VAPOR INTRUSION FIELD INVESTIGATION AND MITIGATION WORK PLAN

FOR AN OFF-SITE RESIDENTIAL AREA NEAR THE LIVONIA ECKLES ROAD SITE LIVONIA, MICHIGAN

Prepared for

RACER Trust

April 2, 2012

Prepared by

Hamp, Mathews & Associates, Inc.
Bath, Michigan

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

A compact disk with Adobe Acrobat file of this complete report provided behind appendices.

Vapor Intrusion Field Investigation and Mitigation Work Plan
For an Off-Site Residential Area Near the Livonia Eckles Road Site
Livonia, Michigan

1. INTRODUCTION

Revitalizing Auto Communities Environmental Response Trust (RACER) contracted Hamp, Mathews and Associates, Inc. (HMA) to develop and implement a series of field investigation activities to evaluate the potential for vapor intrusion (VI) of subsurface chlorinated volatile organic compounds (CVOCs) to indoor air at residential homes southeast of the Livonia Eckles Road Site in Livonia, Michigan. The location of the Eckles Road Site and off-site residential area where VI field investigation activities will be conducted is depicted on Figure 1. A vapor mitigation decision matrix is also provided to describe the data evaluation process that will be used to identify the homes where vapor mitigation is necessary.

2. SITE BACKGROUND

The Livonia Eckles Road site was operated by General Motors ("GM") from 1953 until the buildings were removed in 2001. As part of an ongoing environmental investigation in 2003, GM conducted a survey of the adjoining residential community, southeast of the site (Figure 1), to determine which homes are built on basements, slabs, and crawlspaces. In addition, GM installed monitoring wells in the community to monitor groundwater quality. A number of local residents have been provided annual reports on the groundwater monitoring activities since 2003.

When GM filed for bankruptcy in June 2009, Motors Liquidation Company ("MLC") became the owner and manager of the site. As a result, MLC conducted the required groundwater monitoring in 2009 and 2010. The RACER Trust was formed by the New York Bankruptcy Court (as part of the GM bankruptcy process) and ownership of the site was transferred to the newly created RACER Trust on March 31, 2011. RACER Trust now owns the site and is responsible for completing the remedial work including monitoring the migration of CVOCs in groundwater.

The U.S. Environmental Protection Agency's (USEPA) understanding of the potential for vapors to migrate as soil gas from contaminated groundwater to indoor air has been evolving over the past several years. USEPA has carefully reviewed prior site VI modeling studies to confirm the results and to re-affirm the prior remedial conclusions. At the end of 2011, USEPA looked at the early risk assessments previously prepared for the Livonia Eckles Road Site and has questioned whether relying on calculations and computer models is the best way to determine the extent and magnitude of soil vapor intrusion of CVOCs into homes near and overlying the contaminated groundwater.

Because of USEPA's recent and evolving concern about the use of calculations and computer models, USEPA has asked RACER Trust to conduct a VI field investigation at 17 residential homes which have received notice of migration letters (September, 2003), as their properties overly the currently understood extent of the groundwater plume containing CVOCs. USEPA requested submittal of a sampling plan for the collection and analysis of soil gas and indoor air samples at each home, and the process for determining those homes that require vapor mitigation.

3. FIELD INVESTIGATION SAMPLING PLAN

The purpose of the VI field investigation is to determine if vapor intrusion of CVOCs from contaminated groundwater poses an unacceptable indoor air risk to residences at each of the 17 homes identified for this investigation. The 17 properties that are included in this VI field investigation are shown in Figure 2. As stated previously, 17 homes are included in this investigation based on their receipt of notice of migration letters because CVOCs have been detected in groundwater beneath their properties. The sample results from the VI investigation will also be evaluated with regard to the spatial and temporal distribution of CVOC concentrations to determine if additional homes should be evaluated for VI risk.

Figure 2 also illustrates the approximate extent of the groundwater plume in relation to the 17 properties based on past and recent groundwater sample results for trichloroethene (TCE) at 5 ug/L (USEPA Maximum Contaminant Level - MCL). The plume extent is based on TCE because it is the CVOC of greatest health risk. Groundwater flow direction from the site is southeast, and the depth to groundwater varies from 6 to 10 feet below ground surface along the length of the plume based on monitoring well data collected from 2005 to 2011. The soils above the groundwater table are predominantly sandy.

Seven homes will be addressed in the first VI investigation and the remaining 10 homes in a second investigation. The homeowners at the 17 properties will be requested, via a process outlined below, to sign an access agreement allowing RACER Trust, and their consultants (and USEPA as needed), to have access to their home and property to collect soil gas and indoor air samples[1] to determine if vapor mitigation is necessary.

Access Agreement Process

1. Letter sent to 17 homeowners requesting access for sampling.

2. Phone call to each homeowner to answer questions, and set appointment for home visit.

3. First home visit: explain sampling plan, obtain access agreement, and schedule second visit to conduct an indoor air household source survey and identify sample locations acceptable to the homeowner.

[1] Crawlspace air samples, instead of indoor air samples, will be collected at crawlspace homes.

4. Second home visit: complete the household survey, and installation of near-slab soil gas ports for crawlspace homes.

Only those homeowners that sign access agreements will be sampled.

The 7 homes included in the first VI investigation are identified in Figure 2 by numbering on the homes – 1 through 7, and similarly for homes sampled in the second investigation, they are numbered 8 through 17. The type of VI samples to be collected depends on the type of house construction: slab, crawlspace, or basement, as shown in Table 1. Only one near-slab soil gas sample is proposed for crawlspace and slab homes as the variability among soil gas concentrations will initially be evaluated among the 7 first investigation group of homes along the plume. Additionally, variability in concentrations is not expected to be significant due to the continuous presence of sandy soils in the vadose zone throughout the off-site area. If significant variability in CVOC concentrations is observed, an additional near-slab soil gas sample will be obtained from the crawlspace homes in the first investigation group. Ambient (outdoor) air samples will be collected at locations depicted in Figure 2, and identified in Table 1. Ambient air sample results will be used to determine whether indoor air detections of CVOCs may be associated with ambient air intrusion to indoor air.

The standard operating procedures (SOPs) for each sample type – sub-slab soil gas, near-slab soil gas, indoor air (including crawlspace air), ambient air, and sump water – are presented in Appendix A. The SOPs for sub-slab soil gas, and indoor and ambient air sampling and analysis are based on USEPA approved SOPs 20, 21 and 22 for the USEPA Moraine, Ohio site, with modifications as documented in a memo from HMA to RACER. An SOP for the installation, collection and analysis of near-slab soil gas samples, as well as an SOP for sump water sample collection were developed by HMA and are also provided in Appendix A. A *Quality Control Document* (QCD) is provided in Appendix B to assure the collection of representative field samples and the accurate reporting of sample quality to generate reliable data to support VI mitigation decisions.

As indicated in Table 1, two sampling events/rounds are planned for each investigation. The need for a second (confirmation) sampling event will depend on whether sample concentrations of the CVOCs of concern exceed residential soil gas and/or indoor air VI screening levels (Table 2). The CVOCs of concern for the VI investigation are the same chlorinated VOCs detected in groundwater, and their known degradation products. The sub-slab/near-slab soil gas and indoor air VI screening levels for this site are based on USEPA's "Regional Screening Levels for Chemical Contaminants at Superfund Sites" (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm). The USEPA soil gas screening levels presented in Table 2 are calculated by dividing the indoor air screening level by the USEPA default soil gas to indoor air attenuation factor of 0.1.

4. DATA INTERPRETATION AND MITIGATION DECISION PROCESS

A flowchart, presented in Figure 3, explains the process that will be used for comparing the sample results to determine if vapor mitigation is necessary or if a second sampling event is needed for making this decision. RACER will explain the first sample test results at a follow-up meeting with each resident, and discuss whether a second sampling event is necessary, or whether a vapor mitigation system is needed.

If the results from the first sampling event for each investigation support vapor mitigation, RACER will request an access agreement for installation of a mitigation system. The homeowner will be offered an activated carbon-based air purifier (www.allerair.com/air-purifiers/air-purifiers-5000-vocarb.html) until a vapor mitigation system is installed and operating in their home.

The mitigation system will depend on the structure of the home and will include a depressurization system that creates a vacuum below the foundation of the structure or beneath a membrane that is installed into a dirt floored structure, or a ventilation system for crawlspaces. Electric-powered fans will be used in depressurization systems. For crawlspace ventilation systems, wind-driven turbines may be used to ventilate crawlspaces that are not accessible, separate from the living space, and where soil gas or crawlspace air VOC concentrations are not significantly (i.e., 10 times or more) greater than the USEPA VI screening levels; otherwise, electric-powered fans will be used in the crawlspace ventilation systems. Sealing of the foundations to eliminate potential pathways for soil vapors to enter the building is also a component of each mitigation system.

A unique vapor mitigation system work plan will be prepared for each property to present the design of the mitigation system. As part of the design, a visual survey and vacuum testing will be completed at each property and the property owner will be consulted for preference on equipment installation locations. The work plan will specify the location and components of the mitigation system. The Inspection and Mitigation System Design SOP (SOP 23 in Appendix C) provides the details of this step. A property-specific work plan template is included in Appendix C.

A licensed radon contractor will install the mitigation systems in compliance with all local codes and under the supervision of RACER's consultant. The system installation SOP (SOP 24) is provided in Appendix C.

RACER's consultant will inspect the system installation and verify the vacuum under the foundation, where applicable, at permanent sub-slab sampling points. The property owner will be provided with as built documentation, an Operation and Maintenance (O&M) Manual, a demonstration on how to verify that the system is operating, and contact numbers to report any operational problems or questions. The property owner will be asked to sign a form verifying that they have received the O&M Manual. The contents of the O&M Manual are identified in Appendix D.

Post-installation proficiency sampling (PIPS) of indoor air (first floor, basement and crawlspace air) will be conducted approximately 30, 180 and 360 days after system installation. The PIPS

will also include vacuum measurements for those systems that include a depressurization system. PIPS is described in detail in SOP 25 (Appendix C).

Appendix E also includes a longer-term O&M plan and a Construction Quality Assurance Plan that addresses the mitigation system installations.

TABLE 1

SUMMARY OF VAPOR INTRUSION FIELD SAMPLES AND QA/QC SAMPLES
LIVONIA ECKLES ROAD SITE

INVESTIGATION GROUP	HOME IDENTIFICATION NUMBER	HOUSE CONSTRUCTION	SAMPLE TYPE/MATRIX	NUMBER OF SAMPLES	QA/QC SAMPLES
1	1	Basement	Basement Indoor Air	1	Ambient Air
			First Floor Indoor Air	1	
			Sub-Slab Soil Gas	2	
	2	Crawlspace, Basement, Sump [1]	Crawlspace Air	1	
			Basement Indoor Air	1	Co-Located
			First Floor Air	1	
			Sub-Slab Soil Gas	1	
			Sump Water	1	
	3	Crawlspace	Crawlspace Air	1	
			First Floor Indoor Air	1	
			Near-Slab Soil Gas	1	
	4	Crawlspace	Crawlspace Air	1	Ambient Air
			First Floor Indoor Air	1	
			Near-Slab Soil Gas	1	
	5	Crawlspace	Crawlspace Air	1	
			First Floor Indoor Air	1	Co-Located
			Near-Slab Soil Gas	1	
	6	Crawlspace	Crawlspace Air	1	
			First Floor Indoor Air	1	
			Near-Slab Soil Gas	1	
	7	Basement	Basement Indoor Air	1	Ambient Air
			First Floor Indoor Air	1	
			Sub-Slab Soil Gas	2	Co-Located

[1] The basement at home 2 is approximately 8 feet by 8 feet on the southwest corner of the house, and contains a furnace and water heater. A crawlspace is present *along the outer perimeter of this space*; i.e., the crawlspace does not extend beneath the footprint of the house, only the outer edge of the 8 feet by 8 feet basement space. Consequently, one sub-slab soil gas port is adequate to evaluate the soil gas under this basement. The "sump" is merely a drain hole, and will be sampled if water is present.

"Co-Located" indicates that an additional (duplicate) sample will be collected at the same location.

TABLE 1 Continued

SUMMARY OF VAPOR INTRUSION FIELD SAMPLES AND QA/QC SAMPLES
LIVONIA ECKLES ROAD SITE

INVESTIGATION GROUP	HOME IDENTIFICATION NUMBER	HOUSE CONSTRUCTION	SAMPLE TYPE/MATRIX	NUMBER OF SAMPLES	QA/QC SAMPLES
2	8	Basement	Basement Indoor Air	1	Ambient Air
			First Floor Indoor Air	1	Co-Located
			Sub-Slab Soil Gas	2	
	9	Slab	First Floor Indoor Air	1	
			Sub-Slab Soil Gas	2	
	10	Slab	First Floor Indoor Air	1	Ambient Air
			Sub-Slab Soil Gas	2	
	11	Basement	Basement Indoor Air	1	Co-Located
			First Floor Indoor Air	1	
			Sub-Slab Soil Gas	2	
	12	Crawlspace	Crawlspace Air	1	
			First Floor Indoor Air	1	
			Near-Slab Soil Gas	1	
	13	Basement	Basement Indoor Air	1	Ambient Air
			First Floor Indoor Air	1	
			Sub-Slab Soil Gas	2	Co-Located
	14	Crawlspace	Crawlspace Air	1	
			First Floor Indoor Air	1	
			Near-Slab Soil Gas	1	
	15	Crawlspace	Crawlspace Air	1	
			First Floor Indoor Air	1	Co-Located
			Near-Slab Soil Gas	1	
	16	Basement	Basement Indoor Air	1	Ambient Air
			First Floor Indoor Air	1	
			Sub-Slab Soil Gas	2	Co-Located
	17	Crawlspace	Crawlspace Air	1	
			First Floor Indoor Air	1	
			Near-Slab Soil Gas	1	

TABLE 2

RESIDENTIAL VAPOR INTRUSION SCREENING LEVELS
LIVONIA ECKLES ROAD SITE (LIVONIA, MICHIGAN)

CHEMICAL	CAS NUMBER	VAPOR INTRUSION SCREENING LEVELS ($\mu g/m^3$)	
		INDOOR/CRAWLSPACE AIR[1]	SUB-SLAB/NEAR-SLAB SOIL GAS[2]
Chloroethane	75-00-3	10,000	100,000
1,1-Dichloroethane	75-34-3	15	150
1,1-Dichloroethene	75-35-4	210	2,100
cis-1,2-Dichloroethene	156-59-2	None Listed[3]	None Listed[3]
trans-1,2-Dichloroethene	156-60-5	63	630
1,1,1-Trichloroethane	71-55-6	5,200	52,000
Trichloroethene	79-01-6	2.1	21
Vinyl Chloride	75-01-4	1.6	16

[1] Indoor/Crawlspace air screening levels are the U.S. Environmental Protection Agency (USEPA) "Regional Screening Levels for Chemical Contaminants at Superfund Sites" (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm), except where noted.

[2] Soil gas screening levels are calculated by dividing the indoor air screening level by the USEPA default soil gas to indoor air attenuation factor of 0.1.

[3] The MDEQ residential acceptable indoor air concentration is 36 $\mu g/m^3$. Using the USEPA default soil gas to indoor air attenuation factor of 0.1, the soil gas screening level would be 360 $\mu g/m^3$.

HAMP, MATHEWS & ASSOCIATES, INC.

RACER TRUST
LIVONIA ECKLES ROAD SITE
LIVONIA, MICHIGAN

FIGURE 1
SITE LOCATION

DRAWN BY:	DATE:	PROJECT:	DRAWING ID:
CPB	February 2012	41-1	Michgan Map.dwg

N
W E
S

LEGEND

- PROPERTY BOUNDARY
- APPROXIMATE TRICHLOROETHENE (TCE) GROUNDWATER PLUME OUTLINE
- INVESTIGATION GROUP 1
- INVESTIGATION GROUP 2

S — SLAB
- 2 Sub-Slab Soil Gas Ports
- 1 Indoor Air

B — BASEMENT
- 2 Sub-Slab Soil Gas Ports
- 1 Basement Indoor Air

C — CRAWLSPACE
- 1 Near-Slab Soil Gas Port
- 1 Crawlspace Indoor Air

B/C — BASEMENT AND CRAWLSPACE
- 1 Sub-Slab Soil Gas Port
- 1 Basement Indoor Air
- 1 Crawlspace Indoor Air
- 1 Sump Water

- AMBIENT AIR SAMPLE LOCATION
- MONITORING WELL LOCATION

0 75 150
SCALE (Feet)

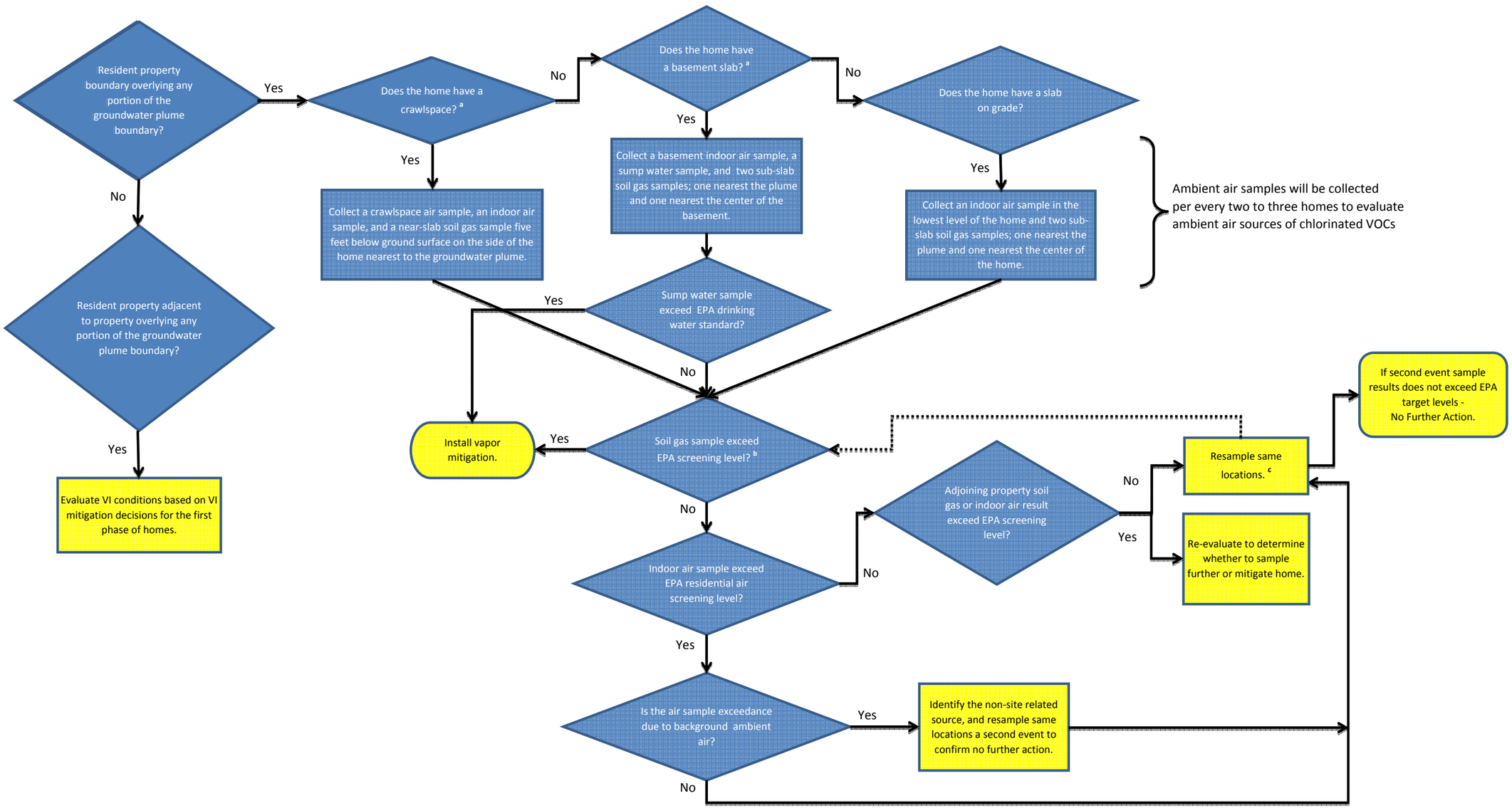
HAMP, MATHEWS & ASSOCIATES, INC.

RACER TRUST
LIVONIA ECKLES ROAD SITE
LIVONIA, MICHIGAN

FIGURE 2
RESIDENTIAL HOMES FOR VAPOR INTRUSION FIELD INVESTIGATION

DRAWN BY:	DATE:	PROJECT:	DRAWING ID:
CPB	February 2012	41-1	Racer Trust Base Map.dwg

Vapor Intrusion Investigation and Mitigation Decision Flow Chart - Livonia Eckles Road Site



Footnotes:

[a] The sampling plan for the home with a crawlspace and basement will include one sub-slab soil gas sample, and one basement indoor air and one crawlspace air sample.

[b] EPA soil gas screening level is 10 times the EPA residential air screening level (see Table 2).

[c] Upon obtaining results from two sampling events at each home that do not exceed EPA soil gas or indoor air screening levels, no further action is needed.

HAMP, MATHEWS & ASSOCIATES, INC.

DRAWN BY: J. Crum

DATE: February 2012

RACER TRUST
LIVONIA ECKLES ROAD SITE
LIVONIA, MICHIGAN

FIGURE 3

Appendix A

Standard Operating Procedures

Hamp, Mathews &
Associates, Inc.

NEAR SLAB SOIL GAS PORT INSTALLATION AND SAMPLING STANDARD OPERATING PROCEDURE

RACER Trust
Eckles Road Site, Livonia, Michigan

HAMP, MATHEWS AND ASSOCIATES, INC.

January 13, 2012

Introduction

Site conditions, such as limited accessibility, frequently dictate the need to sample soil gas around the exterior of buildings rather than through sub-slab or other port setups inside a building. This standard operating procedure (SOP) describes the typical installation and soil gas collection of volatile organic compounds (VOCs) from near-slab soil gas ports.

Personnel and Health and Safety Considerations

Field personnel shall review the project health and safety plan and this SOP prior to mobilization to the site. Field personnel are expected to receive a briefing from the project manager or supervisor to discuss the scope of the work and project objectives. The briefing shall also encompass known or suspected constituents of concern, physical hazards, and site conditions.

HMA field personnel are provided with up to date HAZWOPER refresher courses, hazard communication, first aid, and cardiopulmonary resuscitation (CPR) training.

Utilities

During any subsurface work, all members of the project team are to consider the likelihood of utilities both overhead and below ground level. Overhead utilities are usually wires associated with telephone, television, and electrical services. These wires may also be located in the subsurface. Other subsurface utilities may include water supply; natural gas, propane, or other fuels; sewer; drain tiles or piping; irrigation system lines; and electric supply to outbuildings, signs, or lighting.

The use of tools for drilling or boring shall maintain a minimum of 10 feet of clearance from any overhead wires. Keep in mind that this 10-foot distance is required through the advancement and retraction of tools from a borehole. For instance, when removing a hand auger from the borehole to empty the bucket, do not raise the handle near overhead wires.

For each property, call MISS DIG System Inc. (800-482-7171) to request utility marking a minimum of three days prior to planned field work. Information requested by MISS DIG or other service is the property address and nearest cross road. Describe the location on the property where subsurface work will be performed or if the entire property is to be marked.

Utility locating services will mark individual lines or leads up to the structure, but secondary lines leading out from the building will not likely be marked by these services. The field supervisor shall inquire with the property owner or representative to gain knowledge of any subsurface utilities which may be in the proximity of the field activities.

Equipment

The equipment necessary to install near-slab soil gas ports may vary depending on the site conditions and project requirements. Field personnel shall review and prepare necessary equipment and additional equipment and supplies to support a change in work scope if it is dictated at the site.

For the Eckles Road project, only a few near-slab soil gas ports are expected to be installed at one time. As a result, a hand auger is planned to be used to create a borehole in which to install the port. Subsurface obstructions, rocks, or very tight soils may preclude boring with a hand auger. If difficult drilling conditions exist, alternate methods (e.g., hydraulic soil probe, auger bit driven by an electric hammer drill) to create a borehole may need to be employed.

Typical equipment will include the following items:

- Field notebook;
- Site map;
- Blank boring log pages;
- Personal protective equipment (PPE) appropriate to the site;
- Coring machine, if surface pavement is present (rental);
- Spud bar;
- Hand shovel;
- 2-inch hand auger with extensions;
- Plastic sheeting;
- Photo-ionization detector (PID);
- 1½-inch PVC pipe, 6 feet long;
- Tape measure;
- 6-inch long by 0.5-inch outside diameter stainless steel mesh implant;
- ¼-inch Teflon® tubing;
- ¼-inch valve (brass or stainless steel with compression fittings);
- Coarse well-pack sand;
- Fine granular bentonite clay;
- Distilled water;
- Powdered bentonite and water to mix a slurry;
- Nitrile gloves;
- Work gloves;
- Aluminum flush mount or PVC cap; and
- Redi-mix concrete.

Near-Slab Soil Gas Port Installation

The location and depth of the soil gas port is to be directed by the project manager. Field personnel are to examine marked utilities and consider other unmarked subsurface utilities that may be near the location of the soil gas port. Examine clearance from overhead wires.

If surface pavement is present, set up the coring machine and bore through the pavement. Generally, a 6-inch diameter hole is needed to install a flush-mount cover. Water is necessary to lubricate and cool the core bit. Stop the coring machine once the pavement has been fully penetrated.

If no surface pavement is present, remove landscaping or surface cover. Cut and fold back any landscaping fabric.

Lay plastic sheeting on the surface to cover an area of about 4 feet by 4 feet. Cut an opening in the plastic at the soil gas port location. Advance the hand auger 6 inches at a time. Empty the hand auger bucket onto the plastic sheeting, and describe the soil cuttings on the boring log. If required in the scope of work, take a reading with the PID and record on the boring log. Continue to advance the hand auger to the desired depth. Note soil moisture conditions. If very moist or wet soils are encountered, the depth of soil gas port installation may have to be adjusted. Discuss this with the project manager.

Measure the depth of the hole with the tape measure. Insert the PVC pipe to the bottom of the borehole. Assemble the stainless steel implant onto the tubing and lower to the bottom of the hole through the PVC pipe. Add filter sand inside the pipe until 2 to 3 inches above the implant. Continually raise the pipe and lightly tamp the sand to compact around the implant. Take measurements as needed to assure the sand pack is correct and to record the final depth. The PVC pipe can be removed at this point, or if desired used in the next step.

Pour 8 to 12 inches of dry granular bentonite into the borehole and hydrate with a small amount of distilled water every 3 to 4 inches. Mix powdered bentonite with water in a bucket to create a thick slurry. Take caution that the slurry mix is not too thin that it will pass through the fine granular bentonite. The slurry should have a consistency such that it is slow to pour. Backfill the boring to one-foot below ground level.

Cut the Teflon® tubing to length just below ground level. Affix a brass or stainless steel valve with compression fittings to the top of the tubing. Record the depth intervals of the sand pack, implant, and bentonite on the boring log and/or field notebook.

The surface completion will be determined by the project manager. Generally, for permanent soil gas ports or installations through a paved surface, an aluminum flush mount will be installed. The aluminum flush mount is to be cemented in place. For a temporary installation, a PVC cap can be placed over the soil gas port and pressed slightly into the soil. Restore the surface to

original conditions as closely as possible. Clean the surface as needed. Disposal of excess soil will be directed by the project manager.

Take measurements of the soil gas port location in relationship to physical features (e.g., corner of the building, distance from building, sidewalks, and driveways). Record these measurements in the field notebook.

Allow a minimum of 24 hours for the soil gas port to equalize with the surrounding soil before testing or collecting any soil gas samples.

Soil Gas Sampling Equipment

Soil gas sampling from near-slab soil gas ports will typically follow the procedures of indoor sub-slab soil gas ports, including the use of a helium tracer gas test for possible leakage in the sample train and/or annulus of the borehole. Field equipment includes:

- Helium tracer gas equipment (See SOP 21);
- Appropriate sample tubing and air-tight connections;
- 1-liter stainless steel SUMMA® canisters;
- Flow regulator and gauges;
- Digital vacuum gauge;
- Portable pump;
- PID;
- Field notebook;
- Chain of custody;
- Nitrile gloves; and
- Hand tools – open-end wrench, pliers, Channel Lock® pliers, etc.

Soil Gas Sample Collection

Record the weather conditions, and the time, in the field notebook. Note the temperature, precipitation, if precipitation had occurred in the past 24 hours, likelihood of frozen ground, and damage or suspected changes to the surface completion. If water is apparent in the soil gas port during sampling, note this in the field notebook and postpone sampling as directed by the project manager.

Check all SUMMA® canisters for correct vacuum. The vacuum gauges provided by the analytical laboratory are used to check the initial and final vacuums in the canisters. Pre-sampling vacuum should be in the range of -30 and -25 inches of mercury. Canisters with vacuums outside the range will be replaced with a new canister, and the new canister checked as described.

The sampling equipment will be assembled generally as shown in Figure 1. The lung box is optional. A "shut-in" test prior to purging each sampling point will be conducted to verify the integrity of all above ground sampling equipment. Valves V-1 and V-3 will be closed (valves V-2 and V-4 open) and then a portable pump/lung box and Tedlar® bag will be used to exert a vacuum on the sampling train (80 - 100 inches of water [in-H_2O]). Valve V-2 will then be closed and the vacuum observed for at least 60 seconds to ensure it does not dissipate. Occasionally, the gauge may stick at one location. Lightly tap the gauge to see if it moves. If the test indicates a leak, the connections should be disconnected and carefully reconnected one at a time until the leak is fixed. The leak test must be repeated until all leaks have been fixed.

Open the valve at the top of the soil gas port. Follow ARCADIS "SOP 21, Administering Helium Tracer Gas." This procedure will also purge the sample train tubing.

Following the successful completion of the tracer gas test, open the SUMMA® canister valve to collect the soil gas sample. Record the start time. Monitor the pressure gauge. Close the SUMMA® canister valve when a negative pressure of about 3 inches of mercury is observed. Record the ending time and pressure reading with the digital vacuum gauge.

Remove the flow regulator. Replace and tighten SUMMA® canister plugs. Fill out the sample label on the canister, and record the sample on the chain of custody. Complete other forms provided by the laboratory. Replace the SUMMA® canister in the package provided by the laboratory.

Close the soil gas port valve and replace the flush-mount cover or PVC cap.

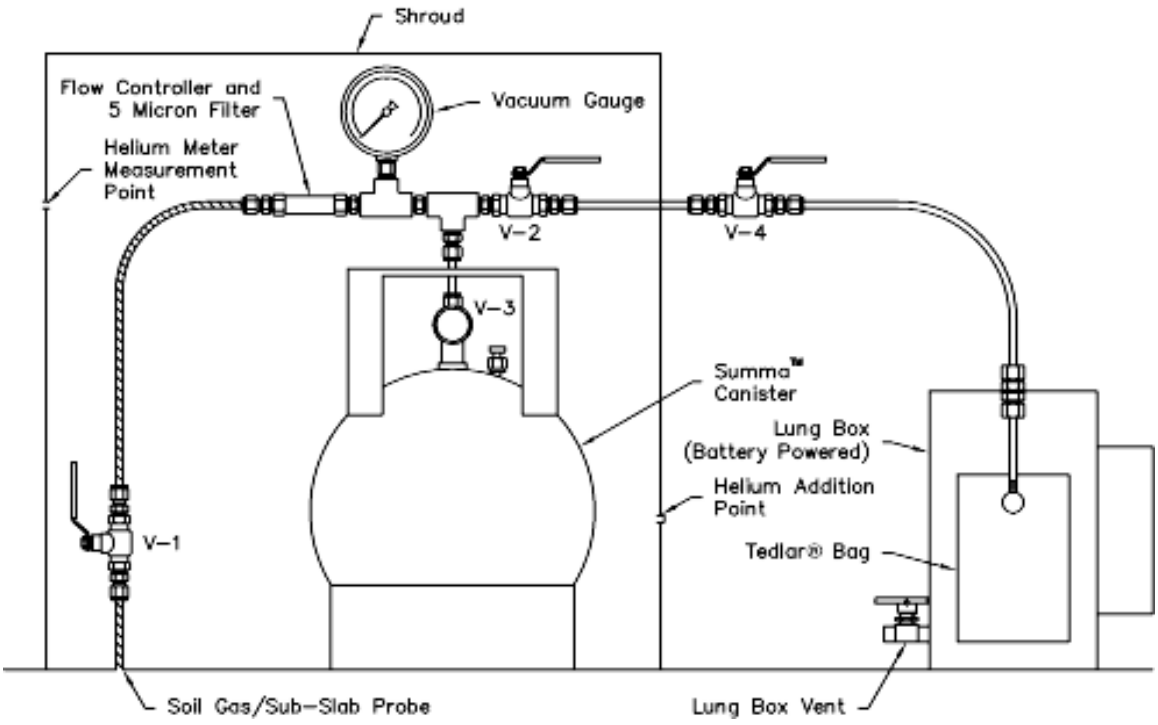


Figure 1. Soil gas sample assembly.

SUMP WATER SAMPLING
STANDARD OPERATING PROCEDURE

RACER Trust
Eckles Road, Livonia, Michigan

HAMP, MATHEWS AND ASSOCIATES, INC.

January 27, 2012

Introduction

Groundwater entering a basement sump may carry chemicals which can volatilize to indoor air. Specific to the RACER Trust Livonia Eckles Road site, shallow groundwater impact has been defined to extend under a residential community. Therefore, sump water may present an exposure risk to residents within a house with a sump. Sump water sampling is needed to determine if impacted water is entering a house(s).

Sump Water Sampling Equipment

The equipment necessary for sampling sump water includes:

- Stiff wire with a hooked end,
- Disposable bailer,
- Laboratory supplied, acid-preserved, 40-ml glass vials with septum lids,
- Cooler with ice,
- Nitrile gloves,
- Field notebook, and
- Chain of custody.

Sump Water Sample Collection

To collect a representative sample of water entering the sump of a house, the following procedures are to be followed:

- Record the residential address and time of sample collection in the field notebook. Take additional notes as needed to document the sample collection.
- Don nitrile gloves.
- Activate the sump to draw in water from the sub-slab piping. Usually, the pump will be activated by a float switch. Using the wire with a hooked end, lift the float until the pump activates. Lower and release the float when the water level in the sump reaches its lowest level.
- Allow water to enter the sump through the attached piping to the original level. If water does not enter the sump, state this in the notebook, and proceed with sampling.
- Lower the bailer to the bottom of the sump to retrieve water.
- Hold the bailer over the sump to avoid spillage onto the floor.
- Using a bottom emptying device included with the bailer, fill two 40-ml glass vials. The vials are considered full when the water level is rounded above the container sides. Do not overfill the vial which may wash out some acid. Lower the cap straight onto the top of the vial and tighten.

- Turn the capped vial over to observe if an air bubble is present in the water sample. If a bubble is present, remove the cap and add additional water to fill the vial and recap.
- Empty the remaining water from the bailer back into the sump.
- Replace any previous sump cover.
- Fill out labels and affix to the vials. Identify the samples by "Sump-Address". Where "address" is the address of the residence.
- Place the filled vials into a cooler with ice.
- Completely fill out a chain of custody for the sample.

The samples are to be delivered to the selected laboratory for analysis of chlorinated volatile organic compounds by USEPA method 8260.

HAMP, MATHEWS & ASSOCIATES, INC.
15266 Ann Drive, Bath, Michigan 48808
[517] 641-7333 Fax [517] 641-7337

TO: Mr. Grant Trigger
Cleanup Manager – Michigan
RACER Trust

FROM: Jeffrey A. Crum
Senior Toxicologist & Vapor Intrusion Specialist

DATE: January 27, 2012

SUBJECT: Livonia Eckles Road Site, Livonia, Michigan: Standard Operating Procedures (SOPs) for Vapor Intrusion Field Investigation

At your request, Hamp, Mathews & Associates, Inc. (HMA) has completed a review of three Standard Operating Procedures (SOPs) completed by ARCADIS for the Moraine, Ohio site. The SOPs are related to the collection of soil gas (SOP 20 and 21) and indoor air and ambient air (SOP 22) samples to assess resident inhalation exposure risk to chlorinated volatile organic compounds (CVOCs) via subsurface vapor intrusion (VI) to indoor air pathway. This review was performed to incorporate any modifications or additions to the ARCADIS SOPs which may be needed to guide the collection and analysis of VI pathway data to best represent the site conditions at the 13000 Eckles Road Site in Livonia, Michigan. HMA's recommended modifications to the above referenced Moraine site SOPs are provided below.

SOP 20 Sub-Slab Soil-Gas Point Installation and Sampling

1. Section I, Scope and Application: Modify text and include rationale for analyzing soil gas samples for CVOCs, as provided below.

   CVOC Soil Gas Sample Analytes

   Sub-slab soil gas samples will be analyzed for the CVOCs detected in the groundwater, and for VOCs that are known degradation products. The chlorinated VOCs detected in groundwater that will be analyzed for in sub-slab soil gas samples are:

   - 1,1,1-Trichloroethane
   - 1,1- Dichloroethane
   - 1,1-Dichloroethene
   - Trichloroethene
   - cis- and trans-1,2-Dichloroethene
   - Chloroethane
   - Vinyl chloride

2. Section IV, Equipment List, bullet on "flow controllers": Replace the text as stated below.

   Flow controllers will be pre-calibrated to sample at a flow rate between 140 – 150 ml/minute, due to the equipment available from Fibertec Inc. of Holt, Michigan.

3. Section V, Procedure, "Permanent Sub-Slab Soil-Gas Point Installation", item "1.": Replace text as provided below.

   HMA will request MISS DIG Systems Inc. (http://www.missdig.net/) to identify locations of utilities entering basement homes to assure that drill bits passing through the slab will not damage utilities. HMA will coordinate discussion with homeowners of basement homes to gather additional information of identified utilities and other potential utilities that may be located immediately beneath the slab.

SOP 21 Administering Helium Tracer Gas for Leak Checks of Soil-Gas or Sub-Slab Sampling Points

1. Section IV, Procedure, item "8.": Modify text as presented below.

   A vacuum pump that purges at a rate of 140 – 150 ml/minute will be used instead of 50 ml/minute to correspond with the sample collection flow-controller rate specified previously in SOP 20 (see item #2 above).

SOP 22 Indoor Air and Ambient Air Sampling

1. Section I, Scope and Application: Add the following text to reflect air sampling consideration for crawlspaces.

   The indoor air sampling SOP for homes with crawlspace construction at the Eckles site is applicable to the collection of crawlspace air samples, with the exception that the SUMMA® canister orifice cannot be located 4 to 5 feet above ground, because the vertical height of the crawlspace is expected to be less than 3 feet. Instead, the SUMMA® canister orifice will be located nearest the center of the crawlspace to minimize ventilation effects, and mid-way between the ground floor and first floor of the home. The canister will be placed either on a flat sturdy stand or hung with stainless steel cable from the first floor framework to achieve the specified vertical height above grade.

Please contact me with any questions.

cc: Dave Favero, RACER Trust
Karen Berry-Spark, Geosyntec Consultants

ARCADIS SOPs 20, 21, and 22

ARCADIS
Infrastructure · Water · Environment · Buildings

Imagine the result

SOP 20

Sub-Slab Soil-Gas Point Installation and Sampling

RACER

Moraine, Ohio

Rev. #: 1.2

Rev Date: February 10, 2011

Approval Signatures

Prepared by: _____ Date: July 7, 2010
Mitch Wacksman

Approved by: _____ Date: July 7, 2010
Christopher Lutes

Modified by: _____ Date: Revised, December 3, 2010
Joseph Rumschlag

Modified by: _____ Date: Revised, February 10, 2011
Mitch Wacksman

I. Scope and Application

This document describes the procedures for installing permanent sub-slab sampling points and collecting soil-gas samples using permanent points. Samples from the points are collected in an evacuated 1-liter SUMMA®-type canister, (evacuated to approximately <28 inches of mercury [Hg]) which provides a recoverable whole-gas sample when allowed to fill to a vacuum of 2-8 inches of Hg. The whole-air sample is analyzed for volatile organic compounds (VOCs) by United States Environmental Protection Agency (USEPA) Method TO-15 using a quadrupole or ion-trap gas chromatograph/mass spectrometer (GC/MS) system to provide compound detection limits of 0.5 parts per billion volume (ppbv) or lower.

The following sections list the necessary equipment and provide detailed instructions for the installation of permanent sub-slab soil-gas points and the collection of sub-slab soil-gas samples for VOC analysis.

Site specific requirements and/or field conditions may require modifications to some of the procedures outlined in this standard operating procedure (SOP). Alterations to the SOP may be completed per approval of the Project Manager.

II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, site-specific training, first-aid, and cardiopulmonary resuscitation (CPR), as needed. ARCADIS field sampling personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel responsible for leading sub-slab soil-gas sample collection activities must have previous sub-slab soil-gas sampling experience.

III. Health and Safety Considerations

Field sampling equipment must be carefully handled to minimize the potential for injury and the spread of hazardous substances. All sampling personnel should review the appropriate health and safety plan (HASP) and job loss analysis (JLA) prior to beginning work to be aware of all potential hazards associated with the job site and the specific installation. For sub-slab soil-gas point installation, drilling with an electric concrete impact drill should be completed only by personnel with prior experience using such a piece of equipment and with the appropriate health and safety measures in place as presented in the JLA. It is possible to encounter high

concentrations of VOCs in sub-slab soil-gas, so the amount of time the borehole remains open should be minimized. For the same reason, when installing sub-slab points in spaces with minimal dilution potential, such as closets, it may be necessary to provide local ventilation. Finally, sub-slab point installation should be completed after any indoor air sampling to avoid cross contamination of the indoor air samples.

IV. Equipment List

The equipment required to install a permanent sub-slab soil-gas point is presented below:

- Appropriate personal protective equipment (PPE; as required by the site specific HASP and the JLA);
- Electric hammer drill (e.g., Bosch®, Hilti®, etc.);
- 5/8-inch and 1 1/2-inch diameter concrete drill bits for impact drill (drill bit length contingent on slab thickness);
- Decontaminated soil-gas point (typically 3-inch stainless steel pipe 9/16-inch OD [1/4-inch NPT threads on one end], 1/4-inch NPT female coupling, stainless steel Swagelok® fitting (or similar) bored through male connector [1/4-inch tube OD x 1/4 inch male NPT]), and stainless steel Swagelok® (or similar) plug for 1/4-inch tube fitting;
- Extra 1/4-inch Swagelok® front and back compression sleeves;
- Tubing cutter with heavy-duty cutting wheel;
- Hand tools, including open-end wrench (typically 9/16-inch), pliers, Channel Lock® pliers, etc.;
- Teflon® tape;
- Quick-setting non-shrink grout powder;
- Modeling clay (VOC free and non-drying);
- Potable water for mixing grout;

- Disposable cups and spoons for mixing grout;
- Spray bottle with potable water;
- Broom and dust pan;
- Paper towels;
- Nitrile gloves;
- Work gloves;
- Knee pads;
- Bottle brush;
- Ground fault circuit interrupter (GFCI);
- Extension cords capable of amperage required for hammer drill;
- Plastic sheeting; and
- Shop vacuum with clean fine-particle filter.

The equipment required for sub-slab soil-gas sample collection is presented below:

- 1-liter stainless steel SUMMA® canisters (order at least one extra, if feasible);
- Flow controllers with in-line particulate filters and vacuum gauges; flow controllers are pre-calibrated to specified sample duration (e.g.,30 minutes) or flow rate (e.g., 50 milliliters per minute [mL/min]); confirm with the laboratory that the flow controller comes with an in-line particulate filter and pressure gauge (order at least one extra, if feasible);
- 1/4-inch OD Teflon® tubing;
- 1/4-inch Swagelok® by 1/8-inch NPT male stainless steel coupling;
- Extra 1/4-inch Swagelok® front and back compression sleeves;

- Decontaminated stainless steel Swagelok® or comparable "T" fitting and needle valve for isolation of purge pump;
- Stainless steel duplicate "T" fitting provided by the laboratory (if collecting duplicate [i.e., split] samples);
- Portable vacuum pump capable of producing very low-flow rates (e.g., 50 to 200 mL/min);
- Electric flow sensor (Bios DryCal® or equivalent);
- Tracer gas testing supplies (refer to "Administering Tracer Gas" SOP #21);
- Appropriate-sized open-end wrench (typically 9/16-inch and 1/2-inch);
- Tedlar® bag to collect purge air or length of tubing sufficient to vent it outside the structure;
- Compound pressure/vacuum gauge;
- Portable weather meter, if appropriate;
- Chain-of-custody (COC) form;
- Sample collection log (attached);
- Nitrile gloves;
- Work gloves;
- Field notebook.

V. Procedure

Permanent Sub-Slab Soil-Gas Point Installation

Permanent sub-slab soil-gas points are installed using an electric drill and manual placement of the sub-slab point. After a dry fit, the sub-slab point is inserted into the hole and grouted with a quick-setting, non-shrink grout powder. The soil-gas point is equipped with a plug. The plug is removed and a compression fitting nut and ferrules are used to allow collection of a sub-slab soil-gas sample through Teflon® tubing. The sub-slab point and tubing will be purged with a portable sampling pump prior to collecting the sub-slab soil-gas sample. Detailed installation methods are as follows:

1. Complete utility clearance in accordance with ARCADIS Utility Locate SOP with assistance from Ohio Utility Protection Service (OUPS) prior to drilling activities.

2. Assemble the sub-slab sample point assembly. Teflon® tape should never be used with Swagelok® connections; it should be used on normal NPT threads.

3. Remove, only to the extent necessary any covering on top of the slab (e.g., carpet).

4. Lay down plastic sheeting to keep the work area clean. Check to make sure shop vacuum is working properly and fine concrete particles will not pass through filter.

5. Advance the 1 1/2-inch drill bit approximately 2 1/2 inches into the slab. This hole is drilled deep enough to permit the top of the sampling point to be set flush with the slab when the 1/4-inch tubing (9/16-inch OD) is inserted into the 5/8-inch hole drilled under Step 6, below. Clean up cuttings with shop vacuum, bottle brush, and dust pan.

6. Drill a 5/8-inch-diameter hole into the concrete slab using the electric drill. Do not fully penetrate the slab at this time. Stop drilling approximately 1 inch short of penetrating the slab. To gage this, a typical concrete slab is 4-6 inches thick. Therefore, stop drilling at 3 inches.

7. Use the shop vacuum, bottle brush and dust broom to clean up the work area and material that may have fallen into and around the drill hole.

8. Advance the 5/8-inch drill bit the remaining thickness of the slab and approximately 3 inches into the sub-slab material to create an open cavity.

   Note (if possible) from the drill cuttings any evidence for the types of materials in the immediate sub-slab – i.e. moisture barriers, sand, gravel, etc.

9. Use the bottle brush, whisk broom, and dust pan to quickly clean material around and within the hole. The hole should not be left open for any extended length of time to ensure that VOCs below the slab do not migrate into indoor air (plug with clay during clean up). Do not use the shop vacuum to clean up the drill hole after the full thickness of the slab has been penetrated.

10. Using an assembled sub-slab point, test fit the components so that the proper length of 1/4-inch tubing and depth of the 2 1/2-inch hole provides enough space for the coupling. Adjust so that the sample point plug will lie flush with the slab surface and does not create a tripping hazard.

11. If necessary, re-drill the 5/8-inch hole to ensure it remains clear. This can also be accomplished using a piece of steel rod, sample tubing, or even a piece of heavy wire (e.g., coat hanger).

12. Wrap the sample point assembly with Teflon® tape or VOC free modeling clay, to the extent necessary, for a snug fit of the assembly into the 5/8-inch diameter hole and also to prevent migration of cement to the sub-slab. Ensure that Teflon® tape or modeling clay does not interfere with the cement that will be used to permanently fix and seal the sample point.

13. Prepare a mixture of VOC-free non-shrink quick-setting cement and water according to the manufactures directions in a disposable cup using a plastic spoon for mixing.

14. Before cementing in the sub-slab point, moisten the 1 1/2-inch drill hole with the spray bottle to provide better adhesion.

15. Cement in the sub-slab point using the plastic spoon to apply the cement into the annular space between the coupling and the 1 1/2-inch drill hole.

16. Replace the surface covering (e.g., carpet) if warranted. Sample collection location should be returned to pre-sampling conditions to the extent feasible given the presence of a permanent point.

17. Proceed to sub-slab soil-gas sample collection after waiting a minimum of 24 hours for equilibration following sub-slab point installation.

