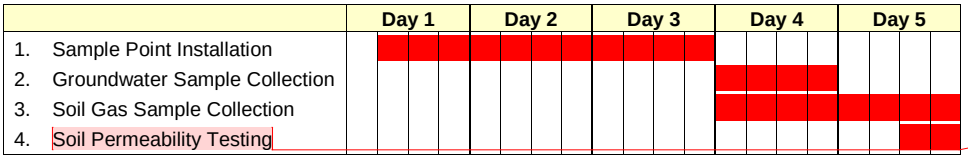


Figure 2.1.1: Conceptual plan for field validation of soil type and moisture content as basis for selection of Tier 2 vapor intrusion screening criteria.



Comment [EPA9]: How quickly could we get the results from this?

Figure 2.1.2: Field Schedule for Tier 2 Demonstration Program

Table 2.1.1: Summary of Tier 2 Evaluation Sampling Program

Component	Matrix	Number of Samples	Analyte	Location
Validation of Tier 2 Screening Procedures and Criteria: Sample Program for Each Demonstration Site	Soil	12	Permeability	4 soil intervals from each of 3 clusters
	Soil	12	Physical properties	4 soil intervals from each of 3 clusters
	Groundwater	9	VOCs	Each sample point with groundwater (3 clusters)
	Leak tracer (for each soil gas point)	15	Helium or SF_6	Each soil gas sample point (3 clusters)
	Soil gas:	15	VOCs	Each soil gas sample point (3 clusters)

2.1.2 Streamlined Tier 3 Evaluation Based on Building Foundation Permeability

Our preliminary study of three single-family residences at Hill AFB indicates that induced building depressurization does not increase the magnitude of vapor intrusion relative to baseline building pressure. However, the depressurization does improve the ability to distinguish vapor intrusion from indoor sources of VOCs. These results indicate that sampling at times of naturally-occurring low building pressure (e.g., winter months) is not required to evaluate "worst case" vapor intrusion conditions, and that the potential for vapor intrusion impacts can be accurately assessed through a single sampling event. The field validation program for the expedited Tier 3 evaluation will provide further data regarding the impact of induced building depressurization on the magnitude of vapor intrusion. For the field validation program, sampling will also be conducted under positive building pressure conditions. These conditions are expected to suppress any vapor intrusion providing a more accurate quantification of the contribution of background sources of VOCs to concentrations in indoor air (see Figure 2.1.3).

At Site 45, the Tier 3 field program will be conducted in the New Dry Cleaning Facility. This facility does not use PCE or other chlorinated dry cleaning chemicals which could interfere with the ability to evaluate the migration of these chemicals from the subsurface into the building. The sampling program for the validation of the Tier 3 procedure is summarized in Table 2.1.2 and the field schedule is provided in Figure 2.1.4.

Comment [EPA10]: To clarify what you may have heard from other regulatory agencies with respect to OSHA governing exposures and therefore VI not needing to be assessed, if the industrial facility uses the same chemicals or is required under OSHA to monitor for the same chemical exposures, then it may not be necessary to assess VI risk under CERCLA. A site specific determination must be made as to whether or not conditions exist which require a CERCLA assessment. For example, there may be office space within a facility, that is separate from the processing rooms, which is not monitored under OSHA, even though the processing rooms are. In this site specific scenario at Site 45, this statement indicates PCE or other chlorinated solvents are not used (and in fact have reportedly never been used) in the Site 45 new dry cleaner facility, and consequently it would not be anticipated that OSHA is requiring monitoring for PCE or its daughter products. Therefore, it is a requirement that this facility be evaluated for VI risks under CERCLA unless justification can be made otherwise. Additionally, other potentially exposed facilities need to be assessed, including any within 100 feet of gw or sg concentrations which exceed screening values, as well as hypothetical residential and industrial structures over the undeveloped portions of Site 45.

