



Workplan to Conduct a Pilot Study to  
Facilitate the Design and Installation of a  
Full-Scale Soil Vapor Extraction System

P-Building at 100 East Patterson Street  
Tecumseh, Michigan

April 2012





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*Prepared For  
Tecumseh Products Company*

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# Section 1

## Introduction

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As a follow-up to Tecumseh Products Company's (TPC) meeting with USEPA on March 5-6, 2012, this Workplan to Conduct a Pilot Study to Facilitate the Design and Installation of a Full-Scale Soil Vapor Extraction System in P-Building at 100 East Patterson Street (Workplan) was prepared to describe the proposed pilot soil vapor extraction (SVE) system design for the portion of the former site known as P-Building (also known as Orbitec). The former TPC site is located at 100 East Patterson Street in Tecumseh, Michigan (Figure 1).

### 1.1 Site Description

The former TPC site is occupied by a series of interconnected buildings/building additions that occupy approximately 750,000 square feet (main building). Letter designations, *i.e.*, Area K, Q-Building, etc., for each building/building addition are shown on Figure 2. The proposed SVE system will be installed at P-Building located along the northern perimeter of the former TPC site. P-Building occupies approximately 162,000 square feet.

### 1.2 Site Operations and Future Use

TPC began manufacturing and storage operations at the site in the 1930s. TPC operations focused on the production and reconditioning of compressors and condensing units for refrigeration and air conditioning units. Manufacturing operations ceased at the site in June 2008. The site was purchased by Tecumseh Bakery, LLC, a holding company for Consolidated Biscuit Company (CBC), in December 2009. When CBC was purchased by Healthside Food Solutions in April 2010, Tecumseh Bakery, LLC, became an independent entity, and plans to occupy the site for bakery operations were terminated. In February 2012, the site was purchased by Tecumseh Food Machinery and Engineering, LLC. Current plans for the facility include separation of P-Building and S-Building from the remainder of the plant, so that portion of the facility can be leased or sold as a separate parcel, and to facilitate demolition of the remainder of the facility.

### 1.3 Summary of Investigation Activities

Investigation activities conducted at the former TPC site indicate that on-site soil, shallow groundwater, soil gas and indoor air are affected by chlorinated volatile organic compounds (CVOCs). In particular, at the five sub slab vapor sample locations in P-Building, sub-slab soil gas concentrations of trichloroethene (TCE) ranged from <290 parts per billion by volume (ppbv) to 13,400 ppbv over two sample events, compared to a non-residential sub-slab soil gas screening



level (SGSL) of 84 ppbv. Indoor air concentrations of TCE at five co-located samples ranged from 8.7 ppbv to 19.8 ppbv compared to a non-residential indoor air criterion of 1.7 ppbv. At the time indoor air sampling was conducted the non-residential indoor air criterion was 7.8 ppbv. In September 2011, updated final TCE toxicity values were published by the USEPA on the Integrated Risk Information System (IRIS). Updated TCE toxicity values resulted in a reduction in the TCE indoor air criterion, makes the previously proposed use of the heating and ventilation system to reduce TCE concentrations through ventilation less feasible (RMT, 2010b).

## 1.4 Purpose and Scope

TPC proposed the installation of a SVE system in P-Building during a meeting with USEPA on March 5-6, 2012. As discussed during that meeting, the proposed SVE system will be designed for the following:

- n To ensure that on-site indoor air concentrations in the occupied area remain below long-term non-residential indoor air criteria (assuming that future operations do NOT contribute CVOCs to the indoor air);
- n To reduce or eliminate the potential for lateral migration of affected soil gas from the site; and
- n To extract residual CVOCs from the on-site soil matrix reducing the long-term potential for migration of CVOCS into soil gas and groundwater, *i.e.*, source control.

This Workplan was prepared to provide design and installation details for the proposed pilot study which will be conducted to support full-scale SVE system design.



## Section 2

# Site Conditions

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### 2.1 Site Topography

The site slopes at a grade of approximately 2-percent to the east. The surface elevation along the western boundary of P-Building is approximately 800 feet above mean sea level (ft MSL), and the surface elevation along the eastern boundary of P-Building is approximately 796 ft MSL.

### 2.2 Geology

TRC evaluated the unconsolidated materials underlying the site through a review of logs from soil borings advanced at the site during field activities conducted by TRC from April 2009 through August 2011. Logs of soil borings and monitoring wells installed during the investigation activities were provided to USEPA in previous investigation reports.

A geologic cross section was developed from these boring logs to illustrate the geology underlying the former TPC site near the proposed SVE system location. Figure 3 shows the orientation of the cross-section transect, while Figure 4 provides the cross section.

As shown on the cross section, the site geology generally consists of a surficial silty/sandy clay interval ranging from 3 to 7 feet thick, underlain by unconsolidated fine to coarse sand and gravel. A deep clay layer is present beneath the sand and gravel layer. Soil boring data suggests that this second clay layer is continuous across the study area. The elevation of the top of the clay confining unit ranges from approximately 750 ft MSL to 760 ft MSL beneath the northern portion of the site.

The unconsolidated fine to coarse sand and gravel is an unconfined aquifer beneath the site. Data collected from the soil borings and monitoring wells installed during subsurface investigation activities indicate that shallow groundwater typically ranges in depth from approximately 22 to 24 feet below ground surface (ft bgs) (approximately 780 ft MSL) along the western perimeter of the site to approximately 5 to 8 ft bgs (approximately 778 ft MSL) along the eastern perimeter of the site. The aquifer has saturated thickness ranging from approximately 20 to 30 feet. Groundwater flow is typically to the east-northeast toward the River Raisin, the nearest body of water, which is located 1,500 to 2,500 feet east of the site.



The proposed SVE system will target the unsaturated portion of the permeable sand and gravel unit beneath the site. The thickness of the unsaturated portion of this unit decreases from west to east. Beneath P-Building the thickness of the unsaturated sand and gravel unit ranges from approximately 17 feet in the west to 13 feet in the east. The thickness of this permeable unsaturated zone continues to decrease to the east, and in some areas the water table intersects the overlying silty/sandy clay layer.



## Section 3

# Conceptual SVE System Design

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### 3.1 Building Description

The proposed SVE system will be installed at P-Building located along the northern perimeter of the former TPC site located at 100 East Patterson Street in Tecumseh, Michigan. P-Building occupies approximately 162,000 square feet. The western wall of P-Building is shared with S-Building in the north. At present, the western wall of P-Building is also shared with the remainder of the facility in the south (Figure 2). However, the current owner intends to separate P-Building from the remainder of the former manufacturing area, in order to make P-Building more marketable to potential buyers and/or lessees.

Currently there are no doors or windows from P-Building directly into S-Building. A sub-slab depressurization system was installed to mitigate the potential for volatilization to indoor air in S-Building in October 2011 (TRC 2011b, TRC 2012b). Once the remainder of the former TPC manufacturing facility has been separated from P-Building, P-Building will be physically isolated from the remainder of the facility preventing the migration of affected indoor air from the remainder of the facility into P-Building.

A portion of P-Building was originally constructed in 1948. The original building footprint was approximately 44,000 square feet. This portion of P-Building was historically used for machining operations, and is an area of potentially affected soils. In 1994, well after use of TCE had been discontinued at the site, P-Building was expanded approximately 200 feet to the east and 130 feet to the south into areas that had historically been used for employee parking and building access. The expansion included renovation of the existing portions of the building. In particular, the existing slab was removed and replaced. The new slab was constructed of 8-inch thick concrete over clean fill. As noted above, surface topography slopes to the east. In order to maintain a level floor, the depth of clean fill beneath the slab increases from several inches in the west to more than 2 feet in the east.

At present P-Building is unoccupied. In general the layout is separated into two main areas. The northern portion of P-Building is a large open area separated from the southern portion of P-Building by a row of smaller rooms including restrooms and a control room. The southern portion of P-Building is sub-divided into several large areas including loading docks along the southern wall.



### 3.2 Conceptual Pilot System Design

Investigation activities conducted at the former TPC site indicate that on-site soil, shallow groundwater, soil gas and indoor air are affected by CVOCs. Indoor air concentrations of TCE measured in P-Building exceed the long-term non-residential indoor air criterion of 1.7 ppbv (calculated using TCE toxicity values which were updated in September 2011). The reduction in the TCE indoor air criterion makes the previously proposed use of the heating and ventilation system to reduce TCE concentrations through ventilation less feasible (RMT, 2010b).

When CBC was purchased by Healthside Food Solutions, in April 2010, Tecumseh Bakery, LLC, became an independent entity, and plans to occupy the site for bakery operations were terminated. In February 2012, the site was purchased by Tecumseh Food Machinery and Engineering, LLC. Current plans for the facility include separation of P-Building and S-Building from the remainder of the plant, so that portion of the facility can be leased or sold as a separate parcel, and to facilitate demolition of the remainder of the facility.

TPC proposed the installation of SVE system in P-Building during a meeting with USEPA on March 5-6, 2012. As discussed during that meeting, the proposed SVE system will be designed for the following:

- n To ensure that on-site indoor air concentrations in the occupied area remain below long-term non-residential indoor air criteria (assuming that future operations do NOT contribute CVOCs to the indoor air);
- n To reduce or eliminate the potential for lateral migration of affected soil gas from the site; and
- n To extract residual CVOCs from the on-site soil matrix reducing the long-term potential for migration of CVOCs into soil gas and groundwater, i.e. source control.

The pilot SVE system design was prepared with three primary objectives 1) to provide data that can be used to design and optimize the full-scale SVE system, 2) to be expandable, i.e., the pilot system components can be maintained and included in the full-scale system design, and 3) to reduce the potential for on-site volatilization to indoor air and lateral migration until the full-scale system is designed and installed.

The pilot SVE system design and installation are described in detail in Section 4. Pilot SVE system performance evaluation details are described in Section 5.



# Section 4

## Pilot System Design and Installation

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Pilot SVE system design details and proposed installation methods are described below. Engineering design drawings for the pilot SVE system are provided in Appendix A. Data gathered during the pilot test (see Section 5) will be used to support full scale system design and operation.

### 4.1 Extraction Point Design Details

Four extraction wells (SVE-X) will be installed along the north wall of P-Building at the approximate locations shown on Sheet 3 of 7 (Appendix A). The purpose of these wells is to evaluate whether the soil vapor extraction process is a viable alternative to reduce soil vapor intrusion into indoor air within P-Building and to reduce the potential for lateral migration of impacted soil vapors beyond the site boundaries. The effectiveness of these wells to extract soil vapors and to establish air flow in surrounding soils will be evaluated using installed multi-depth soil gas vacuum monitoring points equipped with vacuum monitoring gages as described in Section 5. Details of a typical extraction well are illustrated in Detail 1 on Sheet 7 of 7 (Appendix A).

The concrete floor slab at each extraction well location will be saw-cut to expose the underlying sub-slab soils. Once the concrete is removed, each extraction well will be constructed by drilling an 18-inch diameter hole to a depth of approximately 18 ft bgs, or 2 to 4 feet above the typical depth to groundwater, using 12.25-inch inside diameter hollow stem augers. The well will be constructed using a 4-inch diameter 30-slot (0.030-in) stainless steel well screen, installed from 8 to 18 ft below grade (10 ft long section). The annular space surrounding the wells screen will be backfilled with uniform washed pea gravel. Bentonite chips/granular bentonite (hydrated in place) will be placed above the pea gravel well screen pack to provide an effective surface seal and to minimize the potential for drawing air from the surface at each extraction well point. A non-shrinking concrete-bentonite grout will fill the remaining annular space.

The extraction well riser pipe will consist of 4-inch diameter schedule 40 PVC, and will extend from the top of the well screen to approximately 6 inches below the surface. A pipe tee (capped in the direction of the surface) will be installed at the top of the riser pipe, with the horizontal leg of the tee extending the riser pipe toward the P-Building northern wall. A 90-degree elbow will extend the riser pipe vertically up the wall (and will be protected behind the steel guard rail) and then along the roof-wall I-beam (see Sheet 6 of 7; Appendix A). The horizontal portion



of the riser pipe will be bedded in sand, and a reinforced concrete surface seal will cover the pipe and the remaining void within the floor slab.

## 4.2 Extraction Piping Design Details

Above-grade riser pipe at each soil vapor extraction well be constructed of 4-inch diameter Schedule 80 PVC. The riser pipe will be equipped with a lockable butterfly valve to control air flow from each well. The riser pipe will also be equipped with a sample tap for collection of photoionization detector (PID) readings, for vapor flow and vacuum monitoring. The above grade portion of the riser pipe will be secured to the roof-wall I-beams and wall support structures using pipe hangers and supports (see Sheet 7 of 7; Appendix A).

Each extraction well riser pipe will connect to a 340-foot long 4-inch diameter Schedule 80 header pipeline. The header pipeline will be secured to the building wall and/or to roof support structures as shown on Sheets 4 and 6 of 7 (Appendix A). The header pipeline will be sloped 0.1 to 0.2 ft per 100 ft of pipe run to allow condensation to drain toward the extraction wells or toward the air-water separation tank (see Section 4.3). Pipeline size calculations based on head loss estimations are contained in Appendix B.

## 4.3 SVE Pilot System Blower Details

The soil vapor extraction vacuum blower and appurtenances used during the pilot test will be housed in a ventilated 8-ft wide by 18-ft long insulated trailer, located outside P Building as shown on Sheet 3 of 7 (Appendix A). The 4-inch diameter manifold pipe will penetrate the western wall of P Building (see Detail 4; Sheet 7 of 7; Appendix A), and will connect to the vacuum header of the SVE blower within the SVE trailer. The vacuum header within the trailer will contain the following components:

- n Inlet vacuum gauge and air by-pass valve
- n Air-water separation tank
- n Inlet air filter
- n Air flow meter
- n Vacuum relief valve (to reduce blower vacuum in the event of a clogged inlet filter)

The SVE blower will be a Roots (or equivalent) positive displacement-type vacuum blower capable of extracting up to 450 actual cubic feet per minute (acfm) at 8-inches Hg (vacuum). Note that actual blower flow may be limited based on air permit exemption requirements as described in Section 5.5. The blower will be powered with a 10 horsepower motor. The blower exhaust manifold will be equipped with the following components:



- n Thermometer and thermostat (to shut the blower down on high temp condition caused by low air flow)
- n Discharge silencer
- n Sample port
- n Exhaust stack vented above the roof line.

See Appendix C for a fan curve and blower system component details.

For the pilot test, the electrical power to the SVE blower will be supplied using the existing building power supply. Alternatively, if terms of usage for the existing electrical supply cannot be arranged with the owner, a diesel-powered electrical generator will be operated to provide electrical power to the SVE blower motor. For long-term operation, a separate metered power drop will be installed to provide power for the full-scale system.

#### 4.4 Temporary Multi-Level Subsurface Vacuum Monitoring Point Details

Temporary subsurface vacuum monitoring points (TVP-XX) will be installed at 10 locations as shown on Sheet 3 of 7 (Appendix A). At each location, a nested pair of vacuum monitoring points will be installed; the deep point will be installed at a depth of 15.5 to 16 ft bgs (approx.) and the shallow point will be installed at a depth of 10 to 10.5 ft bgs (approx.). The multi-level vacuum monitoring point design will allow for an assessment of flow patterns within the subsurface soils, specifically as it relates to depth within the vadose zone soils.

Each nested pair will be constructed in a single borehole. The 2.5-inch borehole will be constructed to 16 ft bgs (approx.) using Geoprobe® direct-push technology. Each vacuum monitoring point will be constructed with a 6-inch long stainless steel monitoring implant (Geoprobe® Vapor Implant AT8617S, or similar) and a length of ¼-inch diameter tubing. Each nested pair will be constructed as illustrated in Details 2 and 3 on Sheet 7 of 7 (Appendix A), and as described below:

- n The deep monitoring point will be installed at the bottom of the borehole.
- n The annular space surrounding the deep monitoring point screen will be backfilled with clean sand to approximately 1 foot above the top of the screen.
- n Granular bentonite chips will be placed above the sand well screen in 6- to 8-inch lifts to approximately 11.5 ft bgs (1 foot below the bottom of the shallow monitoring point screen). Each lift will be hydrated in place prior to the addition of the next lift to help ensure an effective seal between the shallow and deep monitoring point.



- n An approximately 1-foot thick sand pack (10.5 to 11.5 ft bgs) will be installed above the bentonite seal to ensure that the bentonite does not swell to plug the shallow monitoring point.
- n The shallow monitoring point will be installed above the sand at 10 to 10.5 ft bgs.
- n The annular space surrounding the shallow monitoring point screen will be backfilled with clean sand to approximately 1 foot above the top of the screen (9 to 10 ft bgs).
- n Granular bentonite will be placed above the sand well screen in 6- to 8-inch lifts to approximately 1 ft bgs. Each lift will be hydrated in place prior to the addition of the next lift to help ensure an effective seal between the shallow and deep monitoring point.
- n Tubing from nested pairs will extend at least 12-inches above the top of the bentonite. Care will be taken to properly label each monitoring point so that the shallow and deep monitoring points are easy to distinguish.
- n Each probe will be capped with a ball valve and equipped with a barbed hose fitting.
- n The majority of the temporary vacuum monitoring points are located inside P-Building which is currently not in use. Therefore, a protective monitoring point cover and concrete surface seal are not required. Interior monitoring locations will be identified and protected from traffic associated with incidental building use by traffic cones. Exterior monitoring points will be located in the City of Tecumseh right-of-way. These monitoring points will be finished with a flush-mount protective cover to protect them from inclement weather and right-of-way users.
- n Temporary vacuum monitoring points will be abandoned following installation and evaluation of the full-scale SVE system.

During pilot testing, a portable vacuum gauge will be connected to the probe, and the ball valve will be opened to measure vacuum propagation away from the extraction wells in order to assess zone of vacuum influence. Vacuum measurements will be taken at both shallow and deep probes to assess the distribution of subsurface flow vertically throughout the vadose zone soils.



# Section 5

## Performance Evaluation

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Pilot study performance evaluation will be conducted to confirm full-scale system design parameters. Key parameters to be evaluated include:

- n Air flow rates achievable from each pilot study extraction well under given vacuum conditions.
- n Measurable vacuum at specified distances from each extraction well (zone of vacuum influence).
- n Qualitative and quantitative estimates of VOC emissions from the extraction system over time. A VOC emission evaluation will ensure air permit exemption compliance during the pilot study, and will be used to assess the need for future air emission control devices and/or an air permit.
- n Overall SVE system performance.

The proposed performance evaluation will include short-term stepped-rate tests for estimating individual extraction well capacities/system curves as well as a long-term constant rate test utilizing all four extraction wells to evaluate the overall area of influence and extraction system performance. Testing and monitoring locations are displayed on Sheet 4 of 7 of the Soil Vapor Extraction System Design drawings contained in Appendix A.

### 5.1 Temporary Multi-Level Subsurface Vacuum Monitoring Point Locations

Performance monitoring gas probes will be installed in accordance with the plan outlined in Section 4.4 of this Workplan. The ten pressure monitoring locations (TVP-XX) are displayed on Sheet 4 of 7 of the SVE design drawings contained in Appendix A. Locations were selected to provide the required data for preparation of distance-drawdown plots for evaluating well efficiency and radius of vacuum influence for each well during the stepped-rate tests and long-term constant rate test. Additional consideration for probe placement was given to evaluating the effect of the sewer line located approximately 8-feet south and running parallel to the north wall (as shown on Sheet 4 of 7 in Appendix A).

### 5.2 Equipment Requirements

Equipment requirements for performance testing include:

- n Vacuum Gauge(s) – Magnehelic® Differential Pressure Gages (or equivalent) with sensitivity to 0.01 inch of water



- n Flow Measuring Device – Hot wire anemometer
- n Portable Temperature Probe
- n Photoionization Detector (PID)
- n Barometer/Thermometer

## 5.3 Stepped-Rate Test Evaluation

The purpose of the step-rate test is to evaluate vapor recovery rates obtainable at various applied vacuum rates. Data collected will be used to determine possible system curves as well as well-specific radius of vacuum influences. Approximately two days will be dedicated to performing stepped-rate tests at extraction points SVE-1, SVE-2, SVE-3, and SVE-4. Note that during the stepped rate tests, the S-Building sub-slab depressurization/ventilation system will be temporarily turned off to avoid the confounding effects of a second extraction system in close proximity to the P-Building SVE system.

### 5.3.1 Field Procedures and Data Collection

The following sequence describes the procedures and data collection requirements for performing a single stepped-rate test. Following the completion of this sequence, a different extraction well will be isolated and the sequence will be repeated.

1. Isolate flow to one extraction well by closing all wellhead butterfly valves except for the well to be tested.
2. Completely open the blower dilution valve. (Do not turn on the blower yet).
3. Collect baseline readings at all monitoring locations, including the test extraction well, adjacent closed extraction wells, and multi-level vacuum monitoring probes. Data requirements include:
  - a. Time of all recorded data.
  - b. Pressure at the blower, test extraction well, and vacuum monitoring locations.
  - c. PID readings at the blower and extraction wells.
4. Turn on the blower and record:
  - a. Time
  - b. Flow rate, pressure, temperature, and PID reading at the blower (*i.e.*, exhaust stack).
  - c. Flow rate, pressure, and temperature at test extraction well.



