Solutia Inc.
575 Maryville Centre Drive
St. Louis, Missouri 63141

Tel: 314-674-3312
Fax: 314-674-8808

gmrina@solutia.com

September 30, 2011

Mr. Kenneth Bardo - LU-9J VIA FEDEX
U.S. EPA Region V
Corrective Action Section
77 West Jackson Boulevard
Chicago, IL 60604-3507

Re: 100% Soil Vapor Extraction System Design
Big Mo & Former Benzene Pipeline Areas
Solutia Inc., W. G. Krummrich Plant, Sauget, IL

Dear Mr. Bardo:

Enclosed please find the subject document regarding full-scale implementation of soil vapor extraction (SVE) in the referenced areas at Solutia Inc.'s W. G. Krummrich Plant, Sauget, IL.

The "Final Decision" dated February 26, 2008, for the W. G. Krummrich Plant requires in part that, in a "Construction Completion Report," "a registered professional engineer and the Solutia Project Manager shall certify that the remedy for [volatile organic compound]-contaminated soil has been conducted in accordance with the U.S. EPA-approved final design and specifications, to the best of their knowledge ...." The enclosed document is intended to be that "final design and specifications" to serve as the basis for that certification for the Big Mo and Former Benzene Pipeline Areas. (Per the "Work Plan for Full-Scale Soil Vapor Extraction" submitted on November 1, 2010, similar "final designs and specifications" for the North Tank Farm and Little Mo SVE treatment areas will be submitted in 2012 and 2016, respectively.)

Per the "Semiannual Progress Report" submitted on September 15, 2011, well drilling for the Big Mo and Former Benzene Pipeline Areas was completed as of September 9, 2011. Construction of the associated remediation systems is now under way.

Per the enclosed document:

- a "Construction Completion Report," including as-built drawings signed and stamped by a registered professional engineer and the above certification, for the Big Mo and Former Benzene Pipeline Areas are scheduled to be submitted in February 2012; and
- an "Interim Completion Report" for the Big Mo and Former Benzene Pipeline Areas, including the additional certification required by the "Final Decision" that "remediation objectives have been attained," is scheduled to be submitted in March 2016.

Lastly, per the "Semiannual Progress Report" submitted on September 15, 2011, "final designs and specifications" (similar to the enclosed) for the thermally enhanced soil vapor extraction (T-SVE) and enhanced aerobic bioremediation (EABR) systems for the Former Chlorobenzene Process Area (CPA) are scheduled to be submitted by October 31, 2011.

If you have any questions regarding this submittal, please contact me at (314) 674-3312 or gmrina@solutia.com

Sincerely,

Gerald M. Rinaldi

Gerald M. Rinaldi
Manager, Remediation Services

Enclosure

cc: Distribution List

DISTRIBUTION LIST

100% Soil Vapor Extraction System Design
Big Mo & Former Benzene Pipeline Areas
Solutia Inc., W. G. Krummrich Plant, Sauget, IL

XDD, LLC

Scott Crawford	22 Marin Way, Stratham, NH 03885
Jaydeep Parikh, P.E.	101 East Mill Street, Quakertown, PA 18951

Solutia

Bill Johnson	575 Maryville Centre Drive, St. Louis, MO 63141
Brett Shank	500 Monsanto Avenue, Sauget, IL 62206

100% SOIL VAPOR EXTRACTION SYSTEM DESIGN BIG MO & FORMER BENZENE PIPELINE AREAS

W.G. KRUMMRICH FACILITY
SAUGET, ILLINOIS

Prepared For:

SOLUTIA INC.
575 Maryville Centre Drive
St. Louis, MO 63141

Prepared By:

XDD, LLC
22 Marin Way
Stratham, New Hampshire 03885
Tel: (603) 778-1100
Fax: (603) 778-2121

September 2011

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES
(CONTINUED)

LIST OF APPENDICES

Executive Summary

XDD, LLC (XDD) has prepared this 100% Soil Vapor Extraction (SVE) system design document (SVE design document) for the remediation of unsaturated zone soil impacts at the former Big Mo and Benzene Pipeline areas of the Solutia Inc. (Solutia) W.G. Krummrich Facility in Sauget, Illinois ("the site", or "the Plant").

Treatment Areas: The areas targeted for SVE treatment include the Former Benzene and Chlorobenzene Storage area (Big Mo area), the Former Benzene Pipeline area, the North Tank Farm/Former Overhead Steamer Tank area, and the Near Little Mo area. The target treatment areas are shown on **Figure 1**. This SVE design document is limited to the application of SVE at the Big Mo and Former Benzene Pipeline areas. The primary contaminants of concern (COCs) are benzene and chlorobenzene.

Geology and Hydrogeology: Geology at the Big Mo and Former Benzene Pipeline treatment areas consists of three major soil units:

- Sandy fill/upper silty sand layer (extending from ground surface to approximately 10 feet below ground surface [feet bgs]).
- Intermediate silty clay layer (encountered between 5 to 12 feet bgs). In some areas the intermediate silty clay layer was not detected.
- Lower silty sand layer (encountered below the silty clay layer to a depth of approximately 15 feet bgs).

Groundwater levels typically range from 10 feet bgs to greater than 15 feet bgs. Water levels are directly influenced by the level of the Mississippi River (located approximately one mile west of the site). Due to fluctuations of groundwater levels, it is anticipated that portions of the lower silty sand layer will be submerged seasonally.

Overview of SVE Design and Operational Strategy:

- The SVE system is designed to treat only the sandy fill/upper silty sand and lower silty sand layers. Separate SVE wells (76 shallow and 82 deep screen intervals) will be installed at 40-foot on-center spacing for each of these soil layers.
- The intermediate silty clay will not be directly targeted as the soil permeability in this unit is too low for SVE technology to be effective (as discussed in the *Soil Vapor Extraction Pilot Test Report*, dated November 2010).
- The SVE system will include an air injection (AI) component. A total of 74 SVE wells will be configured so that they can be operated in an AI mode. Air injection provides a source of clean air to the subsurface which improves the overall air flushing performance. This is particularly advantageous for the lower silty sand layer because the overlying silty clay unit could potentially limit the amount of surface air infiltration and affect the SVE performance in this layer (as discussed in the *Soil Vapor Extraction Pilot Test Report*).
- The SVE system will be operated in one of the two target soil layers at a given time. Seasonal fluctuations of the water table will not allow continuous operation in the lower silty sand layer; therefore, it is more cost-effective to design the SVE system to focus on one target layer at a time. In addition, as SVE treatment progresses, it is typical that some areas will clean up faster. During system optimization, those areas which have achieved cleanup can be taken offline, and the system resources can be refocused in both the deep and shallow areas concurrently.

- Upon completion of the SVE operations, bioventing (BV) will potentially be used as an additional treatment measure. BV involves injection of ambient air to enhance aerobic biodegradation of COCs remaining within low permeability layers within the unsaturated zone. This process will rely on both oxygen diffusion into the low permeability layers, and COCs diffusing out of the low permeability layers into the aerobic unsaturated zone, to potentially achieve additional COC mass reduction. The SVE equipment will be modified as necessary to perform BV operations.

SVE Design Modeling: SVE pilot testing results from the Big Mo area were used as the design basis for this full-scale SVE system. Two-dimensional (2-D) and three-dimensional (3-D) computer air flow models were used to design the SVE well placement/spacing:

- SVE well placement was based upon a Radius of Influence (ROI) evaluation using the 2-D model. The ROI is the maximum distance from a single SVE well where a minimum amount of air flushing occurs. The minimum flushing rate is expressed as a pore volume exchange rate (PV per year). Based on the modeling, a typical design target of 500 to 1,000 PV/year can be achieved at an ROI of 20 to 25 feet.
- The 3-D modeling was then performed to confirm that a minimum pore air velocity of 0.01 centimeters per second (cm/s) would occur throughout the target layer. This pore air velocity is equivalent to the 500 to 1,000 PV/year exchange rates. Note that the 2-D ROI analysis is based upon a single SVE well. When multiple SVE wells are operated together, there is some competition for the available pore air in the subsurface. In addition, the presence of the intermediate silty clay layer could further limit surface air infiltration to the lower silty sand layer, thus affecting the net pore volume exchange rate. The 3-D modeling confirmed that the target minimum pore air velocity can be achieved throughout the majority of the target layers.
- For the types of COCs being treated (i.e. primarily benzene), an overall air flushing target of 2,000 to 3,000 pore volumes is typical. The SVE system was designed to achieve this

overall flushing target within three to four years of operation (accounting for alternating periods of operation within the sandy fill/upper silty sand and the lower silty sand layers).

Remediation Objectives: The overall remediation objective is to reduce COC mass within the Big Mo and Former Benzene Pipeline areas. Achievement of the remediation objectives will be determined based upon the cumulative mass removal rate of COCs approaching an asymptotic condition. In turn, this will be based upon the vapor-phase COC concentration in the SVE system discharge dropping below 10% of the initial baseline vapor-phase COC concentration for a period of greater than seven consecutive calendar days.

SVE Shutdown and Potential Transition to BV Mode: When the SVE system achieves an asymptotic mass removal condition, there will be little additional benefit of continuing SVE operations. At this point, an evaluation of potential impacts to underlying groundwater and/or potential human health risks associated with the residual COC concentrations remaining in the unsaturated zone soils will be conducted. Based on the results of the risk evaluations, there are two potential options:

1. If the risk evaluations indicate that there is an acceptable level of risk and/or residual risks can be addressed by institutional controls, then a recommendation would be made to shutdown the SVE system.
2. If the risk evaluations indicate the need for further action, and BV can potentially address the residual risk, then a transition to BV will be recommended.

A report will be prepared for the United States Environmental Protection Agency (USEPA) making the appropriate recommendation to either shutdown the SVE system or transition into a BV mode of operation. Upon USEPA’s approval of either recommendation, the appropriate action would be taken.

Operations and Monitoring: Process and performance monitoring will be conducted during SVE system operations to evaluate overall vapor concentrations and track COC mass removal rates over time.

Wellfield vapor concentrations will also be periodically evaluated (using vapor probes or the SVE wells under either dynamic [i.e., system on] or static [i.e., system off] conditions) to assess the progress of remediation activities. This data will be used as part of the system optimization strategy which will include:

- Rotation of the SVE/AI combination wells to redistribute air flow at appropriate time intervals.
- Maximizing volatile organic compound (VOC) mass removal rates by focusing SVE wells on areas of higher vapor concentration/vapor production.

A key aspect to the overall operation strategy will be to perform regular monitoring of the site groundwater levels. The objective of this monitoring is to determine when water levels drop sufficiently to expose the lower silty sand layer, and then take the opportunity to reconfigure the SVE/AI to operate in that zone for as long as possible.

Soil sampling will be conducted annually during system operation to assess the overall COC mass reduction.

Schedule: The Big Mo/Former Benzene Pipeline SVE system is anticipated to begin operation in early 2012 and operate for up to four years. The project schedule is summarized in **Table ES-1**.

Table ES-1: Summary of Big Mo/Former Benzene Pipeline Areas Schedule

Task Description	Dates
• Design and Permitting	January-October 2011
• Construction	August-December 2011
• Construction Completion Report	Submittal February 2012
• Operation	January 2012-March 2016
• Soil Sampling	January 2013-January 2016
• SVE Shutdown / Transition Recommendation Report	Submittal March 2016

1.0 INTRODUCTION

XDD has prepared this 100% SVE system design document (SVE design document) for the remediation of unsaturated zone soil impacts in the Big Mo and Former Benzene Pipeline areas of the Solutia Inc. (Solutia) W.G. Krummrich Facility in Sauget, Illinois ("the site" or "the Plant").

This 100% SVE system design document includes layouts and design details for well and wellhead construction, system manifolding, process piping, SVE system process equipment, vapor treatment, and installation of associated utilities. The drawings are schematics and as such do not show all potential construction conditions. Modifications to this SVE design document can occur due to minor interferences and structural obstructions as a component of the construction work.

1.1 SUMMARY OF REMEDIATION APPROACH

SVE will be implemented within the unsaturated portion of the Big Mo and Former Benzene Pipeline Treatment Areas (approximately 0 to 15 feet bgs) using a dual-level SVE and Air Injection (AI) well network. The shallow SVE/AI wells will be designed to target the upper sandy fill/silty sand unit lying above the intermediate silty clay layer. The deep SVE/AI wells are designed to target the lower silty sand unit below the intermediate silty clay layer and above the water table. The intermediate silty clay layer will not be directly targeted by the SVE system because it has a low permeability and is not amenable to soil vapor extraction technology. Refer to **Section 2.0** for a more detailed description of the geology within the SVE target interval.

Upon completion of the SVE operations, BV will potentially be used as an additional treatment measure. BV involves injection of ambient air to enhance aerobic biodegradation of COCs remaining within low permeability layers within the unsaturated zone. This process will rely on both oxygen diffusion into the low permeability layers, and COCs diffusing out of the low permeability layers into the aerobic unsaturated zone, to potentially achieve additional COC mass reduction.

1.2 REMEDIATION OBJECTIVES

On February 26, 2008, the United States Environmental Protection Agency (USEPA) issued a Final Decision requiring Solutia to implement SVE at the site. Per the Final Decision, SVE will be applied to unsaturated zone soils impacted with VOCs. The VOCs that are considered the COCs for SVE treatment are primarily benzene and chlorobenzene.

The overall remediation objective is to reduce COC mass within the following four areas at the site:

- Former Benzene and Chlorobenzene Storage area (Big Mo area);
- Former Benzene Pipeline area;
- North Tank Farm/Former Overhead Steamer Tank area; and
- Near Little Mo area.

This SVE design document focuses specifically on the Big Mo and Former Benzene Pipeline areas. Refer to **Figure 1** for the locations of these treatment areas. The SVE shutdown protocol is summarized in **Section 11.3.**

2.0 SITE BACKGROUND INFORMATION

The W.G. Krummrich Facility is a 314-acre facility located at 500 Monsanto Avenue, Sauget, Illinois. The site is approximately one mile east, and in the floodplain, of the Mississippi River. The site is located in a heavily industrialized area, and has a history of approximately 100 years of industrial operations.

2.1 TREATMENT AREA CHARACTERIZATION

Soil characterization was conducted by URS Corporation (URS) in 2009 and 2010 within the proposed treatment areas. Soil cores were geologically characterized and field screened for total organic vapors (which includes VOCs). Selected samples were then analyzed for VOCs by USEPA Method 8260B. The results of the soil characterization are presented in the *Soil Vapor Extraction Treatment Area Characterization Report* (*Characterization Report*) by URS, submitted to USEPA in November 2010.

The areas for SVE treatment are based on the *Characterization Report*. The extent of the Big Mo and Former Benzene Pipeline treatment areas are presented in **Figure 2**. Note that the treatment areas are based upon the detailed soil characterization, but areas that are inaccessible to SVE technology due to the presence of buildings, etc., are not proposed for treatment.

2.2 GEOLOGY AND HYDROGEOLOGY

Three soil units are observed in each of the treatment areas:

- Sandy fill/upper silty sand layer (extending from ground surface approximately 10 feet bgs).

- Intermediate silty clay layer (variable in thickness, and encountered at depths ranging from approximately 5 to 12 feet bgs). In some areas, the intermediate silty clay layer was not detected.
- Lower silty sand layer (encountered below the silty clay layer to a depth of approximately 15 feet bgs).

Geological cross-sections for the Big Mo and Former Benzene Pipeline treatment areas are presented in **Figures 3A-3C**.

2.2.1 GROUNDWATER LEVEL TRENDS

Groundwater levels within the treatment area are directly influenced by the Mississippi River, approximately one mile west of the site. Historical groundwater level trends are presented in **Figure 4** (elevation data are presented in **Appendix A**). As shown in the figure, fluctuations in water levels in regional wells and site monitoring wells correlate closely with the Mississippi River stage.

Since 2008, groundwater levels have been relatively high compared to historical data, and portions of the lower silty sand layer have been submerged. However, based upon historical groundwater level trends, it is expected that periods of dryer conditions will occur that will allow SVE to be applied at the deeper target intervals (depths to 15 feet bgs).

Precipitation infiltration into the pilot test area did not dramatically affect groundwater levels, and did not affect SVE performance (as evidenced by pilot test observations). Therefore, an impermeable rain cap (asphalt or similar) is not required for full-scale operation.

2.3 CONTAMINANTS OF CONCERN

A summary of soil COC concentration data from the proposed treatment area is provided in **Appendix B** (a complete data set is presented in the *Characterization Report*). Benzene and chlorobenzene are the primary COCs. Therefore, for the purposes of the SVE system design, only benzene and chlorobenzene are included in the design calculations.

2.3.1 MAXIMUM SOIL CONCENTRATIONS

The maximum soil concentrations at the Big Mo and the Former Benzene Pipeline areas (based on the 2009-2010 soil characterization) are presented in **Table 1** (refer to **Appendix B** for more detailed data). Non-aqueous phase liquid (NAPL) has been observed in some soil borings which likely influenced the measurement of the maximum soil concentration (as discussed in **Section 2.3.2**).

2.3.2 SOIL SATURATION LIMIT CALCULATIONS

The theoretical maximum soil concentration, also called the soil saturation limit (C_{sat}), is the maximum concentration of a contaminant, or a mixture of multiple contaminants, that can exist adsorbed to the soil surfaces, dissolved in soil moisture, and as vapor in the soil pore space.

The C_{sat} estimates for the primary COCs are presented below (calculations are presented in **Appendix C**).

- Benzene C_{sat} = 1,000 milligrams per kilogram (mg/kg).
- Chlorobenzene C_{sat} = 300 mg/kg.

As indicated in **Table 1**, the maximum benzene and chlorobenzene concentrations in the Big Mo and Former Benzene Pipeline treatment areas exceed the theoretical C_{sat} values for these compounds.

If soil concentrations are higher than C_{sat}, then it is suspected that NAPL is present. The theoretical maximum soil concentration, assuming that all the available pore space is saturated with NAPL, would be equivalent to C_{sat} plus the mass of NAPL in the soil pores (calculations are presented in **Appendix C**):

- Benzene C_{sat} + 100% NAPL Saturation = 165,000 mg/kg.
- Chlorobenzene C_{sat} + 100% NAPL Saturation = 207,000 mg/kg.

As shown in **Table 1**, the maximum soil concentrations in the Big Mo and Former Benzene Pipeline areas are below 100% NAPL saturations for benzene and chlorobenzene calculated on Table C-2. .

2.3.3 MASS ESTIMATES

An estimate of COC mass for each treatment area and the vertical distribution of the COC mass were calculated. The COC mass estimates are summarized in **Table 2**. Detailed mass estimate calculations are presented in **Appendix D**.

3.0 SOIL VAPOR EXTRACTION REMEDIATION DESCRIPTION

SVE is an in-situ remediation process designed to remove VOCs from unsaturated zone soils by inducing air flow through the soil pores. VOCs partition into the air stream as it passes through the soil pores, and the air containing VOCs is subsequently extracted at the SVE wellheads.

In general, the conceptual design of a SVE system is based upon flushing enough air through the soils to achieve the remediation objectives. Some of the key conceptual design concepts are provided in the sections below.

3.1 TARGET PORE VOLUME EXCHANGE RATES

When air is extracted from a SVE well, the resulting pore air velocities are highest near the well. The pore air velocity decreases exponentially with distance from the extraction well as a result of both the increased soil volume, and leakage of air from the surface into the soil pores. The pore air velocity at each distance from the extraction well can be converted into a pore air flushing rate. The pore air flushing rate represents the number of times the air within a unit volume of soil pores is removed over a period of time. This flushing rate is typically expressed as pore volumes per year (PV/year). Based on this relationship and competition for the available air in the pores, soils located at the midpoint between SVE wells will typically have the fewest PV exchanges per year, and soil near the SVE wellheads will have the highest PV exchanges per year.

Total Number of Pore Volumes Required: The number of PV exchanges required to achieve a desired level of mass reduction is a function of several factors, but is generally related to the volatility of the target COCs, efficiency of air flow/contaminant contact, contaminant concentrations, and the distribution of COC impacts within the soils (i.e., mass transfer limitations).

In practice, approximately 2,000 to 3,000 pore volume exchanges with air will typically be required to reach asymptotic removal rates from soil impacted with residual levels of VOCs. Since the pore volume exchange rate will be lowest at the midpoint between SVE wells, the minimum number of pore volume exchanges must occur at those locations to ensure that the entire soil treatment volume is adequately flushed.

Remediation Timeframe Based on Pore Volume Flushing Rates: Theoretically, the time it takes to flush the minimum volume of air will control the overall remediation timeframe. For design purposes, approximately 500 to 1,000 PV/year is a typical minimum flushing rate design target, based on site-specific conditions. At this flushing rate, approximately two to four years of remediation is a standard operational timeframe for a well-designed SVE system.

3.2 RADIUS OF INFLUENCE AND SVE WELL SPACING

The center-to-center spacing design of a SVE well network is based upon the ROI of the SVE wells. ROI is the distance from an SVE well where the minimum pore volume exchange rate (typically 500 to 1,000 PV/year) is achieved. Refer to **Section 3.4.1** for a discussion of the ROI assessment that was completed for this conceptual design. The SVE design will also include the installation and operation of AI wells to assist in achieving the minimum pore volume exchanges within the soil volume to be treated.

3.3 SVE PILOT TEST RESULTS SUMMARY

A summary of the SVE pilot test results and key design parameters is provided in this section. Refer to the *Soil Vapor Extraction Pilot Test Report* for comprehensive results and design details.

The Big Mo area was chosen for the pilot test because this area exhibited the most elevated COC concentrations (based on historical borings S0607 and SB-A01 at 2,400 mg/kg and 13,000 mg/kg benzene, respectively), and the area is geologically similar to the other treatment areas. The pilot test encompassed an area of 60 feet long by 80 feet wide (4,800 square feet).

Test wells were installed within each of the following geological units (the descriptions below are specific to the Big Mo pilot test areas):

- Sandy fill/upper silty sand layer (ground surface to approximately 10 feet bgs);
- Intermediate silty clay layer (approximately 10 to 12 feet bgs). The intermediate silty clay layer was not detected consistently within the pilot test area; and
- Lower silty sand layer (approximately 12 to 15 feet bgs).

As reported in the *Soil Vapor Extraction Pilot Test Report*, the primary objectives of the SVE pilot test were to:

- Develop full-scale SVE design parameters, including well-to-well spacing, wellhead flow rates and vacuums/pressures, etc;
- Demonstrate COC mass reduction and estimate the COC mass removal rates achievable with SVE technology; and
- Confirm the most effective operational configuration using combinations of SVE and AI wells.

Key results of the SVE pilot test are listed below and are summarized in **Table 3**:

- Well Performance Characteristics:
  - A SVE wellhead vacuum of approximately 20 to 50 inches of water (in. H_2O) was required to achieve air extraction flow rates up to 25 to 30 standard cubic feet per minute (scfm). Some wells performed at higher flow rates with lower vacuums, but these wells were assumed to be atypical of the general vacuum requirements for the majority of the system. Therefore, the more conservative wellhead performance characteristics were selected for full-scale design purposes.
  - AI wellhead pressures of 20 to 60 in. H_2O were required to achieve air injection flow rates of 20 scfm to 80 scfm.
  - Use of AI wells with SVE wells provided an improvement in air flow through the target soils and increased the achievable COC mass removal rate.

- COC Mass Removal Rates: The initial vapor-phase concentration from the Big Mo area was approximately 5,100 parts per million by volume (ppmv) benzene, based on laboratory analysis of the pilot SVE system effluent (from the wellfield). The initial mass removal rate from the Big Mo pilot test area was approximately 20 lbs of benzene per hour.

  The COC mass removal rate declined to below 2 lbs of benzene per hour by the end of the pilot test. The average mass removal rate during the initial three months of pilot testing was 7 lbs of benzene per hour (average vapor concentration of 1,300 ppmv, based on field photoionization detector [PID] measurements).

  Based on vapor-phase mass removal rates, approximately 16,000 lbs of benzene were removed during the pilot test. Asymptotic conditions were not achieved (and were not expected to be) during the relatively short duration of the SVE pilot test.

- COC Mass Reduction on Soils: Soil sampling indicated that approximately 17,000 lbs of benzene had been removed from the pilot test area after the initial six weeks of operation. After re-focusing the pilot test system on a smaller sub-area, an additional 500 lbs of benzene was estimated to have been removed (from the sub-area only). The 17,000 lbs removed represents approximately 20% (entire pilot test area) and 30% (pilot test sub-area) of the estimated initial COC mass, respectively. The COC mass reduction observed from the soil data was generally consistent with the COC mass removal estimated from the vapor discharge of the SVE system (i.e., estimated at 16,000 lbs).

- Other Key Observations:
  - Water table elevations were at a historically high level during the pilot testing, which prevented extensive testing in the intermediate silty clay and lower silty sand layers.
  - SVE is not likely to be effective for treating the intermediate silty clay layer. No measurable air flow rate could be achieved in this unit.
  - Brief operation of the lower silty sand layer SVE wells exhibited very similar wellhead air flow/vacuum relationships compared to the sandy fill/upper silty sand layer SVE wells. Therefore, air flow characteristics estimated during the pilot test are expected to be applicable to the lower silty sand layer for the purposes of this full-scale SVE design. The intermediate silty clay unit, where present, will impact the availability of air to the SVE wells and will be accounted for in the design. These results are also applicable to the other target areas based on prior testing that indicated all of the treatment areas have similar soil characteristics.

3.4 SVE DESIGN MODELING

Data from the SVE pilot test was used to estimate the design ROI and well spacing required for full-scale treatment. A brief summary of the conceptual SVE design process is provided in this section.

Summary of the Conceptual SVE Design Process:

- The center-to-center SVE well spacing was based upon a ROI of 20 feet at 25 to 30 scfm per well. The design ROI was based upon two-dimensional air flow modeling using the SVE pilot test data, and is discussed in detail in **Section 3.4.1** below.
- Using this design ROI, the SVE well grid was designed with approximate 40-foot spacing.
- For the types of COCs at this site, an overall air flushing target of 2,000 to 3,000 pore volumes is typical (as previously discussed in **Section 3.1**). The SVE system was designed to achieve this overall flushing target within three to four years of operation in each area (as discussed in **Section 3.4.2** below).
- When multiple SVE wells are operated together, there is some competition for the available pore air in the subsurface. In addition, the presence of the intermediate silty clay layer could further limit surface air infiltration to the lower silty sand layer. Three-dimensional air flow modeling was conducted to confirm that the minimum required air flushing would occur in a multiple well configuration (as discussed in **Section 3.4.3** below).