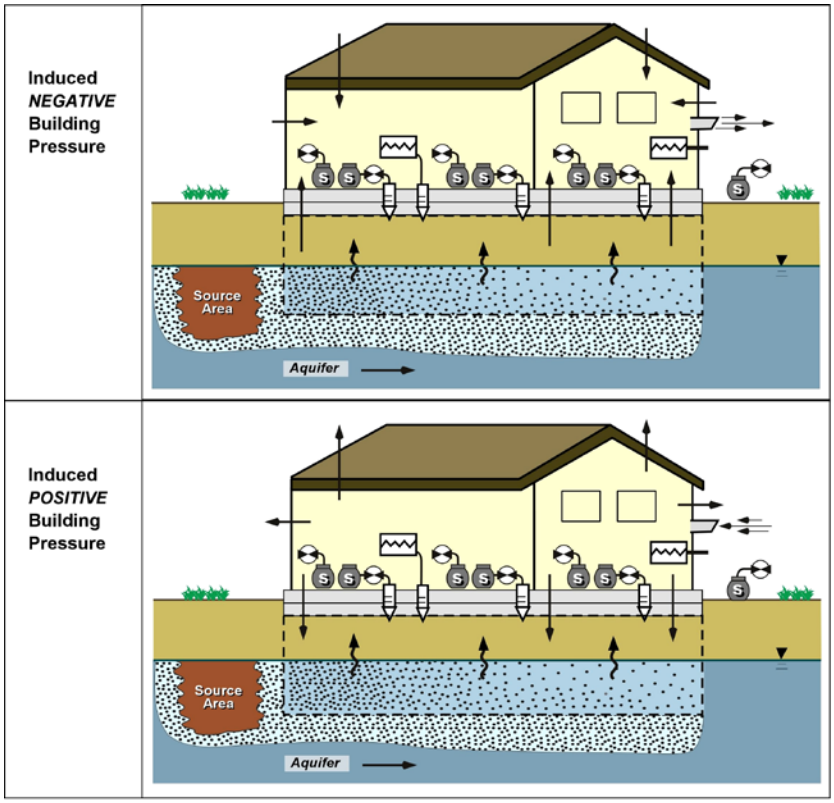


Figure 2.1.3: Conceptual basis for measurement of foundation permeability as part of expedited Tier 3 evaluation of vapor intrusion.

	Day 1			Day 2				Day 3		
1. Sample Point Installation		■								
2. SF6 Release and Pressure Measurement		■	■	■	■	■	■	■	■	■
3. Depressurization Start/Equilibration		■	■	■	■	■				
4. Collection of Depressurization Samples: VOCs					■	■				
5. Collection of Depressurization Samples: Radon						■				
6. Pressurization Start/Equilibration							■	■	■	■
7. Collection of Pressurization Samples: VOCs									■	■
8. Collection of Pressurization Samples: Radon										■

Figure 2.1.4: Tier 3 Field Testing Schedule

Table 2.1.2: Summary of Tier 3 Evaluation Sampling Program

Component	Matrix	Number of Samples	Analyte	Location
Tier 3 Building Investigation (each test building)	Indoor air	6	Radon, SF6, VOCs	Indoors, 3 locations (negative pressure and positive pressure events)
	Sub slab vapor	6	Radon, SF6,VOCs	Sub-slab, 3 locations (negative pressure and positive pressure events)
	Ambient air	1	Radon, SF6, VOCs	Outdoors, upgradient, once at each location
	Pressure Gradient	NA	Differential pressure between indoor/outdoor and indoor/sub slab space	Continuous sampling at various sample points during positive and negative pressure conditions

Comment [EPA11]: How do you determine location of indoor and sub slab sample locations? EPA needs to have input into this or the data may not be accepted. Also, for Site 45 VI assessment, samples need to be taken during stable conditions (undisturbed), before any positive or negative artificial influences have been put into action.

Comment [EPA12]: See comment above.

Comment [EPA13]: Your CSM indicates the location of the ambient sample is on the side away from the main soil source, but right next to the building ventilation egress. This seems counter to an ambient sample. If the ventilation point can be controlled it would make sense the vent be located on the same side with the soil source, and the ambient sample be taken upgradient and away from both sources. Perhaps this is just a problem with the drawing not being able to show 3 dimensions and remote distances, but it is also a case where you will have to evaluate field conditions at the time.

2.2 BASELINE CHARACTERIZATION ACTIVITIES

Site 45 has been characterized through prior site investigations that have included the installation of several soil borings, temporary groundwater sample points, and permanent monitoring wells. These investigations have served to provide an understanding of the shallow geology and the distribution of site contaminants that is sufficient to support the design and implementation of the field investigation program. As a result, no additional baseline characterization activities will be conducted for the field demonstration.

2.3 DESIGN AND LAYOUT OF TECHNOLOGY COMPONENTS

The field program at Site 45 will consist of i) installation of sampling points and collection of soil samples for geotechnical testing and ii) field testing and collection of water and/or gas samples. Section 2.3 describes the procedures to be used for installation of the sampling points and Sections 2.4 and 2.5 describe the field testing and sample collection and analysis methods, respectively.

2.3.1 Installation of Sampling Points for Evaluation of Tier 2 Screening Procedure

Comment [EPA14]: For the data to be acceptable to evaluate VI at Site 45, a determination will have to be made as to whether or not this procedure meets EPA standards and if the location of the samples are satisfactory, based on building and subsurface specifics.

Three clusters of sample points will be installed for groundwater and soil gas sampling. Each cluster will contain three sample points that penetrate the groundwater-bearing unit and 7 sample points placed in the vadose zone above the groundwater bearing unit for a total of 10 sample points at each cluster. In the vadose zone, 5 of the 7 points will be designed for collection of soil gas samples and 2 sample points will be designed for measurement of soil permeability (see Figure 2.3.1).