5. Increase the vacuum at the test extraction well by closing the dilution valve at the blower. The dilution valve should be adjusted so that a vacuum pressure of approximately 2 inches Hg is being applied to the extraction system header at the blower. Allow the system to stabilize (approx. 10 to 15 minutes) and record:
  - a. Time
  - b. Flow rate, pressure, temperature, and PID readings at the blower.
  - c. Flow rate, pressure, and temperature at the test extraction well.
  - d. Pressure at adjacent monitoring locations, including the adjacent closed extraction wells and vacuum monitoring points. If pressure influences are observed at adjacent locations, additional locations moving radially away from the test well should be monitored until no influences are observed.
6. Repeat Step 5, closing the dilution valve further, increasing the vacuum applied to the test extraction well by an additional 2 inches Hg. Follow the data recording requirements outlined in Step 5.
7. Repeat Steps 5 and 6 in a series of equal 2 inches Hg increases of applied vacuum at the blower until the maximum applied vacuum is achieved at the blower (approx. 10 inches Hg), until to maximum allowable flow rate (approximately 270 SCFM) based on the air permit exemption calculations (Appendix D) or until additional flow cannot be obtained from a well at an increased vacuum (*i.e.*, maximum achievable flow of a well is reached). In the event that maximum allowable/achievable flow rates are encountered at low applied vacuum levels, this procedure may be modified to have reduced stepped-rate increases (*i.e.*, 1 inch Hg increases).
8. (OPTIONAL) Once maximum vacuum/flow conditions are reached, the stepped-rate test may be performed in reverse by decreasing the applied vacuum in equal increments and performing the monitoring outlined in Step 5 until the applied vacuum is 0" Hg. Ascending stepped-rate test results should be similar to corresponding descending test results and provide a check on the quality of the data.
9. Once the stepped-test is complete at a given well, turn off the blower and allow the system to stabilize back to a level where initial background conditions are observed (*i.e.*, zero pressure measured at the test well and adjacent monitoring locations).
10. Repeat the stepped-rate testing at a new test extraction well beginning with Step 1 of this procedure.

### 5.3.2 Data Evaluation

Following the completion of the stepped-tests, data evaluation will include:

- Preparation of system curves for the four wells tested. System curves will consist of plotting observed wellhead flow versus vacuum applied for each well tested.



- Radius of Influence (ROI) evaluations by plotting applied pressure versus pressure readings observed at all monitoring points during each stepped-test. Additional evaluations, including observed pressure contour maps and statistical analysis of all observed effects may be completed.

## 5.4 Constant Rate Pilot Test Evaluation

Following the conclusion of individual stepped-rate tests, the SVE system will be configured to operate all four extraction wells to perform a long-term constant rate pilot test. The purpose of the constant rate test is to evaluate the well operation configurations, extraction well efficiencies/achievable flow rates, system radius of influence(s), and vapor recovery rates/contamination reduction trends during system operation. The pilot constant rate test will be operated continuously until the final system is installed, estimated to be approximately eight weeks.

### 5.4.1 Monitoring and Sampling Schedule

During the period that the constant rate pilot test is being performed, the following monitoring and sampling will be completed.

- Immediately prior to system start-up, baseline monitoring at the installed gas extraction wells and vacuum monitoring locations will be completed. Monitoring will consist of vacuum and PID readings as outlined in Section 5.4.2.
- Approximately 48-hours after start-up, standard operation and maintenance (O&M) data collection and an initial air permit exemption compliance sample collection will be performed in accordance with Sections 5.5.2 and 5.5.3.
- Approximately 1-week after start-up, standard O&M data collection and confirmation air permit exemption compliance sample collection will be performed in accordance with Sections 5.5.2 and 5.5.3.
- Weekly O&M monitoring will be completed by a TRC technician throughout the duration of the constant rate pilot test.

### 5.4.2 Field Procedures and Data Collection

The following describes the procedures, data collection requirements, and considerations for performing the long-term constant rate test.

- The SVE network will be configured to apply vacuum to all four wells simultaneously by opening the valves at each wellhead. (Do not turn the blower on yet.)
- If performed on a different day than the stepped-rate test, baseline readings will be collected including:



- § Time of all recorded data.
- § Pressure at the blower, extraction wells, and vacuum monitoring locations.
- § PID readings at the blower and extraction wells.
- The blower will be turned on. The blower will be operated at the maximum allowable flow (270 SCFM) unless preliminary data obtained during the individual stepped-tests indicates that this total flow cannot be achieved. If needed, the dilution valve at the blower will be opened to decrease the total vacuum applied to the extraction well network to allow the system to operate at the maximum achievable/missible flow rate.
- An operation and maintenance checklist will be completed by the field technician at start-up and subsequent O&M events. At a minimum, the inspection will include the following:
  - § Meteorological data, including: precipitation, barometric pressure, and ambient temperature.
  - § Blower operation parameters, including: blower inlet vacuum, flow rate, and temperature; blower outlet pressure, temperature and PID readings; blower amperage, bleed rate, and volume of condensate in tank.
  - § Individual SVE wellhead vacuum, flow rate, temperature, and PID readings. PID readings will be collected by temporarily shutting the butterfly valve immediately upstream of the installed sample ports while operating the PID meter.
  - § Pressure readings at the ten vacuum monitoring points.
  - § The condition of system piping, fittings, and pipe supports. Deficiencies identified during inspections will be corrected as soon as possible.
  - § Modifications to the SVE system configuration. Due to the use of one main extraction header pipe, wellhead valves may need to be adjusted to balance flows and/or to maximize flow from certain wells that exhibit higher potential flow rates.
- Additional O&M and sampling will be performed as needed depending on the need for further system modifications and the results of the 48-hour and 1-week sample events.

#### 5.4.3 Data Evaluation

Data evaluation during and following the constant rate pilot test may include:

- Evaluation of the pilot scale blower performance for use during future full-scale design.



- Evaluation of achievable wellhead flow rates and responses to change in applied wellhead pressure.
- ROI evaluations by plotting applied vacuum versus vacuum readings observed at all monitoring points. Additional evaluations, including observed vacuum contour maps and statistical analysis of all observed data.
- Correlation between sample laboratory data to corresponding PID readings. Correlations will be used to estimate system air emissions.
- During the pilot test, flow rate and gas concentrations data will be collected to confirm compliance with the air permit to install (PTI) exemption requirements (see Section 5.5). Total VOC emissions will be determined by measuring flow rate and VOC concentration at each emission source, including the proposed SVE system, the S-Building sub-slab depressurization/ventilation system, and the methane ventilation system. The three emissions sources will be combined to determine the cumulative monthly facility emissions.

## 5.5 Air Permit Exemption Compliance Evaluation

An air permit evaluation was prepared to determine if an air permit is required for operation of the proposed pilot SVE system. The evaluation is contained in Appendix D. Based on anticipated air flow rates (up to 270 SCFM) and mass extraction rates, the operation of the pilot test is exempt from air permitting requirements.

During the pilot test flow rate and gas concentrations data will be collected to confirm compliance with the PTI exemption requirements. Total VOC emissions will be determined by measuring flow rate and VOC concentration at each emission source, including the proposed SVE system, the S-Building sub-slab depressurization/ventilation system, and the methane ventilation system. The three emissions sources will be combined to determine the cumulative monthly facility emissions.

### 5.5.1 Flow Rates

Flow rates will be measured at each of the three emission sources approximately 48-hours after SVE pilot system start-up, in conjunction with standard O&M data collection. The exhaust flow rate at the SVE pilot system will be confirmed approximately 1-week after SVE pilot system start-up, in conjunction with standard O&M data collection.



### 5.5.2 Sample Collection

Air samples will be collected at each of the three emission sources approximately 48-hours after SVE pilot system start-up, in conjunction with standard O&M data collection. VOC concentrations for the SVE pilot system are expected to decline over time. Therefore a second air sample will be collected from the SVE system exhaust approximately 1-week after SVE pilot system start-up, to confirm the initial sample results and to help develop a correlation between system PID readings and actual VOC concentrations. Samples will be collected as described below:

- The grab sample will be collected in a laboratory supplied certified-clean 1-liter SUMMA® sample canister. The canister will be evacuated to a nominal 26 to 30 inches of mercury and shipped to the field under Chain-of-Custody documentation.
- The sampling apparatus will be assembled, and a vacuum shut-in test will be performed to confirm that there are no significant leaks in the sample train prior to use.
- The sample information, including canister number, flow controller number, and initial canister vacuum will be recorded on TRC standard air sampling forms.
- The valve on the sample canister will then be opened to begin sample collection. The initial canister vacuum and starting sample collection time will be recorded.
- Once the vacuum gage indicates that sample collection is complete, the valve on the sample canister will be closed. The final canister vacuum and ending sample collection time will be recorded.

Field procedures for sample documentation, handling, storage, shipment, preservation, and Chain-of-Custody will be conducted in accordance with the procedures outlined in the Quality Assurance Project Plan (QAPP) (RMT, 2010d). Samples will be analyzed by H&P Mobile Geochemistry by USEPA Method TO-15 for the site constituents of concern (COCs), specifically 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethene, cis-1,2-dichloroethene, trans-1,2-dichloroethene, tetrachloroethene, 1,1,1-trichloroethane, trichloroethene, and vinyl chloride. Field personnel will document sample collection procedures on field data forms or in field notebooks.

### 5.5.3 Data Evaluation

Data evaluation during and following the constant rate pilot test may include:

- System flow rates and concentrations of site COCs will be used to determine the cumulative monthly facility emissions and to verify compliance with PTI exemption requirements.



- Correlation between sample laboratory data to corresponding PID readings. Correlations will be qualitatively evaluated to predict trends in air emissions, and assess the need for additional sampling.
- Based on the cumulative facility emissions, the maximum allowable SVE system flow rate will be recalculated. If cumulative monthly VOC-emissions exceed the 20 pound per month limit (*i.e.*, measured concentrations are higher than predicted), the SVE system flow will be reduced to meet PTI exemption requirements, until an emission treatment system is installed and/or an air permit is obtained. If cumulative monthly VOC-emission do not exceed the 20 pound per month limit (*i.e.*, the total system flow is less than the re-calculated maximum allowable flow), SVE pilot system flow rates may be increased to maximize system performance.

## 5.6 Reporting and Full Scale System Design

Results of the stepped rate test evaluation, of the constant rate test evaluation, and of the air permit exemption compliance evaluation will be used to design a full-scale SVE system for P-Building. A Workplan for the Installation of a Full-Scale Soil Vapor Extraction System in P-Building at 100 East Patterson Street will be prepared which will document the pilot test results and will describe the full-scale system design, installation, and monitoring program.



## Section 6

# References

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- Lindeburg, Michael R. 2009. Environmental Engineering Reference Manual for the PE Exam, 2<sup>nd</sup> ed. Professional Publications Inc. (PPI). 2009.
- MDEQ. 2005. Permit to Install – Determining Applicability Guidebook. October 2005.
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- RMT, Inc. 2010a. Technical Memorandum: Status Update – Characterization of Volatile Organic Compounds in Groundwater; Former Tecumseh Products Company Site, Tecumseh, Michigan. February 12, 2010.
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- RMT, Inc. 2010c. Technical Memorandum: Summary of Off-Site Soil Gas Investigation Activities – March through April 2010; Former Tecumseh Products Company Site, Tecumseh, Michigan. July 15, 2010.
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TRC Environmental Corporation. 2011b. Workplan for the Installation of a Sub-Slab Depressurization/Ventilation System, S-Building at 100 East Patterson Street, Tecumseh, Michigan. September 2011.

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TRC Environmental Corporation. 2012b. Sub-Slab Depressurization/Ventilation System Construction Documentation and Indoor Air Sample Results for S-Building at 100 East Patterson Street. February 20, 2012.

TRC Environmental Corporation. 2012c. TCE Toxicity Updates. February 1, 2012.

US Army Corps of Engineers. 2002. Engineering and Design- Soil Vapor Extraction and Bioventing. EM 1110-1-4001. June 3, 2002.

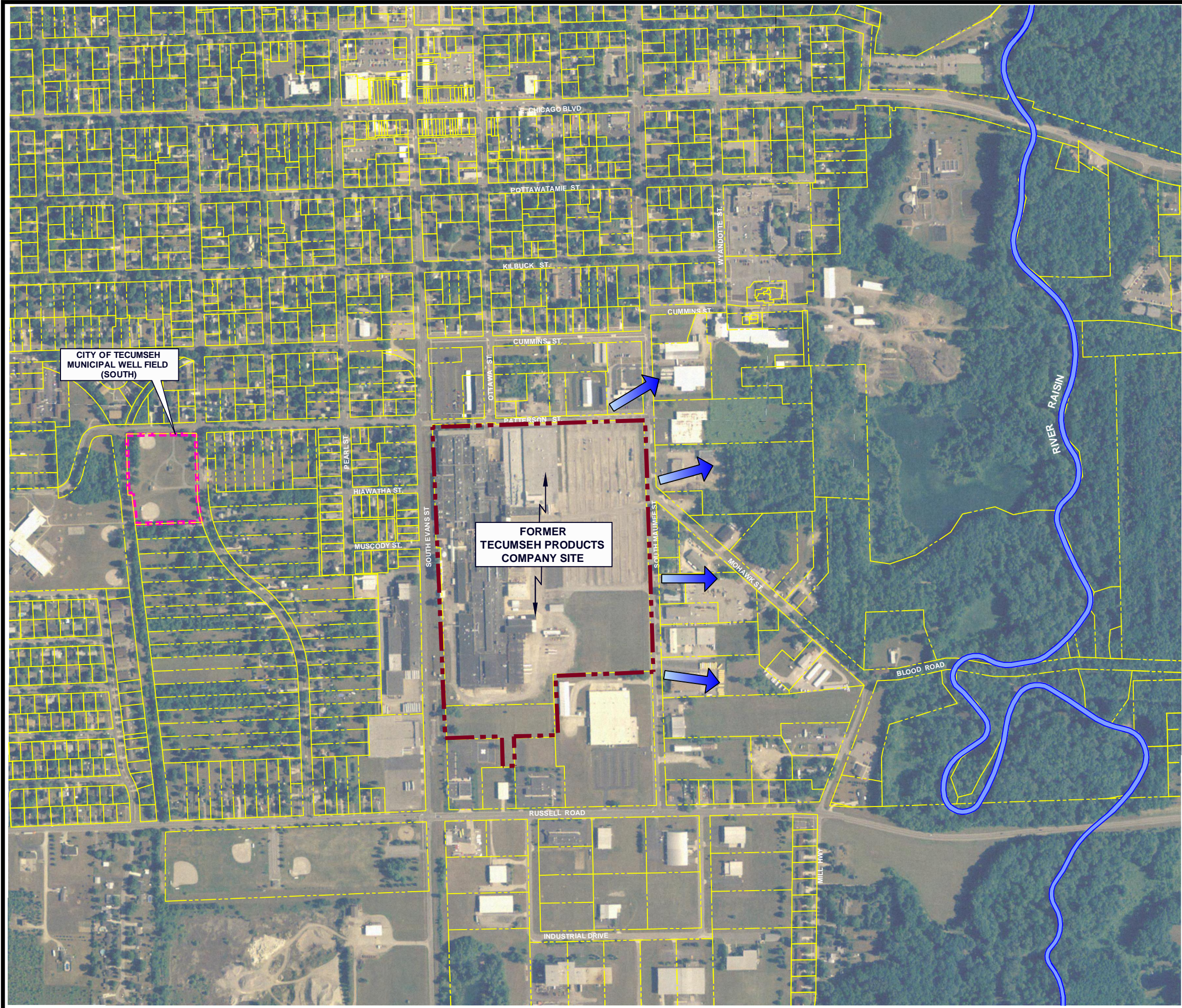
USEPA. 2002. OSWER draft guidance for evaluating the vapor intrusion to indoor air pathway from groundwater and soils (subsurface vapor intrusion guidance). EPA/530-D-02-004. November 2002.



# Figures

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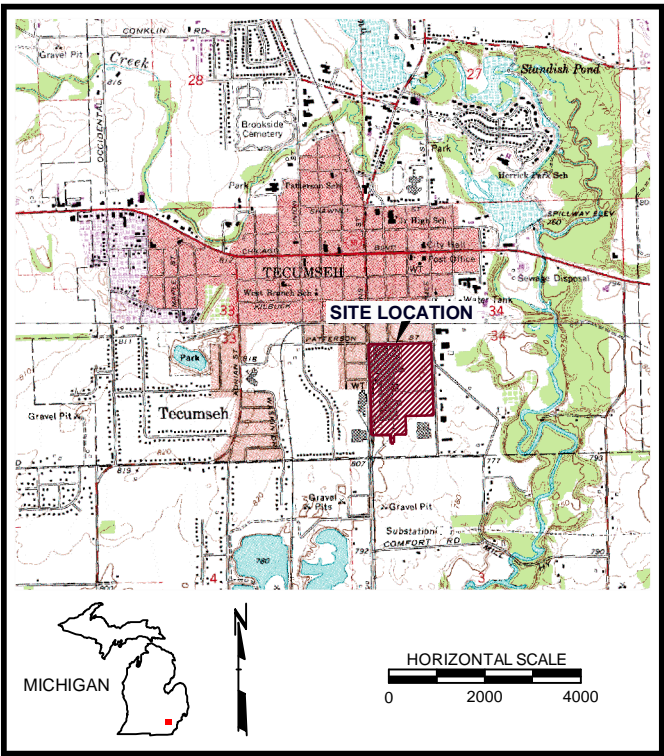
LEGEND

- CITY OF TECUMSEH PROPERTY BOUNDARIES
- FORMER TECUMSEH PRODUCTS SITE BOUNDARY
- PARCEL BOUNDARIES
- GROUNDWATER FLOW DIRECTION

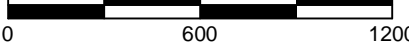
NOTE

1. BASE MAP DEVELOPED FROM SITE PLAN PROVIDED BY THE CITY OF TECUMSEH, DRAWING NO. CITY.DWG, MARCH 2009, AERIAL PHOTOGRAPH PROVIDED FROM REMOTE SENSING & GIS RESEARCH AND OUTREACH SERVICES (RS&GIS), PUBLICATION DATE: 06-29-2007, File:TECUMSEHSOUTH\_NE.ECW.

SITE TOPOGRAPHY INSET MAP



APPROXIMATE HORIZONTAL SCALE

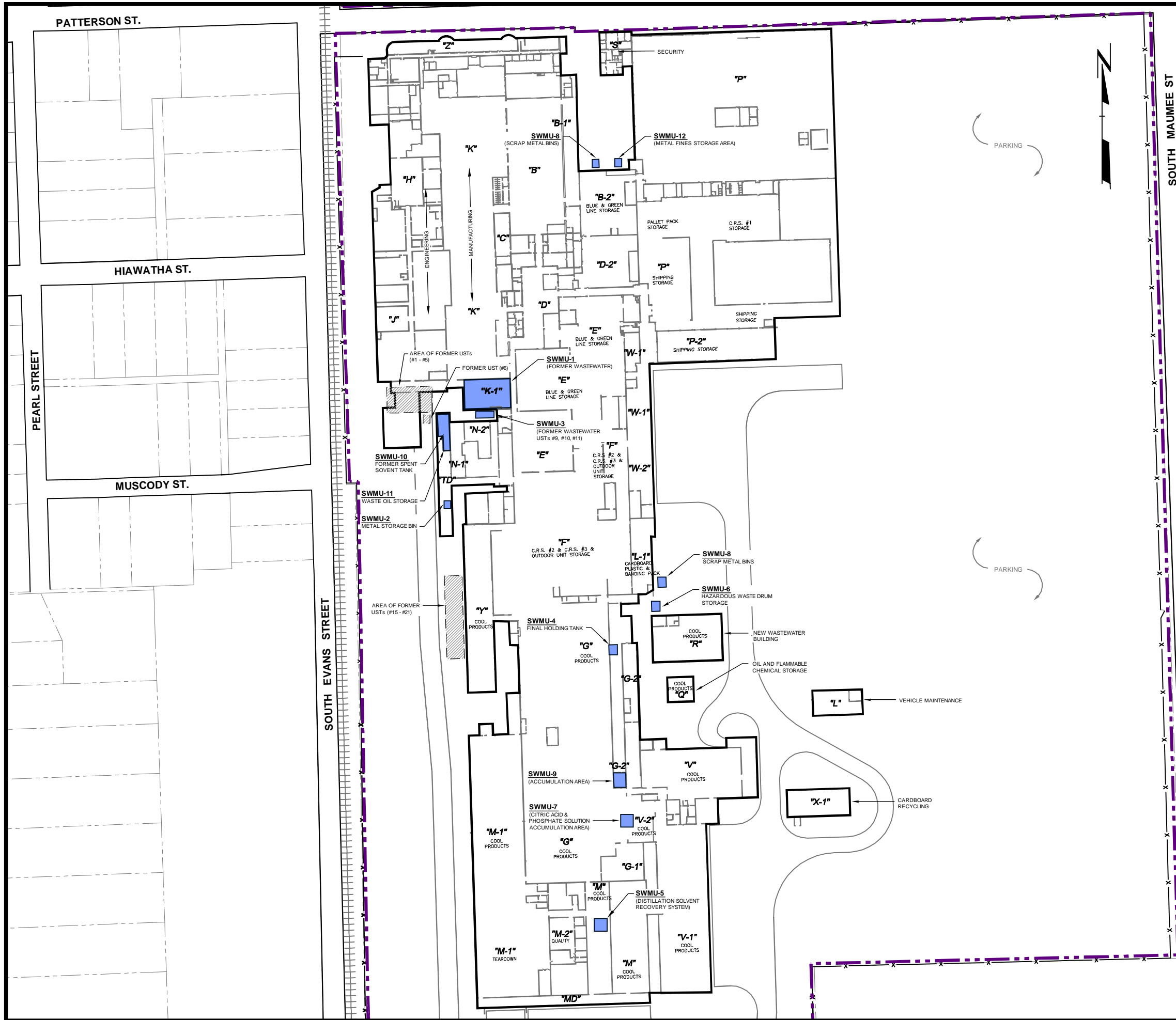


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TITLE: SITE LOCATION PLAN AND VICINITY			
DRAWN BY: SJL/DGS	SCALE: AS INDICATED	PROJ. NO. 187156.0001.02	FIGURE 1
CHECKED BY: SEM	DATE PRINTED:	FILE NO. 187156.0001.02.01.dwg	
APPROVED BY: GC	DATE: MARCH 2012		