Sub-Slab Soil-Gas Sample Collection

Once the permanent sub-slab point is installed, the following procedures should be used to collect the sample in a SUMMA® canister:

1. Record the following weather information from inside the building being sampled in the field notebook:

    a. wind speed and direction (if capable with in-field measuring device);

    b. ambient temperature;

    c. barometric pressure; and

    d. relative humidity.

2. Before sampling, remove the sample point plug and attach a compound pressure/vacuum gauge to the end of the sample point to record the pressure gradient occurring between indoors and sub-slab. Record the positive or negative pressure reading in the field notebook. Cap the sample point once the reading is collected.

3. Check all SUMMA®-type canisters for correct vacuum. The vacuum gauges provided by the analytical laboratory as part of the sample train (i.e., canister and flow controller) are used to record the initial and final vacuums in the air sampling canister. Pre-sampling vacuum in the canister should be between -30 inches of mercury (in Hg) and -25 in Hg. In the event a canister is not within this initial range, it will be rejected and a new canister, flow controller and vacuum will be similarly checked.

4. Remove the brass plug from the SUMMA® canister and connect the flow controller with in-line particulate filter and vacuum gauge to the SUMMA® canister. Do not open the valve on the SUMMA® canister. Record in the field

notebook and COC form the flow controller number with the appropriate SUMMA® canister number.

5. When collecting duplicate or other quality assurance/quality control (QA/QC) samples as required by applicable regulations and guidance, couple two SUMMA® canisters using stainless steel Swagelok® duplicate sample T-fitting supplied by the laboratory. Attach flow controller with in-line particulate filter and vacuum gauge to duplicate sample T-fitting provided by the laboratory.

6. Complete a "shut in" or "leak down" test prior to sampling each sub-slab soil-gas sample point to test the integrity of all above ground sampling equipment supplied by the laboratory (i.e., SUMMA® canister, flow controller, vacuum gauge, and associated fittings). All above ground sampling equipment will be assembled and the cap from the SUMMA® canister will be placed on the end of the sample train, effectively producing a closed system. The SUMMA® canister valve will then be briefly opened then closed; the vacuum applied by the canister is then effectively "shut-in" to the sample train. The vacuum gauge will be observed for at least one minute, and if there is any appreciable loss in vacuum, fittings should be adjusted to remedy the situation and create a leak-free environment. In the event a leak cannot be remedied, field staff should reject the sampling apparatus and choose another unit.

7. Connect a Swagelok® (or comparable) T-fitting to the end of the sample tubing. On one end of the T-fitting connect a short length of Teflon® tubing to the assembled sample train (flow control with in-line particulate filter and vacuum gauge and SUMMA® canister). On the other end of the T-fitting connect a Swagelok® (or similar) two-way valve using a short length of 1/4-inch OD Teflon® tubing.

8. Connect the two-way valve and the properly calibrated portable vacuum pump using a length of tubing. Affix a Tedlar® bag to the purge pump to capture all purged air. The purged air should be evacuated outside the building.

9. Purge 3 volumes of air from the sub-slab soil-gas point and sampling line using a portable pump at a rate of approximately 50 mL/min. Calculate three-times the volume of the inside of the sample tubing and sample point using the calculation:

$$V_1 + V_2 = V_t$$

where:

$V_1 = \pi r^2 h =$ open space volume of sample tubing

$V_2 = \pi r^2 h =$ open space volume of sample point
$V_t =$ total volume

$r =$ inner radius of sample point or sample tubing

$h =$ height of sample point or length of tubing

10. A tracer-gas leak test should be conducted to ensure that ambient leakage is either not occurring or is within acceptable limits. Check the seal established around all sub-slab soil-gas points and connections by using a tracer gas (e.g., helium) or other method established in the state guidance documents. [Note: Refer to SOP 21 "Administering Tracer Gas," for procedures on tracer gas use.] If unacceptable leaks are detected ($\geq$ 5% of the source concentration), take corrective action to seal all potential sources of leak in the sampling train. If the problem cannot be corrected, a replacement sub-slab point should be installed and sampled. Measure organic vapor and tracer gas levels within the Tedlar® bag, as appropriate

11. Close the two-way valve to isolate the purge pump.

12. Open the SUMMA® canister valve to initiate sample collection. Record on the sample log (attached) the time sampling began and the canister pressure.

13. On a floor plan or sketch of the area being sampled, include the following information:

    - Sample location;
    - Locations of heating, ventilation, and air conditioning equipment;
    - Chemical storage areas;
    - Any attached garages or utility areas;
    - Doorways and stairways;

- Any sumps, drains, or other utility perforations;
- Separate footings sections or buildings constructions; and
- The nearest street and the direction of north.

14. Take a photograph of the SUMMA® canister and surrounding area unless prohibited by the building owner.

15. Check the SUMMA® canister approximately half way through the sample duration and note progress on sample logs.

Termination of Sample Collection

1. Due to the short duration of sampling, field staff should stay with the SUMMA® canister throughout sampling.

2. Stop collecting the sample when the canister vacuum reaches approximately 5 inches of Hg (leaving some vacuum in the canister provides a way to verify if the canister leaks before it reaches the laboratory) or when the desired sample time has elapsed.

3. Record the final vacuum. Stop collecting the sample by closing the SUMMA® canister valve. Record the date, local time (24-hour time notation) of valve closing on the sample collection log, and COC form.

4. Disconnect sample tubing from the sample point and replace flush-mount cap.

5. Remove the particulate filters and flow controllers from the SUMMA® canisters, re-install the brass plugs on the canister fittings, and tighten with the appropriate wrench.

6. Package the canisters and flow controllers in the shipping container supplied by the laboratory for return shipment to the laboratory. The SUMMA® canisters should not be preserved with ice or refrigeration during shipment.

7. Complete the appropriate forms and sample labels as directed by the laboratory (e.g., affix card with a string).

8. Complete the COC form and place the requisite copies in a shipping container. Close the shipping container and affix a custody seal to the container closure. Ship the container to the laboratory via carrier (e.g., Federal Express) for analysis.

9. Replace the surface covering (e.g., carpet) if warranted. Sample collection location should be returned to pre-sampling conditions to the extent feasible given the presence of a permanent sample point. Document with photographs.

Decommissioning of Permanent Sub-Slab Soil-Gas Points

1. Remove, only to the extent necessary any covering on top of the permanent sample point (e.g., carpet).

2. Lay down plastic sheeting to keep the work area clean. Check to make sure shop vacuum is working properly and fine concrete particles will not pass through filter.

3. Using a hammer, carefully strike the sample point on the top of the plug to dislodge the permanent point from the slab. Repeat until the sample point becomes loose inside the borehole.

4. Remove the sample point from the slab.

5. Use the shop vacuum, bottle brush and dust broom to clean up the work area and material that may have fallen into and around the drill hole.

6. Prepare a mixture of VOC-free, non-shrink, quick-setting cement and water according to the manufactures directions in a disposable cup using a plastic spoon for mixing.

7. Place cement in 11/2-inch borehole using the plastic spoon until the hole is filled and wait until the cement sets.

8. Replace the surface covering (e.g., carpet) if warranted.

9. Document with photos.

VI. Cautions

The following cautions and field tips should be reviewed and considered prior to installing or collecting a sub-slab soil gas sample.

- When drilling sample collection holes, utilities may be in the area. Always complete utility location, identification and marking before installing sub-slab sample points as required by the ARCADIS Utility Location Policy and Procedure. Be aware that public utility locator organizations frequently do not provide location information within buildings so alternative lines of evidence must be used.

- Sampling personnel should not handle hazardous substances (such as gasoline), permanent marking pens, wear/apply fragrances, or smoke cigarettes/cigars before and/or during the sampling event.

- Care should be taken to ensure that the flow controller is pre-calibrated to the proper sample collection time (confirm with laboratory prior to sampling event, and confirm on packaging list). Sample integrity is maintained if the sampling event is shorter than the target duration, but sample integrity can be compromised if the event is extended to the point that the canister reaches atmospheric pressure. Excessive vacuum remaining in the canister can also result in elevated reporting limits.

- If low-flow conditions are encountered (when air flow rates are less-than 10 mL/min or when vacuum is greater than 10 inches of Hg) and preclude the collection of representative sub-slab soil-gas samples, due to high moisture conditions and/or tight soils, a replacement sub-slab point should be installed, for up to three attempts.

- Field personnel will properly seal the sub-slab point at the slab surface to prevent leaks of atmosphere into the sub-slab point during purging and sampling.

- Quick-setting non-shrink grout and modeling clay or other materials used to seal the hole should only be obtained from an approved ARCADIS source and should not be purchased off the shelf from an unapproved retail source. Data indicate that some modeling clays may contain VOCs that can affect sample results.

- It is important to record the canister pressure, start and stop times and sample identification on a proper field sampling form. Often SUMMA® canisters are collected over a 24 hour period. The time/pressure should be recorded at the start of sampling, and then again one or two hours later. It is a good practice to lightly tap the pressure gauge with your finger before reading it to make sure it isn't stuck. If the canister is running correctly for a 24 hour period then the vacuum will have decreased slightly after an hour or two (for example from 29 inches to 27 inches of Hg). Consult your project manager (PM), risk assessor or air sampling expert by phone if the SUMMA® canister does not appear to be working properly.

- Ensure that there is still measureable vacuum in the SUMMA® after sampling. Sometimes the gauges sent from the lab have offset errors, or they stick.

- When sampling carefully consider elevation. If your site is over 2,000 feet above sea level or the difference in elevation between your site and your lab is more than 2,000 feet then pressure effects will be significant. If you take your samples at a high elevation they will contain less air for a given ending pressure reading. High elevation samples analyzed at low elevation will result in more dilution at the lab, which could affect reporting limits. Conversely low elevation samples when received at high elevation may appear to not have much vacuum left in the http://www.uigi.com/Atmos_pressure.html.

- If possible, have equipment shipped two to three days before the scheduled start of the sampling event so that all materials can be checked. Order replacements if needed.

- Requesting extra canisters from the laboratory should also be considered to ensure that you have enough equipment on site in case of an equipment failure.

- Check the seal around the soil-gas sampling point by using a tracer gas (e.g., helium) or other method established in the appropriate guidance document.

- A Shipping Determination must be performed, by DOT-trained personnel, for all environmental and geotechnical samples that are to be shipped, as well as some types of environmental equipment/supplies that are to be shipped.

VII. Waste Management

The waste materials generated by these activities should be minimal. Personal protective equipment, such as gloves and other disposable equipment (i.e., tubing) should be collected by field personnel for proper disposal.

VIII. Data Recording and Management

Measurements will be recorded in the field notebook and/or sample log (attached) at the time of measurement with notations of the project name, sample date, sample start and finish time, sample location (e.g., GPS coordinates, distance from permanent structure [e.g., two walls, corner of room]), canister serial number, flow controller serial number, flow rate, initial vacuum reading, and final vacuum reading. Field sampling logs and COC records will be transmitted to the Project Manager.

IX. Quality Assurance

Duplicate samples should be collected in the field as a quality assurance step. Duplicate samples will be collected at a rate of 1 per 10 air samples (10%).

Soil-gas sample analysis will generally be performed using USEPA TO-15 methodology or a project specific constituent list. Method TO-15 uses a quadrupole or ion-trap GC/MS with a capillary column to provide optimum detection limits (typically 0.5-ppbv for most VOCs prior to any dilution). Duplicate sub-slab soil-gas samples should be collected via a split sample train, allowing the primary and duplicate sample to be collected from the sub-slab soil-gas point simultaneously.

Trip blank samples will not be used during sub-slab soil-gas sampling. SUMMA® canisters are self-sealed containers which do not permit any contamination to enter during shipment or storage. Furthermore all parts of the SUMMA® canister are metal and non-porous; therefore, there is no potential for any contamination to be absorbed. The batch certified clean SUMMA® canisters will be provided by the laboratory. The only potential contamination would come from a possible leak in the SUMMA® canister. The integrity of each SUMMA® canister will be confirmed prior to sampling by measuring the vacuum within the canister, with follow up measurements after the canister is filled in the field, and upon arrival at the laboratory.

X. References

CEPA. 2010. Advisory – Active Soil Investigation. California Environmental Protection Agency. March.

OEPA. 2010. Sample Collection and Evaluation of Vapor Intrusion to Indoor Air. Guidance Document for Remedial Response and Voluntary Action Program. Division of Emergency and Remedial Response. May.

Sub-slab/Soil-Gas Sample Collection Log

		Sample ID:	
Client:		**Boring Equipment:**	
Project:		**Sealant:**	
Location:		**Tubing Information:**	
Project #:		**Miscellaneous Equipment:**	
Samplers:		**Subcontractor:**	
`		**Equipment:**	
Sampling Depth:		**Moisture Content of Sampling Zone):**	
Time and Date of Installation:		**Approximate Purge Volume:**	

Instrument Readings:

Date	Time	Canister Vacuum (a) (inches of Hg)	Temperature (°F)	Relative Humidity (%)	Air Speed (mph)	Barometric Pressure (inches of Hg)	PID (ppb)

(a) Record canister information at a minimum at the beginning and end of sampling

SUMMA® Canister Information:

Size (circle one):	**1 L 6 L**
Canister ID:	
Flow Controller ID:	
Notes:	

Tracer Test Information (if applicable):

Initial Helium Shroud:	
Final Helium Shroud:	
Tracer Test Passed:	**Yes No**
Notes:	

General Observations/Notes:

Approximating One-Well Volume (for purging):

$V_1 + V_2 = V_t$ where: $V_1 = \pi r^2 h$ = open space volume of sample tubing; $V_2 = \pi r^2 h$ = open space volume of sample point; V_t = total volume; r = inner radius of sample point, or sample tubing; h = height of sample point or length of tubing.

ARCADIS
Infrastructure · Water · Environment · Buildings

Imagine the result

SOP 21

Administering Helium Tracer Gas for Leak Checks of Soil-Gas or Sub-Slab Sampling Points

RACER

Moraine, Ohio

Rev. #: 2.1

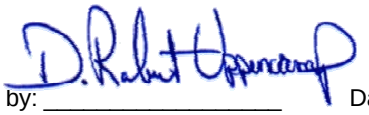
Rev Date: August 11, 2011

ARCADIS

SOP 21
Administering Helium Tracer Gas
Rev. #: 2.1 | Rev Date: August 11, 2011

Approval Signatures

Prepared by: _____ Date: May 20, 2008
Mitch Wacksman



Reviewed by: _____ Date: May 20, 2008
Robert Uppencamp

Approved by. _____ Date: November 14, 2008
Christopher Lutes

Modified by: _____ Date: Revised, August 20, 2010
Trey Fortner

Modified by: _____ Date: Revised, December 3, 2010
Joseph Rumschlag

Modified by: _____ Date: Revised, August 11, 2011
Carolyn Grogan

I. Scope and Application

When collecting sub-slab soil-gas samples as part of a vapor intrusion evaluation, a tracer gas serves as a quality assurance/quality control device to verify the integrity of the soil-gas point seal. Without the use of a tracer, verification that a sub-slab soil-gas sample has not been diluted by ambient or indoor air is difficult.

This standard operating procedure (SOP) focuses on using helium as a tracer gas. However, depending on the nature of the contaminants of concern, other compounds can be used as a tracer including sulfur hexafluoride (SF6), butane and propane (or other gases). In all cases, the protocol for using a tracer gas is consistent and includes the following basic steps: (1) enrich the atmosphere in the immediate vicinity where the sample point or sample tubing intersects the surface with the tracer gas; and (2) measure a vapor sample from the sample tubing for the presence of high concentrations (>5%) of the tracer. A pail, bucket, garbage can or even a plastic bag can serve to keep the tracer gas in contact with the sample point during the testing.

There are two basic approaches to testing for the tracer gas:

1. Include the tracer gas in the list of target analytes reported by the laboratory; or

2. Use a portable monitoring device to analyze a sample of soil-gas for the tracer prior to sampling for the compounds of concern. (Note that tracer gas samples can be collected via syringe, Tedlar® bag, etc. They need not be collected in SUMMA® canisters or minicans.)

This SOP focuses on monitoring helium using a portable sampling device, although helium can also be analyzed by the laboratory along with other volatile organic compounds (VOCs). Real-time tracer sampling is generally preferred as the results can be used to confirm the integrity of the sample point seals prior to formal sample collection.

During the initial stages of a sub-slab soil-gas sampling program, tracer gas samples should be collected at each of the sampling points. If the results of the initial samples indicate that the sample point seals are adequate, the Project Manager can consider reducing the number of locations at which tracer gas samples are used. At a minimum, at least 10% of the subsequent samples should be supported with tracer gas analyses. When using permanent soil-gas points as part of a long-term monitoring program, the sample point should be tested prior to the first sampling event. Tracer

gas testing of subsequent sampling events is not necessary unless conditions have changed at the site.

Site specific requirements and/or field conditions may require modifications to some of the procedures outlined in this SOP. Alterations to the SOP may be completed per approval of the Project Manager.

II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, site-specific training, first-aid, and cardiopulmonary resuscitation (CPR), as needed. ARCADIS field sampling personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel responsible for leading the tracer gas testing must have previous experience conducting similar tests.

III. Equipment List

The equipment required to conduct a helium tracer gas test are presented below:

- Appropriate PPE for site (as required by the Health and Safety Plan).
- Helium (laboratory grade).
- Regulator for helium tank.
- Shroud (plastic bucket, garbage can, etc).
    - The size of the shroud should be sufficient to fit over the sub-slab soil-gas point. It is worth noting that using a smaller shroud obviously uses less helium as well; this may be important when projects require a number of helium tracer tests.
    - The shroud will need to have three small holes in it. These holes will include one on the top (to accommodate the sample tubing), and two on the side (one for the helium detector probe, and one for the helium line).

- The shroud ideally encloses the entire sampling train.

- Helium detector capable of measuring from 1 - 100% (Dielectric MGD-2002, Mark Model 9522, or equivalent).

- Tedlar® bags.

- Seal material for shroud (rubber gasket, modeling clay, bentonite, etc). Although the sealing material is not in direct contact with the sample if no leak occurs, sealing materials with high levels of VOC emissions should be avoided, since they could easily contaminate a sample from a point in which a trace leak occurs.

- Field notebook.

IV. Procedure

The procedure used to conduct the helium tracer test should be specific to the shroud being used and the methods of soil-gas point installation. The helium tracer test can be conducted when using temporary or permanent sample point installs and from inside or outside a facility. However, when using the tracer gas within an indoor area you must provide adequate ventilation because helium is an asphyxiant.

1. Attach Teflon® sample tubing to the sample point. This can be accomplished utilizing a number of different methods depending on the sample install (i.e., barbed fitting, Swagelok® fitting, ball valve, etc.).

2. Place the shroud over the sample point and tubing.

3. Pull the tubing through hole in top of shroud. Seal opening with modeling clay.

4. Place weight on top of shroud to help maintain a good seal with the ground.

5. Insert helium tubing into hole in side of shroud, seal with modeling clay to prevent leaks.

6. Fill shroud with helium. While filling shroud allow atmospheric air to escape either by leaving a crack with the surface or by providing a release value on the side of the shroud.

7. Use the helium detector to test level of helium gas from the bottom of the shroud (where the sample tubing intersects the ground). Helium should be added until the environment inside the shroud has > 60% helium.

8. Purge the sample point through the sample tubing into a Tedlar bag using a hand held sampling pump. The sample pump should be operating at a rate of 50 mL/minute (the purge rate should not exceed the sample collection rate).Use a stand-alone flow sensor to monitor purge flow-rate during purge (Bios DryCal or equivalent). Test the air in the Tedlar® bag for helium using portable helium detector. If the sample point has been installed properly there should be zero helium in purge air.

9. If > 5% helium is noted in purge air, add more clay or other material to the seal the sample point at the surface and repeat the testing procedure. If the seal cannot be fixed, re-install sample point.

10. Monitor and record helium level in shroud before, during and after tracer test.

11. Monitor and record helium level in purge exhaust at the end of purging.

12. At successful completion of tracer test and sample point purging, the soil-gas sample can be collected (if the helium shroud must be removed prior to sample collection be mindful not disturb the sample tubing and any established seals).

V. Cautions

Helium is an asphyxiant! Be cautious with its use indoors!

Care should be taken not to pressurize shroud while introducing helium. If the shroud is completely air tight and the helium is introduced quickly, the shroud can be over-pressurized and helium can be pushed into the ground.

Because minor leakage around the sample point seal should not materially affect the usability of the soil-gas sampling results, the mere presence of the tracer gas in the sample should not be a cause for alarm. Consequently, portable field monitoring devices with detection limits in the low ppm range are more than adequate for screening samples for the tracer. If high concentrations (>5%) of tracer gas are observed in a sample, the sample point seal should be enhanced to reduce the

infiltration of ambient air and the tracer test readministered. If the problem cannot be rectified, a new sample point should be installed.

VI. Data Recording and Management

Measurements will be recorded in the field notebook at the time of measurement with notations of the project name, sample date, sample start and finish time, sample location, and the helium concentrations in both the shroud and the purge air before, during, and after tracer testing. Any problems encountered should also be recorded in the field notes.

ARCADIS

APPENDIX: Compressed Gases—Use and Storage

In general, a compressed gas is any material contained under pressure that is dissolved or liquefied by compression or refrigeration. Compressed gas cylinders should be handled as high-energy sources and therefore as potential explosives and projectiles. Prudent safety practices should be followed when handling compressed gases since they expose workers to both chemical and physical hazards.

Handling

- Safety glasses with side shields (or safety goggles) and other appropriate personal protective equipment should be worn when working with compressed gases.
- Cylinders should be marked with a label that clearly identifies the contents.
- All cylinders should be checked for damage prior to use. Do not repair damaged cylinders or valves. Damaged or defective cylinders, valves, etc., should be taken out of use immediately and returned to the manufacturer/distributor for repair.
- All gas cylinders (full or empty) should be rigidly secured to a substantial structure at 2/3 height. Only two cylinders per restraint are allowed in the laboratory and only soldered link chains or belts with buckles are acceptable. Cylinder stands are also acceptable but not preferred.
- Handcarts shall be used when moving gas cylinders. Cylinders must be chained to the carts.
- All cylinders must be fitted with safety valve covers before they are moved.
- Only three-wheeled or four-wheeled carts should be used to move cylinders.
- A pressure-regulating device shall be used at all times to control the flow of gas from the cylinder.
- The main cylinder valve shall be the only means by which gas flow is to be shut off. The correct position for the main valve is all the way on or all the way off.
- Cylinder valves should never be lubricated, modified, forced, or tampered with.
- After connecting a cylinder, check for leaks at connections. Periodically check for leaks while the cylinder is in use.
- Regulators and valves should be tightened firmly with the proper size wrench. Do not use adjustable wrenches or pliers because they may damage the nuts.
- Cylinders should not be placed near heat or where they can become part of an electrical circuit.
- Cylinders should not be exposed to temperatures above 50 °C (122 °F). Some rupture devices on cylinders will release at about 65 °C (149 °F). Some small cylinders, such as lecture bottles, are not fitted with rupture devices and may explode if exposed to high temperatures.
- Rapid release of a compressed gas should be avoided because it will cause an unsecured gas hose to whip dangerously and also may build up enough static charge to ignite a flammable gas.

- Appropriate regulators should be used on each gas cylinder. Threads and the configuration of valve outlets are different for each family of gases to avoid improper use. Adaptors and homemade modifications are prohibited.
- Cylinders should never be bled completely empty. Leave a slight pressure to keep contaminants out.

Storage

- When not in use, cylinders should be stored with their main valve closed and the valve safety cap in place.
- Cylinders must be stored upright and not on their side. All cylinders should be secured.
- Cylinders awaiting use should be stored according to their hazard classes.
- Cylinders should not be located where objects may strike or fall on them.
- Cylinders should not be stored in damp areas or near salt, corrosive chemicals, chemical vapors, heat, or direct sunlight. Cylinders stored outside should be protected from the weather.

Special Precautions

Flammable Gases

- No more than two cylinders should be manifolded together; however several instruments or outlets are permitted for a single cylinder.
- Valves on flammable gas cylinders should be shut off when the laboratory is unattended and no experimental process is in progress.
- Flames involving a highly flammable gas should not be extinguished until the source of the gas has been safely shut off; otherwise it can reignite causing an explosion.

Acetylene Gas Cylinders

- Acetylene cylinders must always be stored upright. They contain acetone, which can discharge instead of or along with acetylene. Do not use an acetylene cylinder that has been stored or handled in a nonupright position until it has remained in an upright position for at least 30 minutes.
- A flame arrestor must protect the outlet line of an acetylene cylinder.
- Compatible tubing should be used to transport gaseous acetylene. Some tubing like copper forms explosive acetylides.

Lecture Bottles

- All lecture bottles should be marked with a label that clearly identifies the contents.
- Lecture bottles should be stored according to their hazard classes.
- Lecture bottles that contain toxic gases should be stored in a ventilated cabinet.
- Lecture bottles should be stored in a secure place to eliminate them from rolling or falling.

- Lecture bottles should not be stored near corrosives, heat, direct sunlight, or in damp areas.
- To avoid costly disposal fees, lecture bottles should only be purchased from suppliers that will accept returned bottles (full or empty). Contact the supplier before purchasing lecture bottles to ensure that they have a return policy.
- Lecture bottles should be dated upon initial use. It is advised that bottles be sent back to the supplier after one year to avoid accumulation of old bottles.

ARCADIS
Infrastructure · Water · Environment · Buildings

Imagine the result

SOP 22

Indoor Air and Ambient Air Sampling

RACER

Moraine, Ohio

Rev. #: 1.2

Rev Date: February 9, 2011

Approval Signatures

Prepared by:  Date: July 7, 2010
Mitch Wacksman

Approved by:  Date: July 7, 2010
Christopher Lutes

Modified by:  Date: Revised, December 3, 2010
Trey Fortner

Modified by:  Date: Revised, February 9, 2011
Mitch Wacksman

I. Scope and Application

This document describes the procedures to collect indoor air and ambient air samples. Samples are collected in an evacuated 6-liter SUMMA®-type canister, (evacuated to <28 inches of mercury [Hg]) which provides a recoverable whole-gas sample when allowed to fill to a vacuum of 2-8 inches of Hg. The whole-air sample is analyzed for volatile organic compounds (VOCs) by United States Environmental Protection Agency (USEPA) Method TO-15 using a quadrupole or ion-trap gas chromatograph/mass spectrometer (GC/MS) system to provide compound detection limits of 0.5 parts per billion volume (ppbv) or lower.

The following sections list the necessary equipment and provide detailed instructions for placing the sampling device and collecting indoor air or ambient air samples for VOC analysis.

Site specific requirements and/or field conditions may require modifications to some of the procedures outlined in this standard operating procedure (SOP). Alterations to the SOP may be completed per approval of the Project Manager.

II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, site-specific training, first-aid, and cardiopulmonary resuscitation (CPR), as needed. ARCADIS field sampling personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel responsible for leading indoor air or ambient air sample collection activities must have previous indoor air or ambient air sampling experience.

III. Health and Safety Considerations

Field sampling equipment must be carefully handled to minimize the potential for injury and the spread of hazardous substances. All sampling personnel should review the appropriate health and safety plan (HASP) and job loss analysis (JLA) prior to beginning work to be aware of all potential hazards associated with the job site and the specific task. The following are examples of hazards that are often encountered in conducting indoor air or ambient air sampling:

- In crawl spaces, hazards often include low head room, limited light, poisonous insects, venomous snakes, insulation, electrical and plumbing lines, and sharp debris.

- In residential buildings and neighborhoods unfamiliar pets can pose a hazard. Even though proper permission for sampling may have been secured, it is still possible to encounter persons suspicious of or hostile to the sampling team. Two sampling personnel are required at all times due to these hazards.

- In occupied industrial buildings be aware of the physical hazards of ongoing industrial processes. Examples include moving forklifts and equipment pits.

IV. Equipment List

The equipment required for indoor air or ambient air sample collection is presented below:

- Appropriate PPE (as required by the Health and Safety Plan);

- 6-liter, stainless steel SUMMA® canisters (order at least one extra, if feasible);

- Flow controllers with in-line particulate filters and vacuum gauges (flow controllers are pre-calibrated by the laboratory to a specified sample duration [e.g., 24-hour]). Confirm with lab that flow controller is equipped with an in-line particulate filter and pressure gauge (order an extra set for each extra SUMMA® canister, if feasible);

- Appropriate-sized open-end wrenches (typically 9/16-inch);

- Chain-of-custody (COC) form;

- Building survey and product inventory form (example attached);

- Portable photoionization detector (PID) (for use identifying potential background sources during building survey described below);

- Sample collection log (attached);

- Field notebook;

- Camera if photography is permitted at sampling locations;

- Portable weather meter capable of collecting barometric pressure, relative humidity, and temperature, if appropriate;

- Box, chair, tripod, or similar to hold canister above the ground surface; and

- Teflon sample tubing may be used to sample abnormal situations (i.e., sumps, where canisters must be hidden, etc.). In these situations ¼-inch Swagelok fittings or other methods may be appropriate to affix tubing to canister. Staff should check this before heading out into field.

V. Procedure

Initial Building Survey for Indoor Air Samples (if applicable to project)

1. Complete the appropriate building survey form and product inventory form (attached) as necessary in advance of sample collection. The product inventory should include ingredients of products as well as quantities. A copy of this completed form will be provided to the property owner to discuss potential background sources.

2. Confirm with building occupants that Instructions for Occupants during Indoor Air Sampling Events has been followed, and use of products that may provide interference with sample results has been discontinued and specified products removed to a non-attached structure at least 48-hours before sampling.

3. Identify on a site plan all underground utilities, piping, or conduits coming into or out of the building to be sampled.

4. Survey the area for the apparent presence of items or materials (i.e. foundation cracks) that may potentially produce or emit constituents of concern and interfere with analytical laboratory analysis of the collected sample. Record relevant information on survey form and document with photographs.

5. Record date, time, location, and other relevant notes on the sampling form.

6. Items or materials that contain constituents of concern and/or exhibit elevated PID readings shall be considered probable sources of VOCs. Request approval of the owner or occupant to have these items removed to a structure not attached to the target structure at least 48 hours prior to sampling, if possible.

7. Set a date and time with the owner or occupant to return for placement of SUMMA® canisters.

Preparation of SUMMA®-Type Canister and Collection of Indoor Air or Ambient Air Sample

1. Record the following information from wherever the sample is being collected (i.e. inside a building for indoor air samples or outside for ambient air samples) on the sampling form (use a hand-held weather meter, contact the local airport or other suitable information source [e.g., weather.gov] to obtain the following information):

    - ambient temperature;
    - barometric pressure;
    - wind speed; and
    - relative humidity.

2. Choose the sample location in accordance with the sampling plan. If a breathing zone sample is required, place the canister on a ladder, tripod, box, or other similar stand to locate the canister orifice 4 to 5 feet above ground or floor surface. If the canister will not be overseen for the entire sampling period, secure the canisters as appropriate (e.g., lock and chain). Canister may be affixed to wall/ceiling support with nylon rope or placed on a stable surface. In general, areas near windows, doors, air supply vents, and/or other potential sources of "drafts" shall be avoided. Ambient air samples should be placed upwind of the sampling area.

3. Record SUMMA® canister serial number and flow controller number on the sampling log and chain of custody (COC) form. Assign sample identification on canister ID tag, and record on the sample collection log (attached), and COC form.

4. Remove the cap from the SUMMA® canister. Attach the flow controller with in-line particulate filter and vacuum gauge to the SUMMA® canister with the appropriate-sized wrench. Tighten by hand first, then gently with the wrench. Use caution not to over tighten fittings.

5. Open the SUMMA® canister valve to initiate sample collection. Record the date and local time (24-hour time notation) of valve opening on the sample collection log, and COC form. Collection of duplicate samples will include collecting two samples side by side at the same time.

6. On a floor plan or sketch of the area being sampled, include the following information:

   - Sample location;
   - Locations of heating, ventilation, and air conditioning equipment;
   - Chemical storage areas;
   - Any attached garages or utility areas;
   - Doorways and stairways;
   - Any sumps, drains, or other utility perforations;
   - Separate footings sections or buildings constructions; and
   - The nearest street and the direction of north.

7. All SUMMA®-type canisters received from Air Toxics will be checked for correct vacuum. The vacuum gauges provided by the analytical laboratory as part of the sample train (i.e., canister and flow controller) are used to record the initial and final vacuums in the air sampling canister. Pre-sampling vacuum in the canister should be between -30 inches (in) of Hg and -25 in Hg. In the event a canister is not within this initial range, it will be rejected and a new canister, flow controller and vacuum will be similarly checked.

8. Record the initial vacuum pressure in the SUMMA® canister on the sample log and COC form.

9. When collecting duplicate or other quality assurance/quality control (QA/QC) samples as required by applicable regulations and guidance, two SUMMA® canisters will be placed side-by-side and allowed to collect a sample during the exact same period of time.

10. Take a photograph of the SUMMA® canister and surrounding area, if possible.

11. The SUMMA® canister should be checked, if possible, at least once during the 24-hour sampling process and the progress noted on the sampling log.

Termination of Sample Collection

1. Arrive at the SUMMA® canister location at least 1-2 hours prior to the end of the sampling interval (e.g., 24-hour), if possible.

2. Stop collecting the sample when the canister vacuum reaches approximately 5 inches of Hg (leaving some vacuum in the canister provides a way to verify if the canister leaks before it reaches the laboratory) or when the desired sample time has elapsed.

3. Record the final vacuum. Stop collecting the sample by closing the SUMMA® canister valve. Record the date, local time (24-hour time notation) of valve closing on the sample collection log, and COC form.

4. Remove the particulate filter and flow controller from the SUMMA® canister, re-install brass cap on canister fitting, and tighten with wrench.

5. Package the canister and flow controller in the shipping container supplied by the laboratory for return shipment to the laboratory. The SUMMA® canister does not require preservation with ice or refrigeration during shipment.

6. Complete the appropriate forms and sample labels as directed by the laboratory (e.g., affix card with string).

7. Complete COC form and place requisite copies in shipping container. Close shipping container and affix custody seal to container closure. Ship to laboratory via overnight carrier (e.g., Federal Express) for analysis.

VI. Cautions

- Care must be taken to minimize the potential for introducing interferences during the sampling event. As such, keep canisters away from heavy pedestrian traffic areas (e.g., main entranceways, walkways) if possible. If the canisters are not to be overseen for the entire sample duration, precautions should be taken to maintain the security of the sample (e.g., do not place in areas regularly accessed by the public, fasten the sampling device to a secure object using lock and chain, label the canister to indicate it is part of a scientific project, notify local authorities, place the canister in secure housing that does not disrupt the integrity/validity of the sampling event). Sampling personnel should not handle hazardous substances (such as gasoline), permanent marking pens (sharpies), wear/apply fragrances, or smoke cigarettes before and/or during the sampling event.

- If a sub-slab soil-gas sample is collected from a permanent point at the same residence then wait a minimum of 24 hours after the installation of the point before sampling indoor air to minimize cross-contamination from sub-slab soil-gas that may have entered the indoor air during the installation of the point.

- Ensure that the flow controller is pre-calibrated to the proper sample collection duration (confirm with laboratory). Sample integrity can be compromised if sample collection is extended to the point that the canister reaches atmospheric pressure. Sample integrity is maintained if sample collection is terminated prior to the target duration and a measurable vacuum (e.g., 2 to 5–inches Hg) remains in the canister when sample collection is terminated.

- It is important to record the canister pressure, start and stop times and sample identification on a proper field sampling form. Often SUMMA® canisters are collected over a 24 hour period. The time/pressure should be recorded at the start of sampling, and then again one or two hours later. It is a good practice to lightly tap the pressure gauge with your finger before reading it to make sure it isn't stuck. If the canister is running correctly for a 24 hour period then the vacuum will have decreased slightly after an hour or two (for example from 29 to 27 inches Hg). Consult your project manager (PM), risk assessor or air sampling expert if the SUMMA® canister does not appear to be working properly.

- When sampling carefully consider elevation. If your site is over 2,000 feet above sea level or the difference in elevation between your site and your lab is more than 2,000 feet then pressure effects will be significant. If you take your samples at a high elevation they will contain less air for a given ending pressure reading. High elevation samples analyzed at low elevation will result in more dilution at the lab, which could affect reporting limits. Conversely low elevation samples when received at high elevation may appear to not have much vacuum remaining http://www.uigi.com/Atmos_pressure.html.

- If possible, have equipment shipped two to three days before the scheduled start of the sampling event so that all materials can be checked. Order replacements if needed.

- Requesting extra canisters from the laboratory should also be considered to ensure that you have enough equipment on site in case of an equipment failure.

- A Shipping Determination must be completed, by DOT-trained personnel, for all environmental and geotechnical samples that are to be shipped, as well as some types of environmental equipment/supplies that are to be shipped.

- When collecting ambient air samples it is advisable to contact the local police department to inform them of the sampling and the equipment (i.e. SUMMA®) to be used. This will inhibit any false alarms from concerned citizens.

VII. Waste Management

No specific waste management procedures are required.

VIII. Data Recording and Management

Measurements will be recorded in the field notebook and/or sample log (attached) at the time of measurement with notations of the project name, sample date, sample start and finish time, sample location (e.g., GPS coordinates, distance from permanent structure [e.g., two walls, corner of room]), canister serial number, flow controller serial number, flow rate, initial vacuum reading, and final vacuum reading. Field sampling logs and COC records will be transmitted to the Project Manager. A building survey form and product inventory form (Attachment A) may also be completed for each building within the facility being sampled during each sampling event as applicable.

IX. Quality Assurance

Duplicate samples should be collected in the field as a quality assurance step. Duplicate samples will be collected at a rate of 1 per 10 air samples (10%).

Indoor air sample analysis will be according to USEPA Method TO-15. This method uses a quadrupole or ion-trap GC/MS with a capillary column to provide optimum detection limits. The GC/MS system requires a 1-liter gas sample (which can easily be recovered from a 6-liter canister) to provide a 0.5 ppbv detection limit. The 6-liter canister also provides several additional 1-liter samples in case subsequent re-analyses or dilutions are required. This system also offers the advantage of the GC/MS detector, which confirms the identity of detected compounds by evaluating their mass spectra in either the SCAN or SIM mode.

Trip blank samples will not be used during indoor air or ambient air sampling. SUMMA® canisters are self-sealed containers which do not permit any contamination to enter during shipment or storage. Furthermore all parts of the SUMMA® canister are metal and non-porous; therefore, there is no potential for any contamination to be absorbed. The batch certified clean SUMMA® canisters will be

provided by the laboratory. The only potential contamination would come from a possible leak in the SUMMA® canister. The integrity of each SUMMA® canister will be confirmed prior to sampling by measuring the vacuum within the canister, with follow up measurements after the canister is filled in the field, and upon arrival at the laboratory.

ARCADIS

Building Survey and Product Inventory Form

Directions: This form must be completed for each residence or area involved in indoor air testing.

Preparer's Name: _____

Date/Time Prepared: _____

Preparer's Affiliation: _____

Phone No.: _____

Purpose of Investigation: _____

1. OCCUPANT:

Interviewed: Y / N

Last Name: _____ First Name: _____

Address: _____

County: _____

Home Phone: _____ Office Phone: _____

Number of Occupants/Persons at this Location: _____

Age of Occupants: _____

2. OWNER OR LANDLORD: (Check if Same as Occupant ___)

Interviewed: Y / N

Last Name: _____ First Name: _____

Address: _____

County: _____

Home Phone: _____ Office Phone: _____

ARCADIS

3. BUILDING CHARACTERISTICS:

Type of Building: (circle appropriate response)

Residential	School	Commercial/Multi-use
Industrial	Church	Other: _____

If the Property is Residential, Type? (circle appropriate response)

Ranch		2-Family 3-Family
Raised Ranch	Split Level	Colonial
Cape Cod	Contemporary	Mobile Home
Duplex	Apartment House	Townhouses/Condos
Modular	Log Home	Other:_____

If Multiple Units, How Many? _____

If the Property is Commercial, Type?

Business Type(s) _____

Does it include residences (i.e., multi-use)? Y / N If yes, how many? _____

Other Characteristics:

Number of Floors_____ Building Age_____

Is the Building Insulated? Y / N How Air-Tight? Tight / Average / Not Tight

4. AIRFLOW:

Use air current tubes or tracer smoke to evaluate airflow patterns and qualitatively describe:

Airflow Between Floors

_____

_____

_____

Airflow Near Source

Outdoor Air Infiltration

Infiltration Into Air Ducts

5. BASEMENT AND CONSTRUCTION CHARACTERISTICS: (circle all that apply)

a.	**Above grade construction:**	wood frame	concrete	stone brick	
b.	**Basement type:**	full	crawlspace	slab	other _____
c.	**Basement floor:**	concrete	dirt	stone	other _____
d.	**Basement floor:**	uncovered	covered	covered with _____	
e.	**Concrete floor:**	unsealed	sealed	sealed with _____	
f.	**Foundation walls:**	poured	block stone	other _____	
g.	**Foundation walls:**	unsealed	sealed	sealed with _____	
h.	**The basement is:**	wet	damp	dry	moldy
i.	**The basement is:**	finished	unfinished	partially finished	
j.	**Sump present?**	Y / N			
k.	**Water in sump?**	Y / N / NA			

Basement/lowest level depth below grade: _____(feet)

Identify potential soil vapor entry points and approximate size (e.g., cracks, utility ports, drains)

Potential Vapor Point Entry	Field Screening Results (ppm)	Comments

Are the basement walls or floor sealed with waterproof paint or epoxy coatings? Y / N

6. HEATING, VENTILATING, AND AIR CONDITIONING: (circle all that apply)

Type of heating system(s) used in this building: (circle all that apply – note primary)

Hot air circulation	Heat pump	Hot water baseboard
Space heaters	Stream radiation	Radiant floor
Electric baseboard	Wood stove	Outdoor wood boiler
Other _____		

The primary type of fuel used is:

Natural gas	Fuel oil	Kerosene
Electric	Propane	Solar
Wood coal		

Domestic hot water tank fueled by: _____

Boiler/furnace located in: Basement Outdoors Main Floor Other_____

Air conditioning: Central Air Window Units Open Windows None

Are there air distribution ducts present? Y / N

Describe the supply and cold air return ductwork, and its condition where visible, including whether there is a cold air return and the tightness of duct joints. Indicate the locations on the floor plan diagram.

_____

_____

_____

7. OCCUPANCY:

Is basement/lowest level occupied? Full-time Occasionally Seldom Almost Never

General Use of Each Floor (e.g., family room, bedroom, laundry, workshop, storage):

Basement _____

1st Floor _____

2nd Floor _____

3rd Floor _____

4th Floor _____

8. FACTORS THAT MAY INFLUENCE INDOOR AIR QUALITY:

a. Is there an attached garage? Y / N

b. Does the garage have a separate heating unit? Y / N / NA

c. Are petroleum-powered machines or vehicles stored in the garage (e.g., lawnmower, ATV, car)?

Y / N / NA Please specify: _____

d. Has the building ever had a fire? Y / N When? _____

e. Is a kerosene or unvented gas space heater present? Y / N Where? _____

f. Is there a workshop or hobby/craft area? Y / N Where & Type? _____

g. Is there smoking in the building? Y / N How frequently? _____

h. Have cleaning products been used recently? Y / N When & Type? _____

i. Have cosmetic products been used recently? Y / N When & Type? _____

j. Has painting/staining been done in the last 6 months? Y / N Where & When? _____

k. **Is there new carpet, drapes or other textiles?** Y / N Where & When? _____

l. **Have air fresheners been used recently?** Y / N When & Type? _____

m. **Is there a kitchen exhaust fan?** Y / N If yes, where _____

n. **Is there a bathroom exhaust fan?** Y / N If yes, where vented?_____

o. **Is there a clothes dryer?** Y / N If yes, is it vented outside? Y / N

p. **Has there been a pesticide application?** Y / N When & Type?_____

q. **Are there odors in the building?** Y / N

If yes, please describe: _____

Do any of the building occupants use solvents (e.g., chemical manufacturing or laboratory, auto mechanic or auto body shop, painting, fuel oil delivery, boiler mechanic, pesticide application, cosmetologist) at work? Y / N

If yes, what types of solvents are used? _____

If yes, are their clothes washed at work? Y / N

Do any of the building occupants regularly use or work at a dry-cleaning service? (circle appropriate response)

Yes, use dry-cleaning regularly (weekly) No

Yes, use dry-cleaning infrequently (monthly or less) Unknown

Yes, work at a dry-cleaning service

Is there a radon mitigation system for the building/structure? Y / N

Date of Installation: _____

Is active mitigation system recommended? Y / N

Are there any Outside Contaminant Sources? (circle appropriate responses)

Contaminated site with 1000-foot radius? Y / N Specify _____

Other stationary sources nearby (e.g., gas stations, emission stacks, etc.): _____

_____

Heavy vehicle traffic nearby (or other mobile sources): _____

ARCADIS

9. WATER AND SEWAGE:

Water Supply: Public Water Drilled Well Driven Well Dug Well Other: _____

Sewage Disposal: Public Sewer Septic Tank Leach Field Dry Well Other: _____

10. RELOCATION INFORMATION: (for oil spill residential emergency)

a. Provide reasons why relocation is recommended: _____

_____

b. Residents choose to: remain in home relocate to friends/family relocate to hotel/motel

c. Responsibility for costs associated with reimbursement explained? Y / N

d. Relocation package provided and explained to residents? Y / N

11. FLOOR PLANS:

Draw a plan view sketch of the basement and first floor of the building. Indicate air sampling locations, possible indoor air pollution sources and PID meter readings. If the building does not have a basement, please note.

Basement:

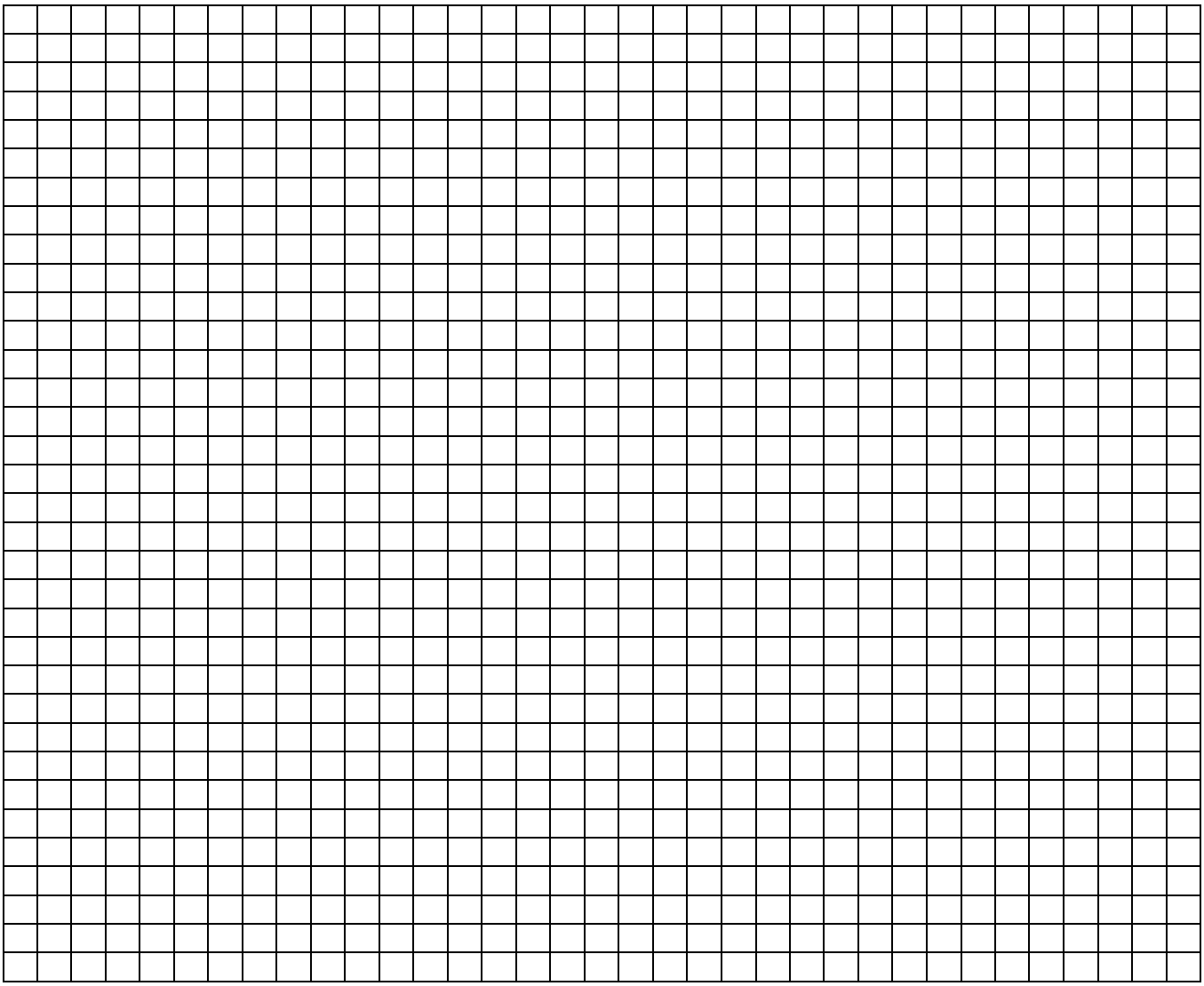
First Floor:

ARCADIS

12. OUTDOOR PLOT:

Draw a sketch of the area surrounding the building being sampled. If applicable, provide information on spill locations, potential air contamination sources (industries, gas stations, repair shops, landfills, etc.), outdoor air sampling location(s), and PID meter readings.