Sample points (groundwater wells and soil gas points) will be installed using direct push techniques that will generate intact soil cores which will be logged in accordance with the USCS classification guidelines. During soil core logging, special attention will be given to the soil type and moisture content of the vadose soils. Horizons of interest identified during inspection of the initial soil core will be captured in a plastic sleeve during the installation of a subsequent sample point in the same cluster. The sleeve will be sealed and placed in a cooler for transport to the geotechnical laboratory for analysis. Samples submitted for geotechnical analysis will be analyzed for the parameters identified in Table 2.5.1.

Based on the expected static water level, the monitoring wells in each cluster will be installed so that the shallowest well will be at the top of the water table during periods of the highest expected water table elevation. The remaining wells will be set with each screen at a depth of 2 ft below the previous well (may vary based on field conditions). Soil gas sample points will be installed in the three sample point clusters in conjunction with the groundwater monitoring sample points. The deepest boring will be advanced first and will be used to log the shallow geology. The next deepest boring will be used to collect four representative samples for geotechnical analysis (see Section 5.5.1). The remaining borings will be advanced with no sample collection or logging. The soil gas points will be installed in the same manner as the monitoring wells and will be completed at varying depths above the water table to allow for an evaluation of the influence of soil type and soil moisture content on vapor migration. The specific depths for sample point completion will be selected based on consideration of total vadose zone thickness and the elevation of specific soil layers that are expected to impact VOC attenuation in the vadose zone.

Comment [EPA15]: Does this mean an assumption of no rain events during the data gathering period, but at a water table elevation max that is tidally and potentially seasonally influenced? During high tide? Does the 6 inches of well screen ensure allowance for tidal influence?

Comment [EPA16]: Do you have literature which specifies what thickness of vadose zone is needed to establish consistent attenuation over greater or lesser thicknesses? At Site 45 you may have at best 4 -5 feet of vertical thickness.

Monitoring wells and vadose zone permeability points will be constructed of one-inch schedule 40 PVC pipe with flush threaded joints. The well screen consists of 6 inches of number ten slotted PVC with a threaded cap on the bottom with no sump. The screened interval of the well will be packed with U.S. mesh interval 20/40 sand. The remainder of the borehole will be filled with bentonite chips and hydrated to create an annular seal. Monitoring wells will be capped with a tight fitting PVC slip cap. The soil gas sampling points will be constructed of stainless steel vapor implant points attached securely to 1/8th inch Nylaflow tubing and lowered to the bottom of the borehole. A sand pack using U.S. mesh interval 20/40 sand will be installed to approximately 6-inches above the vapor implant point. The remainder of the borehole will be filled with bentonite chips to the ground surface and hydrated to create an annular seal. Monitoring wells and soil gas points will be completed at the surface using an aluminum flush mount man-way installed in a concrete pad or existing surface asphalt or concrete cover. Example construction specifications are shown on Figure 2.3.1. Proposed sample cluster locations are shown on Figure 2.3.2.