1540 Eisenhower Place  
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Fax: 734.971.9022



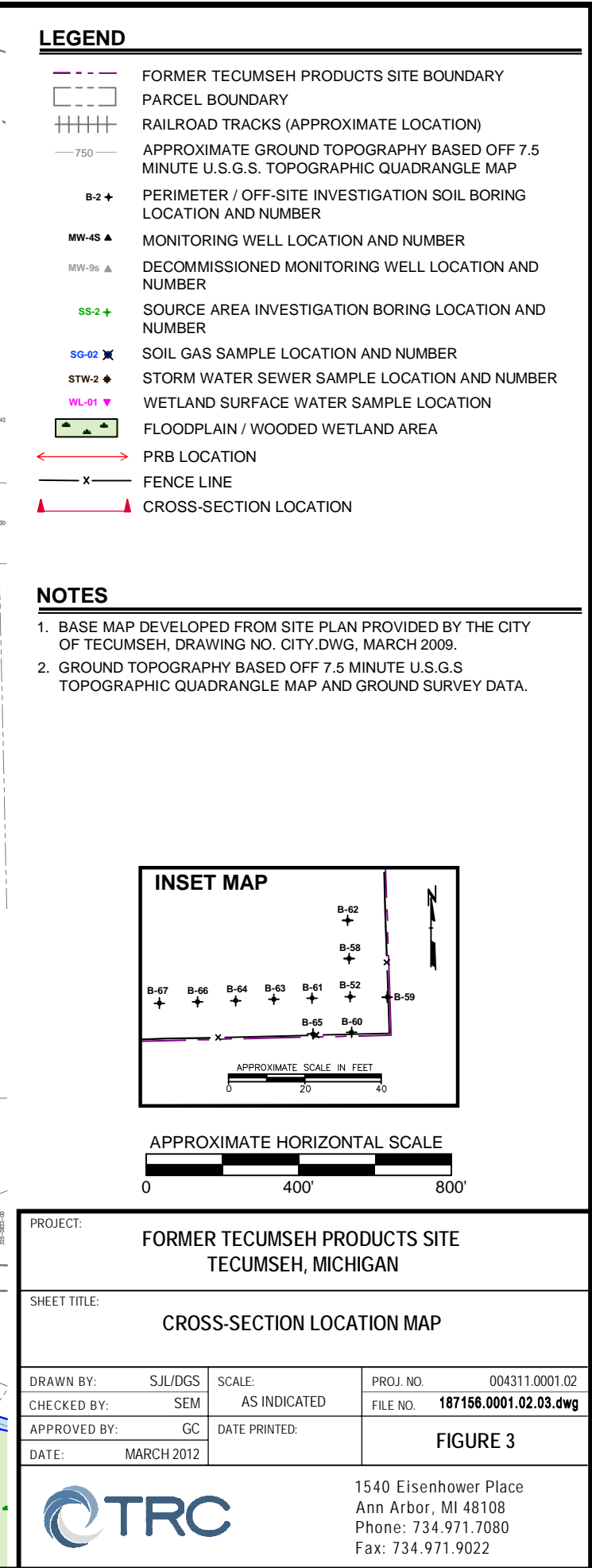


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CHECKED BY: SEM	DATE PRINTED:	FIGURE 2	
APPROVED BY: GC	DATE: MARCH 2012		



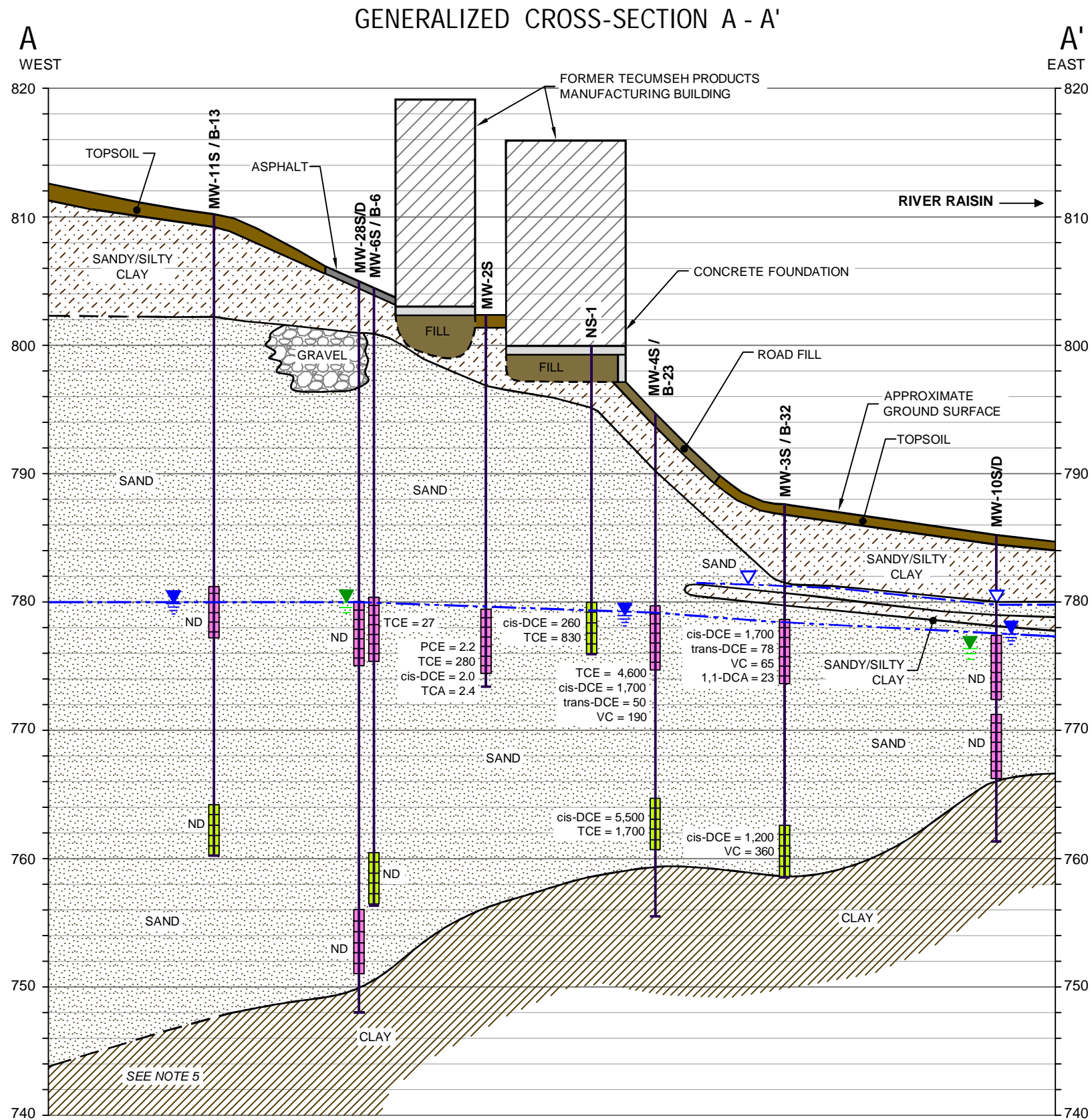
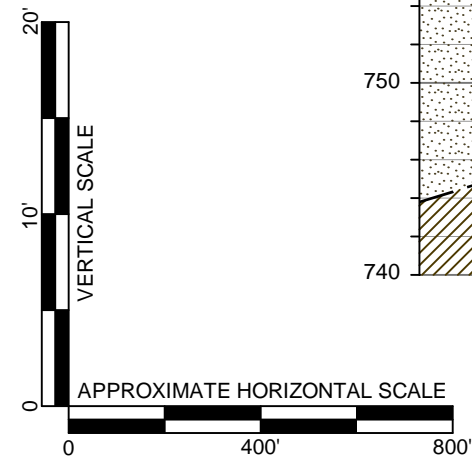
1540 Eisenhower Place  
Ann Arbor, MI 48108  
Phone: 734.971.7080  
Fax: 734.971.9022



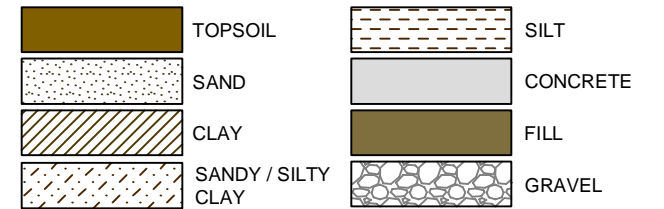




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Dwg Size: 0.54 Mb  
Plot Date: March 29, 2012  
Plot Time: 9:27 AM  
Attached Xrefs: FIG04 XS A-A  
Attached Images: Layout:



## LEGEND



PCE = TETRACHLOROETHENE  
TCE = TRICHLOROETHENE  
TCA = 1,1,1-TRICHLOROETHANE  
1,1-DCE = 1,1-DICHLOROETHENE  
1,1-DCA = 1,1-DICHLOROETHANE  
cis-DCE = 1,2-cis-DICHLOROETHENE  
trans-DCE = 1,2-trans-DICHLOROETHENE  
VC = VINYL CHLORIDE  
ND = NOT DETECTED

## NOTES

- GROUND SURFACE AND STRATIGRAPHIC CONTACTS ARE APPROXIMATE AND EXTRAPOLATED FROM NEAREST SOIL BORING DATA.
- SEE FIGURE 3 FOR LOCATION / ORIENTATION OF THIS GEOLOGIC CROSS SECTION.
- GROUNDWATER ANALYTICAL DATA REFLECTS MOST RECENT SAMPLE EVENT AS OF SEPTEMBER 2011.
- DETECTED GROUNDWATER CONCENTRATIONS FOR CONSTITUENTS OF HIGHEST CONCERN ARE PROVIDED IN MICROGRAMS PER LITER.
- THE ELEVATION OF THE TOP OF CLAY NEAR MW-11S IS ESTIMATED BASED ON WELL LOGS FROM THE CITY OF TECUMSEH WELL FIELD, WHICH IS LOCATED APPROXIMATELY 1,000 FEET WEST OF MW-11S. TOP OF CLAY AT THE CITY WELL FIELD IS AT APPROXIMATELY 740 FEET MSL.

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CHECKED BY: SEM		PROJ. NO. 004311.0001.02	
APPROVED BY: GC		FILE NO. 187156.0001.02.04.dwg	
DATE: MARCH 2012		FIGURE 4	



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Fax: 734.971.9022



# Appendix A

## Design Drawings

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Tecumseh Products Company  
Former Tecumseh Products Site  
Tecumseh, Michigan

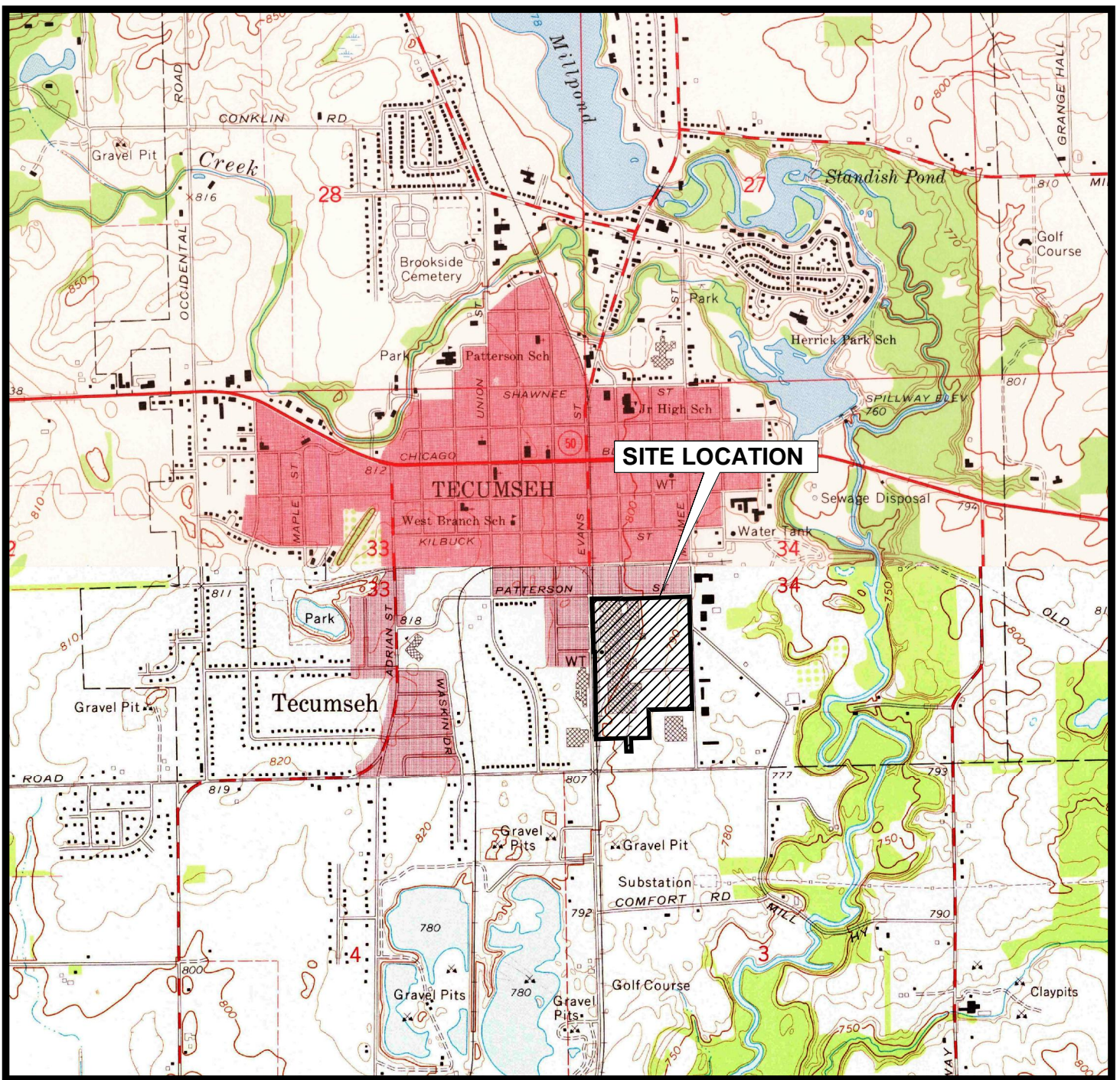
PILOT SOIL VAPOR EXTRACTION SYSTEM DESIGN

PREPARED FOR: Tecumseh Products Company  
Ann Arbor, Michigan

PREPARED BY: TRC Engineers Michigan, Inc.  
Ann Arbor, Michigan

DATE: April 2012

Site Location Map

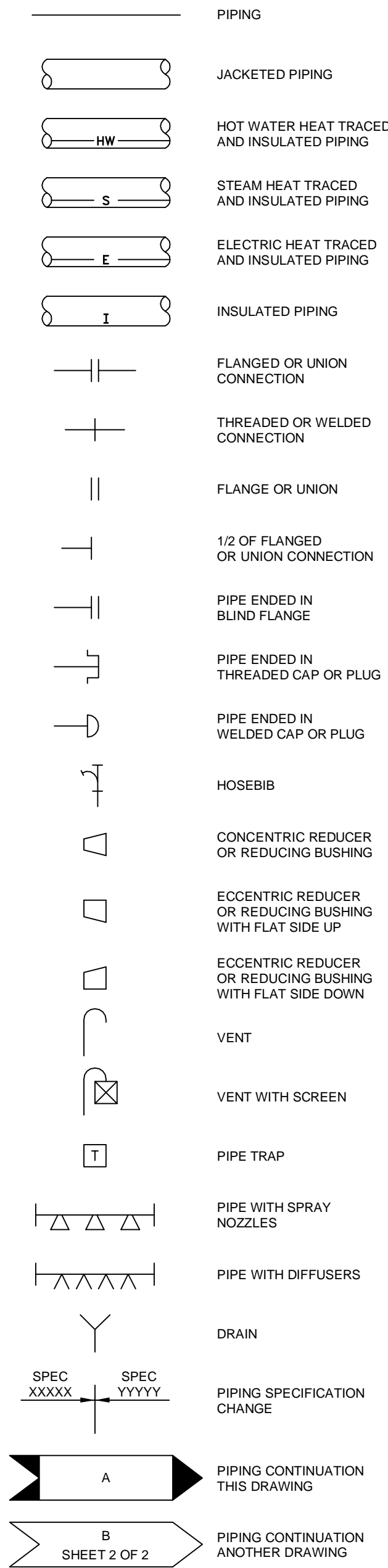


Drawing Index

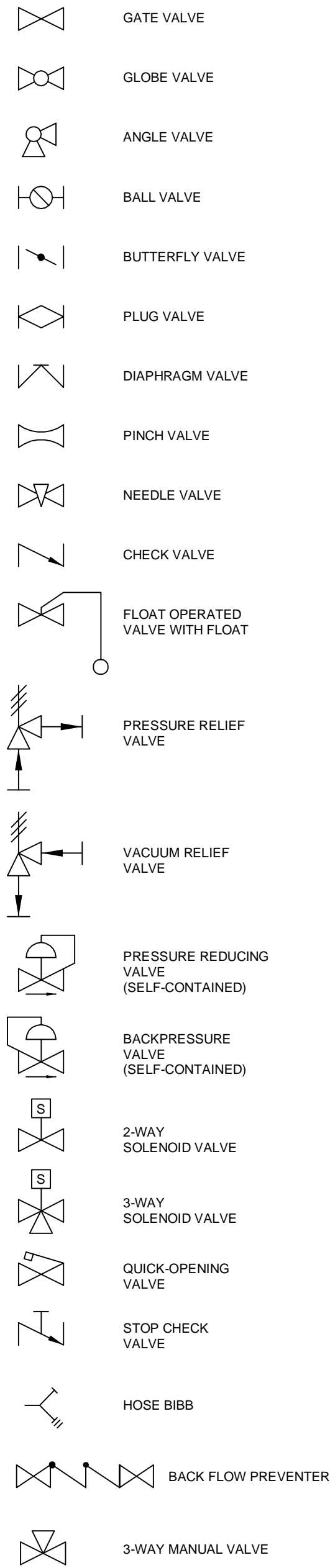
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2	Piping and Instrumentation Diagram Symbol Sheet
3	Site Plan
4	SVE System Layout (Pilot Test)
5	Piping and Instrumentation Diagram
6	Riser Pipe Connection Diagrams
7	Civil Details