Also indicate compass direction, wind direction and speed during sampling, the locations of the well and septic system, if applicable, and a qualifying statement to help locate the site on a topographic map.



13. PRODUCT INVENTORY FORM:

Make and Model of field instrument used: _____

List specific products found in the residence or area that have the potential to affect indoor air quality (e.g., gasoline or kerosene storage cans, glues, paints, cleaning solvents/products, polishes/waxes, new furniture/ carpet, nail polish/hairspray/cologne).

Location	Product Description	Size (units)	Condition*	Chemical Ingredients	Field Instrument Reading (units)	Photo** Y/N

Indoor Air or Ambient Air Sample Collection Log

		Sample ID:	
Client:		**Outdoor/Indoor:**	
Project:		**Sample Intake Height:**	
Location:		**Tubing Information:**	
Project #:		**Miscellaneous Equipment:**	
Samplers:		**Time On/Off:**	
Sample Point Location:		**Subcontractor:**	

Instrument Readings:

Date	Time	Canister Vacuum (a) (inches of Hg)	Temperature (°F)	Relative Humidity (%)	Air Speed (mph)	Barometric Pressure (inches of Hg)	PID (ppb)

(a) Record canister information at a minimum at the beginning and end of sampling

SUMMA Canister Information:

Size (circle one):	**1 L 6 L**
Canister ID:	
Flow Controller ID:	
Notes:	

General Observations/Notes:

Appendix B

Quality Control Document

Hamp, Mathews &
Associates, Inc.

QUALITY CONTROL DOCUMENT

RACER Trust
13000 Eckles Road, Livonia, Michigan

HAMP, MATHEWS AND ASSOCIATES, INC.

February 14, 2012

Introduction

This *Quality Control Document* has been prepared by Hamp, Mathews and Associates, Inc. (HMA) for the RACER Trust Eckles Road Site in Livonia, Michigan. This document is intended to relate to ambient air, indoor air, soil gas, and sump water sample collection and analysis. This *Quality Control Document* is presented to RACER Trust as a guide for data quality assurance and quality control (QA/QC) for this project. It is to be followed by personnel through all phases from sample collection to analysis.

Project Description

Detailed project activities are presented in the *Vapor Intrusion Field Investigation and Mitigation Work Plan* prepared by HMA. In summary, this project will evaluate the vapor intrusion (VI) pathway within a residential subdivision related to an underlying trichloroethene groundwater plume. To assess the VI pathway, soil gas, indoor air, and crawlspace air samples will be collected and analyzed. The project involves the installation of sub-slab and near slab soil gas ports, collection of soil gas samples, and the placement of 24-hour collection devices for indoor and crawlspace air samples. One water sample from a basement sump is also planned. Laboratory analyses are to be performed by Fibertec Environmental Services, Inc. located in Holt, Michigan. Air and soil gas samples will be analyzed by USEPA method TO-15. The sump water sample will be analyzed by USEPA method 8260. Target analytes are the chlorinated volatile organic compounds listed below along with laboratory quantification limits.

Compound	Air (ppbv)		Water (μg/l)	
	Quantification Limit	Reporting Limit	Quantification Limit	Reporting Limit
1,1,1-trichloroethane	0.27	0.5	0.25	1.0
1,1-dichloroethane	0.27	0.5	0.5	1.0
1,1-dichloroethene	0.27	0.5	0.25	1.0
trichloroethene	0.27	0.5	0.25	1.0
cis-1,2-dichloroethene	0.27	0.5	0.25	1.0
trans-1,2-dichloroethene	0.25	0.5	0.25	1.0
chloroethane	0.26	0.5	1.0	5.0
vinyl chloride	0.26	0.5	0.25	1.0

This project will not attempt to obtain numerous samples from the same locations to verify concentrations, trends in concentrations, or seasonal fluctuations in concentrations. Samples are expected to represent conditions during the heating season; likely a worst case. Only one follow-up sampling event is planned to verify concentrations which are below applicable screening levels or criteria. If the first sample event shows excedences of applicable screening levels or criteria, mitigation efforts are planned for those specific homes. In this event, no confirmation

sampling is planned. Following installation of a mitigation system, three rounds of sampling will be performed to assess performance.

Due to the number of homes (17) which have been selected for soil gas and indoor air sampling, the sampling activities will be completed in phases or rounds. Those seven homes deemed most at risk are to be included in the first round of sampling. A second round would include verification sampling for those homes which did not have excedences in the first round. Rounds three and four will involve original and verification sampling at the remaining ten houses. Data from all sampling events will be assessed to ascertain if the VI investigation needs to be expanded beyond the 17 homes cited in this document.

Data Quality Objectives

The data quality objectives for this project are to obtain representative field samples and to perform analytical evaluation of those samples to support decisions assessing the VI pathway for multiple homes. Since sample collection for each residence will be minimized and only verified if applicable screening levels or criteria are not exceeded, accurate data collection is of paramount importance. Each step of the project, from initial field activities through reporting, must assure that the data quality is not compromised.

To assure data quality, standard operation procedures (SOPs) have been carefully prepared to direct the installation of sub-slab soil gas ports, installation of near-slab soil gas ports, soil gas sample collection, and sump water collection. These SOPs are included as attachments to the project *Vapor Intrusion Field Investigation and Mitigation Plan*. Field personnel will follow these SOPs. Fibertec Environmental Services, Inc. maintains its own SOPs for sample preparation and analysis. Fibertec has provided its *Quality Assurance Manual* which is also included as an attachment to the *Vapor Intrusion Field Investigation and Mitigation Plan*.

Sample Handling and Custody

Samples of all media are physical evidence and must be handled and documented to maintain the integrity of that evidence.

Sample collection will follow the appropriate SOP. Documentation during sample collection provides a record of factors which may have an effect on the quality of the sample whether those are meteorological, environmental, or related to sample collection. Notes of observations including pressure readings, weather conditions, description of surrounding area, etcetera, can all be used to understand external influences on sample quality. Field personnel are instructed to record names of personnel, sample location, sample times, observed conditions, and other information per the SOP in a field notebook or on individual sampling data sheets during sampling activities. Photographs provide visual evidence of field conditions during the sampling

event. HMA staff will take digital photographs as deemed appropriate. The time and location of any photographs will be recorded in the notebook.

Sample containers will be acquired from the laboratory performing the analysis. Summa canisters will be cleaned and batch certified by the laboratory. Sample containers for water samples (40-ml glass vials) will be laboratory persevered with an appropriate amount of the preservative required for the analytes and method of analysis.

Sample containers shall be handled with appropriate care by field personnel during transport to the field, during sample collection, labeling, and transport to the laboratory. Samples will be collected as dictated by the specific SOP. Samplers shall take precautions to prevent possible cross contamination, including handling of sample tubing and other equipment. Sample labels are to be filled out at the time of sample collection to include all appropriate information to distinguish the project, the sample, and the requested analysis. For summa canisters, the start and stop pressures and times are to be written on the attached label. The sample will be recorded on a chain of custody using the same identifying information as on the sample label. The sample will then be placed in an appropriate container for shipment – a box for summa canister, a cooler for water samples.

The chain of custody will be retained by the sampler to record additional samples collected during the sample event. The chain of custody becomes a permanent record of the sampling event and must be filled out legibly and completely. The sampler shall fill in all appropriate information on the chain of custody to ascertain the project:

- company responsible for payment;
- company contact information;
- project reference numbers, codes, or purchase orders;
- HMA project manager contact information; and
- sample identification, time, number of containers, and requested analyses.

If additional sample or analytical clarification is needed, provide a description in the notes section. The sampler shall retain the samples and chain of custody in their possession until delivery to or pick up by the laboratory staff.

For any transfer of the samples from one person to another, the person relinquishing possession is to sign the chain of custody and note the date and time. The person receiving the samples is to verify that the samples being transferred are all identified on the chain of custody and that no samples are missing. That person then signs the chain of custody to take possession of the samples. The chain of custody is then retained by the person taking possession. A carbonless copy of the chain of custody completed at the time of transfer is to be retained by the person relinquishing the samples.

Upon receipt at the laboratory, the samples will be logged into their internal sample tracking system. Each sample will be cross checked with the paper chain of custody provided by the sampler. Any discrepancies shall be documented on the chain of custody, and the HMA project manager is to be informed. The laboratory will assign its own internal sample numbers and relate their project code with the chain of custody number. Internal sample tracking and analyses of the samples is part of the laboratory quality assurance manual.

Upon reporting the analytical results, the laboratory shall provide an Adobe Acrobat file of their report and the chain of custody for distribution to the HMA project manager and others as instructed. The original paper copy of the analytical report is to be provided to RACER Trust along with the original top copy of the chain of custody. Fibertec is to retain a copy of the chain of custody, analytical report, sample logs, instrument calibration data, and other internal records.

The HMA project manager is to collect and retain all field notebooks, sampling data sheets, copies of analytical data report, chain of custody, and other information pertinent to the sampling event in a file. This file shall be retained by HMA, or released to RACER Trust upon request.

Field QA/QC Sample Collection

Four rounds of sampling is planned which will involve original sample collection and verification sampling where needed. Due to the number of home and residents, coordination of all sample collection during a single day may be difficult. Additional site visits may be necessary to accommodate the individual schedules of all residents.

Table 1 identifies the samples which are planned during the sampling rounds. Specific verification sampling activities for investigation group 2will be determined by the results of the original sampling in investigation group 1.

During the 24-hour indoor and crawlspace air sample collection events, ambient air samples will be collected also. Three ambient air samples locations are planned for each of the four sample events. The sample locations will be spread out across the properties being sampled to provide a broad representation of background concentration in ambient air. Sample collection will be by summa canister placed generally downwind of the house on the properties noted in Table 1. A summa canister will be set up to collect the ambient air sample after initiation of the indoor air sample collection for those individual properties. The summa canisters will be positioned approximately five feet above ground level and attached to a fixed object.

Field co-located QA/QC samples will be collected with the frequency of one per 10 sample locations or fewer. Co-located samples will be submitted to the laboratory with the designation CL-N. “N” is a sample number. The co-located samples will be used to determine the reproducibility of the sampling procedure and laboratory analysis. For indoor or crawlspace air samples, two summa canisters will be setup side by side to sample air in the same location. For

soil gas, two samples will be drawn from a single soil gas port back to back. The first sample will be identified as the original and the second as the co-located sample. Both samples will be collected using the same sample tubing train and using the same procedures.

The ambient air and co-located samples will be recorded on the chain of custody and submitted to the laboratory for analysis of the analytes listed on page 1.

Resulting crawlspace concentrations will be compared to USEPA regional screening levels for residential air. Trichloroethene (TCE) will be compared to an indoor air screening level of 2.1 $\mu g/m^3$. Due to the possibility of confounding indoor sources of CVOCs, indoor air sample concentrations will only be used for communication with the resident.

The sub-slab and near-slab soil gas samples will also be compared with the USEPA regional screening levels for indoor air with the application of a 0.1 attenuation factor applied to the screening level (e.g., for TCE 2.1 $\mu g/m^3 \div 0.1 = 21 \mu g/m^3$).

The results of co-located samples will be compared with the results of their original sample. Some minor variability in analytical results between the two samples is expected. If a discrepancy of greater than ten percent is noted, this may indicate an issue with the sample collection or analysis. A review of field notes, field procedures, equipment, sample containers, and internal laboratory review will be performed in an attempt to determine a reason for the discrepancy. If a cause for the difference in sample analyses cannot be identified and rectified or if the difference is less than ten percent, the higher reported analytical result will be compared to the applicable screening level.

The sump water sample will be compared to USEPA maximum contaminant levels or other applicable drinking water standards.

TABLE 1

SUMMARY OF VAPOR INTRUSION FIELD SAMPLES AND QA/QC SAMPLES
LIVONIA ECKLES ROAD SITE

INVESTIGATION GROUP	HOME IDENTIFICATION NUMBER	HOUSE CONSTRUCTION	SAMPLE TYPE/MATRIX	NUMBER OF SAMPLES	QA/QC SAMPLES
1	1	Basement	Basement Indoor Air	1	Ambient Air
			First Floor Indoor Air	1	
			Sub-Slab Soil Gas	2	
	2	Crawlspace, Basement, Sump [1]	Crawlspace Air	1	
			Basement Indoor Air	1	Co-Located
			First Floor Air	1	
			Sub-Slab Soil Gas	1	
			Sump Water	1	
	3	Crawlspace	Crawlspace Air	1	
			First Floor Indoor Air	1	
			Near-Slab Soil Gas	1	
	4	Crawlspace	Crawlspace Air	1	Ambient Air
			First Floor Indoor Air	1	
			Near-Slab Soil Gas	1	
	5	Crawlspace	Crawlspace Air	1	
			First Floor Indoor Air	1	Co-Located
			Near-Slab Soil Gas	1	
	6	Crawlspace	Crawlspace Air	1	
			First Floor Indoor Air	1	
			Near-Slab Soil Gas	1	
	7	Basement	Basement Indoor Air	1	Ambient Air
			First Floor Indoor Air	1	
			Sub-Slab Soil Gas	2	Co-Located

[1] The basement at home 2 is approximately 8 feet by 8 feet on the southwest corner of the house, and contains a furnace and water heater. A crawlspace is present *along the outer perimeter of this space*; i.e., the crawlspace does not extend beneath the footprint of the house, only the outer edge of the 8 feet by 8 feet basement space. Consequently, one sub-slab soil gas port is adequate to evaluate the soil gas under this basement. The "sump" is merely a drain hole, and will be sampled if water is present.

"Co-Located" indicates that an additional (duplicate) sample will be collected at the same location.

TABLE 1 Continued

SUMMARY OF VAPOR INTRUSION FIELD SAMPLES AND QA/QC SAMPLES
LIVONIA ECKLES ROAD SITE

INVESTIGATION GROUP	HOME IDENTIFICATION NUMBER	HOUSE CONSTRUCTION	SAMPLE TYPE/MATRIX	NUMBER OF SAMPLES	QA/QC SAMPLES
2	8	Basement	Basement Indoor Air	1	Ambient Air
			First Floor Indoor Air	1	Co-Located
			Sub-Slab Soil Gas	2	
	9	Slab	First Floor Indoor Air	1	
			Sub-Slab Soil Gas	2	
	10	Slab	First Floor Indoor Air	1	Ambient Air
			Sub-Slab Soil Gas	2	
	11	Basement	Basement Indoor Air	1	Co-Located
			First Floor Indoor Air	1	
			Sub-Slab Soil Gas	2	
	12	Crawlspace	Crawlspace Air	1	
			First Floor Indoor Air	1	
			Near-Slab Soil Gas	1	
	13	Basement	Basement Indoor Air	1	Ambient Air
			First Floor Indoor Air	1	
			Sub-Slab Soil Gas	2	Co-Located
	14	Crawlspace	Crawlspace Air	1	
			First Floor Indoor Air	1	
			Near-Slab Soil Gas	1	
	15	Crawlspace	Crawlspace Air	1	
			First Floor Indoor Air	1	Co-Located
			Near-Slab Soil Gas	1	
	16	Basement	Basement Indoor Air	1	Ambient Air
			First Floor Indoor Air	1	
			Sub-Slab Soil Gas	2	Co-Located
	17	Crawlspace	Crawlspace Air	1	
			First Floor Indoor Air	1	
			Near-Slab Soil Gas	1	

ATTACHMENT A

FIBERTEC ENVIRONMENTAL SERVICES, INC.
QUALITY ASSURANCE MANUAL

HAMP, MATHEWS &
ASSOCIATES, INC.

Fibertec
environmental
services

Quality Assurance Manual
Revision 6.3
(3/11/11)

Fibertec, Inc.
1914 Holloway Drive
Holt, MI 48842
(517) 699-0345

www.fibertec.us

This manual has been reviewed and approved by the president, laboratory director, and quality assurance officer laboratory of Fibertec, Inc. as indicated below.

Matthew H. Frisch - *President* — Date: 3/3/11

Daryl P. Strandbergh - *Laboratory Director* — Date: 3/3/2011

Peter Priniski - *Quality Assurance Officer* — Date: 3/3/11

The following units are subject to the standards outlined in this manual: entire environmental laboratory, including: semi-volatile organics department, volatile organics department, trace metals department, wet chemistry department.

Table of Contents

Section 1 – Introduction and Scope

The purpose of this Quality Manual is to outline the quality system for the laboratory. The Quality Manual defines the policies, procedures and documentation that assure analytical services continually meet a defined standard of quality that is designed to provide clients with data of known and documented quality and, where applicable, demonstrate regulatory compliance.

This manual also serves to provide guidance to laboratory staff in support of maintaining and improving Fibertec's quality system through documentation of Fibertec's laboratory quality policies and procedures.

All laboratory staff and the activities conducted by the following departments are subject to the standards outlined in this manual.

1) Semi-volatile organics Laboratory
2) Metals Laboratory
3) Volatile organics Laboratory
4) Wet chemistry Laboratory
5) Sample Preparation Laboratory
6) Sample Receiving
7) Project Management/Support
8) Report Generation
9) Waste Management

Compliance with the standards outlined in this manual is required to achieve and maintain the highest quality laboratory data. Where an individual test method or procedure requires an even higher standard, that procedure's requirements supersede those described herein.

This manual incorporates the requirements outlined in National Environmental Laboratory Accreditation Conference (NELAC) Quality Systems, (6/5/03), as well as quality control procedures adapted from American Society for Testing and Materials (ASTM), and United States Environmental Protection Agency (USEPA) standards.

Policy Statement

We are committed to providing our clients with accurate and timely analytical results. Our corporate vision is to provide the highest quality services in the shortest possible time and at the most reasonable price.

1.1 Changes from the Previous Revision

Lab Operations Coordinator description (section 2.2.4, 15.1.4)
Note to File procedure (section 4.1.2).
Added references to associated SOPs (in various areas)
Non-standard Methods (section 17.5)
CCV fail criteria clarification (section 18.3.4)

Reagents (section 19.4)
Diluent (section 19.6)
Data Quality Assessment (section 21.1)

1.2 Scope of Testing

Fibertec Environmental Service's scope of analytical testing services includes those analytical and preparative methods listed in **Appendix A**.

Matrices analyzed include Ground Water, Waste Water, Effluent, TCLP, Soil, Sludge, Oil, Non-aqueous Liquid, Air, Solid Sorbent Material, and other extracts.

1.3 References and Appendices

National Environmental Laboratory Accreditation Conference, Quality Systems, June 5, 2003.

EPA 2185 – Good Automated Laboratory Practices, 1995

Title 35: Environmental Protection, Subtitle A: General Provisions, Chapter II: Environmental Protection Agency, Part 186, Accreditation of Laboratories for Drinking Water, Wastewater and Hazardous Waste Analysis, Section 186.120 – Definitions

40 CFR Part 136, Appendix B, Definition and Procedure for the Determination of the Method Detection Limit. Revision. 1.11

USEPA, "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods", SW-846, On Line.

USEPA, "Methods and Guidance for Analysis of Water"

Standard Methods for the Examination of Water and Wastewater, 20th Edition

1.4 Glossary and Acronyms Used

The use of the terms "must" and "shall" are intended to communicate a mandatory requirement in this and other quality assurance documents (e.g. SOPs). The terms "may" and "should" are intended to communicate a recommendation or option. The employment of this option shall be communicated in the associated preparatory or analytical documentation (e.g. prep log or analytical run log).

The following definitions are reprinted, in whole or in part, from Title 35: Environmental Protection, Subtitle A: General Provisions, Chapter II: Environmental Protection Agency, Part 186, Accreditation of Laboratories for Drinking Water, Wastewater and Hazardous Waste Analysis, Section 186.120 – Definitions, and the NELAC Standard 2003.

Acceptance limits means the data quality limits specified for analytical method performance.

Accreditation means the issuance by the Certifying Agency of certificates of competency to laboratories meeting the minimum standards established by the Agency in the NELAC Standard. Accreditation is not a guarantee of the validity of the data generated by the accredited laboratory.

Accredited laboratory means a laboratory that has met the criteria established by the NELAC Standard.

Accrediting authority means the state or federal agency having the responsibility and accountability to grant accreditation to laboratories via the NELAC program.

Accuracy means a measure of the degree of agreement between an observed value generated by a specific procedure and a true value. Accuracy includes a combination of random error (precision) and systematic error (bias) components which are due to sampling and analytical operations.

ASTM means the American Society for Testing and Materials, West Conshohocken, PA, a not-for-profit, voluntary standards development system.

Analyte means a chemical element, chemical compound, or physical property.

Analyte of interest means the chemical element, chemical compound, or physical property for which the laboratory is performing an analysis to determine the quantity in a sample for reporting.

Analyzed reagents (AR) means chemicals analyzed for impurities where the level of impurities is reported in accordance with specifications of the Committee on Analytical Reagents of the American Chemical Society.

Analytical standard means a solution of a compound or a mixture of compounds of known purity in an appropriate solvent used to prepare calibration standards. An analytical standard will be traceable to NIST standard reference materials.

Applicant laboratory means any laboratory seeking initial accreditation.

Application means a verified written request for accreditation containing all the information required in the NELAC Standard 2003.

Application package means the application, invoice, accreditation fee and related materials described in the NELAC Standard 2003.

Approved performance evaluation program means a performance evaluation program which meets the requirements of the NELAC Standard 2003.

Approved test methods means the analytical methods published by the EPA or other nationally recognized analytical authority (such as ASTM, Standard Methods, etc.).

ASTM E1301-95 means Standard Guide for Proficiency Testing by Interlaboratory Comparisons.

Audit means a thorough, systematic, qualitative examination of a laboratory for compliance with this Part, including but not limited to an examination of any of the following: facilities, equipment, personnel, training, procedures, documentation, record keeping, data verification, data validation, data management, data reporting, or any aspect of the laboratory's activities which affect the laboratory's ability to meet the Agency's conditions for accreditation or comply with this Part.

Batch means one to 20 environmental samples of the same matrix that are prepared together with the same process and personnel, using the same lot of reagents with a maximum time between the start of processing of the first sample and the start of processing of the last sample being 24 hours.

Bias means the systematic or persistent distortion of a measurement system which causes errors in one direction (the expected sample measurement is different from the true value).

Bi-Weight program means the computer program utilized by the USEPA to evaluate performance evaluation study data. The Bi-Weight program uses statistical evaluation procedures that are robust to outliers. The Bi-Weight program can be obtained from the United States Environmental Protection Agency, National Exposure Research Laboratory, National Water Quality Assurance Programs Branch, Ecological Exposure Research Division, Cincinnati, OH 45268.

Blind sample means a subsample for analysis with a composition known to the submitter that is used to test the analyst's, analyst-in-training's, or technician's proficiency in the execution of the measurement system. The analyst, analyst-in-training, or technician will know the identity of the sample but not its composition. The laboratory management may know the identity and composition of the blind sample. PE samples are blind samples who's values are only known by the vendor.

Calibrate means initial calibration which usually needs to be verified with an ICV and on-going verification done by CCV.

Calibration blank means a volume of deionized water containing the same reagents, solvents, acids, or preservatives contained in the calibration standards. The calibration blank is used to determine the response of the instrument to the zero concentration of an analyte of interest.

Calibration standard means a solution of an analyte or mixture of analytes of known purity in an appropriate solvent used to calibrate the analytical instrument response with respect to analyte concentration.

Certificate (certificate of approval) means a document issued by the Agency to a laboratory that has met the criteria and conditions for accreditation as set forth in the NELAC Standard. The certificate will be used as proof of accredited status. A certificate is always accompanied with a scope of accreditation.

Certification means accreditation.

Certified laboratory means an accredited laboratory.

Certifying authority means an accrediting authority.

Chromatographic range means the time frame over which analytes move out of the chromatography column.

Competence means the ability of a laboratory to meet the Certifying authority's conditions for accreditation and to conform to the criteria contained in the NELAC Standard, 2003.

Confidence interval means that range of values, calculated from an estimate of the mean and standard deviation, which is expected to include the population mean with a stated level of certainty. These values may be estimated from LCS recovery data and applied to client data, upon request from the client.

Continuing calibration verification (CCV) check means the analysis of continuing calibration verification check standard to determine the state of calibration of an instrument between recalibrations, as required by NELAC 2003, section 5.5.5.10.

Continuing calibration verification check standard means a solution of an analyte or mixture of analytes of known purity in an appropriate solvent used to perform the continuing calibration verification check. The source of the analyte will be the same as the source of the calibration standards' source or it will be a second source.

Controlled access storage means a refrigerator, cooler, rooms or building in which samples are held and from which samples will be removed only by authorized laboratory personnel.

Corrective action means an action taken by the laboratory to eliminate or correct the causes of an existing nonconformance in order to prevent the recurrence of the nonconformance.

Corrective action plan means a plan of corrective actions.

Deficiency means a failure of a laboratory to meet any requirement of the NELAC Standard.

Deficiency report means a narrative from the Certifying Agency which details areas of noncompliance with the NELAC Standard.

Desk audit means an audit of a laboratory's documentation maintained in support of the NELAC accreditation.

Director means the Director of the Kansas Department of Health and Environment.

Document means any written or pictorial information describing, defining, specifying, reporting, or certifying any activities, requirements, procedures, or results.

Drinking water means water used or intended for use as potable water.

Drinking water analyses means analyses performed on water used or intended for use as potable water.

Drinking water sample data means analytical results generated by drinking water analysis.

Effective date means the date that the document becomes 'active' and is implemented in the laboratory.

Environmental samples means samples, excluding any laboratory generated quality control samples such as matrix spikes, duplicates, and laboratory control samples, for which the laboratory analytical results will be reported to clients.

Environmental sample data means measurement and preparation documents generated in support of the analysis and reporting of environmental samples.

EPA No. 600/8-91/213 means Standard Operating Procedure for Lead in Paint by Hotplate or Microwave-Based Acid Digestions and Atomic Absorption or Inductively Coupled Plasma Emission Spectrometry.

Evidentiary chain-of-custody means the procedures and records which ensure that an intact, contiguous written record tracing the possession and handling of samples from the point that clean sample containers are provided by the laboratory or the point of sample collection through disposal are maintained.

Final performance evaluation report means a statement prepared by the USEPA or an Agency approved performance evaluation program that describes or evaluates a laboratory's performance after the laboratory's analyses of performance evaluation samples.

Initial calibration means the analyses of calibration standards for a series of different specified concentrations of an analyte of interest used to define the linearity and dynamic range of the response of the instrument to an analyte.

Initial calibration verification (ICV) check means analysis of an initial calibration verification check standard to determine the state of calibration of an instrument before sample analysis is initiated, as required by NELAC 2003, section 5.5.5.2.2.1.d.

Initial calibration verification check standard means a solution of an analyte or mixture of analytes of known purity in an appropriate solvent used to perform the initial calibration verification check.

Initial demonstration of capability (IDOC) study means the procedures performed by an analyst that insure that the analyst does not analyze unknown samples via a new or unfamiliar method prior to obtaining experience as described in the NELAC Standard 2003, appendix C of the 5 th chapter.

Inorganic means all parameters not included in organic parameters.

Laboratory means a facility that is equipped and used for the testing of samples for the fields of testing described by matrix, technology, and analyte/analyte group. A laboratory with a main facility and an annex in the same city as the main facility and within 5 miles of the main facility will be considered one laboratory.

Laboratory control sample (LCS) means an uncontaminated sample matrix with known quantities of analytes. The analytes shall be obtained from a source differing from that of the calibration. The laboratory control sample is analyzed exactly like a sample to determine whether the measurement system is performing as expected using the evaluation procedures described in the analytical SOP and to determine whether the laboratory is capable of making accurate and unbiased measurements.

Laboratory control Duplicate (LCD) When precision must be evaluated, a second LCS is prepared and analyzed.

Least precise step means the part of the analytical procedure that result in the greatest error in measurement.

Linear calibration range means linear dynamic range.

Limit of Detection (LOD) an estimate of the minimum amount of a substance that an analytical process can reliably detect.

Limit of Quantitation (LOQ) the minimum concentration of a target analyte that may be reported with a specified level of confidence.

Linear dynamic range means the range of concentrations over which the analytical system exhibits a linear relationship between the amount of material introduced into the instrument and the instrument's response.

Litigation sample means a sample, knowingly analyzed by the laboratory, for possible legal action.

Major remodeling means any remodeling of the laboratory facility that requires the acquisition of a local building permit.

Matrix means the predominant material of which the sample to be analyzed is composed. Sample matrices are:

*** Aqueous** means any aqueous sample other than drinking water, potable water, or saline or estuarine water;

*** Drinking water** means water used or intended for use as potable water;

*** Non-aqueous liquid** means any organic fluid with < 15% settleable solids;

*** Saline or estuarine waters** means any aqueous sample from an ocean or estuary.

*** Solids** means soils, sediments, sludges and other matrices with > 15 % settleable solids.

*** Chemical waste** means a product or by-product of an industrial process that results in a matrix not previously defined.

Matrix spike (MS) means an aliquot of matrix fortified (spiked) with known quantities of specific analytes and subjected to the entire analytical procedure in order to determine the effect of the matrix on an approved test method's recovery system.

Matrix spike duplicate (MSD) means a replicate matrix spike that is prepared and analyzed in order to determine the precision of the approved test method.

Measurement system means any instruments, gauges, tolls, devices, equipment, procedures, methods, or aggregates thereof, used to acquire or control sample data generated pursuant to report to clients.

Method means a procedure or technique for performing an activity (for example sample preparation and sample analysis).

Method blank (MB) means a sample which does not contain an analyte of interest above an acceptable level, generally less than the reporting level, and which is processed simultaneously with and under the same conditions as samples being analyzed for analytes of interest.

Method detection limit (MDL) means the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix type containing the analyte. Unless specified by the approved test method, the method detection limit shall be determined using the procedures specified in 40 CFR part 136, appendix B.

Megohm-cm means megohm-centimeter.

mg means milligram.

µmhos/cm means micromhos per centimeter.

National Environmental Laboratory Accreditation Conference (NELAC) means a voluntary association of state and federal agencies whose purpose is to establish and promote mutually acceptable performance standards for the operation of environmental laboratories.

Neat compound means an undiluted compound.

NIST means the Untied States Department of Commerce, Technology Administration, National Institute of Standards and Technology (formerly National Bureau of Standards).

Nonconformance means deficiency of a laboratory to meet any requirement of the NELAC Standard.

On-site evaluation means the physical process on inspecting a laboratory to assess the ability of the laboratory to meet the Agency's conditions for accreditation and to assess the laboratory's conformance with the criteria found in the NELAC Standard 2003.

On-site evaluation deficiency report means a report generated by the Agency in response to non-conformances noted in the course of a laboratory on-site evaluation.

Operating condition means the state of the measurement system when samples are analyzed.

Organic means all analytes analyzed by all forms of gas chromatography and high pressure liquid chromatography (excluding ion chromatography).

Parameter means an analyte.

Pattern of peak profile recognition for identification means a series of chromatographic peaks used to identify multi-component analytes such as the Aroclors, petroleum products, Toxaphene and technical Chlordane. The series of peaks used to identify a multi-component analyte have characteristic sizes, shapes and retention times.

PE means performance evaluation.

Performance evaluation program means the aggregate of providing rigorously controlled and standardized samples to a laboratory for analysis, reporting of results, statistical evaluation of the results in comparison to peer laboratories and the collective demographics and results summary of all participating laboratories.

Performance evaluation sample means a sample prepared and supplied either by the Agency or and Agency approved performance evaluation program, whose composition is unknown to the laboratory management, analyst, analyst-in-training, and technician. The performance evaluation sample is provided to test whether the laboratory can produce analytical results within specified performance limits.

Performance evaluation testing means the determination of laboratory performance by means of comparing and evaluating tests on the same or similar items or materials by two or more laboratories in accordance with predetermined conditions.

Performance evaluation study means a single testing event within a performance evaluation program.

Plan of corrective action means a report, including specific items addressed and specific dates of completion, generated by a laboratory in response to a non-conformance from internal or external audit, performance sample failure, or process malfunction.

Practical Quantitation Limit (PQL) – the concentration equal to the lowest acceptable concentration on the current calibration curve. The PQL must be higher than the MDL. No numerical values may be reported below this value unless accompanied with a “J” flag indicating the value is an estimate.

Precision means the measure of mutual agreement among individual measurements of a sample, usually under prescribed similar conditions, usually expressed as the standard deviation, variance, or range, in either absolute or relative terms.

Preliminary performance evaluation report means a statement prepared by a laboratory which is sent to the USEPA or an Agency approved performance evaluation program which lists the laboratory’s results obtained from the analyses of performance evaluation samples and the approved test method used to obtain the results.

Quality assurance means an integrated system of activities involving planning, quality control, quality assessment, reporting, and quality improvement to ensure that a product or service meets the requirements of the published methods or established standards of performance.

Quality assurance plan (QAP) means a written description of the laboratory’s integrated system of activities involving planning, quality control, quality assessment, reporting and quality improvement to ensure that a product or service meets defined standards of quality with a stated level of confidence.

Quality control means the overall system of technical activities whose purpose is to measure and control the quality of a product or service so that it meets the needs of users.

Quality control acceptance limits means the statistically determined or approved test method specified limits within a single measurement, quality control data point, series of measurements or series of quality control data points will fall when the analytical process is producing data of satisfactory quality.

Quality control chart means a graphical plot of data points used to demonstrate statistical control and monitor a measurement process. The charts have a vertical scale plotted in units of the analytical results, a horizontal scale in units of time or sequence of results, and lines within which or around which the data points are expected to lie.

Quality control check sample means an aliquot of method blank fortified with a solution of the analytes of interest of known concentration obtained from an outside source. The quality control check sample is used to check either laboratory or instrument performance. Quality control procedures means the activities used to measure and monitor the accuracy and reliability of an analytical procedure or method.

Quantitating means the arithmetic process of determining the amount of analyte in a sample.

Replicate means two or more equal aliquots taken from the same sample container and analyzed independently for the same constituent.

Reporting Limit (RL) – a concentration established by the laboratory to meet regulatory or client specific requirements, under which no numerical value is reported. The RL is usually above the PQL but MUST be at or above the MDL.

Revocation means the withdrawal of all or part of a laboratory's accreditation by the Certifying Authority.

Sample means any solution or media introduced into an analytical instrument on which an analysis is performed excluding calibration standards, initial calibration verification check standards, calibration blanks, and continuing calibration verification check standards.

Sample tracking means an unbroken trail of accountability that ensures the physical security of samples, data, and records.

Sample duplicate means two equal aliquots taken from the same sample container and analyzed independently for the same constituent.

Scope of accreditation means a document issued by the Certifying Authority which lists the field-of-testing, approved test methods, and analytes for which the laboratory is accredited.

Second source means a different vendor or manufacturer, or different lots from the same vendor or manufacturer.

Spike concentration means a specified amount of an analyte of interest in a matrix spike, laboratory control sample, or quality control check sample.

Stable means resistant to displacement or change.

Standard operating procedure (SOP) means a written, laboratory specific document which details the method of an operation, analysis or action whose techniques and procedures are thoroughly prescribed and which is accepted as the method for performing certain routine or repetitive tasks.

Statistical outlier test means a mathematical process for determining that an observation is unusually large or small relative to the other values in a data set.

Surrogate means an organic compound which is similar to the analytes of interest in chemical composition and behavior in the analytical process, but which is not normally found in environmental samples.

Suspension means the temporary removal of all or part of a laboratory's accreditation for a defined period of time. The purpose of suspension is to allow a laboratory time to correct deficiencies or areas of noncompliance with program requirements as defined in the NELAC Standard.

Standard Methods means Standard Methods for the Examination of Water and Wastewater, 20th edition, 1998.

Test means a technical operation that consists of the determination of one or more characteristics or performances of a given product, material, equipment, organism, physical phenomenon, process or service according to a specified procedure.

Traceability means the property of a result of a measurement whereby it can be related to appropriate standards, usually international or national standards, through an unbroken chain of comparisons.

True value means the accepted or actual value of the quantity being measured.

USEPA means the United States Environmental Protection Agency.

USEPA Water Pollution (WP) Performance Evaluation Study means a performance evaluation program originally sponsored by the USEPA. Laboratory participation is now initiated by contacting vendors approved by NELAC http://www.nelac-institute.org/ptproviders.php.

USEPA Water Supply (WS) Performance Evaluation Study means a performance evaluation program originally sponsored by the USEPA. Laboratory participation initiated by contacting vendors approved by NELAC http://www.nelac-institute.org/ptproviders.php.

Validation means confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled. Validation is the process of examining a sample result to determine conformance with users' needs.

Verification means confirmation by examination of and provision of objective evidence that specified requirements have been fulfilled. Verification is the process of examining a result of a given activity to determine conformance with the NELAC Standard.

Section 2 – Organizational Roles and Responsibilities

Laboratory management is responsible for the development of a proactive program to prevent and detect improper, unethical and illegal action in the laboratory. This includes: proficiency testing (single and double-blind); post-analysis electronic data and data storage audits; effective program to improve employee vigilance and co-monitoring; and separate SOPs identifying appropriate and inappropriate laboratory and instrument data manipulation practices. [Related SOPs: G-342 "Laboratory Ethics and Data Integrity", G-220 "Chromatographic Manual Integration Procedure"]

Laboratory management is responsible for defining the qualification and training requirements for staff positions within the laboratory. In addition, laboratory management is responsible for the documentation of all education, training and performance of laboratory staff to ensure that qualified personnel are performing appropriate duties. It is one of the Technical Director's roles to verify that the background and training of each employee is adequate for the performance of the analytical or preparative tasks that they are assigned.

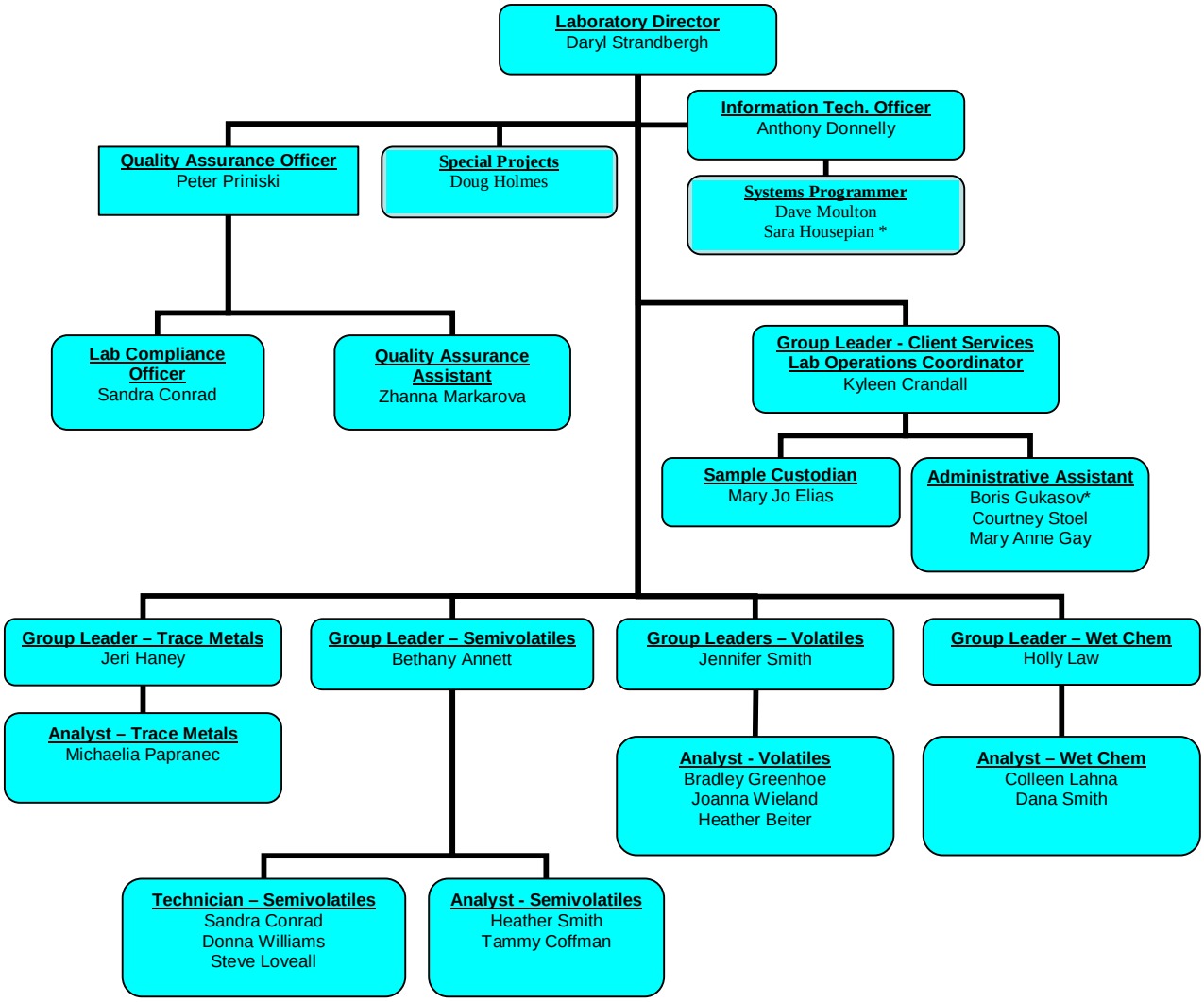
The laboratory approved signatories for lab reports are the following:

1) Laboratory/Technical Director — Daryl Strandbergh
2) Quality Assurance Officer — Peter Priniski
3) Client Services Group Leader — Kyleen Crandall
4) Information Tech. Officer — Anthony Donnelly

2.1 Laboratory Organizational Structure

FES Organization Chart

Updated: Sept 7, 2010



**part-time employee/non-company*

2.2 Responsibility and Authority

2.2.1 Laboratory Director is responsible for the following:

1 Analytical and operational activities of the laboratory
2 Supervision of personnel employed by the laboratory
3 Assuring that sample acceptance criteria are met, that samples are logged into the sample tracking system, that samples are properly labeled, and that samples are properly stored
4 The production and quality of data reported by the laboratory
5 Designating laboratory supervisors, and
6 Designating at least one individual as the quality assurance officer
7 Ensuring the laboratory is staffed with personnel who possess the appropriate educational and/or technical background requirements of their job
8 Monitoring standards of performance in QC/QA oversight of quality system
9 Monitoring the validity of analyses performed and data generated to assure reliable data
10 Oversight of service and turnaround of laboratory
11 Maintenance of laboratory licensure, certification and accreditation
12 Provide direction and consistency in support of quality system
13 Allocation of financial resources for the laboratory
14 Ensure prompt and thorough investigation and resolution of customer complaints
15 Client interaction
16 Set laboratory policies and allocates resources

2.2.2 The Technical Director is responsible for the following:

1 Monitor standards of performance of QA/QC
2 Monitor the validity of analyses performed and data generated to assure reliability
3 Monitor the technical competence of personnel
4 If absent for more than 15 consecutive days, another employee with appropriate qualification must be assigned this task. If absent for more than 35 days, the accreditation body must be informed of the temporary replacement in writing.

2.2.3 Quality Assurance Officer is responsible for the following:

1 Coordinating QA/QC procedures and analytical data review procedures in the laboratory
2 Verifying that the requirements of the laboratory quality system are met
3 Updating this quality manual as needed
4 Conducting internal audits of the entire laboratory annually
5 Notify management of deficiencies in the quality system and monitor corrective action.
6 Maintenance of lab accuracy and precision data
7 Maintenance of lab training records.
8 Coordinating of the lab performance sample program

2.2.4 Laboratory Operations Coordinator

1 Evaluates the current capacity to accept new work
2 Determines current status of client projects
3 Determines current status of Corrective Action Efforts
4 Provides status reports to clients and managers
5 Communicates approaching deadlines to staff
6 Aids in resolving scheduling conflicts

2.2.5 Group Leaders are responsible for the following:

1 Supervising analysts, analysts-in-training and technicians in the area of analytical responsibility
2 Reviewing and verifying data produced by an analyst-in-training
3 Reviewing and verifying data produced by a technician
4 Compliance with QA system
5 Development and review of Standard Operating Procedures (SOPs)
6 Assures compliance with client requirements
7 Monitors laboratory adherence to approved policies and procedures
8 Oversee data quality

2.2.6 Analysts are responsible for the following:

1 Reviewing and verifying data produced by analysts-in-training or technician when a laboratory supervisor does not review and verify the data
2 Compliance with quality system
3 Development and review of SOPs
4 Compliance with client requirements
5 Oversight of data quality
6 Monitors laboratory adherence to approved policies and procedures
7 Perform routine maintenance as required

2.2.7 Technicians are responsible for the following:

1 Obtaining the correct sample containers from sample storage
2 Following approved preparative procedures
3 Communicating any deviations needed from procedures to project management and documenting the deviation.
4 Record any observations that may impact the quality of the analytical result.

Section 3 – Quality Systems

3.1 Quality Policy

All quality control measures shall be assessed and evaluated on an on-going basis. The quality control acceptance criteria shall be used to determine the validity of the data. The validity of the data is communicated to the client either prior to release of the final report or as part of the final report.

3.2 Quality Manual

The Quality Manual defines the policies, procedures and documentation that assure analytical services continually meet a defined standard of quality that is designed to provide clients with data of known and documented quality and, where applicable, demonstrate regulatory compliance.

Section 4 – Document Management

4.1 Controlled Documents

Fibertec defines controlling a document as the process of maintaining the document in an unmodified state to ensure the available document is current. The term assures the user that the document they have is the latest operational version of the document. Laboratory controlled documents are only found on the laboratory intranet. Printed versions of these documents may be generated by Fibertec personnel, but are considered ‘uncontrolled’ and must be verified by the user.

Controlled documents that are required for employees to know and follow must have a signature page associated with the original hard copy. The employee may either review the document on line or the hardcopy. The employee then signs the signature page indicating that they have read, understood, and agree to follow the guidance of the reviewed document.

4.1.1 Changes to Controlled Documents

When major changes are needed in controlled documents, a revision is initiated by the analyst, group leader or QAO. After review, corrections, and approval, the SOPs, QAM, CHP documents are reduced to a PDF and made available on the company intranet. The original documents are kept in the QA Office. Spreadsheets, logbook pages, bench sheets, reside on the intranet. An E-mail is sent to the IT group to implement the electronic copy and to the affected group leader to have their affected personnel review the document and sign the review sheet associated with the revision, when appropriate. [Related SOPs: G301 “Record Keeping System and Design”, G-308 “Control of Documents Procedure”]

4.1.2 Note to File Procedure

Minor modifications to control documents may be implemented by filling out a ‘Note to File’ form. This form describes the required change, the section in the document where the change must be made and concludes with the approval signatures of the group leader, QAO, and Technical Director. The form is then scanned and associated with the electronic controlled document. The original approved ‘Note to File’ form is placed in the original SOP folder with the hard copy of the original SOP. The change is incorporated into the next revision of that document.

4.2 Obsolete Documents

When documents are superseded or no longer valid, the document is removed from the intranet and an E-mail is sent to the affected group leader(s) requesting that all personnel responsible for the activities described in the new document review the new version of the document and sign the review form found in the QA Office.