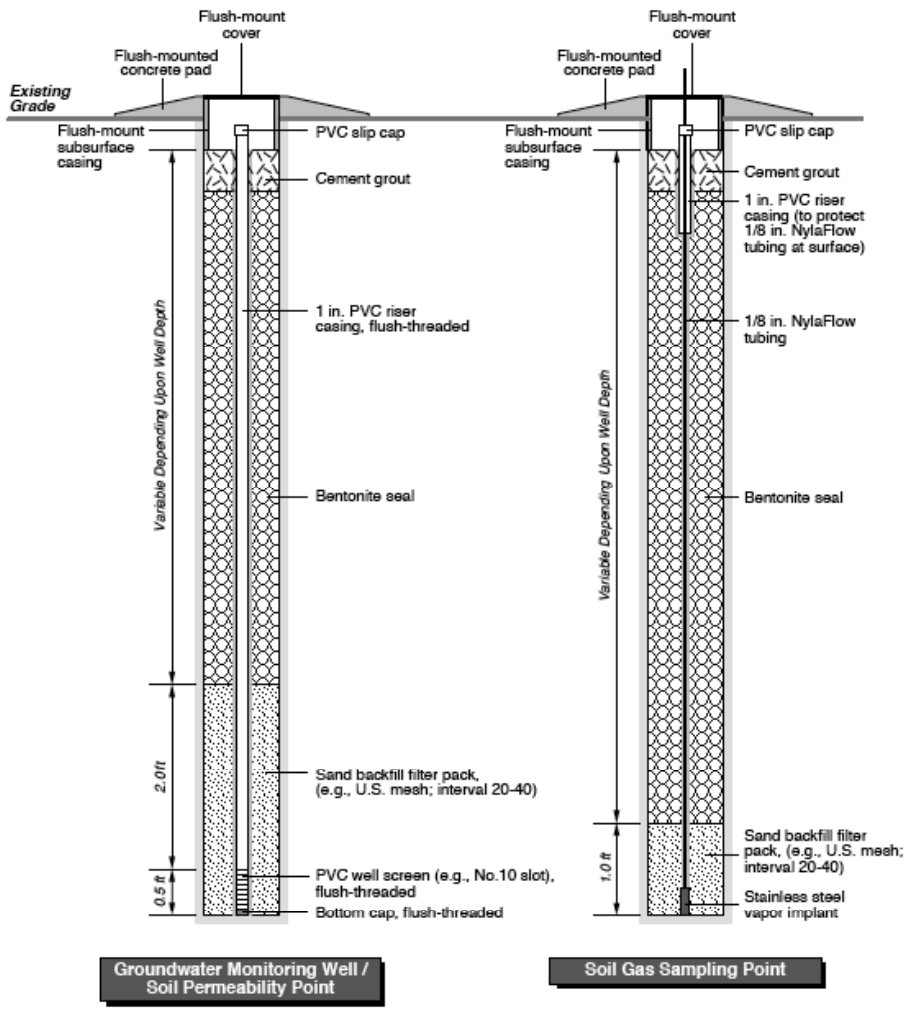


Figure 2.3.1: Example Construction Specifications for Monitoring Wells and Soil Gas Sample Points.

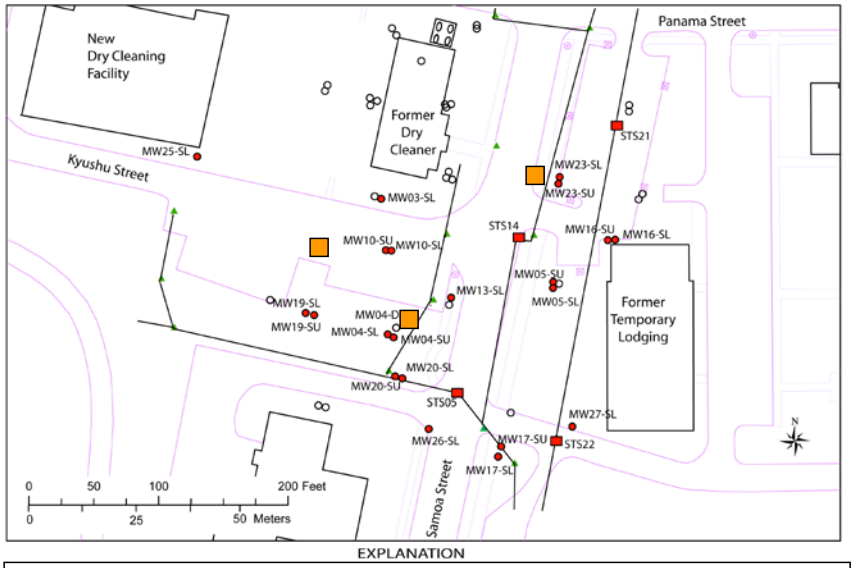


Figure 2.3.2: Proposed Sample Point Cluster Locations for Tier 2 Field Program.

Comment [EPA17]: Given these sample locations and the location of the highest concentrations of the plume and the distance removed from the facility (>100 feet), as well as the potential location of the DNAPL immediately adjacent to the New Dry Cleaner Facility, it appears the data may be used in assessment of hypothetical residential and industrial facilities over the undeveloped portion of the Site, but the data may not be appropriate for assessment of the New Dry Cleaner or the Attorney Building, given they are at best only barely within 100 feet of only 1 of 3 sample locations. Further justification would be needed to apply this data to these two facilities. These may present a "worst case" scenario for the Attorney Bldg, however, the impact of the crawl space would have to be considered and site specific data may still be required at some point. Given the potential for DNAPL in the vadose zone near the New Dry Cleaner, site specific data would also be required there (your Tier 3 data gathering may or may not suffice – see below.) The Navy may also make arguments as to whether or not the attenuation factors calculated from this data should apply to the New Dry Cleaner Facility and the Attorney Building, but be sure to address the questions raised in these comments.

2.3.2 Installation of Sampling Points for Validation of Tier 3 Investigation Program

Sub-slab Sample Points: The Tier 3 field program will be conducted in the New Dry Cleaning Facility (see Figure 2.3.2). Three sub-slab sample points will be installed at locations to characterize the distribution of VOCs and radon below the building foundation. Two additional sample points will be installed specifically for measurement of cross-foundation pressure gradient. Specific sample point locations will be selected to minimize the disturbance of building activities. Sample points for the collection of sub-slab gas samples will be installed by drilling a 3/8 inch hole through the building slab and into the underlying soil or fill material to a depth of 3 to 4 inches below the base of the foundation. A length of ¼ inch nylon tubing will be placed in the hole and sealed in place with a plug of Teflon tape or a combination of Teflon tape and bentonite clay, modeling clay, or wax. The end of the tube will be fitted with a compression fitting to provide an airtight attachment to the sample train and will be plugged when samples are not being collected. An example sub-slab sample point is shown in Photo 2.3.1.