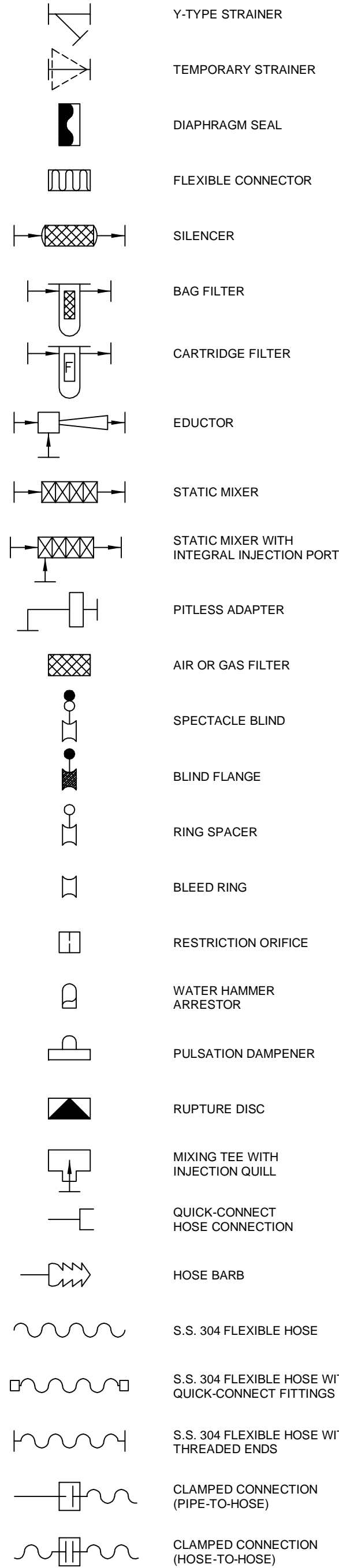
## PIPING SYMBOLS <sup>(1)</sup>



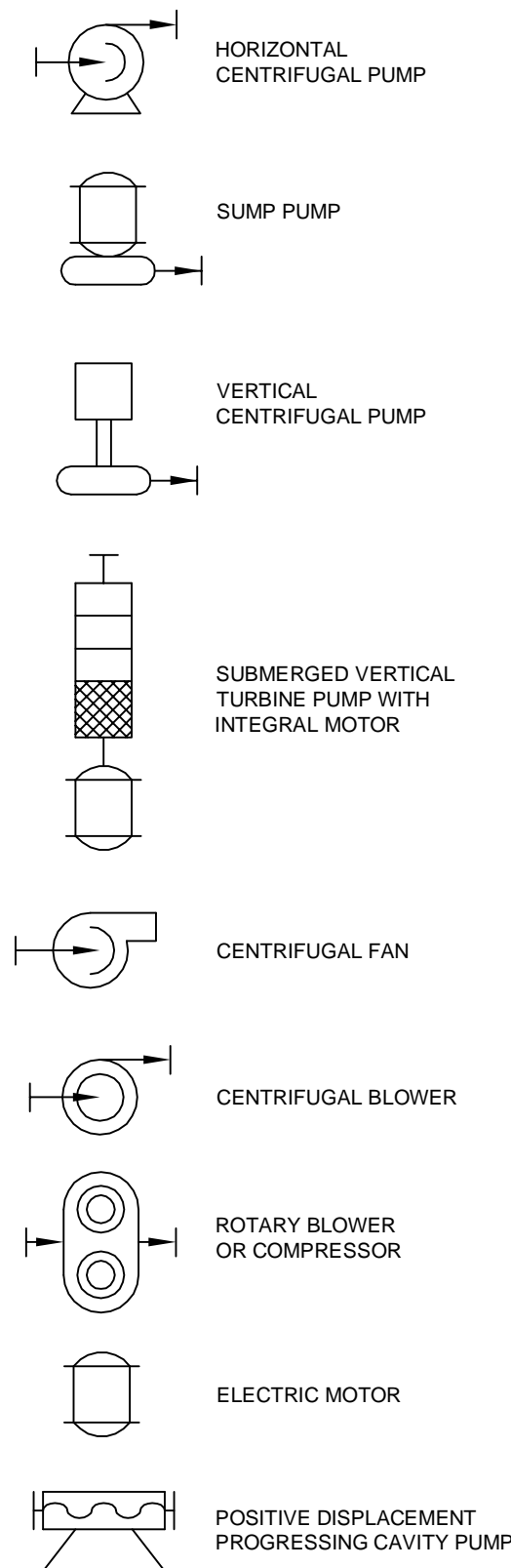
## VALVE SYMBOLS <sup>(2)</sup>



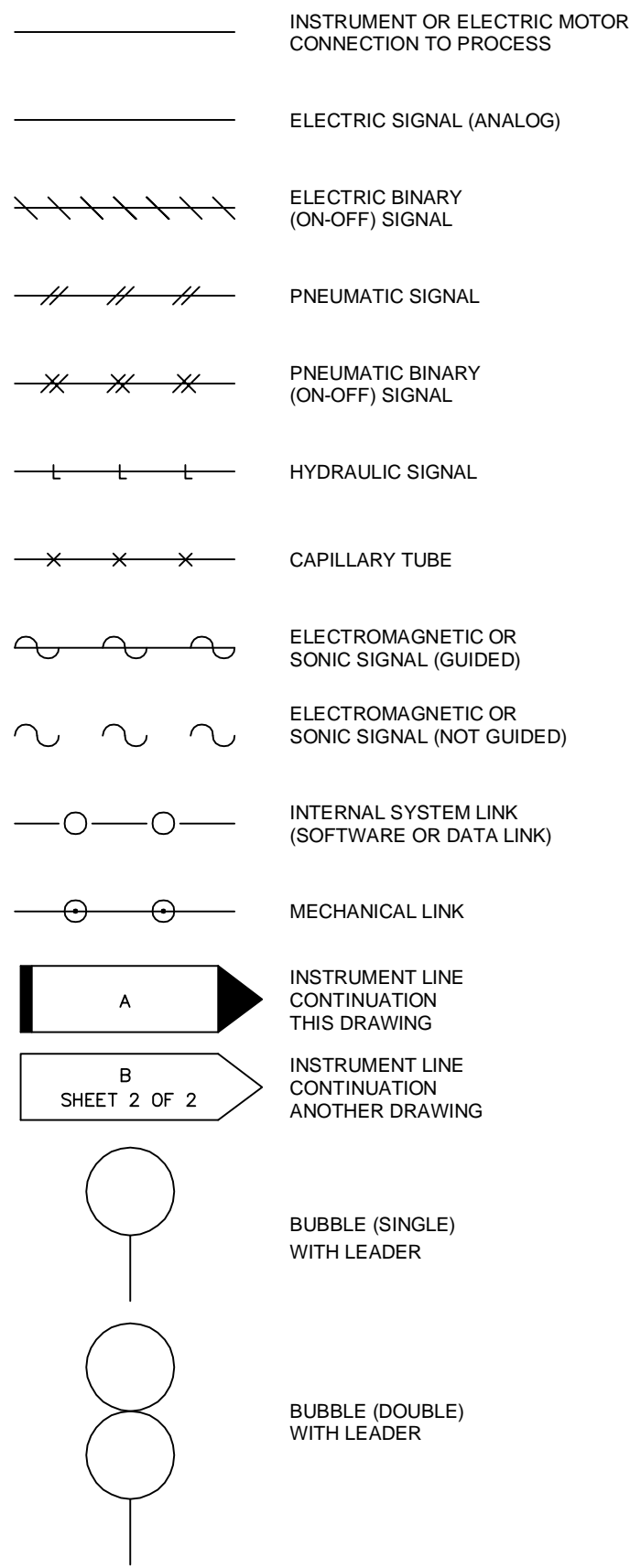
## SPECIALTY SYMBOLS



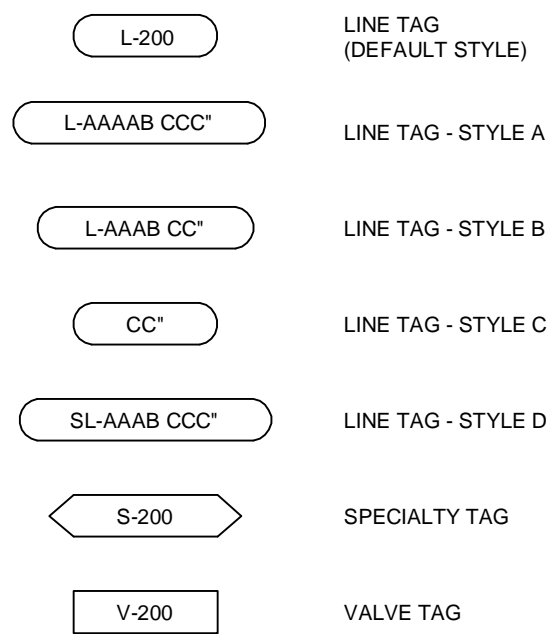
## EQUIPMENT SYMBOLS



## INSTRUMENT LINE SYMBOLS <sup>(3)</sup>

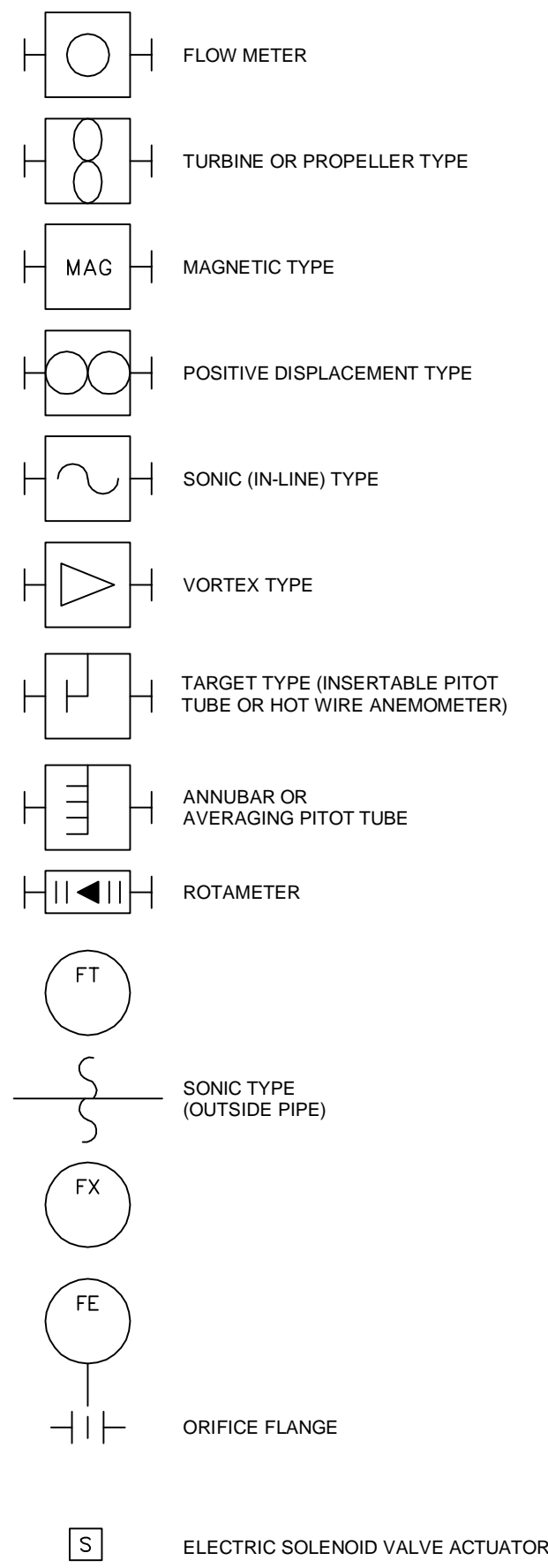


## TAGGING SYMBOLS

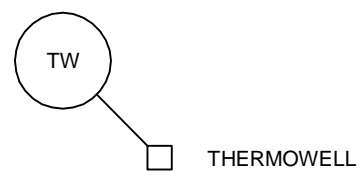


## INSTRUMENT PRIMARY ELEMENT SYMBOLS

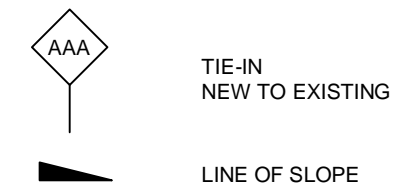
### FLOW ELEMENTS



## TEMPERATURE ELEMENTS



## GENERAL SYMBOLS



## INSTRUMENT IDENTIFICATION CHART <sup>(3)</sup>

	FIRST LETTER		SUCCEEDING LETTERS		
	MEASURED OR INITIATING VARIABLE	MODIFIER TO FIRST LETTER	READOUT OR PASSIVE FUNCTION	OUTPUT FUNCTION	MODIFIER
A	ANALYSIS		ALARM		
B	BURNER, COMBUSTION				
C	USER'S CHOICE			CONTROL	
D	USER'S CHOICE	DIFFERENTIAL			
E	VOLTAGE		SENSOR (PRIMARY ELEMENT)		
F	FLOW RATE	RATIO (FRACTION)			
G	USER'S CHOICE		GLASS VIEWING DEVICE		
H	HAND				HIGH, OPEN
I	CURRENT (ELECTRICAL)		INDICATE		
J	POWER	SCAN			
K	TIME, TIME SCHEDULE	TIME RATE OF CHANGE		CONTROL STATION	
L	LEVEL		LIGHT		LOW, CLOSED
M	USER'S CHOICE	MOMENTARY			MIDDLE INTERMEDIATE
N	USER'S CHOICE				
O	USER'S CHOICE		ORIFICE, RESTRICTION		
P	PRESSURE, VACUUM		POINT (TEST) CONNECTION		
Q	QUANTITY	INTEGRATE, TOTALIZE			
R	RADIATION		RECORD		
S	SPEED, FREQUENCY	SAFETY		SWITCH	
T	TEMPERATURE			TRANSMITTER OR TRANSDUCER	
U	MULTIVARIABLE		MULTIFUNCTION	MULTIFUNCTION	MULTIFUNCTION
V	VIBRATION, MECHANICAL ANALYSIS			VALVE, DAMPER, LOUVER	
W	WEIGHT, FORCE		WELL		
X	UNCLASSIFIED	X-AXIS	UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED
Y	EVENT, STATE OR PRESENCE	Y-AXIS		RELAY, COMPUTE, CONVERT	
Z	POSITION, DIMENSION	Z-AXIS		DRIVER, ACTUATOR, UNCLASSIFIED FINAL CONTROL ELEMENT	

## INSTRUMENT AND FUNCTION SYMBOLS <sup>(3)</sup>

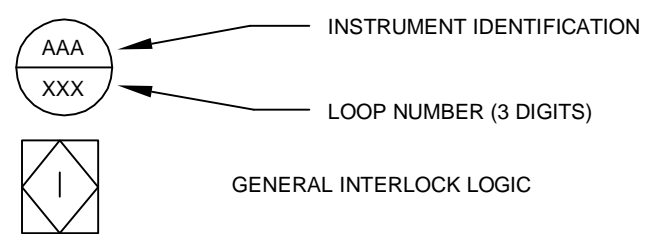
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		NORMALLY ACCESSIBLE TO OPERATOR	NORMALLY INACCESSIBLE TO OPERATOR	NORMALLY ACCESSIBLE TO OPERATOR	NORMALLY INACCESSIBLE TO OPERATOR
DISCRETE INSTRUMENTS					
SHARED DISPLAY AND/OR SHARED CONTROL					
COMPUTER FUNCTION					
PROGRAMMABLE OR RELAY LOGIC CONTROL					

## MISCELLANEOUS INSTRUMENT SYMBOLS

### DEFINITIONS OF ABBREVIATIONS

H-O-A	HAND-OFF-AUTOMATIC
ON-OFF	ON-OFF
O-A	OFF-AUTOMATIC

### INSTRUMENT DESIGNATION



### NOTES:

- INCLUDES PIPING, TUBING, AND DUCTING.
- VALVE SYMBOLS ARE FOR VALVES WITH MANUAL OPERATOR, EXCEPT WHERE A VALVE IS SHOWN WITH A HANDWHEEL EXTENSION OR WITH AN AUTOMATIC OPERATOR.
- ADAPTED FROM INSTRUMENT SOCIETY OF AMERICA STANDARD ISA-S5.1-1984 "INSTRUMENT SYMBOLS AND IDENTIFICATION".

3					
2					
1					
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TECUMSEH, MICHIGAN					
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APPROVED BY:	DM	DATE PRINTED:	SHEET 2 of 7		
DATE:	APRIL 2012				
			1540 Eisenhower Place Ann Arbor, MI 48108 Phone: 734.971.7080 Fax: 734.971.9022		

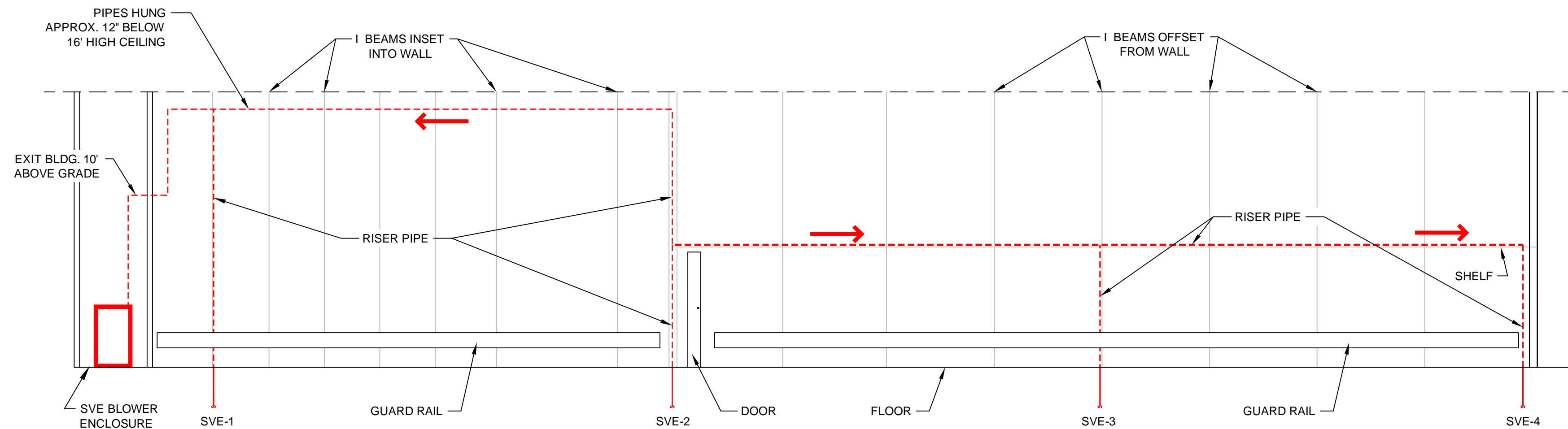
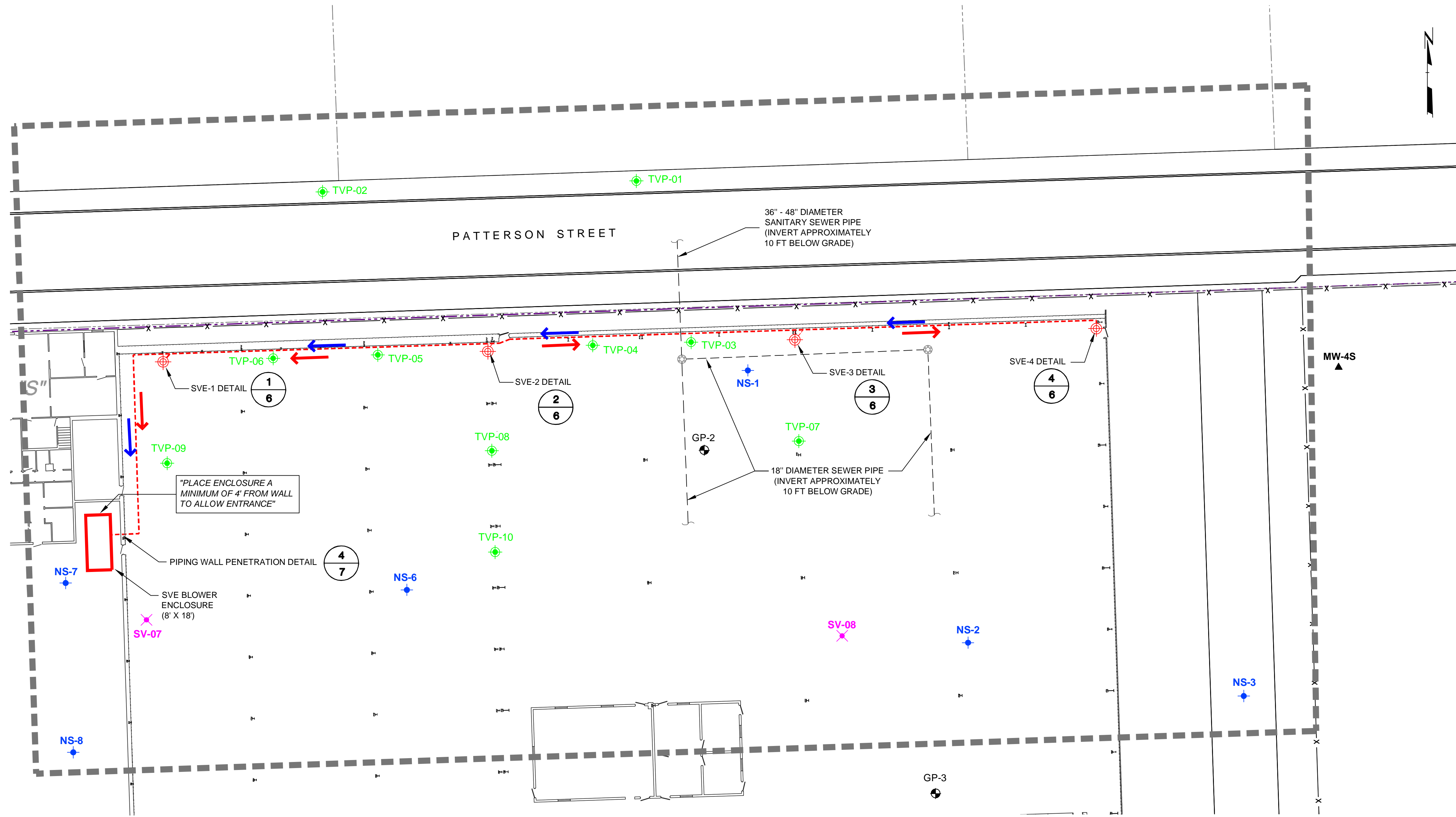




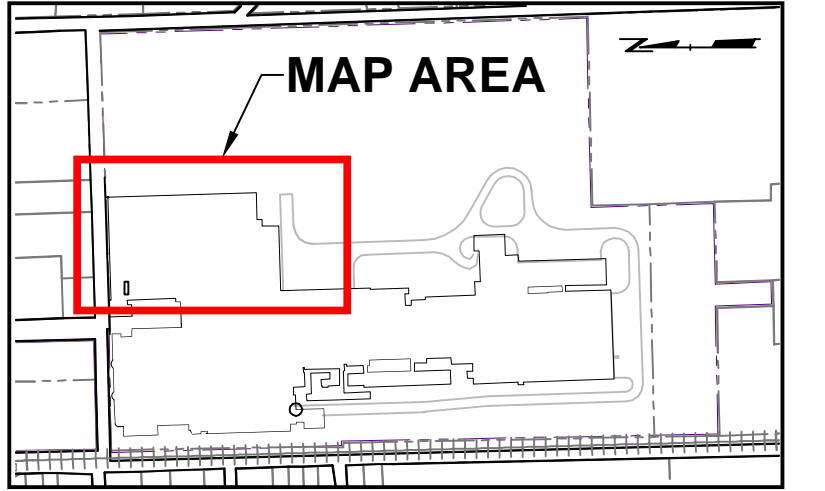


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Checked By: [Redacted] Date: 10/10/16  
Designed By: [Redacted] Date: 10/10/16  
Title: SVE SYSTEM LAYOUT (PILOT TEST)  
Drawing No: 187156.0001.04.dwg  
Drawing Date: 10/10/16  
Drawing Scale: 1" = 10' - 0"

Project: PILOT SOIL VAPOR EXTRACTION SYSTEM DESIGN  
Former Tecumseh Products Site  
Tecumseh, Michigan  
Drawing No: 187156.0001.04.dwg  
Drawing Date: 10/10/16  
Drawing Scale: 1" = 10' - 0"



NORTH WALL PROFILE VIEW

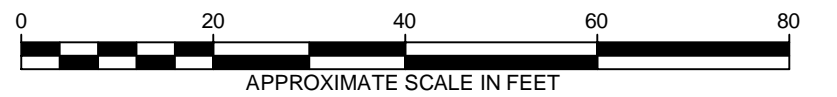


#### LEGEND

- FORMER TECUMSEH PRODUCTS SITE BOUNDARY
- GP-24 ATG GEOPROBE BORING LOCATION AND NUMBER
- SV-08 SUB-SLAB VAPOR SAMPLING LOCATION AND NUMBER
- NS-6 NORTHERN SOURCE AREA INVESTIGATION BORING LOCATION AND NUMBER
- MW-4S MONITORING WELL LOCATION AND NUMBER
- SG-07 SOIL GAS SAMPLE LOCATION AND NUMBER
- SVE-4 SOIL VAPOR EXTRACTION / VAPOR MIGRATION MITIGATION WELL
- TVP-1 TEMPORARY VACUUM MONITORING POINT LOCATION
- ABOVE GRADE SVE CONVEYANCE PIPING
- AIR FLOW DIRECTION
- PIPE SLOPE DIRECTION
- SANITARY SEWER MANHOLE AND SEWER LINE

#### NOTES

- BASE MAP DEVELOPED FROM SITE PLAN PROVIDED BY TECUMSEH PRODUCTS COMPANY, DRAWING NO. 09039stk.DWG
- ABOVE GRADE PIPING WILL BE CONSTRUCTED OF 4" SCHEDULE 80 PVC MATERIAL.
- CONTRACTOR SHALL PROVIDE PIPE SUPPORTS A MINIMUM OF EVERY 12 FEET AND WITHIN 12 INCHES OF EVERY DIRECTIONAL CHANGE.
- CONTRACTOR SHALL SLOPE PIPING SO THERE IS CONTINUOUS SLOPE DIRECTION FROM ONE HIGH POINT LOCATION (IN EACH RUN FROM EXTRACTION WELL TO MANIFOLD) EITHER BACK TOWARDS EXTRACTION WELL OR TOWARD THE BLOWER SKID.
- CONTRACTOR SHALL PLACE TWO- TO EIGHT-INCH THICK (WHERE FEASIBLE DUE TO THE DEPTH OF THE FLOOR CUT/EXCAVATION) NEW 3,500 PSI CONCRETE WITH 4-6% AIR ENTRAINMENT, REINFORCED WITH ONE LAYER OF #00 GAUGE 6" MESH DOWELED INTO EXISTING CONCRETE AT A MINIMUM OF 24" INTERVALS.
- ABOVE GROUND PIPING ROUTES SHOWN ARE APPROXIMATE. ACTUAL PIPING ROUTES MAY BE ALTERED IN THE FIELD BY TRC AND OWNER.