4.3 Standard Operating Procedures

Standard operating procedures (SOPs) document and outline all phases of current laboratory activities. This includes directions for the operation of all laboratory equipment, sample handling, calibration and verification practices, assessment of data integrity, corrective actions, handling of customer complaints, and all test methods. SOPs will be manufacturer equipment manuals, or internally produced documents. Copies of all SOPs shall be accessible to all personnel, and shall be organized and kept up-to-date. Each SOP shall indicate the effective date of its use, the revision number and appropriate laboratory management approval. [Related SOPs: G-300 “Development of Standard Operating Procedures”]

4.3.1 Test Method SOPs

Test method SOPs will consist of copies of published methods or methods that have been written by laboratory personnel. A published test method will substitute for a laboratory SOP only when the method is followed without deviation. Modifications to test methods must be documented to clearly show the variation from the published method and the approval of the modification by laboratory management. Modification is not permitted for VAP projects from Ohio. Each test method SOP shall include or reference the following:

- Identification of test method (Title Page w/ Approval Signatures, unique ID#, active dates)
- Scope and Application
- Summary of the test method

- Deviations from test method
- Definitions
- Interference
- Safety
- Equipment and supplies
- Reagents and standards
- Sample collection, preservation, shipment and storage
- Quality Control
- Initial Demonstration of Performance Requirements
- Limit of Detection Criteria
- Calibration, standardization
- Procedure
- Data analysis and calculations
- Method performance and Acceptance
- Pollution prevention and waste management
- References
- Changes from last revision
- Tables
- Worksheets

4.3.2 Administrative SOPs

Administrative SOPs are work documents describing activities not having QC requirements and address administrative activities. Examples include: LIMS reporting procedures, Sample Receiving Activities, Preparing Sample Bottles, Disposal of Expired Samples, etc. Administrative SOPs contain the following sections.

- Title
- Summary
- Definitions
- Procedure
- References
- Changes Since Last Revision
- Tables or Forms

Section 5 – Review of Requests, Tenders and Contracts

5.1 Procedure for the Review of Work Requests

Prior to accepting new projects into the laboratory, the following items are verified:

1 The laboratory has the appropriate analytical equipment/facilities required to perform the work
2 The laboratory has any necessary certifications that will be required to perform the work (i.e. drinking water)
3 The laboratory's current workload will allow the new work to be performed in a timely manner in order to achieve the client's required turnaround as well as all data quality objectives
4 The client is provided a copy of the Laboratory Acceptance Policy so they are aware of the required sample containers, sample volume, and preservatives.

When the above items are successfully addressed, the laboratory proceeds with accepting the new project.

5.2 Documentation of Review

Record of review, including any significant changes, shall be maintained in the client folder. Records shall include any client specific requirements and include the date and identification of the person in the lab responsible for communicating the client requirements to the lab and reporting function. For more complex requirements a comprehensive record must be maintained.

Section 6 – Subcontracting of Tests

When the laboratory accepts new projects with the intention of subcontracting either a portion or the entire project to a third party laboratory, the laboratory shall contact the client by E-mail, informing the client that a portion of the project will be sub-contracted, the reason for the sending of the sample(s) and that future requests for the parameter(s) involved will also be sub-contracted. This documentation and the client reply is retained with the project file.

When the laboratory subcontracts work that requires NELAP compliance, the laboratory shall ensure that the subcontracting laboratory is NELAP approved, or otherwise certified to perform the tests and report results for the tests it will perform.

All tests performed by the subcontracted laboratory shall be clearly indicated on the final laboratory report with the name and accreditation number (if applicable) clearly linked to the applicable test result(s). [Related SOP: G-303 “Subcontracting”]

Section 7 – Purchasing Services and Supplies

The laboratory shall verify that any product or service obtained conforms to the requirements of NELAP and is consistent with the laboratory data quality objectives. The laboratory shall ensure that purchased equipment and consumables materials are not used until they have been inspected, calibrated or otherwise verified as compliant with the requirements of the calibrations or tests concerned. [Related SOPs: G-304 “Purchasing”]

The Fibertec Purchasing Agent shall maintain certification records of all suppliers of outside services or supplies in their respective vendor information file, when available.

For the purpose of this manual, the following list is comprised of the suppliers that provide the current majority of laboratory services, and is subject to change without notice.

Service	*Supplier*
Deionized Water	Culligan Water Conditioning, 3460 Dunkel Rd., Lansing, MI 48911 (517) 393-1300
Compressed/Liquid Gases	Air Gas, 2140 Mint Rd., Lansing, MI 48906
Laboratory Consumables and Reagents	Fisher Scientific, Dept. CH 10119, Palatine, IL 60055-0119
Proficiency Test Samples	NSI Solutions, Inc., 7517 Precision Drive, Suite 101, Raleigh, NC 27617
Reference Material Calibration	Toby’s Instrument Shop, 1382 Industrial Drive, Suite 6, Saline, MI 48176

Section 8 – Service to the Client

8.1 Client Confidentiality

In order to protect client confidentiality, the laboratory maintains the following policies:

1) Laboratory personnel are informed of the confidential nature and possible legal ramifications of divulging client information. This includes:
   a) Stressing the ethical basis for confidentiality in testing
   b) Explanation of the possible liability of laboratory, as well as personal liability (i.e. legal action or removal)
2) Any client project information that is requested by a third party is not released without the written or documented verbal approval of the original client. This includes:
   a) All client project information
   b) Client-laboratory communications and directives
   c) All project raw data
   d) Final laboratory report
3) All documents relating to client projects are maintained under controlled access conditions. This means:
   a) All documents are stored on-site at the laboratory
   b) All main entry points to the laboratory facility are manned by at least one laboratory staff member during normal business hours
   c) Secondary external entries to laboratory facilities remain locked during normal business hours and all entries are locked in the evening
   d) Guests must sign in when entering the laboratory facility, must have a staff member escort them while in the laboratory, and must sign out when leaving the laboratory

All client information is subject to the above stated policy.

Section 9 – Complaints

Complaints received by the laboratory must be dealt with in a timely and thorough manner. When a complaint arises regarding the quality of a sample result, or concerning a laboratory practice, the following general chain-of-events shall proceed:

1) Complaining party is directed to the client services manager. Depending on the severity of the issue, the laboratory manager may become involved.
2) The complaint is recorded in detail on a standardized form.
3) An investigation is conducted into resolving the issue.
4) Where a discrepancy in data results is involved (i.e. non-agreement between related tests for the same sample):
   a) The analyst is notified of the complaint
   b) The analyst shall review all data associated with the discrepant results, and shall report any findings to laboratory management:
      i) Where no discrepancy is found by the analyst or laboratory manager regarding data validity, the laboratory manager shall relate this to the complaining party.
      ii) When a discrepancy is found, the analyst shall initiate corrective action and the complaining party shall be notified immediately of the discovery.
      iii) Laboratory manager shall offer to re-analyze the affected samples free of charge, or other resolution that is acceptable to the complaining party. (i.e. sending sample aliquot to third party lab for analysis at laboratory's expense).
5) When a complaint is directed toward a laboratory practice that may be questionable:
   a) Laboratory management initiates investigation into the validity of the questionable practice.
      i) If there is documented acceptance for the practice in question, the complaining party shall be notified that the practice is SOP.

ii) If the practice is found to be without basis in good lab laboratory procedure, laboratory management shall initiate corrective action, and audit the process to bring it into compliance.

6) The complaining party shall then be notified of the results of the corrective action and an acceptable resolution shall be reached.

In all cases where a complaint raises doubt regarding compliance with a NELAP requirement, the complaint shall be thoroughly investigated and documented. [Related SOPs: G-332 "Resolution of External Complaints"]

Section 10 – Control of Non-Conforming Work

A laboratory staff member may recognize the need for a departure from an approved procedure due to client request, sample related issue or other extenuating circumstance. The staff member then obtains a "departure from SOP" form from the QA Office and documents the project, sample(s), date, applicable SOP, client identification, reason for departure from standard procedure, describe the departure. The form is then approved by a laboratory manager and QA Officer. The client then is notified of the need to depart from standard procedure and is informed of the potential impact the change will have in the results generated. The client approval, date and time is recorded. The completed form is kept with the project folder. [Related SOPs: G-315 "Laboratory Management Procedure for the Exceptional Departure from Documented Policies or Standard Specifications"]

During the review of data, quality control sample results, performance samples, internal or external audit, if the Quality Control Officer detects any analytical system, analyst or technician unable to produce acceptable analytical results, the Quality Control Officer, at his discretion, may halt work until the analytical system, analyst or technician is brought into compliance with current acceptance criterion.

If impacted data has lead to reports that have left the lab before a problem has been recognized, the client is notified within 24 hours of the recognition and verification of the problem.

Section 11 – Corrective Action

Corrective action involves the process of recognizing a non-conformance, investigating, assigning cause and correcting out-of-control processes or procedures. The goal of corrective action is to improve quality by identifying root causes, identifying methods of improvement, and evaluating the effectiveness of the change. An added goal is preventing the reoccurrence of mistakes. [Related SOPs: G-311 "Corrective Action Procedure"]

The laboratory director, managers, supervisors and QAO oversee the corrective action process. All corrective actions are documented and the documentation maintained by the QAO. All corrective actions must be addressed in a timely and thorough fashion. Areas that may generate corrective action reports include:

- On-going instrument problems
- Failed performance sample
- Internal/external audit finding
- On-going reporting problems
- Other issues that affect client samples or results

What is not included is singular (one time) QC batch failure

When a deviation is recognized, it is the responsibility of the employee or supervisor to evaluate the extent of the deviation and to initiate corrective action. The following guide assists in investigating indefinite deviations from standard operating procedure:

1) Out-of-control event is identified
2) Corrective action reports (CAR) are initiated by any employee who notices procedures, equipment, or supplies that adversely affect the quality of the preparation or analysis of samples
3) The CAR is submitted to the QAO, who logs the concern for tracking purposes.
4) Resolution deadline is established by QAO and is assigned to a lead investigator.
5) Corrective action report form is filled out to include:
    a) Staff responsibility
    b) Nature of problem
    c) What is the scope of the impact of the problem?
    d) What immediate action or correction must take place?
    e) Investigation and identification of the root cause:
        i) Verify the method for appropriateness for the desired analyte, sensitivity, matrix interferences, etc.
        ii) Verify quality control indicators for acceptable accuracy and precision
        iii) Verify manual calculations or those used by instrument or spreadsheet software applications
        iv) Check for data reporting errors (i.e. transcription, transposition, incorrect units)
        v) Verify that all preparation and analytical procedures were followed as documented in the standard operating procedure
    f) Immediate action required.
    g) Proposed resolution
    h) Evaluation of effectiveness of resolution
    i) Signatures of responsible staff and QAO
6) Corrective action form submitted to technical director for approval
7) Laboratory practices modified to incorporate corrective action resolution
8) Client/Agency notified of corrective action resolution (if applicable)

All data generated in support of a corrective action report shall be linked to the corrective action report. If the result of a corrective action requires a modification of a test method or procedure, that proposed modification shall be integrated into a method revision and approved by laboratory management prior to its implementation.

11.1 Selection and Implementation of Corrective Action

The laboratory shall select and implement the actions most likely to eliminate the problem and prevent recurrence of the observed non-conformance. The laboratory must document these changes.

11.2 Monitoring of Corrective Action

Following the completion of the corrective action report, laboratory management will review the report and evaluate its effectiveness in resolving the deviation. The review process is as follows:

1) The responsible analyst submits the completed corrective action report to the group leader for initial approval.
2) The report is then submitted to the quality assurance officer and laboratory director for approval.
3) Approval of the corrective action is then indicated with the signatures of the group leader, QAO, and laboratory director.
4) The report is maintained in the Corrective Action Report ring-binder by the QAO, along with records of client notification (when applicable).

If the corrective action is determined to be unacceptable at any point in the review process, the report will be returned to the responsible personnel for further evaluation.

The findings and corrective actions resulting from audits must be addressed in a timely fashion, as determined by laboratory management, generally one week to develop the action plan or complete a

simple Corrective Action, if two or more weeks are necessary, an additional form is used to track the progress. Laboratory management is then responsible for following up on and ensuring that the findings have been addressed and dealt with satisfactorily. The QAO verifies the action's effectiveness both short term (within one to three weeks) and long term (four to six months) and again during the area annual internal audit. The QAO may also issue a 'targeted internal audit' form as described in 14.1 to verify effectiveness of a CAR activity.

11.3 Technical Corrective Action

To the extent possible, results are reported only if all quality control measures meet acceptance criteria. If criteria are not met and the data must be reported all samples associated with the failed QC measures must be reported with the appropriate qualifiers.

11.4 Policy for Exceptionally Permitting Departure from Documented Policies and Procedures

Laboratory staff member recognizes the need for a departure from SOP due to a client request, sample issue, or other extenuating circumstance. (Example: client request for a specific test on an incompatible or non-standard matrix) [Related SOPs: G-315 "Laboratory Management Procedure for the Exceptional Departure from Documented Policies or Standard Specifications"]

Staff member obtains a "Departure from SOP" form from the QAO office and documents the following:

- Staff identification
- Date
- Applicable SOP (from which departure is necessary)
- Project number of affected project(s) and sample(s) NOTE: alternatively, the client project name/number may be referenced
- if the departure will be repeated.
- Client identification
- Reason for SOP departure
- Description of SOP departure
- Initial Managerial Approval

At this point, the form is then submitted to a laboratory manager for review.

The manager may then edit the SOP departure, and/or sign off on the SOP departure form, giving the departure initial managerial approval. NOTE: The reviewing manager must ensure that the departure is documented well enough to provide a complete account of the departure from SOP, and that the departure is technically justified.

The laboratory manager then forwards the form to the quality assurance officer (QAO) for review.

The QAO reviews the departure to verify that all quality assurance items from the original SOP can be fulfilled. Should the departure require additional and/or modified QC requirements, the QAO delineates them on the form. The QAO then signs and returns the form to the laboratory manager for client approval.

Once the departure or revised departure has been given preliminary approval by management and the QAO, the laboratory manager, client service coordinator or director must communicate the intention to use the departure to the client.

Section 12 – Preventive Action

Preventive action is the procedure used to identify opportunities to improve our processes not in response to complaint or non-compliance. Fibertec responds to preventive action in two ways. We have a suggestion box placed in the lunch room which is available to all employees. Also, during Monday morning meetings, group leaders are given opportunities to suggest changes to improve our processes, SOPs or procedures.

Section 13 – Control of Records

13.1 Records Management and Storage

The integrity of the laboratory record keeping system is based on the security of the laboratory building. Storage of data is designed to allow easy yet restricted access of appropriate laboratory staff, while maintaining the physical condition and confidentiality of data contents.

All laboratory records, including original observations, calculations and derived data, calibration records and a copy of the test report are retained for 5 years, following the last data entry. After 5 years, data are destroyed unless the laboratory has been provided with a written request for extended storage. VAP project data must be retained for 10 years after which the Ohio agency will be notified by certified mail and given the option to obtain the data prior to its disposal. [Related SOPs: G-301 “Record Keeping System and Design”]

Thorough documentation of laboratory practices is essential to ensure compliance with the laboratory quality system. It is company policy to maintain unequivocal, accurate records and that are required to completely recreate all work performed at an earlier date. This documentation must also be sufficient enough to withstand legal scrutiny. Recordkeeping in the laboratory shall adhere to the following guidelines:

1) Records shall include identity of personnel involved in sampling, sample receipt, preparation, calibration, and testing.
2) All information relating to the laboratory facilities, equipment, test methods and related lab activities such as sample receipt, sample prep, or data verification shall be documented.
3) Recordkeeping system shall facilitate the retrieval of all working files and archived records for inspection and verification purposes, e.g. set format for naming electronic files.
4) All changes to records shall be signed or initialed by responsible staff.
5) All generated data except those generated by automated data collection systems, shall be recorded directly, promptly and legibly in indelible ink.
6) Entries in records shall not be obliterated by methods such as erasures, overwritten files or markings. All corrections to record keeping errors shall be made by one line marked through the error. The individual making the correction shall sign or initial and date the correction. These criteria also shall apply to electronically maintained records (i.e., instrument data files).
7) All records pertaining to NELAP accreditation shall be made available to the accrediting authority upon request.

13.2 Legal Chain of Custody Records

The laboratory currently has no clients that require this service. The lab, however, recognizes that any of our environmental samples may eventually become involved in litigation. Since this is a possibility, the building is limited access and the sample containers and subsequent data are controlled.

Section 14 – Audits and Management Review

Audit processes serve as a means of evaluating the laboratory's performance at a point in time. Audits are conducted internally by laboratory staff, externally by accrediting agencies and clients and serve as a very useful learning tool for improving laboratory performance.

The QAO conducts annual audits of the laboratory system. The QAO schedules audits of individual departments over a one-week period to determine overall system performance.

The QAO maintains all documentation relating to audit processes. Clients shall be notified immediately in writing when deficiencies could have an effect on the validity of analytical data. Laboratory management shall ensure that any and all audit deficiencies are dealt with in a timely manner.

Various components of the laboratory quality system act as a continuous audit of laboratory performance. These quality checks include:

- Monitoring positive and negative quality control indicators
- The use of control charts to establish accuracy and precision control limits
- Participation in proficiency testing programs
- The use of NIST traceable reference materials, and second source standards
- Monitoring the correlation of related analyses for a sample

14.1 Internal Audits

Internal audits of system performance are initiated by laboratory management and conducted by laboratory staff. Internal audits generally focus on one area of concern, or are a verification of the resolution of a corrective action. [Related SOPs: G-310 "Internal Audit Procedure"]

As dictated by personnel availability, an internal audit shall be performed by an experienced staff member, who is not directly involved in the activities which are being audited. The Fibertec internal audit schedule is;

- December – QA Department, IT Department, Training Records/Documentation, SOPs
- January – VOC Lab, SVOC Lab, Client Services, Sample Receipt
- February – Metals Lab, Wet Chem Lab, Preparation Lab
- March – QA Management Review

In general, the items that are evaluated during internal audits may include:

- Determine the status of previous internal or external audit findings
- Review of analytical records (hard copy and electronic)
- Review of procedures to determine compliance with associated SOP(s)
- Review of safety concerns and compliance
- Interview analyst/technician
- Review of the documentation of non-conformances

As a follow up to Corrective Action, the QA Officer will verify the effectiveness of the correction both on a short term basis and long term basis as described in the SOP# G-311.

14.2 External Audits

External audits are initiated by clients or other outside agencies, or are conducted as a requirement of certification or regulatory compliance. To maintain objectivity, external audits are usually conducted by a third party that does not have a vested interest in the audit's outcome.

14.3 Performance Audits

All work areas have varying levels of peer review of generated documents. Included in this review is daily review of the processes involved in generating of the documentation including the QC.

14.4 System Audits and Management Reviews

On an annual basis, management performs a QA system review. This review seeks to evaluate the status of the Quality programs and accommodate the laboratory business growth. This should result in the creation of objectives to guide the laboratory business in concurrence with the corporate growth. Evaluated are the following:

- Status of the findings from previous management review goals
- suitability of policies and procedures
- reports from group leaders
- outcomes from internal audits
- corrective and preventative actions
- external audits
- PE performance
- Changes in current and future business opportunities
- Client feedback
- Complaints

The summary of this review is reduced to writing.

Section 15 – Personnel, Training and Data Integrity

15.1 Job Descriptions

15.1.1 Laboratory Director

Qualifications -

1 Hold a minimum of a bachelor's degree in natural or physical sciences, or have completed enough course work in chemistry to equal a minor in chemistry, or
2 Have had a minimum of two years experience managing a laboratory

Responsibilities as described in 2.2.1

Authority –

1 Review and approve laboratory reports
2 Approve purchase requests
3 Hiring, promotion and removal of laboratory personnel

15.1.2 Technical Director

Qualifications -

1 Hold a minimum of a bachelor's degree in natural or physical sciences, or have completed enough course work in chemistry to equal a minor in chemistry, or
2 Have had a minimum of two years experience managing a laboratory

Responsibilities as described in 2.2.2

Authority –

1 Approve Corrective Action
2 Acknowledge technical competence, may waive educational requirements based on experience

15.1.3 Quality Manager

Qualifications –

1 Hold a bachelor's degree in natural or physical sciences or have completed enough course work in chemistry to equal a minor in chemistry, or
2 Have a minimum of one year experience as an analyst in a laboratory and have documented training in quality assurance and quality control (QA/QC)
3 Where applicable, have functions independent from laboratory operations
4 Have a general knowledge of the analytical methods for which data review is performed

Responsibilities as described in 2.2.3

Authority –

1 Enforce laboratory compliance with quality system
2 Hold reports or reject data due to quality concerns
3 Allow resumption of work when quality indicators demonstrate acceptable performance

15.1.4 Laboratory Operations Coordinator

Qualifications –

1 Have a minimum of one year experience as a project manager
2 Have basic understanding of sample receiving, storage, and disposal
3 Have good working knowledge of the LIMS
4 Have good working knowledge of the laboratory reporting functions
5 Have good organization and communication skills

Responsibilities as described in 2.2.4

Authority –

1 Turn down new projects that exceed current capacity
2 Inform group leaders of approaching deadlines
3 Inform management when projects may exceed expected completion dates

15.1.5 Group Leader

Qualifications –

- Hold a minimum of a bachelor's degree in natural or physical sciences or have completed enough course work in chemistry to equal a minor in chemistry, or
- Have had a minimum of one year of experience in the analyses pertaining to the applicable fields of testing

Responsibilities as described in 2.2.5

Authority –

1 Rerun analysis when data is compromised
2 Delegation of laboratory duties
3 Initiate Corrective Actions

15.1.6 Analyst

Qualifications –

1 Hold a bachelor's degree in natural or physical sciences or have completed enough course work in chemistry to equal a minor in chemistry, or
2 Have had a minimum of one year of experience in the analyses pertaining to the applicable fields of testing
3 Analyst shall:
   - Have satisfactorily completed a minimum of fours hours training that is offered by the equipment manufacturer, professional organization, a university or another qualified training facility, or
   - Serve a two-week period of apprenticeship under an experienced analyst, and
   - After appropriate training, perform the initial demonstration of capability (IDOC)

- Have on file documentation indicating acceptable continuing demonstration of capability (CDOC), such as described in "Employee Training" SOP# G-380 and a certification that the analyst has read, understood and agreed to perform the most recent version of the method, the approved method or standard operating procedure. Such documentation shall demonstrate that the required training is up-to-date.

Responsibilities as described in 2.2.6

Authority –

1 Rerun analysis when data is compromised
2 Delegation of laboratory duties
3 Initiate Corrective Actions

15.1.7 Technician

Qualifications –

1 Completed High School or equivalent, and
2 Demonstrate understanding of approved procedures by IDOC and annual CDOC.

Responsibilities as described in 2.2.7

Authority –

The Technician is the first line of defense in recognizing sample anomalies that may lead to quality excursions. Recording and communicating sample matrix/preparative observations is imperative in defining the confidence the laboratory has in the associated reported data.

15.2 Data Integrity and Ethics

The validity and usefulness of data provided by the laboratory are dependent upon good and ethical laboratory practices. To this end, laboratory personnel shall be required to sign a statement recognizing this policy against unethical and/or fraudulent laboratory activities, and the potential personal and legal ramifications of such actions, up to and including termination from Fibertec, Inc. and criminal prosecution.

15.3 Data Integrity and Ethics Training

Within the first two weeks of working at Fibertec, the employee must be trained on Ethics and Integrity and sign their agreement statement. On an annual basis, all employees must view an Integrity Refresher training. The employee must sign an attendance form and the Laboratory Director approves the training with his signature. [Related SOPs: G-342 "Laboratory Ethics and Data Integrity"]

15.4 General Training

Training of laboratory staff must be kept up-to-date, and documentation of this training must be maintained by laboratory management. These training records are kept in the QA Office. This documentation includes:

1 Completed IDOC summary for each test or preparation the employee is responsible, showing that the employee has met the method recovery and precision requirements.
2 Evidence of completion of training workshops for specific laboratory equipment, analytical techniques or procedures, when available
3 Evidence of completion of ethical and legal awareness training, and compliance with these guidelines in laboratory practices

Staff training can be considered up-to-date if the training file contains the employees signature on the form that states that technical personnel have read, understood, and agree to perform this version of the SOP and there is documentation of continued proficiency by at least one of the following, once per year, in the training record folder:

1 Acceptable performance of a blind sample
2 Completed demonstration of capability
3 Successful analysis of a blind performance sample on a similar test method using the same technology, requires documentation for only one of the test methods
4 At least four consecutive laboratory control samples with acceptable levels of precision and accuracy
5 Analysis of authentic samples with results statistically indistinguishable from those obtained by another trained analyst

Specifics of initial training is described in SOP# G-380 “Employee Training”

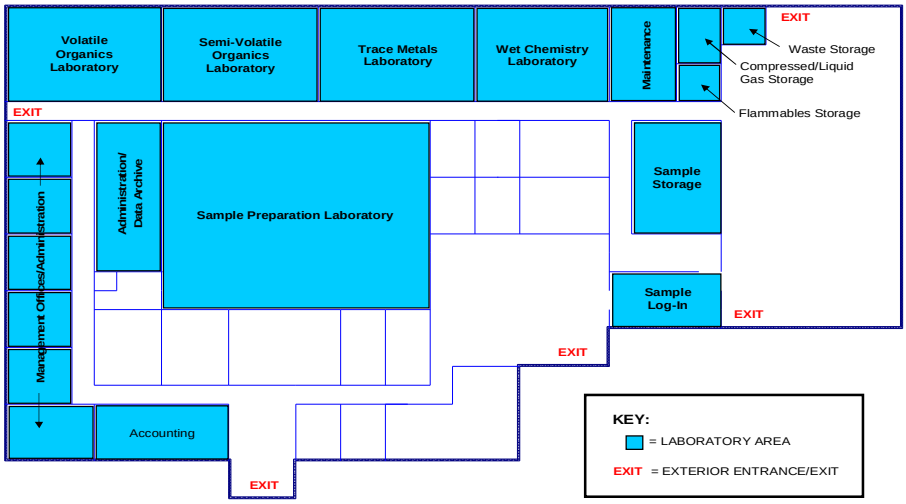
Section 16 – Accommodations and Environmental Conditions

The laboratory operates out of an approximately 16,500 square foot facility located in Holt, Michigan, just south of Lansing.

The laboratory environment has been designed to enhance productivity while providing a safe, secure working environment. Conditions such as humidity, temperature, and air handling are maintained to achieve the standards required by test methods and instrument manufacturers, and are monitored to maximize the efficiency of the laboratory. In addition, electrical instability, excessive sound, and vibration levels are minimized to virtually eliminate their potential effect on test performance.

In those instances where environmental conditions must be monitored (i.e. humidity in gravimetric filter analyses) the laboratory maintains appropriate documentation to reflect compliance with the test method requirement.

Figure 1. General Building Layout.



16.1 Building security

Building security serves as the basis for sample and record integrity. Most laboratory entrances remain locked during normal business hours and require key-card access. The front sample drop-off entrances are supervised by Fibertec personnel during business hours and lock automatically at 5:15PM. In addition, visitors must sign in and be accompanied by a staff member while on premises.

16.2 Work areas

Laboratory work areas consist of well-defined laboratories. All laboratories are designed to safely contain the chemicals used and to prevent the cross-contamination of potential target analytes into neighboring laboratories.

Laboratories must be kept as neat and orderly as possible. "Good housekeeping" practices play a key role in quality control by minimizing contamination, thereby increasing accuracy and precision in measurements. In addition, all hallways and work areas must be kept free from clutter. These areas include:

- Laboratory access entryways
- Sample receipt/storage
- Chemical/waste storage
- Data handling/storage

Section 17 – Test Methods and Method Validation

Test methods used in the laboratory follow standardized, published and "EPA approved" methodology. When the use of a referenced test method is requested, only that method shall be used. Procedures must be appropriate for a given sample matrix, consistent with the accuracy required, and the intended use of the analytical data while meeting regulatory sensitivity requirements. For Ohio VAP projects, no 'modified' published methods may be employed and any revision to the analytical SOP for their projects requires pre-approval. [Related SOPs: G-300 "Development of Standard Operating Procedures"]

Where test methods are employed using the Performance Based Measurement System (PBMS), the method shall be fully documented and validated, and be available to the client and other recipients of the relevant reports.

Test methods used in the laboratory originate from the following sources:

- Standard Methods for the Examination of Water and Wastewater 20th or 21st Edition (SMWW)
- Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW-846)
- Methods for Chemical Analysis of Water and Wastes (MCAWW)
- American Society for Testing and Materials (ASTM)
- National Institute for Occupational Health and Safety (NIOSH)
- Hach Water Analysis Handbook, 3rd Edition (HACH)
- Other published methods upon agreement with the client prior to working with the sample(s)

Various matrix classifications will require specific analytical methodology. The primary classifications are:

1) Wastewater (Surface Water):
   a) Any surface or wastewater that is released from a property and regulated under the clean water act (CWA)
   b) Analyses must comply with 40 CFR, Part 136
   c) SMWW procedures are approved for metals and wet chemistries
   d) EPA 600-series methods are approved for organic analyses
2) Hazardous Waste, (Solid Waste, Groundwater):
   a) Regulated under the Resource Conservation and Recovery Act (RCRA)
   b) Analyses must comply with 40 CFR, Part 261
   c) SW-846 procedures are appropriate along with quality requirements outlined in SW-846 chapter one
3) Drinking Water:
   a) Regulated under the Safe Drinking Water Act (SDWA)

b) Analyses must comply with 40 CFR, Part 141 for primary drinking water pollutants, and 40 CFR, Part 143 for secondary drinking water pollutants
c) SMWW procedures are approved for metals and wet chemistries
d) EPA 500-series methods are approved for organic analyses

Refer to Appendix A for a list of test methods performed by Fibertec, Inc.

17.1 Demonstration of Capability (DOC)

Successful completion of the training process is documented through the completion of a "Demonstration of Capability" (DOC) certificate. This certificate states the trainee's name, the test method and matrix, and shows the signed concurrence by laboratory management that the trainee has successfully completed the requirements to show proficiency with the test method. All data produced in support of the DOC shall be retained by the laboratory.

For a new analyst to complete a demonstration of capability, they must successfully analyze four consecutive laboratory control samples. The samples must be prepared and analyzed according to the current version of the controlling SOP. The average analyte recovery and standard deviation are then compared to laboratory acceptance limits for accuracy and precision. All analytes must meet IDOC acceptance criteria prior to reporting any client samples. If unacceptable, the analyst shall initiate corrective action and address the problems with the analysis prior to starting work on client samples. For analytes that do not lend themselves to traditional spiking (i.e., pH, TSS), the D.O.C. will be performed using QC samples. [Related SOPs: G-380 "Employee Training"]

The DOC must be:

1 followed by annual continuing demonstration of method performance
2 maintained and all supporting data must be made readily available
3 repeated each time there is a change in personnel, instrument type or test method

17.2 On-Going (or Continuing) Proficiency

Ongoing proficiency is demonstrated by performing another DOC study, being solely responsible for the successful preparation and/or analysis of a single blind PE sample, or other techniques described in SOP# G-380, "Employee Training".

17.3 Initial Test Method Evaluation

Before an analytical process is implemented for the analysis of environmental samples, it must be evaluated to determine it's performance as described in 17.3.1 through 17.3.5. The procedure is then written into an SOP in the format described in section 4.3.1. [Related SOPs: G-300 "Development of Standard Operating Procedures"]

17.3.1 Limit of Detection (LOD)

The LOD is an estimate of the minimum amount of a target that can be reliably detected. Fibertec doesn't report any value outside valid instrument calibration standards without qualifying "J" flags. No LOD study is required.

17.3.2 Limit of Quantitation (LOQ)

The LOQ is the minimum level of a target analyte that can be reported with a specified degree of confidence. Fibertec doesn't report any value outside valid instrument calibration standards without

qualifying "J" flags. No LOQ study is required.

17.3.3 Method Detection Limit (MDL)

The MDL is determined as described in the procedure published in 40 CFR part 136, appendix B. A synopsis is found in Appendix D of this document.

17.3.4 Precision and Bias

A known amount of the target analyte(s) are introduced to the target matrix and the matrix is prepared and analyzed by the proposed methodology. Four replicates are evaluated as well as one replicate not spiked. This describes an IDOC. The average recovery and precision of this study demonstrates the method performance in regards to the bias and precision of the proposed method. This information is forwarded to the client requesting the analysis who will verify that these values meet the quality requirements of their project.

17.3.5 Selectivity

Absolute retention time and relative retention time aid in the identification of components in chromatographic analyses and to evaluate the effectiveness of a column to separate constituents. The laboratory shall develop and document acceptance criteria for retention time windows.

A confirmation shall be performed to verify the compound identification when positive results are detected on a sample from a location that has not been previously tested by the laboratory. Such confirmations shall be performed on organic tests such as pesticides, herbicides, or when required by the analytical test method except when the analysis involves the use of a mass spectrometer. Confirmation is required for pesticides and herbicides, unless stipulated in writing by the client. All confirmation shall be documented.

The laboratory shall document acceptance criteria for mass spectral tuning.

17.4 Estimation of Uncertainty

The laboratory employs procedures which maximize recoveries and improve the precision of analytical measurements. In spite of this effort, there exists a level of uncertainty in each analytical result. One means of evaluating that uncertainty is observing the acceptance range for the precision of replicate analyses (ie. MS/MSD % RSD acceptance range). Upon request from a client, the lab will estimate the uncertainty in an analytical measurement from lab data, taking into account variability contributed by each step in the preparation of the sample and analytical process. A report of analytical uncertainty is then generated for the client.

Uncertainty relating to sample reported values would be incomplete since the laboratory has no control over how samples are collected, transported, stored prior to delivery and the variable nature of most environmental samples.

17.5 Laboratory-Developed or Non-Standard Method Validation

The process of using a non-standard method begins with the request from the client for analyses of target analytes or sample matrix which is not found in the scope of any of our current published methods. The client expresses the need for the analysis, the needed level of sensitivity and level of validation necessary to support the reported data.

For full validation, the laboratory evaluates our existing methods and related SOPs to propose the procedures for the preparation and analysis of the target analyte(s). Standards are obtained and

analyzed to verify that the analytes can be detected, the instrument can be calibrated, and the initial level of sensitivity can be defined. The analyst then prepares a spike with the target analyte(s) and prepares an LCS to determine the ability to extract or digest the material and recover the target analyte(s) from the given matrix. Once recovery is optimized, an MDL is performed to demonstrate that the requested reporting level may be supported. An IDOC is performed to demonstrate recovery and precision.

Method validation involves the evaluation of the calibration, IDOC, and MDL in light of the requested reporting level, analytical range and recoveries expected from the initial client request. If the validation indicates that the client needs would be met, samples for the method may be processed and analyzed. Results from the analysis of client samples will communicate the use of non-standard methodology in the final report.

17.6 Control of Data

The data used to develop and approve methods are organized and stored in the lab. The data includes, but is not limited to, IDOC, MDL studies, linearity evaluation, instrumentation and/or sample preparation optimization trials, etc. After one year, the data is archived and stored in the warehouse for at least four more years (10 years total for Ohio VAP projects, after which Ohio must be notified by certified mail and may opt to obtain the records). This data is available to clients or regulators upon request.

Section 18 – Equipment

18.1 General Equipment Requirements

When equipment is purchased, there exists a purpose for the acquisition. The analyst must document that the equipment meets its purpose. (i.e. ovens maintaining 105 ± 2 ºC, refrigerator 4 ± 2 ºC, etc.) For analytical equipment, the analyst documents this by performing a multipoint calibration (if the equipment allows), MDL study to verify the validity of our reporting limit, and a DOC as described in section 17.1.

18.2 Support Equipment

This section applies to devices that are not considered analytical equipment. Devices include, but not limited to: balances, thermometers, ovens, freezers, incubators, etc.

18.2.1 Support Equipment Maintenance

All support equipment must be maintained in working order. Any repairs or maintenance must be recorded. The equipment must be calibrated or verified at least annually. If it fails verification, it must be removed from service or labeled as “out of service”.

18.2.2 Support Equipment Calibration

Prior to use each working day, balances, ovens, refrigerators, freezers, and incubators shall be checked using a NIST traceable reference.

Volumetric pipettes (other than class-A), must be evaluated on a weekly basis. Variable set pipettes are evaluated each working day. The evaluation is done by dispensing a measured volume of reagent water to a small beaker that has been tared on an analytical balance. The measured mass must agree with the density adjusted by the temperature for that volume.

18.3 Analytical Equipment

Analytical equipment must be calibrated to deliver data of known quality. The basics of calibration and calibration verification listed here is superseded by calibration requirements that are defined in the promulgated method or by instrument requirements. Specific requirements are found in each analytical SOP.

18.3.1 Maintenance for Analytical Equipment

Analytical equipment is supplied with "factory specifications" which define normal capabilities. If the equipment can not demonstrate these factory specifications, maintenance is required before a stable calibration should be attempted. Documentation of this maintenance is required.

18.3.2 Initial Instrument Calibration

Details of the initial calibration, including: number of calibration standards, concentrations, calculations, acceptance criteria must be part of the analytical SOP.

Sufficient raw data must be retained to permit the reconstruction of the initial calibration curve. Included in the raw data must be: the calibration date, analytical method, instrument, analyst initials, analyte concentrations, response from the instrument.

Sample results must be based on the responses generated during the initial calibration and NOT from the daily calibration verification.

All initial calibration curves must be verified with a standard obtained from a second source or at least a standard from a different lot number than the standards that generated the initial calibration. Traceability shall be to a national standard when available.

Criteria for acceptance of the calibration and verification must be part on the analytical SOP.

The lowest acceptable calibration standard is the lowest reportable concentration. The lowest standard must be above the calculated MDL and below the client reporting limit. Any value over the highest acceptable concentration in the curve requires either reanalysis after dilution or reporting a "J" flag.

If the reference method doesn't define the number of calibration points required, the default number is 5. The analytical SOP must define the number of standards required for calibration.

18.3.3 Continuing Instrument Calibration

When the initial calibration is not performed on the day of analysis, the validity of the calibration is verified prior to sample analysis. The details of this task are listed in the analytical SOP.

Calibration shall be verified for each analyte. Verification must be performed at the beginning and end of each analytical batch (except if an internal standard is used, in which case only one is required at the beginning).

Sufficient raw data records must be retained to permit reconstruction of the continuing calibration verification. Criteria for acceptable evaluation are listed in the analytical SOP.

18.3.4 Unacceptable Continuing Instrument Calibration Verifications

If the CCV fails, it may be due to the standard going bad or the instrument status changing. The standard may be analyzed on another instrument to verify it's validity or another preparation of it from the same

stock source may be tested. If the standard is determined to be acceptable, a second analysis of the standard is analyzed on the instrument that had failed. If it still fails, the instrument is determined to have changed and maintenance is performed. After corrective action, a subsequent CCV is analyzed and if acceptable, the CCV is again analyzed to demonstrate instrument stability. If acceptable, analysis of samples is permitted. If the CCV fails, the instrument must be recalibrated. There may be instances when data must be reported with one or more CCV exceedances. In those instances, the results must be appropriately qualified, unless the CCV fails high indicating a high system bias and the associated samples are non-detect, the data may then be reported with no qualification.

Section 19 – Measurement Traceability

Measurement traceability encompasses both the devices used to analyze environmental samples as well as support equipment used in sample preparation and storage. Measurement values are compared with standards that can be traced to a national standard such as NIST. Evaluated devices include incubators, water baths, hot blocks, ovens, refrigerators, freezers, pipettes, balances and analytical scales, as well as the solutions used to calibrate analytical equipment.

19.1 Reference Standards

Purchased standards consist of pure chemical material 99+% if available, or premixed chemical combinations of known quality, NIST traceable standards are purchased, when available, for both calibration and spiking materials. Laboratory prepared solutions and standards are derived from these purchased standards. Standards are purchased at the highest possible purity levels to meet or exceed method requirements. The purity of each standard is NIST traceable, when available, and serves as the basis for accuracy in analytical determinations. Gas standards are purchased from Spectra Gases or Scott Gases and are certified traceable to NIST, when available.

19.2 Reference Materials

A reference thermometer and a NIST traceable mass set are stored in the QAO office to evaluate support equipment thermometers, balances and other devices. This evaluation is accomplished at least annually. The thermometer and the mass set is recertified on an annual basis. These devices are not used for any other purpose.

19.3 Transport and Storage of Reference Standards and Materials

Organic reference standards are stored in the lab according to manufacturer's recommendation, away from environmental samples. Once opened, they are stored in a freezer unless manufacturer recommendations advise differently, and labeled with the date opened. Reference inorganic standards are stored with other standards and are labeled when opened.

19.4 Reagents

Reagents are Reagent Grade or better. Upon receipt, the lot number of all containers is recorded and a Fibertec tracking number is applied to the container by the QA assistant. Along with the lot number, date of receipt, date opened and expiration date are recorded on the label.

Beach/play sand may be used for Matrix in soil Method Blank and Lab Control Samples (except for Metals analysis). The sand is baked at 400 ºC for at least 4 hours, then cooled and placed in a clean glass jar and covered with foil. After the baking is complete, a unique LIMS generated lot number is applied to each jar from that 'baking batch'. The baked sand is kept at room temperature, covered with foil until it will be used.

19.5 Labeling of Reference Standards, Reagents, and Materials

Upon receipt of reagents and standard materials, the following information is entered into the laboratory reagent/standard log:

- Unique laboratory ID
- Reagent name and quality grade
- Vendor name/Supplier
- Catalog number
- Lot number
- Receipt date
- Expiration date (if applicable)
- Recipient
- Storage Location

The following information is recorded directly on the reagent/standard container:

- Receipt date as (R)
- Date opened as (O)
- Expiration date as (E)

All dilutions and mixtures of laboratory standards and reagents are given a unique identification, expiration date, and are linked to the original reagent(s) and/or standard(s) in a log book. Individual laboratory departments maintain their own reagent/standard logs.

19.6 Diluents

Diluents used to reduce the concentration of reference standards, reagents and samples must be known quality. Solvents used, such as Methylene chloride, Acetone, or Hexane are HPLC or Pesticide residue grade. Methanol is purge and trap grade. Acids such as Nitric, Sulfuric, Acetic, Hydrochloric, or Phosphoric are reagent grade or better (metals require Trace Metals grade). Diluent (reagent or deionized) water is available in each lab from the white taps. This water is deionized by both anionic and cationic reduction ion exchange beds as provided by Culligan. The level of conductivity is checked daily by indicator light. This water is also used as Method Blank and LCS matrix for most lab areas.

Section 20 – Sample Management

Samples are transported in a manner that is safe, maintains the COC, preserves sample integrity and meets applicable shipping regulations.

20.1 Sample Receipt

Upon receipt, login personnel open sample shipment containers in a designated login area. A fume hood, gloves, and eye protection are available to login personnel for opening containers in the event of known or suspected hazardous exposure. [Related SOPs: G-312 “Sample Log-In Procedures”]

The internal temperature of the shipping container or cooler is measured and recorded directly on the COC form. The samples are then carefully removed from the shipping container, checked for physical integrity and verified against the accompanying COC form to check the following:

1) Proper, full and complete documentation, including:
   a) Sample Identification
   b) Date/time of collection

c) Collector's name
d) Preservation type
e) Sample type
f) Special remarks

2) Proper sample labeling with unique identification
3) Use of appropriate sample containers (see appendix E)
4) Adherence to specific hold times (see appendix E)
5) Requested analysis is clearly indicated, including method numbers
6) Adequate sample volume for the requested analyses

20.2 Sample Acceptance

The Laboratory Acceptance Policy is posted in the Sample Receiving Area and on our Web-site, provided to new or potential clients by a sales representative, sent with our Holiday Hours notification, and sent to any client who submits samples not meeting the acceptance requirements. Laboratory policy is to accept samples only when the following conditions have been met:

1 Samples that require thermal preservation shall be acceptable if the arrival temp is either within 2 ℃ of the required temperature range (i.e., 4 ℃ can be just above the freezing point of water to 6 ℃). Samples that are hand delivered to the laboratory on the same day they are collected, will be considered acceptable if there is evidence that the refrigeration process has begun (i.e., arrived on ice).
2 All sample containers are intact
3 All samples listed on COC are present and properly labeled
4 All containers listed on COC are present and properly preserved
5 Analytical hold times for the requested parameters have not expired

When there is doubt as to the items suitability for testing, where the sample does not match the description provided, or where the required test is not fully specified, the client shall be notified before proceeding. If samples do not meet the above acceptance criteria, the laboratory shall:

1) Retain correspondence and/or records of conversations concerning the final disposition of rejected samples, or
2) Fully document any decision to proceed with the analysis of samples not meeting the acceptance criteria:
   a) The condition of the samples shall be noted on the chain of custody at least, or transmittal form and lab receipt documents.
   b) Data from samples not meeting acceptance criteria shall be unambiguously qualified on the final laboratory report, indicating the nature and substance of the deviation.
   c) If an attestation form is required for the project, any excedance is unambiguously documented on this form.

20.3 Sample Identification

Chain-of-custody (COC) procedures provide a method of establishing ownership of samples as they are processed from sampling to receipt at the laboratory. The laboratory COC form documents sample transfers by means of signature, date, and time for both relinquishing and receiving samples. COC forms also serve to document client and sample information, including all sampling times and dates, sample container and preservative types, and the required test parameters. In addition, all transfers of samples, subsamples, extracts and digests to a third party must utilize the COC procedure. Upon receipt, the sample bottles are examined and the labels compared against the COC. Discrepancies are brought to the attention of the project manager, who will contact the client to clarify any problems prior to the beginning of any work, whenever possible.

20.4 Sample Storage

Hold times are prescribed by analytical methodology and are set forth to maintain the chemical integrity of samples. Specific required hold times are enumerated in Appendix E. During sample log-in, it is the responsibility of login personnel to verify that sample analytical hold times are not exceeded. When samples arrive with short analytical hold times, or are near hold time expiration, appropriate laboratory staff must be notified to complete the affected procedures as soon as possible in order to maintain analytical integrity.

In the event of samples being received outside of hold times, the client will be notified immediately. If the client elects to pursue analysis outside of hold time, a comment will be added to the "Sample Log-in/Work Request Order" reflecting the request. A comment will also be added to the final analytical report, qualifying all results affected by the exceeded hold time.

Samples are stored at above freezing to 6 ºC until removed from the cooler to perform analysis. Samples are returned to the cooler until all analyses are completed. [Related SOPs: G-302 "Sample Management Procedures"]

20.5 Sample Disposal

After the final report has been issued, the samples are kept in the cooler for at least 30 days. After this time, the samples are removed from the cooler and stored in the warehouse for an additional 60 days prior to disposal, unless the client has arranged for extended storage or the return of the sample(s).

When at least 90 days have elapsed since the issuance of the final report, aqueous samples containing no significant hazard (ie. Less than 0.2 µg/L Mercury) are neutralized and send down the sanitary sewer. Solid samples containing no significant hazard are disposed of in the solid waste stream.

Hazardous samples and organic wastes are isolated and removed by a licensed waste hauler. All local, state and federal waste guidelines must be adhered to.

20.6 Sample Transport

Samples are either sent to the lab via common courier, delivered by client (or representative), or retrieved by an employee. If the sample(s) were not collected within 60 minutes of receipt, the samples must be received in a cooler containing ice or an ice equivalent. Samples not received as described will be reported with the appropriate qualifier.

20.7 Sampling Records

Clients are responsible for completing a chain of custody identifying the submitted sample(s), requested analyses, sampling information, as well as client contact information.

Section 21 – Quality of Test Results

21.1 Data Quality Assessment

The quality of analytical results from environmental samples are highlighted by evaluating the; accuracy, precision, completeness, comparability and representativeness as required by the Quality Assurance Project Plan. This assessment involves the following.

21.1.1 Accuracy – the lab has several activities designed to determine the accuracy of the values reported. These include:

a) Traceability of Instrumentation – each analytical instrument has a unique identification number. Documentation exists listing where and when used with the raw data and what maintenance was performed in the maintenance log.
b) Traceability of Standards – each standard and measurement device is compared against a national standard of known accuracy whenever possible. Dilutions of the standards are uniquely identified so that they may be traced back to their certification documentation.
c) Traceability of Samples – each sample and sample container is assigned a unique identification number by our LIMS. The LIMS links this identification number to sampling site, time, sampler name, and preservation.
d) Traceability of Data – data is collected to allow complete reconstruction from the field records, preparation, analysis, reporting, through data storage.
e) Methodology – EPA, Standard Methods, and SW-846 methods shall be used when available to generate data of known accuracy.
f) Spiked samples – recoveries will be compared with predetermined acceptance limits.

21.1.2 Precision – the lab has several activities designed to demonstrate the reproducibility of the measurement process. Examples include:
a) Replicate Samples
b) Collocated Samples
c) Preparation Batch Precision – MS/MSD or LCS/LCSD pairs

21.1.3 Completeness – the field QAPP determines the number and types of samples needed to support the planned action resulting from the evaluation of the data generated from the sampling study.

21.1.4 Comparability – the lab performs procedures to assure the comparability of the generated data. Examples include:
a) Consistency of reporting units
b) Standardized sampling and analysis
c) Standardized data reporting format

21.1.5 Representativeness – the lab exercises procedures to assure that all results are as accurate and precise as possible and represent the material as presented in the samples submitted to the lab. It is the responsibility of field personnel to submit sufficient samples to draw conclusions regarding representativeness of the reported data to the site from which of the sample(s) were submitted.