Comment [EPA18]: For Site 45 VI risk assessment, specific sample locations should have been located to take into consideration location of source contaminants, building construction factors, preferential pathways, etc. as opposed to minimizing facility disruptions.

One of the two points installed for measurement of pressure gradients will be drilled to a depth of 2 ft below grade based on the building foundation using a drill bit extension or a slab bar. ¼ inch nylon tubing will be placed in the hole and sealed in place with a small amount of sand followed by a bentonite slurry. The foundation penetration will be sealed with bentonite clay, modeling clay, or wax.

Photo 2.3.1: Example Sub Slab Sample Point

Indoor Sample Points: Three indoor air sample points will be selected to characterize the distribution of VOCs, radon, and SF6 tracer gas inside the building. Specific sample points will be selected based on evaluation of building operating characteristics and will be located to minimize the disturbance of building activities.

Comment [EPA19]: Including use in various spaces? And what else?

Outdoor Sample Point: One air sample point will be selected to characterize the concentration of VOCs, radon, and SF6 tracer gas outside the building. The specific sample point will be selected at an upwind location based on evaluation of building operating characteristics and current wind direction.

Comment [EPA20]: Including location of building ventilation?

Building Envelope Pressure Gradient Measurement Points: Up to four points will be identified that can be used to measure the pressure gradient across the building envelope (i.e., ambient/indoor pressure gradient). At each measurement point, ¼ inch tubing will be installed across the building envelope to allow measurement of the pressure gradient using a portable pressure transducer.

2.4 FIELD TESTING

One round of field testing and sample collection will be conducted following installation of the sampling points. The field testing program for the validation of the Tier 2 and Tier 3 procedures is described below.

2.4.2 Field Testing for Evaluation of Tier 2 Screening Procedure

Following collection of soil gas samples (Section 2.5.1), the permeability of the vadose zone soils will be determined using a vacuum pump and flow meter. Soil gas will be extracted by applying a vacuum to the soil gas monitoring point, and the resulting flow measured using laboratory-grade flow meters. The steady state vacuum will be measured at three different flow rates at each sample point, and the soil permeability determined by the relationship between the flow rate and vacuum.

2.4.1 Field Testing of Tier 3 Evaluation Procedure

Pressure gradients across the building foundation compared to pressure gradients across the building envelope will be used to evaluate the building foundation permeability. Pressure gradients will be measured using an Omniguard 4 differential pressure transducer, which is equipped with a data logger. The pressure transducer has 2 pressure ports, a reference port open to the indoor atmosphere, and a second port that is open to the area to be measured (sub slab space or outside the building). The pressure transducer measures the pressure difference between the two ports, providing a differential pressure measurement. A photo of the pressure transducer installation is presented in Photo 2.4.1.

Comment [EPA21]: Will data be collected during which there is no artificial pressure influences (i.e. status quo for operational facility)? This would be needed for Site 45 VI assessment.

At the initiation of each testing phase (i.e., negative pressure and positive pressure), the pressure gradient will be measured at each measurement point: the three sub-slab sample collection points, the two cross-foundation pressure gradient measurement points, and the building envelope pressure gradient measurement points. Pressure gradient at each measurement location will be recorded for a period of at least one minute. During the collection of the composite samples for VOC analysis, continuous pressure gradient measurements will be recorded at one cross-foundation measurement point and one building envelope measurement point.

Comment [EPA22]: For Site 45 evaluation, a steady state status quo phase prior to any disturbance of conditions would need to be added.

Comment [EPA23]: How do you determine how much time is needed for the facility and sub-slab concentrations to recover before sampling?

Photo 2.4.1: Pressure transducer installation.

2.5 SAMPLING PLAN

2.5.1 Sampling Plan for Validation of Tier 2 Screening Procedure

Comment [EPA24]: For acceptance for Site 45 VI risk assessment, it will have to be determined if these procedures comply with EPA protocols.

Validation of the Tier 2 screening procedure will involve collection and analysis of soil samples for geotechnical analysis and groundwater and soil gas samples for analysis of VOC concentrations.

Collection and Analysis of Soil Samples: Procedures for the selection of the soil samples for geotechnical analysis are described in Section 2.3.1. Soil samples will be collected from within the vadose zone using plastic core-barrel liners in an effort to maintain the geotechnical soil sample integrity and to collect representative "in-place" soil properties as closely as possible. These liners will be immediately capped upon collection, marked with the sample identification and depth interval, and placed in a dry-ice cooler for transportation under chain-of-custody control to PST Laboratories, located in Houston, Texas. The number of samples to be collected and the analytical methods are provided in Tables 2.1.1 and 2.5.1, respectively.