3					
2					
1					
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DATE: APRIL 2012					



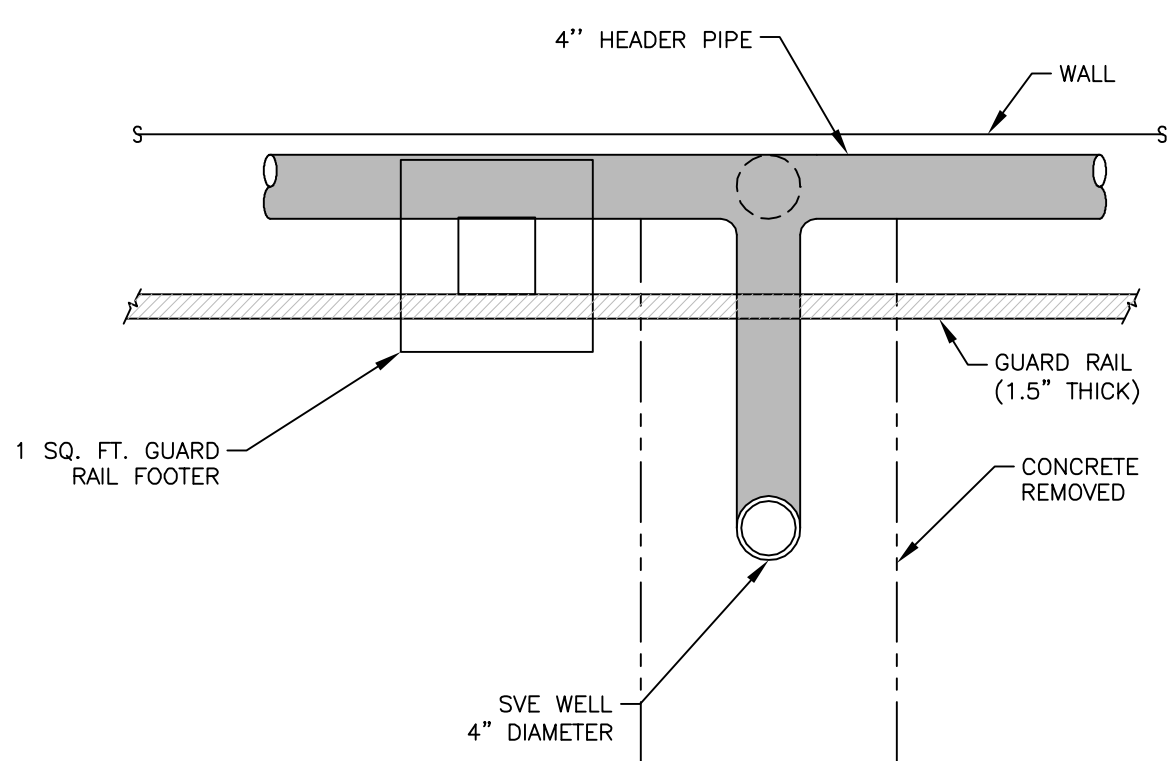
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Ann Arbor, MI 48108  
Phone: 734.971.7080  
Fax: 734.971.9022



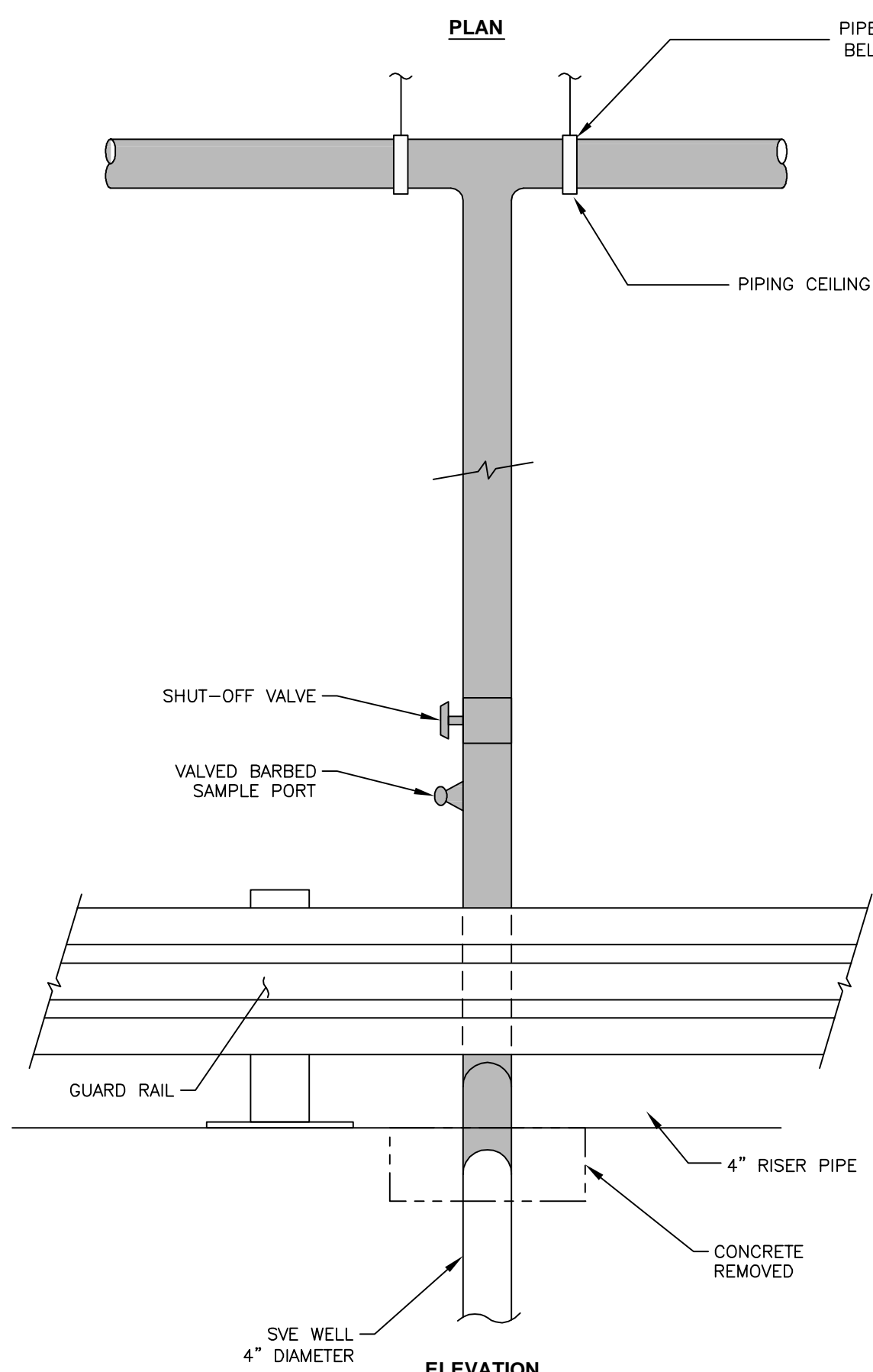




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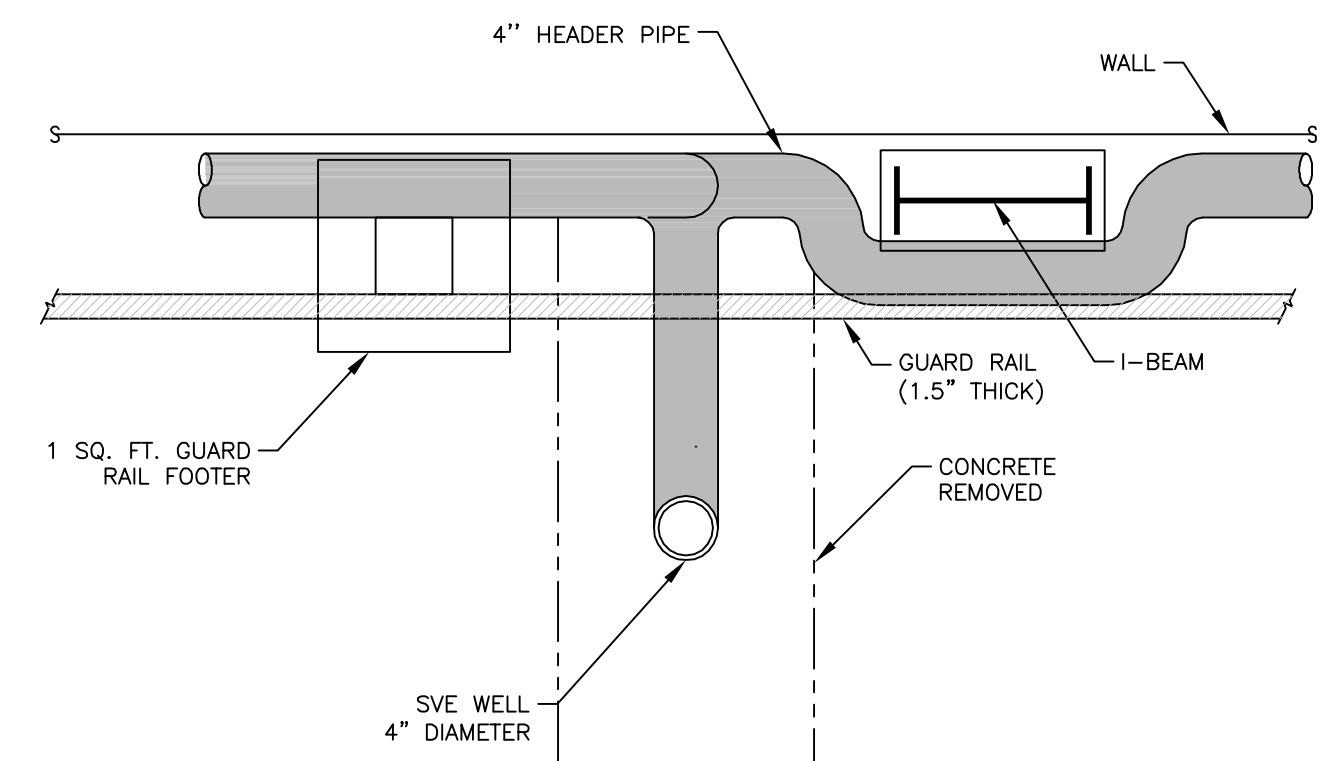


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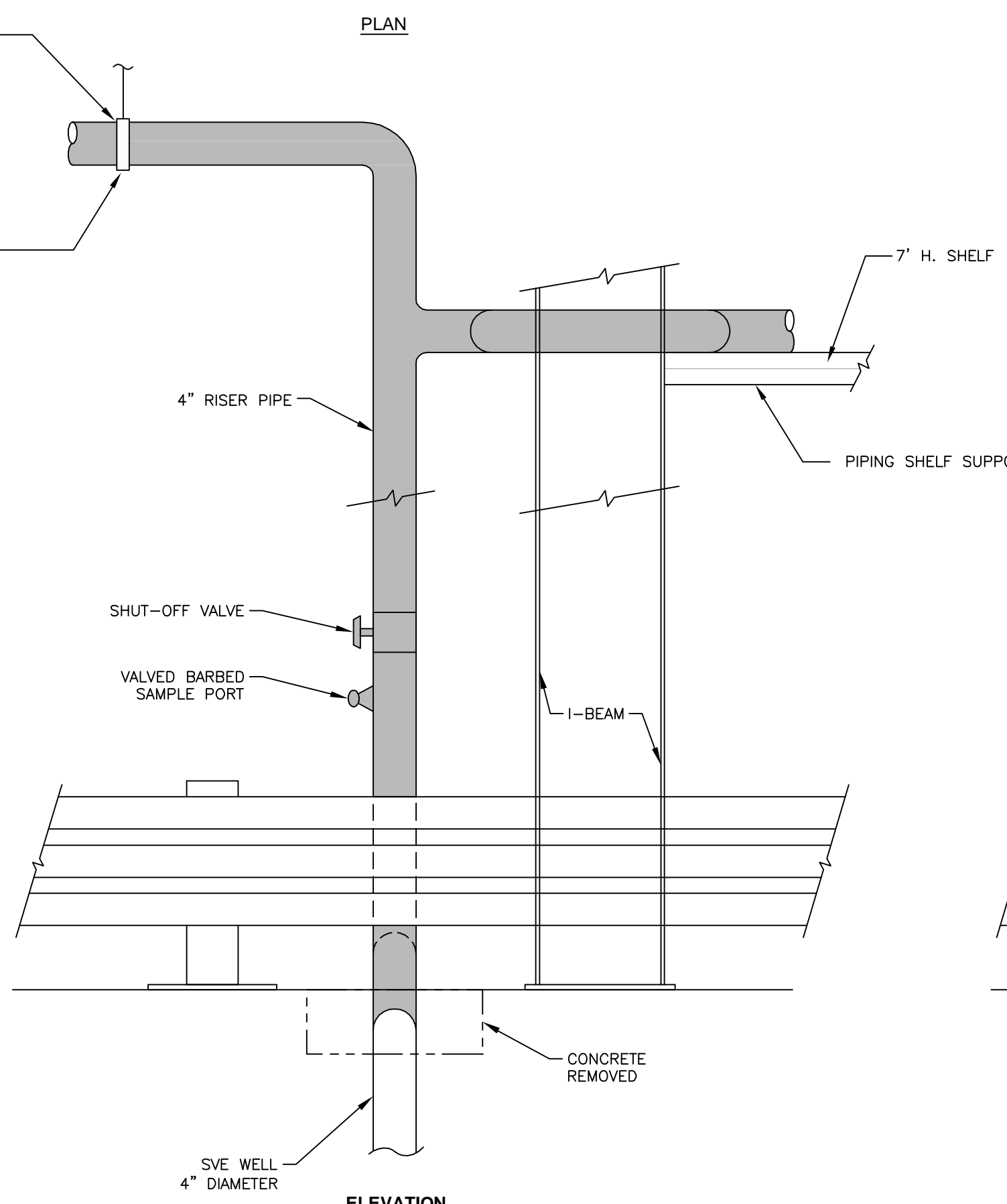


ELEVATION

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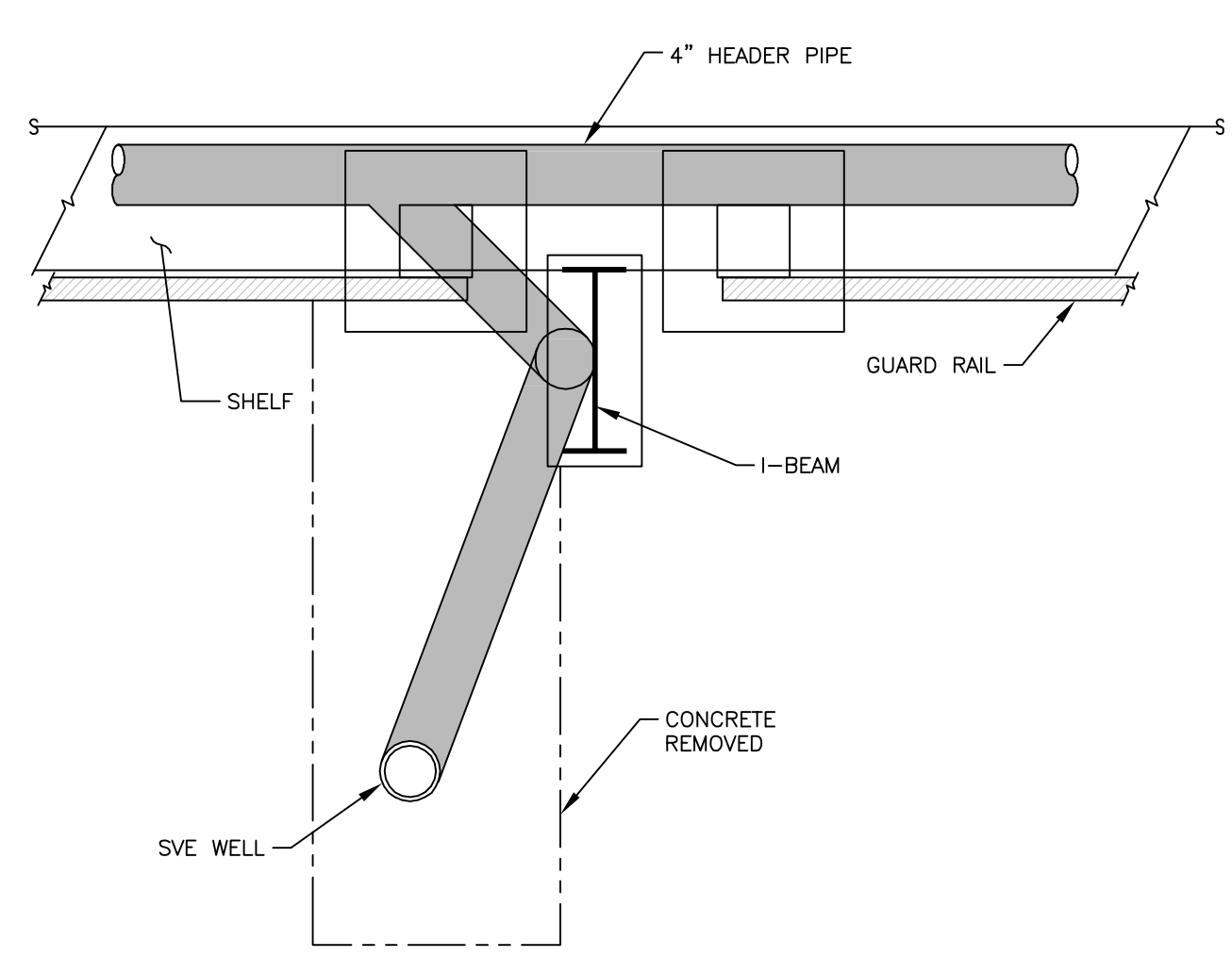


PLAN

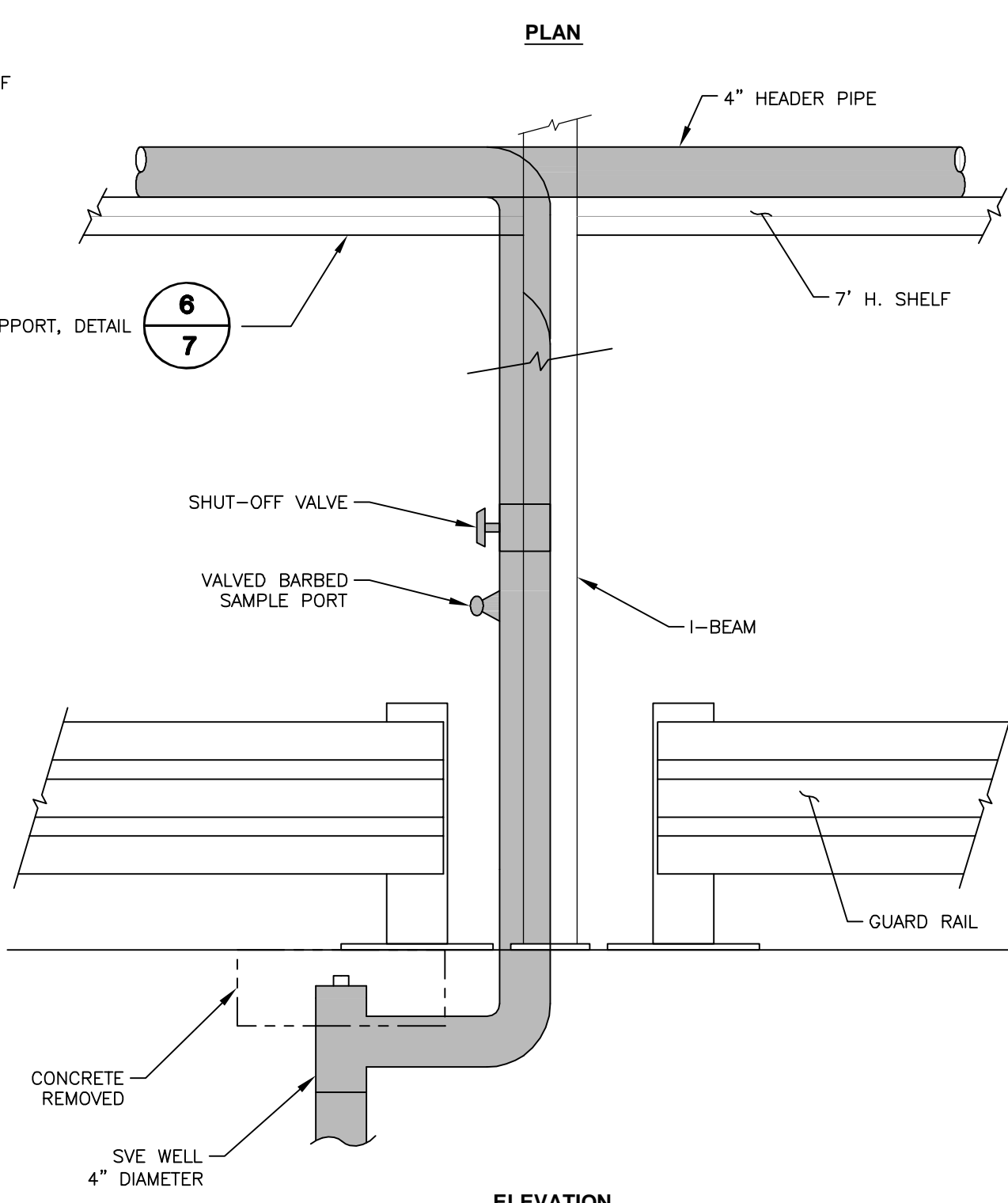


ELEVATION

2  
4  
SVE 2  
(NOT TO SCALE)