3.4.1 SOIL PERMEABILITY ESTIMATE AND RADIUS OF INFLUENCE MODELING

The design ROI for a single SVE well was estimated using a 2-D analytical air flow model[1] (refer to the *Soil Vapor Extraction Pilot Test Report*). The model estimates pore air velocities and pore volume exchange rates using the actual SVE test well extraction flow rate, wellhead vacuum, and resulting vacuum distribution around the test well during the pilot test.

The results of the air flow modeling are summarized below:

- Intrinsic Soil Permeability: Model simulations provided an estimate of the effective intrinsic soil permeability (in both the radial and vertical directions, or K_r and K_z respectively):
    - The sandy fill/upper silty sand layer was estimated at $K_r = K_z = 3.94 \times 10^{-7}$ square centimeters (cm^2) (isotropic conditions). Permeabilities could not be estimated for the lower silty sand layer due to water saturation. Permeabilities were not estimated for the intermediate silty clay layer because air flow could not be induced in this unit.
    - The effective surface cover permeability, $K_c/B_c{}^2$, was estimated at 3.58×10^{-10} cm^2.

- Radius of Influence: Based on the SVE pilot test results and modeling analyses, a PV exchange rate of 500 to 1,000 PV/year can be achieved in the sandy fill/upper silty sand layer at a ROI of 20 to 25 feet (assuming wellhead extraction flow rates of 25 to 30 scfm). The PV exchange/ROI results from the *Soil Vapor Extraction Pilot Test Report* are presented in **Appendix E (Table E-1 and Figure E-1)**.

---

[1] Baehr, A.L. and Joss, C.J. 1995. "An updated model of induced air flow in the unsaturated zone," Water Resources Research Vol 31, n 2, pp 417-421.

[2] The computer model assumes that the surface cover is 10 cm thick (represented by B_c), and the overall permeability of this surface cover is a function of its thickness (i.e., K_c/B_c).

3.4.2 Pore Volume Exchange Assessment

Using the design ROI determined during the pilot test, the total number of pore volume exchanges occurring over an operating period of one to four years was calculated. The total pore volume exchanges occurring at the mid-points between SVE wells after multiple years of operation is presented in **Appendix E (Table E-1 and Figure E-1)**.

As shown in Appendix E (**Figure E-1)**, a well spacing of 40 feet on center will achieve the required number of pore volume exchanges (i.e., 2,000 to 3,000) within two to three years of operation, assuming wellhead flow rates of 25 to 30 scfm.

3.4.3 Three-Dimensional Air Flow Modeling

The 2-D ROI modeling analysis discussed in **Section 3.4.1** is based upon a single SVE well. When multiple SVE wells are operated together, there is some competition for the available pore air in the subsurface. In addition, the presence of the intermediate silty clay layer could further limit surface air infiltration to the lower silty sand layer, thus affecting the net pore volume exchange rate.

`Therefore, a three-dimensional air flow simulation was performed as part of the system design (using the American Petroleum Institute [API] AIR3D computer model[3]). Using the effective intrinsic soil permeabilities estimated with the 2-D model, the 3-D air flow model was used to verify that superposition of multiple vapor extraction/air injection wells will provide adequate air velocities (i.e., and pore volume exchange rates) in all the target layers.

It is not necessary to model a complete SVE system configuration to evaluate if there are potential issues with competition for air which would require well field refinements. Therefore,

---

[3] AIR-3D: A Three-Dimensional Model of Air Flow in the Unsaturated Zone. American Petroleum Institute. 1994

a portion of the proposed SVE well grid was simulated to demonstrate that the minimum air flushing velocities are occurring throughout the target layers. A pore air velocity of 0.01 centimeters per second (cm/s) is a typical minimum air velocity target[4], and this velocity is equivalent to the required minimum pore volume exchange rate (i.e., 500 to 1,000 PV/year as determined by the 2-D modeling).

This 3-D air flow modeling confirmed that adequate air flushing will occur throughout the target layers. Results of the model, including the air velocity vector plots, are presented in **Appendix F**.

[4] DiGiulio, D.C. and R. Varadhan. 2001. Development of Recommendations and Methods to Support Assessment of Soil Venting Performance and Closure. USEPA Office of Research and Development (EPA/600/R-01/070).

4.0 SUMMARY OF REMEDIATION SYSTEM DESIGN

The overall remediation approach for the site consists of SVE to remove contaminant vapors and AI to increase the efficiency of the SVE system by providing atmospheric air to the shallow and deep soil intervals. Select SVE wells will be configured for operation in either extraction or injection mode (combination SVE/AI wells). The extracted vapors will be treated using a thermal oxidizer unit. Condensate generated by the SVE system will be treated using liquid-phase granular activated carbon (LGAC) prior to discharge to the on-site sewer. Light and dense non-aqueous phase liquids (LNAPL/DNAPL) that are accumulated within the SVE system condensate will be separated and drummed for characterization and off-site disposal.

4.1 OVERVIEW OF SVE SYSTEM DESIGN

Key design elements of the full-scale treatment system are outlined below and a complete summary of the SVE process flow is presented on **Figure 5.**

Target Depth Intervals: The SVE system is designed to treat only the sandy fill/upper silty sand and lower silty sand layers (refer to **Section 2.2**). Separate SVE wells (shallow and deep screen intervals) will be installed in each of these soil layers. Refer to **Section 5.0** for the detailed SVE well design.

Wellheads and Manifold Piping: Wellhead assemblies will be provided for each SVE and combination SVE/AI well. Above grade piping will be used to connect the wells and external process piping for the thermal oxidizer (ThermOx) units and the sewer discharge to the main equipment container. Below grade piping and trenching will be used to connect wells located in roads/access-ways to the main manifold or branch lines at above grade locations. See **Section 6.0** for detailed SVE well and manifold piping design.

Piping Heat Trace and Insulation: The SVE branch and main manifold pipes will be heat-traced and insulated. The AI manifold will be insulated only. Clean-outs, wellheads including the well riser pipes from the wellhead to surface grade, and lateral assemblies will be insulated only and sloped (where applicable) to prevent water accumulation and freezing. The treated condensate discharge line to the sewer will also be heat-traced and insulated (i.e., portions that are installed above ground). See **Section 6.2.5** for more detailed information regarding piping heat-trace and insulation.

SVE: The SVE system is a high flow, low vacuum system designed to extract soil vapors from the sandy fill/upper silty sand and lower silty sand layers. The system is designed with the capacity to operate in one of the two target soil layers at any given time. The design extraction rate and vacuum at the SVE wells is between 25 and 30 scfm per well at up to 50 in. H_2O vacuum. The total SVE system design capacity is 2,000 scfm. See **Section 7.0** for the detailed SVE system design.

Air Injection System: The SVE system for each target treatment area will include an AI system. The AI system is a high flow, low pressure system designed to increase the efficiency of the SVE system by providing atmospheric air to the shallow and deep soil intervals. Select SVE wells can be configured for operation in either extraction or injection mode (combination SVE/AI wells). The AI system is designed with the capacity to operate in one of the two target soil layers at any given time. The AI wells will operate between 20 and 80 scfm per well at a maximum injection pressure of 60 in. H_2O. The total AI system design capacity is 1,500 scfm. See **Section 7.0** for the detailed AI design.

Condensate Treatment: Soil vapor extracted by the SVE system will pass through air-moisture separator (AMS) units. Condensate (water and potentially LNAPL) collected in the AMS units will be automatically transferred to an oil-water separator (OWS). LNAPL will be separated from the condensate and held within an internal storage tank within the OWS. When the internal

LNAPL storage tank in the OWS reaches capacity, the separated LNAPL will be manually transferred into Department of Transportation (DOT)-approved 55-gallon drums to be disposed of by Solutia. Liquid from the OWS will be pumped through two LGAC units placed in series prior to discharge to the facility sewer (under permit with the American Bottoms Regional Waste Water Treatment Facility).

System Controls: A programmable logic controller (PLC) will control all automated functions of the SVE system. The PLC system will allow remote monitoring and review of operating status at any time. The remote monitoring system will be used to monitor flows, vacuums/pressures and operating temperatures, as well as the position of safety sensors and controls (e.g., pressure switches, level switches, motor operated valves, etc.). The PLC will also control the appropriate system response to alarm conditions. An autodialer system will be incorporated into the design to transmit alarm conditions to the operator.

Vapor Treatment: The SVE process vapor will pass through the AMS and SVE blowers, and then routed to two natural gas fired ThermOx units operating in parallel. The ThermOx units will be used to oxidize VOCs in the extracted vapors prior to discharge to the atmosphere under an Illinois Environmental Protection Agency (IEPA) Construction Permit. A 2,000 scfm ThermOx unit (ThermOx #1) will be used throughout the entire duration of the SVE treatment in the Big Mo area. A second, 1,000 scfm ThermOx unit (ThermOx #2) will be used to supplement the first unit until initial concentrations of VOCs decline. Each of the ThermOx units will be designed with a heat exchanger to increase operational efficiency.

As vapor concentrations decline, natural gas usage may increase to maintain the operating temperature within the ThermOx. To reduce long-term natural gas usage, both ThermOx units will be designed so that a catalyst can be added to the process stream at a later date. A catalyst is used to significantly reduce the activation energy needed to start oxidation reactions and reduces the required fuel usage. It is anticipated that initial operating conditions associated with the mass loading of benzene concentrations in the vapor stream will preclude use of catalysts in the two ThermOx units. See **Section 8.0** for the detailed vapor treatment design.

When the benzene vapors have decreased significantly enough that operation of two ThermOx units is not longer cost effective (catalyst and/or natural gas usage), ThermOx #2 will be relocated to another treatment area which is impacted with chlorobenzenes and benzenes (North Tank Farm). ThermOx #2 will be designed with the ability to be fitted with an acid-gas scrubber and will be constructed with materials compatible with benzene, chlorobenzene, and acid-gas vapors (to be described in detail as part of the North Tank Farm SVE system design).

Electrical Design: Electricity will be supplied to the SVE equipment container via an overhead connection. The electrical service will be 480-volt three phase. All external wires, control panels, and enclosures associated with the SVE system are to be weatherproof and constructed to NEMA 4X standards. All connections will be permanent and all equipment will be grounded. The equipment connections include connection of electrical service and grounding of all process and supporting equipment. This includes connection to the process equipment control panel, thermal oxidizer (ThermOx) units, and completion of Class I, Division II seals at all wiring interior/exterior transitions. See **Section 9.0** for the detailed electrical design.

Bioventing System: If necessary, the SVE equipment will be reconfigured into a BV. The mechanical configuration of the potential BV system will be developed as needed and is not discussed in detail in the SVE design document.

4.2 GENERAL DESIGN CONSIDERATIONS

The following considerations were incorporated into the system design:

- Design capacity to operate in either the shallow or deep soil interval at one time;
- Ability to inject clean air (via the AI system) to enhance SVE treatment of the soils;
- Freeze protection for year-round operation;
- Automated systems to decrease operation and maintenance costs;
- Alarm schedule built into the PLC telemetry to protect equipment and personnel;
- Chemical compatibility with benzene and chlorobenzene;
- Location of overhead and subsurface utilities;
- Compliance with National Fire Protection Association (NFPA) Class 1 Division 2 requirements for an area where ignitable concentrations of flammable gases, vapors, or liquids are not likely to exist under normal operating conditions; and
- Compliance with the Plant's safety standards and Occupational Safety and Hazard Administration (OSHA) regulations.

4.3 APPLICABLE CONSTRUCTION AND SAFETY STANDARDS

The installation will be conducted in accordance with standard construction codes and guidance documents. Where applicable, the latest revisions of the following codes will be met.

1. ANSI – American National Standards Institute
2. ASTM – American Society for Testing and Materials
3. CGA – Compressed Gas Association
4. FM – Factory Mutual
5. IBC – International Building Code
6. ICEA – Insulated Cable Engineers Association

7. IEEE – Institute of Electrical and Electronic Engineers
8. OSHA – Occupational Safety and Health Administration
9. NEC – National Electric Code
10. NEMA – National Electric Manufacturer's Association
11. NFPA – National Fire Protection Association
12. UL – Underwriter Laboratories

5.0 WELL LAYOUT AND CONSTRUCTION DESIGN

The following construction and installation details are included in this section:

- Decommissioning of former pilot test wells.
- Soil sampling in the treatment area.
- SVE well and vapor probe locations. SVE and SVE/AI proposed well locations and proposed vapor probe locations are shown on **Figures 6A and 6B**. Shallow and deep SVE/AI wells will be spaced approximately 40-feet on-center based on the SVE ROI modeling described in **Section 3.4**.
- Typical SVE/AI well construction details (refer to **Figure 7)**.
- Typical single and nested vapor probe details (refer to **Figure 7)**.
- Below grade well and vapor probe installation details (refer to **Figure 7**).
- Well construction tables (including well depth and well screen lengths). SVE well and vapor probe construction are presented on **Table 4**. Well and vapor probe design parameters are summarized in **Table 5.**

5.1 DECOMMISSIONING OF FORMER PILOT TEST WELL NETWORK

A total of 26 existing 2-inch outer diameter polyvinyl chloride (PVC) or chlorinated PVC (CPVC) wells in the former pilot test area will be decommissioned prior to full-scale SVE system construction. Refer to **Figure 8** for the SVE pilot test site plan. The wells will be decommissioned in accordance with Illinois Administrative Code Title 77, Chapter I, Subchapter r, Part 920, Section 920.120. Decommissioning includes the following:

- The well casing or liner will be removed to at least 2 feet below final grade.

- Wells will be sealed from the bottom up to where the well casing is removed with neat cement grout or a bentonite product manufactured for well sealing.
- Soil cuttings and associated debris will be collected into one or more roll-off containers (or similar) provided by Solutia. Solutia will arrange for disposal of the materials.
- A neat bentonite/cement grout will be pumped into the well riser (through a tremie pipe) as it is removed from the borehole until within 1 foot of the ground surface.
- A sealing form will be submitted to the Illinois Department of Public Health or approved local health department within 30 days of well decommissioning.

5.2 SOIL CHARACTERIZATION

At a minimum of 20 SVE well locations in the treatment area, a soil boring will be advanced to identify the proper installation depth for the shallow and deep SVE wells. Limited identification of specific soil intervals will be performed from 0 feet bgs to 15 feet bgs. Continuous soil cores will be collected using a split spoon sampler (or equivalent). Soil cores will be examined visually for geological characteristics and logged, by the Project Geologist.

5.3 SVE AND AI WELL CONSTRUCTION DETAILS

A total of 76 shallow and 82 deep SVE wells will be installed in the treatment area as follows:

- Boreholes will be advanced at each shallow and deep well location to a predetermined depth interval. Each borehole will, at a minimum, have a 6-inch interior diameter (ID).

- SVE wells will be constructed of 2-inch ID, 0.02-inch slotted stainless steel well screens (or equivalent) and completed to surface grade with solid 2-inch ID threaded (NPT) carbon steel riser (**Figure 7**).
- Shallow well screens will vary from 1 to 5 feet in length and will be installed with the bottoms from approximately 5 feet bgs to 10 feet bgs, dependent on the surrounding lithology. Deep well screens will vary between 2.5 and 5 feet in length and will be installed with the bottoms at 15 feet bgs (**Table 5**). Prior to drilling activities, well screen lengths may be refined further to minimize construction costs.
- A number 2 (#002) sand pack (or equivalent) will surround the well screen and extend approximately 6 inches above the top of the screen.
- A 1-foot granular bentonite seal will be placed above the sand pack.
- A cement bentonite grout will be placed above the bentonite seal and will extend to ground surface. For the 15 shallow wells installed in road/access ways the cement bentonite grout seal will be completed to approximately 4 feet bgs.
- Wells will be completed to a minimum of 6 inches above ground surface for eventual connection to the SVE system; protective outer casings will not be required.
- 15 shallow and 15 deep wells installed in road/access ways will be completed below grade during a second mobilization in an 8-inch ID (minimum) flush mounted road box with adequate drainage to protect against water accumulation. Due to the system design, the below grade wells must be accessible for construction and installation of the below grade manifold piping. A second mobilization will be required to install the road boxes and complete the below grade wells.
- A PVC slip cap will be used to seal the above ground wells and a threaded cap/plug will be used to seal below ground wells once the road boxes have been installed.

5.4 VAPOR PROBE CONSTRUCTION DETAILS

A total of 32 nested shallow and deep vapor probes will be installed at 16 locations in the treatment area as follows:

- Shallow and deep vapor probes will be nested in the same boring (**Figure 7**). The shallow screen will be installed in the sandy fill/upper silty sand layer, and the deep screen will be installed in the lower silty sand layer.
- Boreholes will be advanced at each vapor probe location to the deep vapor probe target depth interval determined through soil sampling and well installation activities. Each borehole will, at a minimum, have a 6-inch ID to accommodate the two probes.
- The vapor probes will be constructed of 1-inch ID, 0.02-inch slotted stainless steel well screens (or equivalent) with a 1-foot sump constructed of 1-inch ID carbon steel riser. The probes will be completed to surface grade with solid 1-inch threaded (NPT) carbon steel riser (**Figure 7**).
- Shallow and deep vapor probe well screens will be installed at approximately the same depths as the mid-point of the screened intervals of adjacent shallow and deep SVE wells (**Table 5**).
- A #002 sand pack (or equivalent) will surround the deep vapor probe screen and sump and extend approximately 6 inches above the top of the screen.
- A bentonite seal will be placed above the #002 sand pack of the deep vapor probe and extend to a minimum of 6 inches below the shallow vapor probe sump.
- A #002 sand pack will extend from the top of the deep vapor probe bentonite seal to 6 inches above the top of the shallow vapor probe screen.
- A 1-foot granular bentonite seal will be placed above the sand pack.
- A cement bentonite grout will be placed above the bentonite seal and will extend to ground surface.

- The majority of vapor probes will be completed a minimum of 2 feet above ground surface; a protective outer casing will not be required.
- 10 vapor probes (5 locations) installed in road/access ways will be completed below grade, with shallow and deep probes nested in an 8-inch ID (minimum) flush mounted road box.
- Vapor probes will be completed with a PVC slip-on cap.

5.5 LOGISTICS

5.5.1 UTILITY CLEARANCE

The W.G. Krummrich facility utility maps were used to identify locations of known existing and/or abandoned utilities within the treatment area. Well locations/excavation locations have been adjusted to be clear of known subsurface utilities.

5.5.2 PRE- AND POST-DRILLING SURVEYING

SVE, AI, and vapor probe locations will be marked using a flag/stake or paint by a surveyor prior to the start of the drilling program (by others under subcontract to Solutia/XDD). Actual drilling locations may be moved by the Project Geologist to avoid overhead obstructions (e.g., pipe racks, etc.) or in the event that subsurface obstructions prevent installation in the desired location (i.e., utilities, drilling refusal due to concrete, cobbles, etc.).

A survey will be conducted after completion of the drilling program by Solutia/XDD to determine the as-built well coordinates.

5.5.3 AVAILABLE SUPPORT UTILITIES

No electrical service will be available in the area during drilling activities. A portable generator, if required, will be properly grounded by a qualified electrician. Ground fault circuit interrupt (GFCI) devices will be used on all temporary electrical equipment. Extension cords will be rated for industrial use in accordance with OSHA 1926.405, and will be Underwriter Laboratories (UL) or Factory Mutual (FM) approved per OSHA 29CFR1910.303 (a).

Potable water for decontamination or other drilling operations will be available from a plant hydrant.

5.6 DECONTAMINATION AND WASTE HANDLING/DISPOSAL

Soil, groundwater, and decontamination fluids will be generated during well installation and construction activities. A waste accumulation area and a decontamination area will be established within the work area. All wastes will be containerized and properly labeled. Waste characterization and disposal of wastes will be performed by Solutia/XDD. Waste materials will be disposed of by Solutia in accordance with all applicable regulations.

5.6.1 EQUIPMENT DECONTAMINATION AND DECONTAMINATION AREAS

Drilling equipment will be decontaminated prior to entry to the site. During drilling activities, all equipment and vehicles will be regularly inspected to ensure contaminated materials are not tracked outside of the work area. Drilling equipment will also be decontaminated prior to final demobilization from the site. Potable water for decontamination will be acquired from a on-site hydrant (requires 24-hour notice to the plant), and will be staged in close vicinity to the decontamination area.

Primary Decontamination Area: A primary decontamination area will be constructed by the drilling contractor, and will consist of a bermed area with a 6-millimeter (mil) polyethylene liner (minimum), or equivalent. Decontamination of augers, drill rods, vehicles, or other large equipment shall be performed in this area using a pressure washer. The decontamination pad will be sufficiently sized to ensure that the largest piece of equipment can be adequately decontaminated. Also, the area will be designed so that vehicles can be driven into and out of the area (if required) while maintaining containment of any accumulated fluids. The decontamination area shall also be constructed to allow for collection of decontamination fluids and sediments, and to facilitate transfer of these materials to drums or roll-offs as needed (e.g., a sump area with pump, etc.).

Temporary Decontamination Area(s): Small drilling equipment (split spoon samplers, etc.), hand tools, and other miscellaneous equipment that comes in contact with soils or groundwater will be decontaminated over a temporary decontamination area. The temporary decontamination areas may be located adjacent to the active drilling operations, and may consist of 6-mil polyethylene liners/berms, plastic trays, or equivalent. Decontamination of small equipment will be performed using two water buckets (i.e., one for gross decontamination and one for rinse), detergent (e.g., Alconox®), and brushes.

5.6.2 WASTE ACCUMULATION AREAS AND WASTE HANDLING

Soil roll-offs (if required) and drums will be staged in a designated area. Soil roll-offs will be liquid tight and lined with 6-mil (minimum) polyethylene roll-off liners. Soil roll-offs will be equipped with rain covers with an appropriate water-shedding design to prevent pooling water on the surface of the cover, and will be equipped with appropriate tie downs. Roll-offs will be secured at the end of each days' activities. Drums will be DOT-rated, open-top steel construction with lid gasket seal and bolt rings.

A temporary satellite accumulation area will be established for staging of 55-gallon drums. As needed, all 55-gallon drums will be moved by the drilling contractor to the existing waste storage warehouse (BBU Building) located south of the Big Mo area.

- Soils and Decontamination Derived Sediments: Soils/drill cuttings, sample cores, and sediments from equipment decontamination will be contained in the lined/covered roll-off containers, or in 55-gallon drums, as needed. Drums of soil accumulated at the point of drilling activities may be consolidated within the soil roll-off containers (if used). However, soils containing NAPL may be segregated and remain within drums to be disposed of separately, if required. Any drums of soil that are not consolidated within the roll-off containers will be transferred to the waste storage warehouse (BBU building). All soils/sediment containers will be properly labeled, and will be characterized for disposal by Solutia/XDD.
- Groundwater and Decontamination Water: Impacted liquids from decontamination of equipment and impacted groundwater from well purging/sampling will be contained in 55-gallon DOT drums. Drums will be properly labeled and placed in the satellite accumulation area. When a drum is full, it will be transferred to the waste storage warehouse (BBU building). Drums will be characterized for disposal by Solutia/XDD.
- Uncontaminated Bulky Waste: Uncontaminated bulky waste (i.e. general trash and other debris) will be kept separated from impacted soil and groundwater, or other hazardous waste streams. These wastes will be bagged, as necessary, and disposed of in a dumpster as directed by Solutia.
- NAPL Segregation: NAPL liquids (if encountered) will be segregated to the extent possible during waste accumulation, and transferred to separate 55-gallon DOT drums. Drums will be properly labeled and placed in the satellite accumulation area. When a drum is full, it will be transferred to the waste storage warehouse (BBU building). Drums will be characterized for disposal by Solutia/XDD. NAPL drums will be

electrically grounded during filling using a grounding rod (installed by a certified electrician).

6.0 SVE/AI CONSTRUCTION DESIGN

Specifications for the main manifold piping system and related components required to connect the SVE and SVE/AI wells to the process equipment (i.e., SVE/AI equipment skids) are provided in this section, and include the following:

- Demobilization and deconstruction of the SVE pilot test;
- SVE and AI manifold piping layouts and specifications;
- Construction of below grade SVE and combination SVE/AI manifolds, including trenching, piping of wells completed below grade, and below grade to above grade transition manifolds;
- Construction of the SVE and combination SVE/AI wellhead assemblies;
- Connection of process utilities including electrical supply, natural gas supply, and sewer discharge;
- Equipment installation including equipment container, ThermOx units, and connections between process equipment;
- Connection of field manifold piping to the process equipment; and
- Insulation and heat trace design (provided in **Section 6.2.5**).

6.1 SVE PILOT TEST DEMOBILIZATION

Demobilization and deconstruction of the pilot test equipment consists of the following:

- Disassembly and containerization (for disposal using a roll-off or similar, to be provided by Solutia) of all above grade piping materials including SVE system and sewer discharge pipes. Solutia will be responsible for disposal of the materials.

- Relocation of the equipment container to a location out of the Big Mo remediation area.

6.2 SYSTEM CONSTRUCTION OVERVIEW

The target treatment areas are shown on **Figure 6A** (also shown on Figure 6B**)**. The main process equipment will be housed in a steel shipping container(s).

Above grade piping will be used to connect the wells and external process piping for the ThermOx units and the sewer discharge to the main equipment container. A total of one (1) SVE manifold and one (1) AI manifold will be constructed. Below grade piping and trenching will be used to connect wells located in roads/access ways to the main manifold or branch lines at above grade locations.

6.2.1 FIELD MANIFOLD PIPING

The well field piping for each treatment area will consist of Schedule 40 PVC (for the SVE manifolds) or Schedule 80 CPVC (for the AI manifolds). CPVC will be used for the AI manifolds because it can handle temperatures of up to 130 degrees Fahrenheit (°F) without decreasing the pressure handling capacity of the material. The main manifold lines will connect the process equipment to the well fields. Individual branches will run from the main lines to each SVE/AI wellhead.

The SVE and AI piping layouts are presented on **Figures 6A and 6B**, respectively. The manifold piping details are presented on **Figures 9A-9H** and the piping support spacing requirements are presented on **Figure 10**. The general material specifications of the SVE and AI field manifold piping are presented on **Tables 6A and 6B**, respectively.

The field manifold piping consists of the following:

- The SVE and AI lines will connect to the treatment area wells. SVE lines will be of Schedule 40 PVC construction. AI lines will be of Schedule 10 carbon steel (section of 12-inch ID manifold pipe closest to the equipment container, see **Figures 6A and 6B**) and Schedule 80 CPVC construction. Pipe sizes include 6-inch ID branch lines connected to a 12-inch ID main manifold line which connects to the equipment container.
- All SVE and AI branch and main manifold lines are to be assembled and installed above grade.
- The SVE and AI branch lines will have a cleanout at each terminus.
- Manifold piping will be secured with stanchions/supports which will be placed at a spacing adequate to prevent pipe sagging.
- The SVE main manifold line (12-inch ID) will be installed to a minimum slope of 1 inch per 100 feet toward the equipment container.
- The SVE branch lines (6-inch ID) will be installed to a minimum slope of 1 inch per 100 feet toward the wellheads.
- Both the AI branch and main manifold lines will be installed to a minimum slope of 1 inch per 100 feet toward the wellheads.
- SVE branch and manifold lines will be insulated and heat traced. AI branch and manifold lines will be insulated only.