21.2 Essential Quality Control Procedures

The quality control protocols specified by the laboratory SOPs shall be followed. The following essential standards must be incorporated into the laboratory SOPs where appropriate.

- Method Blank
- Laboratory Control Sample(s)
- Matrix Spike(s) if sufficient sample exists
- Sample Duplicate if method requires

21.3 Internal Quality Control Practices

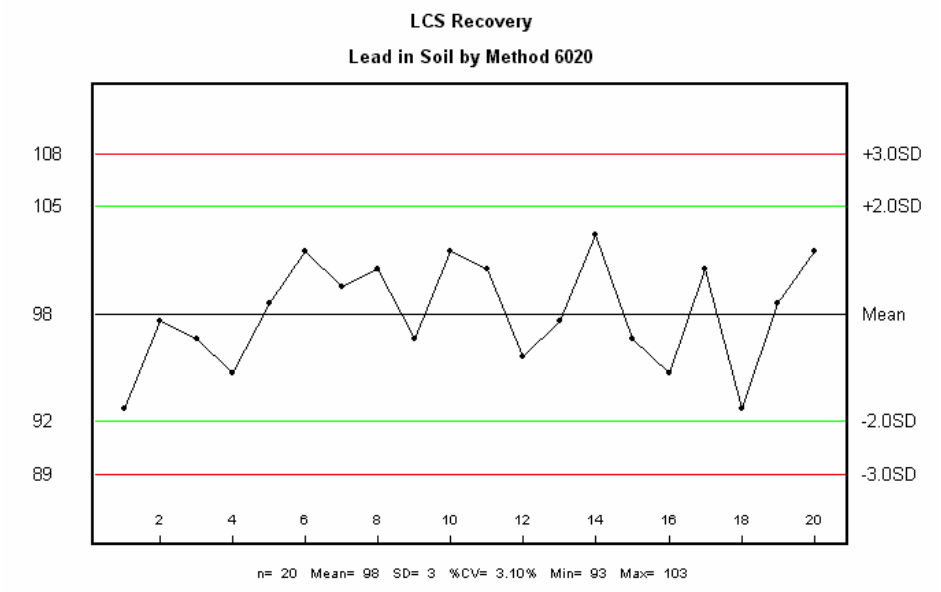
Analysts must do what they can to consistently perform their analytical task so the ongoing measures of quality can be projected from the batch QC to all samples within the preparative and analytical batches.

Control charting is a technique by which analyte recovery acceptance windows may be generated. Acceptance windows, or control limits are initially method-defined, and are updated after a minimum of twenty data points have been collected. Limits are updated on an annual basis, as needed, or as defined in the referenced method whichever is more frequent.

The control chart is a graphical representation of the statistical data set showing the mean recovery, upper/lower warning limits, and upper/lower control limits. Control charts may be used by the laboratory to visualize trends, method precision, and out-of-control data values. Control charts are produced and maintained by the IT department. Individual control charts are matrix, QC sample type, analytical method, and analyte specific.

Control charts may be generated for surrogates, laboratory control sample (LCS), and matrix spike (MS) percent recovery data.

Figure 2. – Example of Control Chart



Control Limits

Control limits determine the acceptable range for analyte recoveries in batch and analytical QC samples. If the recovery data fall within control limits, associated sample data are released for reporting to clients. However, if QC data fall outside of control limits, reporting of sample data will be placed on hold until corrective action resolves the out-of-control situation or flagging of the associated data.

The lower and upper control limits (LCL/UCL) are determined at least annually and calculated as follows:

$$LCL = \bar{x} - 3s$$
$$UCL = \bar{x} + 3s$$

Where: $\bar{x}$ = Mean Percent Recovery Value

s = Standard Deviation

Method vs. Laboratory Acceptance Criteria

When a test method or regulation states performance requirements that differ from internal laboratory or regulatory acceptance criteria, the more stringent requirements must be followed. This includes analyte recovery accuracy, precision, and control limit requirements.

21.4 Method Blanks

Purpose –
The method blank is used to assess the preparation batch for possible contamination during the preparation and processing steps. The method blank shall be processed along with and under the same conditions as the associated samples to include all steps of the analytical procedure. Procedures shall be in place to determine if the method blank is contaminated. Any affected samples associated with a contaminated method blank shall be reprocessed for analysis or the results reported with the appropriate data qualifying codes.

Frequency –
The method blank shall be analyzed at a minimum of 1 per preparation batch. In those instances for which no separate preparation batch is used (example: volatiles in water) the batch shall be defined as environmental samples that are analyzed together with the same method and personnel, using the same lots of reagents, not to exceed the analysis of 20 environmental samples.

Composition –
The method blank shall consist of a matrix that is similar to the associated samples and is known to be free of the analytes of interest. Lab Reagent Water is used for aqueous batches and generally, baked beach sand is used for soils. The sand is baked at 400 ºC for at least 4 hours. Cool to room temperature while remaining foil covered. Sand is not used for matrix in metals analysis preparation, since sand always contains impurities which are metal oxides. These oxides lead to variable levels of target analytes. For metals analysis, all reagents used in the preparation of the samples within the batch are placed in a clean digestion tube and processed as an environmental sample.

Evaluation Criteria and corrective action –
While the goal is to have no detectable contaminants, each method blank must be critically evaluated as to the nature of the interference and the effect on the analysis of each sample within the batch. The source of contamination shall be investigated and measures taken to minimize or eliminate the problem and affected sample reprocessed or data shall be appropriately qualified if:

1. The concentration of a targeted analyte in the blank is at or above the reporting limit as established by the test method or by regulation, AND is greater than 1/10 of the amount of any measured sample.
2. The blank contamination otherwise affects the sample results as per the test method requirements or the individual project data quality objectives.
3. For Ohio VAP projects, no target analyte may be detected in the Method Blank at or above the reporting limit. If detected, the batch must be re-prepared after corrective actions are taken to eliminate the problem.

21.5 Laboratory Control Samples

The LCS is used to evaluate the performance of the total analytical system, including all preparation and analytical steps. Results of the LCS are compared to established criteria and, if found to be outside of these criteria, indicates that the analytical system is “out of control”. Any affected samples associated with an out of control LCS shall be reprocessed for re-analysis or the results reported with appropriate data qualifying codes. For Ohio VAP projects, all ‘contaminant of concern’ (COC) must meet LCS acceptance criteria.

The LCS shall be analyzed at a minimum of 1 per preparation batch. Exceptions would be for those analytes for which no spiking solutions are available such as total suspended solids, total dissolved solids, total volatile solids, total solids, pH, color, odor, temperature, dissolved oxygen or turbidity. In those instances for which no separate preparation method is used (example: volatiles in water) the batch shall be defined as environmental samples that are analyzed together with the same method and

personnel, using the same lots of reagents, not to exceed the analysis of 20 environmental samples. If there is insufficient sample to include a MS/MSD in the preparation batch, prepare a second LCS to assess batch precision.

The LCS is a controlled matrix, known to be free of the analytes of interest (usually the same material as the Matrix Blank), spiked with known and verified concentrations of analytes. NOTE: the matrix spike may be used in place of this control (except for Ohio VAP Projects), as long as the acceptance criteria are as stringent as for the LCS and an assignable cause exists for the failed LCS. Alternatively, the LCS will consist of a media containing known and verified concentrations of analytes or as Certified Reference Material (CRM). All analyte concentrations shall be within the calibration range of the methods. The following shall be used in choosing components for the spike mixtures:

The components to be spiked shall be as specified by the mandated test method or other regulatory requirement as requested by the client. In the absence of specified spiking components, the laboratory shall spike for the following:

For those components that interfere with an accurate assessment such as spiking simultaneously with technical Chlordane, Toxaphene and PCBs, the spike must be chosen that represents the chemistries and elution patterns of the components to be reported.

For those test methods that have extremely long lists of analytes, a representative number will be chosen. The analytes selected should be representative of all analytes reported. The following criteria shall be used to determine the minimum number of analytes to be spiked.

a) For methods that include 1-10 targets, spike all components;

b) For methods that include 11-20 targets, spike at least 10 or 80%, whichever is greater;

c) For methods with more than 20 targets, spike at least 16 components.

The results of the individual batch LCS are calculated in percent recovery. The laboratory shall document the calculation for percent recovery.

The individual LCS is compared to the laboratory established acceptance criteria or client specified assessment criteria. If these criteria do not exist, use criteria as published in the mandated test method.

A LCS that is determined to be within the criteria effectively establishes that the analytical system is in control and validates system performance for the samples in the associated batch. Samples analyzed along with a LCS determined to be “out of control” must be considered suspect and the samples reprocessed and re-analyzed or the data reported with appropriate data qualifying codes. If the LCS indicates a potential high bias and the associated samples “non-detect”, the samples will be reported without flags.

21.6 Matrix Spikes and Matrix Spike Duplicates

The laboratory must document the procedures for determining the effect of the sample matrix on method performance. These procedures relate to the analysis of matrix specific Quality Control (QC) samples and are designed as data quality indicators for a specific sample using the designated test method. These controls alone are not used to judge laboratory performance.

Examples of the matrix specific QC include: Matrix Spike (MS); Matrix Spike Duplicate (MSD); sample duplicates; and surrogate spikes. The laboratory has procedures in place for tracking, managing, and handling matrix specific QC criteria including spiking appropriate components at appropriate concentrations, calculating recoveries and relative percent difference, evaluating and reporting results based on performance of the QC samples.

Purpose –
Matrix specific QC samples indicate the effect of the sample matrix on the precision and accuracy of the results generated using the selected method. The information from these controls is sample/matrix specific and would not normally be used to determine the validity of the entire batch.

Frequency –
The frequency of the analysis of matrix specific samples shall be determined as part of a systematic planning process (e.g. Data Quality Objectives) or as specified by the required mandated test method. If sufficient sample is available, a MS/MSD pair is prepared at least once every 20 samples.

Composition –
The components to be spiked shall be as specified by the mandated test method. Any permit specified analytes, as specified by regulation or client requested analytes shall also be included. If there are no specified components, the laboratory shall spike per the following:

For those components that interfere with an accurate assessment such as spiking simultaneously with technical chlordane, Toxaphene and PCBs, the spike must be chosen that represents the chemistries and elution patterns of the components to be reported.

For those test methods that have extremely long lists of analytes, a representative number will be chosen. The analytes selected should be representative of all analytes reported. The following criteria shall be used to determine the minimum number of analytes to be spiked. However, the laboratory shall ensure that all targeted components are included in the spike mixture over a 2 year period.

a) For methods that include 1-10 targets, spike all components;

b) For methods that include 11-20 targets, spike at least 10 or 80%, whichever is greater;

c) For methods with more than 20 targets, spike at least 16 components.

Evaluation Criteria and Corrective Action –
The results from matrix spike/matrix spike duplicate are primarily designed to assess the precision and accuracy of analytical results in a given matrix and are expressed as percent recovery (%R) and relative percent difference (RPD). The LIMS performs the calculation for relative percent difference.

Results are compared to the laboratory established acceptance criteria, or client specified criteria. If these criteria do not exist, use criteria as published in the mandated test method. For matrix spike results outside established criteria the data is reported with appropriate data qualifying flags.

21.7 Matrix Duplicates

Purpose –
Matrix duplicates are defined as replicate aliquots of the same sample taken through the entire analytical procedure. The results from this analysis indicate the precision of the results for the specific sample using the selected method. The matrix duplicate provides a usable measure of precision only when target analytes are found in the sample chosen for duplication.

Frequency –
The frequency of the analysis of matrix duplicates is determined as part of a systematic planning process or as specified by the mandated test method. In most cases, batch precision is determined by duplicate LCS or MS/MSD, since the limitation of unusable information when the sample is non-detect is no longer an issue.

Composition –

Matrix duplicates are performed on replicate aliquots of actual samples. The composition is not usually known.

Evaluation Criteria and Corrective Action –
The results from matrix duplicates are primarily designed to assess the precision of analytical results in a given matrix and are generally expressed as relative percent difference (RPD) or other statistical treatment. Results are compared to acceptance criteria that is either method defined or laboratory determined. Results outside these criteria will lead to the sample result being flagged.

21.8 Surrogate Spikes

Purpose –
Surrogates are used most often in chromatographic test methods and are chosen to reflect the chemistries of the targeted components of the method. Added prior to sample preparation/extraction, they provide a measure of recovery for every sample matrix.

Frequency –
Except where the matrix precludes its use or when not available, surrogate compounds must be added to all samples, standards, and blanks for all appropriate test methods.

Composition –
Surrogate compounds are chosen to represent the various chemistries of the target analytes in the method. They are often specified by the mandated method and are deliberately chosen for their being unlikely to occur as an environmental contaminant. Often this is accomplished by using deuterated analogs of selected compounds.

Evaluation Criteria and Corrective Action –
The results are compared to the laboratory established acceptance criteria. Where there are no established criteria, the laboratory will determine internal criteria and document the method used to establish the limits. Surrogates outside the acceptance criteria must be evaluated for the matrix effect on sample results. The appropriate corrective action will be guided by the data quality objectives or other site specific requirements. Results reported from analyses with surrogate recoveries outside the acceptance criteria should include appropriate data qualifiers.

21.9 Proficiency Test Samples or Interlaboratory Comparisons

Proficiency testing (PT) involves the analysis of single-blind samples by the laboratory. Fibertec must obtain PT samples from a NELAP-approved PT sample provider. The laboratory receives and analyzes the PT samples, and reports the results to the sample provider. The laboratory's results are then compared to certified values, and an evaluation of the laboratory's performance is generated.

To maintain the validity of PT as a measurement of overall laboratory performance, PT samples are prepared as the vendor instructs then treated as normal client samples by the laboratory (i.e., preparation, analysis, and reporting).

At a minimum, the laboratory participates in at least one semi-annual PT program to fulfill the requirements of certifying agencies and as part of good laboratory practice. The laboratory currently participates in the following PT programs:

1 NELAC WP (semi-annual)
2 NELAC Soil (semi-annual)
3 EPA DMR-QA (annual)
4 AIHA PAT (quarterly)

In the event of an unacceptable performance on a PT sample, the laboratory shall initiate and complete a corrective action process. The results of the corrective action (i.e., investigation and action taken) shall then be available to the primary NELAC accrediting authority or client upon request. [Related SOPs: G-325 "Procedure for the Treatment of Proficiency Test Samples"]

21.10 Data Review

Individual test method SOPs contain the technique for data reduction for the test method. [Related SOPs: G-364 "Data Review and Results Validation"]

21.10.1 Primary Data Review

It is the responsibility of the primary analyst performing the work to review the quality control indicators that accompany the analytical batch. In addition to the prepared sample batch quality control samples, instrument analytical quality control indicators must be monitored for acceptable performance.

The evaluation of positive and negative quality control indicators will identify most out-of-control situations and determine the appropriate corrective action, if required. Depending upon the extent of the deviation, the analyst will define the treatment of the associated data set accordingly. For example, data will be reported with qualification(s), or the entire sample set will require re-preparation and/or reanalysis.

Once the raw data have been reviewed and reduced to a summary report, the primary analyst performs the following:

1) Double check of quality control indicators and compliance with control limits
2) Double check of manual calculations, including manual integrations and data transcription:
   ✓ All manual integrations shall conform to accepted procedures.
3) Review of automated calculations performed by spreadsheet applications
4) Indicate completion and acceptance by initialing or signing and dating the summary report

Once the primary review is complete, the raw data and summary report are submitted to a laboratory supervisor or second experienced analyst for review and approval. Every analytical sequence that contains reportable data must undergo secondary review (100% peer review).

21.10.2 Secondary Review (Peer Review)

A second experienced analyst or group leader conducts the secondary review step. This allows a second "set of eyes" to review the work and to possibly find errors that may have been overlooked by the primary analyst. The reviewing analyst or group leader is responsible for reviewing the same quality control indicators as the primary analyst. This review will, also, involve visually checking several identifications, manual calculations, integrations, etc. Problems or questions raised are sent back, with the data, to the primary analyst for correction or clarification.

Once the secondary review is complete, data are approved in the LIMS and released to the laboratory administrative staff for generation of the final laboratory report. The final review occurs for all reports sent to clients (100% of reports).

21.10.3 Final Review

Final review is the last validation step prior to the release of analytical data to the client. This review step has two parts; 1) administrative staff review, and 2) management review.

Following the completion of all laboratory analyses for a project, the data are re-organized by the administrative staff into a summary report. At this time, the administrative staff reviews data for completeness, appropriately qualified results, agreement with client requirements and typographical

errors.

Following the final review of the report by the administrative staff, the report is submitted to laboratory management for review and signature. The laboratory director, QAO, or designee review the final report, paying attention to possible technical errors or necessary data qualifiers. Once the report has been reviewed, it is then prepared for submittal to the client by the administrative staff.

21.10.4 Qualifying Data

Analytical data shall be reported to clients only when all associated quality control indicators are acceptable. However, laboratory protocol defines instances when data generated under out-of-control conditions will be reported. These "qualified" data are noted in the final report by adding a standardized letter code (or flag) next to the numerical concentration value, as well as a footnote explaining the code.

Appropriate single letter flags are listed, with their explanations, in Appendix B.

Section 22 – Reporting of Results

The overall goal in reporting laboratory data is to provide clear, concise and complete information in a timely manner and in a format that is useful to laboratory clients. In addition, clients may request customized report formats to meet regulatory requirements, or for automatic digital transfer into existing documents. At the discretion of laboratory management, additional items may be included in the report format, especially in instances where further explanation or qualification of data is required. [Related SOPs: G-107 "Report Generation Procedure"]

22.1 Test Reports

Tier II Test Reports will contain the following:

- A title (i.e. "Laboratory Results")
- Name and Address of Laboratory w/contact information
- Unique identification of the report (work order number) and number of pages
- Name and Address of Client (project name, if available)
- Description of the client sample(s) (client ID numbers if available)
- Test results and any qualifications related to quality or accreditation
- Date of receipt, date and time of collection, date of analysis, date and time of prep (if hold ≤ 72 hours)
- Identification of the test methods
- Reference the sample collection method, if applicable
- Any deviations from, additions to or exclusions from the method performed
- Signature and title of the person(s) accepting responsibility for the content of the report
- Statement to the effect that the results relate only to the samples submitted
- Identification of all data provided by subcontract labs
- Unambiguous reporting limits

Tier III Report

The Tier III report has two sections. The first section contains the complete Tier II report as described above. The second section contains a summary of all QC information from the preparation and analytical batches. This includes a summary of the Method Blank findings, Laboratory Control Findings, Matrix Spike Recovery, Surrogate Summary Report, Internal Standard Summary (if appropriate), Continuing Calibration Summary, Calibration Summary.

Tier IV Report

The Tier IV report contains three sections, a completed Tier II, the completed Tier III, and copies of the Raw Instrument Data, raw data for the calibration, a copy of any appropriate analytical log book pages, a

copy of the preparation bench sheet for the samples and a narrative describing any excedances. Standard Preparation records will be supplied if requested.

Other final report formats/information is available to clients upon request. For VAP projects, an Affidavit must accompany the final report attesting to the data was the result of meeting all the method requirements.

22.2 Supplemental Test Report Information

Any additional information observed by technician or analyst that helps clarify the quality of the data may be added to the final report narrative.

22.3 Environmental Testing Obtained from Subcontractors

If the client requires analyses not performed by Fibertec, with the client's approval, the work may be sub-contracted to a second lab. If the client requires the contract lab to be certified or accredited, information related to that certificate will be included in the report.

22.4 Electronic Transmission of Results

Electronic data deliverables (EDDs) are available upon request by the client.

22.5 Amendments to Test Reports

If an error is discovered in the data or reporting mechanism after a final report is sent to the client, an amended report is issued and the client is alerted. The amended report is clearly marked as "amended".

Section 23 – Appendices

Appendix A – Scope of Analysis

SW846 Method #	Title
1010	Pensky-Martens Closed-Cup Method for Determining Ignitability
1030	Ignitability of Solids
1311	Toxicity Characteristic Leaching Procedure
1312	Synthetic Precipitation Leaching Procedure
1631 rev E	Mercury by Cold Vapor Atomic Fluorescence
3005A	Acid Digestion of Waters for Total Recoverable or Dissolved Metals for Analysis by FLAA or ICP Spectroscopy
3050B	Acid Digestion of Sediments, Sludges and Soils
3060A	Alkaline Digestion for Hexavalent Chromium
3510C	Separatory Funnel Liquid-Liquid Extraction
3535A	Solid-Phase Extraction (SPE)
3546	Microwave Extraction
3550C	Ultrasonic Extraction
3580A	Waste Dilution
3585	Waste Dilution for Volatile Organics
3600C	Cleanup
3620C	Florisil Cleanup
3660B	Sulfur Cleanup
5030B	Purge-and-Trap for Aqueous Samples
5035	Closed-System Purge-and-Trap and Extraction for Volatile Organics in Soil and Waste Samples
6010C	Inductively Coupled Plasma-Atomic Emission Spectrometry
6020A	Inductively Coupled Plasma-Mass Spectrometry
7196A	Chromium, Hexavalent (Colorimetric)
7470A	Mercury in Liquid Waste (Manual Cold-Vapor Technique)
7471A	Mercury in Solid or Semisolid Waste (Manual Cold-Vapor Technique)
8015A/C	Nonhalogenated Organics Using GC/FID
8081B	Organochlorine Pesticides by Gas Chromatography
8082A	Polychlorinated Biphenyls (PCBs) by Gas Chromatography
8151A	Chlorinated Herbicides by GC Using Methylation or Pentafluorobenzylation Derivatization
8260B	Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)
8270C	Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)
9010B	Total and Amenable Cyanide: Distillation
9013	Cyanide Extraction Procedures for Solids and Oils
9014	Titrimetric and Manual Spectrophotometric Determinative Methods for Cyanide
9034	Titrimetric Procedure for Acid Soluble and Acid-Insoluble Sulfides
9038	Sulfate (Turbidimetric)
9040B	pH Electrometric Measurement
9041A	pH Paper Method
9045C	Soil and Waste pH
9050A	Specific Conductance

9056	Determination of Inorganic Anions by Ion Chromatography
9060	Total Organic Carbon
9065	Phenolics (Spectrophotometric, Manual 4-AAP with Distillation)
9070	Oil and Grease
9095A	Paint Filter Liquids Test
9211	Potentiometric Determination of Bromide in Aqueous Samples with Ion-Selective Electrode
9214	Potentiometric Determination of Fluoride in Aqueous Samples with Ion-Selective Electrode
9215	Potentiometric Determination of Sulfide in Aqueous Samples and Distillates with Ion selective Electrode
9253	Chloride (Titrimetric, Silver Nitrate)
HCN Test Method	Test to Determine Hydrogen Cyanide Released From Wastes
H_2S Test Method	Test to Determine Hydrogen Sulfide Released From Wastes

Methods for Chemical Analysis of Water and Wastes (MCAWW)

EPA Method #	**Title**
120.1	Conductance (Specific Conductance, μmhos at 25°C)
150.1	pH (Electrometric)
160.1	Residue, Filterable (Gravimetric, Dried at 180°C)
160.2	Residue, Non-Filterable (Gravimetric, Dried at 103-105°C)
160.3	Residue, Total (Gravimetric, Dried at 103-105°C)
160.4	Residue, Volatile, Total (Gravimetric, Ignition at 550°C)
170.1	Temperature (Thermometric)
180.1 R2.0	Determination of Turbidity by Nephelometry – Revision 2.0
200.2 R2.8	Sample Preparation Procedure for Spectrochemical Determination of Total Recoverable Elements – Revision 2.8
200.7 R4.4	Determination of Trace Elements in Water and Wastes by Inductively Coupled Plasma - Atomic Emission Spectrometry – Revision 4.4
200.8 R5.4	Determination of Trace Elements in Water and Wastes by Inductively Coupled Plasma - Mass Spectrometry – Revision 5.4
245.1 R3.0	Determination of Water by Cold Vapor Atomic Absorption Spectrometry – Revision 3.0
245.5	Mercury in Sediment (Manual Cold Vapor Technique)
300.0 R2.1	Determination of Inorganic Anions By Ion Chromatography – Revision 2.1
305.1	Acidity (Titrimetric)
310.1	Alkalinity (Titrimetric, pH 4.5)
310.2	Alkalinity
330.5	Chlorine, Total Residual (Spectrophotometric, DPD)
335.4	Cyanide, Total (Spectrophotometric)
340.2	Fluoride (Potentiometric, Ion Selective Electrode)
350.3	Nitrogen, Ammonia (Potentiometric, Ion Selective Electrode)
353.3	Nitrogen, Nitrate-Nitrite (Colorimetric, Cadmium Reduction)
360.1	Oxygen, Dissolved (Membrane Electrode)
365.3	Phosphorus, All Forms (Colorimetric, Ascorbic Acid, Two Reagent)
375.4	Sulfate (Turbidimetric)
405.1	Biochemical Oxygen Demand (5 days, 20°C)
410.4 R2.0	The Determination of Chemical Oxygen Demand by Semi-Automated Colorimetry – Revision 2.0
415.1	Organic Carbon, Total (Combustion or Oxidation)
420.1	Phenolics (Spectrophotometric, Manual 4-AAP with Distillation)
608	Organochlorine Pesticides and PCBs
624	Purgeables

625	Base/Neutrals and Acids
1664RA	N-Hexane Extractable Material (HEM; Oil and Grease) and Silica Gel Treated N-Hexane Extractable Material (SGT-HEM; Non-Polar Material) by Extraction and Gravimetry – Revision A

Hach Water Analysis Handbook, 3rd Edition (HACH)

HACH Method #	Title
8000†	Oxygen Demand, Chemical
8507†	Nitrite, LR – Diazotization Method
8167‡	Chlorine, Total – DPD Method
8023‡	Chromium, Hexavalent – 1,5-Diphenylcarbohydrazide Method
8051‡	Sulfate – SulfaVer 4 Method
8195‡	Turbidity – Nephelometric Method

† Cited in Table 1A of 40 CFR Part 136.3 as approved for NPDES compliance monitoring.
‡ Reviewed by the EPA Alternate Test Procedure (ATP) program and recommended as acceptable for NPDES compliance monitoring.

Standard Methods for the Examination of Water and Wastewater 20th Edition (SMWW)

Standard Method #	Title
2130 B.	Turbidity (Nephelometric Method)
2310 B.	Acidity (Titration Method)
2320 B.	Alkalinity (Titration Method)
2340 B.	Hardness (Hardness by Calculation)
2350 B.	Oxidant Demand/Requirement (Chlorine Demand/Requirement)
2510 B.	Conductivity (Laboratory Method)
2540 B.	Solids (Total Solids Dried at 103-105°C)
2540 C.	Solids (Total Dissolved Solids Dried at 180°C)
2540 D.	Solids (Total Suspended Solids Dried at 103-105°C)
2540 E.	Solids (Fixed and Volatile Solids in Liquids Ignited at 550°C)
2540 F.	Solids (Settleable)
2540 G.	Solids (Fixed and Volatile Solids is Solids)
2550 B.	Temperature (Laboratory and Field Methods)
3112 B.	Metals by Cold-Vapor Atomic Absorption Spectrometry (Cold Vapor-Atomic Absorption Spectrometric Method)
3120 B.	Metals by Plasma Emission Spectroscopy (Inductively Coupled Plasma (ICP) Method)
3125 B.	Metals by Inductively Coupled Plasma/Mass Spectrometry (Inductively Coupled Plasma Mass Spectrometry (ICP/MS) Method)
3500-Cr B.	Chromium (Colorimetric Method)
4110 C.	Determination of Anions By Ion Chromatography (Single Column Ion Chromatography with Electronic Suppression of Eluent Conductivity and Conductimetric Detection)
4500-CN^- B.	Cyanide (Preliminary Treatment of Samples)
4500-CN^- C.	Cyanide (Total Cyanide After Distillation)
4500-CN^- E.	Cyanide (Colorimetric Method)
4500-CN^- G.	Cyanide (Cyanides Amenable to Chlorination After Distillation)
4500-Cl G.	Chlorine (Residual) (DPD Colorimetric Method)
4500-Cl I.	Chlorine (Residual) (Iodometric Electrode Technique)
4500-Cl^- B.	Chloride (Argentometric Method)
4500-F^- D.	Fluoride
4500-H^+ B.	pH Value (Electrometric Method)
4500-NH_3 D.	Nitrogen (Ammonia) (Ammonia-Selective Electrode Method)
4500-NO_3^- E.	Nitrogen (Nitrate) (Cadmium Reduction Method)
4500-O G.	Oxygen (Dissolved) (Membrane Electrode Method)

4500-P B., 4	Phosphorus (Sample Preparation, Sulfuric Acid-Nitric Acid Digestion)
4500-P E.	Phosphorus (Ascorbic Acid Method)
4500-S^{2-} C.	Sulfide (Sample Pretreatment to Remove Interfering Substances or to Concentrate the Sulfide)
4500-S^{2-} D.	Sulfide
4500-SO_4^{2-} E.	Sulfate (Turbidimetric Method)
5210 B.	Biochemical Oxygen Demand (BOD) (5-Day BOD Test)
5220 D.	Chemical Oxygen Demand (COD) (Closed Reflux, Colorimetric Method)
5310 B.	Total Organic Carbon (TOC) (High-Temperature Combustion Method)
5520 B.	Oil and Grease (Partition-Gravimetric Method)
5520 F.	Oil and Grease (Hydrocarbons)
5530 D.	Phenols (Direct Photometric Method)
5540 C.	Surfactants
6200 B.	Volatile Organic Compounds (Purge and Trap Capillary-Column Gas Chromatographic/Mass Spectrometric Method)
6410 B.	Extractable Base/Neutrals and Acids (Liquid-Liquid Extraction Gas Chromatographic/Mass Spectrometric Method)
6431 B.	Polychlorinated Biphenyls (PCBs) (Liquid-Liquid Extraction Gas Chromatographic Method)
6440 C.	Polynuclear Aromatic Hydrocarbons (Liquid-Liquid Extraction Gas Chromatographic/Mass Spectrometric Method)
6630 C.	Organochlorine Pesticides (Liquid-Liquid Extraction Gas Chromatographic Method II)

American Society for Testing and Materials (ASTM)

ASTM Method #	**Title**
D 2974-87	Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils
D 2216-92	Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock
D 421-85	Standard Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants
D 422-63	Standard Test Method for Particle-Size Analysis of Soils
D 482-95	Standard Test for Ash from Petroleum Products
D 1475-96	Standard Test Method for Density of Liquid Coatings, Inks, and Related Products
D 2216-92	Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock
D 3987-85	Standard Test Method for Shake Extraction of Solid Waste with Water
D 1291-89	Standard Practice for Estimation of Chlorine Requirement or Demand of Water, or Both

National Institute for Occupational Health and Safety (NIOSH)

NIOSH Method #	**Title**
7300	Elements by ICP

Appendix B - Data Qualifiers

Code	**Description**
U	The analyte was not detected at or above the reporting limit.
E	The analyte was detected at a concentration greater than the calibration range, therefore the result is estimated.
*****	Value reported is outside QA limits.
W	Results reported on a Wet-weight basis.
J	The concentration is an estimated value.
B	The analyte was detected in the associated method blank.
X	Matrix interference has resulted in a raised reporting limit or distorted result.
A	Spike recovery or precision unusable due to dilution
G	Surrogate recovery outside of acceptance range

V	Continuing Calibration Verification failed established acceptance criteria for this analyte
L	The LCS lead to recovery outside of established acceptance criteria
N	Sample Spike yielded recovery outside of acceptance limit
F	MS or MSD did not look like the parent sample possibly due to non-uniform matrix

Appendix C – Laboratory Equipment

Sample Handling Department

Quantity	Equipment Description
1	Walk-In Cooler (approximately 1200 cubic feet)

Sample Preparation Laboratory

Quantity	Equipment Description
4	CPI ModBlock™ 48-position Digestion Blocks
1	Lars Lande Tumble Extractor
1	Vollrath 2000 Warmer Water Bath
2	Sartorius BA310P Balance, Top Loading
1	Zymark Turbo-Vap
1	Equatherm Oven
1	AND – 120i, Top Loading Balance
1	Thermolyne Muffle Oven
1	Ohaus SC4010 Balance, Top Loading
1	Ethos EX, Microwave Extractor
2	Ultrasonic Dismembrator
1	Magic Chef™ 12.1 cu.ft. Refrigerator/Freezer
1	Kenmore 14 Refrigerator/Freezer
1	Frigidaire™ UFS219N Freezer

Volatiles Laboratory

Quantity	Equipment Description
2	Hewlett Packard 5890A Gas Chromatograph-5971-or- 5972 Mass Spectrometer
4	Hewlett Packard 6890A Gas Chromatograph-5975 Mass Spectrometer
1	Perkin/Elmer Clarus 600 Gas Chromatograph/Mass Spectrometer
2	Teledyne – Solatek Autosampler with Velocity Concentrator
1	EST – Encon, Centurion
1	Tekmar – AutoCan
1	Tekmar ALS 2016/LSC 2000 Automatic Sampler
1	Entech 7500A Autosampler
1	Entech 7150 Sample Concentrator
1	Millipore ZHE Tumble Extractor
2	Bransonic 221 Sonicator
2	Montgomery Ward LGS 2015C Refrigerator/Freezer
1	Avanti 489RC/RA/RW Refrigerator/Freezer

5	Ohaus SC4010 Balance, Top Loading
1	Custom Made Canister Cleaning Oven, J.C. Metal

Semi-Volatiles Laboratory

Quantity	Equipment Description
2	Hewlett Packard 6890 Gas Chromatograph/5975 Mass Spectrometer
1	Hewlett Packard 6890 Gas Chromatograph/5973 Mass Spectrometer
2	Hewlett Packard 5890A Series II Gas Chromatograph/Mass Spectrometer
2	Hewlett Packard 5890A Series II Gas Chromatograph/Flame Ionization Detector
1	Hewlett Packard 6890 Gas Chromatograph/FID
3	Hewlett Packard 5890A Series II Gas Chromatograph/ Electron Capture Detector(s)
1	Hewlett Packard 7890 Gas Chromatograph/ Flame Ionization Detector
1	Tekmar ALS 2016/LSC 2000 Automatic Sampler

Trace Metals Laboratory

Quantity	Equipment Description
1	Perkin Elmer/Elan 9000 Inductively Coupled Plasma-Mass Spectrometer
1	Perkin Elmer Plasma 4300 Inductively Coupled Plasma-Atomic Emission Spectrometer
1	PSA Millennium – Low Level Mercury
1	CETAC/Varian M6000A Mercury Analyzer

Wet Chemistry Laboratory

Quantity	Equipment Description
1	Dionex 2000 Ion Chromatograph with Autosampler
1	Dionex DX-500 Ion Chromatograph
1	Shimadzu 5000A Total Organic Carbon Analyzer
1	Hach DR2000 Direct Read Spectrophotometer
1	WH Lauda – Pensky-Martens Flash Point Tester
1	Hach CO150 Conductivity Meter
1	Orion 850 Dissolved Oxygen Meter
1	Hach EC30 pH/ISE Meter
1	AquaKem 200 – Discrete Analyzer
1	Sartorius Balance, Top Pan
1	Scout Ohaus Balance
1	Barnstead E-Pure™ Water Filtration System
1	Hach 45600 COD Reactor
1	Kontes MIDI-VAP 2000 Distillation Apparatus
1	MicroDist - Lachat
1	Thermolyne Muffle Oven
1	Hach Ratio/XR Turbidimeter
1	Mettler AE200S Balance, Analytical
1	Fisher Scientifie – Accumet-25
1	Refrigerator – Haier
1	Dessicater

1	Orion 5-Star
1	ShelLab 2020 BOD Incubator

Quality Assurance Department

Quantity	**Equipment Description**
1	Troemner Class I Weight Set
1	Fisher Class S Weight Set
1	Christian Becker Class S Weight Set
1	Sartorius R300S Balance, Analytical
1	Fisher 15-078-3A Digital Thermometer, Traceable
1	Fisher 15-078-2B High Temperature Probe, Traceable

Appendix D – Routine Calculations

Rounding Rules and Significant Figures

Laboratory policy is to report all analytical data using two significant figures, unless otherwise directed by a client or regulatory agency. We recognize that near the analytical detection limit there is only one significant figure, thereby increasing variability in analytical results.

NOTE: All digits in numbers from instrument raw data and those derived in spreadsheet or other calculations are used in laboratory calculations until the final reported result is achieved.

For water sample raw data and following percent solids correction for soil sample data, results are modified using standard rounding rules to achieve two significant figures. The rounding rules are as follows:

1) If the third digit is ≤ 4, the second digit remains unchanged.
2) If the third digit is ≥ 5, the second digit is raised.

Example:

- $12.4 \Rightarrow 12$
- $0.00126 \Rightarrow 0.0013$
- $1.25 \Rightarrow 1.3$

Calculation of Percent Recovery

Percent recovery (%R) is determined as follows:

$$\%R = \left(\frac{a}{b}\right) \times 100$$

Where: a = Actual Value

b = Expected Value

Calculation of Mean

The mean ($\overline{x}$) is determined as follows:

$$\overline{x} = \frac{\sum x}{n}$$

Where: x = Recovery Value
n = Number of Values

Using MS Excel™, the mean ($\overline{x}$) is determined using the following formula:

=AVERAGE(**number1**, [number2], …)

Calculation of Relative Percent Difference

Relative percent difference (%RPD) is determined as follows:

$$\%RPD = \left(\frac{|V_1 - V_2|}{(V_1 + V_2) \div 2} \right) \times 100$$

Where: V_1 = First Value
V_2 = Second Value

Using MS Excel™, the relative percent difference (%RPD) is determined using the following formula:

=((ABS(number1-number2))/(AVERAGE(number1+number2)))*100

Calculation of Standard Deviation

The standard deviation (s) is determined as follows:

$$s = \sqrt{\frac{\sum (x - \overline{x})^2}{n-1}}$$

Where: x = Recovery Value
$\overline{x}$ = Mean Recovery Value
n = Number of Values

Using the MS Excel™, the standard deviation (s) is determined using the following formula:

=STDEV(**number1**, [number2], …)

Calculation of Method Detection Limit

For operational purposes, when it is necessary to determine the MDL in the matrix, the MDL must be determined by multiplying the appropriate one-sided 99% t-statistic by the standard deviation obtained from a minimum of seven

analyses of a matrix spike containing the analyte of interest at a concentration three to five times the estimated MDL, where the t-statistic is obtained from standard references or the table below.

No. of samples:	t-statistic
7	3.143
8	2.998
9	2.896
10	2.821

Estimate the MDL as follows:

Obtain the concentration value that corresponds to:

a) an instrument signal/noise ratio within the range of 2.5 to 5.0, or
b) the region of the standard curve where there is a significant change in sensitivity (i.e., a break in the slope of the standard curve).

Determine the variance (S^2) for each analyte as follows:

$$s^2 = \frac{1}{n-1}\left[\sum_{i=1}^{n}(x_i - \bar{x})^2\right]$$

where x_i = the i^{th} measurement of the variable x

and $\bar{x}$ = the average value of x;

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

Determine the standard deviation (s) for each analyte as follows:

$$\mathbf{s = (S^2)^{1/2}}$$

Determine the MDL for each analyte as follows:

$$\mathbf{MDL = t_{(n-1,\ \alpha = .99)}(s)}$$

where $t_{(n-1,\ \alpha = .99)}$ is the one-sided t-statistic appropriate for the number of samples used to determine (s), at the 99 percent level.

The concentration chosen for the first iteration of the MDL study in nominally at the Reporting Limit. If the result of the study is that a lower concentration is required to obtain a calculated MDL between 20 to 60% of the spiked concentration, reduce the spike concentration 1:5 or 1:10 and repeat the preparation and analysis. Accept the result of this second study, regardless of the concentration vs. MDL ratio, since the result clearly supports the higher Reporting Limit.

Some clients require that the concentration of the spike be at or below the reporting level. (For example, Ohio requires the spike to be below the reporting limit.) For such clients, the reporting level will be elevated to be above or at the spike level, if necessary, to meet this requirement.

Appendix E – Sample Container/Preservative/Holding Requirements

Liquid/ Water

	Analyte	*Sample Volume†*	*Container*	*Chemical Preservative*	*Hold Times*
Organics	Volatiles, Gasoline Range Organics	120 mL	Glass vial	HCl	14 Days
	Semi Volatiles	1 Liter	Amber	None	7 Days extract/ 40 Days analyze
	PCBs	1 Liter	Amber	None	1 Year extract (wastewater) 7 Day extract (liquids)/ 40 Days analyze
	Organochlorine Pesticides	1 Liter	Amber	None	7 Days extract/ 40 Days analyze
	Organochlorine Pesticides/ PCBs	2 Liters	Amber	None	7 Days extract/ 40 Days analyze
	2,4-D, 2,4,5-TP	1 Liter	Amber	None	7 Days extract/ 40 Days analyze
	Organochlorine Herbicides	1 Liter	Amber	None	7 Days extract/ 40 Days analyze
	Diesel Range Organics	1 Liter	Amber	None	7 Days extract/ 40 Days analyze
	Ethylene Glycol	40 mL	Glass vial	None	7 Days
	Glycols (ethylene, propylene)	40 mL	Glass vial	None	7 Days
	Alcohols (n-butanol, t-butanol, ethanol, isobutanol, isopropanol, methanol)	40 mL	Amber vial	None	7 Days
	Analyte	***Sample Volume†***	***Container***	***Chemical Preservative***	***Hold Times***
Inorganics	Mercury	500 mL	Poly	$HN0_3$	28 Days
	Metals Filtering (dissolved metals)	500 mL	Poly	None	Immediately
	Total Metals	500 mL	Poly	$HN0_3$	6 Months
	Alkalinity	250 mL	Poly	None	14 Days
	Biochemical Oxygen Demand	500 mL	Poly	None	48 Hours
	Bromide	250 mL	Poly	None	28 Days
	Carbon, Total Organic	40 mL	Amber	HCl	28 Days
	Chemical Oxygen Demand	125 mL	Poly	H_2SO_4	28 Days
	Chromium, Hexavalent	500 mL	Poly	None	24 Hours
	Chloride	250 mL	Poly	None	28 Days
	Chlorine Demand	2 Liters	Amber	None	24 Hours
	Chlorine, Total Residual	250 mL	Poly	None	24 Hours
	Cyanide, Amenable	250 mL	Poly	NaOH	14 Days
	Cyanide, Total	250 mL	Poly	NaOH	14 Days
	Dissolved Oxygen	500 mL	Amber	None	Immediately
	Fats, Oils, & Grease	1000 mL	Amber	HCl	28 Days
	Fluoride	250 mL	Poly	None	28 Days
	Hardness	500 mL	Poly	$HN0_3$	6 Months
	Ignitability	500 mL	Poly/Glass	None	7 Days
	Nitrogen, Ammonia	500 mL	Poly	H_2SO_4	28 Days
	Nitrogen, Total Kjeldahl	500 mL	Poly	H_2SO_4	28 Days
	Nitrogen, Nitrate	250 mL	Poly	None	48 Hours
	Nitrogen, Nitrite	250 mL	Poly	None	48 Hours
	Nitrate Plus Nitrite	250 mL	Poly	H_2SO_4	28 Days
	pH	150 mL	Poly	None	Immediately
	Phenolics, Total	1 Liter	Amber	H_2SO_4	28 Days
	Phosphorus, Ortho (dissolved)*(total)	250 mL	Poly	None	48 Hours
	Phosphorus, Total	250 mL	Poly	H_2SO_4	28 Days
	Reactivity	500 mL	Poly/Glass	None	7 Days
	Solids, Total	500 mL	Poly	None	7 Days
	Solids, Total Dissolved	500 mL	Poly	None	7 Days
	Solids, Total Suspended	500 mL	Poly	None	7 Days
	Solids, Total Volatile	500 mL	Poly	None	7 Days
	Specific Conductance	250 mL	Poly	None	28 Days
	Sulfate	250 mL	Poly	None	28 Days
	Sulfide, Total	500 mL	Poly	Zn Acetate NaOH	7 Days
	Turbidity	250 mL	Poly	None	48 Hours

Requires filtering
† Some analyses can be combined, contact laboratory with questions

Soil/ Solid

	Analyte	***Sample Volume†***	***Container***	***Chemical Preservative***	***Hold Times***
Organics	Volatiles (5035), Gasoline Range Organics	40 mL	Glass vial	MeOH	14 Days
	Volatiles (5030), Gasoline Range Organics	4 oz	Glass jar	None	14 Days
	Semi Volatiles	4 oz	Glass jar	None	14 Days extract/ 40 Days analyze
	PCBs	4 oz	Glass jar	None	14 Days extract/ 40 Days analyze
	Organochlorine Pesticides	4 oz	Glass jar	None	14 Days extract/ 40 Days analyze
	Organochlorine Pesticides/ PCBs	4 oz	Glass jar	None	14 Days extract/ 40 Days analyze
	2,4-D, 2,4,5-TP	4 oz	Glass jar	None	14 Days extract/ 40 Days analyze
	Organochlorine Herbicides	4 oz	Glass jar	None	14 Days extract/ 40 Days analyze
	Diesel Range Organics	4 oz	Glass jar	None	14 Days extract/ 40 Days analyze
	Ethylene Glycol	4 oz	Glass jar	None	14 Days
	Glycols (ethylene, propylene)	4 oz	Glass jar	None	14 Days
	Alcohols (n-butanol, t-butanol, ethanol, isobutanol, isopropanol, methanol)	4 oz	Glass jar	None	14 Days
	Analyte	***Sample Volume†***	***Container***	***Chemical Preservative***	***Hold Times***
Inorganics	Metals	4 oz	Glass jar	None	6 Months
	Mercury	4 oz	Glass jar	None	28 Days
	Bromide	4 oz	Glass jar	None	28 Days
	Carbon, Total Organic	4 oz	Glass jar	None	28 Days
	Chromium, Hexavalent	4 oz	Glass jar	None	28 Days
	Chloride	4 oz	Glass jar	None	28 Days
	Corrosivity	4 oz	Glass jar	None	7 Days
	Cyanide, Amenable	4 oz	Glass jar	None	28 Days
	Cyanide, Total	4 oz	Glass jar	None	28 Days
	Fluoride	4 oz	Glass jar	None	28 Days
	Ignitability	4 oz	Glass jar	None	7 Days
	Nitrogen, Ammonia	4 oz	Glass jar	None	28 Days
	Nitrogen, Total Kjeldahl	4 oz	Glass jar	None	28 Days
	Nitrogen, Nitrate	4 oz	Glass jar	None	48 Hours
	Nitrogen, Nitrite	4 oz	Glass jar	None	48 Hours
	Nitrate Plus Nitrite	4 oz	Glass jar	None	28 Days
	pH	4 oz	Glass jar	None	Immediately
	Phosphorus (water soluble)	4 oz	Glass jar	None	6 Months
	Specific Conductance	4 oz	Glass jar	None	28 Days
	Sulfate	4 oz	Glass jar	None	28 Days
	Sulfide, Total	4 oz	Glass jar	None	7 Days
	Analyte	***Sample Volume†***	***Container***	***Chemical Preservative***	***Hold Times***
Geotechnical	Particle Size- Sieve Hydrometer	8 oz	Glass jar	None	6 Months
	Dry Bulk Density	25 cm length	GP Sleeve	None	6 Months
	Specific Gravity	4 oz	Glass jar	None	6 Months
	Fraction Organic Carbon- Walkley Black	4 oz	Glass jar	None	6 Months
	Fraction Organic Matter	4 oz	Glass jar	None	6 Months
	% Moisture	4 oz	Glass jar	None	6 Months
Air	TO-15 Volatiles	6 Liter/ 1 Liter	Summa Canister/ Bottle Vac	None	30 Days
	Volatiles	1 Liter	Tedlar Bag	None	72 Hours

Appendix C

Vapor Mitigation SOPs

Hamp, Mathews &
Associates, Inc.