Collection and Analysis of Groundwater Samples: Groundwater samples will be collected from each sample point that has become infiltrated with groundwater (this may include saturated soil gas sample points). Duplicate samples will be collected at the greater frequency of one per event or one per every ten samples. Prior to sampling, all groundwater sampling points will be gauged to determine whether groundwater has infiltrated the well and to measure the static water level. If monitoring wells yield sufficient water, they will be purged in accordance with standard low-flow purge methods. Otherwise, monitoring wells will be pumped dry using a peristaltic pump and allowed to recharge prior to the sampling event. Following purging, groundwater will be collected using the peristaltic and placed in method-specific containers, 40ml VOA vials. During the sampling event, physical properties such as temperature, specific conductance, and pH will be measured if there is sufficient volume. Groundwater samples will be placed on ice pending transport to the laboratory under chain-of-custody control within approximately 24 hours of collection. Analyses will be conducted in accordance with the appropriate EPA SW-846 methodology by STL, Inc., located in Houston, Texas. The number of samples to be collected and the analytical methods are provided in Tables 2.1.1 and 2.5.1, respectively.

Collection and Analysis of Soil Gas Samples: Soil gas samples will be collected from each sample point not containing groundwater. To ensure collection of gas from the desired sample interval, the soil gas sample points will be fitted with a packer that serves to isolate the screened interval from the riser casing (see Figure 2.3.1). 1/8th inch diameter nylaflow tubing will be connected through the packer and extend to the ground surface where it will be connected to the surface sample train. Prior to sample collection, the sample point will be purged of three sample line volumes using a 60 mL syringe.

Soil gas samples will be collected using Summa canister sample containers. Summa canisters will be attached to a sample train that incorporates a vacuum gauge and a port for purging the sample point. The sample point will be purged of 3-line volumes of gas and then the sample forwill be collected (without opening the sample train). The soil gas sample will be collected by

opening the sample train valve to the Summa canister and then opening the Summa can valve itself, ensuring all other openings on the sample train have been valved off. During sample collection the vacuum present in the Summa canister will be monitored to insure proper sample collection. When sample collection is complete, the Summa can valve will be closed and the container removed from the sample train for transport to the lab. Soil gas samples collected for off-site analysis will be transported to Columbia Analytical Services (CAS) under chain-of-custody control and will be analyzed by US EPA Method TO-15 for project specific COCs. During the sample collection procedure, a leak tracer compound (helium or SF_6) will be released into a sample shroud placed over the sample point. The concentration of this leak tracer compound in the sample will be used to evaluate leakage during sample collection.

Table 2.5.1: Analytical Methods to be used for Sample Analysis

Matrix	Analyte	Method	Container	Preservative	Holding Time
Soil	Intrinsic Permeability	API RP 40/ ASTM D2434	Undisturbed core	None	None
	Porosity, total and air-filled	API RP 40	Undisturbed core	None	None
	Dry bulk density	API RP 40/ASTM D4564/ASTM D2937	Undisturbed core	None	None
	Volumetric moisture content	ASTM DD216/ASTM D4959/ASTM D4643	Undisturbed core	None	None
	Fraction organic carbon	Walkley-Black, EPA 9060	Undisturbed core	None	None
Ground water	VOCs	US EPA 8260B	40 ml VOA vial	HCl	14 days
Vapor	Radon	Mathieu & Berelson	500 ml Tedlar bag	None	14 days*
	Chlorinated VOCs	US EPA TO-15	Summa Can	None	28 days
	SF6	NIOSH 6602	Summa Can	None	28 days

* = No holding time specified, but lab tests demonstrate accurate results after 14 days storage in Tedlar bag (McHugh et al., 2008).

2.5.2 Sampling Plan for Validation of Tier 3 Evaluation Procedure

Validation of the Tier 3 evaluation procedure will involve collection and analysis of indoor air, ambient air, and sub-slab soil gas samples under negative pressure and positive pressure building conditions.

Comment [EPA25]: See comment above pertaining to steady state status quo.

Induction of Negative and Positive Building Pressure: A negative or positive building pressure will be created by i) altering the operation of the HVAC system to ensure a net negative or positive air balance through the HVAC system or ii) using a box fan or blower to create a negative pressure or a positive pressure. The resulting pressure gradients will be recorded as described in Section 2.4. Negative and positive pressure conditions will be maintained for 12 hours prior to initiation of sample collection to allow the chemical concentrations to reach steady state.

Comment [EPA26]: Is there literature to support the 12 hours?

Measurement of Building Air Exchange Rate: A tracer gas, Sulfur Hexafluoride (SF_6), will be used to evaluate the indoor air exchange rate, the rate of air exchange between the building and ambient air. In indoor air, exchange rate will be measured by releasing SF_6 at a central location within the building and measuring steady-state SF6 concentration at each indoor air sample location after 12 or more hours. The SF6 release system is shown in Photo 2.5.1.