6.2.2 BELOW GRADE SVE AND SVE/AI MANIFOLDS

A total of 30 wells will be completed below grade (**Figure 6A**). Below grade piping and trenching will be used to connect wells located in roads/access ways to the corresponding wellhead assemblies (described in **Section 6.2.3**) at above grade locations and laterals will connect the wellheads to the main manifold or branch lines. Trenching details are presented on **Figure 11**.

Below grade trenching and manifolds will consist of:

- Trenches will be a minimum of 42 inches deep. Trench widths will vary by location; at a minimum, piping must be spaced 1 inch from the trench wall.
- All spoils from the trenching work will be staged in a roll-off supplied by the subcontractor for characterization by Solutia.
- If multiple pipes are placed in a single trench, pipes will be spaced one inch apart.
- 2-inch ID carbon steel piping and fittings installed within a trench connecting the below grade SVE and SVE/AI wells to the above grade manifolds. For the combination SVE/AI wells, only one pipe will be installed in the trench. The transition between extraction and injection will be controlled using the gate valves on the wellhead assemblies (above grade).
- Above grade manifolds including Schedule 40 PVC and/or Schedule 80 CPVC piping and fittings connecting the SVE and SVE/AI wellhead assemblies to the corresponding manifold.

As shown on **Figures 6A and 6B**, there are 5 general areas where below grade wells will be installed for select SVE and/or combination SVE/AI well locations. **Figures 9A through 9H** present the above grade manifold designs for each of the details (A through E).

6.2.3 SVE AND SVE/AI WELLHEAD DESIGN

Wellhead controls at each SVE and SVE/AI combination well will include flow-control gate valves and sample ports. At the SVE/AI combination wells, tee-fittings with two gate valves will be used at the wellheads to allow the well operation to switch from extraction to injection as required. Flow and vacuum measurements will be measured through the sample port. The SVE and AI system includes a total of 158 wells (**Figures 6A and 6B**):

- 84 wells designed for SVE only and connected to the SVE manifold.
- 74 wells designed for both vapor extraction and air injection connected to both the SVE and AI manifold.

Wellhead assemblies will be provided for each SVE and combination SVE/AI well based on the designs presented on **Figures 12A and 12B**, respectively. General material specifications of the SVE and SVE/AI wellheads are presented on **Tables 6A and 6B**, respectively.

The SVE wellhead assemblies will consist of:

- 2-inch ID Schedule 40 PVC piping and fittings to connect the SVE well to the wellhead assembly.
- One sample port for vacuum measurements, vapor sampling, and pitot tube flow measurements.
- One flow control valve (gate valve or similar, per specifications).
- One 2-inch ID Schedule 40 PVC lateral piping, reinforced vacuum/pressure hose, and fittings to connect the wellhead assembly to the SVE manifold.
- SVE wellhead assemblies will be insulated.

- All SVE wellhead laterals will have a minimum of one PVC support for spans greater than 5 feet.

The combination SVE/AI wellhead assemblies will consist of:

- Schedule 80 CPVC piping connecting the wellhead assemblies to the SVE/AI well.
- Wellhead assemblies constructed of both Schedule 40 PVC (SVE connection) and Schedule 80 CPVC (AI connection) piping and fittings.
- One Schedule 40 PVC lateral piping (SVE), one Schedule 80 CPVC lateral piping (AI), reinforced vacuum/pressure hose, and fittings to connect the wellhead assembly to the corresponding SVE or AI manifold.
- One sample port for vacuum measurements, vapor sampling, and pitot tube flow measurements.
- Two flow control valves (gate valve or similar, per specifications).
- SVE/AI wellhead assemblies will be insulated (see **Section 6.2.5**).
- All SVE/AI wellhead laterals will have a minimum of one PVC support for spans greater than 5 feet.

Each wellhead assembly will be secured to the corresponding well with slip-on PVC or CPVC connections (solvent welded according to accepted pipe fitting standards), or Teflon® taped NPT fittings. All connections will be air tight and able to withstand the operating vacuum/pressure as per manufacturer specifications of the fittings.

Laterals that extend greater than 5 feet between the wellhead assembly and the manifold piping will be supported. To reduce the potential for breakage caused by thermal expansion, reinforced vacuum/pressure hose will be used to connect the laterals to the branch or main manifold lines. The laterals will be sloped towards the well at a minimum slope of 1 inch per 20 feet.

6.2.4 UTILITY CONNECTION SPECIFICATIONS

The utility connection specifications consist of:

- Extension of the existing facility natural gas pipeline and connection of the pipeline to the ThermOx units.
- Installation of a treated water discharge line with connection to the facility sewer.

Utilities maps for natural gas and sewer connections are presented on **Figures 13A-14B**. For general material specifications, see **Table 6C**.

Natural Gas Connection:

The ThermOx units require natural gas as a fuel source to operate and will therefore be tied into the plant's existing natural gas supply. The closest connection to the plant's natural gas supply is shown on **Figure 13A**. General natural gas connection details are presented on **Figure 13B**. For general material specifications, see **Table 6C**. The natural gas connection consists of:

- Testing of the existing 4-inch natural gas pipe.
- Installation of a 4-inch ID adjustable valve at the facility's natural gas supply as a backup to the existing valve on the natural gas line. The valve will be specified by the subcontractor with XDD approval.
- Upon termination of the existing 4-inch ID supply line, the 4-inch ID pipe will be reduced to 3-inch ID carbon steel pipe that will be mounted on/hung from the existing

overhead pipe supports. Newly constructed natural gas pipe will be hung in the same manner as the existing pipe.

- Transition overhead 3-inch ID pipe to approximately 3 feet above ground surface once the pipeline is west of I Street and the existing railroad tracks.
- Connection from the above ground surface transition to the ThermOx units includes installation of a 3-inch ID butterfly valve, reduction from 3-inch ID to 2-inch ID carbon steel pipe, installation of a non-adjustable pressure regulator, and completion to the ThermOx units with 2-inch ID carbon steel.

All new pipeline construction will be fitted via pressure-tight welded connections (**Table 6C**). The portion of the natural gas pipeline installed three feet above ground surface will be suspended in roller saddles (or similar) supported by single leg uni-strut (**Figure 13B and Table 6C**). This line will be protected by 8-foot long concrete jersey barriers spaced 4-feet apart.

Sewer Discharge Connection

A connection to the facility sewer will be installed for discharge of the treated condensate (**Figure 14A**). The discharge line will be installed one foot above ground surface and be constructed of 2-inch stainless steel (**Figure 14B**). The pipeline will connect to the plant's existing manhole located at Sewer 1-BB (**Figure 14B**). The final sewer connection will consist of an elbow that transitions through the edge of the sewer manhole cover, with a minimum 24-inch drop tube to prevent potential surface freezing conditions from blocking the outlet. For general material specifications, see **Table 6C**.

The sewer discharge connection consists of the following:

- Installation of 2-inch ID threaded carbon steel piping and fittings from the exterior wall of the equipment container to the sewer manhole.
- Installation of piping supports spaced per requirements for 2-inch ID Schedule 20 carbon steel piping.
- The discharge pipe will be installed to a minimum slope of 1 inch per 100 feet towards the manhole.
- The sewer discharge pipeline will be protected from freezing conditions via heat tracing using and protected using the appropriately rated ultraviolet and weatherproof insulation (see **Section 7.0**).

6.2.5 WINTERIZATION

The SVE branch and manifold pipes will be heat traced and insulated. The AI branch and manifold pipes will be insulated only. Clean-outs, wellheads including the well riser pipes from the wellhead to surface grade, and lateral assemblies will be insulated only and sloped (where applicable) to prevent water accumulation and freezing.

The treated condensate discharge line to the sewer will also be heat-traced and insulated (i.e., portions that are installed above ground).

Heat Trace

The heat trace will be self-regulating (SR), thermostatically controlled and consist of industrial series 240 volt (V), copper braid thermo-plastic heat tape classified as NFPA Class I, Division II. The thermostat is set to maintain a pipe temperature of 40^{o}F with a 5^{o}F temperature differential. Conductive aluminum heat trace will also be applied to the pipes to allow more efficient heat transfer from the heat trace cable to the pipelines.

The heat trace electrical panel will have a National Electric Manufacturer's Association (NEMA) 3R rating (if installed on the exterior of equipment container). If electrical connections associated with the heat trace are installed on the interior of the equipment container, all electrical connections and fittings will comply with the Class I, Division II specification.

A single strand of heat trace will be applied to SVE pipelines of 4-inch ID. Two strands of heat trace will be applied to SVE pipelines of 6-inch ID or greater. Valves and fittings on the SVE lines will not require additional heat trace wrapping, and some slack will be provided to allow for maintenance/disassembly of valves/fittings, if required.

Pipe Insulation

Insulation and protective jacketing material will be resistant to long-term exposure to outdoor factors such as cold, heat, and sun exposure. One or both of the following insulation materials may be used:

- Fiberglass Pipe Insulation: Pre-formed, noncombustible, rigid, tubular fiberglass pipe insulation will comply with ASTM C 547 and will be Class 3 (to 850°F [454 degrees Celsius {°C}]). An integral vapor retarder jacket will be included (consisting of kraft paper, reinforced with a glass fiber yarn, and bonded to an aluminum foil, with self-sealing longitudinal closure laps (SSL) and butt strips, or equivalent). Fiberglass insulation will be jacketed with aluminum (0.016" Type T-23003 H-14 sheeting, in accordance with ASTM B209), or with Ultraviolet (UV) resistant PVC jacketing (provided that the manufacturer's recommendation with regard to pipe size, surface temperature, and thermal expansion/contraction is followed). Insulation thickness will be 1-inch minimum on 2-inch ID and smaller pipes, and 1.5-inch minimum on larger pipes.

- Foam Insulation: Flexible closed-cell foam (elastomeric [HT/Armaflex® or similar], or polyolefin/polyethylene [Tubolit®, or similar]) may be specified. Insulation will be rated for 150^{o}C service temperature (HT/Armaflex® or similar). All seams and butt joints will be sealed with an appropriate sealant for foam insulation (Armaflex® insulation and adhesive, or similar). Insulation shall be installed in compression to allow for expansion and contraction (install an additional 1.5 inches of insulation for every 6 feet of installed pipe, or an additional 2% of measured pipe length). Seams will be staggered when applying multiple layers of insulation. Two coats of protective finish will be applied (WB Armaflex® Finish, or similar). Insulation thickness will be 1-inch minimum on 2-inch ID and smaller pipes, and 1.5-inch minimum on larger pipes.

7.0 SYSTEM EQUIPMENT DESIGN AND SPECIFICATION REQUIREMENTS

A full-scale SVE system will be fabricated and installed for simultaneous treatment of the Big Mo and Former Benzene Pipeline areas. This SVE system will be equipped with the capacity to extract vapors at approximately 25 to 30 scfm per well (total capacity approximately 2,000 scfm). The AI system will be equipped with the capacity to inject air at 20 to 80 scfm per well at pressures up to 60 in. H_2O.

The general design parameters for each SVE system (including overall flow rates, wellhead design flow rates/vacuums/pressures, etc.) are summarized in **Table 7**. The general process flow and specific details for each piece of the process equipment are discussed in the following sections.

The SVE system will consist of the following four main interlocked components:

1. A SVE system to induce vacuum in the wells and extract vapor from the subsurface.
2. An AI component to inject air into the subsurface to improve air flow distribution.
3. A condensate handling system, designed to separate moisture (and potential LNAPL) from the SVE vapor stream, and to provide treatment/discharge of the accumulated condensate.
4. Turnkey container or trailer to house the equipment and allow operational personnel to monitor and service equipment without obstructions.

7.1 DESIGN SUMMARY AND SPECIFICATIONS

The SVE design is presented in **Tables 8 through 14**. The SVE system will be constructed as follows:

- The SVE system will be designed to provide 2,250 scfm at 10 inches of mercury ("Hg) measured at the inlet of the skid or enclosure wall and less than 1" Hg at the skid or enclosure outlet.
- The AI component will be designed to provide 1,500 scfm at 6 pounds per square inch (psi) at the skid or enclosure outlet.
- The condensate handling system will be designed to separate, treat, and discharge water and/or LNAPL accumulating at a rate of 0.5 gallons per minute (gpm).

The SVE system primarily consists of:

- three positive displacement blowers;
- three ambient air intake air filters/silencers;
- three inline particulate filters;
- three air moisture separators with demisters;
- one oil water separator;
- one bag particulate filter; and,
- two LGAC units, in series.

The AI component of the SVE system primarily consists of:

- two positive displacement blowers; and
- two ambient air intake air filters/silencers.

The equipment will also include:

- one PLC with telemetry capabilities (SVE and AI); and
- one telemetry system with cell phone autodialer.

The vapor component of the SVE effluent will be treated by two thermal oxidation units which will be interlocked with the PLC. The process overview for the SVE system and AI component is presented in **Figure 15A** and **Figure 15B**, respectively. The general system specifications are listed on **Table 8**, with the general parts list for the SVE and AI equipment provided in **Tables 9 and 10**, respectively.

7.1.1 National Fire Protection Association Requirements

The SVE system, associated equipment, and wiring associated with the enclosure will be constructed to Class I, Division II Standards. All equipment for the Class I, Division II skids or enclosure shall be constructed of the non-incendive, non-sparking, purged/pressurized, hermetically sealed, or sealed device types as per National Fire Protection (NFPA 496) and Underwriter Laboratories (UL 1604) standards.

7.2 SYSTEM CONTROLS

Automatic controls will be provided to protect the process equipment. **Table 11** presents the general system control specifications for the equipment. Process gauges/indicators will be provided as required to monitor the performance of each system (see **Figures 15A and 15B, and Tables 9 and 10**). The equipment will be configured in accordance with all manufacturers' required specifications for all process monitoring devices (e.g., flow meters).

All equipment will have Hand/Off/Auto switches (HOA) and panel lights to indicate operational status. Alarm indicator lights with first-fault lockout will be provided for all major equipment and process sensors/switches. Each motor associated with the process equipment will have an associated motor starter (with thermal overloads as well as circuit breaker wiring protection), a maintained HOA selector switch, and a green run light.

7.3 MAIN CONTROL PANEL AND INTERLOCKS

If any shutdown due to an alarm condition occurs, the operator will be notified via the cell phone autodialer (via phone, fax, and/or email). The operational status of the system will also be monitored remotely via a telemetry system.

The main control panel for the SVE system will be weather-proof and located outside of the pre-assembled enclosure and will be constructed to NEMA 4X standards. The Input-Output Schedules of the control panel, including the alarm conditions that will cause the entire system to shutdown, are presented in **Table 12**.

All lights, selector switches, push buttons, and all other panel face-mounted devices will be labeled with white letters engraved on black metal labels. The alarm lights for the SVE system will be arranged separately on the control panel. Any system reset switches that need to be energized to function, will be located on the exterior of the main control panel. Additionally, all panel internal devices, wires, and terminals will be properly labeled.

7.4 TELEMETRY SYSTEM AND AUTODIALER

The SVE system/process analog data (i.e., air flow rate, vacuum, pressure, and temperature readings) and the operational status of the system will be monitored remotely via a telemetry system installed in the main system control panel. As discussed previously, a system alarm autodialer will call out in the event of a system shutdown/alarm condition(s). The autodialer will be housed in the main system control panel with inputs for all alarm conditions for the system. Both the autodialer and telemetry system will be equipped with battery backup.

7.5 EQUIPMENT CONTAINER

The equipment container will be constructed to the following minimum specifications:

- Conformance to all state (Illinois), local (Sauget), and Plant building and safety codes, as applicable.
- Electrical wiring that meets Class I, Division II standards/National Fire Protection Association 85.
- A lower explosive limit (LEL) meter that is readable from the exterior of the housing and results in a system shutdown and alarm condition should atmospheric concentrations exceed 10% of the LEL for benzene (1,200 ppmv).
- Sample port mounted on the exterior of the container no more than 6 inches above the floor to monitor ambient air conditions inside the container prior to entry.
- Smoke alarms with audio and visual indicators on the interior and exterior of the housing.
- Connections for electrical and sewer systems.
- Manually controlled louvered vents. For additional enclosure ventilation specifications, see **Section 7.5.1**.
- Minimum of two man-doors with holdbacks and access doors for carbon change-outs. Man doors will be lockable, capable of fully opening with holdbacks, and be 36 inches wide. The access doors will be lockable, capable of fully opening with holdbacks, and be the width of the equipment container/housing.
- Fluorescent overhead lighting in accordance with National Electric Code (NEC) illumination requirements.

- Emergency lights and glow-in-the-dark egress route outlined on the floor.
- Alarm beacon mounted on the outside of the container and flashes if system is in alarm.

7.5.1 Enclosure Ventilation and Noise Requirements

The site location is one that frequently experiences temperatures below freezing (32 °F). Since the enclosure will contain equipment that will handle water, a thermostatically controlled heating system (Class I, Division II rating) will be installed to prevent freezing within the interior equipment and manifolding.

During summer months, the interior temperature of the enclosure will be thermostatically controlled with ventilation fan(s) capable of ventilating at a minimum of 10 building exchanges per hour capacity, or a similarly adequate means. The ventilation system will be capable of keeping the interior temperature within the operating limits of all equipment.

Noise control will include construction of noise dampening material as required to prevent nuisance noise. Additionally, all external points of ventilation on the enclosure will be fitted with sound dampening louvers to minimize noise transmission at the site.

7.6 MISCELLANEOUS SYSTEM SPECIFICATIONS

Additional general and miscellaneous specifications pertaining to the process equipment are outlined in **Table 13**. Specifications address labeling, security, and potential health and safety issues with the system. Additionally, all valves will be labeled by the fabricator as normally open, normally closed, or variable as outlined in **Table 14.**

8.0 VAPOR TREATMENT SYSTEM SPECIFICATIONS

The vapor treatment system is designed for an initial process flow rate of 3,000 scfm using two ThermOx units (ThermOx #1: capacity of 2,000 scfm, and ThermOx #2: capacity of 1,000 scfm). The ThermOx units will treat volatile organic compounds (VOCs), primarily benzene, in SVE discharge prior to discharge to the atmosphere per requirements of the Illinois Environmental Protection Agency (IEPA) Clean Air Act Permit Program (CAAPP) Construction Permit. It is anticipated that initial benzene concentrations will be at the maximum allowable concentration for the ThermOx units based on the %LEL (up to 40% LEL, 4,800 ppmv). As mass removal rates decline during ongoing operation of the SVE system, the second ThermOx unit will eventually be taken off-line and relocated to the North Tank Farm area.

8.1 VAPOR TREATMENT SYSTEM DESIGN SUMMARY AND SPECIFICATIONS

1) Each ThermOx unit will consist of a Recuperative thermal oxidizer [for a total maximum process flow capacity of 3,000 scfm and minimum destruction & removal efficiency (DRE) of 98%] including:

    a) Combustion/retention chamber

        i. Residence time: >1 sec.

        ii. Thermal Operating Range:

            (a) ThermOx #1: 1,400 – 1,550 °F

            (b) ThermOx #2: 1,400 – 1,800 °F

        iii. Minimum Operating Temperature: 1,450 °F (600 °F in catalytic mode)

        iv. Materials of construction: ThermOx #1 will be constructed of materials compatible with benzene. ThermOx #2 to be constructed of materials suitable for benzene and acid exposure throughout the process flow (as described in **Section 4.1**).

v. Combustion chamber insulation

vi. Exposed surfaces will be limited to 140 °F for personnel protection

vii. Personnel access

b) Heat Exchanger (Shell & Tube)

i. Material of construction: ThermOx #1 will be constructed of materials compatible with benzene. ThermOx #2 to be constructed of materials suitable for benzene and acid exposure throughout the process flow (as described in **Section 4.1**).

ii. Heat Exchanger insulation: limit exposed surfaces to a maximum of 140°F for personnel protection

iii. Inspection ports: Removable access/inspection ports to allow visual inspection of heat exchanger internals during shutdown periods

c) Burners will be in accordance with NFPA 85

i. Fuel source: natural gas

ii. Fuel source pressure, not to exceed 75 psi

iii. Turn down ratio: a minimum turndown of 10:1, to handle changing conditions during the thermal remediation process

iv. Self-checking interlock

v. Flame scanner

vi. Visible flame check

d) Combustion Air Blower

i. Motor: 480-volt (V), 3 phase

ii. Drive: Direct

e) Fuel Gas Train will be in accordance with NFPA 85 and includes:

i. An automatic fuel control valve modulated by a temperature controller with electric actuator

ii. Pressure regulators for main fuel

iii. Low and high fuel gas pressure switches

iv. Fuel gas safety shutoff valves

v. Pressure gauges

vi. Process gas differential pressure flow meter

vii. Combustion air differential pressure flow meter

viii. Gas cocks

ix. Automatic double block and bleed valves with proof of closure switches on all block automatic valves.

f) Pilot Gas Train will include:

i. Pressure regulator

ii. Pressure gauges

iii. Gas Cocks

iv. Automatic Igniter with flame verification

v. Solenoid shutoff valves

vi. Automatic double block and bleed valves with proof of closure switches on all block automatic valves

g) Process Stream will include

i. Automatic double block and bleed valves with proof of closure switches on all block automatic valves

h) Automatic Dilution Valve

i) Flame Arrestor Package will include

   i. Thermocouple and high temperature limit switch
   ii. Differential pressure gauge

j) NEMA-4X local control panel will be constructed with physical separation barrier (e.g., fiberglass, Plexiglas, etc.) between high voltage (120V or greater) and low voltage components. Separate cabinets for power and control are acceptable to meet this requirement. The control panel(s) will include:

   i. Electrical classification: General outdoor
   ii. Main disconnect switch
   iii. Annunciation displayed on front panel
   iv. Start/stop buttons with indicator lights
   v. Temperature controller (indicating)
   vi. High temperature limit (indicating)
   vii. Motor starters
   viii. Fuses (as required)
   ix. Interlocking relays (as required)
   x. Control transformer
   xi. Safety interlock system
   xii. Burner management system
   xiii. UL 508 A/B listed, with UL nameplate affixed to interior of cabinet

k) Controls and Instrumentation will include, but are not limited to:

   i. Flow measurement of all inlet streams
   ii. Temperature measurement around heat exchanger and oxidizer streams

l) Safety Interlock System will include, but is not limited to:

i. Oxidizer shutdown on inlet high temperature

ii. Oxidizer shutdown on outlet high temperature

2) Each system will include a blower compatible with the ThermOx units specified above. General requirements are as follows:

a) Blower package will be capable of maintaining a vacuum of 30” H_2O vacuum at the oxidizer heat exchanger inlet.

b) Type: a sealed blower will be used to prevent vapors or odors from escaping to the environment

c) Variable capacity either via variable speed drive or adjustable recirculation loop

3) Each system will include a discharge stack

4) Instrumentation and controls

a) Blower high temperature alarm

b) Oxidizer to fresh air feed in the event of loss of recirculation loop flow

c) A two pen chart recorder with capacity to record the combustion chamber temperature (and catalyst outlet temperature) with a field adjustable minimum change-out frequency of one month

d) In addition to the above, the following outputs will be provided for process control:

i. Oxidizer operation hours

ii. Oxidizer vapor flow rate

iii. Oxidizer heat exchanger process inlet temperature

iv. Combustion air flow rate

v. Cooling air flow rate (if applicable)

vi. Stack discharge temperature

vii. Stack discharge flow rate

8.2 MAIN CONTROL PANEL AND INTERLOCKS

The main control panels for each of the ThermOx systems will be weather-proof and located on the exterior of the skids constructed to NEMA 4X standards. The control panel for each of the ThermOx units will provide the following digital inputs (4-20 milliamp signals) to the PLC associated with the SVE system:

- A ready signal when each ThermOx is ready to receive flow from the SVE system.
- General ThermOx Alarm: An alarm signal when the ThermOx system is unable to receive process flow from the SVE system due to warm-up or operating conditions that are outside of operating parameters.

Additionally, each of the ThermOx units will contain/accept a digital input from the SVE system alarm condition resulting in a normal shutdown sequence for each of the ThermOx units.

Alarm lights for the ThermOx units will be arranged separately on each of the individual control panels. Any system reset switches that need to be energized to function will be located on the exterior of the main control panel. Additionally, all panel internal devices, wires, and terminals will be properly labeled.

9.0 ELECTRICAL DESIGN

The electrical design includes the following:

- Disconnection and relocation of existing utility pole power drop panel (used in SVE Pilot Test).
- Connection of power drop panel to the plant electrical supply.
- Connection of all process equipment to the electrical supply.
- Installation of heat trace on the applicable system pipes and fittings.

9.1 ELECTRICAL SYSTEM DETAILS

Electricity will be supplied to the equipment container via an overhead connection as presented in **Figure 16**. The electrical service will be 480-volt three phase. The estimated electrical loads for the SVE system components are summarized on **Table 15**. **Table 15** will be finalized upon receipt of the equipment design specifications from the equipment vendor. All external wires, control panels, and enclosures associated with the SVE system are to be weatherproof and constructed to NEMA 4X standards. All connections will be permanent and all equipment will be grounded.

9.2 EQUIPMENT CONNECTION SPECIFICATIONS

The equipment connections include connection of electrical service and grounding of all process and supporting equipment. This includes connection to the process equipment control panel, thermal oxidizer (ThermOx) units, and completion of Class I, Division II seals at all wiring interior/exterior transitions.

9.3 HEAT TRACE SPECIFICATIONS

Heat trace will be applied to select process piping which has the possibility to contain water in either liquid or vapor form. Electric heat trace will be supplied and installed on all above grade SVE branch and main manifold lines and sewer discharge piping including external connections at the equipment container wall (**refer to Section 6.0**).

10.0 IMPLEMENTATION TASKS

10.1 PERMITTING

Permits will be required for several operations during this project. The permit requirements will be renewed/updated as necessary for each phase of work and are summarized below.

10.1.1 IEPA Clean Air Act Permit Program Construction Permit

Solutia will obtain the necessary permits for construction and operation of the off-gas treatment systems. The off-gas treatment systems will be designed, built, and operated to ensure compliance with all applicable regulations.

10.1.2 Wastewater Discharge Permit

Treated condensate will be discharged to the plant's sewer system via a temporary connection for final treatment at the Village of Sauget P-Chem Plant and the American Bottoms Regional Treatment Facility (ABRTF). A modification to the plant's existing permit will be required.