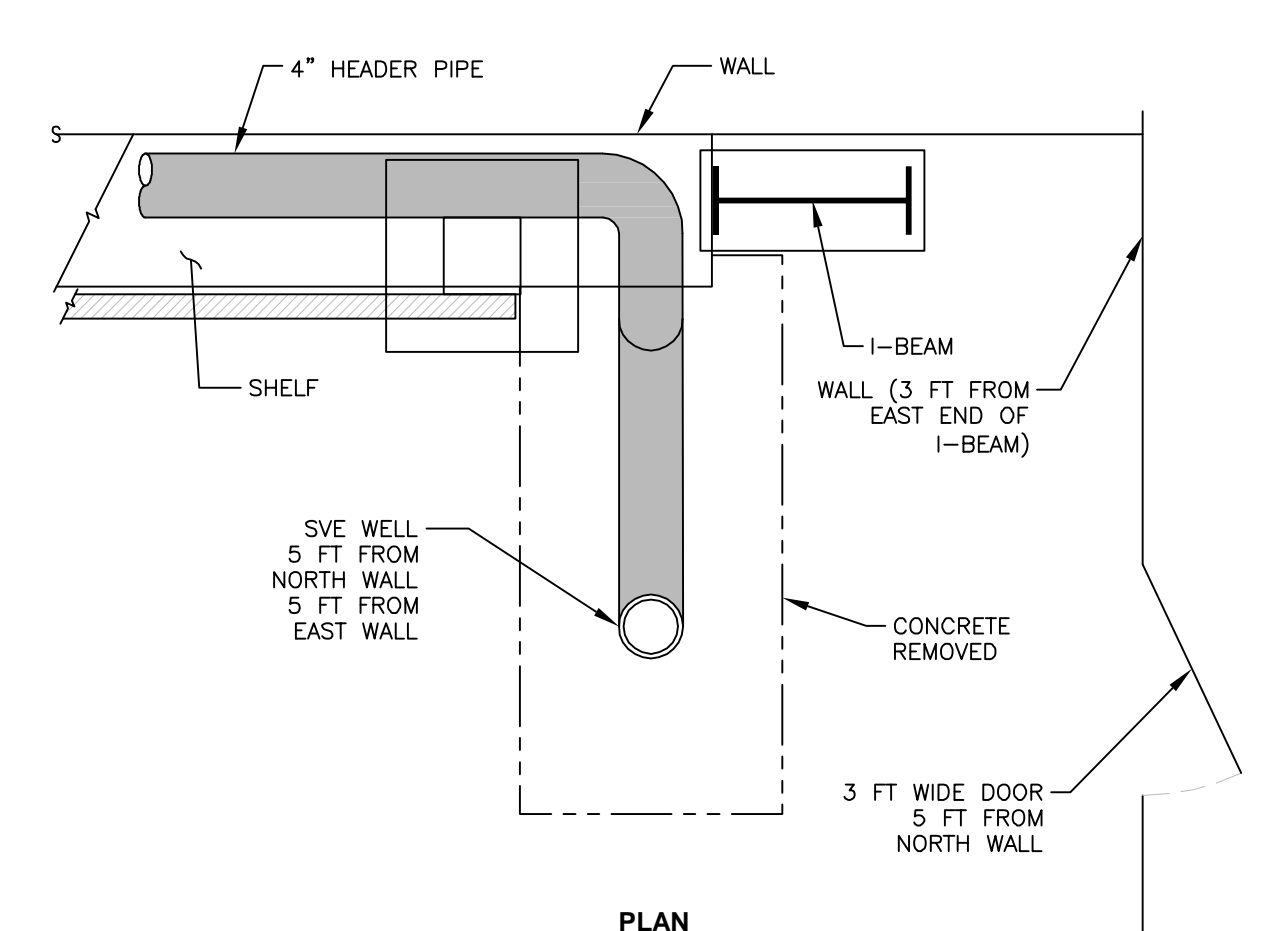


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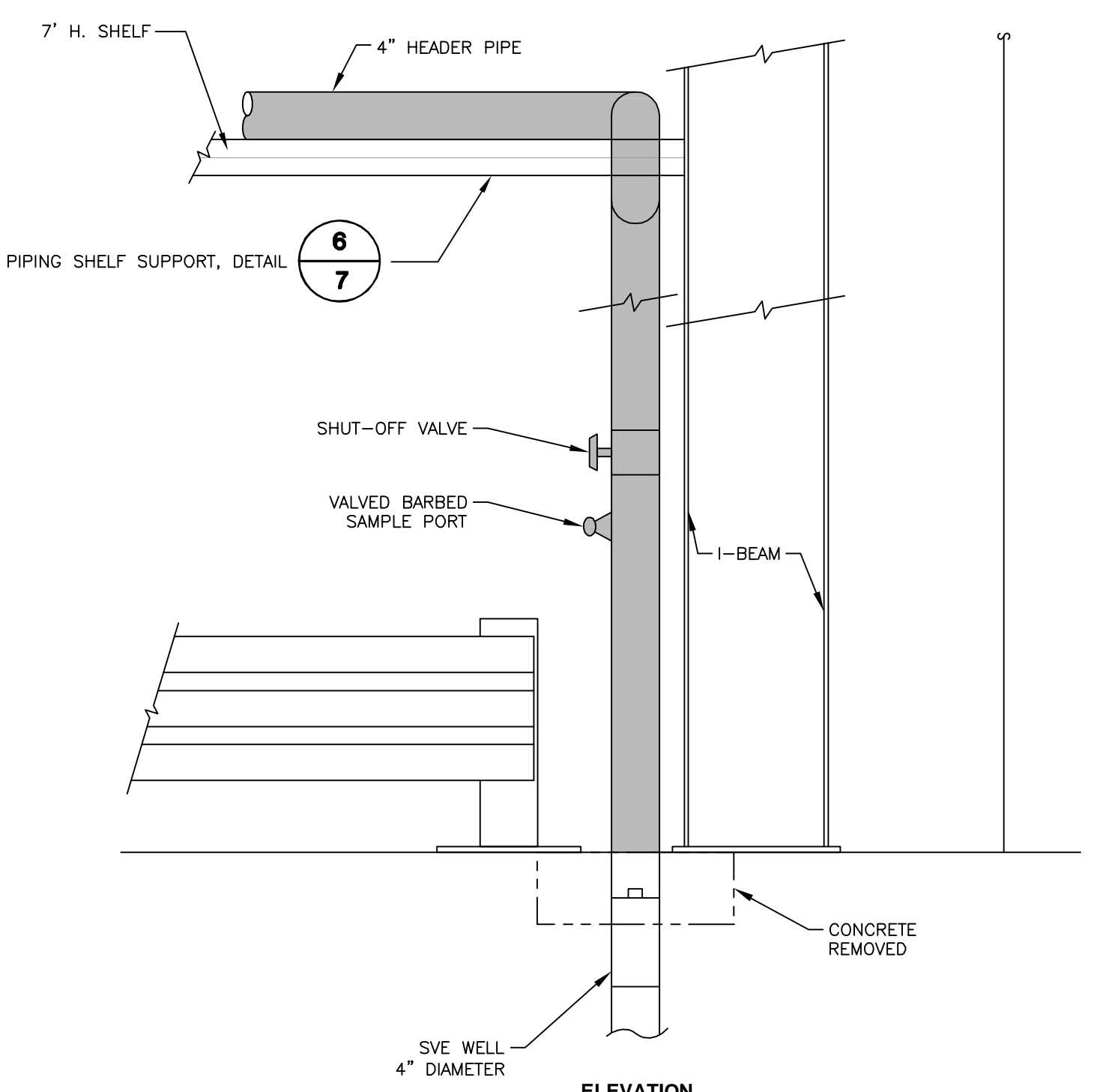


ELEVATION

3  
4  
SVE 3  
(NOT TO SCALE)



PLAN




ELEVATION

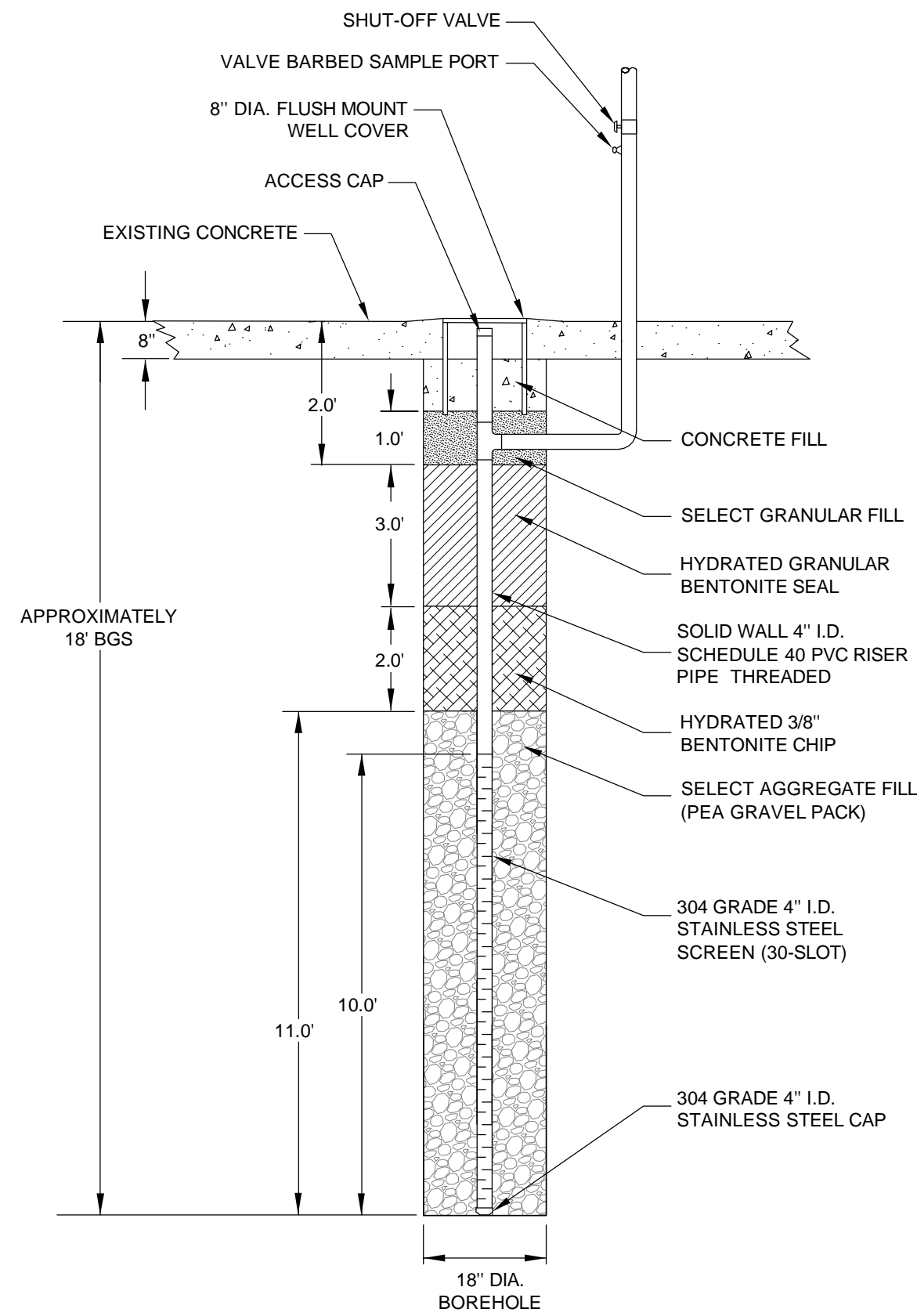
4  
4  
SVE 4  
(NOT TO SCALE)

NOTES:  
1. FOR TYPICAL WELL HEAD COMPLETION  
DETAILS FOR ALL SVE WELLS, SEE DETAIL

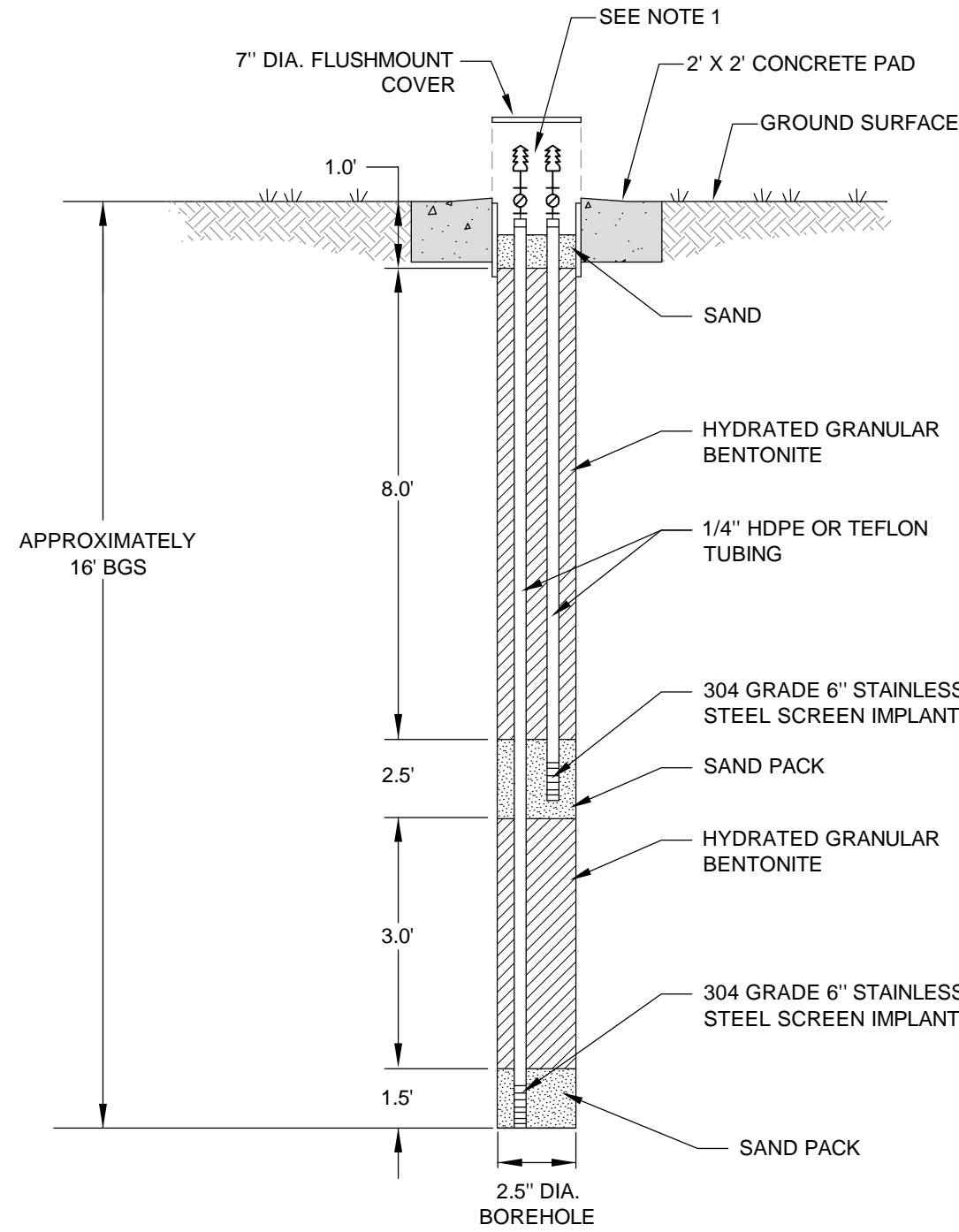
1  
7

3					
2					
1					
NO.	BY	DATE	REVISION		APPD
PROJ: PILOT SOIL VAPOR EXTRACTION SYSTEM DESIGN FORMER TECUMSEH PRODUCTS SITE TECUMSEH, MICHIGAN					
TITLE: RISER PIPE CONNECTION DIAGRAMS					
DRAWN BY: WAB		SCALE: AS INDICATED		PROJ. NO. 187156.0001.02	
CHECKED BY: SPISM		DATE PRINTED:		FILE NO. 187156.0001.06.dwg	
APPROVED BY: DM		DATE: APRIL 2012		SHEET 6 OF 7	
		1540 Eisenhower Place Ann Arbor, MI 48108 Phone: 734.971.7080 Fax: 734.971.9022			
		TRC			

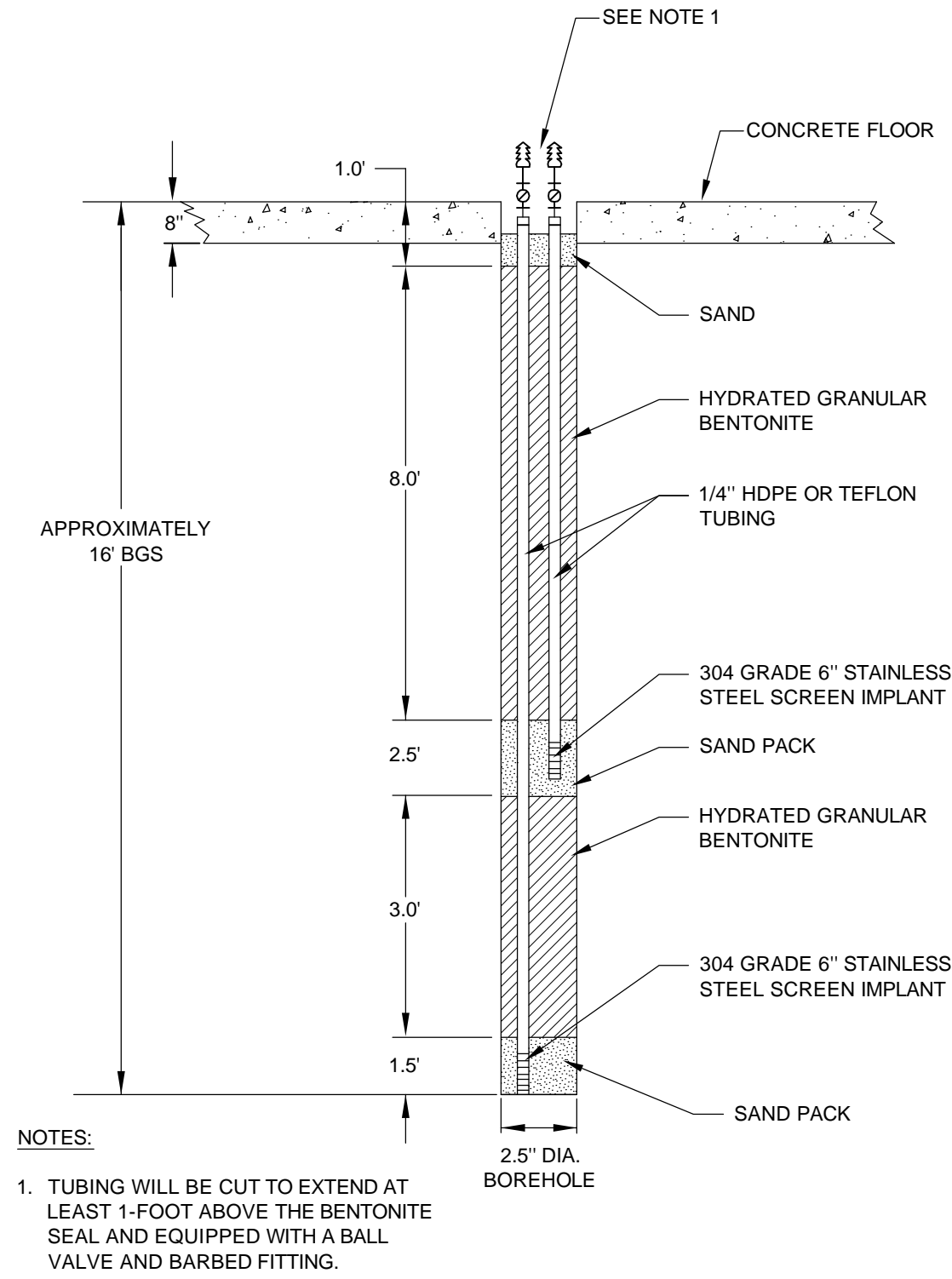




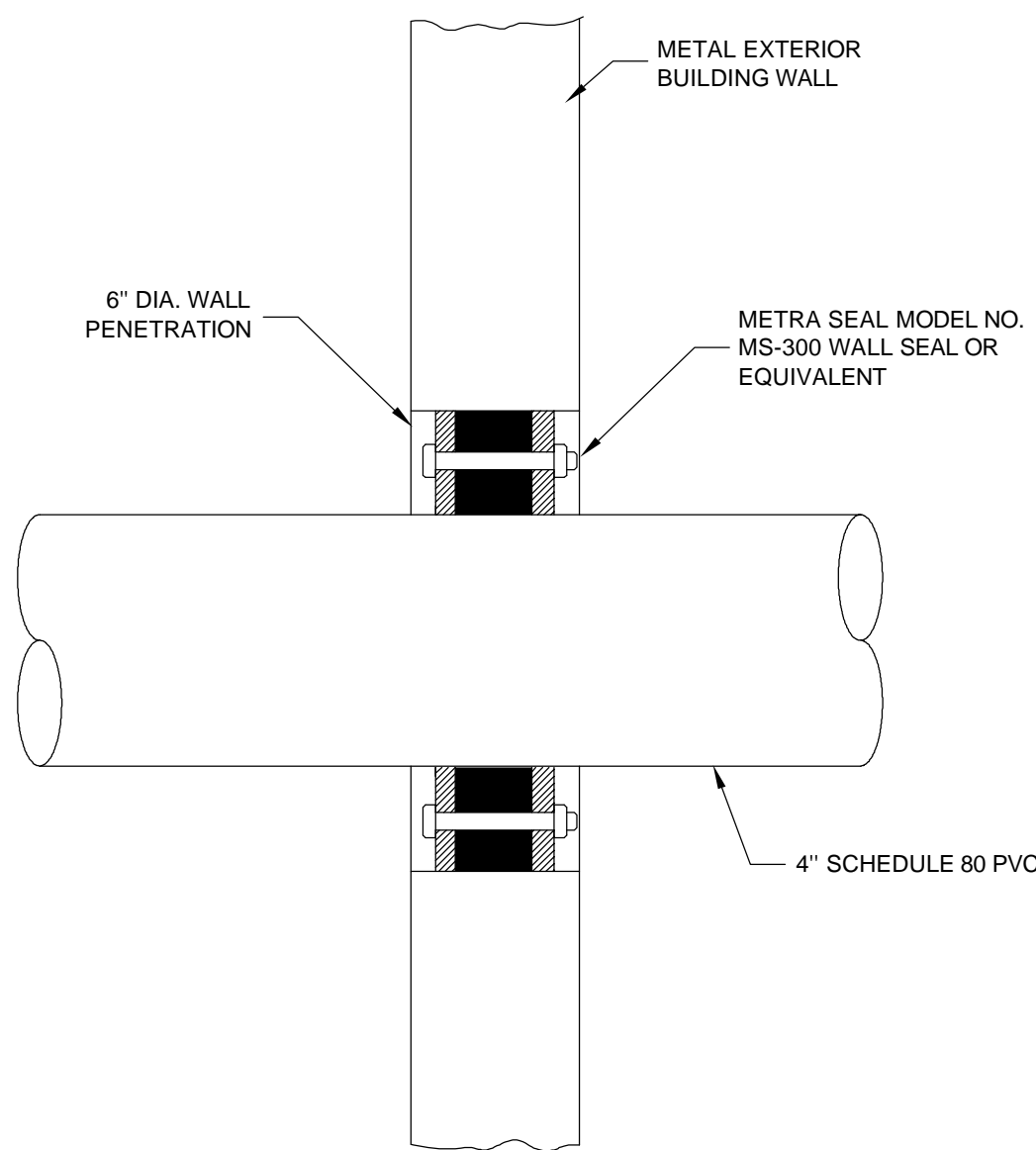
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(TYPICAL)**  
(NOT TO SCALE)