Photo 2.5.1: SF6 Tracer Gas Release System.

Collection and Analysis of Indoor and Ambient Air Samples: Indoor air samples will be collected at three locations. At each location, a 6L Summa canister will be used to collect an 8 hour composite sample for analysis of VOCs and SF6. A tedlar bag will be used to collect a grab sample for radon analysis. This sample collection plan will be implemented twice, once during the negative pressure event and once during the positive pressure event.

An ambient air sample will be collected outside of the test building, upwind of the building, to serve as an ambient background sample. One sample 8-hour composite will be collected for VOC analysis by US EPA method TO-15 using a 6L Summa canister, and one grab sample will be collected using a tedlar bag for radon analysis. Laboratory analysis of ambient air samples may identify compounds associated with on-going site activities. Laboratory analyses will be used in conjunction with field observations of site activities to identify likely background sources of VOCs.

Collection and Analysis of Sub-Slab Gas Samples: Three each sub slab sampling points will be sampled during the two sampling events, a negative building pressure and positive building pressure. At each location, a 6L Summa canister will be used to collect an 8 hour composite sample for analysis of VOCs and SF6. A tedlar bag will be used to collect a grab sample for radon analysis. The number of samples to be collected and the analytical methods are provided in Tables 2.1.2 and 2.5.1, respectively.

2.5.3 Quality Assurance Procedures

Comment [EPA28]: For acceptance for Site 45 VI risk assessment, it will have to be determined if these procedures comply with EPA protocols.

The integrity of the data generated by this investigation will be maintained by adherence to a Quality Assurance Project Plan (QAPP) prepared for this investigation. The QAPP identifies the requirements we feel are necessary to obtain high quality data and includes requirements for QA/QC sampling, detection limits, methods, and field and laboratory performance. In addition to the information provided in the QAPP, the following quality assurance procedures will be followed.

- *Calibration of Analytical Equipment.* The majority of project data will be generated by fixed analytical laboratories with acceptable quality control programs to assure proper operation of analytical equipment. Measurement of groundwater physical properties (pH, temperature, conductivity) will be performed using a handheld meter that is properly calibrated before use. The differential pressure transducer used to measure the pressure difference between indoor and subslab pressures does not require calibration. A field helium meter used to evaluate sample points for leaks will be calibrated per the manufacturer's instructions prior to use.
- *Quality Assurance Sampling.* General quality assurance guidelines of a minimum of one duplicate sample per ten samples collected will be followed for all groundwater, soil gas, sub slab vapor, and indoor air. If less than 10 samples are collected then at least one duplicate sample will be collected from each matrix. A field blank sample will be collected to demonstrate appropriate sampling techniques for groundwater, and trip blanks will accompany all groundwater samples submitted for laboratory analysis.
- *Decontamination Procedures.* During the well installation process, all down-hole boring equipment will be decontaminated using water and a suitable detergent to avoid transferring contaminants between borings. All sampling equipment will be single-use, disposable material (tubing, sample containers). Re-used vapor sample point materials (compression fittings, sample tubing) are flushed/purged before samples are collected. Sample containers used for collection of indoor and ambient vapor samples (Summa canisters) will be required to be individually certified clean by the lab that provides them to prevent any contamination from previous samples. Samples collected for radon analysis will be collected using single use Tedlar sample bags.
- *Sample Documentation.* Field documentation is facilitated by pre-printed tables, labels, and logs that allows precise notation of sample collection and field conditions. Samples are identified using pre-determined sample IDs that are consistent between site locations and conducive to assembly of data into databases. Sample labels will be prepared prior to the field investigation to minimize errors and keep sample collection orderly. Data collected during the sampling events is recorded on pre-printed data sheets developed specifically for this application. Pressure readings collected on the differential pressure transducer is logged by the instrument and then later downloaded as an electronic data file. All samples submitted for laboratory analysis will be submitted under chain-of-custody control and all laboratory reports will include a narrative that discusses any quality control excursions. Photographic documentation of the project activities will be collected throughout the project for inclusion in the final report.

2.6 DATA ANALYSES AND REPORTING

Following completion of the sampling and analysis program at Site 45, the data will be reviewed and analyzed to determine whether the QA/QC criteria have been achieved. We will provide data transmittal package to site personnel that includes i) a brief description of the investigation results, summary tables and figures, and iii) copies of laboratory data packages. Following completion of the first 8 (out of 16) field demonstrations, we will prepare detailed report documenting the results of these investigations. This initial report is expected to be complete by October 2009. A copy of this report will be provided to personnel of all of the demonstration sites for review and comment.

Comment [EPA29]: Copy EPA and DHEC for consideration of data use.

3.0 MANAGEMENT AND STAFFING

The duties and responsibilities of GSI personnel are described below. A diagram of the project management hierarchy is presented in Figure 3.1.