10.2 DESIGN AND PROJECT OPERATIONS PLANS

The design and project operations plans described in the following sections will be developed for work at the site. The plans will be updated as required for each treatment area.

10.2.1 Health and Safety Plan

A site-specific Health and Safety Plan (HASP) will be developed. The HASP will cover work activities, and will integrate with the facility-specific safety requirements.

10.2.2 OPERATIONS, MAINTENANCE, AND MONITORING MANUAL

An Operations, Maintenance, and Monitoring (OM&M) Manual will be developed including area-specific details. This manual will include staffing requirements, standard procedures for work activities, and other instructions for the operations staff. This manual will focus on how to track performance, general maintenance procedures, and procedures for determining when operations are complete.

10.2.3 SAMPLING AND ANALYSIS AND QUALITY ASSURANCE PROJECT PLANS

A combined Sampling and Analysis Plan (SAP) and Quality Assurance Project Plan (QAPP) will be developed for the work activities described in this document.

10.2.4 SPILL PREVENTION, CONTROL, AND COUNTERMEASURE PLAN

A Spill Prevention, Control, and Countermeasure Plan (SPCC Plan) will be prepared for the activities associated with the project. The SPCC Plan will address the following elements:

- Operating procedures that will be employed to prevent oil or hazardous materials spills.
- Control measures that will be installed to prevent a spill.
- Countermeasures to contain, clean up, and mitigate the effects of a spill.

10.3 MOBILIZATION

Staff, materials, and equipment will be mobilized to the site to implement the scope of work, per the schedule as discussed in **Section 13.0**. Basic mobilization and site preparation activities include the following tasks:

- Fabrication of necessary components (SVE system equipment, ThermOx units, etc.).
- Perform survey and utility marking.
- Mobilize temporary facilities (office trailer, storage container, restroom facilities, etc.).
- Establish exclusion zones.
- Construct equipment pads (gravel and/or concrete) as required.

Staffing during the mobilization phase is expected to consist of a Construction Manager and up to two field technicians. Local subcontractors may also be contracted to perform site construction tasks, as required.

10.4 SVE WELL AND VAPOR PROBE INSTALLATION

A qualified drilling contractor will be subcontracted to collect soil borings and install the SVE wells and vapor probes for the SVE system. The drilling contractors will also abandon the existing SVE Pilot Test wells.

Staffing during the drilling phase is expected to consist of two experienced geologists or engineers to oversee the drilling activities.

10.5 MANIFOLD INSTALLATION

A qualified mechanical contractor will be subcontracted to install the manifold systems (including all connections between the ThermOx, AS, ET, and other SVE/AI equipment as necessary), and wellhead controls. Soil excavation/trenching will be required in some areas for the portions of the system piping that will be below grade.

This task will also include installation of the freeze protection equipment, consisting of heat-trace/insulation and heated enclosures for appropriate equipment.

10.6 EQUIPMENT INSTALLATION

SVE equipment installation will include set-up and field connections of equipment that has been pre-fabricated by an equipment vendor. Qualified mechanical and electrical subcontractors will be contracted for the field piping/electrical connections.

10.7 SYSTEM START-UP/EQUIPMENT SHAKE-DOWN

Equipment shake-down will be performed to ensure all automation and safety controls are fully functional. The equipment shakedown will be performed with the SVE well field isolated from the system so there is no potential discharge during the pre-start testing. System shake-down activities will include:

- A pre-startup safety review meeting will be conducted to confirm that the system construction and final installation satisfies the Solutia Process Hazard Analysis (PHA) review.
- Pressure testing of all major piping.
- Leak-check vapor and liquid transfer lines.
- Test liquid and vapor treatment systems with clean water and ambient air.
- Check all motors for proper rotation.
- Verify and calibrate all instrument signals.
- Verify all analog and discrete signals to/from the PLC.
- Set all valves to the proper pre-start positions.
- Collect background VOCs, vacuum/pressure, and water level data.

10.8 SYSTEM OPERATION

The system operation phase will include general operation, monitoring, and maintenance which are discussed in **Section 11.0** of this document.

10.9 SYSTEM DEMOBILIZATION

After completion of SVE operations and/or BV operations in the Big Mo/Former Benzene pipeline treatment areas, the SVE/BV system will be demobilized and deconstructed; SVE wells and vapor probes will be decommissioned; and, site restoration will be completed as needed following demobilization activities.

SVE System Demobilization: When treatment is completed, all piping and equipment associated with the SVE system will be deconstructed and demobilized from the site. The SVE system demobilization includes the following:

- SVE wellheads, laterals, branch and main manifold piping, below grade piping, the sewer discharge line, natural gas lines, and associated fittings and valves will be disassembled and containerized (for disposal using a roll-off or similar).
- The SVE equipment shed will be relocated for use at another site (if applicable).
- Utility connections including natural gas and electrical will be disconnected from the main utility tie-in and disassembled.

Well Abandonment: When treatment is completed, all SVE wells and vapor probes will be abandoned per 35 Illinois Administrative Code 920 and other applicable Illinois EPA regulations and guidelines as described in **Section 5.1**.

Site Restoration: Prior to final demobilizing from the site, rough grading will be performed as needed to maintain adequate drainage, and generally return the site to a condition substantially similar to its condition prior to the start of construction.

11.0 OPERATION AND MONITORING

This section provides a description of the operation strategies, vapor monitoring programs, and soil sampling programs to meet the remediation objectives. This section also includes a brief description of the anticipated day-to-day operation tasks, including process monitoring, general maintenance, and logging/reporting requirements. These activities will be fully outlined in the OM&M manual for the project.

The schedule and operational sequence for treatment of the Big Mo and Former Benzene Pipeline Areas is provided in **Section 12.0** of this document.

11.1 GENERAL SYSTEM MONITORING

General system operations include routine process monitoring, performance monitoring, and compliance monitoring. The goal of monitoring is to record SVE system data to assess the overall progress towards the remediation objectives. Additional details regarding the system monitoring activities will be included in the OM&M manual.

11.1.1 PROCESS MONITORING

Process monitoring includes measurement of flow rates, vacuums/pressures, vapor concentrations, and temperature data at multiple points within the SVE process stream. This also includes monitoring water/condensate (e.g. totalizer readings), NAPL recovery rates, and the operating parameters of the ThermOx units.

Process monitoring data will be used to evaluate mechanical performance of the system to ensure equipment is operating within the desired performance range (i.e., target flow rates) and within manufacturer’s specifications. In addition, this data will aid in identifying mechanical issues and/or for system troubleshooting purposes.

11.1.2 Groundwater Level Monitoring

A key aspect to the overall operation strategy will be regular monitoring of the site groundwater levels. In November 2010 water table elevations were at a historical high, which submerged the lower silty sand layer. Part of the overall operation strategy is to determine when water levels drop sufficiently to expose the lower silty sand layer, and then take the opportunity to reconfigure the SVE system to operate in that zone for as long as possible.

Groundwater levels will be monitored at the nearby monitoring well (BSA-MW01S) in the Big Mo and Former Benzene Pipeline treatment areas during routine site checks. If necessary, one or more monitoring wells may be installed in the vicinity of a treatment area to provide water level data.

11.1.3 Performance Monitoring

Performance monitoring data generally includes:

1. Measurement of vapor concentrations in the SVE process (via field PID measurement and/or vapor samples for laboratory analysis).
2. Measurement of vapor concentrations, vacuums/pressures, flow rates, and temperatures at wellheads and vapor probes (to assess subsurface air flow patterns and changes in vapor concentrations as the system is operated over time).

Performance monitoring data will be used in conjunction with process monitoring data to estimate vapor mass removal rates, overall mass removed by the SVE system, and provide data regarding vapor concentrations remaining in the subsurface.

11.1.4 COMPLIANCE MONITORING

Compliance monitoring data has a specific purpose to satisfy the air and water discharge permit requirements. Compliance monitoring generally includes:

1. Sampling the SVE system vapor concentrations to confirm treatment efficiency of the ThermOx units, and ensure air permit compliance.
2. Sampling the LGAC influent/effluent water concentrations, to confirm treatment efficiency, and ensure water discharge permit compliance.

11.2 WELL FIELD OPTIMIZATION

The following well flow optimization strategies will be employed during the operation phase of the SVE system:

- Rotation of the SVE /AI combination wells to redistribute air flow at appropriate time intervals.
- Conduct static soil-gas rebound surveys to determine which portions of the treatment area have achieved adequate benzene mass reduction (which would be quantified with soil sampling).
- Maximizing VOC mass removal rates as possible by focusing SVE wells on areas of higher vapor concentration/vapor production.

Details and the anticipated intervals of optimization events will be included in the OM&M manual.

11.3 SVE REMOVAL RATE EVALUATION

Process and performance monitoring data will be used to track COC vapor mass removal rates (see **Section 11.1**). In addition, well field vapor concentrations will be monitored and the SVE system will be regularly optimized to ensure that the system resources are focused within the areas that yield higher vapor removal rates (see **Section 11.2**).

As the SVE treatment progresses, COC mass removal rates may decline to a low and steady level. This is usually due to an equilibrium between the air being flushed through the soils and a mass-transfer-limited condition of the remaining contaminants (i.e., the contaminants are not directly contacted by air moving through the soils, and/or they are diffusing from lower-permeability soil units, etc.). At this point, the cumulative mass removal may have reached an "asymptotic" condition, and continued SVE operation will have little additional benefit. Once asymptotic conditions are suspected, the SVE shutdown protocol will be evaluated. An asymptotic condition will be based upon the observation that the COC vapor mass removal rate is less than 10% of the observed baseline for greater than seven consecutive calendar days. Reductions in mass removal rates due to saturated soil conditions (i.e., submerged or partially submerged SVE wells screens and/or target soil intervals) will not be considered an asymptotic condition. If the cumulative mass removal rates are determined to be asymptotic, an evaluation of potential impacts to underlying groundwater and/or potential human health risks associated with the residual COC concentrations remaining in the unsaturated zone soils will be conducted. Based on the results of the risk evaluations, there are two potential options:

1. If the risk evaluations indicate that there is an acceptable level of risk and/or residual risks can be addressed by institutional controls, then a recommendation would be made to shutdown the SVE system.
2. If the risk evaluations indicate the need for further action, and BV can potentially address the residual risk, then a transition to BV will be recommended.

The protocol will provide the basis for a recommendation to USEPA to shutdown the SVE system or make the transition to BV. SVE operations will continue in the treatment areas until USEPA approval of the corresponding recommendation to shutdown or transition to BV. Appendix G provides additional details associated with the SVE shutdown protocol.

11.4 SOIL SAMPLING

In general, soil sampling will be conducted using a Geoprobe. Soil cores will be collected and field-screened for total organic vapors at discrete intervals using a PID and jar vapor-headspace methods. Screening results will be considered when selecting the soil interval to be submitted for laboratory analysis of VOCs by USEPA Method 8260.

The soil data will be used to assess overall benzene mass reduction on the soils over the course of the remediation process. A brief description of the proposed soil sampling program is included in this section (a more detailed soil sampling program will be discussed in the Sampling and Analysis Plan).

11.4.1 Baseline Soil Sampling

The 2009-2010 soil characterization sampling data (refer to the *Characterization Report*) will be used as the baseline soil concentrations. The initial benzene mass estimate was based on this data and was discussed in **Section 2.3.3**.

11.4.2 Interim Soil Sampling

Interim sampling will be performed to demonstrate the progress of soil treatment. Interim soil samples will be collected annually following start-up of the SVE system, as applicable (refer to the schedule in **Section 12.0**). Samples will be co-located with selected baseline soil sample locations.

11.4.3 FINAL SOIL SAMPLING

Based on process and performance monitoring data, when the SVE system has reached an asymptotic mass removal condition (refer to **Section 11.3**), a final soil sampling event will be conducted to determine the overall level of benzene mass reduction on the soils. Samples will be co-located with selected baseline and interim soil sample locations.

11.5 DATA EVALUATION

Process and performance monitoring data will be entered into a spreadsheet to track trends in the data. Review of this data (with graphical presentation of trends as applicable) will allow evaluation of:

1. Overall contaminant mass removal rates and totals (as vapor, water, and NAPL).
2. Changes in operational parameters of system process equipment (such as increasing or decreasing flow rates, vacuums/pressures, temperatures, etc.) that may indicate changes in the remedial process, or impending maintenance issues.
3. Wellfield performance (including observations of vacuums/pressures and changes in VOCs levels at the wellheads and vapor probes). This data will be used to assess if wellfield optimization is necessary for optimal air flow or mass removal rates.
4. Groundwater level assessment to determine when to configure the system for operation in the lower silty sandy layer.

Additional monitoring can be conducted if warranted based on observed data trends (for example, if blower temperatures collected during the process monitoring indicate a potential impending maintenance issue).

11.6 REPORTING

An *Interim Construction Completion Report* will be generated for the Big Mo and Former Benzene Pipeline Areas and will be submitted to USEPA. A *Final Completion Report* will be generated once remediation has been completed at all the site areas.

General status reporting will be conducted on a quarterly basis. Status reports will detail:

- Total mass removed (per reporting period and cumulatively over the operational lifetime of the system).
- Process parameters recorded during site visits and downloaded via the telemetry system.
- Flow, pressure, vacuum, and total VOC measurements collected in the field at the SVE/AI wellheads.
- Laboratory sample results and the associated laboratory and data validation reports.
- SVE discharge monitoring results.
- Any system outages and corrective measures taken.
- Scheduled maintenance, reconfiguration, or system optimization events.

Permit compliance reporting will also be conducted per the requirements of the specific permit.

As the SVE system attains the remedial objectives, an assessment will be conducted to determine if the SVE system should be shutdown and/or transitioned into a BV mode. This is discussed in **Section 11.3**. A final completion report will be provided to USEPA upon completion of SVE/BV operations.

12.0 SCHEDULE

This section outlines the anticipated project schedule. The schedule will be dependent upon actual SVE system performance. The proposed project schedule is presented in **Figure 17**.

In general the proposed remedial operation sequence is as follows. The process will begin with design, permitting, and installation of the Big Mo/Benzene Pipeline area SVE system. This system will be dedicated to this area and will include the purchase and mobilization of ThermOx unit #1 and a dedicated SVE system. ThermOx #2 will also be acquired at this time to provide additional vapor treatment capacity for this treatment area over the initial year of operation. It is anticipated that this area will be treated for up to four years (which accounts for operation in both the sandy fill/upper silty sand and lower silty sand layers).

TABLES

TABLE 1
Maximum Soil Concentrations
W.G. Krummrich Facility, Sauget, Illinois

Treatment Area	Benzene (mg/kg)	Chlorobenzene (mg/kg)
Big Mo	42,000	810
Former Benzene Pipeline	990	2,000

mg/kg = milligrams per kilogram

Note:
1. Refer to Appendix B for comprehensive soil data.

TABLE 2
Mass Estimates
W.G. Krummrich Facility, Sauget, Illinois

Soil Layer	Big Mo Area	Former Benzene Pipeline Area	**Total COCs**	
	Lbs	Lbs	**Lbs**	**Percent of Total Mass**
Sandy Fill/Upper Silty Sand	80,000	9,000	**89,000**	**17%**
Intermediate Silty Clay	120,000	10,000	**130,000**	**25%**
Lower Silty Sand	290,000	8,000	**298,000**	**58%**
Total Mass Per Area	**490,000**	**27,000**	**517,000**	
Percent of Total Mass	**95%**	**5%**	**100%**	

Lbs = pounds
COCs = Contaminants of Concerns

Note:
1. Refer to Appendix D for soil mass estimate calculations and assumptions.

TABLE 3
Soil Vapor Extraction Pilot Test Results Summary
W.G. Krummrich Facility, Sauget, Illinois

Well Performance		
Wellhead Flow rate	SVE Wellhead Performance	AI Wellhead Performance
	25 to 30 scfm	20 to 80 scfm
Wellhead Vacuum(-) / Pressure(+)	-20 to -50 in H_2O	+20 to +60 in H_2O
SVE Removal Performance		
SVE Vapor Concentrations and Mass Removal Rates	Initial	Average
Mass Removal Rates	20 Lbs/Hour (as benzene)	7 Lbs/Hour (as benzene)
Vapor Concentrations	5,100 ppmv (TO-15 analysis, benzene)	1,300 ppmv (Total VOCs via PID)
Mass Removed (as vapor)	16,000 Lbs as benzene	
Soil Permeability		
Intrinsic Soil Permeability[1,2]	$K_r = K_z = 3.94x10^{-7}$ cm^2	$K_c/B_c = 3.58x10^{-10}$ cm^2
Radius of Influence (ROI)[3]		
Wellhead Extraction Flow Rate	500 PV/year	1,000 PV/year
25 scfm	ROI = 25 ft	ROI = 20 ft
30 scfm	ROI = 27 ft	ROI = 21 ft
Soil COC Reductions		
Full Area: COC Mass Estimate (Lbs/benzene):	Baseline (January 2009)	Intermediate (March 2010)
	Lbs benzene	Lbs benzene
	79,000	62,000
Percent Reduction:	21%	
Mass Removed (Soil Data, Lbs as benzene)	17,000 Lbs as benzene	
Sub-Area: COC Mass Estimate (Lbs/benzene):	Baseline (May 2010)	Final (June 2010)
	1,600	1,100
Percent Reduction:	31%	
Mass Removed (Soil Data, Lbs as benzene)	500 Lbs as benzene	

SVE = soil vapor extraction
ft = feet
PID = photoionization detector
Lbs = pounds
mg/kg = milligrams per kilogram
scfm = standard cubic feet per minute
cm^2 = square centimeters
ppmv = parts per million by volume
COC = Contaminants of Concern
% = percent
ROI = radius of influence
PV = pore volume
SVE = soil vapor extraction
AI = air injection

Notes:
1. The permeability model results demonstrated that the sandy fill/upper silty sand layer is isotropic; the horizontal permeability (K_r) is equal to the vertical permeability (K_z).
2. The computer model assumes that the surface cover is 10 cm thick (represented by B_c) and the overall permeability of this surface cover is a function of thickness (i.e., K_c/B_c).
3. The full-scale design ROI is the radial distance from a SVE well where the minimum target number of PV exchanges will occur (500 PV/year and 1,000 PV/year).

TABLE 4

Soil Vapor Extraction Well and Vapor Probe Material Specifications
W.G. Krummrich Facility, Sauget, Illinois

Components	Details	Units	Specifications
General Specification	Total Shallow SVE Wells	76 ea.	Installed to a maximum of 10 ft bgs (see Table 1A)
	Total Deep SVE Wells	82 ea.	Installed to a maximum of 15 ft bgs (see Table 1A)
	Vapor Probes	32 ea.	Nested shallow and deep locations to approximately 5 and 13 ft bgs, respectively (see Table 1A)
Shallow SVE Wells	Slotted Screen	260 ft	2-inch interior diameter, 0.02-inch machine slotted Type 304 or 316 stainless steel screen; minimum opening equal to 7% of surface area; screen to be bottom finished with welded or NPT air tight cap
	Screen Sandpack	na	Grade 2S (Holliston Sand Company) well sand at a specific gravity of 2.65
	Bentonite Seal	na	Baroid or similar bentonite pellet seal less than 1 x 10^{-8} cm/sec permeability
	Cement Bentonite Grout Seal	na	Mixture of 3.75 pounds of standard sodium bentonite gel powder for every 94 pound sack of cement (ASTM C-150 Type I or II); water content of mixture between 6 - 7 gallons of water per 94 pounds of cement
	Riser Pipe	270 ft	2-inch interior diameter carbon steel riser pipe; connections between sections completed using air-tight NPT couplings
	Above grade surface completion	61 ea.	Carbon steel riser pipe to extend a minimum of 6 inches above surface grade an completed with a 2-inch slip cap.
	Below grade surface completion	15 ea.	8-inch interior diameter (minimum) aluminum manhole with water tight cover; manhole constructed with 2S sand along base to promote drainage.
Deep SVE Wells	Slotted Screens	330 ft	2-inch interior diameter, 0.02-inch machine slotted Type 304 or 316 stainless steel screen; minimum opening equal to 7% of surface area; screen to be bottom finished with welded or NPT air tight cap
	Screen Sandpack	na	Well gravel grade 2S (Holliston Sand Company) at a specific gravity of 2.65
	Bentonite Seal	na	Baroid or similar bentonite pellet seal less than 1 x 10^{-8} cm/sec permeability
	Cement Bentonite Grout Seal	na	Mixture of 3.75 pounds of standard sodium bentonite gel powder for every 94 pound sack of cement (ASTM C-150 Type I or II); water content of mixture between 6 - 7 gallons of water per 94 pounds of cement
	Riser Pipe	950 ft	2-inch interior diameter carbon steel riser pipe; connections between sections completed using air-tight NPT couplings
	Above grade surface completion	67 ea.	Carbon steel riser pipe to extend a minimum of 6 inches above surface grade an completed with a 2-inch slip cap
	Below grade surface completion	15 ea.	8-inch interior diameter (minimum) aluminum manhole with water tight cover; manhole constructed with 2S sand along base to promote drainage.
Vapor Probes	Slotted Screens	32 ft	1-inch interior diameter, 0.02-inch machine slotted Type 304 or 316 stainless steel screen; minimum opening equal to 7% of surface area; screen to be bottom finished with welded or NPT air tight cap
	Screen Sandpack	na	Well gravel grade 2S (Holliston Sand Company) at a specific gravity of 2.65
	Bentonite Seal	na	Baroid or similar bentonite pellet seal less than 1 x 10^{-8} cm/sec permeability
	Cement Bentonite Grout Seal	na	Mixture of 3.75 pounds of standard sodium bentonite gel powder for every 94 pound sack of cement (ASTM C-150 Type I or II); water content of mixture between 6 - 7 gallons of water per 94 pounds of cement
	Riser Pipe and Sump	362 ft	1-inch interior diameter carbon steel riser pipe; connections between sections completed using air-tight NPT couplings; vapor probes will be completed a minimum of 2 feet above ground surface
	Slip-on Cap	32 ea.	Polyvinyl chloride slip-on cap;
	Above grade surface completion	22 ea.	Carbon steel riser pipe to extend a minimum of 6 inches above surface grade an completed with a 2-inch slip cap
	Below grade surface completion	10 ea.	Shallow and deep nested vapor probes will be completed within the same manhole; 8-inch interior diameter (minimum) aluminum manhole with water tight cover; manhole constructed with 2S sand along base to promote drainage

SVE = Soil Vapor Extraction
ea. = each
ft = feet
ft bgs = feet below ground surface
cm/sec = centimeters per second
na = not applicable (see note 3)

Notes:

1. Minimum borehole annulus is 6 inches.
2. Linear feet specified, volumes associated with sandpack, bentonite seal, and cement bentonite seal dependant upon final annulus of borehole.
3. Annular material specifications are included in this table for reference only. Wells will be constructed per design specifications presented on Figure 2. Actual material volumes will be determined in the field during well and vapor probe installation.

TABLE 5

Well and Vapor Probe Design Parameters
W.G. Krummrich Facility, Sauget, Illinois

Wells	Target Soil Layer	Typical Screen Interval[1]	Approximate Well Spacing	Configuration of Wells				Design Air Flow Rate per Well[2]	Design Wellhead Vacuum[2]
		(ft bgs)	(ft)	Single	Nested	Combined AI[2]	Total in Layer	(scfm/well)	(in. H_2O)
Big Mo Area									
SVE - Shallow	Sandy fill/Upper Silty Sand	4 - 9	40	3	65	30	68	25-30	up to 50
SVE - Deep	Lower Silty Sand	10 - 15		9	65	30	74		
Vapor Probe - Shallow[3]	Sandy fill/Upper Silty Sand	6 - 7	NA	0	14	NA	14	NA	NA
Vapor Probe - Deep[3]	Lower Silty Sand	12 - 13		0	14	NA	14	NA	NA
Former Benzene Pipeline Area									
SVE - Shallow	Sandy fill/Upper Silty Sand	4 - 9	40	0	8	4	8	25-30	up to 50
SVE - Deep	Lower Silty Sand	10 - 15		0	8	4	8		
Vapor Probe - Shallow	Sandy fill/Upper Silty Sand	6 - 7	NA	0	3	NA	3	NA	NA
Vapor Probe - Deep	Lower Silty Sand	12 - 13		0	3	NA	3	NA	NA

SVE = soil vapor extraction
AI = air injection
ft = feet

bgs = below ground surface
scfm = standard cubic feet per minute
in. H_2O = inches of water

NA = Not applicable

Notes:

1. The typical well screen interval may range from approximately 5 to 7 ft thick for the shallow wells and up to 5 ft for the deep wells. This is the result of variability in the thickness of the target geological layers. The ranges presented in this table will be used as a guide; actual well screen target intervals may vary when installed.
2. Select shallow and deep SVE wells are designed to operate in either vapor extraction or air injection modes (i.e., combination AI wells). The design well head flow rate and pressure for the air injection mode is 20 to 80 scfm at up to +60 in. H2O.
3. The existing nested 11 vapor probes (VP-01S/D through VP-06S/D, VP-09S/D, VP-10S/D, VP-A01SD, VP-A02S, and VP-A03S/D) in the SVE Pilot Test Area

TABLE 6A

Soil Vapor Extraction General Piping Specifications

W.G. Krummrich Facility, Sauget, Illinois

Components	Details	Units	Specifications
SVE Wellhead Assembly (Figure 12A)	2" Piping with couplers[2]	1,260 ft	Schedule 40 PVC solvent welded slip-on, or flanged
	2" standard Tee	84 ea.	
	2" Screw cap	84 ea.	
	2" Coupler	84 ea.	Carbon steel or Schedule 40 PVC NPT air tight threaded coupling for transition from carbon steel riser pipe to Schedule 40 PVC; vendor specified with approval
	2" Coupler	168 ea.	Schedule 40 PVC female solvent welded slip-on air tight threaded male NPT connection (connection to gate valve)
	2" Gate Valve	84 ea.	Brass; vendor specified with approval
	2" Reinforced vacuum tubing	90 ft	Approximately 1 ft of reinforced vacuum tubing per wellhead assembly; must be chemically compatible with benzene; vendor specified with approval
	2" Hose barb	168 ea.	Stainless steel or brass male NPT air tight threaded hose barb; vendor specified with approval
	2" Hose clamp	336 ea.	Hose clamps for vacuum tubing; 2 per fitting; vendor specified with approval
	2" Cam and groove hose coupling	168 ea.	Stainless steel, female NPT air tight threaded cam and groove hose coupling; 2 per well; vendor specified with approval
	2" Coupler	168 ea.	Schedule 40 PVC solvent welded slip-on with air tight threaded male NPT connection (connection to cam and groove hose coupling)
	Reducing Bushing	84 ea.	1/2" x 3/8" Brass male NPT to female NPT bushing
	Ball Valve/Sample Port	84 ea.	3/8" full bore Brass ball valve with 1/8" or 1/4" hose barb
SVE below grade well and trenching details (Figure 11)	2" Riser (trench to above grade)	120 ft	Carbon steel; schedule specified by vendor with approval
	2" 90° Elbow	30 ea.	
	2" Below grade lateral	1,570 ft	
	2" standard Tees	30 ea.	
SVE Branch Lines (Figure 9G and 9H)	6" Piping with couplers[3]	2,500 ft	Schedule 40 PVC solvent welded slip-on, or flanged
	6" standard Tees	149 ea.	
	6" to 2" reducing bushings	147 ea.	
	6" 90° Elbow (for below to above grade wellhead assemblies)	4 ea.	
	6" Braided connector hose	11 ft	Stainless steel hose with carbon steel male NPT or flange fittings (1 ft length per connection for 11 connections; a minimum of 20-inch bend radius; vendor specified with approval
SVE Branch Line Cleanouts (Figures 9G and 9H)	6" 90° Elbow	12 ea.	Schedule 40 PVC air tight threaded NPT, solvent welded slip-on, or flanged connections; vendor specified with approval
	6" to 2" Reducing bushings	12 ea.	
	2" Nipples	12 ea.	
	2" Screw caps	12 ea.	
	2" Ball valves	12 ea.	Brass; vendor specified with approval
SVE Main Manifolding Lines (Figure 9G and 9H)	12" Piping with couplers	600 ft	Schedule 40 PVC solvent welded slip-on, or flanged
	12" standard Tees	20 ea.	
	12" 45° Elbow	3 ea.	
	12" to 2" Reducing bushings	11 ea.	
	12" to 6" Reducing Bushings	11 ea.	
	12" Expansion coupling	5 ea.	Stainless steel expansion joint with flanged fittings; vendor specified with approval
	12" Ball valves (at the SVE container)	1 ea.	Brass; vendor specified with approval

NPT = Nation pipe thread   ft = feet
PVC = Polyvinyl chloride   ea. = each
SVE = Soil vapor extraction   " = inches

Notes:

1. All equipment to be installed according to manufacturer's required specifications. All PVC pipe connections will be airtight and cleaned with a color primer prior to application of the welding solvent. Welding solvent must be rated for outdoor use; vendor selected with approval.
2. Assume 5 ft of 2" Schedule 40 PVC per SVE wellhead assembly from the carbon steel coupling to the wellhead assembly and 10 ft from wellhead assembly to branch/manifold lines (84 SVE connections total).
3. Includes additional piping for construction of the below-to-above grade wellhead manifolds.