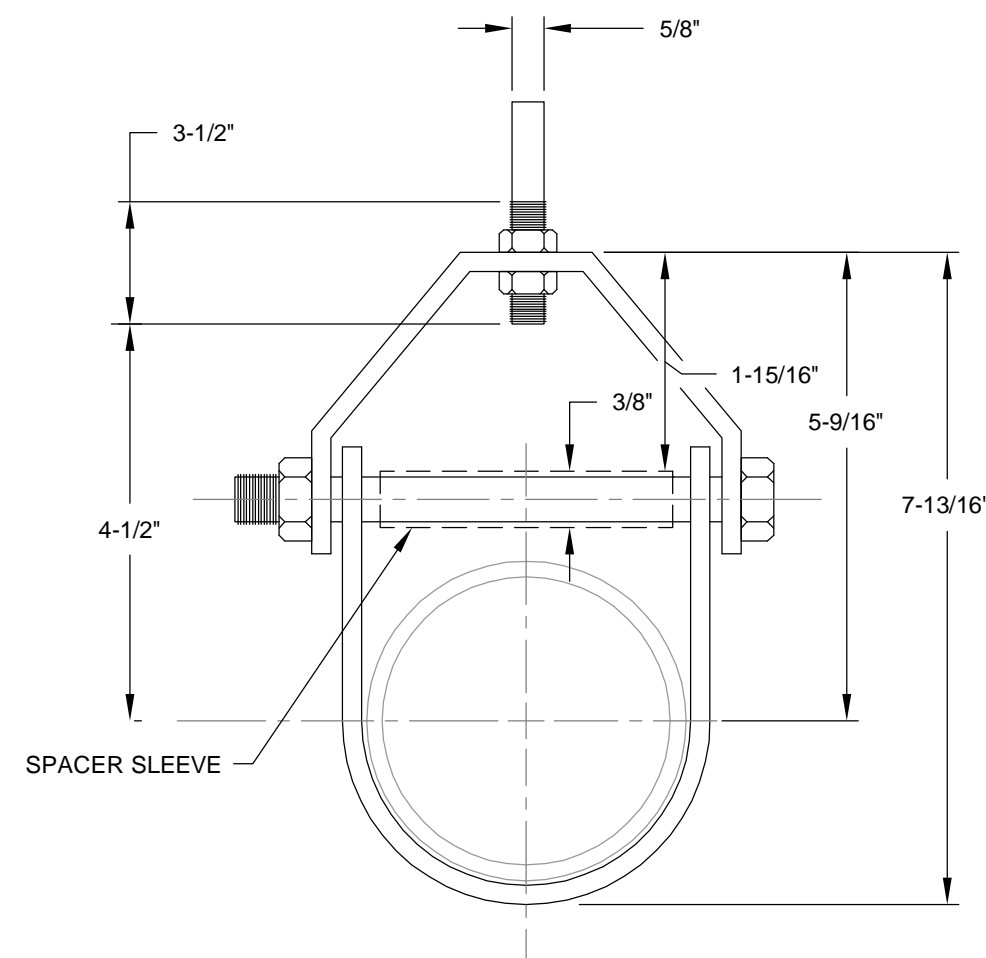
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(TYPICAL)**  
(NOT TO SCALE)



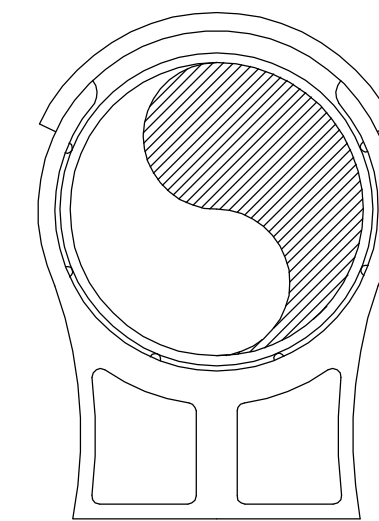
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(TYPICAL)**  
(NOT TO SCALE)



**PIPING WALL PENETRATION**  
(NOT TO SCALE)



**PIPING CEILING HANGER SUPPORT  
(TYPICAL)**  
(NOT TO SCALE)



COBRA PLASTIC PIPE CLIP #437348

**PIPING SHELF SUPPORT  
(TYPICAL)**  
(NOT TO SCALE)

3					
2					
1					
NO.	BY	DATE	REVISION	APP'D	
<b>PROJ: PILOT SOIL VAPOR EXTRACTION SYSTEM DESIGN FORMER TECUMSEH PRODUCTS SITE TECUMSEH, MICHIGAN</b>					
<b>TITLE: CIVIL DETAILS</b>					
DRAWN BY:	DGS	SCALE:	AS INDICATED	PROJ. NO.	187156.0001.02
CHECKED BY:	SPISM	DATE PRINTED:		FILE NO.	187156.0001.07.dwg
APPROVED BY:	DM	DATE:	APRIL 2012	<b>SHEET 7 OF 7</b>	
				1540 Eisenhower Place Ann Arbor, MI 48108 Phone: 734.971.7080 Fax: 734.971.9022	



# Appendix B

## Pipe Size Calculations

---



## Technical Memorandum

**To:** Dave McKenzie, TRC

**From:** Scott Pawlukiewicz, TRC

**Subject:** Pipe Size Calculation Summary for the Pilot Soil Vapor Extraction (SVE) System  
at P-Building of the former Tecumseh Products Company Site, Tecumseh, Michigan

**Date:** March 30, 2012

**cc:** Stacy Metz, TRC

---

This technical memorandum summarizes the methods, assumptions, and results of pipe size design calculations for the pilot soil vapor extraction (SVE) system to be installed at P-Building located along the northern perimeter of the former Tecumseh Products Company (TPC) site located at 100 East Patterson Street in Tecumseh, Michigan.

### Methodology

The Pilot SVE system pipe size calculations included in Table 1 use similar methods to those outlined in Section 5 of the reference document, *Engineering and Design- Soil Vapor Extraction and Bioventing* (US Army Corps of Engineers, 2002). System flow volumes of 200, 300, or 400 cubic feet per meter (cfm) through Sch. 80 PVC pipe with a diameter of 2-inch, 3-inch, 4-inch, or 6-inch were analyzed. The scenario analyzed assumes all flow is from the farthest extraction well location (SVE-4). This scenario represents a “worst-case” scenario to establish the maximum amount of potential system head loss for each pipe size and flow rate. Calculation specifics include:

- n Straight pipe friction loss ( $h_f$ ) was calculated using the Darcy-Weisbach equation.
- n Friction factors ( $f$ ), which were used to calculate straight pipe friction loss, were calculated using the Swamee-Jain equation using the calculated Reynolds number ( $Re$ ) and relative roughness ( $e/D$ ).
- n Minor losses ( $L_m$ ) due to valves and fittings were calculated using “equivalent length of straight pipe” values. The total minor loss equivalent length was added to the actual straight pipe length ( $L$ ) prior to calculating the pipe friction loss ( $h_f$ ).
- n Subsurface pneumatic losses were estimated using a linear relationship between flow rate ( $Q$ ) and the vacuum level induced at the wellhead ( $h_{well}$ ) assuming an estimated regression coefficient ( $a$ ).
- n Total Loss (Piping) was equal to the calculated pipe friction loss ( $h_f$ ) and converted from a pressure head (meters) to pressure loss (mm Hg and inches Hg).
- n Total Loss (Piping + Subsurface) was calculated as pipe friction loss ( $h_f$ ) plus subsurface pneumatic losses ( $h_{well}$ ) and converted from a pressure head (meters) to pressure loss (mm Hg and inches Hg).



## Technical Memorandum

Total calculated head loss values were then compared to the proposed pilot scale blower specifications (400 cfm, 10 inches Hg) to insure that calculated head loss does not exceed blower capacity.

### Assumptions

- n Air property constants (density, viscosity) were assumed to be at 20°C.
- n A specific roughness constant for plastic (PVC or ABS) pipe of 0.000005 ft was assumed.
- n Published PVC Sch. 80 inside pipe diameters were used for this analysis.
- n A total estimated pipe length of 406-feet was used based on the proposed pipe routing from the blower skid to SVE-4.
- n Minor loss equivalent length ( $L_e$ ) values varied based on the pipe diameter modeled.  $L_e$  values were obtained from the US Army Corps of Engineers reference document. Minor loss quantities ( $n$ ) for each fitting type were estimated based on the proposed pipe routing from the blower skid to SVE-4.
- n Subsurface pneumatic losses assumed a regression coefficient ( $\alpha$ ) of 400. This variable is usually determined from pilot scale testing for use in full system design; however, for pilot this pilot study design, a value within the range used in the US Army Corps of Engineers example problem (240 to 680) was assumed.
- n Losses due to valve adjustments (i.e., balancing flow) were not applicable for this analysis (i.e., 0 mm Hg).
- n Pressure loss induced by skid/blower components was assumed to be 1 inches Hg (25.4 mm Hg) based on information provided by the pilot SVE system supplier (ProAct).

### Results

Results of this pipe size analysis include:

- n 4-inch diameter Sch. 80 PVC pipe was selected for the pilot system pipe size. Calculated "Total Loss" due to piping (highlighted cells on the calculation sheet) using 4-inch diameter pipe at 400 cfm was 4.76 inches Hg. This value is below the capacity of the pilot scale blower (10 inches Hg).
- n 6-inch diameter Sch. 80 PVC pipe could be used as an alternative for the pipe network. Calculated "Total Loss" due to piping using 6-inch diameter pipe at 400 cfm was 1.62 inches Hg. This value is also below the capacity of the pilot scale blower (10 inches Hg); however, installation costs of 6-inch diameter pipe would be higher than installing 4-inch diameter pipe.
- n Calculated "Total Loss" for 2-inch and 3-inch diameter Sch. 80 PVC pipe at 400 cfm was 83.60 inches Hg and 14.06 inches Hg respectively, and exceeded the capacity of the pilot scale blower (10 inches Hg).



# Table



Table 1  
Pilot SVE System Design Calculations- Pipe Loss at Various Pipe Diameters and Flow Rates  
Former Tecumseh Products Company Site  
Tecumseh, Michigan

SHEET NOTES: Worst Case Analysis. All flow directed to SVE-4 well individually as part of the Pilot Test.

Date: 3/29/2012  
Performed By: S. Pawlukiewicz (3/27/12)  
Checked By: D. McKenzie (3/29/12)

	Units	Variable	Equation	2" Diameter Pipe at 200, 300, 400 cfm			3" Diameter Pipe at 200, 300, 400 cfm			4" Diameter Pipe at 200, 300, 400 cfm			6" Diameter Pipe at 200, 300, 400 cfm			Comments
Constants																
Density (kg/m <sup>3</sup> )	kg/m3	D		1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	at 20 °C, PE Ref. Manual Appendix 38.C
Viscosity (kg/m*s)	kg/m*s	V		1.82E-05	1.82E-05	1.82E-05	1.82E-05	1.82E-05	1.82E-05	1.82E-05	1.82E-05	1.82E-05	1.82E-05	1.82E-05	1.82E-05	at 20 °C, PE Ref. Manual Appendix 38.C
Gravity (m/s <sup>2</sup> )	m/s2	g		9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	
Spec. Roughness Constant	m	e		1.50E-06	1.50E-06	1.50E-06	1.50E-06	1.50E-06	1.50E-06	1.50E-06	1.50E-06	1.50E-06	1.50E-06	1.50E-06	1.50E-06	PE Ref. Manual Appendix 17.A (0.000005 ft for PVC)
Flow/Pipe Characteristics																
Flow (cfm)	cfm	Q		200	300	400	200	300	400	200	300	400	200	300	400	
Flow (L/s)	L/s	Q	cfm x 28.32 L/ft <sup>3</sup> x 1 min/60 s	94.4	141.6	188.8	94.4	141.6	188.8	94.4	141.6	188.8	94.4	141.6	188.8	
Flow (m3/s)	m <sup>3</sup> /s	Q	L/s x .001 m <sup>3</sup> /L	0.094	0.142	0.189	0.094	0.142	0.189	0.094	0.142	0.189	0.094	0.142	0.189	
Nom. Diameter (in.)	in.	d		1.939	1.939	1.939	2.900	2.900	2.900	3.826	3.826	3.826	5.761	5.761	5.761	PE Ref. Manual Appendix 16.D (Sch. 80 piping)
Nom. Diameter (m)	m	d		0.0492506	0.0492506	0.0492506	0.07366	0.07366	0.07366	0.0971804	0.0971804	0.0971804	0.1463294	0.1463294	0.1463294	
Internal Area (m <sup>2</sup> )	m2	A		0.002	0.002	0.002	0.004	0.004	0.004	0.007	0.007	0.007	0.017	0.017	0.017	
Velocity (m/s)	m/s	v		49.55	74.33	99.10	22.15	33.23	44.30	12.73	19.09	25.45	5.61	8.42	11.23	
Reynolds #		Re	Re = D x v x dens/visc.	1.62E+05	2.43E+05	3.24E+05	1.08E+05	1.63E+05	2.17E+05	8.22E+04	1.23E+05	1.64E+05	5.46E+04	8.19E+04	1.09E+05	
e/D	m/m	$\frac{e}{D}$		3.05E-05	3.05E-05	3.05E-05	2.04E-05	2.04E-05	2.04E-05	1.54E-05	1.54E-05	1.54E-05	1.03E-05	1.03E-05	1.03E-05	Calculated based on input Spec. Roughness and Diameter.
Friction Factor		f	$= 0.25 \log \left( \left[ \frac{e^{.10}}{3.7} \right] + \left[ \frac{5.74}{Re^{.90}} \right] \right)^{-2}$	0.016	0.015	0.015	0.018	0.016	0.015	0.019	0.017	0.016	0.020	0.019	0.018	PE Ref. Manual Swamee-Jain Equation 17.21
Length	ft	L		406	406	406	406	406	406	406	406	406	406	406	406	Estimated based on routing directly to SVE-4.
Length	m	L		123.75	123.75	123.75	123.75	123.75	123.75	123.75	123.75	123.75	123.75	123.75	123.75	
Minor Losses																
Equivalent Lengths																
90 deg. Elbow	m	L <sub>e</sub>		1.49	1.49	1.49	2.22	2.22	2.22	2.93	2.93	2.93	4.42	4.42	4.42	
Tee (str. Thru)	m	L <sub>e</sub>		0.99	0.99	0.99	1.48	1.48	1.48	1.96	1.96	1.96	2.95	2.95	2.95	
Tee (Branched)	m	L <sub>e</sub>		2.96	2.96	2.96	4.43	4.43	4.43	5.84	5.84	5.84	8.79	8.79	8.79	
Gate Valve	m	L <sub>e</sub>		0.40	0.40	0.40	0.59	0.59	0.59	0.78	0.78	0.78	1.18	1.18	1.18	
Globe Valve	m	L <sub>e</sub>		16.78	16.78	16.78	25.09	25.09	25.09	33.11	33.11	33.11	49.85	49.85	49.85	
Butterfly Valve	m	L <sub>e</sub>		2.22	2.22	2.22	3.32	3.32	3.32	4.38	4.38	4.38	6.60	6.60	6.60	
Expansion	m	L <sub>e</sub>		0.76	0.76	0.76	1.14	1.14	1.14	1.51	1.51	1.51	2.27	2.27	2.27	
Contraction	m	L <sub>e</sub>		0.40	0.40	0.40	0.59	0.59	0.59	0.78	0.78	0.78	1.18	1.18	1.18	
Quantities																
90 deg. Elbow	#	n		17	17	17	17	17	17	17	17	17	17	17	17	90-deg: 5 between system and SVE-1, 1 between SVE-1 and SVE-2, 4 between SVE-2 and SVE-3, 7 between SVE-3 and SVE-4
Tee (str. Thru)	#	n		2	2	2	2	2	2	2	2	2	2	2	2	
Tee (Branched)	#	n		2	2	2	2	2	2	2	2	2	2	2	2	
Gate Valve	#	n		0	0	0	0	0	0	0	0	0	0	0	0	Tee (str. Thru): 1 branch for SVE-1, 1 branch for SVE-3
Globe Valve	#	n		0	0	0	0	0	0	0	0	0	0	0	0	Tee (Branched): 1 branch for SVE-2, 1 branch for SVE-4
Butterfly Valve	#	n		1	1	1	1	1	1	1	1	1	1	1	1	
Expansion	#	n		0	0	0	0	0	0	0	0	0	0	0	0	
Contraction	#	n		0	0	0	0	0	0	0	0	0	0	0	0	
Minor Losses																
90 deg. Elbow	m	L <sub>m</sub>	= L <sub>e</sub> x n	25.28	25.28	25.28	37.81	37.81	37.81	49.89	49.89	49.89	75.12	75.12	75.12	
Tee (str. Thru)	m	L <sub>m</sub>		1.98	1.98	1.98	2.97	2.97	2.97	3.92	3.92	3.92	5.90	5.90	5.90	
Tee (Branched)	m	L <sub>m</sub>		5.92	5.92	5.92	8.85	8.85	8.85	11.68	11.68	11.68	17.59	17.59	17.59	
Gate Valve	m	L <sub>m</sub>		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Globe Valve	m	L <sub>m</sub>		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Butterfly Valve	m	L <sub>m</sub>		2.22	2.22	2.22	3.32	3.32	3.32	4.38	4.38	4.38	6.60	6.60	6.60	
Expansion	m	L <sub>m</sub>		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Contraction	m	L <sub>m</sub>		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Total Minor Losses Equivalent Length (m)	m	L <sub>m</sub>	= Σn x L <sub>e</sub>	35.41	35.41	35.41	52.96	52.96	52.96	69.87	69.87	69.87	105.20	105.20	105.20	
Friction Loss + Minor Loss																
TOTAL Equivalent Length (m)	m	L <sub>total</sub>	= L + Σn x L <sub>e</sub>	159.16	159.16	159.16	176.70	176.70	176.70	193.61	193.61	193.61	228.95	228.95	228.95	Darcy-Weisbach
Pressure Head (meters of air)	m	h <sub>f</sub>	=( f x L x v2)/(2 x d x g)	6644.42	13889.80	23507.02	1061.59	2205.98	3716.18	307.58	636.95	1070.27	51.26	105.65	176.94	
Pressure Loss (N/m2)	N/m <sup>2</sup>	h <sub>f</sub>	= h <sub>f</sub> (m) x D x g	78869.94	164873.27	279030.65	12601.16	26185.15	44111.42	3651.03	7560.72	12704.25	608.42	1254.09	2100.28	
Pressure Loss (mmHg)	mmHG	h <sub>f</sub>	= N/m <sup>2</sup> / 133	593.0071	1239.6487	2097.9748	94.7456	196.8808	331.6648	27.4514	56.8475	95.5207	4.5746	9.4292	15.7916	
Subsurface Pneumatic Losses																
Regr. Coefficient (a)		a		400	400	400	400	400	400	400	400	400	400	400	400	Should come from Pilot Study, estimated based on US Army Corps of Eng. SVE Design Manual Example Problem ranging from 240 to 680.
Subsurface Loss (mmHG)	mmHG	h <sub>well</sub>	= a x Q (m <sup>3</sup> /s)	37.76	56.64	75.52	37.76	56.64	75.52	37.76	56.64	75.52	37.76	56.64	75.52	
Pressure Loss induced by Closing Valves																
Valve Loss		h <sub>valve</sub>		0	0	0	0	0	0	0	0	0	0	0	0	Use this section to balance flows by closing well valves.
Pressure Loss induced by Skid/Blower Components																
Blower Silencer, Filters, etc. (1" Hg)	mmHG			25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	
Carbon Filters (add'tl 1" hg)				0	0	0	0	0	0	0	0	0	0	0	0	No carbon filters expected.
TOTAL LOSS (PIPING)	mmHG	= h <sub>f</sub> + h <sub>valve</sub>		618.41	1265.05	2123.37	120.15	222.28	357.06	52.85	82.25	120.92	29.97	34.83	41.19	Calculated total loss compared to proposed pilot scale blower ( Operates at 400 cfm @ 10" Hg ). Compare values to 10" Hg to verify correct pipe sizing.
	inch HG	=mmHG / 25.4		24.35	49.81	83.60	4.73	8.75	14.06	2.08	3.24	4.76	1.18	1.37	1.62	
TOTAL LOSS (PIPING + SUBSURFACE)	mmHG	= h <sub>f</sub> + h <sub>well</sub> + h <sub>valve</sub>		656.17	1321.69	2198.89	157.91	278.92	432.58	90.61	138.89	196.44	67.73	91.47	116.71	Calculated total loss (piping + subsurface).
	inch HG	=mmHG / 25.4		25.83	52.03	86.57	6.22	10.98	17.03	3.57	5.47	7.73	2.67	3.60	4.59	