Geosyntec consultants

2395 Oak Valley Drive, Suite 110
Ann Arbor, Michigan 48103
PH 734.332.8004
FAX 734.332.8063
www.geosyntec.com

Memorandum

Date:	February 9, 2012
To:	Grant Trigger, Cleanup Manager – Michigan, RACER Trust
Copies to:	Dave Favero, RACER Trust
	Jeffrey Crum, Hamp, Mathews & Associates, Inc.
From:	Karen Berry-Spark, William Wertz & Todd McAlary - Geosyntec
Subject:	Livonia, Michigan: Standard Operating Procedures (SOPs) for Vapor Intrusion Mitigation

---

At your request, Geosyntec Consultants, Inc. (Geosyntec) has completed a review of three Standard Operating Procedures (SOPs) 23, 24, and 25 prepared by ARCADIS from the Moraine, Ohio site. The SOPs are related to design, construction and operation and maintenance (O&M) of system to mitigate subsurface vapor intrusion (VI) to indoor air pathway. This review was performed to modify the SOPs to reflect field and building conditions to the Livonia, Michigan site. Mitigation will involve the following steps:

1. Installation of an air purifier as an interim measure to treat volatile organic compounds (VOCs) in indoor air, if the occupant desires;
2. A pre-design home inspection to obtain information to be used in designing the mitigation system;
3. Indoor air sampling during the inspection to evaluate performance of the air purifier;
4. Preparation of a property-specific mitigation work plan for US EPA approval. The work plan will include the detailed design of the mitigation system;
5. Installation and startup of the mitigation system;
6. Removal of the air purifier, if one was installed;
7. Post-installation performance sampling (PIPS) 30, 180 and 360 days after installation of the mitigation system to confirm that the system is operating as needed;
8. Operation and maintenance (O&M) of the system for three years that includes annual inspection of the system; and
9. Long-term O&M of the system that includes annual letters and phone calls to the home occupant and external system checks (or internal if the occupant prefers). The long-term O&M program also includes programs to follow up with homeowners that declined systems, track physical changes to the structure, and changes in property ownership.

Geosyntec's recommended modifications to the above referenced Moraine site SOPs are provided below.

SOP 23 INSPECTION AND VAPOR INTRUSION MITIGATION SYSTEM DESIGN

1. Section V, Procedure, "Vapor Mitigation System Inspection (US EPA 625 and ASTM E2121-03)"

Differential pressures between the subslab soil gas and the indoor air can vary substantially from one minute to the next, and will almost certainly vary from day to day and season to season. Consequently, the following additions to the SOP are recommended:

- If practicable, the mitigation design inspection should be conducted during the winter months so that the measurements are conducted during the "heating season".
- At a minimum, building components that could induce under-pressurization (furnace, hot water heater, clothes dryer) should be operated whenever the pressure field measurements are obtained.

2. Section V, Procedure, item "i."

Section V, item "i." of the SOP includes measuring the building-specific background pressure differential using a manometer at sub-slab probes. Include the use of a smoke stick to aid in establishing the background pressure differential. The smoke provides visual confirmation of flow into the subslab from the basement, and may actually do so in cases where the pressure differential is less than 0.004 inches of water column (in w.c.). Pass the smoke stick over floor penetrations and record the direction the smoke travels (toward or away from the foundation). Either a powdered smoke tube (McMaster Carr product #3880K31, or equivalent) or lighted smoke pen (McMaster Carr product #4101T5 or equivalent) may be used.

The use of a smoke stick provides additional information on background pressure differentials by allowing identification of pressure differentials at additional locations where sub-slab probes are not or cannot be installed (e.g., directly at floor penetrations and cracks), and provides a more sensitive means of establishing the differential where the differential is not resolvable using a manometer. Accurate establishment of the background pressure differential is important to aid in selecting an appropriate fan size. The use of a smoke stick can also be used to aid in identifying floor penetrations requiring sealing as part of the mitigation process.

3. Section V, Procedure, item "k."

Section V, item "k." of the SOP contains a communication test procedure to confirm that the sub-slab venting system causes a pressure differential of 0.004 in w.c. across the floor slab. Many buildings have a baseline level of fluctuation in the pressure differential across the floor slab (caused by wind gusts and other weather effects) that is often much greater than 0.004 in w.c. Therefore, the following additional steps will be added to the Communication Testing procedure (Section V (k) of the SOP) to measure a change induced by the sub-slab venting system:

- Use a pressure transducer and data logger that records the pressure differential very frequently.
- Cycle the wet/dry vacuum on and off to see if an expected saw-toothed pattern is evident amid the fluctuations.

This modification allows pressure changes caused by the sub-slab system to be differentiated from changes due to other effects (e.g., wind gusts, exhaust fan operation) so that an adequately sized fan is selected for installation.

4. Property-Specific Work Plans

The property-specific work plan template will be modified to be include the changes to the SOPs that are described herein and in Appendices D and E. The template will also be modified to refer to the Livonia site rather than the Moraine site.

SOP 24 VAPOR INTRUSION MITIGATION SYSTEM INSTALLATION

1. Section VI, "Active Mitigation System with Crawlspace/Dirt Floor Foundation Installation, items "4." and "5." (Mitigation Systems for Inaccessible Crawlspaces)

The information presented for items 4 and 5 identify mitigations systems for inaccessible crawlspaces, but it is not clear what defines a crawlspace as "inaccessible". Therefore, the following definition of "inaccessible crawlspace" is added to this SOP. An inaccessible crawlspace is a crawlspace that a person cannot reasonably physically enter into while on two feet (i.e., crawlspaces that can be entered by crawling on hands and knees are therefore considered inaccessible).

Section VI, item "4." requires sealing of the openings from the crawlspace to the first floor, and sealing cracks and larger openings within the crawlspace foundation. Cross-ventilation of the inaccessible crawl space should be included in addition to installation and operation of a suction

point. Therefore, the sealing will not include vents to the crawlspace. If vents are not already present, they may be installed to allow cross-ventilation.

Section VI, item "5." describes the mitigation system for inaccessible crawl spaces as:

> *For inaccessible crawlspaces, a PVC pipe will be inserted into the crawl space wall and used as the suction point. A screen will be attached to the end of the pipe to prevent small animals from entering the system.*

If the pipe that is used to remove air from the crawl space is also connected to a sub-slab depressurization (SSD) system used to depressurize a slab or a membrane at another part of the building, the differences in the flow characteristics of those systems may make it difficult to achieve depressurization of the slab or membrane. Separate fans may be required based on diagnostic/communication testing results and/or building geometry.

For inaccessible crawlspaces, wind turbines, such as that depicted in Photograph 10 of Appendix C, will also be considered for installation as a means to ventilate the crawlspace. VOC concentrations and crawlspace size will be considered, amongst other factors, in the selection of a whether to use a wind turbine or electric fan for an inaccessible crawlspace. The selection process will be documented for US EPA approval prior to initiating the work.

2. Section XI. Quality Assurance.

The SOP states that:

> *Upon installation of the mitigation system, an ARCADIS team member will verify that the differential pressure measured by the manometer installed on the system piping is within the design range of 1 to 4 in. w.c.*

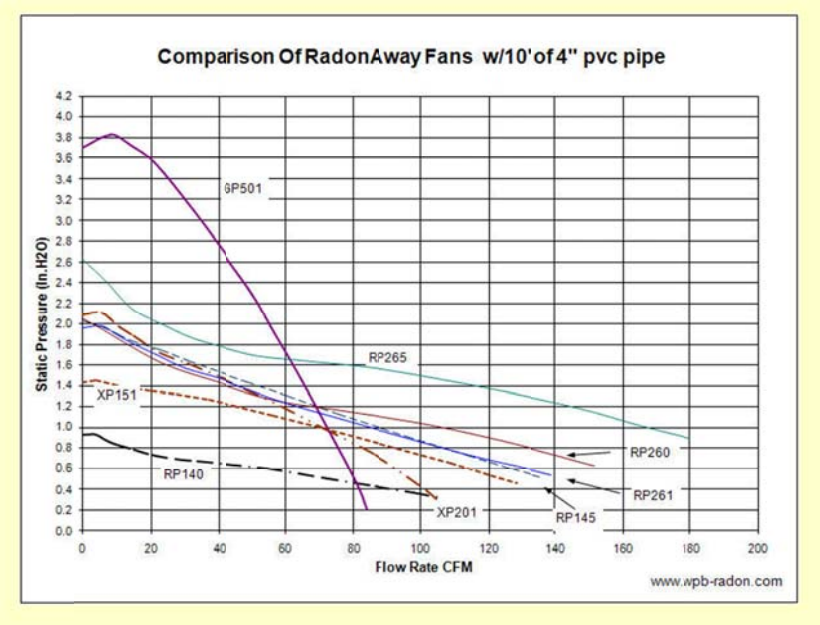
And that:

> *Based on the results of the communication testing, the RadonAway GP-501 fan, or equivalent, was selected for installation of this system. Fan information is included in Attachment 3.*

Depending on the subslab permeability, 1 inch of vacuum may not be needed to achieve the necessary pressure field. Change the text, "within the design range of 1 to 4 in. w.c." to "within the design range necessary to achieve the design pressure field of 0.004 in. w.c. below the slab".

The GP-501 fan is a high suction - low flow fan that may not be optimal for all buildings. Other fans are available (e.g., see the following Figure) and the work plan indicates that other fans may

be considered although this is not clear in this SOP. For clarity, this SOP will be modified to indicate that the selection of a fan for SSD systems will be based on testing for each individual building. The selected fan size will be as small as possible to adequately depressurize the sub-slab region, without drawing an excessive amount of indoor air into the subsurface or crawlspace, because this is not energy efficient.



Plot of flow rate vs. applied vacuum for a range of common Radon mitigation fans (Broadhead, 2010)

3. Other additions to SOP 24:

Mitigation systems will have a condensate bypass device, such as the one depicted on Photograph 1 p.113 of Appendix C.

Mitigation systems will have a rain cap and screen to prevent moisture and rodent/bird entry into the fan.

SOP 25 VAPOR INTRUSION MITIGATION SYSTEM O&M

The letters that reference regulators and public health officials will be changed to those applicable to the Eckles Road, Livonia site.

Satisfactory reductions in the indoor concentrations of VOCs may be attainable even if the pressure field is slightly less than that prescribed in the SOP #24. There may be instances where the energy costs associated with operation of a higher wattage fan (e.g., increased heating and cooling costs due to air leakance to the subslab) may not justify the marginal (if any) reduction of indoor concentrations associated with fully attaining the specified pressure field reduction. The SOP required post-installation proficiency sampling 30, 180 and 360 days after system installation. The sampling includes indoor air sampling and sub-slab pressure measurements. Corrective action will not be required if all indoor air sample results meet the Action Levels and the pressure field meets the 0.004 in w.c. design criteria specified in SOP #24. If all indoor air sampling results meet the Action Levels but the pressure field is slightly less (i.e., 0.003 to 0.004 in w.c.) than the design criteria (0.004 in w.c.), then the need for corrective action will be evaluated.

AIR PURIFIERS AS INTERIM MEASURES

Granular activated carbon (GAC) based air purifiers may be installed as an interim measure in residences needing a vapor mitigation system. The SOP for the installation and operation of the purifiers is attached. The air purifier will be removed once the mitigation system is installed and operating. If an air purifier is installed and operating during the mitigation system design phase, than an indoor air sample will be collected during the pre-design residence inspection to confirm operation of the purifier. The sample will be collected using the SOP for indoor air sampling in Appendix A.

ACTION LEVELS

The Action Levels specified in SOP 24 will be the Screening Levels developed for the Eckles Road, Livonia site. These are provided in Table 2 of the Vapor Intrusion Field Investigation and Mitigation Work Plan.

* * * * *

Attachments:
ARCADIS SOPs 23, 24, and 25
Air Purifier SOP

ARCADIS SOPs 23, 24, and 25

ARCADIS
Infrastructure, environment, buildings

Imagine the result

SOP 23

Inspection and Vapor Intrusion Mitigation System Design

RACER

Moraine, Ohio

Date: May 6, 2011

Revised: August 9, 2011

Approval Signatures

Prepared by: Rebecca A Robbennolt Date: April 26, 2011
Rebecca Robbennolt

Reviewed by: Rachel R. Saari Date: May 3, 2011
Rachel Saari

Approved by: Carolyn Grogan Date: May 6, 2011
Carolyn Grogan Revised Date: August 9, 2011

I. Scope and Application

This Standard Operating Procedure (SOP) describes the inspection and design procedures to be carried out prior to the installation of active vapor mitigation systems at structures with three different foundation types: basement, crawlspace, and slab-on-grade, or any combination of these three. The inspection procedures are based on Sub-Slab Depressurization System (SSDS), Sub-Membrane Depressurization System (SMDS), and Crawlspace Depressurization System (CSDS) design criteria found in American Society for Testing and Materials (ASTM) Designation: E2121-03, Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings (ASTM, 2003), United States Environmental Protection (U.S. EPA) Region 5, Vapor Intrusion Guidebook (U.S. EPA, 2010), U.S. EPA 625, Radon Reduction Techniques for Existing Detached Houses (U.S. EPA, 1993), and U.S. EPA, Indoor Air Vapor Intrusion Mitigation Approaches (U.S. EPA, 2008).

The following sections list the necessary equipment and provide detailed instructions for completing the building inspection and design for active vapor intrusion mitigation systems.

Site-specific requirements and/or field conditions may require modifications to the procedures outlined in this SOP. Alterations to the SOP may be completed per approval of the Project Manager.

II. Personnel Qualifications

ARCADIS field personnel will have current health and safety training including 40-hour HAZWOPER training and site-specific training as needed. ARCADIS field personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel responsible for leading the inspection and design activities will have previous vapor intrusion mitigation experience.

III. Health and Safety Considerations

Materials and equipment must be carefully handled to minimize the potential for injury. All inspection personnel should review the appropriate health and safety plan (HASP) and job loss analysis (JLA) prior to beginning work to be aware of all potential hazards associated with the job site and the specific inspection. Drilling with the concrete core

drill during communication testing should be done only by personnel with prior experience using such equipment.

IV. Equipment List

The equipment required to complete the inspection and design activities active are presented below:

- Appropriate PPE (as required by the Health and Safety Plan)
- Hammer drill
- Wet/Dry vacuum
- Extra vacuum hose
- Micromanometer – The Fluke 922 Airflow Meter / Micromanometer, or equivalent, will be used for this project. Please see the specification sheet attached to this SOP for details.
- Non-shrink grout
- Tubing
- Swagelok fitting
- Modeling clay
- Flashlight
- Tape measure
- Camera
- Field book or inspection form (attached to the end of this SOP)

V. Procedure

Vapor Mitigation System Inspection (US EPA 625 and ASTM E2121-03)

The following definitions that are commonly used in the vapor mitigation system inspection and design process have been provided for clarification purposes:

- Suction point – The location where the proposed vapor intrusion mitigation system will extract sub-slab, sub-membrane, or crawlspace vapors. For example, a suction point could be a perforated polyethylene flex drain in a crawlspace or a polyvinyl chloride (PVC) pipe that is inserted into a vertical or horizontal suction pit. During communication testing, the vacuum should be applied to a point installed in the location of the suction point and identified as EX-1, EX-2, etc.

- Suction pit – The void installed below slab–on-grade or basement slab foundations.

- Sub-slab sample point – The sample locations used to collect sub-slab pressure field extension readings and background differential pressure readings from below the slab foundation. Permanent sub-slab sample points are installed in accordance with SOP 20, Sub-Slab Soil-Gas Point Installation and Sampling, and can also be used for collection of sub-slab samples. Temporary sub-slab sample points are installed to collect sub-slab pressure field extension readings during communication testing and are installed by drilling a small hole through the foundation. After the communication test is performed the holes are abandoned with non-shrink grout. Typically, the temporary sub-slab sample points are replaced with permanent sub-slab sample points during mitigation system installation. The sub-slab sample points should be labeled as SS-1, SS-2, etc.

Conduct a visual survey and hand sketch for the home to identify the unique characteristics of that home that will need to be considered as part of the system design and construction. Identify the following items, and document any preferences that the homeowner expresses.

a. Identify each separate foundation and its type. Sketch the configuration and note the approximate size of each separate area. Select the proposed suction point location(s) for each foundation and locate on the floor plan.

One suction point should be proposed within each foundation area unless communication between foundations can be demonstrated through completion of a communication test as described below. The following are example suction point locations that are appropriate for a variety of foundation scenarios:

- If a property has a partial basement foundation and a slab–on-grade foundation, two suction points would be proposed (one suction point in the basement foundation and one suction point in the slab-on-grade foundation).
- If a property has one crawlspace foundation that supports the entire structure, one suction point is appropriate.
- If a property has one slab–on-grade foundation and one slab–on-grade addition, two suction points should be proposed (one for each foundation) unless communication testing demonstrates pressure field extension to both areas from one suction point.

b. Include the size and location of crawlspace access doors and the approximate working height within each crawlspace. Note any obstacles that may present a problem for access and if any stored materials will need to be removed. Note whether padding and plywood or other materials will be needed to protect the sheeting and whether the access door will need to be protected from pets or other small animals.

c. For slab-on-grade foundations, sketch the floor plan of the first floor, and identify locations such as closets or utility rooms that may be candidates for system installation. If a second floor is present, identify any locations where the system piping could be installed through both floor levels within closets or other acceptable locations. Identify any cracks or other openings in the slab that are accessible for sealing.

d. Sketch the basement floor plan including the identification of finished and unfinished areas, sumps, floor drains not connected to sewers, cracks, wall to floor joint, open block wall cores, plumbing penetrations, and any other areas that may require sealing. Note the presence of stored items that may need to be relocated to access areas for sealing and system installation. Note any significant degradation in the integrity of the floor and/or walls that would require additional sealing measures beyond the standard caulking procedures.

e. If a sump is present, identify the drains that are connected to the sump and the type of sump pump that is present (pedestal or submersible).

f. Identify gas fired appliances; such has furnaces and water heaters that may need to be checked for backdrafting.

g. On the exterior of the home, identify the number of stories, the type and condition of the roof, and any receptors that may need to be avoided when determining the system discharge location.

h. Identify the location where the piping will exit the structure. Ensure that the pipe can be routed to an appropriate discharge location from this point with minimal or no jogs around windows or other obstructions. The discharge location must be located above the eve of the roof and be at least 10 feet above ground level and at least two feet above or ten feet away from any windows or other openings into the structure or into any adjacent structure. Avoid locating the piping outside of a bedroom, where fan noise could be disturbing to the homeowner.

   Fan placement will either be on the exterior piping or within the attic.

i. Use a micromanometer to measure a background differential pressure at the existing sub-slab sample point at homes with basement and/or slab-on-grade foundations, where an active mitigation system is to be installed, to determine the pre-existing sub-slab pressure that will need to be overcome.

j. Determine if a communication test is to be conducted to assist with predicting system coverage across the entire slab. Crawlspace scenarios do not require a communication test because there is no slab to test below. Communication testing should be performed if:

   1. The suction point will be located greater than 20 feet from the furthest extent of the area it is intended to provide coverage for;

   2. Tight soil conditions are suspected based on site geology or previous sample port/point installation (i.e. clay); and/or

   3. Footers or other barriers (i.e., utilities or sumps) are identified or suspected based on a visual survey that may prohibit communication across the foundation.

An Inspection and Design Flow Chart and a Communication Test Schematic have been attached to this SOP.

k. Communication testing may be conducted during a separate visit and will consist of the following.

- Drill a one-inch hole through the slab at the proposed suction point location using a hammer drill. Utilize the wet/dry vac for dust control during drilling and use hearing protection.
- Install temporary sub-slab sample point(s) on opposite side(s) of the slab by drilling small holes (same diameter as the outside diameter of the tubing to be used) through the slab, inserting tubing, and sealing around tubing with modeling clay. Permanent sub-slab sample points will be installed during system construction per the procedures in the Sub-Slab Soil-Gas Point Installation SOP (SOP 20) that is included within this appendix.
- Connect the suction hose of the wet/dry vacuum to the proposed suction point. Connect extra hose to the discharge of the vacuum and route the discharge to the outdoors.
- Connect tubing from temporary sub-slab sample point to the positive port of the micromanometer. Record the sub-slab pressure field extension reading, including the positive or negative sign.
- If a negative pressure of at least 0.004 in w.c. is not obtained at each sub-slab sample point, seal any openings in the slab and repeat the test.
- If after sealing a negative pressure is not obtained at each sub-slab sample point, identify a second suction point location closer to the area that was not being covered, and repeat the test.
- After testing is complete, remove the tubing and clay from the temporary sub-slab sample point (s) and fill the suction hole(s) and temporary sub-slab sample point (s) with non-shrink grout.

l. Test combustion appliances to document any pre-existing backdrafting conditions utilizing the following procedure:

1. Turn on the appliance being tested (If the appliance is a forced air furnace, ensure that the blower starts to run before proceeding).

2. Check for flue gas spillage near vent hood.

If backdrafting is occurring the owner will be advised of the situation. The necessary repairs must be completed by the owner prior to any vapor control work. Note that high efficiency appliances do not require backdraft testing and can be identified by the presence of PVC vent pipes.

VII. Safety Considerations

ARCADIS will comply with all OSHA, state, and local standards or regulations relating to worker safety during inspection of vapor intrusion mitigation system. All necessary PPE will be worn during visual inspection and communication testing.

VIII. Waste Management

The waste materials generated by these activities should be minimal. Personal protective equipment, such as gloves and other disposable equipment (i.e., tubing) should be collected by field personnel for proper disposal. Any soils brought up from the borehole should be disposed of in a manner consistent with the project work plan.

IX. Data Recording and Management

ARCADIS will keep records of all measurements and notes taken during the inspection, and the information gathered will be used to create a property specific work plan. A detailed inspection form will be completed for each building.

X. Quality Assurance

ARCADIS personnel responsible for leading the inspection and design activities will have previous vapor intrusion mitigation experience.

XI. References

ASTM Standard E2121. 2003. Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings. March 2001.

U.S. EPA 625, Radon Reduction Techniques for Existing Detached Houses. October 1993.

U.S. EPA Region 5, Vapor Intrusion Guidebook. October 2010.

U.S. EPA, Indoor Air Vapor Intrusion Mitigation Approaches, October 2008.

Fluke 922
Airflow Meter/ Micromanometer

Technical Data

Today's HVAC technicians need a simple solution for diagnosing ventilation issues. The Fluke 922 makes airflow measurements easy by combining pressure, air flow, and velocity into a single, rugged meter. Compatible with most pitot tubes, the Fluke 922 allows technicians to conveniently enter their duct shape and dimensions for maximum measurement accuracy.

The Fluke 922 Airflow Meter helps you:

- Monitor air pressure across key HVAC components
- Ensure proper air flow balance
- Promote good indoor air quality
- Maintain a comfortable environment

Use the Fluke 922 to:

- Measure pressure drops across filters and coils
- Match ventilation to occupant loads
- Monitor indoor vs. outdoor pressure relationships and manage the building envelope
- Perform duct traversals for accurate airflow readings

Features:

- Powerful meter provides differential and static pressure, air velocity and flow readings
- Rugged design built for field use
- Easy to use without sacrificing performance
- User-defined duct shape and size for maximum airflow accuracy
- Convenient colored hoses help you properly diagnose pressure readings
- Bright, backlit display for clear viewing in all environments
- Min/Max/Average/Hold functions for easy data analysis
- Auto power off saves battery life

FLUKE®

Fluke 922 Airflow Meter Specifications

Feature	Range	Resolution	Accuracy
Operating Specifications			
Air Pressure	± 4000 Pascals ± 16 in H_2O ± 400 mm H_2O ± 40 mbar ± 0.6 PSI	1 Pascal 0.001 in H_2O 0.1 mm H_2O 0.01 mbar 0.0001 PSI	± 1 % + 1 Pascal ± 1 % + 0.01 in H_2O ± 1 % + 0.1 mm H_2O ± 1 % + 0.01 mbar ± 1 % + 0.0001 PSI
Air Velocity	250 to 16,000 fpm 1 to 80 m/s	1 fpm 0.001 m/s	± 2.5 % of reading at 2000 fpm (10.00 m/s)
Air Flow (Volume)	0 to 99,999 cfm 0 to 99,999 m3/hr 0 to 99,999 l/s	1 cfm 1 m3/hr 1 l/s	Accuracy is a function of velocity and duct size
Temperature	0 °C to 50 °C 32 °F to 122 °F	0.1 °C 0.1 °F	± 1 % + 2 °C ± 1 % + 4 °F
General Specifications			
Operating Temperature	0 °C to +50 °C (+32 °F to +122 °F)		
Storage Temperature	-40 °C to +60 °C (-40 °F to +140 °F)		
Operating Relative Humidity	0 % to 90 %, non-condensing		
IP Rating	IP40		
Operating Altitude	2000 m		
Storage Altitude	12000 m		
EMI, RFI, EMC	Meets requirements for EN61326-1		
Vibration	MIL-PREF-28800F, Class 3		
Max Pressure at Each Port	10 PSI		
Data Storage	99 readings		
Warranty	2 years		
Power	Four AA batteries		
Typical Battery Life	375 hours without backlight, 80 hours with backlight		

CE C N10140

Fluke 922 comes complete with the following:
Fluke 922 Airflow Meter, Two Rubber Hoses, Wrist Strap, Four AA Batteries 1.5 V Alkaline, Users Manual and Soft Carrying Case

Fluke 922/Kit comes complete with the following:
Fluke 922 Airflow Meter, 12 in. pitot tube, ToolPak™, Two Rubber Hoses, Wrist Strap, Four AA Batteries 1.5 V Alkaline, Users Manual and Hard Carrying Case

Ordering Information

Fluke-922	Airflow Meter
Fluke-922/Kit	Airflow Meter with 12 in Pitot Tube
PT12	Pitot Tube, 12 in

Optional accessories

PT12
Pitot Tube, 12 in

TPAK
ToolPak™

Fluke. *Keeping your world up and running.®*

Fluke Corporation
PO Box 9090, Everett, WA USA 98206

Fluke Europe B.V.
PO Box 1186, 5602 BD
Eindhoven, The Netherlands

For more information call:
In the U.S.A. (800) 443-5853 or
Fax (425) 446-5116
In Europe/M-East/Africa +31 (0) 40 2675 200 or
Fax +31 (0) 40 2675 222
In Canada (800)-36-FLUKE or
Fax (905) 890-6866
From other countries +1 (425) 446-5500 or
Fax +1 (425) 446-5116
Web access: http://www.fluke.com

Printed in U.S.A. 8/2007 2791462 D-EN-N Rev C

ARCADIS

Vapor Intrusion Mitigation System
Inspection and Design Form

Property Address: _____ Temperature (Ambient): _____ °F
Tenant's Name: _____ Temperature (House): _____ °F
Owner's Name: _____ Barometric Pressure: _____ "Hg
Owner's Address (If Different from Property Address): _____ Weather Conditions: _____

Inspector(s) Name(s): _____
Date and Time: _____
Foundation Type(s): Slab Basement Crawlspace Crawlspace Height: _____
Cracks or Other Areas to be Sealed: Yes No NA
List: _____
Open Block Cores to be Sealed: Yes No NA
List: _____
Sump to be Sealed: Yes No NA Sump Diameter: _____
If Yes, Pedestal Pump, Submersible Pump, or None: _____
Existing Lid to be Reused: Yes No NA
Drain Seals Needed: Yes No
Diameter of Drains: _____ How Many? _____
Backdraft Test Completed on Furnace: Pass Fail NA - High Efficiency
Backdraft Test Completed on Water Heater: Pass Fail NA - Electric or Direct Vent
Reason Backdraft Test not Performed? _____
Failing Backdrafting Condition Reported to Homeowner: Yes No NA
Building Height: 1-Story 2 -Story Other _____
Will Roof be Penetrated: Yes No
Roof Type: Metal Shingle Other _____
Piping to be Installed through or Outside House? _____
Fan will be Located on Exterior or in Attic? _____
Verify Discharge Location will Meet Required Clearance from any Openings into Home or Adjacent Home: Yes No

Suction Point Location and Communication Testing Determination

Are there Multiple Foundation Types? Yes No **(Each foundation type will need to be mitigated)**
If Yes, Indicate Dimensions of Each Foundation: _____
Does the Structure have any Additions? Yes No **(Additions should be considered a separate foundation)**
Is the Suction Point Located Greater than 20 Feet from the Furthest Extent of the Area it is Intended to to Provide Coverage?
Yes No **(If yes, communication testing should be completed)**
Are there Footers or other Barriers that may Impede Communication across Slab? Yes No
(If yes, communication testing should be completed)
Communication Testing to be Completed: Yes No NA
If Communication Testing is not Completed, Reason Why: _____
Background Sub-Slab Pressure: Point ID: _____ Pres: _____ Point ID: _____ Pres: _____

See Back for Communication Test Results

ARCADIS

Vapor Intrusion Mitigation System

Inspection and Design Form

Communication Test Results:

(Apply vacuum to the proposed suction point location(s) during the test.)

Date	Time	Location ID where Vacuum was Applied	Location ID Where Pressure Reading was Collected	Pressure (in w.c.)	Notes

Note: Please label the location IDs on the site sketch consistent with the terminology on the table above.

Is the sub-slab pressure field extension reading more negative than -0.004 in w.c.? Yes No NA **(If No, additional suction points are necessary)**

Note if the Furnace or Air Conditioning is Operating during the Communication Test and Record Background Sub-Slab Pressure Readings.

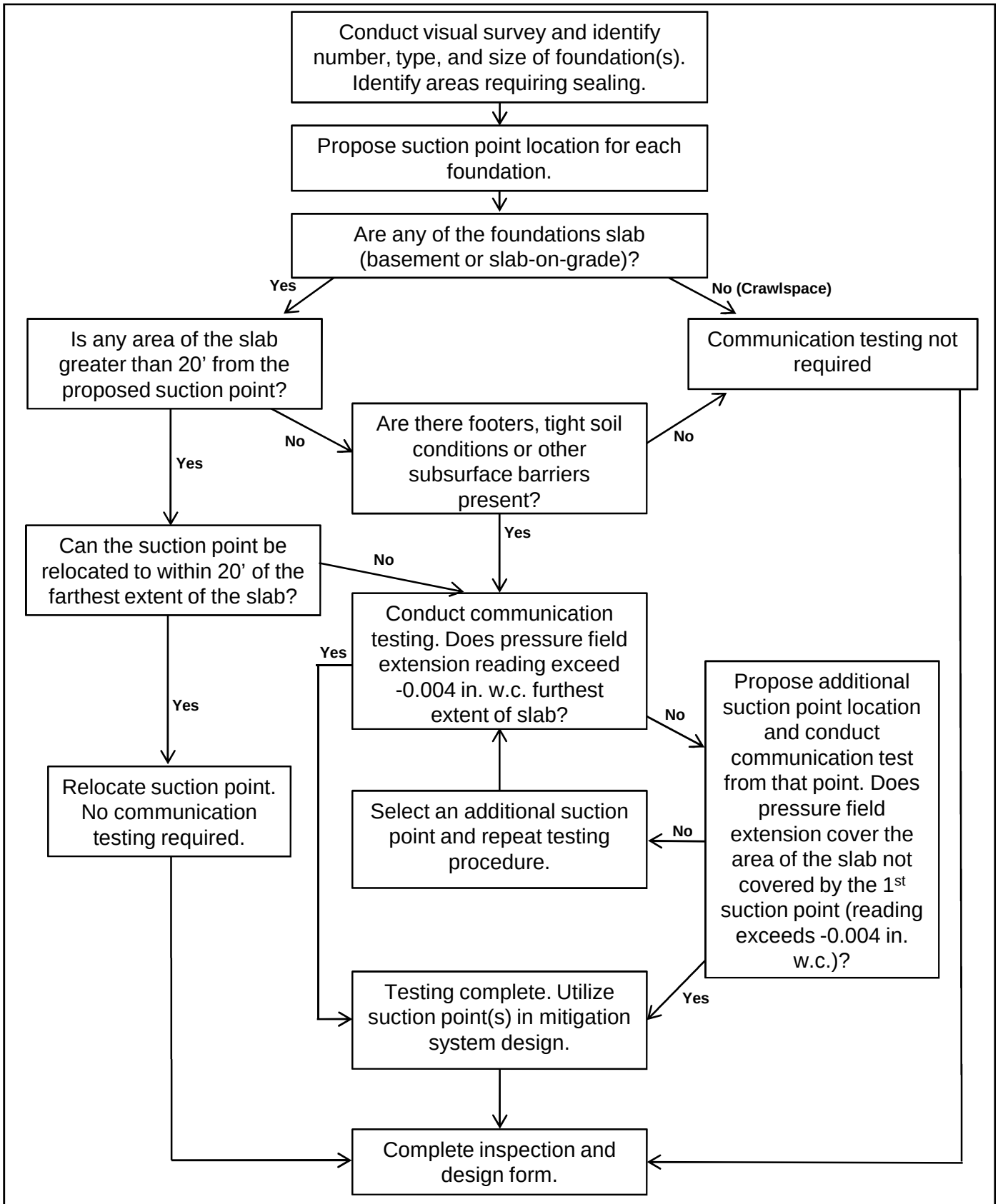
"Hg Inches of Mercury.

In w.c. Inches of Water Column.

A negative pressure reading indicates the presence of a vacuum. A positive reading indicates that there is no vacuum present.

Attach floor plan sketch, including all requirements of the Vapor Mitigation Inspection and Design SOP. Label each foundation type on the sketch.

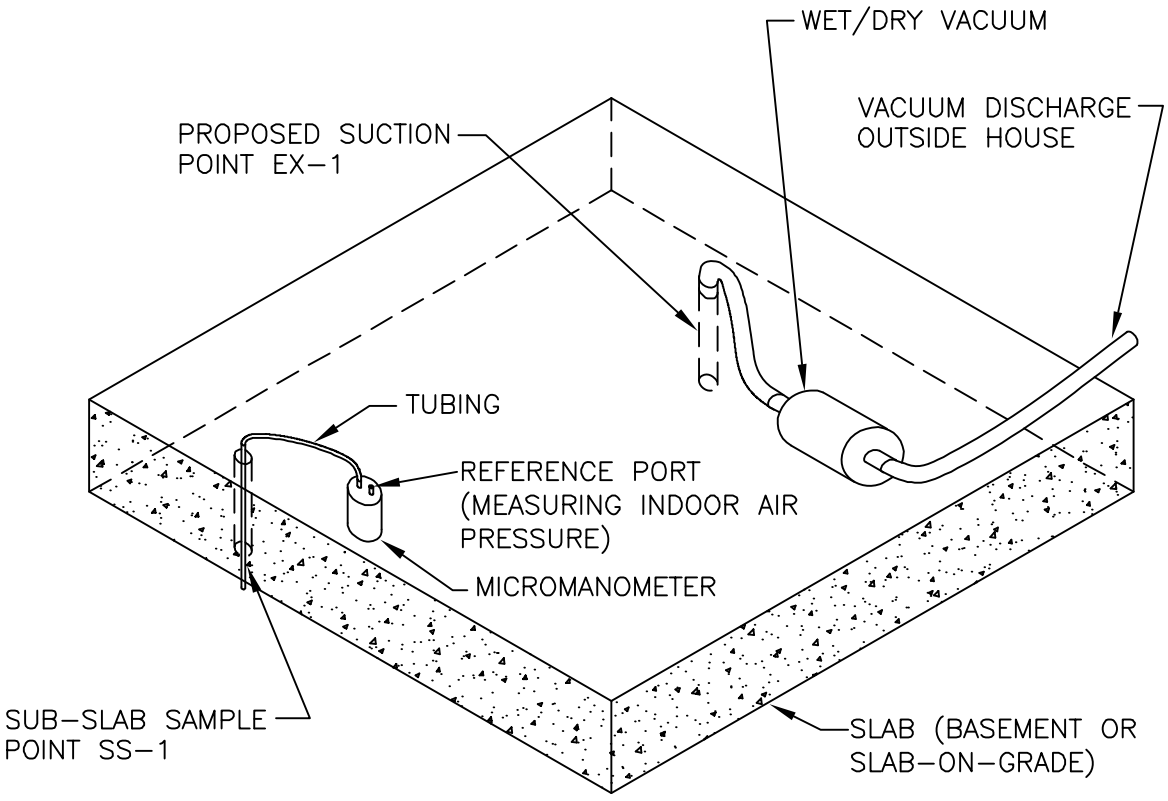
Include photos of exterior of house, all foundation types, exterior discharge location (if applicable), cracks and/or drains to be sealed, and any other relevant photos helpful for understanding the design of the mitigation system.



ARCADIS

SOP 23 INSPECTION AND DESIGN FLOW CHART
RACER
MORAINE, OHIO

Date 8/10/2011	Project Manager N. GILLOTTI	Drawing Name SOP 23 Flow Chart
Drawn By S. BREWER	Lead Design Prof. R. Saari	Checked C. Grogan
Project Number OH000294.2011		Figure Number 1



NOT TO SCALE

RACER
MORAINE,OHIO

OH000294.2011

COMMUNICATION TEST SCHEMATIC SOP 23

ARCADIS

FIGURE
2

ARCADIS
Infrastructure, environment, buildings

Imagine the result

SOP 24

Vapor Intrusion Mitigation System Installation

RACER

Moraine, Ohio

Date: May 6, 2011

Revised: May 26, 2011

Revised: September 12, 2011

Approval Signatures

Prepared by: Rebecca A Robbennolt Date: May 3, 2011
Rebecca Robbennolt

Reviewed by: Rachel R. Saari Date: May 3, 2011
Rachel Saari

Approved by: Carolyn Grogan Date: May 6, 2011
Carolyn Grogan

Modified by: Rachel R. Saari Date: May 26, 2011
Rachel Saari

Modified by: _____ Date: September 12, 2011

Carolyn Grogan

I. Scope and Application

This Standard Operating Procedure (SOP) describes the procedures to install active vapor mitigation systems at structures with three different foundation types: basement, crawlspace, and slab-on-grade, or any combination of these three. The active mitigation system should be designed to depressurize the sub-slab, sub-membrane (crawlspace sealed with reinforced, polyethylene sheeting), or inaccessible crawlspace and prevent the entry of soil vapors into the structure. The active mitigation system design is based on the sub-slab depressurization system (SSDS), sub-membrane depressurization system (SMDS), and crawlspace depressurization system (CSDS) design criteria found in American Society for Testing and Materials (ASTM) Designation: E2121-03, Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings (ASTM, 2008), United States Environmental Protection Agency (U.S. EPA) Region 5, Vapor Intrusion Guidebook (U.S. EPA, 2010), and U.S. EPA 625, Radon Reduction Techniques for Existing Detached Houses (U.S. EPA, 1993), and U.S. EPA, Indoor Air Vapor Intrusion Mitigation Approaches (U.S. EPA, 2008).

The following sections list the necessary equipment and materials and provide detailed instructions for the installation of active vapor intrusion mitigation systems for the above mentioned foundation types.

Site specific requirements and/or field conditions may require modifications to some of the procedures outlined in this SOP. Alterations to the SOP may be completed per approval of the Project Manager.

II. Personnel Qualifications

ARCADIS field personnel will have current health and safety training including 40-hour HAZWOPER training and site-specific training as needed. ARCADIS field personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel are responsible for the coordination of the mitigation system installation with the installation contractor and the oversight of the vapor intrusion mitigation system installation activities. ARCADIS personnel leading the mitigation system installation activities will have previous vapor intrusion mitigation system installation oversight experience.

III. Health and Safety Considerations

Installation materials and equipment must be carefully handled to minimize the potential for injury. All installation personnel should review the appropriate health and safety plan (HASP) and job loss analysis (JLA) prior to beginning work to be aware of all potential hazards associated with the job site and the specific installation. Intrusive methods required for the vapor mitigation system installation (i.e., drilling with a concrete core drilling machine) should be done only by personnel with prior experience of using such equipment. Process pipe installation should be done only by personnel with prior experience and the appropriate training for working at heights. The inline fan shall be wired by a licensed electrician to an independent disconnect switch and to a breaker with sufficient capacity. Installation requirements will be outlined below.

IV. Equipment and Materials List

The equipment and materials required to install active vapor mitigation systems for structures with each of the three different foundation types: basement, crawlspace, and slab-on-grade, or any combinations of these three are presented below:

- Appropriate PPE (as required by the Health and Safety Plan)
- Concrete core drilling machine
- Extension and step ladders
- Drill
- Hand tools
- Lighting
- Vent piping 3 or 4-inch schedule 40 polyvinyl chloride (PVC) pipe, PVC primer, and PVC cement
- Elbows, couplings, pipe supports, and other fittings
- Sealant (silicone and polyurethane caulk)

- 6-mil polyethylene sheeting or 3-mil cross-laminate polyethylene sheeting (crawlspace)
- Untreated 1-inch by 2-inch wood strips, airtight gaskets and mechanical fasteners
- Perforated polyethylene drain tile (crawlspace)
- Backer rod, expandable foam, non-shrink mortar, grouts, etc.
- Roof flashing
- Intumescent fire stops (fire wall penetrations)
- Drain seals and/or water traps
- In-line fan
- Manometer
- Disconnect switch
- Audible alarm

V. Procedure

Active Mitigation System with Basement Foundation Installation (US EPA 625 and ASTM E2121-03)

The following steps will detail installation of an active mitigation system with a basement foundation for the given project.

1. Confirm gathered Information about the Structure: Review floor map to include rooms, crawlspaces, floor drains, cracks, pipe penetrations, plumbing rough-ins, and other openings requiring sealing. Identify any sump pits, drain tile, block walls, or baseboard drainage (see SOP 23 in this Appendix).
2. Backdrafting Check: Prior to system installation, test all combustion appliances and document pre-existing conditions (see SOP 23 in this Appendix).

3. Sealing Potential Vapor Intrusion Routes: Seal all cracks and openings in the basement walls and/or the floor slab to reduce pathways for vapors to enter the structure. Ventilate the structure during caulking activities to prevent the buildup of vapors as necessary. All surfaces to be sealed will be cleaned prior to applying sealant using a wet/dry vacuum. Wire brush may be necessary to loosen dirt or debris prior to vacuuming. Surfaces must be clean, dry, and free of all dirt debris, oil, and grease prior to sealing. Sealing will be conducted utilizing the following methods.

    a. Cracks/Openings: All cracks greater than a 1/2-inch wide will be filled with closed cell foam backer rod prior to applying sealant. Backer rod should be approximately 25 percent larger than the width of the crack. Backer rods should be installed using a roller or flat sided tool to prevent puncture of the rods during installation. Cracks will be sealed with polyurethane caulk by forcing the caulk into the crack and smoothing at or slightly below the floor/wall surface to create a complete seal to each edge of the crack.

    b. Sumps: Sumps will be sealed by installing solid lids with seals around all protrusions through the lid. Lids will be sealed to the floor using a non-permanent caulking, such as silicone, or through the use of an air-tight gasket and mechanical fasteners to allow the opening of the lid for pump maintenance. A view port may also be included in the lid to enable routing inspection of pump performance without repeated removal of the lid.

    c. Drains: Drains installed through sump lids, through crawlspace liners, or through basement floors (not connected to sewer) will be sealed by installing a drain seal consisting of a one way valve which allows water to drain out, but no air to travel up through them or a trapped drain. If a trapped drain is utilized it should be capable of holding a minimum of 6-inches of standing water to minimize the potential for drying out.

    d. Open Block Wall Cores: They will be sealed by filling the top portion of the cores with expanding foam.

    e. Other openings will be evaluated and sealed using polyethylene sheeting, non-shrink grout, mortar, concrete, or expanding foam.

f. Based on specific construction details of each property, other sealing methods may be required.

4. Confirm the Selection and Spacing of Suction Point: Confirm the selection and spacing of the suction points per the design drawing for the structure. The number and spacing of the suction point is based upon diagnostic testing reflective of the properties of soil underneath the building.

5. Confirm Pipe Routing & Fan Placement: These are determined based on design drawing for the structure. Confirm the exterior facade of the property and termination point location with the design drawing.

6. Installation of Suction Pit: Confirm all known utility lines near the proposed suction pit location. Use a portable coring tool to core through the basement slab. Remove approximately1 cubic foot of soil from below the slab. Insert the 3 or 4”-inch PVC vent piping through the slab and seal the opening with polyurethane caulk.

7. Installation of Pipe: Vent piping (3 or 4-inch, Schedule 40 PVC) will be installed from the suction point through the sill plate of the structure and up the exterior of the structure, or routed through the interior of the structure through the attic to the rooftop discharge location per the design drawings. All joints in the PVC piping will be sealed using PVC cement. All of the piping runs will slope back towards the suction point. Extraction piping designed to run along the exterior of the structure will exit the structure at the level of the floor joists. Sealing will be performed around this penetration through the structure. The exterior run of piping will be attached to the side of the structure using clamps. Penetration through the roof and installation of flashing at this penetration will be performed as necessary. For additional pipe installation requirements refer to ASTM E2121 section 7.3.2.

8. Installation of Inline Fan: The Inline fan will be installed within the vent piping on the exterior of the structure when possible. The fan will be mounted and secured in a manner that minimizes transfer of vibration to the structural framing of the building. The fan will be wired through a local disconnect switch to the structure’s electric panel. A padlock will be installed on the disconnect switch to prevent unintentional shut down of the fan. The associated breaker on the panel will be labeled to indicate it is connected to the fan. For additional fan installation requirements refer to ASTM E2121 section 7.3.3.

9. Installation of Manometer: A manometer will be installed on the vent piping within the basement to confirm on-going system operation within the desired range.

10. If an audible alarm is required, a pressure switch will be installed in the system piping. The switch will be calibrated to alarm if the vacuum within the pipe is outside of the normal operating range.

Active Mitigation System with Slab-On-Grade Foundation Installation

Installation procedures for active mitigation systems with slab-on-grade foundations are the same as the procedures for basement foundations with the following exceptions:

1. The suction pit will be installed through the slab and the vent piping (3 or 4-inch, Schedule 40 PVC) will be installed from the suction pit up through the interior of the structure and through the attic to the rooftop discharge location per the design drawings. The in-line fan will be installed within the vent piping inside the attic of the structure.

Active Mitigation System with Crawlspace/Dirt Floor Foundation Installation

Installation procedures for active mitigation systems with crawlspace foundations are the same as the procedures for basement foundations with the following exceptions:

1. Accessible crawlspaces will be sealed using reinforced, polyethylene sheeting. Adjacent sheets will be overlapped by one foot and sealed with polyurethane caulking. Sheeting will be sealed to the perimeter of the crawlspace and around any protrusions using polyurethane caulking and tape as necessary. Sheeting will be secured to the crawlspace walls using 1-inch by 2-inch (thick by wide) wood strips (non-treated) and concrete anchors. Where moisture is a concern aluminum strips can be used. Exterior crawlspace walls will be sealed as necessary with polyurethane caulking or by extending the sheeting up the exterior walls and securing at the top. Crawlspace access openings may also be covered to prevent pets or other small animals from entering and damaging the sheeting.

2. For accessible crawlspaces, concrete will also be considered to seal dirt floor areas where significant foot traffic (i.e., daily) is expected. If the dirt floor is only periodically used (weekly or less) plastic sheeting protected with foam padding and plywood will be considered.

3. For accessible crawlspaces, the suction point will be installed under the crawlspace sheeting. The suction point will consist of a tee connected to a perforated polyethylene drain tile. The drain tile will create the necessary collection area and prevent the sheeting from being pulled into the vent pipe.

4. Inaccessible crawlspaces will be sealed by identifying and sealing openings from the crawlspace to the first floor with appropriate materials (e.g., polyurethane caulking, expanding foam, and/or polyethylene sheeting). Cracks within the crawlspace foundation walls will be sealed with polyurethane caulking. Larger openings in the foundation will be sealed with expanding foam or covered with sheet metal, sealed with polyurethane caulk, and anchored to the foundation with screws.

5. For inaccessible crawlspaces, a PVC pipe will be inserted into the crawlspace wall and used as the suction point. A screen will be attached to the end of the pipe to prevent small animals from entering the system. Polyurethane caulk will be used to seal the area where the pipe enters the crawlspace.

VII. Safety and Health Hazards (ASTM E2121-03 Section 6.0)

ARCADIS will comply with all OSHA, state and local standards or regulations relating to worker safety and occupational exposure while installing vapor intrusion mitigation systems. In addition to OSHA standards and NIOSH recommendations, the following requirements specifically applicable to the safety and protection of mitigation workers while installing vapor intrusion mitigation system will be met.

- ARCADIS or the mitigation system installation subcontractor will advise the workers of the potential hazards of the materials and supplies used, exposure to contaminants, and the importance of protective measures when working in areas of elevated contaminant concentrations.

- ARCADIS or the mitigation system installation subcontractor will ensure that appropriate safety equipment and applicable material safety data sheets are available at the job site during mitigation activities.

- Work areas shall be ventilated as necessary to reduce worker exposure to contaminants, dust, or other airborne pollutants.

- Vapor mitigation work shall not be conducted in any work area suspected of containing friable asbestos-containing material, or where work would render

non-friable asbestos-containing material friable, until a determination has been made by a properly trained or certified person that such work will be undertaken in a manner which complies with applicable asbestos regulations, including those of EPA and OSHA.

- Vapor mitigation work shall not be conducted in any work areas with the potential for exposure to mold or other types of infestations or any other conditions determined to cause an unnecessary safety risk until measures have been taken to eliminate these conditions.