TABLE 6B

Air Injection General Piping Specifications

W.G. Krummrich Facility, Sauget, Illinois

Components	Details	Units	Specifications
Combination SVE and AI Wellhead Assembly (Figure 12B)	2" Piping with couplers[3]	1,200 ft	Schedule 80 CPVC solvent welded slip-on, or flanged
	2" four-way Cross	74 ea.	
	2" 90° Elbow	74 ea.	
	2" Screw cap	74 ea.	
	2" Gate Valve	148 ea.	Brass; vendor specified with approval
	2" Coupler	74 ea.	Carbon steel or Schedule 80 CPVC NPT air tight threaded or flanged coupling for transition from carbon steel riser pipe to Schedule 80 CPVC; vendor specified with approval
	2" Coupling	148 ea.	Schedule 80 CPVC female solvent welded slip-on and air tight threaded male NPT connection (connection to gate valve)
	2" Piping with couplers[3]	740 ft	Schedule 40 PVC solvent welded slip-on, or flanged
	2" 90° Elbow	74 ea.	
	2" Coupling	148 ea.	Schedule 40 PVC female solvent welded slip-on and air tight threaded male NPT connection (connection to gate valve)
	2" Reinforced vacuum tubing	150 ft	Approximately 1 ft of reinforced vacuum/pressure tubing per wellhead assembly; must be chemically compatible with benzene; vendor specified with approval
	2" Hose barb	296 ea.	Stainless steel or brass male NPT air tight threaded hose barb; vendor specified with approval
	2" Hose clamp	592 ea.	Hose clamps for vacuum tubing; 2 per fitting; vendor specified with approval
	2" Cam and groove hose coupling	296 ea.	Stainless steel, air tight threaded female NPT cam and groove hose coupling; 2 per well; vendor specified with approval
	2" Coupler	148 ea.	Schedule 40 PVC solvent welded slip-on with air tight threaded male NPT connection (connection to cam and groove hose coupling)
	2" Coupler	148 ea.	Schedule 80 CPVC solvent welded slip-on with air tight threaded male NPT connection (connection to cam and groove hose coupling)
	Reducing Bushing	74 ea.	1/2" x 3/8" Brass male NPT to female NPT bushing
	Ball Valve/Sample Port	74 ea.	3/8" full bore Brass ball valve with 1/8" hose barb
AI Branch Lines (Figures 9G and 9H)	6" Piping with couplers[4]	1,600 ft	Schedule 80 CPVC solvent welded slip-on, or flanged
	6" standard Tee	74 ea.	
	6" to 2" reducing Bushing	74 ea.	
	6" 90° Elbow	4 ea.	
	6" Braided connector hose	8 connections	Stainless steel hose with carbon steel male NPT or flange fittings; a minimum of 20-inch bend radius; vendor specified with approval
AI Branch Line Cleanouts (Figures 9G and 9H)	6" 90° Elbow	8 ea.	Schedule 80 CPVC air tight threaded NPT with Teflon tape seals, solvent welded slip-on, or flanged connections; vendor specified with approval
	6" to 2" reducing Bushing	8 ea.	
	2" Nipple	8 ea.	
	2" Screw cap	8 ea.	
	2" Ball Valve	8 ea.	Brass; vendor specified with approval
AI Main Manifolding Lines (Figure 9G and 9H)	12" Piping with couplers	235 ft	Schedule 10 Carbon Steel piping with flanged couplings
	12" 45° Elbow	3 ea.	
	12" 90° Elbow	1 ea.	
	12" standard Tee	1 ea.	
	12" Expansion coupling	5 ea.	Stainless steel expansion joint with flanged fittings; vendor specified with approval
	12" Piping with couplers	365 ft	Schedule 80 CPVC solvent welded slip-on, or flanged
	12" standard Tee	6 ea.	
	12" to 6" reducing Bushing	8 ea.	
	12" Ball valve (at the SVE container)	1 ea.	Brass; vendor specified with approval

AI = Air injection
CPVC = Chlorinated polyvinyl chloride
NPT = Nation pipe thread
PVC = Polyvinyl chloride
SVE = Soil vapor extraction
ft = feet
ea. = each
" = inches

Notes:

1. All equipment to be installed according to manufacturer's required specifications.
2. All CPVC and carbon steel pipe connections will be air tight. CPVC connections will be cleaned with a color primer prior to application of the welding solvent. Welding solvent must be rated for outdoor use; vendor selected with approval.
3. Assume 5 ft of 2" Schedule 80 CPVC per SVE wellhead assembly from the carbon steel coupling to the wellhead assembly and 10 ft from wellhead assembly to branch/manifold lines. The piping from the wellhead assembly will be either Schedule 80 CPVC (74 AI connections) or Schedule 40 PVC (74 SVE connections).
4. Includes additional piping for construction of the below-to-above grade wellhead manifolds.

TABLE 6C

External Systems Process Piping and Specifications

W.G. Krummrich Facility, Sauget, Illinois

Components	Details	Units	Specifications
Natural Gas Connection (Figure 13B)	4" Valve (adjustable)	1 ea.	Vendor specified with approval
	3" Valve (adjustable)	1 ea.	
	4" to 3" Bell Reducer	1 ea.	Carbon Steel, air-tight connections - vendor specified schedule with approval
	3" Pipe with welded couplers	160 ft	
	3" 90° Elbow	2 ea.	
	3" to 2" Bell Reducer	1 ea.	
	2" Pipe with welded couplers	400 ft	
	2" Valves (adjustable)	2 ea.	
	2" standard Tee	1 ea.	
	2" Plug	1 ea.	
	Single leg uni-strut	50 ea.	Vendor specified with approval
	Roller saddle pipe supports	50 ea.	Vendor specified with approval
	Natural Gas pressure regulator	1 ea.	2 to 5 psi In-line pressure regulator on 2" carbon steel pipe - vendor specified with approval (see Note 2)
Connections to ThermOx Units	8" Pipe with welded or flanged couplers	25 ft	Carbon Steel, air-tight connections - vendor specified schedule with approval
	Water trap ("p"-trap, pipe bends or equivalent)	4 ft	
	Manual drain and plug	2 ea.	External to the equipment building/container and prior to thermox inlets; carbon steel - vendor specified with approval
Sewer Discharge Connection (Figure 14B)	2" Piping with threaded connections	610 ft	Carbon Steel, water-tight threaded NPT connections - vendor specified schedule with approval
	2" 90° Elbow	3 ea.	
	Single leg uni-strut	80 ea.	Vendor specified with approval
	Roller saddle pipe supports	80 ea.	Vendor specified with approval
Miscellaneous	8' jersey barriers with mounted reflectors	60 ea.	Concrete barriers spaced 4 ft apart - vendor specified with approval

" = inches
ft = feet
ea. = each

ThermOx = Thermal oxidizer
NPT = Nation pipe thread

Notes:

1. All equipment to be installed according to manufacturer's required specifications.
2. Actual operating pressure to be specified by in the Thermal Oxidizer Operation Manual; regulator will be sized accordingly. General operating range of natural gas pressure is 2 to 5 psi.

TABLE 7

Soil Vapor Extraction System Design Summary
W.G. Krummrich Facility, Sauget, Illinois

Target Depth	Target Soil Layer	SVE System - Maximum Capacity[1]				AI System - Maximum Capacity[1]			
		Well Count	Design Extraction Flow Rate per Well (scfm/well)	Design Well Head Vacuum (in. H_2O)	Total System Flow Rate (scfm)	Well Count	Design Injection Air Flow Rate per Well (scfm/well)	Design Well Head Pressure (in. H_2O)	Total System Flow Rate (scfm)
Shallow	Sandy fill/Upper Silty Sand	76	25-30	up to 50	**2,000**	34	20-80	up to 60	**1,000**
Deep	Lower Silty Sand	82				34			

SVE = soil vapor extraction
AI = air injection
ft = feet
bgs = below ground surface
scfm = standard cubic feet per minute
in. H_2O = inches of water
NA = Not applicable

Note:

1. Maximum flow rate of the SVE/AI equipment is shown. Assumes that the well field will be optimized periodically to focus air flow in specific areas. The configuration of the individual combination SVE/AI wells (i.e., operating in SVE or AI mode) will affect the actual SVE/AI flow rates. The system capacity is designed to operate approximately half of the SVE/AI wells at a given time (based on the assumption that lower silty sand layer will be intermittently available for SVE/AI operations).

TABLE 8

SVE System General Specifications
Applies to Piping and Equipment Inside/Outside SVE/AI Container
W.G. Krummrich Facility, Sauget, IL

Item/Part/Component	Location	Description	Specification
SVE Pipe Sloping	Inside	General pipe pitch for SVE Container Manifolding	Manifolding upstream of positive displacement blowers to be sloped 1'/100' minimum towards the air moisture separators.
Steel Pipe	Inside	Steel process pipe	Diameter and configuration according to design drawings; all process steel should be painted; flanged/gasket connections or threaded where appropriate.
SVE Optional Turnkey Enclosure	----	Durable enclosure to house AI/SVE equipment	Container to be constructed from a standard size steel "roll-off" marine shipping container.
Optional Transition Pipe for Turnkey Enclosure	Inside/Outside	SVE and AI inside-outside pipe transition	Female threaded steel ends/fittings (FPT) will be provided outside the AI/SVE container for on-site connections at all the pipe transition locations. All transition piping/fittings will be capped/secured temporarily for shipping.

AI = Air injection
SVE = Soil vapor extraction
1'/100' = One foot vertical change in 100 feet of horizontal length

Notes:
1. All process equipment to be assembled in accordance with all manufactures required specifications.
2. Refer to Figures 15A and 15B for SVE and AI process equipment schematics, respectively.

TABLE 9
SVE System Detailed Specifications
General Part List Applies to Piping and Equipment Associated with SVE Equipment
W.G. Krummrich Facility, Sauget, Illinois

Item/Part	Description	Specification
AFS 101, 201, 301	Air Filter/Silencer	Solberg (or approved equivalent) - sized by vendor with approval
AMS 101, 201, 301	Air Moisture Separator	120-gallon effective capacity, 12" inlet/8"outlet, rated for 20" Hg., includes high efficiency demister (99% efficiency at 10 micron droplet size) and 6" clean out - vendor selected with approval
APF 101, 201, 301	Air Particulate Filter	Solberg (or approved equivalent) - sized by vendor with approval
BFV 101, 201, 301	Butterfly Valve, 8"	Steel/Brass/Ductile Iron True Union/Flanged Butterfly Valve - Vendor selected with approval
BPF 701	Bag Particulate Filter	Sized by vendor with approval
BV 001, 002, 003, 401, 402	Ball Valve, 12"	Steel/Brass/Ductile Iron True Union Ball Valve - Vendor selected with approval
BV 101, 201, 301	Ball Valve, 8"	Steel/Brass/Ductile Iron True Union Ball Valve - Vendor selected with approval
BV 102 - 106, 202 - 206, 303 - 306, 701, 708, 721 - 726, 729	Ball Valve, 1"	Steel/Brass/Ductile Iron True Union Ball Valve - Vendor selected with approval
BV 702 - 707, 709 - 720, 727, 728	Ball Valve, 2"	Steel/Brass/Ductile Iron True Union Ball Valve - Vendor selected with approval
CF 401, 701, 702	Carbon Filter, 2" pipe connection	Steel/Brass/Ductile Iron - vendor selected with approval
CV 001, 002, 003	Vacuum Check Valve, Gate Type, 12"	Steel/Brass/Ductile Iron - vendor selected with approval
CV 101, 201, 301	Pressure Check Valve, Gate Type, 8"	Steel/Brass/Ductile Iron - vendor selected with approval
CV 103, 203, 303, 703	Water Check Valve, Gate Type, 1"	Steel/Brass/Ductile Iron - vendor selected with approval
CV 701, 702	Water Check Valve, Gate Type, 2"	Steel/Brass/Ductile Iron - vendor selected with approval
DD 701, 702	Dry Disconnect Valve, 1"	vendor selected with approval
FA 401, 701, 702	Flame Arrestor, 2" pipe connection	Steel/Brass/Ductile Iron - vendor selected with approval
FC 101, 102, 201, 202, 301, 302	FC 101, 102, 201, 202, 301, 302	Pipe Joining Flex/Flange Coupling - vendor selected with approval
FH 701	Flex Hose, 1"	vendor selected with approval
FIA 401	Air Flow Indicator - Analog, 12" Stainless Stee pipe connection (monitor/record air flow rate/totalizer reading)	0-3,000 scfm; Compact air mass flow meter (or approved equivalent) producing 4-20 mA output signal directly proportional to the air flow rate (4mA - low flow rate and 20mA - high flow rate) operating on 1(40 Volt DC supply; integrated with controller, panel meter, system control panel, telemetry system, and data loggers, flow/totalizer reading display required - vendor selected with approval
FM 101, 201, 301	Air Flow Meter, 8" PVC pipe connection	0-1,250 scfm; Dwyer (or approved equivalent) Pitot Tube Assembly - Magnehelic gauge with mounting bracket and inline averaging pitot tube flow/differential pressure sensor, direct flow reading display of (1,250 scfm required - sized by vendor with approval
FM 102, 202, 302	Air Flow Meter, 8" Steel pipe connection	0-1,250 scfm; Dwyer (or approved equivalent) Pitot Tube Assembly - Magnehelic gauge with mounting bracket and inline averaging pitot tube flow/differential pressure sensor, direct flow reading display of (1,250 scfm required - sized by vendor with approval
FM 001, 401	Air Flow Meter, 12" Steel pipe connection	0-3,000 scfm; Dwyer (or approved equivalent) Pitot Tube Assembly - Magnehelic gauge with mounting bracket and inline averaging pitot tube flow/differential pressure sensor, direct flow reading display of (3,000 scfm required - sized by vendor with approval

TABLE 9

SVE System Detailed Specifications
General Part List Applies to Piping and Equipment Associated with SVE Equipment
W.G. Krummrich Facility, Sauget, Illinois

Item/Part	Description	Specification
FS 101	Flow Sensor, Digital, 8" steel pipe (indicates minimum air flow)	Dwyer (or approved equivalent) - sized by vendor with approval
FS 201	Flow Sensor, Digital, 8" steel pipe (indicates minimum air flow)	Dwyer (or approved equivalent) - sized by vendor with approval
FS 301	Flow Sensor, Digital, 8" steel pipe (indicates minimum air flow)	Dwyer (or approved equivalent) - sized by vendor with approval
FT 701	Water Flow Totalizer - Analog, 2" Steel pipe connection (monitor/record water flow rate/totalizer reading)	0-30 gpm; Analog totalizing liquid flow meter producing 4-20 mA output signal directly proportional to the flow, type 316 stainless steel; integrated with controller, panel meter, system control panel, telemetry system, and data loggers, flow/totalizer reading display required - vendor selected with approval
LGAC 701, 702	Liquid-Phase Granular Activated Carbon Units (Qty. 2)	800 lb. Liquid-Phase Granular Activated Carbon Units (with virgin carbon), rated for >90 psig pressure standard absorbent fill capacity = 800 lbs. ea. - vendor selected with approval
GV 001	12" Brass Gate Valve	Brass Gate Vales; Bleeds ambient air. Vendor selected with approval
GV 101, 201, 301	8" Brass Gate Valve	Brass Gate Vales; Bleeds ambient air. Vendor selected with approval
GV 102, 202, 302	1" Brass Gate Valve	Brass Gate Vales; Water recirculation line. Vendor selected with approval
HM 101	Total Runtime/ hour Meters for PDB 101 (provide calculate motor run time)	Total runtime/hour meter can either be an analog device or a digital input signal
HM 102	Total Runtime/ hour Meters for TP 101 (provide calculate motor run time)	Total runtime/hour meter can either be an analog device or a digital input signal
HM 201	Total Runtime/ hour Meters for PDB 201 (provide calculate motor run time)	Total runtime/hour meter can either be an analog device or a digital input signal
HM 202	Total Runtime/ hour Meters for TP 201 (provide calculate motor run time)	Total runtime/hour meter can either be an analog device or a digital input signal
HM 301	Total Runtime/ hour Meters for PDB 301 (provide calculate motor run time)	Total runtime/hour meter can either be an analog device or a digital input signal
HM 302	Total Runtime/ hour Meters for TP 301 (provide calculate motor run time)	Total runtime/hour meter can either be an analog device or a digital input signal
HM 701	Total Runtime/ hour Meters for TP 701 (provide calculate motor run time)	Total runtime/hour meter can either be an analog device or a digital input signal
HM 702	Total Runtime/ hour Meters for TP 702 (provide calculate motor run time)	Total runtime/hour meter can either be an analog device or a digital input signal
LEL 701	Lower Explosive Limit Meter - Digital (monitor/transmit LEL% reading) shuts down entire system when activated	0-40% LEL: High accuracy LEL meter/transmitter assembly mounted on building/container exterior producing 4-20 mA output signal directly proportional to the building/container interior LEL% (4 mA - 0% LEL and 20 mA - high 40% LEL) operating on 5-40 Volt DC supply; integrated with controller, panel meter, system control panel, telemetry system, and data loggers, LEL% reading display required, also shuts down PDB 101/201/301, TP 101/201/301/701/702, TOX and AC 901/1001 in the event of high LEL% detection - set at 10% - vendor selected with approval
LS 101, 201, 301, 701, 704	AMS 101/ AMS 201/ AMS 301/ OWS 701/ NT 701 - high, high level (alarm) float switch	GEMS (or approved equivalent), fails high - vendor selected with approval
LS 102, 202, 302, 702, 705	AMS 101/ AMS 201/ AMS 301/ OWS 701/ NT 701 - high level float switch	GEMS (or approved equivalent), fails high - vendor selected with approval
LS 103, 203, 303, 703	AMS 101/ AMS 201/ AMS 301/ OWS 701 - low level float switch	GEMS (or approved equivalent), fails high - vendor selected with approval

TABLE 9

SVE System Detailed Specifications
General Part List Applies to Piping and Equipment Associated with SVE Equipment
W.G. Krummrich Facility, Sauget, Illinois

Item/Part	Description	Specification
MD 101, 201, 301	Manual Drain Clean Out	Specified to fit AMS 101, AMS 201 and AMS 301 - selected by vendor with approval
MD 102, 103, 104, 202, 203, 204, 302, 303, 304, 702 - 705, 707, 708, 710, 711, 713, 714, 716 - 718	Manual Drain Clean Out	Steel/Brass/Ductile Iron - vendor selected with approval
MD 701	Manual Drain Clean Out	Specified to fit OWS 701 selected by vendor with approval
MD 706	Manual Drain Clean Out	Specified to fit BPF 701 selected by vendor with approval
MD 709, 712	Manual Drain Clean Out	Specified to fit LGAC 701 and LGAC 702 selected by vendor with approval
MD 715	Manual Drain Clean Out	Specified to fit NT 701 selected by vendor with approval
NS 701	NAPL Storage Drum	55-gallon drum, grounded - vendor selected with approval
NT 701	Oil Water Separator NAPL Storage Tank	Oil/Water Separation NAPL Tank, minimum 10 gal LNAPL storage capacity.
OWS 701	Oil Water Separation Unit	LNAPL/Water Separation Unit (Qty. 1) rated for 30 gpm and minimum 10 gal LNAPL storage capacity.
PDB 101, 201, 301	Positive Displacement Blower Unit	Each rated for 750 scfm at 10" of Hg total dynamic head measured at the trailer inlets and 0" Hg at the trailer outlet- with air intake filter and muffler (pulse control silencer at inlet and outlet); to be equipped with total run time/hour meters (HM 101, HM 201, HM 301)
PI 101, 201, 301	Pressure Indicator	0-100" H_20, steel case (WIKA or approved equivalent)
PI 102, 202, 302, 701, 702, 703, 704, 705	Pressure Indicator	0-30 psi, steel case (WIKA or approved equivalent)
PI 401	Combination Pressure/Vacuum Indicator	0-100 "H_20 pressure and 0-100 "H_20 vacuum, steel case (WIKA or approved equivalent)
PRV 101, 201, 301	Pressure Relief Valve, 6" Stainless Steel	Kunkle (or approved equivalent) pressure capacity set at PDB 101/201/301 pressure capacity, iron/bronze construction required - sized and selected by vendor with approval
PS/PT 401	Pressure Switch/Transmitter, Digital, 12" Steel pipe (monitor/record/transmit pressure reading) (shuts down PDB 101/201/301, TP 101/201/301/701/702 and AC 901/1001 when activated)	0-15 psi: High accuracy pressure transmitter assembly producing 4-20 mA output signal directly proportional to the line pressure (4 mA - no pressure and 20 mA - high pressure) operating on 5-40 Volt DC supply; integrated with controller, panel meter, system control panel, telemetry system, and data loggers, pressure reading display required, also shuts down PDB 101/201/301, TP 101/201/301/701/702 and AC 901/1001 in the event of no/high pressure detection - set at b/w 0 and 5 psi - vendor selected with approval
PS/PT 701	Pressure Switch/Transmitter, Digital, 2" Steel pipe (monitor/record/transmit pressure reading) (shuts down PDB 101/201/301, TP 101/201/301/701/702 and AC 901/1001 when activated)	0-30 psi: High accuracy pressure transmitter assembly producing 4-20 mA output signal directly proportional to the line pressure (4 mA - no pressure and 20 mA - high pressure) operating on 5-40 Volt DC supply; integrated with controller, panel meter, system control panel, telemetry system, and data loggers, pressure reading display required, also shuts down PDB 101/201/301, TP 101/201/301/701/702 and AC 901/1001 in the event of no/high pressure detection - set at b/w 0 and 5 psi - vendor selected with approval
QCV 701, 702, 703, 704	Quick Connect Valve, 2"	vendor selected with approval
SI 101, 201, 301	Silencer, 8" Steel pipe	Two-Chamber Acoustically Packed Design, 8" flanged inlet/outlet, rated for maximum flow

TABLE 9

SVE System Detailed Specifications
General Part List Applies to Piping and Equipment Associated with SVE Equipment
W.G. Krummrich Facility, Sauget, Illinois

Item/Part	Description	Specification
SP 001, 101, 102, 201, 202, 301, 302, 401	Air Sampling Port	1/4" - 1/2" brass ball valve with 3/16" brass or stainless steel barb fitting
SP 102, 202, 302, 401	Air Sampling Port	1/4" - 1/2" brass ball valve with 3/16" brass or stainless steel barb fitting, spring controlled auto close
SP 103, 203, 303, 701, 702, 703, 704	Water Sampling Port	1/4" - 1/2" brass ball valve with 3/16" brass or stainless steel barb fitting, spring controlled auto close
ST 101, 201, 301, 701	Sight Tube, 2"	Transparent/Clear PVC Schedule 80
TI 001, 101, 201, 301	Temperature Indicator	0-150ºF, bimetal, stainless steel case (WIKA or approved equivalent)
TI 102, 202, 302, 401	Temperature Indicator	0-250ºF, bimetal, stainless steel case (WIKA or approved equivalent)
TP 101, 201, 301	Water pump	Progressive Cavity Type pumps, 5-10 gpm at maximum vacuum. Each to be equipped with total run time/hour meter HM 102/202/302; vendor selected with approval
TP 701	Water pump	Progressive Cavity Type pumps, 15-30 gpm at maximum vacuum. Each to be equipped with total run time/hour meter HM 701; vendor selected with approval
TP 702	Water pump	Progressive Cavity Type pumps, 5-10 gpm at maximum vacuum. Each to be equipped with total run time/hour meter HM 702; vendor selected with approval
VI 001, 101, 102, 103, 201, 202, 203, 301, 302, 303	Vacuum Indicator	0-20" Hg vacuum, liquid filled, stainless steel case (WIKA or approved equivalent)
VIA 101, 201, 301	Vacuum Indicator & Switch - Analog (monitor/record/transmit vacuum reading)	0-20" Hg: High accuracy vacuum transmitter assembly producing 4-20 mA output signal directly proportional to the line vacuum (4 mA - low vacuum and 20 mA - high vacuum) operating on 5-40 Volt DC supply; integrated with controller, panel meter, system control panel, telemetry system, and data loggers, vacuum reading display required, also shuts down PDB 101/201/301 respectively, in the event of low/no vacuum detection - set at b/w 0 and 2" Hg - vendor selected with approval
VRV 101, 201, 301	Vacuum Relief Valve, 4"	Kunkle (or approved equivalent), set at 16" of Hg vacuum, iron/bronze construction required - sized and selected by vendor with approval

SVE = Soil vapor extraction
ºF = Degrees Fahrenheit
gpm = Gallons per minute
LEL = Lower Explosive Limit
lbs = Pounds
mA = milli Amps
PLC = Programmable Logic Controller
psi = pounds per square inch
" Hg = Inches of Mercury
" = inches
" H_2O = Inches of Water
PVC = Polyvinyl Chloride
scfm = Standard Cubic Feet per Minute
SVE = Soil Vapor Extraction
TDH = Total Dynamic Head

Notes:
1. All equipment (i.e., process monitoring devices) to be configured with all manufacturer required specifications.
2. Refer to Figure 15A for the SVE process equipment schematic.
3. All pipe measurements are interior diameter.
4. All components will be compatible with benzene.