GSI Principal Investigator: The GSI Principal Investigator (PI, Thomas McHugh) will be responsible for implementing the project. The primary function of the PI will be to ensure that technical, financial, and scheduling objectives are achieved. The PI, supported by the GSI Project Manager and other GSI personnel will:

- Define project objectives and develop a detailed demonstration plan schedule;
- Establish project policy and procedures to address the specific needs of the project;
- Acquire and apply resources as needed to ensure performance within budget and schedule constraints;
- Orient field personnel and support staff to the project's special considerations;
- Review the work performed on each task to ensure quality, responsiveness, and timeliness;
- Review and analyze work performed relative to planned requirements and authorizations;
- Approve reports and deliverables before submittal to ESTCP;
- Retain ultimate responsibility for preparation and quality of interim and final reports; and
- Represent the project team at meetings.

GSI Health and Safety Officer: The GSI Health and Safety Officer will be responsible for overall health and safety practices associated with the field work. Specific functions and duties will include the following tasks:

- Establish the requirements of the project Health and Safety Plan (HASP);
- Arrange or conduct audits of field activities to ensure that proper health and safety procedures are being used;
- Communicate with the PI, GSI Technical Staff, and GSI Field Technical Staff concerning project issues related to health and safety.

GSI QA Manager: The GSI QA Manager will report directly to the PI and will be responsible for reviewing QA documentation to evaluate compliance with sampling and analytical procedures.

GSI Technical Staff: The GSI Technical Staff will assist the PI in field activities such as collecting soil samples and soil cores, performing field analyses, and recording field measurements and office activities such as data review and report development. GSI Technical Staff will be familiar with relevant project reports and plans including the Demonstration Plan, the QAPP, and the Health and Safety Plan.

Federal and State Performers

Samuel Brock, Ph.D., CIH. Dr. Brock is a senior scientist with the Environmental Restoration Directorate at the Air Force Center for Environmental Excellence (AFCEE). For this work, AFCEE will provide technical support, including support on site selection. *Phone: 210 536-3253; email: Samuel.Brock@brooks.af.mil.*

William Morris. Mr. Morris is the designated point of contact for vapor intrusion issues at the Kansas Department of Health and Environment. He will be involved in the planning and peer review of the study and will help identify candidate sites for the field demonstration. *Phone: 785 296-8425; email: bmorris@kdhe.state.ks.us.*

Robert Patton Mr. Patton is a Project Manager in the Remediation Division of the Texas Commission on Environmental Quality. He will be involved in the planning and peer review of the study and will help identify candidate sites for the field demonstration. *Phone: 512 239-2277; email: rpatton@tceq.state.tx.us.*

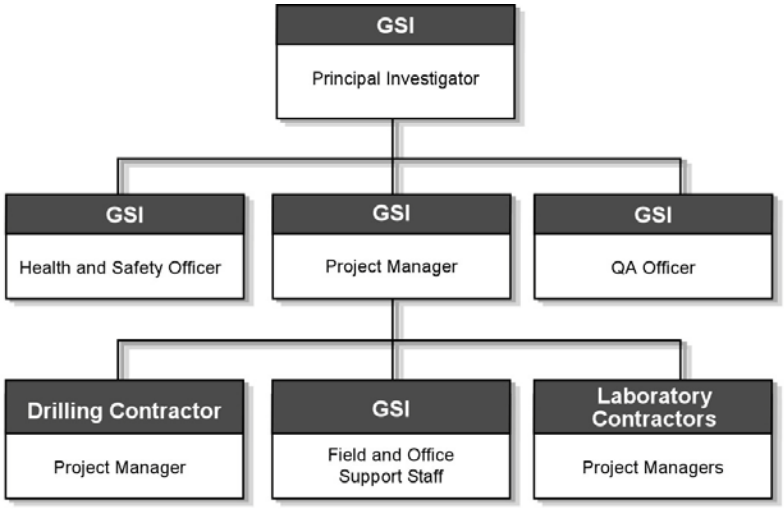


Figure 3.1: Wire Diagram of Project Management

4.0 REFERENCES

GSI Environmental, 2008a. ER-0707 Project Report: Proposed Tier 2 Screening Criteria and Tier 3 Field Procedures for Evaluation of Vapor Intrusion, Issued February 1, 2008.

GSI Environmental, 2008b. ER-0707 Demonstration Plant: Proposed Tier 2 Screening Criteria and Tier 3 Field Procedures for Evaluation of Vapor Intrusion Version 2, Issued October 24, 2008.

McHugh T.E., Hammond, D.E., Nickels, T., Hartman, B. *Use of Radon Measurements for Evaluation of VOC Vapor Intrusion*. Environmental Forensics, Vol. 9 No. 1, March 2008

Schuver, H. *Background of the Vapor Intrusion Pathway & Status of USEPA's Guidance.* 2005. STL Technical Guidance for Indoor Air Vapor Intrusion, Alamo, CA.