VIII. Waste Management

The waste materials generated by these activities should be minimal. Personal protective equipment, such as gloves and other disposable equipment (i.e., tubing) should be collected by field personnel for proper disposal. Any soils brought up from the borehole should be disposed of in a manner consistent with the project work plan.

X. Data Recording and Management (ASTM E2121-03 Section 7.7)

1. The Construction Quality Assurance Manager will complete an As-Built Drawing/Specifications List (attached to this SOP). The construction of the system and details pertaining to the operation of the system will be included in the As-Built Drawing/Specifications List.
2. ARCADIS will provide the property owner with an O&M manual (refer to Appendix F of the Vapor Intrusion Mitigation Work Plan) that includes the following :
    a. A description of the mitigation system installed and its basic operating principles.
    b. A description of the proper operating procedures of any mechanical or electrical systems (manometer, in-line fan, etc.) installed, including manufacturer's operation and maintenance instructions.
    c. Contact information to be used if the system failure warning device indicates system degradation or failure or other system maintenance is found to be needed.

d. Contact information for questions about operation of the mitigation system.

XI. Quality Assurance (ASTM E2121-03 Section 7.6)

Upon installation of active mitigation systems in structures with basement or slab-on-grade foundations, a measurement of a negative pressure below the slab of at least 0.004 inches of water column (in. w.c.) will indicate that the active system is successfully depressurizing the sub-slab area. Measurements will be taken on opposite sides of the foundation from the suction point to ensure the depressurization of the entire slab.

Upon installation of the mitigation system, an ARCADIS team member will verify that the differential pressure measured by the manometer installed on the system piping is within the design range of 1 to 4 in. w.c. They will then mark the operating differential pressure on the manometer and will show the owner how to read the manometer installed on the system piping. If at any time the system is not functioning within the range marked on the monitoring device or the owner notices damage to the system, they will be encouraged to call the phone number listed on the system label. ARCADIS will also provide an O&M manual (refer to Appendix F of the Vapor Intrusion Mitigation Work Plan) to each owner with contact information for any necessary troubleshooting and repairs. All repairs will be made at no cost to the owner.

A post-installation proficiency sampling will be completed approximately 30 days, 180 days, and 360 days after system installation to document that the indoor air (basement, accessible crawlspace, and first floor) is in compliance with the USEPA Regional Screening Levels at a 1×10^{-5} risk level (Action Levels). The sampling will be performed in accordance with the Indoor Air and Ambient Air Sampling SOP (SOP 22) included in this Appendix. Property owners will be provided with a letter to notified them of the sampling results and explain that the results are less than or greater than the Action Levels.

If sampling results are not in compliance with the Action Levels, ARCADIS personnel will evaluate the performance of the active mitigation system and complete any necessary system modifications and/or sealing within 30 days of receiving validated sample results. System modifications could consist of replacing the existing fan with a different size fan or the installation of additional suction point(s). Following completion of the system modifications, an additional post-installation proficiency sampling event

will be completed within 30 days. Additional quality assurance measures will be outlined in the Operation and Maintenance SOP.

XII. References

American Society for Testing and Materials (ASTM) Standard E2121. 2003. Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings. March 2001.

United States Environmental Protection Agency (U.S. EPA), Radon Reduction Techniques for Existing Detached Houses. October 1993.

U.S. EPA Region 5, Vapor Intrusion Guidebook. October 2010.

U.S. EPA, Indoor Air Vapor Intrusion Mitigation Approaches. October 2008.

ARCADIS		As-Built Documentation	
		Site Identifier	
Client	RACER	Installation Location	
Field Personnel		Photo Number(s)	
Site Location	Moraine, Ohio	Date/Time	
Project Number	OH000294.2011.00007A	Contractor	

Vapor Intrusion Mitigation System Inspection and Design Form Date:

Vapor Intrusion Mitigation System Inspection and Design Form Attached: Yes or No

Design Drawings Attached: Yes or No

Design Drawing Deviations

Additional Notes/Observations

ARCADIS

Vapor Intrusion Mitigation System
Installation Checklist

Address Inspected: _____ Property ID #: _____

Tenant's Name: _____ Owner's Name: _____

Owner's Address (If Different from Property): _____ Make and Model of Fan: _____

Inspector's Name: _____ Date Installed: _____

Date: _____

Time: _____

System Pressures	SS-	SS-	SS-	FAN
Observed Pressure Field Extension Reading (in w.c.)				
Required Pressure Field Extension Reading (in w.c.)	-0.004	-0.004	-0.004	Between 1 and 4
Difference (in w.c.)				

1.0 Systems Installation and Interior Piping Requirements

	Yes	No	NA
1.1 Is all system piping Schedule 40 PVC of not less than 3-inch diameter?			
1.2 Are all system piping connections permanently sealed? (Exceptions include installation of fan and sump cover)			
1.3 Does the system piping avoid attachment to or support from existing pipes, ducts, conduits, or any other kind of equipment?			
1.4 Does the system piping avoid blocking windows and doors or access to installed equipment?			
1.5 Are supports for system piping installed at least every 6 feet on horizontal runs?			
1.6 Are vertical runs secured above or below the points of penetration through floors, ceilings, and roof, and at least every 8 feet?			
1.7 Are suction point pipes supported and secured in a permanent manner that prevents their downward movement to the bottom of suction pits?			

2.0 General Sealing Requirements

	Yes	No	NA
2.1 Is the suction point piping penetration through the slab and/or polyethylene sheeting properly sealed using polyurethane caulk or equivalent?			
2.2 Are accessible openings around utility penetrations through the foundation walls and slab, test holes, sub-slab sample points, and any other openings in slabs properly sealed using polyurethane caulk or equivalent?			
2.3 Are openings/cracks sealed where the slab meets the foundation wall using polyurethane caulk or equivalent?			
2.4 Was backer rod used when sealing cracks greater than ½ inch wide?			
2.5 Are drain seals properly installed?			
2.6 Is the sump pit installed with an impermeable cover and sealed with O-ring or silicone caulking?			
2.7 Are open block cores sealed?			
2.8 Is crawlspace sheeting sealed to foundation walls, at overlapping pieces, and at penetrations?			
2.9 Is crawlspace sheeting protected from damage?			
2.10 Is piping penetration through the siding sealed?			
2.11 Is piping centered within roof flashing?			

3.0 Electrical Requirements

	Yes	No	NA
3.1 Is the power supply to the fan hard-wired with an electrical disconnect within line of sight and within 4 feet of the fan?			
3.2 Is the padlock in place on the disconnect switch?			
3.3 Is the electrical service panel labeled to indicate the circuit breaker powering the fan?			

4.0 Monitors and Labeling Requirements

	Yes	No	NA
4.1 Does the suction point have a manometer to measure vacuum?			
4.2 Is the manometer clearly marked to indicate the initial pressure reading?			
4.3 Is a system description label placed on the mitigation system or other prominent location?			
4.4 Is the label legible from a distance of at least 3 feet and does it display the following information: Purpose of the system ("Vapor Intrusion Mitigation"), name, address, and phone number of the contact person?			
4.5 Was backdraft testing successfully completed after system installation?			
4.6 Is the audible alarm operational?			

5.0 System Vent Discharge Point Requirements

	Yes	No	NA
5.1 Is the vent pipe discharge vertical and upward, outside the structure, at least 10 feet above ground level, and at least 12 inches above the surface of the roof?			
5.2 Is the discharge of the vent pipe 10 feet or more away from any window, door, or other opening into conditioned or otherwise occupiable spaces of the structure or any adjacent structure, if the vapor discharge point is not at least 2 feet above the top of such openings?			
5.3 Is the outside vent piping fastened to the structure of the building with hangers, strapping, or other supports that will secure it adequately (every 8 feet and within 2 feet of the discharge)?			
5.4 Is vent stack piping ID at least as large as the largest used in the manifold piping? Manifold piping to which two or more suction points are connected shall be at least 4 inch ID. (3x4 inch aluminum downspout is an acceptable deviation)			
5.5 If metal roof, is piping protected from snow damage?			
5.6 Is exterior piping painted to protect from UV damage?			

6.0 Fan Installation Requirements

	Yes	No	NA
6.1 Is the fan installed in a configuration that avoids condensation buildup in the fan housing?			
6.2 If the fan is mounted on the exterior of buildings, is it rated for outdoor use or installed in a weather proof protective housing?			
6.3 Does the system operate without unacceptable noise or vibration?			

7.0 Design Drawing and As-Built Drawing Requirements

	Yes	No	NA
7.1 Was the system installed per all requirements of the property-specific work plan?			
7.2 Were deviations from the property-specific work plan documented and approved by the U.S. EPA?			

8.0 Notes & Comments (List any deviations from the property-specific work plan.)

9.0 Required Corrective Actions

ARCADIS
Infrastructure, environment, buildings

Imagine the result

SOP 25

Vapor Intrusion Mitigation System Operation and Maintenance

RACER

Moraine, Ohio

Date: May 6, 2011

Revised: May 27, 2011

Revised: September 12, 2011

Approval Signatures

Prepared by: Rebecca A Robbennolt Date: April 26, 2011
Rebecca Robbennolt

Reviewed by: Rachel R. Saari Date: May 3, 2011
Rachel Saari

Approved by: Carolyn Grogan Date: May 6, 2011
Carolyn Grogan

Modified by: Rachel R. Saari Date: May 27, 2011
Rachel Saari

Modified by: Carolyn Grogan Date: September 12, 2011
Carolyn Grogan

I. Scope and Application

This Standard Operating Procedure (SOP) describes the procedures for operation and maintenance (O&M) of active vapor intrusion mitigation systems at structures with three different foundation types: basement, crawlspace, and slab-on-grade, or any combination of these three. The O&M procedures are based on Sub-Slab Depressurization System (SSDS), Sub-Membrane Depressurization System (SMDS), and Crawlspace Depressurization System (CSDS) design criteria found in American Society for Testing and Materials (ASTM) Designation: E2121-03, Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings (ASTM, 2008); United States Environmental Protection Agency (U.S. EPA) 625, Radon Reduction Techniques for Existing Detached Houses (U.S. EPA, 1993); and U.S. EPA Region 5, Vapor Intrusion Guidebook (U.S. EPA, 2010).

The following sections list the necessary equipment and materials and provide O&M instructions for the active vapor intrusion mitigation systems for the above mentioned foundation types.

Site specific requirements and/or field conditions may require modifications to some of the procedures outlined in this SOP. Alterations to the SOP may be completed per approval of the Project Manager.

II. Personnel Qualifications

ARCADIS field personnel will have current health and safety training including 40-hour HAZWOPER training and site-specific training as needed. ARCADIS field personnel will be well versed in the relevant SOPs and possess the required skills and experience necessary to successfully complete the desired field work. ARCADIS personnel are responsible for the coordination and oversight of the vapor intrusion mitigation system O&M activities. ARCADIS personnel leading the O&M activities will have previous vapor intrusion mitigation system O&M oversight experience.

III. Health and Safety Considerations

Materials and equipment must be carefully handled to minimize the potential for injury. All O&M personnel should review the appropriate health and safety plan (HASP) and job loss analysis (JLA) prior to beginning work to be aware of potential hazards associated with the job site and the specific O&M.

IV. Equipment and Materials List

The equipment required for O&M of active vapor intrusion mitigation systems is presented below:

- Appropriate PPE (as required by the Health and Safety Plan)
- Micromanometer
- Flashlight
- Inspection form (included at the end of this SOP)
- Camera

V. Procedure

Annual Operation and Maintenance (US EPA Region 5 Vapor Intrusion Handbook, U.S. EPA 625, and ASTM E2121-03)

Inspections will be conducted by ARCADIS to ensure that it is functioning properly. The inspections will cover the following items:

1. The manometer reading will be recorded and checked against the operating value recorded at the completion of the system installation to ensure the system is operating in the design range.

2. The sub-slab pressure field extension readings will be recorded at the sub-slab points that were installed during system construction. The recorded values will be compared to the values recorded at the completion of the system installation.

3. The condition of the fan and disconnect switch lock will be recorded.

4. The condition of the system piping, fittings, and pipe supports will be recorded.

5. The condition of the foundation sealing including crawlspace sheeting will be recorded.

6. Confirmation that the system O&M manual is present will be recorded.

7. Any changes to the building structure or areas in need of additional sealing will be recorded.

If any deficiencies are found, corrective actions will be undertaken as soon as possible and at a minimum within 30 days of discovery.

VII. Safety Considerations

ARCADIS will comply with all OSHA, state, and local standards or regulations relating to worker safety during the O&M of vapor intrusion mitigation systems. All necessary PPE will be worn during annual inspection.

VIII. Waste Management

The waste materials generated by these activities should be minimal. Personal protective equipment, such as gloves and other disposable equipment (i.e. tubing) should be collected by field personnel for proper disposal.

IX. Data Recording and Management (ASTM E2121-03 Section 7.7)

1. ARCADIS will keep records of all mitigation work performed and maintain those records for three years.
2. Health and safety records shall be maintained for a minimum of 20 years.
3. ARCADIS will provide clients with information that includes the following:
    a. Inspection forms
    b. Documentation of corrective actions completed

X. Quality Assurance

After corrective actions have been implemented, manometer readings and sub-slab pressure field extension readings will be recorded as necessary to document the corrective actions have been successfully implemented.

XI. References

ASTM Designation: E2121-03, Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings. March 2001.

U.S. EPA 625, Radon Reduction Techniques for Existing Detached Houses. October 1993.

U.S. EPA Region 5, Vapor Intrusion Guidebook. October 2010.

Sub-Slab, Sub-Membrane, and Crawlspace Depressurization Systems - Annual O&M Inspection Form

Property Identification Number: _____ Temperature (Ambient): _____ ^{o}F
Tenant's Name: _____ Temperature (House): _____ ^{o}F
Owner's Name: _____ Barometric Pressure: _____ "Hg
Owners Address (If Different from Property): _____ Weather Conditions: _____

Inspector Name: _____
Date: _____
Time: _____

System Inspection

Is Fan Operating?	Yes	No	NA
Any Unusual Fan Noises?	Yes	No	
Are Vent Piping and Piping Joints Intact?	Yes	No	
Any Caulking Required Around Piping Penetrations?	Yes	No	
Is System Padlock Intact (System ON/OFF Switch)?	Yes	No	NA
Is O&M Manual Present?	Yes	No	
Any Areas In Need of Additional Sealing?	Yes	No	

List Areas to be Sealed: _____
List Any Necessary System Repairs: _____

Tenant Observations

Any Change in Fan Noise or Vibration?	Yes	No	
Have you Turned the Fan OFF for Any Period of Time?	Yes	No	NA

Reason? _____

Is Differential Pressure in the Manometer Outside of Normal Operating Range?	Yes	No	NA
Is the System Manometer Steady?	Yes	No	NA
Have You or the Owner Made any Changes to the Basement or Other Foundation?	Yes	No	

Is So, What Were the Changes: _____

ARCADIS

Appendix C

Photographs of Mitigation System Components

PHOTOGRAPH 1: Mitigation system fan and discharge. The fan creates a vacuum under the concrete floor slab or crawlspace. The vacuum draws vapors from under your home into a PVC pipe system that is vented above the structure. The fan must be “on” and running 24 hours a day to ensure the system is operating effectively. The vent pipe must be clear of obstructions at all times. This includes caps and covers.

PHOTOGRAPH 2: Manometer (vacuum pressure gauge) to monitor system performance; the “u-tube” will display a reading greater than zero (the system is designed to operate between 1-4 inches of water column) on the side where the small poly tubing is located when the system is operating effectively.

ARCADIS

PHOTOGRAPH 3: Extraction point. PVC piping extends through the concrete slab floor or crawl-space liner. PVC pipe extends upward to an overhead piping system routed to an “in-line” fan or turbine used to vent the sub-slab space.

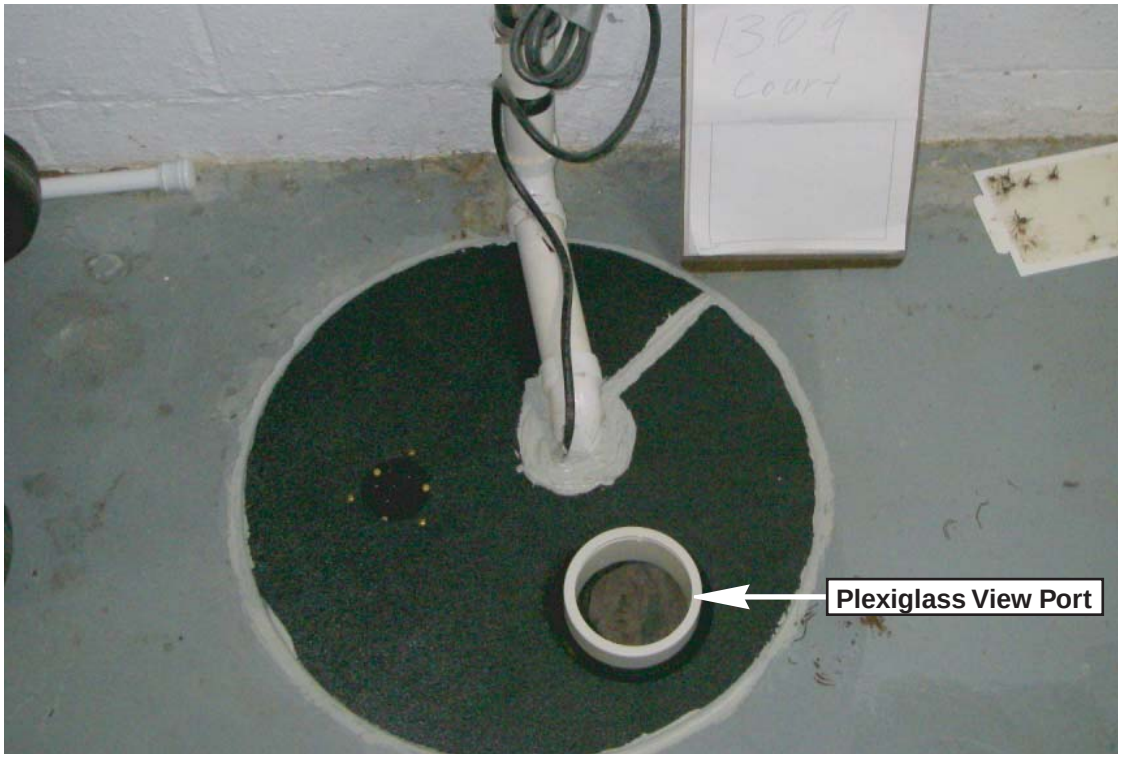
PHOTOGRAPH 4: Overhead extraction piping to exterior fan or turbine. Horizontal piping is installed at a 1% slope back the extraction point. Pipe is supported every 8 feet on vertical piping, every 6 feet on horizontal piping, and near the discharge.

ARCADIS

PHOTOGRAPH 5: Cracks sealed using polyurethane caulk. Any new cracks should be confirmed and sealed during annual inspection or sooner as necessary.

PHOTOGRAPH 6: Liner used to seal damaged wall. Liner should be maintained to ensure vapors are captured by the mitigation system.

ARCADIS



PHOTOGRAPH 7: Sump cover installed and sealed. Lid view port can be used for pump performance inspection without lid removal.

PHOTOGRAPH 8: Crawlspace sealed using polyethylene sheeting. Sheeting is sealed at the perimeter of the crawlspace and around any protrusions. Polyethylene sheeting installed in areas accessible to foot traffic or used for storage are protected using foam padding and untreated plywood.

ARCADIS

PHOTOGRAPH 9: Padlock located on the “on/off” switch located on the exterior of your structure. This system is designed to run in the “on” position at all times to ensure it is effective.

PHOTOGRAPH 10: A wind turbine is used for a passive mitigation system. The turbine should spin freely at times to ensure the system is effective. Any roof penetration is sealed using roof flashing when required.

ARCADIS

ARCADIS

Appendix D

Schematic of Mitigation System Components

RadonAway™
The World's Leading Radon Fan Manufacturer

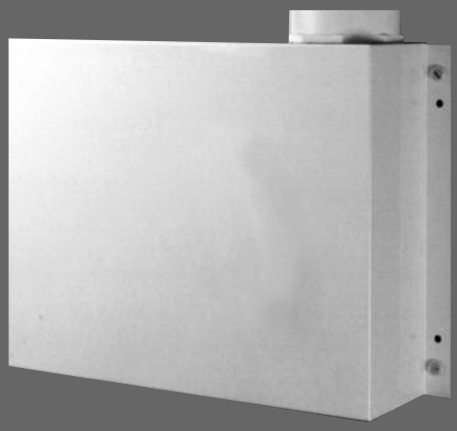
GP500

Radon Mitigation Fans

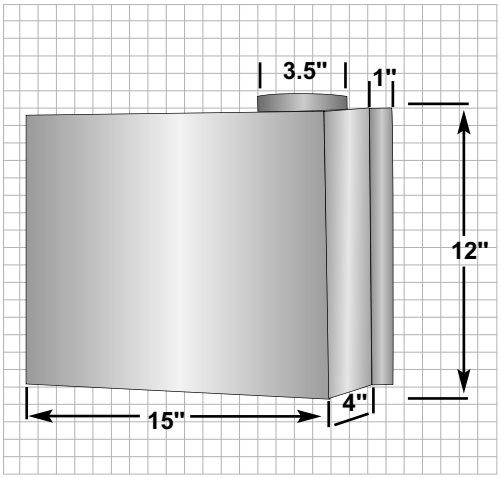
All RadonAway fans are specifically designed for radon mitigation. The GP500 is an attractive alternative to the inline tube fan. The flush mounting of the GP500 protrudes only 4" giving a neat, unobtrusive appearance. The electrical connection is inside the house.

Features:

- Attractive alternative to inline tube fans
- Very quiet and attractive
- Two-year warranty
- Thermally protected
- High performance
- Non-yellowing finish



Model	Watts	Max. Pressure "WC	Typical CFM vs. Static Pressure WC						
			1.0"	1.5"	2.0"	2.5"	3.0"	3.5"	4.0"
GP500	70-130	4.3	88	80	74	65	54	28	14



For Further Information Contact:

3/08
P/N 02001

RadonAway™
The World's Leading Radon Fan Manufacturer

GP Series

Radon Mitigation Fans

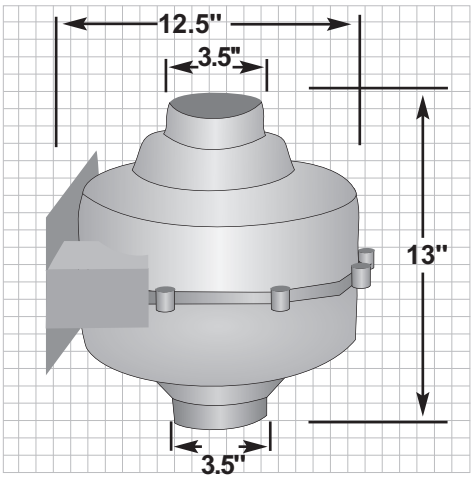
All RadonAway fans are specifically designed for radon mitigation. GP Series Fans provide a wide range of performance that makes them ideal for most sub-slab radon mitigation systems.

Features:

- Five-year hassle-free warranty
- Mounts on duct pipe or with integral flange
- 3.5" diameter ducts for use with 3" or 4" pipe
- Electrical box for hard wire or plug in
- ETL Listed - for indoor or outdoor use
- Meets all electrical code requirements
- Thermally protected
- Rated for commercial and residential use.

Model	Watts	Max. Pressure WC	Typical CFM vs. Static Pressure WC						
			1.0"	1.5"	2.0"	2.5"	3.0"	3.5"	4.0"
GP201	40-60	2.0	82	58	5	-	-	-	-
GP301	55-90	2.6	92	77	45	10	-	-	-
GP401	60-110	3.4	93	82	60	40	15	-	-
GP501	70-140	4.2	95	87	80	70	57	30	10

Choice of model is dependent on building characteristics including sub-slab materials and should be made by a radon professional.



For Further Information Contact:

10/08
P/N 02002

ARCADIS

Appendix E

Property-Specific Work Plan Template

Property-Specific Work Plan for [insert address or ID number]

Introduction

ARCADIS on behalf of Revitalizing Auto Communities Environmental Response Trust (RACER) is proposing to install a mitigation system at [insert address or ID number] based on the results from testing at the subject property on [insert date]. The installation will be conducted per the approved Vapor Intrusion Mitigation Work Plan dated June 3, 2011 and revised on [insert date] and the property-specific design information provided below. This Property-Specific Work Plan (PSWP) has been submitted to the U.S. EPA and was approved on [insert date]. The inspection of the home was completed by ARCADIS and Environmental Doctor (State of Ohio Department of Health licensed Radon Mitigation Contractor/Specialist) personnel per the Inspection and Vapor Intrusion Mitigation Design Standard Operating Procedure (SOP 23) on [insert date]. The design and inspection form is presented in Attachment 1.

Mitigation System Design

The building is a [insert building-specific information]. The active mitigation system for this property will consist of the following [example information provided below]:

- The mitigation system for this property will include a combination sub-slab depressurization system (SSDS) for the basement and a sub-membrane depressurization system (SMDS) for the crawlspace or dirt floor.
- Two suction points will be installed, one under each of the two foundations. A sub-slab suction pit will be installed through the basement slab. A suction point consisting of perforated polyethylene flex drain will be installed in the crawlspace or dirt floor below the membrane consisting of 6-mil reinforced polyethylene sheeting (see Figures 1 and 2).
- Four-inch Schedule 40 polyvinyl chloride (PVC) vent piping will be installed from the sub-slab suction point and crawlspace or dirt floor suction point and piped to a single discharge point located approximately 12 inches above the roof line of the home. The piping leg leading to the crawlspace or dirt floor suction point will contain a valve or damper to balance the air flow. The vent piping will be routed through the interior of the house to the attic, where the fan and disconnect switch will be installed. The piping will penetrate the roof and terminate approximately 12-inches above the roofline (see Figures 1 and 2).
- A U-tube manometer will be installed in the system piping extending up from the basement sub-slab suction point (see Figure 2).
- A label with contact information will be placed on the vent piping near the manometer.
- An audible alarm will be installed on the system piping adjacent to the U-tube manometer (see Figure 2).
- The Operation and Maintenance (O&M) Manual will be attached to the system piping and will include a key for the disconnect switch, which will be locked in the on position.
- The appropriate breaker in the home's electric panel will be labeled as powering the mitigation system fan.
- Permanent sub-slab sample points will be installed during mitigation system installation for future monitoring of sub-slab depressurization.
- The exterior system piping will be sprayed with white Krylon Fusion for aesthetics and UV protection and may be painted to match the exterior of the home based on the preference of the property owner.

See Figures 1 and 2 for drawings of the system configuration. Minor modifications to this property-specific work plan may be necessary during system installation and all modifications will be discussed with the property owner, RACER, radon contractor, and ARCADIS National Environmental Health Association National Radon Proficiency Program (NEHA NRPP) certified radon mitigator before completion. Modifications made to the PSWP will be noted in the as-built diagram provided in the Operation & Maintenance (O&M) Manual that will be provided to the property owner and the U.S. EPA within 10 business days of mitigation system installation.

Sealing

Cracks in the basement foundation will be sealed with polyurethane caulk. Sheeting will be sealed to the crawlspace walls with polyurethane caulking, 1-inch by 2-inch wood strips, and concrete anchors. A sump lid will be installed and sealed. A drain seal will be installed in the basement floor drain, which leads to the sump. Cracks in the basement floor slab and basement ledge will be sealed with polyurethane caulking. The basement sub-slab suction point and vent piping will be sealed with polyurethane caulk where exiting the suction pit and where piped through the wall of the home. See Figure 1 for the location of areas to be sealed.

Backdraft Testing

A backdraft test was completed during the initial design visit on the furnace and water heater and the property passed. The results were reported to the property owner. The windows in the home were closed during testing. Chemical smoke was applied at the flue of the furnace and water heater. The smoke traveled up the flue of each appliance, indicating a passing test. Upon system completion, both appliances will be tested again to verify that they are continuing to draft properly.

If a backdraft test failure is noted at any time during the mitigation design or installation process, the contractor will be assigned to diagnose the cause of the backdraft test failure. If the backdraft test failure is associated with appliance venting, the mitigation contractor will correct the problem and the appliance will be re-tested. If the backdraft test failure is associated with the appliance malfunctioning, the property owner will be asked to repair or replace the appliance prior to mitigation system operation. Mitigation systems can be installed at homes with backdraft failures; however, the mitigation system will be locked in the off position and should not be operated until the backdraft condition has been remedied.

Communication Test/Fan Selection

Communication testing was completed using the permanent sub-slab sample point and temporary sub-slab sample points at the locations indicated on Figure 1 and following procedures outlined in SOP 23. Vacuum readings exceeding negative 0.004 inches water column were recorded at the permanent sub-slab sample points during both communication tests indicating the communication test was successful, as required in the Vapor Intrusion Mitigation Work Plan. Based on the results of the communication testing, the RadonAway GP-501 fan, or equivalent, was selected for installation of this system. Fan information is included in Attachment 3.

Property Owner Requests

The owner signed the mitigation access agreement for the system installation on [insert date] (Attachment 4). The homeowner preferred that the vent piping exit the east side of the house. This request was incorporated into the system design.

Post-Installation Proficiency Sampling

Post-installation proficiency sampling of indoor air (first floor, basement, and accessible crawlspace) samples will be collected approximately 30 days, 180 days, and 360 days after system installation to document that the indoor air is in compliance with the Action Levels. The property owner will be provided with a letter to notify them of the sampling results and an explanation if results are less than or greater than or equal to the Action Levels.

If the post-installation proficiency sampling results are not below the Action Levels, ARCADIS personnel will evaluate the performance of the mitigation system and complete any necessary system modifications and/or sealing within 30 days of receiving validated sample results. System modifications could consist of replacing the existing fan with a different size fan or the installation of additional suction point(s). For the sub-membrane depressurization system, potential system modifications may include installing sub-slab sample points for implementing pressure field extension readings. Following completion of the system modifications, an additional post-installation proficiency sampling event will be conducted for indoor air (first floor, basement, and accessible crawlspaces) within 30 days.

Operation and Maintenance (O&M)

An annual inspection will be conducted by ARCADIS to inspect the mitigation system and ensure that it is functioning properly. Two inspections will be conducted in the first year and the systems will be inspected annually thereafter. The following items will be inspected and recorded on an Inspection Form.

- The manometer reading will be checked to ensure the system is operating in the design range.
- Sub-slab pressure field extension readings will be measured at the permanent sub-slab sample points to ensure sub-slab depressurization of negative 0.004 in. w.c.
- The fan will be checked for unusual noise or vibration.
- The vent piping will be checked for any damage.
- The pipe supports will be checked to ensure they are secure.
- The accessible crawlspaces or other areas sealed with reinforced, polyethylene sheeting will be inspected for damage.
- The foundation sealing and sealing around system piping penetrations will be checked for any additional areas requiring sealing.
- The presence of the padlock on the disconnect switch will be checked.
- The presence of the O&M Manual at the residence will be checked.

Repairs to the mitigation system or additional sealing will be conducted at no cost to the property owner.

A payment will be issued annually to reimburse the property owner for the cost of operating the electric powered fan. The mitigation fans are designed to minimize energy usage, and the cost to operate the fan will be calculated by ARCADIS using local electric rates and the fan wattage.

Schedule

The property owner will be contacted to schedule the installation upon receipt of U.S. EPA approval of this work plan.

Work Plan Attachments:

Figure 1. Basement/Crawlspace Layout

Figure 2. Active Mitigation System Installation Details – Basement/Crawlspace

Attachment 1. Vapor Intrusion Mitigation System Inspection and Design Form [Note: Not included in this template]

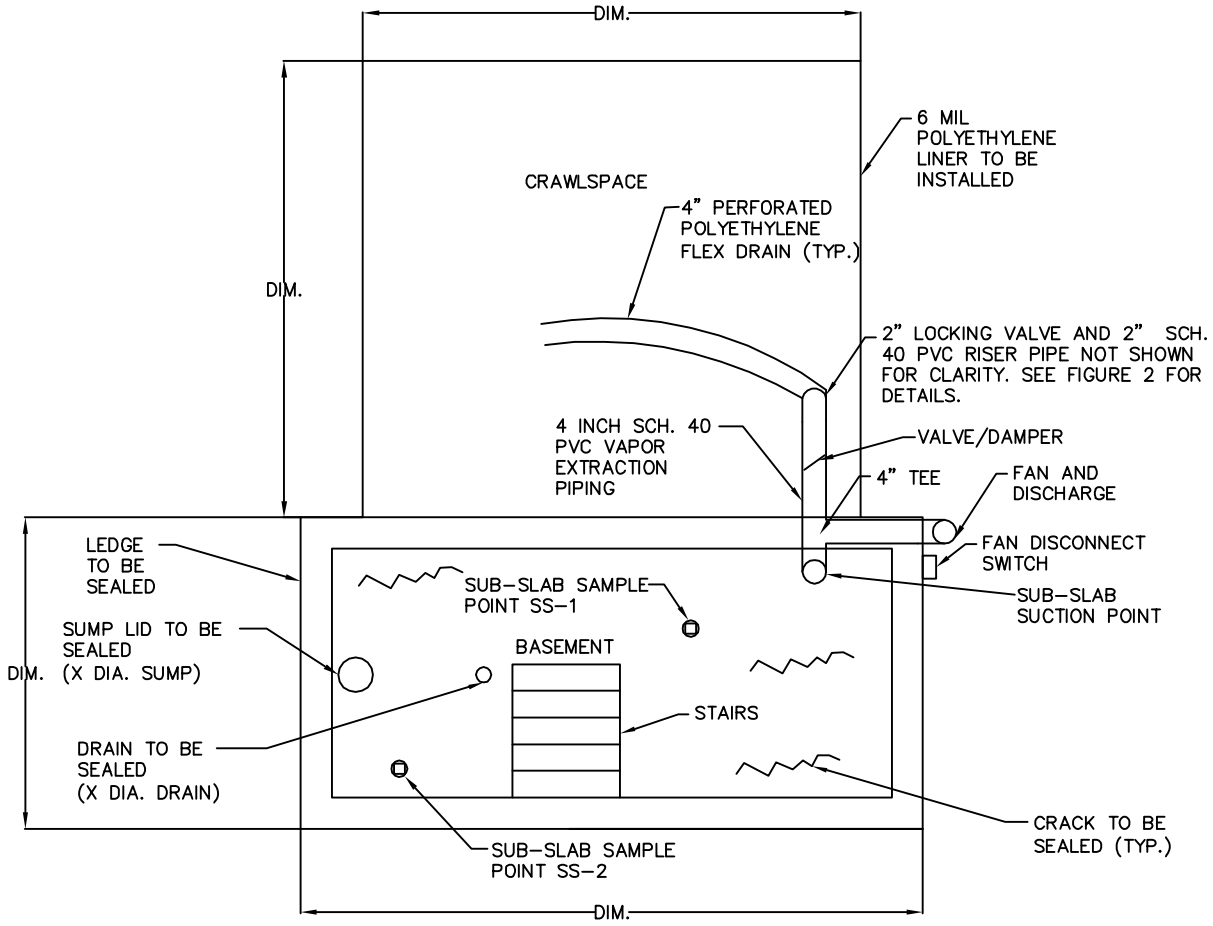
Attachment 2. Material Safety Data Sheets [Note: Not included in this template]

Attachment 3. Mitigation System Components [Note: Not included in this template]

Attachment 4. Access Agreement for Design, Installation, Operation and Maintenance of the Vapor Intrusion Mitigation System [Note: Not included in this template]

NOTES:

1. CRACKS IN BASEMENT/FOUNDATION TO BE SEALED.
2. CRAWLSPACE WILL BE SEALED WITH POLYETHYLENE SHEETING.
3. DIMENSIONS ARE APPROXIMATE.



LEGEND

SCH.	SCHEDULE
DIA.	DIAMETER
DIM.	DIMENSION

NORTH
NOT TO SCALE

RACER
MORAINE,OHIO

OH000294.2011

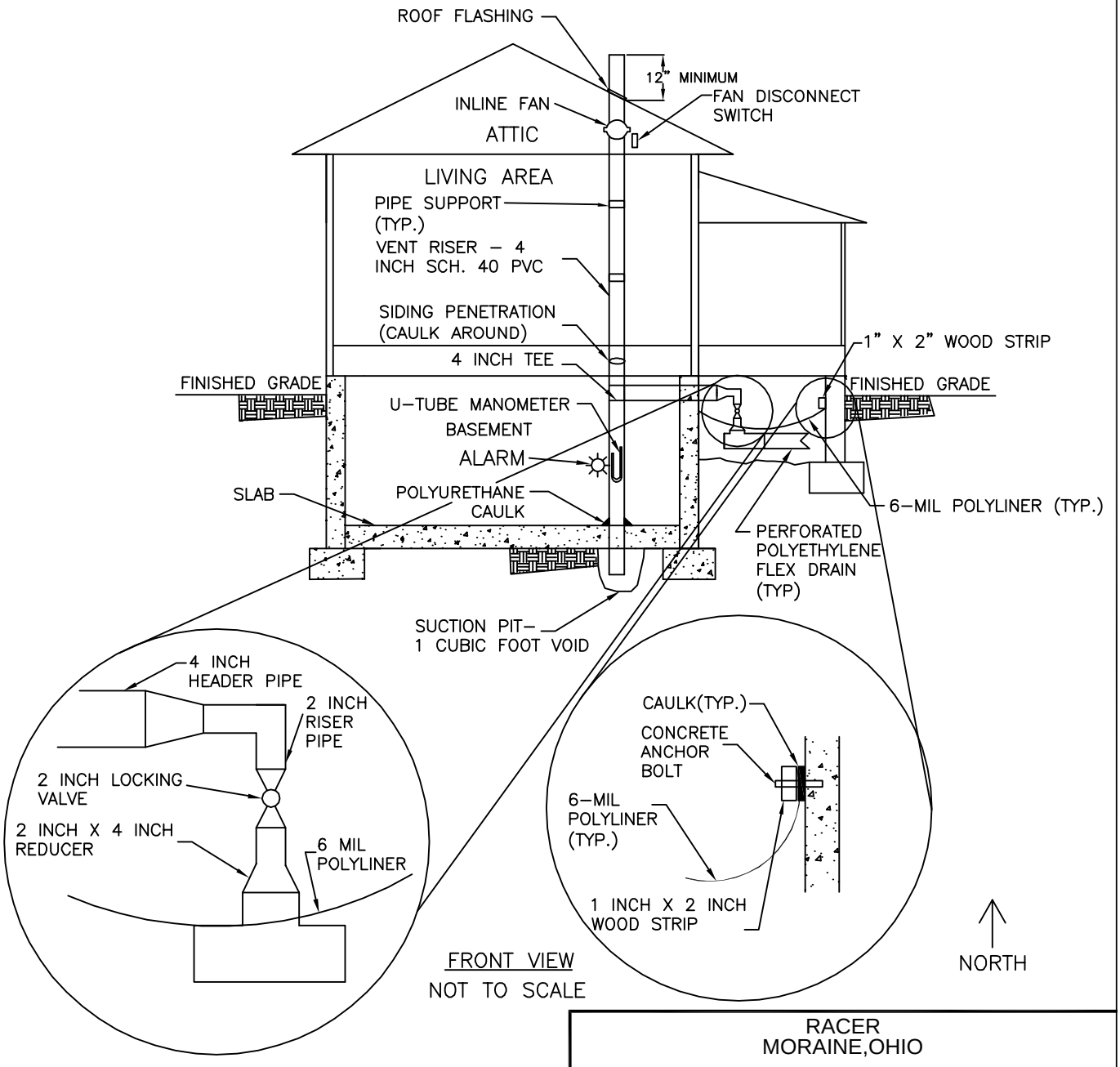
BASEMENT/ CRAWLSPACE LAYOUT
PROPERTY ADDRESS

ARCADIS

FIGURE
1

NOTES:

1. VENT RISER WILL TERMINATE A MINIMUM OF 12 INCHES ABOVE ROOF ELEVATION AND A MINIMUM OF 10 FEET FROM ANY AIR INTAKE LOCATED HORIZONTALLY ADJACENT TO OR ABOVE THE TERMINATION POINT.
2. HORIZONTAL PIPE RUNS SHALL BE SLOPED BACK TOWARDS THE SUCTION POINT AT MINIMUM 1% SLOPE.
3. INSTALL PIPE SUPPORTS NEAR DISCHARGE, EVERY 8 FEET ON VERTICAL PIPING, AND EVERY 6 FEET ON HORIZONTAL PIPING AT A MINIMUM.
4. CRACKS IN BASEMENT/FOUNDATION TO BE SEALED.
5. DIMENSIONS ARE APPROXIMATE.



FRONT VIEW

NOT TO SCALE

RACER
MORAINE,OHIO

OH000294.2011

ACTIVE MITIGATION SYSTEM INSTALLATION DETAILS - BASEMENT/CRAWLSPACE PROPERTY ADDRESS

ARCADIS

FIGURE **2**

AIR PURIFIER SOP

STANDARD OPERATING PROCEDURE FOR INSTALLATION AND OPERATION OF AIR PURIFIERS LIVONIA, MICHIGAN

An AllerAir brand portable indoor air purifier, Model 5000 Vocarb, or equivalent, may be placed in the residence as an interim measure until the installation of a vapor mitigation system. The air purifier will be removed following the installation and startup of the vapor mitigation system.

1. AIR PURIFIER SPECIFICATION

The AllerAir air purifier plugs into a standard 115-volt electrical outlet, weighs approximately 44-lbs, is a cylinder measuring approximately 15 inches in diameter and 21 inches high, is equipped with a three speed fan, and contains three different filter media. Flow through the air purifier is rated at approximately 400 cubic feet per minute (CFM) on the high speed setting and 125 CFM on the low speed.

The first filter is a poly fiber pre-filter that removes dust and other large particles from the indoor air. The pre-filter also prevents larger air born particles from reaching the more sensitive filters, clogging them, thus reducing both their efficiency and operational lifecycle.

The second filter is a medical-grade high efficiency particulate arrestance (HEPA) filter rated at 99.97% efficiency in removing particles down to 0.3 microns in size such as dust, pollen, viruses, pet dander, bacteria, and mold.

The third filter is an 18-lb granular activated carbon (GAC) filter that absorbs volatile organic compounds (VOCs) from the indoor air. Geosyntec has used AllerAir air purifiers at other vapor intrusion sites, including one Michigan residence with a basement in which trichloroethene (TCE) and other chlorinated VOCs in indoor air were reduced to non-detectable concentrations (TCE reduced from 33 micrograms per cubic meter [$\mu g/m^3$] to less than analytical detection limit of 1 $\mu g/m^3$) (Berry-Spark et al., 2005).

2. AIR PURIFIER SETUP AND OPERATION

Remove the air purifier from its packaging and assemble it according to the attached manufacturer's directions. Position the air purifier in a centralized open area in the lowest level of the residence. Plug in and follow the manufacturer's instructions to turn onto the highest setting for a few minutes, then turn the fan to the lowest setting. AllerAir recommends several feet of clearance on all sides and the top of the unit to ensure adequate air circulation. Confirm that the unit is running by listening for the motor and feeling the gentle flow of air at the outlet. Leave the purifier turned on continuously. Additional information is provided in the attached instructions.

3. AIR PURIFIER MAINTENANCE

Filter replacement instructions are attached; however, it is anticipated that the air purifier will not be in operation for more than about two months before a vapor mitigation system is installed.

Once a vapor mitigation system has been installed and operation has started, the air purifier will be removed from the residence.

4. REFERENCES

Berry-Spark, K., T. McAlary, N. Bice and P. Zeeb. 2005. "Mitigation of the Vapor Intrusion Pathway at Four Chlorinated Solvent Sites" in Subsurface Vapor Intrusion to Indoor Air: An Updated. The 14th Symposium in GRA's Series on Groundwater Contaminants. May 25, 2005. San Jose, CA.

Operation and Maintenance Manual

4000/5000/6000 Series

Congratulations!

You are moments away from fresher, cleaner indoor air. Your new AllerAir unit will combat many of the chemicals, gases, odors and particles responsible for poor indoor air quality (IAQ). Poor IAQ may cause or worsen allergies, asthma, multiple chemical sensitivities (MCS) and sick building syndrome. We recommend proper maintenance of your unit to keep it running efficiently for years to come.

Operation:

All units except D and DX models are shipped fully assembled and ready for use. (D and DX model owners may refer to their additional instruction sheet for filter installation, or refer to Page 6 of this booklet.)

Note:
As original packaging is required for warranty returns, new AllerAir owners are advised to keep boxes and shipping materials.

Model No. _____

Serial No. _____

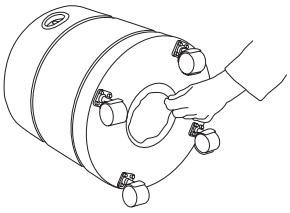
GETTING STARTED

- Keep packaging in case of warranty returns
- Wipe the unit with a soft damp cloth to remove any dust which may have accumulated during shipping
- Check the inlet opening for extra prefilters if ordered. (Bottom of unit)
- Place the unit on its casters and plug it into a 120-volt outlet with ground
- Run the unit on TURBO for a few minutes to re-adjust the airflow patterns in the room
- Depending on your interior conditions, you may choose to run the unit on HIGH during the day and on LOW at night*
- Running the unit on LOW is energy-efficient and increases the amount of air dwell time in the cleansing chambers

*Depending on interior dust conditions. For VOC's, chemicals, smoke or odors we suggest operating continuosly on the low setting to allow for the longest dwell time and adsorbtion.

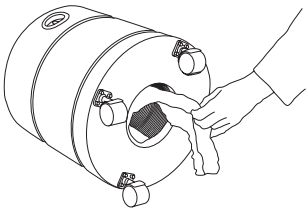
REPLACING OR CLEANING THE PRE-FILTER

We recommend changing or cleaning pre-filters every one to two months.



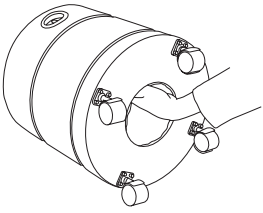
STEP 1

Turn the unit off, unplug it, and gently lay it on its side.



STEP 2

Slowly remove the dirty pre-filter to avoid dispersing its contents.
To clean: Carefully vacuum both sides of the filter.
To discard: Gently insert into a plastic bag and discard.



STEP 3

To install: Gently press the pre-filter flat against the inner walls of the innermost filter. Return the unit to an upright position.

WARNING! REFRAIN FROM POKING OR STICKING ANY OBJECT INTO THE UNIT'S AIR VENT DISCHARGE.

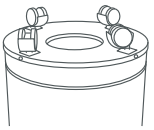
PRE-FILTER ORDER REFERENCE NUMBERS*

To order a new pre-filter, call AllerAir toll-free at 1-888-852-8247 during regular business hours (EST), or send an e-mail to info@allerair.com

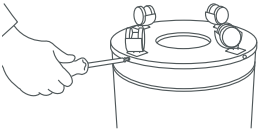
Models	Prefilters	4000	5000	6000	Notes
Exec, Vocarb	Poly Prefilters	A4FMP006	A5FMP009	A6FMP012	packs of 4 or 8
DS Models	Tacky Prefilters	A4FMPS06	A5FMPS09	A6FMPS12	packs of 10
MCS Models	Cotton Prefilters	A4FCP016	A5FCP019	A6FCP022	packs of 6

*Please use the above part numbers when ordering your replacement parts.

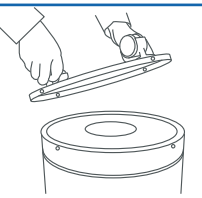
REPLACING HEPA and/or CARBON FILTERS



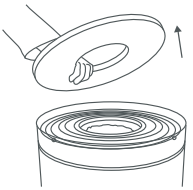
STEP 1
Make sure the unit is set to **"Off"** and the unit is **unplugged**. Place the unit upside down, so that the wheels face up.



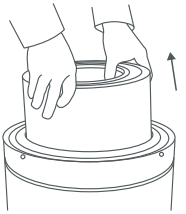
STEP 2
Using a #2 Philips screwdriver, remove the four screws that hold the base onto the unit.



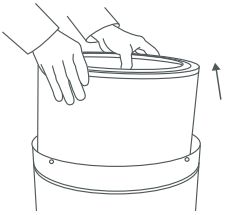
STEP 3
Grasp the wheels. Remove the base by pulling gently on the wheels.



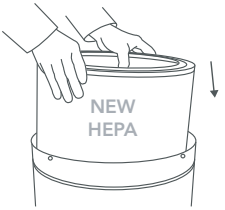
STEP 4
Reach inside the unit, and remove felt pad.