TABLE 10
AI Component Detailed Specifications
General Part List Applies to Piping and Equipment Associated with AI Equipment
W.G. Krummrich Facility, Sauget, Illinois

Item/Part	Description	Specification
AC 901, 1001	Air Compressor	Air Compressors rated for 750 scfm each and 6 psi total dynamic head measured at container wall transitions, power requirements: 230/480 volts and 3-phase, with air intake filters, to be equipped with total run time/hour meters - vendor selected with approval
AFS 901, 1001	Aif Filter/Silencer	Solberg (or approved equivalent) - sized by vendor with approval
BV 901, 1001	6" Ball Valve	Brass, NPT - common, rated for maximum temperature
CV 901, 1001	Air Vacuum/Pressure Check Valve, Gate Type, 6"	Brass/Ductile Iron - vendor selected with approval
FC 901, 902, 1001, 1002	6" Flex/Flange Coupling	Pipe Joining Flex/Flange Coupling - vendor selected with approval
FIA 2001	Air Flow Indicator - Analog, 10" Steel pipe connection (monitor/record air flow rate)	0-2,000 scfm; Compact air mass flow meter (or approved equivalent) producing 4-20 mA output signal (to PLC) directly proportional to the air flow rate (4mA - low flow rate and 20mA - high flow rate) operating on 10-40 Volt DC supply; integrated with controller, panel meter, system control panel, telemetry system, and data loggers, flow reading display required - vendor selected with approval
FM 901, 1001	Air Flow Meter, 6" Stainless Steel pipe connection	0-1,000 scfm; Dwyer (or approved equivalent) Pitot Tube Assembly - Magnehelic gauge with mounting bracket and inline averaging pitot tube flow/differential pressure sensor, direct flow reading display of 0-1,000 scfm required - sized by vendor with approval
FM 2001	Air Flow Meter, 10" Stainless Steel pipe connection	0-2,000 scfm; Dwyer (or approved equivalent) Pitot Tube Assembly - Magnehelic gauge with mounting bracket and inline averaging pitot tube flow/differential pressure sensor, direct flow reading display of 0-2,000 scfm required - sized by vendor with approval
FS 901, 1001	Flow Sensor, Digital, 6" steel pipe (indicates minimum air flow)(monitor/record air flow rate)	Dwyer (or approved equivalent) - sized by vendor with approval
GV 901, 1001	6" Gate Valve	Brass, NPT - common, rated for maximum temperature
GV 2001	10" Gate Valve	Brass, NPT - common, rated for maximum temperature
HM 901, 1001	Total Runtime/Hour Meters for AC 901 and AC 1001 (provide/calculate motor run time)	Total runtime/hour meter provides a digital input signal (to PLC) to provide/calculate motor run time in hours for remote telemetry system - vendor selected with approval
PI 901, 1001	Pressure Indicator	0-30 psi, steel case (WIKA or approved equivalent)
PI 2001	Pressure Indicator	0-30 psi, steel case (WIKA or approved equivalent)
PRV 901, 1001	Pressure Relief Valve	Kunkle (or approved equivalent) field adjustable from 5-30 psi, set at 16 psi (AC 901, 1010 pressure capacity), iron/bronze construction required - sized and selected by vendor with approval
PS/PT 2001	Pressure Switch/Pressure Transmitter, Digital, 10" steel pipe connection (shuts down AC 901/1001 when activated)	High accuracy pressure transmitter assembly producing 4-20 mA output signal (to PLC) directly proportional to the line pressure (4 mA - low pressure and 20 mA - high pressure) operating on 5-40 Volt DC supply; integrated with controller, panel meter, system control panel, telemetry system, and data loggers, pressure reading display required, also shuts down the corresponding air compressors in the event of low/no pressure detection - field adjustable from 0-30 psi, set at 14 psi (below AC 901, 1010 pressure capacity) - vendor selected with approval
SI 901, 902, 1001, 1002	Silencer	Two-Chamber Acoustically Packed Design, 6" flanged inlet/outlet, rated for maximum flow
TI 901, 902, 1001, 1002, 2001	Temperature Indicator	0-200ºF, bimetal, stainless steel case (WIKA or approved equivalent)
TIA 901, 1001	Temperature Indicator & Switch - Analog (monitor/record/transmit air temperature)	0-250°F; High accuracy temperature transmitter assembly producing 4-20 mA output signal (to PLC) directly proportional to the line temperature (4mA - low temperature and 20mA - high temperature) operating on 10-40 Volt DC supply; integrated with controller, panel meter, system control panel, telemetry system, and data loggers, temperature reading display required, also shuts down AC 901/1001 in the event of high temperature detection - set at 175° F - vendor selected with approval
VI 901, 1001	Vacuum Indicator	0-100 "H_2O vacuum, liquid filled, stainless steel case (WIKA or approved equivalent)

AI = Air Injection
DC = Direct current
^{o}F = Degrees Fahrenheit
"H_2O = inches of water
mA = milli Amps
NPT = National Pipe Thread
PLC = Programmable Logic Controller
psi = pounds per square inch
scfm = Standard Cubic Feet per Minute
" = inches

Notes:
1. All equipment (i.e., process monitoring devices) to be configured with all manufacturer required specifications.
2. Refer to Figure 15B for the AI process equipment schematic.
3. All pipe measurements are interior diameter.

TABLE 11

General System Control Specifications
W.G. Krummrich Facility, Sauget, Illinois

Component	Specifications
Programmable Logic Controller (PLC) & System Control Panel	The operation of the AI and SVE system will be controlled through a PLC or an approved equivalent controller. The PLC will be housed in a wall mounted control panel. Controls/interlocks/alarm conditions for all the AI and SVE process equipment, will be located in the control panel. The emergency shut-off for the AI and SVE system will also be provided on the control panel, and inside the housing.
	The control panel will be required to be Underwriter Laboratories, Inc. (UL) listed. All major equipment will be installed with Hand/Off/Auto (HOA) switches and panel lights to indicate operational status. Alarm indicator lights with first fault lockout will be provided for all major equipment and process sensors/switches. These alarm lights for the SVE and AI systems should be arranged separately and labeled on the control panel.
	All AI and SVE process equipment will be powered by the control panel. The SVE and AI systems will have independent system skids interlocked with each other.
	The AI system will be interlocked with the SVE system and will not operate without the SVE system operating (at a minimum, 2 of the 3 SVE blowers need to be operating). Under normal operating mode, any shutdown/shutoff condition of more than one of the SVE blowers will shut down the AI system. Under normal operating mode, any shutdown/shutoff condition of the AI system, will not shut down the SVE system.
	The control panel will be powered by an independent electrical panel. The electrical power requirements (i.e., total amperage, voltage, and phase requirements) for the control panel and the process equipment and all field wiring will be clearly indicated and specified by the equipment vendor.
	The entire system (both the SVE and the AI systems) will be interlocked with the thermal oxidizer(s) (installed by others) and will not operate without the thermal oxidizer operating. Under normal operating mode, any shutdown/shutoff condition of the thermal oxidizer will shut down the entire system. Also, the Thermal Oxidizer(s) will not operate for more than one (1) hour without at least one of the SVE blowers operating. Shut down of all three SVE blowers will shut down the Thermal Oxidizer.
	The entire system (both the SVE and the AI systems) will be interlocked with the %LEL meter and will not operate without a %LEL reading of <10%. Under normal operating mode, any reading >10% (over a 5 minute period) will trigger a shutdown/shutoff condition of the entire AI and SVE system.
	The entire system (both the SVE and the AI systems) will be interlocked with the Building General Temperature Alarm and will not operate without a temperature reading of <120° F. Under normal operating mode, any reading >120° F (over a 5 minute period inside the equipment building) will trigger a shutdown/shutoff condition of the entire AI and SVE system. The alarm thermostat needs to be adjustable between 0-150° F.
Remote Telemetry System	The AI and SVE system operational status and process analog data (i.e., air flow rate, vacuum, pressure, and temperature) will be monitored remotely via a telemetry system (graphical operator interface package) installed in the system control panel. The remote telemetry system will also have the ability to log all the process analog data, change the logging frequency, and allow the process analog data to be downloaded/emailed. The telemetry system will be interfaced using a cell phone line connection.
Autodialer	A system alarm autodialer will be provided to callout in event of system shutdown/alarm conditions. The autodialer will be housed in the control panel with inputs for all alarm conditions for the system.

AI = Air injection
HOA = Hand/Off/Auto
PLC = Programmable Logic Controller
SVE = Soil vapor extraction
UL = Underwriter Laboratories
^{o}F = Degrees Fahrenheit

Notes:
1. System control panel, PLC, remote telemetry system, and autodialer will be selected and designed by the vendor with approval.
2. Refer to Figures 15A and 15B for the SVE and AI process equipment schematics, respectively.

TABLE 12

Summary of SVE and AI Input-Output Schedule

W.G. Krummrich Facility, Sauget, Illinois

Type	System	Data	Notes	Description	Function
Digital Inputs	SVE	FS 101	[1] [2] [3] [4]	Flow sensor, indicates minimum/no air flow (alarm condition)	Allow blower PDB 101 operation when activated. Shall have ~30 second delay to allow PDB 101 to get up to speed. PDB 101, AC 901 and AC 1001 shut down/alarm condition in the event of low/no flow detection.
		FS 201	[1] [2] [3] [4]	Flow sensor, indicates minimum/no air flow (alarm condition)	Allow blower PDB 201 operation when activated. Shall have ~30 second delay to allow PDB 201 to get up to speed. PDB 201, AC 901 and AC 1001 shut down/alarm condition in the event of low/no flow detection.
		FS 301	[1] [2] [3] [4]	Flow sensor, indicates minimum/no air flow (alarm condition)	Allow blower PDB 301 operation when activated. Shall have ~30 second delay to allow PDB 301 to get up to speed. PDB 301, AC 901, and AC 1001 shut down/alarm condition in the event of low/no flow detection.
		LS 101	[1] [2] [4] [5]	Air moisture separator AMS 101 high, high level sensor (alarm condition)	Shut down PDB 101 and provide alarm notification when LS 101 gets wet.
		LS 102		Air moisture separator AMS 101 high level sensor	Activate transfer pump TP 101 when LS 102 gets wet.
		LS 103		Air moisture separator AMS 101 low level sensor	Shut off transfer pump TP 101 when LS 103 becomes dry.
		LS 201	[1] [2] [4] [5]	Air moisture separator AMS 201 high, high level sensor (alarm condition)	Shut down PDB 201 and provide alarm notification when LS 201 gets wet.
		LS 202		Air moisture separator AMS 201 high level sensor	Activate transfer pump TP 201 when LS 202 gets wet.
		LS 203		Air moisture separator AMS 201 low level sensor	Shut off transfer pump TP 201 when LS 203 becomes dry.
		LS 301	[1] [2] [4] [5]	Air moisture separator AMS 301 high, high level sensor (alarm condition)	Shut down PDB 301 and provide alarm notification when LS 301 gets wet.
		LS 302		Air moisture separator AMS 301 high level sensor	Activate transfer pump TP 301 when LS 302 gets wet.
		LS 303		Air moisture separator AMS 301 low level sensor	Shut off transfer pump TP 301 when LS 303 becomes dry.
		LS 701	[1] [2] [4] [5]	Oil Water Separator OWS 701 high, high level sensor (alarm condition)	Shut down PDB 101, PDB 201, PDB 301 AC 901, and 1001 and provide alarm notification when LS 701 gets wet.
		LS 702		Oil Water Separator OWS 701 high level sensor	Activate transfer pump TP 701 when LS 702 gets wet.
		LS 703		Oil Water Separator OWS 701 low level sensor	Shut off transfer pump TO 701 when LS 703 becomes dry.
		LS 704	[1] [2] [4] [5]	Oil Water Separator NAPL Tank NT 701 high, high level sensor (alarm condition)	Shut down PDB 101, PDB 201, PDB 301, AC 901, AC 1001 and ThermOx and provide alarm notification when LS 704 gets wet (at 90% full).
		LS 705		Oil Water Separator NAPL Tank NT 701 high level sensor	Indicates the NAPL Tank NT 701 is 70% full.
		PDB 101	[1] [2] [4] [6] [10]	Blower PDB 101 overload (motor fault)	PDB 101 shut down/alarm notification in the event of motor overload (motor fault) detection.
		PDB 101	[2] [7] [9]	Blower PDB 101 operation	PDB 101 on/off
		PDB 201	[1] [2] [4] [6] [11]	Blower PDB 301 overload (motor fault)	PDB 201 shut down/alarm notification in the event of motor overload (motor fault) detection.
		PDB 201	[2] [7] [9]	Blower PDB 201 operation	PDB 201 on/off
		PDB 301	[1] [2] [4] [6] [12]	Blower PDB 301 overload (motor fault)	PDB 301 shut down/alarm notification in the event of motor overload (motor fault) detection.

TABLE 12

Summary of SVE and AI Input-Output Schedule

W.G. Krummrich Facility, Sauget, Illinois

Type	System	Data	Notes	Description	Function
Digital Inputs	SVE (continued)	PDB 301	[2] [7] [9]	Blower PDB 301 operation	PDB 301 on/off
		PS/PT 401	[1] [2] [4] [5] [30]	Pressure switch/pressure transmitter, set at 14 psi (alarm condition, also an analog input)	Shut down PDB 101, PDB 201, PBD 301, AC 901, AC 1001, TP 101, TP 201, TP 301, TP701, TP 702, TP 703 when activated, and alarm notification in the event of high pressure detection.
		PS/PT 701	[1] [5] [30]	Pressure switch/pressure transmitter, set at 1 psi (alarm condition, also an analog input)	Shut down PDB 101, PDB 201, PBD 301, AC 901, AC 1001, TP 101, TP 201, TP 301, TP701, TP 702, TP 703, TP 801 and AS 801 when activated, and alarm notification in the event of high pressure detection.
		TP 101	[1] [4] [7] [13] [16] [17] [22] [23]	Transfer pump TP 101 overload (motor fault)	TP 101 and PDB 101 shut down/alarm notification in the event of motor overload (motor fault) detection.
		TP 201	[1] [4] [7] [14] [18] [19] [22] [23]	Transfer pump TP 201 overload (motor fault)	TP 201 and PDB 201 shut down/alarm notification in the event of motor overload (motor fault) detection.
		TP 301	[1] [4] [7] [15] [20] [21] [22] [23]	Transfer pump TP 301 overload (motor fault)	TP 301 and PDB 301 shut down/alarm notification in the event of motor overload (motor fault) detection.
		TP 701	[1] [7] [24] [25]	Transfer pump TP 701 overload (motor fault)	TP 701, PDB 101, PDB 201, PDB 301, AC 901, and AC 1001 shut down/alarm notification in the event of motor overload (motor fault) detection.
		TP 702	[1] [7] [24] [25]	Transfer pump TP 702 overload (motor fault)	TP 702, PDB 101, PDB 201, PDB 301, AC 901, and AC 1001 shut down/alarm notification in the event of motor overload (motor fault) detection.
	Air Injection	FS 901	[1] [26]	Flow sensor, indicates minimum/no air flow (alarm condition)	Allow air compressor AC 901 operation when activated. Shall have ~30 second delay to allow AC 901 to get up to speed. AC 901 shut down/alarm notification in the event of low/no flow detection.
		FS 1001	[1] [26]	Flow sensor, indicates minimum/no air flow (alarm condition)	Allow air compressor AC 1001 operation when activated. Shall have ~30 second delay to allow AC 1001 to get up to speed. AC 1001 shut down/alarm notification in the event of low/no flow detection.
		AC 901	[1] [27] [28]	Air compressor AC 901 overload (motor fault)	AC 901 shut down/alarm notification in the event of motor overload (motor fault) detection.
		AC 901	[2] [7] [9]	Compressor AC 901 operation	AC 901 on/off
		AC 1001	[1] [27] [29]	Air compressor AC 1001 overload (motor fault)	AC 1001 shut down/alarm notification in the event of motor overload (motor fault) detection.
		AC 1001	[2] [7] [9]	Compressor AC 1001 operation	AC 1001 on/off
		PS/PT 2001	[1] [30]	Pressure switch/pressure transmitter, set at 16 psi, or compressor pressure capacity (alarm condition, also analog input)	AC 901 and AC 1001 shut down/alarm notification in the event of high pressure detection.
	General	Building Temperature Alarm	[1] [5] [32]	Building high temperature switch/transmitter, set at 120° F (alarm condition, also analog input)	Shut down entire system and provide alarm notification in the event of building high temperature shutdown/shutoff condition. Alarm conditions for the high temperature alarm will need to be manually reset before the entire system can restart. Thermostat to be adjustable between 0-150° F.
		Emergency Stop		Manual emergency stop power interruption (alarm condition)	Shut down entire system and provide alarm notification in the event of interior/exterior emergency stop activation and send alarm notification. Alarm will need to be manually reset, and emergency stop deactivated, before the entire system can restart.
		General Power Failure		Power failure/interruption (alarm condition)	Shut down entire system and provide alarm notification in the event of power failure/interruption, send alarm notification when power is restored.
		General ThermOx Alarm - Therm 501	[1] [3] [5] [31]	Alarm condition/signal from thermal oxidizer ThermOx control panel	Shut down entire system and provide alarm notification in the event of thermal oxidizer ThermOx shutdown/shutoff conditions. Alarm conditions for the general thermal oxidizer ThermOx alarm will need to be manually reset before the entire system can restart.
		LEL 701	[1] [5] [32]	High % LEL switch/% LEL transmitter, set at 10 % LEL (alarm condition, also analog input)	Shut down entire system and provide alarm notification in the event of building/container high % LEL shutdown/shutoff condition. Alarm conditions for the high % LEL alarm will need to be manually reset before the entire system can restart.

TABLE 12

Summary of SVE and AI Input-Output Schedule

W.G. Krummrich Facility, Sauget, Illinois

Type	System	Data	Notes	Description	Function
Digital Outputs	SVE	PDB 101	[7] [33] [34] [35]	Blower PDB 101 permissive operation	PDB 101 permissive on/off
		PDB 101	[31] [36] [37]	Blower PDB 101 operation and alarm shut down	PDB 101 on/off
		PDB 201	[7] [33] [34] [35]	Blower PDB 201 permissive operation	PDB 201 permissive on/off
		PDB 201	[31] [36] [37]	Blower PDB 201 operation and alarm shut down	PDB 201 on/off
		PDB 301	[7] [33] [34] [35]	Blower PDB 301 permissive operation	PDB 301 permissive on/off
		PDB 301	[31] [36] [37]	Blower PDB 301 operation and alarm shut down	PDB 301 on/off
		TP 101, TP 201, TP 301, TP 701, TP 702	[7] [33] [34]	Transfer pumps TP 101, TP 201, TP 301, TP 701, TP 702 permissive operation	TP 101, TP 201, TP 301, TP 701, TP 702 permissive on/off
		System Alarm Notification		System alarm notification to auto dialer/security system/remote telemetry system	In the event of any system alarm condition, provide alarm notification to autodialer/security system/remote telemetry system.
		System Operational Status		System operational status to remote telemetry system	Under normal operating conditions, provide system operation status (on/off) to remote telemetry system.
		TP 101, TP 201, TP 301, TP 701, TP 702	[31] [36]	Transfer pump TP 101, TP 201, TP 301, TP 701, TP 702 operation and alarm shut down	TP 101, TP 201, TP 301, TP 701, TP 702 on/off
		TP 701	[8]	Transfer pump TP 702 operation and alarm shut down	
	Air Injection	AC 901	[7] [33] [34] [35]	Air Compressor AC 901 permissive operation	AC 901 permissive on/off
		AC 901	[2] [4] [31] [36] [37] [40] [41]	Air Compressor AC 901 operation and alarm shut down	AC 901 on/off
		AC 1001	[7] [33] [34] [35]	Air Compressor AC 1001 permissive operation	AC 1001 permissive on/off
		AC 1001	[2] [4] [31] [36] [37] [40] [41]	Air Compressor AC 1001 operation and alarm shut down	AC 1001 on/off
Analog Inputs/Outputs	SVE	FIA 401	[38]	Analog air flow rate indicator	Provide SVE system air flow rate data to remote telemetry system
		FT 701	[38]	Analog liquid totalizing flow meter	Provide discharge water flow rate/totalizer reading to the remote telemetry system.
		HM 101	[38] [39]	Total run time/hour meter	Provide blower PDB 101 total run time/hour data to remote telemetry system.
		HM 102	[38] [39]	Total run time/hour meter	Provide AMS 101 transfer pump TP 101 total run time/hour data to remote telemetry system.
		HM 201	[38] [39]	Total run time/hour meter	Provide blower PDB 201 total run time/hour data to remote telemetry system.
		HM 202	[38] [39]	Total run time/hour meter	Provide AMS 201 transfer pump TP 201 total run time/hour data to remote telemetry system.
		HM 301	[38] [39]	Total run time/hour meter	Provide blower PDB 201 total run time/hour data to remote telemetry system.
		HM 302	[38] [39]	Total run time/hour meter	Provide AMS 301 transfer pump TP 301 total run time/hour data to remote telemetry system.
		LEL 701	[38]	High % LEL switch/% LEL transmitter, set at 10 % LEL (alarm condition, also analog input)	Provide %LEL data to telemetry system. Also shut down PDB 101, PDB 201, PDB 301, AC 901, AC 1001, and ThermOx when activated, and alarm notification in the event of high %LEL detection.

TABLE 12

Summary of SVE and AI Input-Output Schedule

W.G. Krummrich Facility, Sauget, Illinois

Type	System	Data	Notes	Description	Function
Analog Inputs/Outputs (continued)	SVE (continued)	HM 701	[38] [39]	Total run time/hour meter	Provide oil water separator transfer pump TP 701 total run time/hour data to remote telemetry system.
		HM 702	[38] [39]	Total run time/hour meter	Provide oil water separator NAPL tank transfer pump TP 702 total run time/hour data to remote telemetry system.
		PS/PT 401	[1] [5] [30] [38]	Pressure switch/pressure transmitter, set at 16 psi or blower pressure capacity (analog input, also an alarm condition)	Provide combined SVE discharge pressure data to telemetry system. Also shut down PDB 101, PDB 201, PDB 301, AC 901, AC 1001, and ThermOx when activated, and alarm notification in the event of high pressure detection.
		PS/PT 701	[1] [5] [30] [38]	Pressure switch/pressure transmitter, set at 30 psi or LGAC pressure capacity (analog input, also an alarm condition)	Provide combined SVE water discharge pressure data to telemetry system. Also shut down PDB 101, PDB 201, PDB 301, AC 901, AC 1001 and ThermOx when activated, and alarm notification in the event of high pressure detection.
		VIA 101	[1] [5] [38]	Analog vacuum indicator and switch - set b/w 0 and 2" Hg (also an alarm condition)	Provide PDB 101 line vacuum data to remote telemetry system. Also shut down PDB 101, and provide alarm notification in the event of low/no vacuum detection.
		VIA 201	[1] [5] [38]	Analog vacuum indicator and switch - set b/w 0 and 2" Hg (also an alarm condition)	Provide PDB 201 line vacuum data to remote telemetry system. Also shut down PDB 201, and provide alarm notification in the event of low/no vacuum detection.
		VIA 301	[1] [5] [38]	Analog vacuum indicator and switch - set b/w 0 and 2" Hg (also an alarm condition)	Provide PDB 301 line vacuum data to remote telemetry system. Also shut down PDB 301, and provide alarm notification in the event of low/no vacuum detection.
	Air Injection	FIA 2001	[38]	Analog air flow rate indicator	Provide Air Injection system total air flow rate data to remote telemetry system.
		HM 901	[38]	Total run time/hour meter	Provide air compressor AC 901 total run time/hour data to remote telemetry system.
		HM 1001	[38]	Total run time/hour meter	Provide air compressor AC 1001 total run time/hour data to remote telemetry system.
		PS/PT 2001	[1] [5] [30] [38]	Pressure switch/pressure transmitter, set at 16 psi or AC pressure capacity (analog input, also an alarm condition)	Provide air compressor AC 901 and AC 1001 (AI system) discharge pressure data to telemetry system. Also shut down AC 901 and AC 1001 when activated, and alarm notification in the event of high pressure detection.
		TIA 901	[1] [5] [38]	Analog temperature indicator and switch - set at 140° F (also an alarm condition)	Provide air compressor AC 901 discharge temperature data to remote telemetry system. Also shut down AC 901 and provide alarm notification in the event of high temperature detection.
		TIA 1001	[1] [5] [38]	Analog temperature indicator and switch - set at 140° F (also an alarm condition)	Provide air compressor AC 1001 discharge temperature data to remote telemetry system. Also shut down AC 1001 and provide alarm notification in the event of high temperature detection.
	General	LEL 701	[38]	High % LEL switch/% LEL transmitter, set at 10 % LEL (alarm condition, also analog input)	Provide %LEL data to telemetry system. Also shut down PDB 101, PDB 201, PDB 301, AC 901, AC 1001, and ThermOx when activated, and alarm notification in the event of high %LEL detection.

TABLE 12

Summary of SVE and AI Input-Output Schedule

W.G. Krummrich Facility, Sauget, Illinois

Design Notes:

[1] Reset for all the alarm conditions will be located on the control panel.
[2] Air compressors AC 901 and AC 1001 will operate continually with no alarm conditions present. Under normal operating mode (on "AUTO"), air compressors AC 901 and AC 1001 will only operate if two or more PDBs (PDB 101, PDB 201, PDB 301) are operating. Under normal operating mode, any shutdown/shutoff condition or more of the PDB's will shut down AC 901 and AC 1001.
[3] Alarm condition for FS 101, FS 201, and FS 301 will need to be manually reset before PDB 101, PDB 201, PDB 301, AC 901, AC 1001 and the ThermOx can restart.