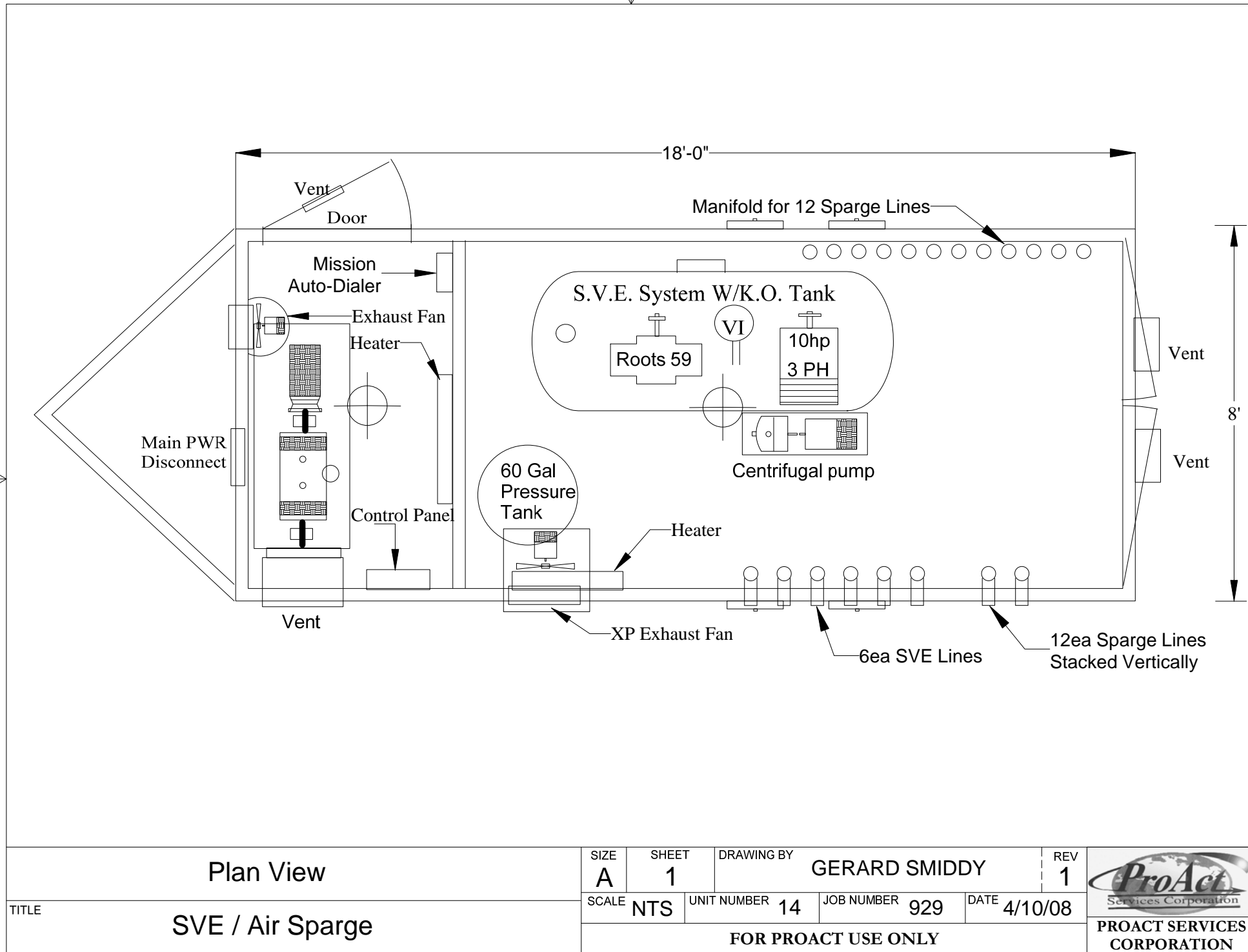


# Appendix C

## Blower Specifications

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800-536-9933

www.pdblowers.com

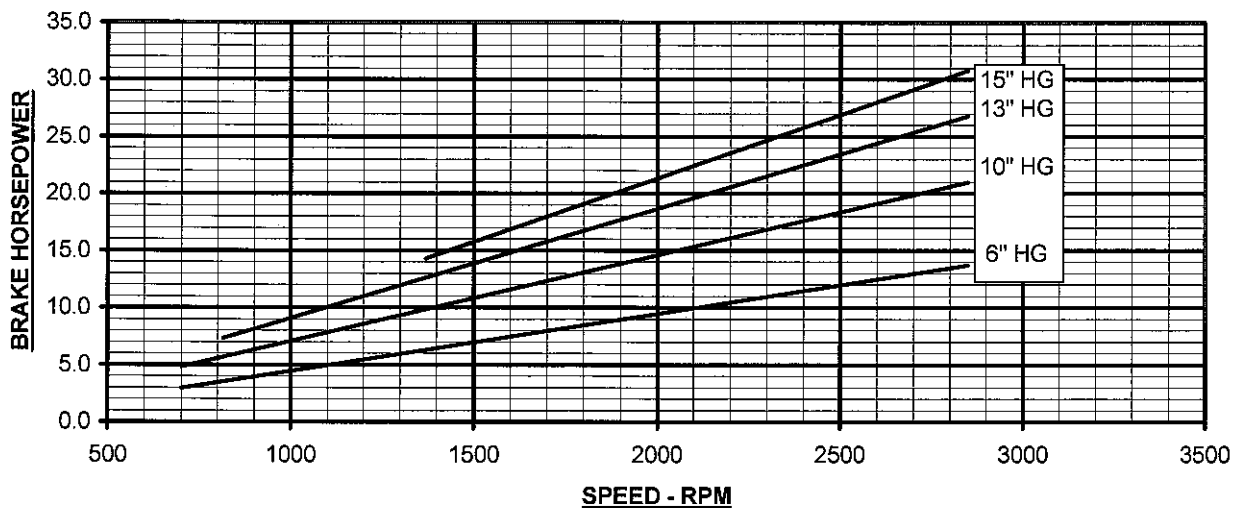
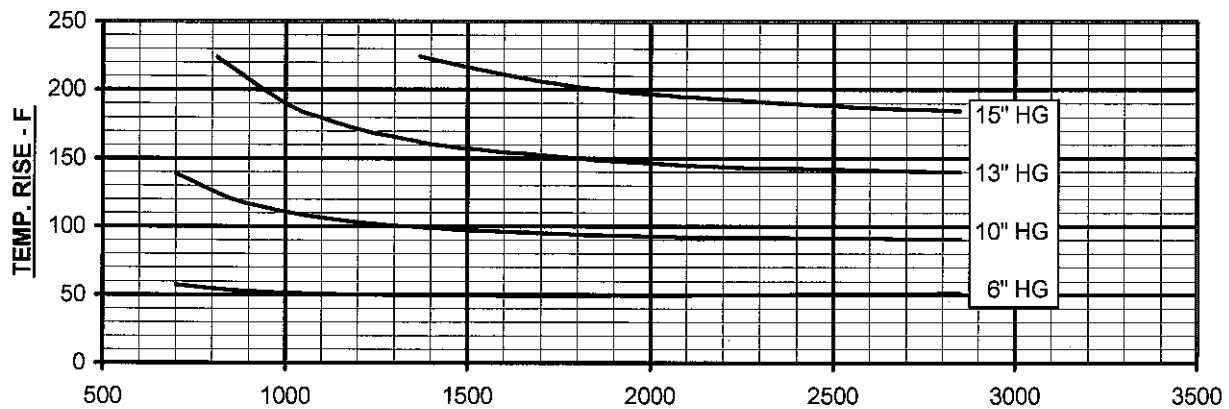
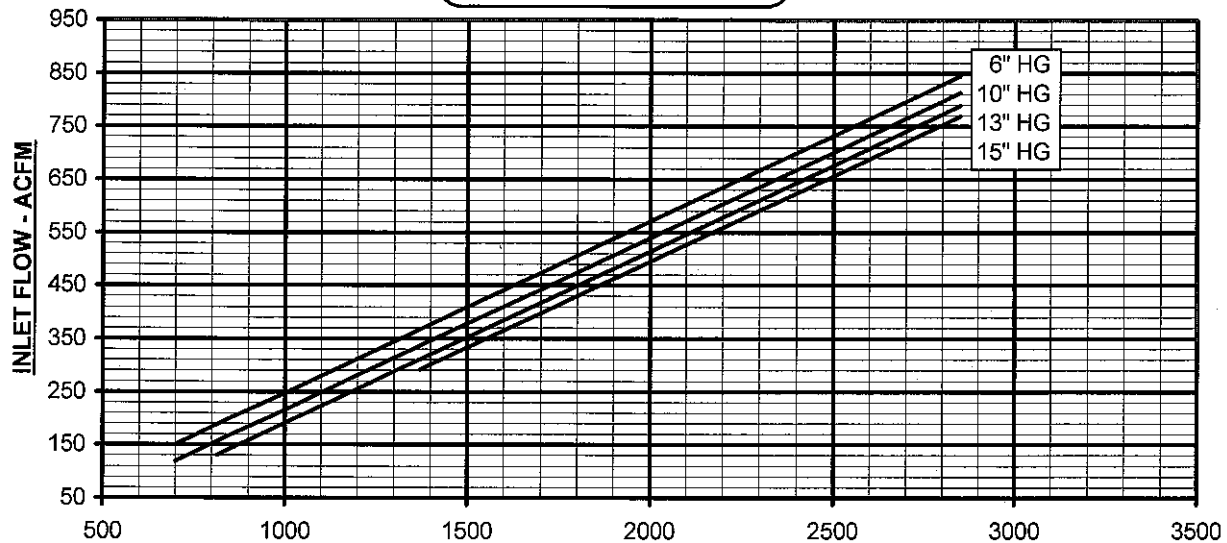
**VACUUM PERFORMANCE**

**FRAME 59 U-RAI**

MAX. VACUUM = 15" HG

MAX. SPEED = 2850 RPM

PERFORMANCE BASED ON AIR,  
INLET AT 68°F  
DISCHARGE PRESSURE = 30" HG ABS.  
DECEMBER 2004



VC-12-59



# Appendix D

## Air Permit Calculations

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TRC Environmental Corporation  
1540 Eisenhower Place  
Ann Arbor, MI 48108

Main 734-971-7080  
Fax 734-971-9022

## Technical Memorandum

**To:** File

**From:** Colin Daining, Project Engineer

**Subject:** Permit to Install (PTI) Exemption Determination to Operate Sub-Slab  
Depressurization/Soil Vapor Extraction (SVE) System Pilot Test

**Date:** March 16, 2012

**cc:** Stacy Metz, Dave McKenzie, and Graham Crockford; TRC Environmental Corp.

**Project No.:** 187156.0001.0000

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### Introduction

TRC intends to install a sub-slab ventilation/soil vapor extraction (SVE) system at the former Tecumseh Products Company facility in Tecumseh, Michigan. Prior to installation of the full-scale system, a pilot test will be performed to determine full-scale design parameters including:

- n soil gas extraction rate for vacuum extraction wells
- n anticipated radius of influence based on applied vacuum
- n VOC mass extraction rates, including determining the necessity of air permitting and/or implementation of emission controls in full-scale system design and operation.

### Permits to Install (PTI) Exemption Determination

The proposed pilot SVE system, consisting of four soil gas extraction wells, has potential to emit volatile air contaminants, including carcinogenic volatile organic compounds (VOCs) and hazardous air pollutants (HAPs) into the atmosphere, and therefore may be subject to Michigan R336.1201 "Permits to Install (PTI)" (Michigan Rule 201). TRC performed a determination in accordance with R226.1278a(1)c (Michigan Rule 278a), described herein, to assess whether the pilot test emission unit is exempt from PTI requirements, as defined in R336.1290 "Permit to Install Exemptions; Emission Units with Limited Emissions" (Michigan Rule 290). See Attachment 1.

An estimate of extracted soil gas concentration during the proposed pilot test was developed for each constituent of concern based on previously collected sub-slab vapor concentrations



## Technical Memorandum

measured in 2009 and 2010 (see Table 1). The average calculated concentrations for each constituent were categorized as carcinogenic and/or as a hazardous air pollutant (HAP), and then totaled accordingly. Using 20 pounds per month (lbs/mo) as an exemption limit for a maximum “uncontrolled” emission rate for total carcinogenic VOCs (see R336.1290(a)(ii)(C)), TRC calculated an estimated maximum air flow of 279 standard cubic feet per minute (SCFM) for the pilot test (see Table 2).

Given an air flow of 279 SCFM, no Rule 278 criteria were exceeded, thus no Prevention of Significant Deterioration (PSD) requirements were exceeded. The total potential to emit, assuming the aforementioned air flow, is not greater than 10 tons per year of any HAP or 25 tons per year of any combination of HAP, and therefore does not meet the definition and requirements of a “Major Source” as defined in 40 CFR 63.2 National Emission Standards for Hazardous Air Pollutants for Source Categories, and therefore will not be subject to the federal Site Remediation MACT rules (40 CFR 63 Subpart GGGGG).

Also, based on available information, the facility has no existing air permits, and therefore, has no current permit limitations.

### PTI Exemption Verification

During the pilot test flow rate and gas concentrations data should be collected to confirm compliance with the PTI exemption requirements. Total VOC emissions will be determined by measuring flow rate and VOC concentration at each emission source, including the proposed SVE system, the S-Building sub-slab depressurization/ventilation system, and the methane ventilation system. The three emissions sources will be combined to determine the cumulative monthly facility emissions.

Based on the cumulative facility emissions, the maximum allowable SVE system air flow rate will be recalculated. If cumulative monthly VOC-emissions exceed the 20 pound per month limit<sup>1</sup> (i.e. measured concentrations are higher than predicted), the SVE system flow will be reduced to meet PTI exemption requirements, until an emission treatment system is installed and/or an air permit is obtained. If cumulative monthly VOC-emission do not exceed the 20 pound per month limit (i.e. the total system flow is less re-calculated maximum allowable flow), SVE pilot system flow rates may be increased.

VOC concentrations are expected to decline overtime. Therefore, VOC-concentration data collected during the first week of pilot SVE system operation should provide a conservative estimate of maximum allowable air flow rate for the PTI exemption. However the addition of new extraction wells during expansion to a full-scale system will likely affect to VOC concentration data. Even if the PTI exemption is confirmed for the pilot test, PTI exemption verification as outlined above should be repeated for the full-scale SVE system.

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<sup>1</sup> A total of 20 pounds per month of carcinogenic VOCs, in accordance with R336.1290.



# Attachment 1

## R336.1290 – Permit to Install Exemptions

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***R 336.1290 Permit to install exemptions; emission units with limited emissions.***

*Rule 290. The requirement of R 336.1201(1) to obtain a permit to install does not apply to any of the emission units listed in (a) if the conditions listed in (b), (c), and (d) are met. Notwithstanding the definition in R 336.1121(a), for the purpose of this rule, uncontrolled emissions are the emissions from an emission unit based on actual operation, not taking into account any emission control equipment. Controlled emissions are the emissions from an emission unit based on actual operation, taking into account the control equipment.*

*(a) An emission unit which meets any of the following criteria:*

*(ii) Any emission unit that the total uncontrolled or controlled emissions of air contaminants are not more than 1,000 or 500 pounds per month, respectively, and all of the following criteria are met:*

*(A) For noncarcinogenic air contaminants, excluding noncarcinogenic volatile organic compounds and noncarcinogenic materials which are listed in R 336.1122(f) as not contributing appreciably to the formation of ozone, with initial threshold screening levels greater than or equal to 2.0 micrograms per cubic meter, the uncontrolled or controlled emissions shall not exceed 1,000 or 500 pounds per month, respectively.*

*(B) For noncarcinogenic air contaminants, excluding noncarcinogenic volatile organic compounds and noncarcinogenic materials which are listed in R 336.1122(f) as not contributing appreciably to the formation of ozone, with initial threshold screening levels greater than or equal to 0.04 micrograms per cubic meter and less than 2.0 micrograms per cubic meter, the uncontrolled or controlled emissions shall not exceed 20 or 10 pounds per month, respectively.*

*(C) For carcinogenic air contaminants with initial risk screening levels greater than or equal to 0.04 micrograms per cubic meter, the uncontrolled or controlled emissions shall not exceed 20 or 10 pounds per month, respectively.*

*(D) The emission unit shall not emit any air contaminants, excluding noncarcinogenic volatile organic compounds and noncarcinogenic materials which are listed in R 336.1122(f) as not contributing appreciably to the formation of ozone, with an initial threshold screening level or initial risk screening level less than 0.04 micrograms per cubic meter.*

*(b) A description of the emission unit is maintained throughout the life of the unit.*

*(c) Records of material use and calculations identifying the quality, nature, and quantity of the air contaminant emissions are maintained in sufficient detail to demonstrate that the emissions meet the emission limits outlined in this rule.*

*(d) The records are maintained on file for the most recent 2-year period and are made available to the air quality division upon request.*



# Tables

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Table 1  
Sub-Slab Soil Gas VOC Concentration Data  
Proposed SVE System for P-Building  
Former Tecumseh Products Company Site, Tecumseh, Michigan

Well ID	2009 Results					2010 Results					Average Extraction Well VOC Concentration For All Points
	SV-07	SV-08	SV-09	SV-10	SV-18	SV-07	SV-08	SV-09	SV-10	SV-18	
Date Sampled	10/29/09	10/29/09	10/29/09	10/29/09	10/29/09	1/5/10	1/5/10	1/5/10	1/5/10	1/5/10	
1,1,1-Trichloroethane	<321	<280	<321	<290	324	152	185	59.8	<29.4	91.3	205
1,1-Dichloroethane	<321	<280	<321	<290	2,910	119	33.5	<17.5	<29.4	762	508
1,2-Dichloroethane	<321	<280	<321	<290	<310	<17.5	<17.5	18	<29.4	<17.5	162
cis-1,2-dichloroethene	1,030	<280	<321	<290	313	806	225	<17.5	<29.4	138	345
TCE	4,120	13,400	510	<290	11,100	1,720	2,370	453	644	6,820	4,143
Tetrachloroethene	<321	<280	<321	<290	<310	<17.5	<17.5	<17.5	<29.4	<17.5	162
Vinyl Chloride	<315	<274	<315	<284	<304	<17.1	<17.1	<17.1	<28.8	<17.1	159

Notes:

1. Concentrations are in parts per billion by volume (ppb<sub>v</sub>).
2. When calculating average concentrations, non-detects were treated as equivalent to the reporting limit (as shown in red).
3. Soil gas sampling method includes sample collection in summa canisters for analysis using USEPA Method TO-15.



Table 2  
VOC AND Toxic Air Contaminants Potential Emission Calculations  
Proposed SVE System for P-Building  
Former Tecumseh Products Company Site, Tecumseh, Michigan

Exemption Requirements

- Total Uncontrolled Carcinogenic VOCs                      20 lbs/month      0.000456621 lbs/min<sup>1</sup>
- Total Uncontrolled Air Contaminants                      1000 lbs/month      0.02283105 lbs/min<sup>1</sup>
- Initial Risk Screening Level (IRSL) must be equal to or greater than 0.04 ug/m<sup>3</sup>

Contaminant	Molecular Weight	HAP	IRSL	Carcinogenic	Average Vapor Point Concentration			Maximum Allowable Uncontrolled Flow	Uncontrolled Emission Rate		
	g/g-mol		(ug/m3)		(ppbv)	(mg/m <sup>3</sup> )	(lbs/scf)	(scfm) <sup>2</sup>	(lbs/hr)	(lbs/mo) <sup>3</sup>	(tpy) <sup>4</sup>
<b>Total Carcinogenic VOC</b>					5.13E+03	2.62E+04	1.64E-06	<b>279.0</b>	2.74E-02	20.00	<b>0.12</b>
<b>Total Air Contaminants</b>					5.68E+03	2.87E+04	1.79E-06	<b>12751.6</b>	3.00E-02	21.88	<b>0.13</b>
<b>Total HAP</b>					5.18E+03	2.69E+04	1.68E-06		2.81E-02	20.54	<b>0.12</b>
<b>Trichloroethylene</b>	131.39	Yes	0.2	Yes	4.14E+03	2.20E+04	1.38E-06		2.30E-02	16.81	<b>0.10</b>
<b>1,1-Dichloroethane</b>	98.96	No	None	Yes	5.08E+02	2.04E+03	1.27E-07		2.13E-03	1.55	<b>0.01</b>
<b>1,2-Dichloroethane</b>	98.96	No	0.04	Yes	1.62E+02	6.50E+02	4.06E-08		6.79E-04	0.50	<b>2.97E-03</b>
<b>1,1,1-Trichloroethane</b>	133.42	No	None	No	2.05E+02	1.11E+03	6.93E-08		1.16E-03	0.85	<b>5.08E-03</b>
<b>Tetrachloroethylene</b>	165.83	Yes	1.7	Yes	1.62E+02	1.09E+03	6.80E-08		1.14E-03	0.83	<b>4.98E-03</b>
<b>cis-1,2-dichloroethene</b>	96.94	No	None	No	3.45E+02	1.35E+03	8.45E-08		1.42E-03	1.03	<b>6.20E-03</b>
<b>Vinyl Chloride</b>	62.50	Yes	0.11	Yes	1.59E+02	4.02E+02	2.51E-08		4.20E-04	0.31	<b>1.84E-03</b>

Notes:

1. Assumes 8,760 hr/yr and 730 hr/mo.
2. SCFM = standard cubic feet per minute (at 68°F and 1 atm)
3. Potential emissions based on operation at avg. soil gas conc. (lb/scf) x max. flow rate (scfm) x 60 min/hr x 8,760 hr/yr x yr/12 months.
4. Potential emissions based on operation at avg. soil gas conc. (lb/scf) x max. flow rate (scfm) x 60 min/hr x 8,760 hr/yr x ton/2000 lb.