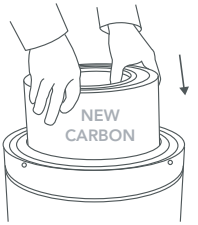
STEP 5
First, **remove** the carbon filter. (pull up gently by placing thumbs on the inner side of the filter)



STEP 6
Then, **remove** the HEPA filter with the same technique.

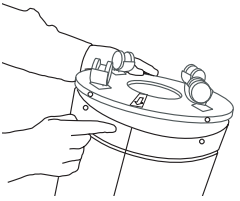


STEP 7
Now, **place** the new HEPA filter into the unit.

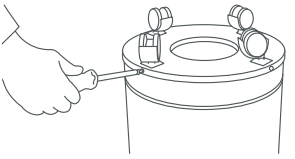


STEP 8
Then, **place** the new carbon filter into the unit.
See page 5 for instructions on replacing carbon filling.

STEP 9
Put back the felt pad removed in **STEP 4.**



STEP 10
Replace the base, making sure the arrow on the gold sticker lines up with unit's rear seam.



STEP 11
Replace the four screws.

STEP 12
Turn the unit back onto its wheels. It is now ready for use.

HEPA & CARBON FILTERS ORDER GUIDE

- These replacement filters will extend the life of your AllerAir unit. Please be sure to follow the instructions for changing the filters in your unit.
- We recommend changing pre-filters every two months, HEPA filters every three to five years, and carbon filters every two years.

ORDER REFERENCE NUMBERS

Please use the numbers in the following charts when placing your order. Call AllerAir at 1-888-852-8247 during regular business hours (EST) or send an e-mail to info@allerair.com.

HEPA Filter Order Guide

Please use the following part numbers when ordering your replacement parts.

Models	4000	5000	6000
Exec, Vocarb	A4FMH0411	A5FH0411	A6FH0411
MCS	–	A5FH0420	–

Microparticulate Electrostatic Filter Order Guide

Please use the following part numbers when ordering your replacement parts.

This is the filter that wraps around any D, DX, DS or MCS D carbon filter.

Models	4000	5000	6000
D Models	A4FMR002	A5FMR002	A6FMR002
DX Models			
DS Models			
MCS D Models			

Replacement Carbon Filter Order Guide

Please use the following part numbers when ordering your replacement parts.

If you have ordered a special blend of carbon in the past please let us know about it when ordering the replacement.

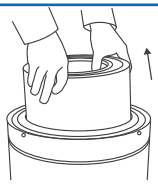
**Please refer to your carbon filter depth when ordering a replacement.

Models	4000	5000	6000
Exec Models 2"**	A4FCW320	A5FCW320	A6FCW320
Exec Models 2.5"**	A4FCW325	A5FCW325	A6FCW325
Vocarb Models 2"**	A4FCW220	A5FCW220	A6FCW225
Vocarb Models 2.5"**	A4FCW225	A5FCW225	A6FCW225
D Exec Models 3"	A4FCW330	A5FCW330	A6FCW330
D Vocarb Models 3"	AA4FCW230	A5FCW230	A6FCW230
DX Exec Models 3.5"	A4FCW335	A5FCW230	A6FCW335
DX Vocarb Models 3.5"	A4FCW235	A5FCW235	A6FCW235
DS Models 3"	A4FCW630	A5FCW630	A5FCW630
MCS Models 2"	A4FCW120	A5FCW120	A6FCW120
DXS 3.5"	–	A5FCW635	A6FCW635

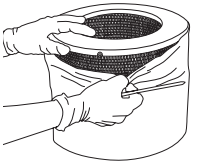
REFILLING THE CARBON CANISTER

- Your AllerAir unit contains a refillable carbon filter. You may choose to refill it* or simply purchase a new filter. **Tools Required:** Philips screwdriver, garbage bag large enough to hold all of the old carbon, rubber mallet.

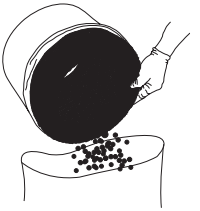
  *When changing the carbon filter, it should be placed on a newspaper or protective surface as it may leak some carbon particles.
- AllerAir makes a special funnel to evenly refill carbon filters. Call 1-888-852-8247 during regular business hours (EST) or send an e-mail to info@allerair.com.



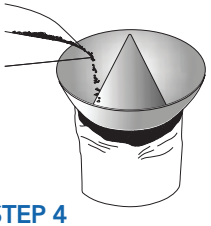
STEP 1
Remove the carbon filter from the unit by pressing thumbs against the inner rim and pulling up.



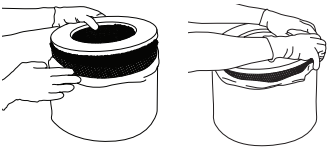
STEP 2
Gently pull back the pre-filter to access the four screws at the top of the filter. Remove the screws with a Philips screwdriver and take off the lid of the filter.



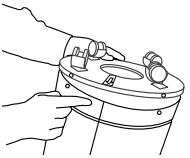
STEP 3
Discard all of the old carbon. Pour it into a garbage bag of adequate size and tie the bag shut.



STEP 4
Pour in the new carbon, using a funnel if desired. As you pour, tap the sides of the filter with the rubber mallet to help settle the carbon granules.



STEP 5
When the filter is full, replace the lid and its screws. Adjust the pre-filter, and gently slide the filter back into the unit.



STEP 6
Replace the felt gasket. Replace the base of the unit. Align the arrow on the gold sticker with the unit's seam, and replace the four screws with a Philips screwdriver.

Empty Carbon Canisters Order Guide

Models	4000	5000	6000	Notes
2" Canister**	A4FC0500	A5FC0500	A6FC0500	Exec & Vocarb; MCS models
2.5" Canister**	A4FC1500	A5FC1500	A6FC1500	Exec & Vocarb models
D Models	A4FC2500	A5FC2500	A6FC2500	–
DX Models	A4FC3500	A5FC3500	A6FC3500	–

Please use these part numbers when ordering your replacement parts.

**Please refer to your carbon filter depth when ordering a replacement.

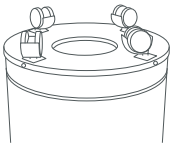
Bulk Carbon Order Guide

Models	4000	5000	6000
Exec Mix	AM000911	AM000911	AM000911
Vocarb Mix	AM000912	AM000912	AM000912
Tobacco Smoke Mix	AM000912	AM000912	AM000912
MCS Mix	AM000901	AM000901	AM000901
Special Blend Mix	Please Call		

Please use these part numbers when ordering your replacement parts.

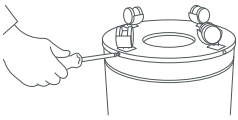
FILTER ASSEMBLY D, DS and DX

The model you have selected is shipped in 2 separate boxes to protect certain components. The filter comes in one box, and the outer shell of the unit, containing the motor and the fan, comes in another. Filters must be installed before turning the unit on in order for it to work. AllerAir technicians recommend removing the base, installing the filter, and replacing the base according to the following steps:



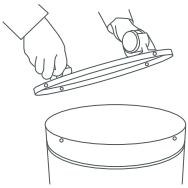
STEP 1

Make sure the unit is set to "**Off**," and **unplug it**. Lay the unit upside down, so that the wheels face up.



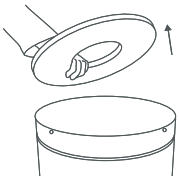
STEP 2

Using a #2 Philips screwdriver, remove the four screws that hold the base onto the unit.



STEP 3

Grasp the wheels. Remove the base by pulling gently on the wheels.



STEP 4

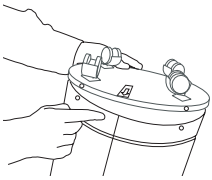
Reach inside the unit, and remove only **1** of the **2** felt pads.

STEP 5

Gently insert the carbon filter (either a Model D, DS or DX Carbon) into the unit, either end up.

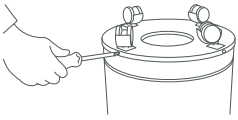
STEP 6

Put back the felt pad removed in **STEP 4**.



STEP 7

Replace the base, making sure the arrow on the gold sticker lines up with unit's rear seam.



STEP 8

Replace the four screws.

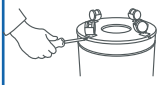
STEP 9

Turn the unit back onto its wheels. It is now ready for use.

REPLACING UV BULB AND BALLAST

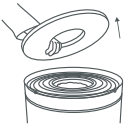
WARNING! ALWAYS UNPLUG UNIT FROM POWER SOURCE BEFORE PERFORMING ANY MAINTENANCE.

STEP 1
Turn the unit **"Off"** and **unplug it.** Gently turn it over and lay it upside down.



STEP 2
Using a #2 Philips screwdriver, remove the four screws that hold the base onto the unit.

STEP 3
Gently grasp the wheels, and remove the lid by pulling gently.

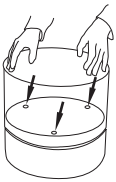


STEP 4
Remove the felt pad.

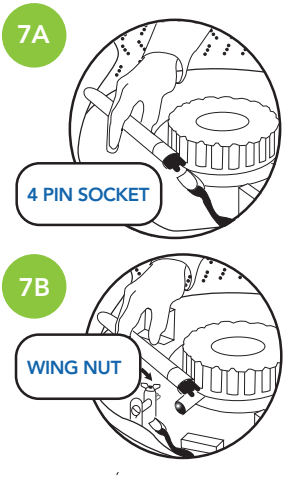
Carbon Filters

STEP 5
Remove the filter(s) according to the indicated directions.

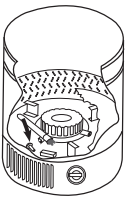
HEPA Filters



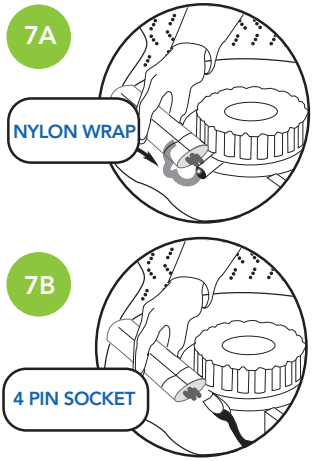
STEP 6
Remove the three screws in the filter end plate. and remove the end plate.



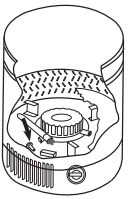
STEP 7
For a 10-watt bulb:



A. Unplug the four-pin socket from the bulb.
B. Loosen the wing nut that holds the bulb in place.
C. Carefully remove the bulb.

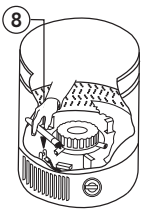


STEP 7
For a 20-watt bulb:



A. Carefully cut the band of nylon that holds the UV bulb in place (for shipping purpose only).
B. Unplug the four-pin socket.
C. Carefully remove the bulb.

STEP 8
Place the new bulb in the holder. Make sure it is horizontal. Make sure it is not touching any of the other components.



STEP 9
Replace the four-pin socket.

STEP 10
Replace the filter end plate. Replace the screws, filter(s) and bottom with the 4 screws.

IMPORTANT! UV SYSTEMS NOT AVAILABLE IN CALIFORNIA.

TEN YEAR LIMITED WARRANTY

Your AllerAir unit comes with a 10-year limited warranty excluding expendable parts such as pre-filters and filters. This warranty provides for the repair of any defective components and labor for 5 years from the date of delivery. An additional 5-year warranty is provided on parts. This product is not covered against damage resulting from misuse. This warranty is provided to the original purchaser and may not be transferred. A return authorization number is required for warranty repairs. Please contact AllerAir at 1-888-852-8247 for more information.

THE ALLERAIR AIR FILTRATION SYSTEM

ACTIVATED CARBON

Your AllerAir air purifier contains activated carbon that permanently traps dangerous airborne chemicals, gases and odors. This vital filter should be changed approximately every two to three years, depending on the environment in which the unit is operating. You can also upgrade your Exec, Vocarb or D unit at any time to accommodate a larger and deeper carbon filter suitable for removing heavier concentrations of chemicals, gases and odors.

PRE-FILTER

The pre-filter included with your unit removes larger particles and helps prolong the life of your HEPA filter. The pre-filer should be vacuumed or replaced every three months.

LASER TESTED, MEDICAL-GRADE HEPA*

HEPA or high-efficiency particulate air filters were originally developed by the military to remove radio-active dust, and are now the primary particle filtration systems used in hospitals, laboratories, electronic clean rooms and any application where clean air is critical. Today, HEPA filters are widely recommended by allergists, doctors and indoor air quality experts for home and office. They trap an amazing 99.97% of airborne particles at 0.3 microns, including dust, hair, pollen and even some bacteria and viruses. Depending on the particle level in the environment in which the unit is used, your HEPA filter should be replaced every three to five years.

*Note that chemical and odor models D and DX feature a micro-particle filter which is rated to trap at least 95% airborne particles.

THE ALLERAIR ADVANTAGE

- Our units offer complete air filtration removing airborne chemicals, gases, odors and particles.
- Our deep bed, activated carbon filters last longer than the average thin filter which is generally carbon sprayed onto a synthetic material.
- Our units do not use dangerous ozone technology
- Our units are manufactured to clean your air and therefore are not made with a plastic housing, or other materials which may off-gas chemicals.
- Our units are powered by American-made motors that are energy efficient and cost only pennies a day to operate.

IMPORTANT NOTICE! PLANNING ON PAINTING YOUR HOME? READ THIS FIRST:

Particles from paint may clog your HEPA filter, therefore we recommended that users unplug their units and remove the HEPA filter, storing it off-site until the paint job is complete. Due to the serious toxic nature of paint it is also recommended that your carbon filter be replaced or refilled in the weeks after the paint job is complete. See, Replacing HEPA and/or carbon filters, for instructions on how.

AllerAir Air Purifiers®

1.888.852.8247
www.allerair.com

Appendix D

O&M Manual Contents

Hamp, Mathews &
Associates, Inc.

XXX XX, 2012

[RESIDENT MAILING INFORMATION]
RE: Operation and Maintenance (O&M) Manual
[ADDRESS], Livonia, Michigan

Dear [NAME]:
The Revitalizing Auto Communities Environmental Response Trust (RACER) appreciates your cooperation with the installation of an active vapor mitigation system at your home. On [DATE], 2012, [NAME OF CONTRACTOR], an approved contractor under the supervision of [NAME OF CONSULTANT] personnel, on behalf of RACER, completed the installation of an active vapor mitigation system at your home, located at [ADDRESS] in Livonia, Michigan. RACER completed this work in cooperation with the United States Environmental Protection Agency (U.S. EPA) in association with the former General Motors facilities in Livonia, Michigan.

The following attachments make up the O&M Manual specific to your property: a copy of the signed access agreement, a copy of the sample results letter, a copy of confirmation sample results letter, photos of each component of your mitigation system, mitigation system as-built drawings, Material Safety Data Sheets (MSDSs) for the products used during system installation, the fan warranty information, the manufacturer's instructions, a copy of the initial O&M inspection form, a copy of the annual O&M inspection form, contact information for any questions you may have regarding the vapor mitigation system, and a form that should be signed to acknowledge your receipt of the O&M Manual. In addition, enclosed with this manual is a key for the padlock on the fan disconnect switch. To confirm vapor mitigation system performance, the system will be inspected annually for the first three years. Thereafter, RACER will contact you annually by letter and phone to confirm the system is operating. RACER will also conduct external inspections; if you prefer, the RACER will arrange for internal inspections instead.

We greatly appreciate your participation in this program. If you have any questions concerning this matter, please do not hesitate to contact XXX at XXX-XXXX-XXXX. You may also contact [NAME OF COUNTY HEALTH CONTACT], County Health Department at XXX-XXX-XXXX if you have concerns about the sampling results.

Sincerely,
Geosyntec

cc: RACER, EPA

Attachments:
Copy of Signed Access Agreement
Copy of Sample Results Letter
Copy of Confirmation Sample Results Letter
Photos of the Active Mitigation System
Mitigation System As-Built Drawings (Layout and Installation Details)
MSDSs
Fan Warranty Information
Manufacturer's Instructions
Initial O&M Inspection Form
Annual O&M Inspection Form
Contact Information
O&M Manual Receipt Form

Appendix E

Long-Term O&M and Construction Quality Assurance Plans

Hamp, Mathews & Associates, Inc.

Geosyntec consultants

2395 Oak Valley Drive, Suite 110
Ann Arbor, Michigan 48103
PH 734.332.8004
FAX 734.332.8063
www.geosyntec.com

Memorandum

Date:	February 9, 2012
To:	Grant Trigger, Cleanup Manager – Michigan, RACER Trust
Copies to:	Dave Favero, RACER Trust
	Jeffrey Crum, Hamp, Mathews & Associates, Inc.
From:	Karen Berry-Spark and William Wertz - Geosyntec
Subject:	Livonia, Michigan: Standard Operating Procedures (SOPs) for Vapor Intrusion Mitigation

---

At your request, Geosyntec Consultants, Inc. (Geosyntec) has completed a review of the operation and maintenance (O&M) and Construction Quality Assurance (CQA) plans prepared by ARCADIS from the Moraine, Ohio site. The plans are related to O&M and CQA of systems to mitigate the subsurface vapor intrusion (VI) to indoor air pathway. This review was performed to modify the plans to reflect field and building conditions at the Livonia, Michigan site. Geosyntec's recommended modifications to the above referenced Moraine site plans are provided below.

1. MODIFICATIONS TO THE LONG TERM O&M REQUIREMENTS

1.1 Proposed Modifications

Section 4.6 of the attached ARCADIS CQA Plan addresses O&M requirements for the vapor mitigation systems and calls for an annual inspection of the system. The inspection includes pressure measurements and inspection of equipment. A long-term annual inspection may not be necessary to ensure that the mitigation system is functioning properly, and may not be of interest to some homeowners. After three annual inspections demonstrate the reliability of the system at a home, the following alternative approach is proposed:

- The use of annual letters (including an 800 number for homeowner questions) that remind homeowners that they have a system and provide a copy of the operating manual;

- Annual external "fan checks" as a substitute for internal inspections, with internal checks provided if the homeowner prefers;

- A phone call (or phone message if nobody answers) as a follow up to the annual letter to confirm that the system is still operating as designed and to determine whether maintenance is required. This phone call can also be used to identify changes to the structure and confirm ownership, as identified below.

The following will also be added to this plan:

- Follow up communications in cases where a homeowner declines a mitigation system - Provisions to either continue to offer the homeowner a system (in an annual letter) or to ensure that a subsequent purchaser of the property is either aware that a mitigation system was offered and declined, or that they are offered an opportunity to have a system installed.

- Changes in ownership of the property - A program for identifying changes in property ownership and communicating with the new owners in a timely fashion to ensure that they are familiar with the purpose and function of the mitigation system.

- Physical changes in the mitigated structure - A program that triggers a reassessment of the functionality of a mitigation system whenever there is a substantial physical change in the structure (such as construction of a new addition or porch, or a change in the HVAC system).

1.2 Technical Basis

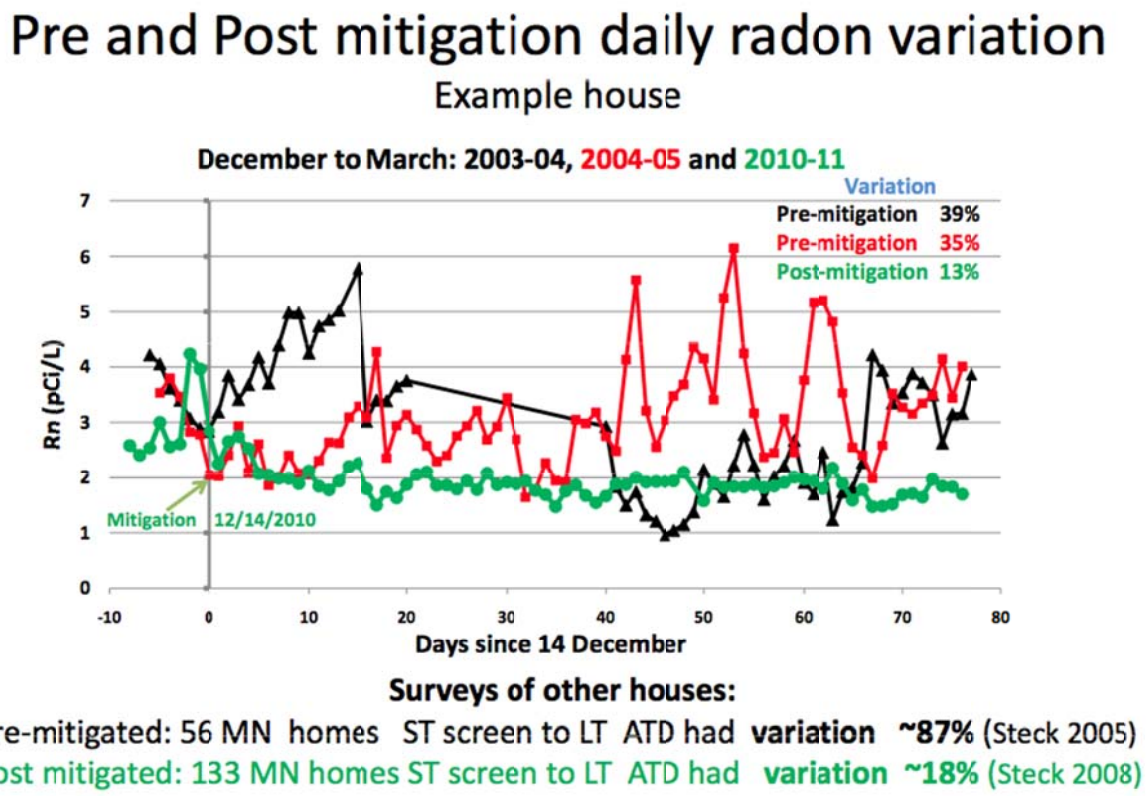
Section 1.1 recommends that pressure field extension monitoring be eliminated from the long-term OM&M program after the first three years of O&M. Pressure field extension testing is included to help demonstrate the efficacy of the mitigation system at the time of system commissioning, during the Post-Installation Proficiency Sampling (PIPS), and during the first three years of O&M.

The rationale for the approach described in Section 1.1 is based on the fact that sub-slab depressurization (SSD) systems have a proven record of reliability and that verification that the vacuum on the SSD mitigation suction point(s) remained similar to its value at the time of commissioning would serve as an effective surrogate for pressure field extension testing. If the vacuum on the SSD is stable, it is logical to assume that the pressure field beneath the building would be stable as well. This is an approach that is included in the "Guidance for Evaluating Soil Vapor Intrusion in the State of New York" and has been applied successfully on vapor

intrusion mitigations systems throughout that state. As a practical matter, our experience has been that most homeowners prefer not to have the pressure field extension holes in their basement for an extended period of time.

We were unable to identify any published literature data on the long-term pressure field extension to demonstrate that the pressure field will remain more or less constant throughout the post-mitigation period. There are, however, published papers in the radon literature and in the volatile organic vapor intrusion literature that demonstrate the long-term efficacy of SSD mitigation systems by means of chemical sampling. A presentation by Dr. Daniel Steck at the 2011 AEHS Annual West Coast Conference EPA Vapor Intrusion Workshop titled "Factors Affecting Radon Entry and Indoor Concentrations, Lessons for Chlorinated VI" includes the following graphic depiction of radon concentrations from a mitigated house in Minnesota.

(see: https://iavi.rti.org/WorkshopsAndConferences.cfm?PageID=documentDetails&AttachID=469)

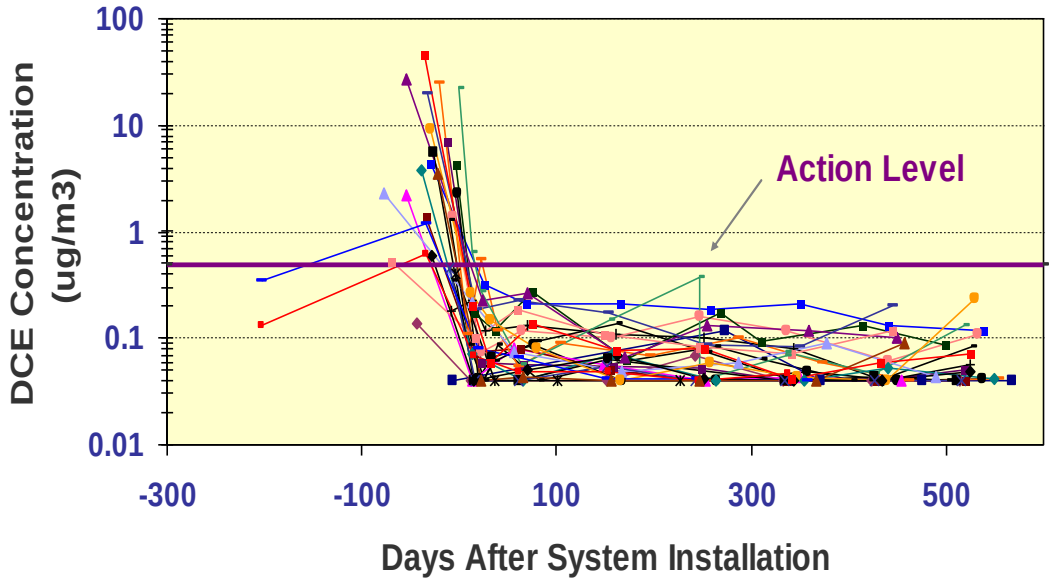


Notice that the post-mitigation concentrations were substantially more stable than those prior to mitigation.

Those findings are consistent with the post-mitigation sampling results Steck reported in 2008. (Proceedings of the American Association of Radon Scientists and Technologists 2008 International Symposium Las Vegas NV, September 14-17, 2008. AARST © 2008). In Steck's survey of more than 100 homes with professionally installed mitigation systems that had been in operation for six months to seven years, the average radon concentration of radon had been reduced from 10 pCi/l to 1 pCi/l. Steck noted that the median post-mitigation radon concentration was essentially the same as the regional outdoor concentration, and that the concentration did not "strongly depend on the age of the system".

Those findings are also consistent with the personal experience of William Wertz, Ph.D., a Senior Consultant at Geosyntec. Dr. Wertz installed an SSD system in his home more than 15 years ago and has been tracking radon concentrations with a "Safety Siren Pro Series 3" radon monitor and suction point vacuum with a Dwyer Magnehelic analog manometer since the system was installed. The mitigation system resulted in a drop in basement radon concentrations from 16 pCi/l to < 1 pCi/l. Post-mitigation radon concentrations have ranged from 0.5 pCi/l to 0.9 pCi/l. The vacuum reading (2.9 in H_2O) has essentially remained constant over that time period.

Folkes (2008) observed similar stability in post-mitigation chemical samples from homes in Colorado (see Folkes, D. J. "Strategic Approaches to Vapor Intrusion Mitigation" AFCEE Technology Transfer Workshop, San Antonio, Tx, March 2008)



(see: https://iavi.rti.org/WorkshopsAndConferences.cfm?PageID=documentDetails&AttachID=469)

Although these post-mitigation data sets do not provide a direct basis for establishing the long-term stability of the sub-slab pressure fields, if significant variations in the pressure field below the slab were to have occurred at these sites, one would have observed unacceptable spikes in the post-mitigation concentration of the constituents of concern.

Attachments: ARCADIS CQA Plan

* * * * *

RACER Eckles Geosyntec Modifications LT OMM and CQA Plan.doc

ARCADIS CQA PLAN

ARCADIS
Infrastructure · Water · Environment · Buildings

Imagine the result

Construction Quality Assurance Plan

RACER

Former Delphi Harrison Thermal Systems Moraine Plant
Former General Motors Powertrain Group, Moraine Engine Plant
Former General Motors Truck Group, Moraine Assembly Plant

Moraine, Ohio

May 6, 2011
Revised June 3, 2011
Revised September 7, 2011

ARCADIS

Table of Contents

1. Introduction

1.1 Background

In coordination with the United States Environmental Protection Agency (U.S. EPA), Revitalizing Auto Communities Environmental Response Trust (RACER), formerly Motors Liquidation Company (MLC) is completing sub-slab and indoor air sampling in the Riverview Plat neighborhood located southwest of the Moraine Site (Site). The sub-slab soil-gas, ambient air, and indoor air (first floor, basement, and crawlspace) sampling program was outlined in the Revised Sub-Slab and Indoor Air Sampling Work Plan submitted to the U.S. EPA on March 4, 2011. The sampling of all properties where access has been granted in the Riverview Plat neighborhood began on March 7, 2011 and is on-going as of the date of this document. Upon receipt of the final laboratory reports and completion of data validation, the data will be compared to the indoor air and sub-slab action levels for residential and commercial scenarios. Based on the data, it will be determined if a vapor intrusion mitigation system is necessary for each property. This Construction Quality Assurance Plan (CQAP) has been prepared as an appendix to the Vapor Intrusion (VI) Mitigation Work Plan for the properties that require mitigation. VI mitigation will include active sub-slab depressurization systems (SSDS), sub-membrane depressurization systems (SMDS), and crawlspace depressurization systems (CSDS).

1.2 Quality Control and Quality Assurance & CQAP Definitions

Quality Assurance (QA) and Quality Control (QC) are defined as follows:

- QA – A planned and systematic pattern of means and actions designed to provide confidence that materials or services meet contractual and regulatory requirements. QA is typically performed to assure RACER and/or the Regulatory Oversight Agency that delivered materials or services are of desired quality.

- QC – Those actions that provide a means to measure and regulate the characteristics of a material or service to meet contractual and regulatory requirements. QC is typically performed by or for the provider of materials or services as a control mechanism on the quality of the provider's efforts.

In the context of this CQAP, the terms are further defined as:

- Construction quality assurance (CQA) refers to the means and actions employed by the Project Manager to confirm conformity of the systems' installation with this CQAP, drawings, and specifications. This activity begins prior to construction, continues throughout construction, and ends with acceptance of the installation. CQA is provided under the oversight of the Project Manager.

- Construction quality control (CQC) refers to those actions taken by the manufacturer, fabricator, or Contractor to provide materials and workmanship that meet the requirements of this CQAP, drawings, and specifications. CQC may include inspections, verifications, audits, and evaluation of materials and workmanship necessary to determine and document quality of the construction. CQA is performed independently of CQC.

1.3 Purpose

This CQAP intends to provide a quality assurance protocol to be implemented that will ensure that construction of VI mitigation systems meet or exceed a certain level of quality and workmanship as defined in the construction drawings and technical specifications detailed in the VI Mitigation Work Plan. This CQAP will address quality during the following phases of construction:

- Pre-construction Activities,

- VI Mitigation System Installation, and

- Post-construction Activities.

The construction guidelines of the CQAP shall be followed to monitor and document the quality of materials used and the conditions and manner of their placement. The CQAP will also serve to detect deviations from the construction drawings or technical specifications caused by error or negligence on the part of the Contractor, and allow for suitable corrective measures to be taken. Finally, by adhering to the plan, the Contractor and the Engineer can address and resolve design problems during the construction phase of the project.

2. Roles and Responsibilities

The successful completion of the installation of VI mitigation systems depends upon the interaction of many qualified parties. An organizational flow chart of the parties involved in the CQA/CQC of the VI mitigation systems may be found on Figure 1, attached to this document. Definitions and responsibilities of the parties involved are provided below.

2.1 Oversight Personnel

2.1.1 Regulatory Oversight Agency

The Regulatory Oversight Agency may provide on-site monitoring and observation of construction activities and CQA measures. Representatives from the Regulatory Oversight Agency may participate in project meetings and be provided with the results and data of CQA. The Regulatory Oversight Agency will be informed of field decisions that were made based on the necessity to deviate from the approved design. The Regulatory Oversight Agency has the responsibility to review, and either approve or reject design revisions or variance requests during the VI mitigation system construction.

For the purposes of this document, the Regulatory Oversight Agency is the U.S. EPA and/or the Ohio EPA.

2.1.2 RACER

RACER is funding the activities pertaining to the installation of VI mitigation systems by ARCADIS. RACER will be responsible for communication with the property owners and the U.S. EPA.

2.1.3 ARCADIS

ARCADIS is the environmental engineering consultant responsible for the CQA and CQC of the construction process for the installation of VI mitigation systems. ARCADIS is the official on-site representative of the RACER and will supervise field activities, review Contractor submittals, recommend and approve design or field modifications should they be necessary, and document the various phases of construction. In this capacity, ARCADIS will be knowledgeable of the construction drawings and technical specifications governing the remediation of the Site.

ARCADIS is responsible for organization and ensuring implementation of this CQAP. ARCADIS will inform RACER and the Regulatory Oversight Agency of deviations from the construction drawings and technical specifications and will provide the certifications required during the various phases of the project. Responsibility for construction deficiencies shall lie with the Contractor, not ARCADIS. ARCADIS will be familiar with general construction techniques, regulatory requirements, and the CQAP.

2.1.3.1 Project Manager

The ARCADIS Project Manager (Nancy Gillotti) maintains overall responsibility for carrying out the provisions of this CQAP. The Project Manager is responsible for verifying that VI mitigation system construction activities are completed in accordance with this CQAP, and all components of the construction are consistent with the approved property-specific work plan. The Project Manager may perform periodic inspections to confirm the CQA program's compliance with this CQAP. The Project Manager will rely on the Construction Manager and field personnel to confirm that this CQAP is implemented correctly and that the Contractor has provided the required submittals; the Contractor is in compliance with this CQAP, drawings, and specifications; and that CQA field tasks are performed, such as material inspection. The Project Manager will be informed of items that do not conform to the drawings, specifications, and this CQAP and will be directly involved in resolving these issues.

The Project Manager will be supported by the Construction Manager. The Project Manager may delegate work to the Construction Manager, but will be responsible for any delegated work. The Project Manager is the prime contact with RACER and the U.S. EPA for the Contractor, Construction Management Staff, and CQA Staff.

2.1.3.2 Construction Manager

The ARCADIS Construction Manager (personnel to be determined) has overall responsibility for all aspects of the project, including the implementation of CQA activities. The Construction Manager shall provide the design review and final approval for all property-specific work plans. The Construction Manager will be a National Environmental Health Association National Radon Proficiency Program (NEHA NRPP) certified radon mitigator. The Construction Manager shall also provide support to the field personnel should any discrepancies arise during CQA.

As such, the Construction Manager will:

- Confirm that CQA procedures are completed in accordance with this CQAP; and

- Verify Contractor qualifications and assist the CQA Manager in coordinating Contractor activities.

The Construction Manager will be supported by the Construction Field Coordinator. The Construction Manager may delegate work to the Construction Field Coordinator, but will be responsible for any delegated work.

2.1.3.3 Project Health and Safety Manager

The ARCADIS Project Health and Safety Manager (personnel to be determined) has overall responsibility for the health and safety aspects of the VI mitigation system installation, including review and approval of the Health and Safety Plan (HASP). Modifications to CQA procedures should be reviewed with the Project Health and Safety Manager prior to implementation to confirm that adequate health and safety measures are employed. Inquiries regarding health and safety procedures for construction activities or CQA activities should be addressed to the Project Health and Safety Manager. The Project Health and Safety Manager must approve changes or addenda to the HASP. The Project Health and Safety Manager is not expected to be on site daily but will be supported by a CQA Manager and Field Technicians. The Project Health and Safety Manager may delegate work to the CQA Manager, but will be responsible for any delegated work.

2.1.3.4 Construction Field Coordinator

The ARCADIS Construction Field Coordinator (personnel to be determined) shall provide the field construction itinerary to all Field Site Personnel including the CQA Manager, Field Technicians, and Contractors. The Construction Field Coordinator will also provide office activity support to the Field Site Personnel. The Construction Field Coordinator may delegate work to the CQA Manager, but will be responsible for any delegated work.

2.2 ARCADIS Field Site Personnel

2.2.1 CQA Manager

The ARCADIS CQA Manager (personnel to be determined) has overall responsibility for construction aspects of the installation of VI mitigation systems, including the

facilitation of CQA activities. The CQA Manager reports to the Construction Manager and Construction Field Coordinator. The CQA Manager will:

- Manage daily construction activities;
- Prepare the daily construction report;
- Maintain contact with the Project Health and Safety Manager;
- Coordinate Contractor activities and verify Contractor qualifications; and
- Coordinate and schedule support personnel for construction oversight tasks at the Site.

The CQA Manager will be supported by a Field Technician. The CQA Manager may delegate work to the Field Technician but is responsible for any delegated work.

2.2.2 Field Technicians

Field Technicians are the adjunct persons to the CQA Manager. Field Technicians are responsible for seeing that the CQC and CQA procedures are adhered to during all field activities.

2.3 Contractors

Contractors will complete construction activities at the Site, including mobilizations, site preparation, and installation of VI mitigation systems all of which are in accordance with the property-specific work plan, as directed by ARCADIS. Contractors must perform the VI installation in accordance with the property-specific work plan, complete timely submittal of all documentation, facilitate the completion of CQA activities, notify the construction manager of issues related to CQA, participate in project meetings and planning, and comply with this CQAP. The Contractor will have a site specific HASP and/or will acknowledge that they will follow the HASP prepared for the Site by ARCADIS.

2.4 Property Owner

The Property Owner (or Home Owner) may or may not occupy the home in which the VI mitigation system is being installed. The Property Owner may, if they choose,

provide preferences in the location of the VI mitigation system, which will be incorporated to the extent possible into the property-specific work plan. The Property Owner's signed acknowledgement of the property-specific work plan and signed access agreement will be required prior to system installation.

3. Quality Assurance/Quality Control Meetings and Documentation

Routine meetings will be conducted between the Contractor, ARCADIS CQA Manager, ARCADIS Construction Manager, and Regulatory Oversight Agency (if available) to discuss and review the construction activities, work schedule, and potential changes in construction activities or construction products. The results of these discussions and follow-up actions will be included in meeting minutes and/or outlined in daily construction reports.

3.1 Project Meetings

To maintain clear and open channels of communication through construction, specific project meetings will be held regularly. These meetings are detailed below.

3.1.1 Pre-Construction Construction Quality Assurance Meeting

A pre-construction CQA meeting will be held prior to commencing construction activities to confirm that concerns can be adequately addressed prior to construction. This meeting will include the Contractors, Construction Manager, CQA Manager, Construction Field Coordinator, and the Project Health and Safety Manager.

The purpose of the pre-construction CQA meeting is to coordinate the completion of CQA activities, discuss potential problems that might cause quality issues and delays in construction, and discuss the roles and responsibilities for CQA activities. It is important that the rules regarding testing and repair be known and accepted by each party.

Specific topics considered for the pre-construction CQA meeting may include the following:

- Review the responsibilities of each party;
- Review lines of authority and communication;
- Review critical design details for the installation of VI mitigation systems, including the property-specific work plan;
- Review project schedule;

- Review CQA activities;
- Review methods for documenting and reporting, and for distribution of documentation and reports;
- Review any modifications to this CQAP that may be necessary;
- Review and develop appropriate Job Loss Analyses (JLAs) relating to the construction process; and
- Review work area security.

Meeting minutes will be recorded and transmitted to the parties in attendance.

3.1.2 Weekly Progress Meeting

A weekly progress meeting will be held at the Site. The purpose of the weekly progress meeting is to discuss construction activities and CQA activities. At a minimum, the weekly progress meeting will be attended by the Contractors, CQA Manager, and Field Technicians. Attendance of the weekly progress meeting by telephone is acceptable. Topics to be discussed at the weekly progress meeting may include:

- Review the previous week's construction activities;
- Review the work activity and locations for the coming week;
- Review the work schedule;
- Discuss weekly assignments for the construction personnel and equipment;
- Discuss status of CQA activities;
- Discuss potential problems;
- Review construction documentation requirements; and
- Discuss health and safety, and recognize potential hazards in upcoming work.

The CQA Manager will coordinate the weekly progress meeting; develop and circulate a weekly meeting agenda; prepare weekly meeting minutes and distribute to RACER, the Regulatory Oversight Agency, Project Manager, Project Health and Safety Manager, Construction Field Coordinator, and Construction Manager.

3.1.3 Daily Work Meeting/Tailgate Meeting

Daily work meetings/Tailgate meetings will be held at the beginning of each work day at the Site. If VI mitigation system installation activities at multiple homes in one day are anticipated, the variances between homes and construction activities proposed for those homes will be considered during the daily meetings. The purpose of the daily work meeting is to discuss construction activities and CQA activities. At a minimum, the daily work meetings will be attended by the Field Technicians and Contractors. Topics to be discussed at the daily work meetings may include:

- Discuss the previous day's construction activities;
- Review the construction activities for the current day;
- Review CQA activities for the current day; and
- Review health and safety-related requirements/issues per the HASP.

The Field Technician will coordinate the daily work meetings.

3.1.4 Request for Information

In the case of any discrepancies discovered in the proposed VI mitigation system or during inspection of the VI mitigation system by the CQA Manager and/or Field Technician, the Contractor may issue, in writing, a request for information (RFI). Any request by the Contractor for substitution/change from the approved VI mitigation system design shall be accompanied by appropriate literature and justification for said substitution/change. The CQA Manager is responsible for reviewing, filing, and responding to any RFI initiated by the Contractor. The CQA Manager may request input from the Certified Mitigator/Construction Manager in responding to any RFI initiated by the Contractor.

4. Quality Control Plan

The Construction Manager will implement a CQA/CQC procedure which will include pre-installation, installation, and post-installation phases. The usage of the three phase system is necessary to ensure that system designs supplied by ARCADIS are being adhered to by the Contractors and their activities during installation. This will ensure proper system construction and performance for the best possible functionality of the VI mitigation system.

4.1 Contractor Selection

Several Contractors will be considered for installation of VI mitigation systems. It is the responsibility of ARCADIS and RACER to select the Contractor. The following considerations will be evaluated when selecting a Contractor:

1) Safety Record - Contractors will be required to submit a safety record prior to being considered for use on the project. The record must contain information for the past 3 years of operation. Contractors will be required to submit a summary of their training, policies, and reporting of safety.

2) Experience - Contractors will be required to provide photos of systems their company has installed, worker resumes, a summary of applicable experience, and types/number of systems installed in the past 3 years. Contractors must also have sufficient manpower to complete the installation process in a safe and efficient time frame.

3) Price - Contractors must submit a proposal that is competitive for labor and materials for installation of VI mitigation systems.

4.2 Pre-Installation Phase

The property-specific work plan for each property shall be finalized and approved by the U.S. EPA and the Property Owner.

4.2.1 Pre-Construction CQA Meeting

Prior to commencing field activities, ARCADIS will meet with the selected Contractor to review this plan and the design information for clarity. The review will address design criteria, and the property-specific work plan. If any information is deemed unclear, the

appropriate documentation will be returned to ARCADIS for clarification or modification. A recommended agenda with specific topics for the pre-construction meeting includes the following:

1. Introductions
2. Tour Home or Building to be Mitigated
3. Review Documents and Procedures
    A. Property-Specific Work Plan
    B. CQA Requirements
    C. Health and Safety Plan
4. Define Lines of Communication
    A. Lines of Communication
    B. Progress Meetings
    C. Procedures for Approving Design Clarifications and Changes During Installation
5. Review Site Requirements
    A. Safety Rules
    B. Site Rules
    C. Work Schedule
    D. Storage of Materials
    E. Available Facilities
    F. Contractor Submittals

6. Discuss Construction Issues

    A. Property-Specific Work Plan

    B. Construction Procedures

        1) Proposed Construction Sequencing

        2) Equipment

        3) Construction Waste Management

    C. Construction Schedule

4.3 Installation Phase

The Installation Phase of the Quality Control Plan ensures that oversight of the construction activities is being done by either the CQA Manager or Field Technician, which are reported back to the appropriate ARCADIS personnel. The Installation Phase of the Quality Control Plan will be repeated for each VI mitigation system installation. As part of the Installation Phase of the Quality Control Plan, there are certain construction aspects which must be addressed:

- Review of safety procedures and JLAs to ensure compliance with the HASP;
- Inspection of the area where the VI mitigation system is to be installed;
- A materials check to ensure all materials to be used, including tools and hardware to be used, meet the requirements of the property-specific work plan;
- Oversight of the Contractor to ensure the level of workmanship meets acceptable standards and the systems are being installed to the property-specific work plan. The oversight may include adherence to the work plan of the following system installation components (if applicable):
    - Suction points
    - Vent piping and securing of piping
    - In-line fan

  - Manometer audible alarm, unless the property owner objects to installation of the alarm
  - Disconnect switch and wiring
  - Sealing
  - Roof flashing

- Communication with the Contractors as needed related to safety talking-points that may arise during installation; and

- Improvements or deviations to the finalized property-specific work plan shall be communicated during this phase to all ARCADIS personnel, RACER and the U.S. EPA before implementation/communications with the Contractor.

Since each residence or structure is unique in its construction, configuration, and age; it is necessary to consider each residence separately with respect to the design of VI mitigation system design. Therefore, as stated in the VI Mitigation Work Plan, a property-specific work plan will be created and implemented at each property. However if the need for any deviations arises during construction, the VI Mitigation Work Plan will be adhered to.

4.4 Post-Installation Phase

Following the successful installation of the VI mitigation system, ARCADIS will inspect the construction of the system and operation thereof. If there is a need for corrective actions, it will be done as soon as possible by the Contractor. If necessary, the following corrective actions may be taken:

- As-Is – Observed nonconformance does not adversely affect construction or operation;

- Fix – Observed nonconformance requires minor repairs or modifications to enable proper system operation;

- Modify – Disassembly or additional actions are required; and

- Refuse – The system or work is unacceptable. Additional actions must be taken by the Contractor to remove/revamp the system or work to meet specifications.

All nonconformance issues shall be documented and communicated to the Construction Manager and Construction Field Coordinator.

4.5 Proficiency Sampling

Proficiency sampling will be done within approximately 30, 180, and 360 days after installation of VI mitigation systems and again five years after the 360 day sampling. If post-installation proficiency sampling indicates concentrations of chemicals of concern are above the action levels, mitigation system modifications may be required. Procedures for proficiency sampling of indoor air will be completed in accordance with the VI Mitigation Work Plan. Indoor air (first floor, basement, and accessible crawlspace) samples will be collected for confirmation that the VI mitigation system is functioning as intended.

When active mitigation systems are installed in homes with basement or slab-on-grade foundations, one to two sub-slab sample points will be installed for collection of sub-slab pressure field extension measurements. A measurement of a negative pressure below the slab of 0.004 inches of water column will indicate that the active system is successfully depressurizing the sub-slab area. Sample points will be located on opposite sides of the foundation from the suction point to ensure the depressurization of the entire slab. Sample points will remain in place for measurements to be taken within 30 days of system installation and during annual inspections.

Documentation of the proficiency sampling will be in accordance with the VI Mitigation Work Plan.

4.6 System Operation and Maintenance (O&M)

An annual inspection will be conducted by ARCADIS to inspect the active mitigation systems and ensure that they are functioning properly. Two inspections will be conducted in the first year and the systems will be inspected annually thereafter. The following items will be inspected and recorded on the Inspection Form included in the O&M SOP (SOP 25) in Appendix B of the VI Mitigation Work Plan.

- The manometer reading will be checked to ensure the system is operating in the design range.

- Sub-slab pressure field extension readings will be measured at the sub-slab pressure points to ensure sub-slab depressurization of negative 0.004 in w.c.

- The fan will be checked for unusual noise or vibration.
- The vent piping will be checked for any damage.
- The pipe supports will be checked to ensure they are secure.
- Crawlspaces or other areas sealed with reinforced, polyethylene sheeting will be inspected for damage.
- The foundation sealing and sealing around system piping penetrations will be checked for any additional areas requiring sealing.
- The presence of the padlock on the disconnect switch will be checked.
- The presence of the O&M Manual at the residence will be checked.

5. Documentation

5.1 Field Documentation

All activities in the field pertaining to construction, installation, and O&M of VI mitigation systems shall be recorded and documented.

5.2 Construction Quality Assurance Documentation

Upon completion of the work, CQA documentation will be included in the Operation and Maintenance (O&M) Manual. The property owner and the U.S. EPA will receive an O&M Manual for each system installed. The documentation shall summarize the activities of the project, and document aspects of construction and installation of VI mitigation systems.

The CQA documentation shall include the following information:

- Parties and personnel involved with the project;
- Scope of work;
- Outline of project;
- Quality assurance methods;
- Test results (conformance, destructive and non-destructive, including laboratory data); and
- Design drawings.

The Contractor shall document in a report that the installation activities proceeded in accordance with the CQA Plan except as noted in that report.

6. References

ARCADIS, Inc., 2011. Revised Sub-Slab and Indoor Air Sampling Work Plan, Motors Liquidation Company, Moraine, Ohio. March 4, 2011.