[4] If PDB 101, 201, and 301 switch is in "HAND" or "AUTO" position, any shutdown/shutoff condition of any two PDBs (PDB 101, PDB 201, PDB 301) will shut down AC 901 and AC 1001, if AC 901 and AC 1001 are in "AUTO" position.
[5] Alarm conditions for the general building general temperature alarm, thermal oxidizer ThermOx alarm, LEL 701, LS 101, LS 201, LS 301, LS 701, LS 707, PS 301, PS/PT 401, PS/PT 701, PS/PT 2001, VIA 101, VIA 201, VIA 301, TIA 901, TIA 1001 will need to be manually reset before PDB 101, PDB 201, PDB 301 AC 901 and AC 1001 and ThermOx can restart.
[6] Alarm condition for PDB 101, PDB 201, and PDB 301 overload will need to be manually reset before PDB 101, PDB 201, PDB 301, AC 901, AC 100 and ThermOx can restart.
[7] PDB 101, PDB 201, PDB 301, AC 901, AC 1001, TP 101, TP 201, TP 301, and TP 701 shall be controlled with HOA (Hand/Off/Auto) switches.
[8] TP 702 will only run under manual operation, and will be controlled with an On/Off switch.
[9] If PDB 101, PDB 201, and PDB 301 switch is in "OFF" position, AC 901 and AC 1001 will operate in "HAND" position, not in "AUTO" position.
[10] If PDB 101 switch is in "HAND" or "AUTO" position, PDB 101 overload shutdown condition will shut down PDB 101.
[11] If PDB 201 switch is in "HAND" or "AUTO" position, PDB 201 overload shutdown condition will shut down PDB 201.
[12] If PDB 301 switch is in "HAND" or "AUTO" position, PDB 301 overload shutdown condition will shut down PDB 301.
[13] Alarm condition for TP 101 overload will need to be manually reset before TP 101 and PDB 101 can restart.
[14] Alarm condition for TP 201 overload will need to be manually reset before TP 201 and PDB 201 can restart.
[15] Alarm condition for TP 301 overload will need to be manually reset before TP 301 and PDB 301 can restart.
[16] If TP 101 switch is in "HAND" or "AUTO" position, TP 101 overload shutdown condition will shut down PDB 101.
[17] If TP 101 switch is in "OFF" position, PDB 101 will operate in "HAND" position, not in "AUTO" position.
[18] If TP 201 switch is in "HAND" or "AUTO" position, TP 201 overload shutdown condition will shut down PDB 201.
[19] If TP 201 switch is in "OFF" position, PDB 201 will operate in "HAND" position, not in "AUTO" position.
[20] If TP 301 switch is in "HAND" or "AUTO" position, TP 301 overload shutdown condition will shut down PDB 301.
[21] If TP 301 switch is in "OFF" position, PDB 301 will operate in "HAND" position, not in "AUTO" position.
[22] If TP 101, TP 201, and TP 301 switches are in "OFF" position, PDB 101, PDB 201, PDB 301, AC 901, AC 1001, TP 101, TP 201, TP 301, and thermal oxidizer ThermOx will operate in "HAND" position, not in "AUTO" position.

[23] If any two transfer pump (TP 101, TP 201, TP 301) switches are in "HAND" or "AUTO" position, an overload shutdown condition (from any two TP's) will shut down the corresponding PDB's, AC 901 and AC 1001, if they are in "AUTO" position.
[24] If TP 701 and TP 702 switches are in "HAND" or "AUTO" position, TP 701, and TP 702 overload shutdown conditions will shut down PDB 101, PDB 201, PDB 301, AC 901, AC 1001, and ThermOx respectively, if they are in "AUTO" position.
[25] If TP 701 switch is in "OFF" position, PDB 101, PDB 201, PDB 301, AC 901, AC 1001, TP 101, TP 201, TP 301, and thermal oxidizer ThermOx will operate in "HAND" position, not in "AUTO" position.
[26] Alarm condition for FS 901, FS 1001 will need to be manually reset before AC 901 and AC 1001 can restart.
[27] Alarm conditions for AC 901 and AC 1001 overload will need to be manually reset before AC 901 and AC 1001 can restart.
[28] If AC 901 switch is in "HAND" or "AUTO" position, AC 901 overload shutdown condition will shut down AC 901.
[29] If AC 1001 switch is in "HAND" or "AUTO" position, AC 1001 overload shutdown condition will shut down AC 1001.
[30] Alarm condition for PS/PT 401, PS/PT 701, and PS/PT 2001 will need to be manually reset before PDB 101, PDB 201, PDB 301, AC 901, AC 1001 and thermal oxidizer ThermOx can restart.
[31] The General alarm condition for thermal oxidizer TOX 501 will need to be manually reset before the entire system (both the SVE and AI systems) can restart. Also, under normal operating mode (on "AUTO"), the entire system will only operate if thermal oxidizer ThermOx is operating.
[32] The General alarm condition for thigh % LEL and the building temperature alarm will need to be manually reset before the entire system (both the SVE and AI systems) can restart. Also, under normal operating mode (on "AUTO"), the entire system will only operate if the LEL meter/transmitter is reading <10% LEL, and the building temperature alarm is reading <120° F.
[33] The General alarm condition for thermal oxidizer TOX 501 will need to be manually reset before the entire system (both the SVE and AI systems) can restart. Also, under normal operating mode (on "AUTO"), the entire system will only operate if thermal oxidizer ThermOx is operating.
[34] When TP 101 or TP 201, TP 301, TP 701, TP 702, PDB 101, PDB 201, PDB 301, AC 901, AC 1001 switch is in "OFF" position, the corresponding motor will remain off.
[35] When PDB 101, PDB 201 and PDB 301 switches are in "AUTO" position, operation of AC 901 or AC 1001 will start PDB 101, PDB 201, and PDB 301, unless PDB 101, PDB 201, or PDB 301 is shut down due to any alarm condition that requires manual reset.
[36] On power up with no active alarms and all HOA switches in "AUTO" position.
[37] Shut down of AC 901 and AC 1001 (AI system), will not shut down PDB 101, PDB 201, and PDB 301 (SVE system).
[38] All analog data signals will be sent to the remote telemetry system through the control panel.
[39] Total run time/hour meter can either be an analog device or a digital input signal (to PLC) to provide/calculate motor run time in hours for remote telemetry system.
[40] AC 901 and AC 1001 will only operate if two or more PDBs (PDB 101, PDB 201, PDB 301) are operating.
[41] Shutdown of AC 901 will not shutdown AC 1001, and vice versa.

General Notes:

1. Refer to Figure 15A for the soil vapor extraction (SVE) system process equipment details.
2. Refer to Figure 15B for the Air Injection (AI) system process equipment details.
3. All system controls are to be housed in one or two control panels.
4. Indicator lights on the control panel shall indicate all alarm conditions.
5. All alarm conditions/system shutdown events and analog inputs/outputs are to be logged via the remote telemetry system. The logging frequency/interval for the analog inputs/outputs is to be determined.

General Control Logic:

1. The SVE and AI systems will have independent system skids interlocked with each other, as specified in this table.
2. The AI system will be interlocked with the SVE system and will not operate without the SVE system operating. Under normal operating mode, any shutdown/shutoff condition of the SVE will shut down the AI system. Under normal operating mode, shutdown of the AI system will not shutdown the SVE system.
3. The AI and SVE system will include liquid-phase granular activated carbon (LGAC) for treatment of moisture generated by the SVE system and a Thermal Oxidation unit to be located near the exterior of the equipment container will treat the vapor stream.
4. The entire system (both the SVE and the AI systems) will be interlocked with the thermal oxidizer and will not operate without the thermal oxidizer operating. Under normal operating mode, any shutdown/shutoff condition of the thermal oxidizer will shut down the entire system. Also, the Thermal Oxidizer will not operate for more than 30 minutes without at least one of the SVE blowers operating. Shut down of all three SVE blowers, simultaneously, will shut down the Thermal Oxidizer.

TABLE 13
Miscellaneous System Specifications
W.G. Krummrich Facility, Sauget, Illinois

Item	Specification
	General
Equipment labels	All equipment, valves, gauges, ports, etc. will be labeled in accordance with the P&ID (see Figures 15A and 15B).
Equipment/site security and access	All control panels, gates, doors, etc. will have capability to be locked. A total of 4 sets of keys will be provided be vendor.
Trip hazards	Mark pipes or other obstructions that are a potential trip hazard with high visibility paint or tape.
	Equipment
Coupling guards on transfer pumps	Rotating pump parts will have coupling guards; vendor selected with approval and installed.
External resets for controls	Control panel must have external reset buttons accessible on the front of the panel for all switches that require power to be reset.
Grounding	All equipment will be grounded; vendor specified.
Level switch labels	All level switches will be clearly labeled.
Pipe flow direction and labels	All piping will be labeled with contents (air/water), flow direction (arrows), and temperature (HOT); vendor to label.
Pipe insulation	Pipes that will be HOT (i.e. blower discharge, air compressor discharge) will be insulated; vendor specified.
Pressure relief valves	All pressure relief valves, and sample ports with high pressure or potential for fluid or vapor discharge, will be oriented so that discharge is away from head level and will not cause a hazard at head/face level.
Valve handles	All valves will be lockable round handled instead of straight-lined; vendor selected with approval. If ball valve lever type, the valve shall be lockable or the handles can be removed to avoid accidental closure,
Sample ports accessibility	All sample ports will be accessible without the use of ladder; vendor to extend sample ports if necessary.

P&ID = Piping and Instrumentation Diagram

TABLE 14

Valves Normally Opened or Closed
W.G. Krummrich Facility, Sauget, Illinois

SOIL VAPOR EXTRACTION			
Valve #	**Normally Opened**	**Normally Closed**	**Variable Position**
BFV 101	X		
BFV 201	X		
BFV 301	X		
BV 001-003	X		
BV 101,103-106	X		
BV 102		X	
BV 201,203-206	X		
BV 202		X	
BV 301,303-306	X		
BV 302		X	
BV 401,402	X		
BV 702-707, 709-720	X		
BV 701,708,721		X	
BV 722-725, 727, 728	X		
BV 726, 729		X	
GV 001	X		
GV 102,202,302		X	
GV 101,201,301			X

AIR INJECTION			
Valve #	**Normally Open**	**Normally Closed**	**Variable Position**
BV 901	X		
BV 1001	X		
GV 901			X
GV 1001			X
GV 2001	X		

BFV = Butterfly valve
BV = Ball valve
GV = Gate valve
MD = Manual drain
SP = Sample port

Notes:
1. All manual drains are in normally closed position with threaded plugs.
2. All sample ports are in normally closed position.

TABLE 15

Electrical Load Summary Table
W.G. Krummrich Facility, Sauget, Illinois

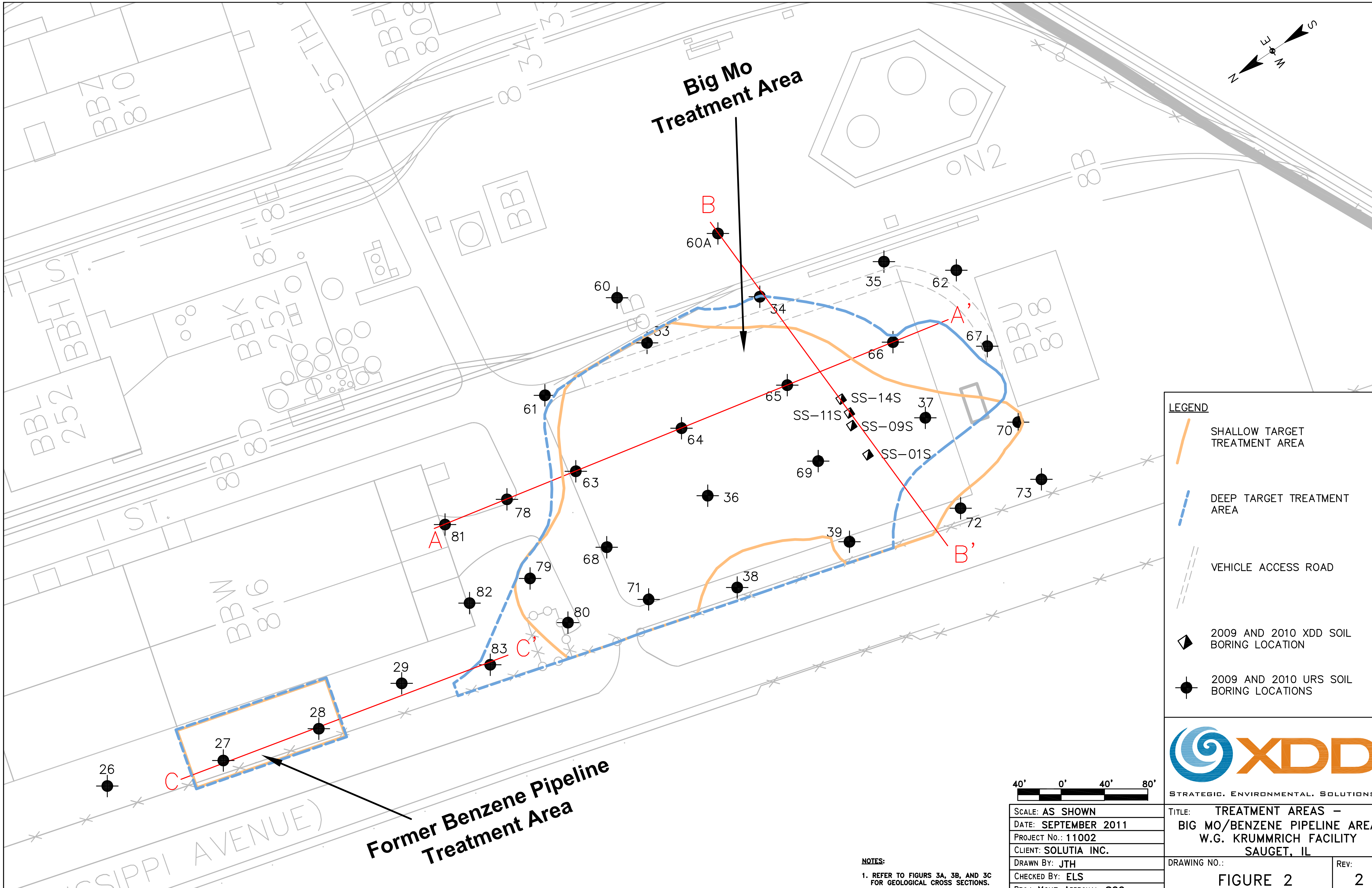
LOAD DESCRIPTION	HP	VOLTAGE	TOTAL AMPS	L1 AMPS	L2 AMPS	L3 AMPS	SOURCE
SVE System							
High Flow SVE Blower 1 (750 scfm @ 9" Hg)	30	460	40 (FLA)	40	40	40	
High Flow SVE Blower 2 (750 scfm @ 9" Hg)	30	460	40 (FLA)	40	40	40	
High Flow SVE Blower 3 (750 scfm @ 9" Hg)	30	460	40 (FLA)	40	40	40	
ThermOx Fan 1 (2,000 scfm - 25 hp)	25	230	34 (FLA)	34	34	34	75 A branch circuit protection.
Fan 1 control voltage	--		5	5	5	5	
ThermOx Fan 2 (1,000 scfm - 15 hp)	15	230	21 (FLA)	21	21	21	45 A branch circuit protection.
Fan 2 control voltage	--		5.0	5	5	5	
AWS Transfer Pumps - 3 pumps (2 hp each)	2	460	10.2	10.2	10.2	10.2	A from load summary for SVE pilot (3.4 A each pump).
OWS Transfer Pump	1	460	2.1	2.1	2.1	2.1	A from load summary for SVE pilot.
NAPL Transfer Pump	0.75	460	1.6	1.6	1.6	1.6	A from control panel schematic for SVE pilot test.
Equalization Tank Transfer Pump	2	460	3.4	3.4	3.4	3.4	A from load summary for SVE pilot test.
AI System							
AI Blower 1 (750 scfm capacity @ 10 PSI)	30	460	40 (FLA)	40	40	40	Estimation based on amp load summary for SVE pilot.
AI Blower 1 (750 scfm capacity @ 10 PSI)	30	460	40 (FLA)	40	40	40	
Air Stripper							
Air Stripper Blower	7.5	460	11	11.0	11.0	11.0	A from load summary for SVE pilot.
Air Stripper Transfer Pump	1.5		2.6	2.6	2.6	2.6	A from load summary for SVE pilot.
Winterization							
Heat Trace (10 W/ft)		208	161	161			Estimation based on 10 watts/ft.
Equipment Container							
XP Building Heater	3600W	460	12.9	12.9	12.9	12.9	
5kVA Transformer for Secondary Loads	5000VA	460	10.4	10.4		10.4	A from load summary for SVE pilot.
Misc. Equipment							
Area Lights		230	6.0	6.0			x2 A from load summary for SVE pilot area.

TOTAL AMPERAGE - 460V	**254.2**
TOTAL AMPERAGE - 230V	**232.0**
KVA	**92.3**
460V Current from 230V loads	**116.0**

SVE = soil vapor extraction
scfm = standard cubic feet per minute
" Hg = inches of mercury
FLA = full load amps
hp = horse power
W/ft = watts per foot
A = amps
VA = voltage-amps
PSI = pounds per square inch

FIGURES

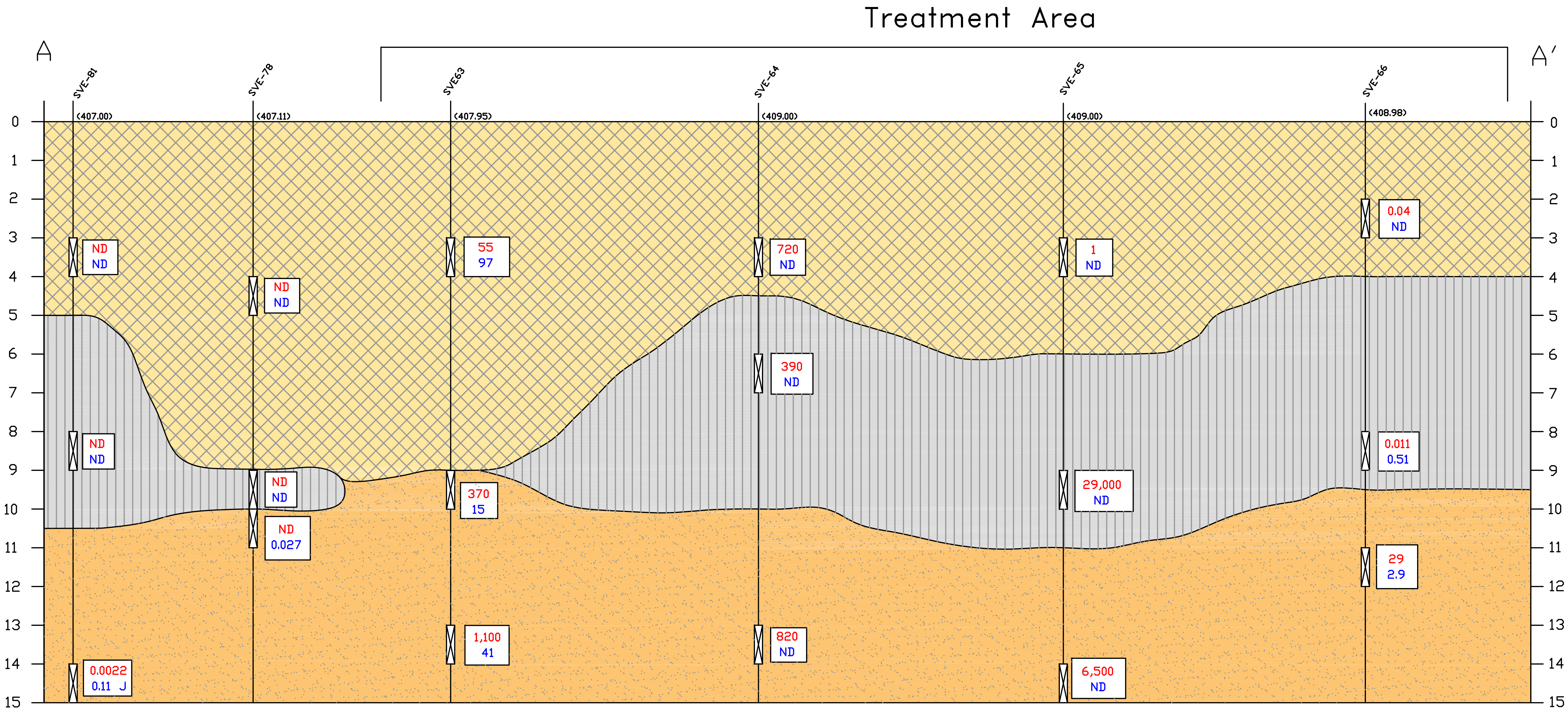
N
North Tank Farm Area
Former Steamer Overhead Tank Area
Former Benzene Pipeline Area
Near Little Mo Area
Former Benzene and
Chlorobenzene Storage Area (Big Mo Area)
STATE ROUTE 3
125' 0' 125' 250'
XDD
STRATEGIC. ENVIRONMENTAL. SOLUTIONS.
SCALE: AS SHOWN
DATE: SEPTEMBER 2011
PROJECT NO.: 11002
CLIENT: SOLUTIA INC.
DRAWN BY: JTH
CHECKED BY: ELS
PROJ. MGMT. APPROVAL: SC
TITLE: W.G. KRUMMRICH FACILITY
TREATMENT AREAS
SAUGET, IL
DRAWING NO.:
FIGURE 1
REV:
1



XDD
STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

NOTES:
1. REFER TO FIGURES 3A, 3B, AND 3C FOR GEOLOGICAL CROSS SECTIONS.

SCALE: AS SHOWN	TITLE: TREATMENT AREAS – BIG MO/BENZENE PIPELINE AREA W.G. KRUMMRICH FACILITY SAUGET, IL
DATE: SEPTEMBER 2011	
PROJECT NO.: 11002	
CLIENT: SOLUTIA INC.	
DRAWN BY: JTH	DRAWING NO.: FIGURE 2
CHECKED BY: ELS	REV: 2
PROJ. MGMT. APPROVAL: SCC	



LEGEND:

- SANDY FILL/UPPER SILTY SAND LAYER
- INTERMEDIATE SILTY CLAY LAYER
- LOWER SILTY SAND LAYER
- URS SOIL SAMPLE LOCATION (2009 OR 2010)
- (408.98) SURFACE ELEVATION (FEET ABOVE MEAN SEA LEVEL)

NOTES:

- 140 BENZENE mg/kg
- 3.5 CHLOROBENZENE mg/kg
- ND CONCENTRATION BELOW LABORATORY REPORTING LIMIT
- J ESTIMATED VALUE DETECTED BELOW THE LABORATORY REPORTING LIMIT AND ABOVE THE METHOD DETECTION LIMIT

20' 0' 20' 40'
HORIZONTAL SCALE

1.5' 0' 1.5' 3'
VERTICAL SCALE

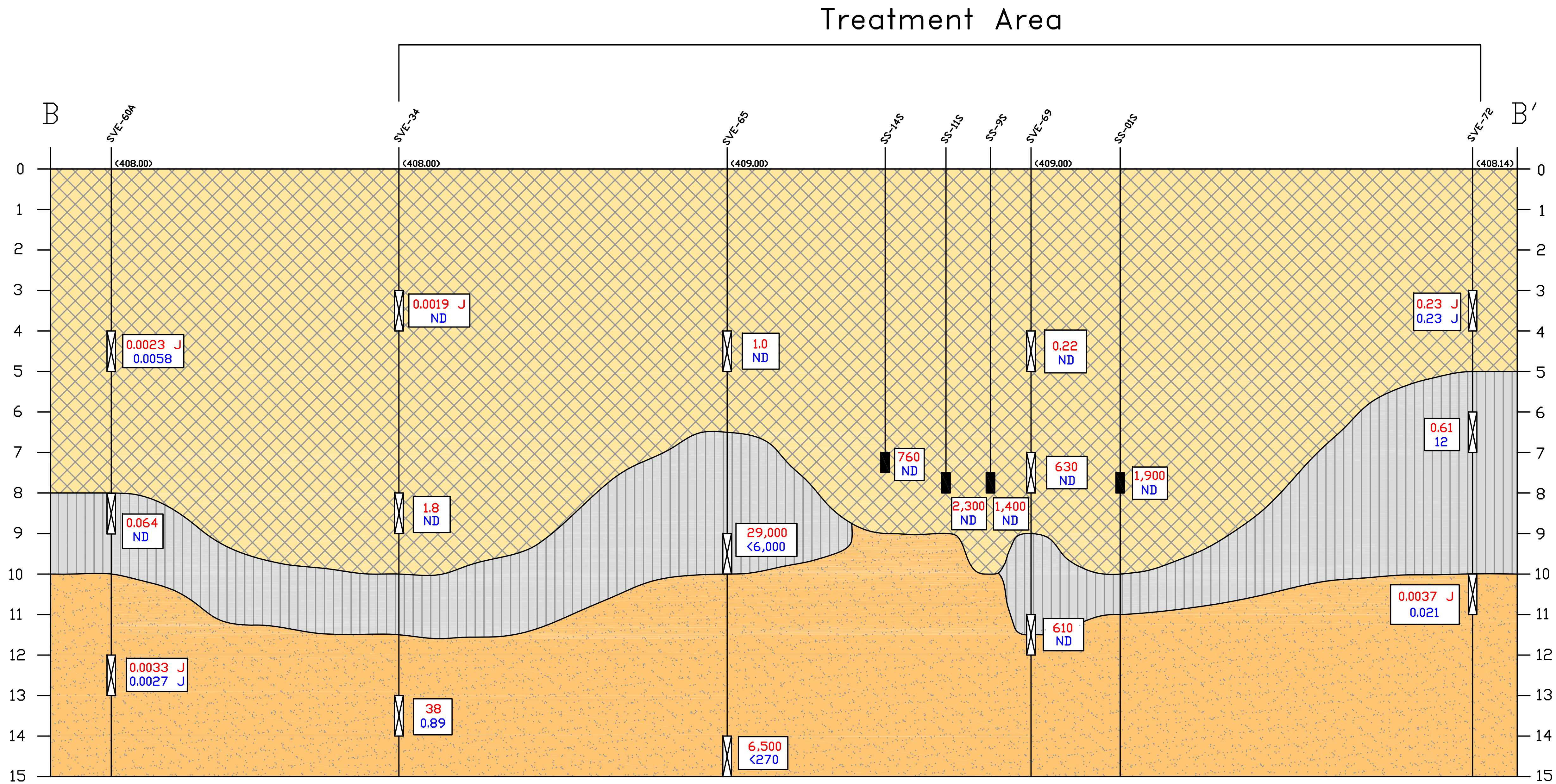
XDD
STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

SCALE:	AS SHOWN
DATE:	SEPTEMBER 2011
PROJECT NO.:	11002
CLIENT:	SOLUTIA INC.
DRAWN BY:	PC
CHECKED BY:	ELS
PROJ. MGMT. APPROVAL:	SC

TITLE: GEOLOGICAL CROSS SECTION BIG MO (A–A')

DRAWING NO.: FIGURE 3A

REV: 2



LEGEND:

	SANDY FILL/UPPER SILTY SAND LAYER
	INTERMEDIATE SILTY CLAY LAYER
	LOWER SILTY SAND LAYER
	URS SOIL SAMPLE LOCATION (2009 OR 2010)
	SVE PILOT TEST INTERMEDIATE SOIL SAMPLE LOCATION (MARCH 2010)
(408.14)	SURFACE ELEVATION (FEET ABOVE MEAN SEA LEVEL)

NOTES:

140	BENZENE mg/kg
3.5	CHLOROBENZENE mg/kg
ND	CONCENTRATION BELOW LABORATORY REPORTING LIMIT
J	ESTIMATED VALUE DETECTED BELOW THE LABORATORY REPORTING LIMIT AND ABOVE THE METHOD DETECTION LIMIT

15' 0' 15' 30'
HORIZONTAL SCALE

1.5' 0' 1.5' 3'
VERTICAL SCALE

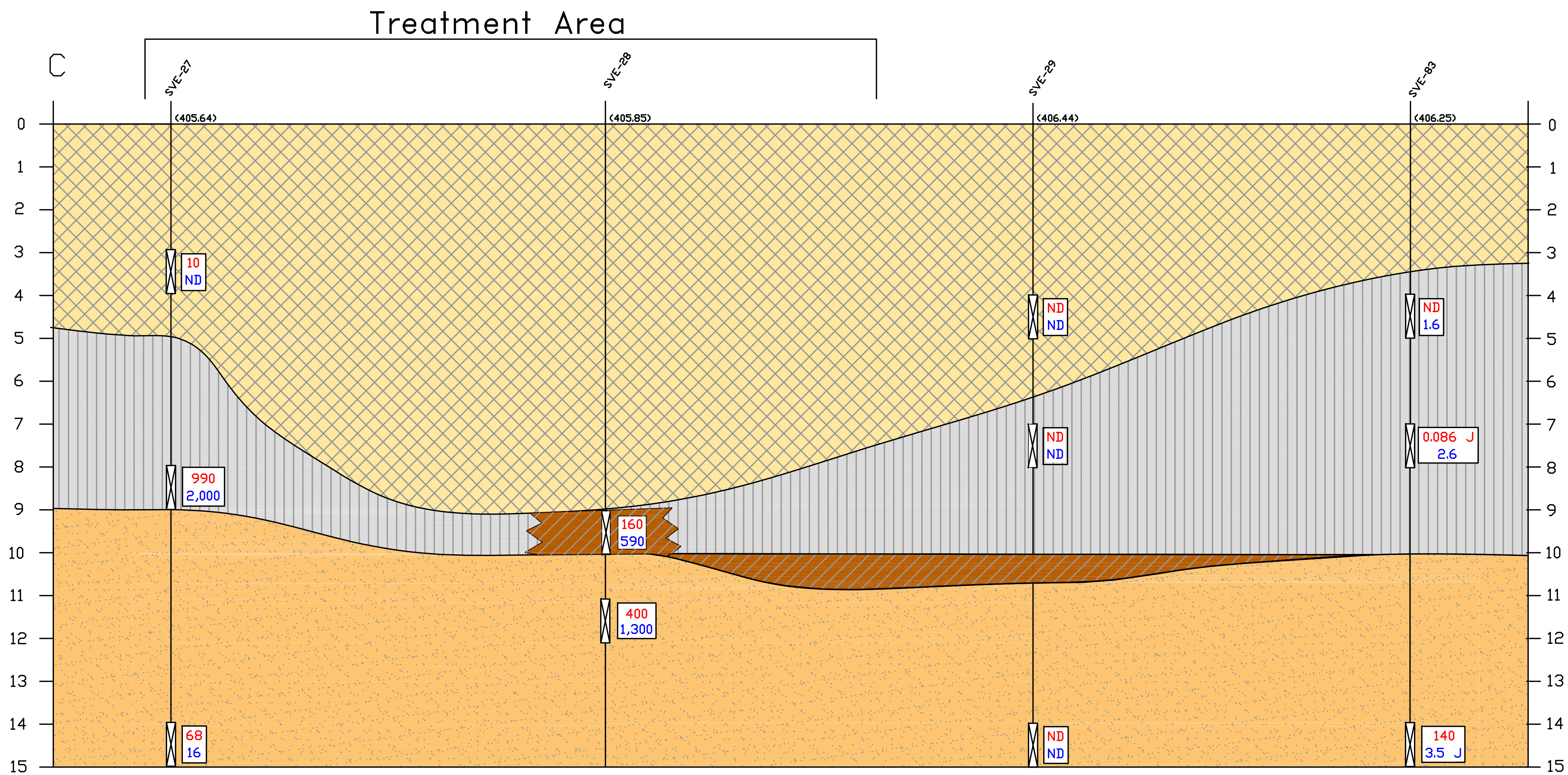
XDD
STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

SCALE: AS SHOWN
DATE: SEPTEMBER 2011
PROJECT NO.: 11002
CLIENT: SOLUTIA INC.
DRAWN BY: PC
CHECKED BY: ELS
PROJ. MGMT. APPROVAL: SC

TITLE: GEOLOGICAL CROSS SECTION BIG MO (B-B')

DRAWING NO.: FIGURE 3B

REV: 1



LEGEND:

SANDY FILL/UPPER SILTY SAND LAYER

INTERMEDIATE SILTY CLAY LAYER

LOWER SILTY SAND LAYER

CLAYEY SAND LAYER

URS SOIL SAMPLE LOCATION (2009 OR 2010)

(406.25) SURFACE ELEVATION (FEET ABOVE MEAN SEA LEVEL)

NOTES:

140 BENZENE mg/kg

3.5 CHLOROBENZENE mg/kg

ND CONCENTRATION BELOW LABORATORY REPORTING LIMIT

J ESTIMATED VALUE DETECTED BELOW THE LABORATORY REPORTING LIMIT AND ABOVE THE METHOD DETECTION LIMIT

25' 0' 25' 50'
HORIZONTAL SCALE

1.5' 0' 1.5' 3'
VERTICAL SCALE

XDD
STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

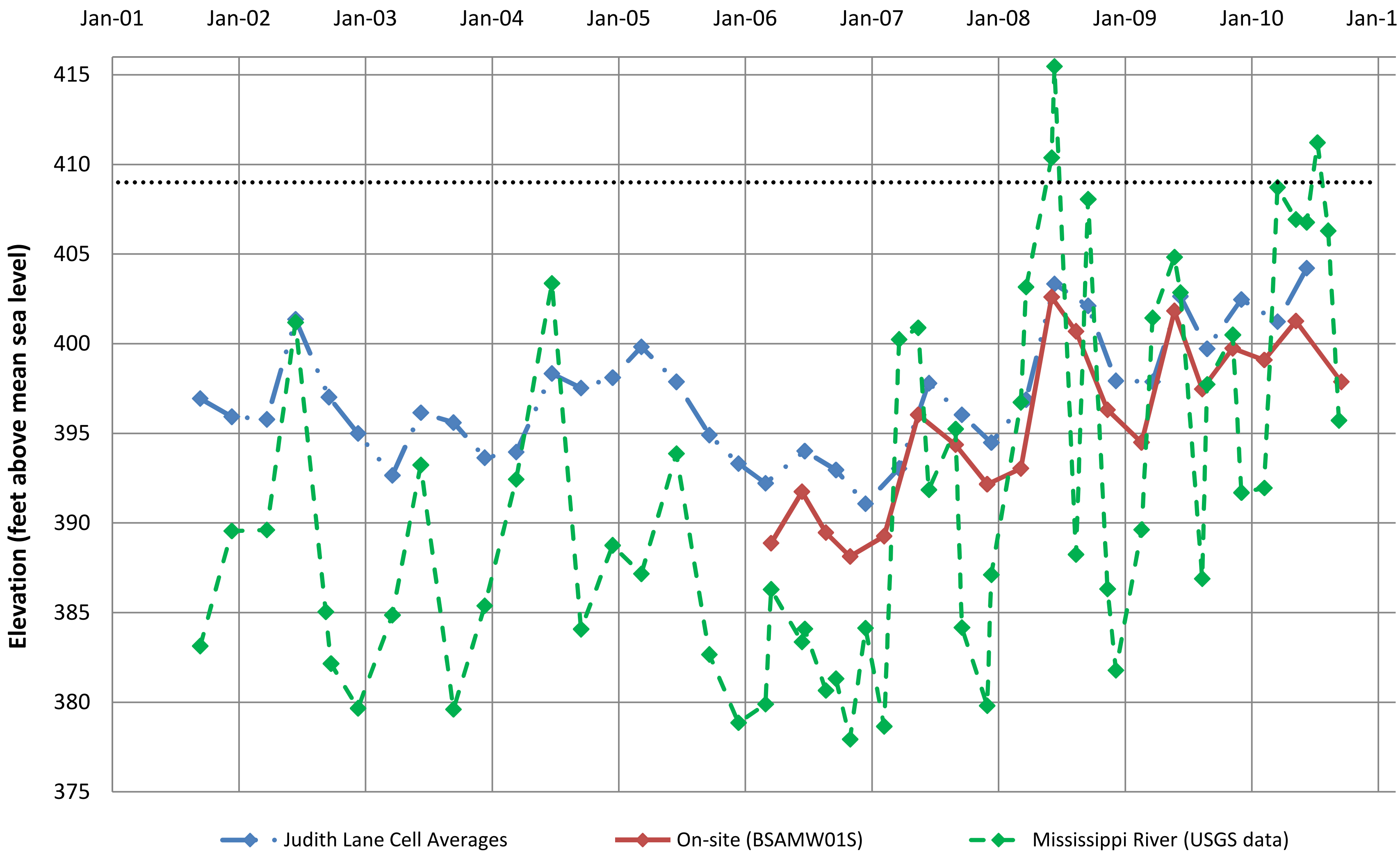
SCALE: AS SHOWN
DATE: SEPTEMBER 2011
PROJECT NO.: 11002
CLIENT: SOLUTIA INC.
DRAWN BY: PC
CHECKED BY: ELS
PROJ. MGMT. APPROVAL: SC

TITLE: GEOLOGICAL CROSS SECTION FORMER BENZENE PIPELINE (C–C')

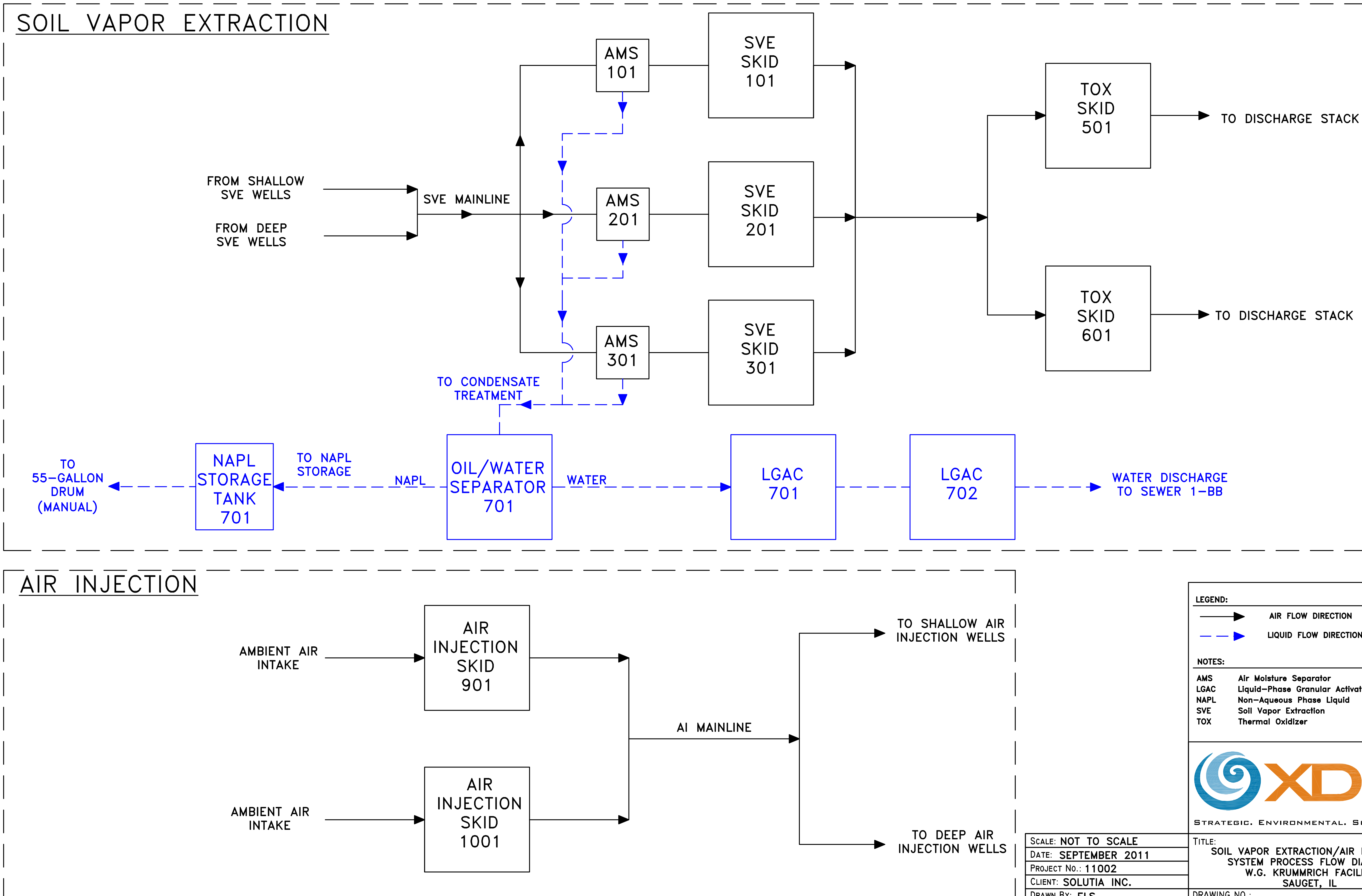
DRAWING NO.: FIGURE 3C

REV: 2

Figure 4
Historical Groundwater Trends
Final SVE System Design
W.G. Krummrich Facility, Sauget, Illinois



Notes:
1. The elevation data presented is based on nearby and on-site groundwater level measurements and the surface water level of the Mississippi River measured at the St. Louis, Missouri station.



LEGEND:

AIR FLOW DIRECTION

LIQUID FLOW DIRECTION

NOTES:

AMS	Air Moisture Separator
LGAC	Liquid-Phase Granular Activated Carbon
NAPL	Non-Aqueous Phase Liquid
SVE	Soil Vapor Extraction
TOX	Thermal Oxidizer

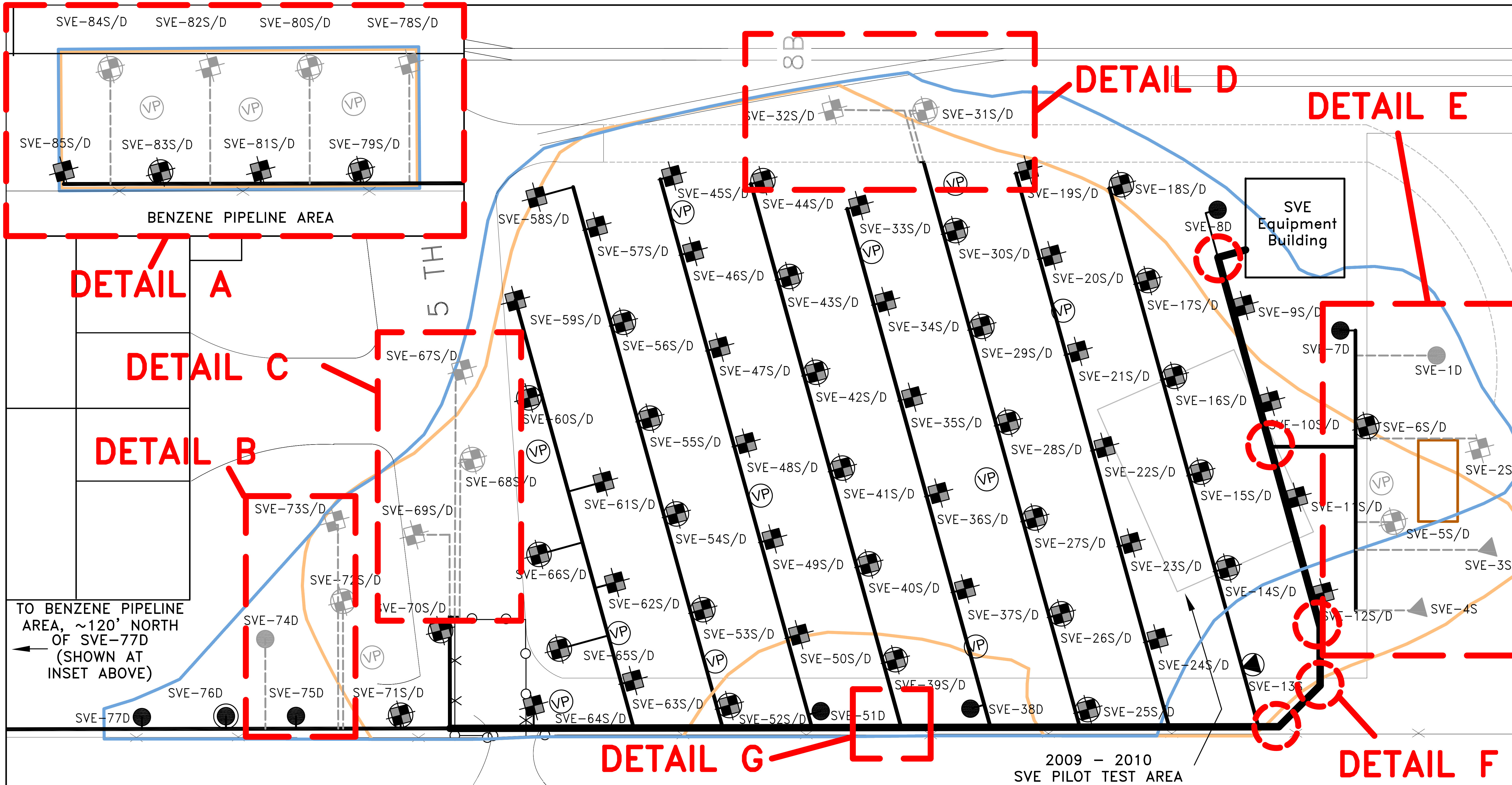
XDD
STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

SCALE: NOT TO SCALE
DATE: SEPTEMBER 2011
PROJECT NO.: 11002
CLIENT: SOLUTIA INC.
DRAWN BY: ELS
CHECKED BY: DK
PROJ. MGMT. APPROVAL: SCC

TITLE:
SOIL VAPOR EXTRACTION/AIR INJECTION SYSTEM PROCESS FLOW DIAGRAM
W.G. KRUMMRICH FACILITY
SAUGET, IL

DRAWING NO.: FIGURE 5

REV: 1



LEGEND:

- 2-INCH SCHEDULE 40 POLYVINYL CHLORIDE (PVC) PIPING (SUPPORTS TO HAVE A MAXIMUM SPACING INTERVAL OF 5 FEET)
- 6-INCH SCHEDULE 40 PVC PIPING (SUPPORTS TO HAVE A MAXIMUM SPACING INTERVAL OF 6.5 FEET)
- 12-INCH SCHEDULE 40 PVC PIPING (SUPPORTS TO HAVE A MAXIMUM SPACING INTERVAL OF 8 FEET)
- ALL PIPING IS GRAY & DASHED WHERE PROPOSED TO BE INSTALLED BELOW GRADE
- ABOVE GRADE SHALLOW AND DEEP NESTED SVE WELL LOCATION
- BELOW GRADE SHALLOW AND DEEP NESTED SVE WELL LOCATION
- ABOVE GRADE SHALLOW SVE WELL LOCATION
- BELOW GRADE SHALLOW SVE WELL LOCATION
- ABOVE GRADE DEEP SVE WELL LOCATION
- BELOW GRADE DEEP SVE WELL LOCATION
- INDICATES ABOVE GRADE COMBINED SVE/AI WELL LOCATION
- INDICATES BELOW GRADE COMBINED SVE/AI WELL LOCATION
- ABOVE GRADE NESTED VAPOR PROBES
- BELOW GRADE NESTED VAPOR PROBES
- LOCATION OF VEHICLE ACCESS ROAD
- EXTENT OF SHALLOW TARGET TREATMENT AREA
- EXTENT OF DEEP TARGET TREATMENT AREA
- LOADING DOCK
- EXPANSION COUPLING LOCATION (SEE FIGURE 9F)

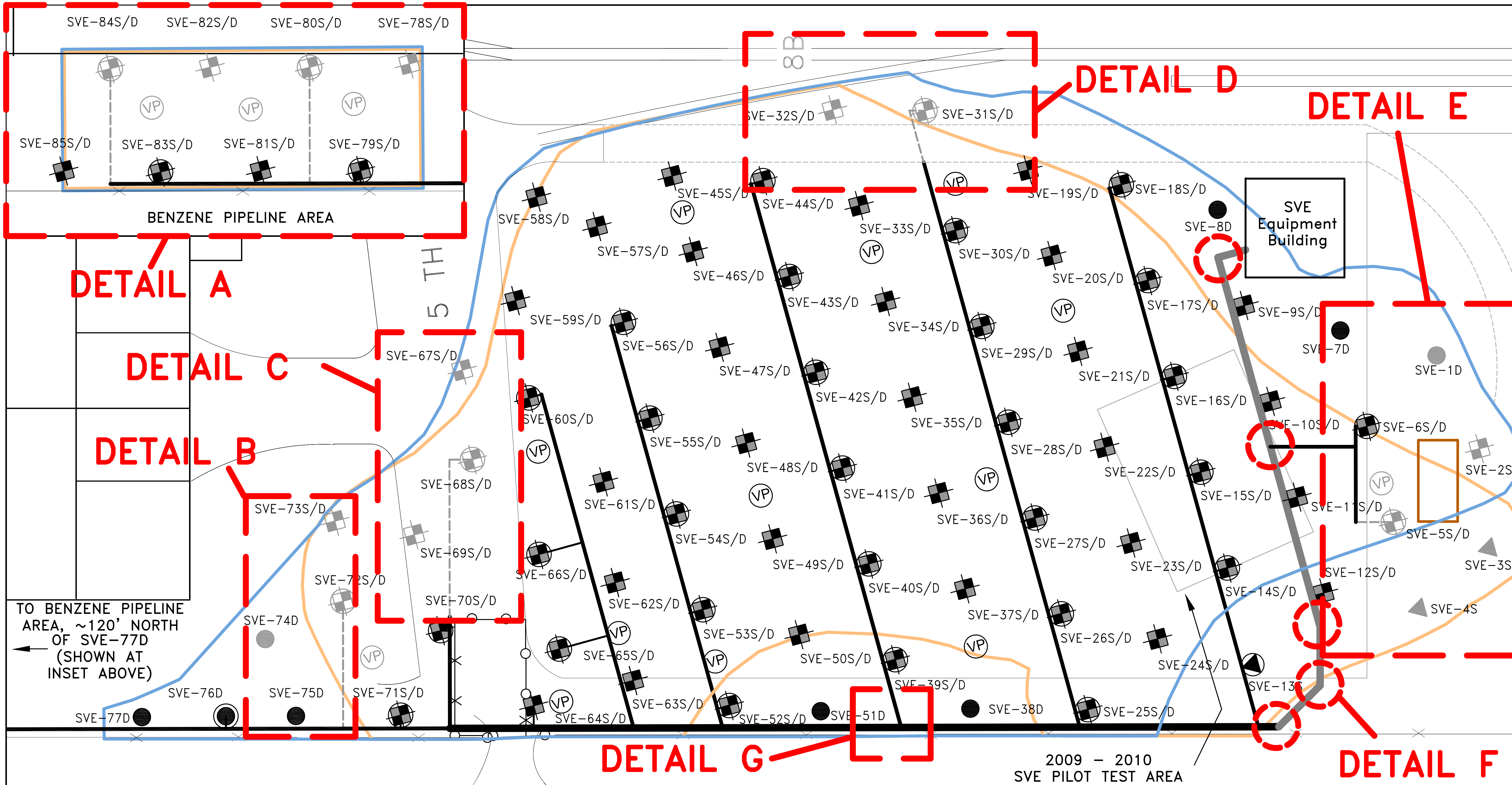
NOTES:

– REFER TO FIGURES 9A THROUGH 9G FOR PIPING MANIFOLD DETAILS A THROUGH G
– ALL ABOVE GRADE BRANCH AND MANIFOLD PIPING WILL BE HEAT TRACED AND INSULATED
–CLEANOUTS WILL BE INSTALLED AT THE TERMINUS OF ALL BRANCH AND MAIN SVE LINES (FIGURE 9H)

20' 0' 20' 40'

XDD
STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

SCALE: AS SHOWN	TITLE: SOIL VAPOR EXTRACTION PIPING LAYOUT W.G. KRUMMRICH FACILITY SAUGET, IL
DATE: SEPTEMBER 2011	
PROJECT NO.: 11002	
CLIENT: SOLUTIA INC.	
DRAWN BY: LBC	DRAWING NO.: FIGURE 6A
CHECKED BY: SCC	REV: 3
PROJ. MGMT. APPROVAL: SCC	



LEGEND:

- 2-INCH SCHEDULE 80 CHLORINATED POLYVINYL CHLORIDE (CPVC) PIPING (SUPPORTS TO HAVE A MAXIMUM SPACING INTERVAL OF 6 FEET)
- 6-INCH SCHEDULE 80 CPVC PIPING (SUPPORTS TO HAVE A MAXIMUM SPACING INTERVAL OF 7.5 FEET)
- 12-INCH SCHEDULE 80 CPVC PIPING (SUPPORTS TO HAVE A MAXIMUM SPACING INTERVAL OF 8 FEET)
- 12-INCH SCHEDULE 10 CCARBON STEEL PIPING (SUPPORTS TO HAVE A MAXIMUM SPACING INTERVAL OF 8 FEET)
- ALL PIPING IS GRAY & DASHED WHERE PROPOSED TO BE INSTALLED BELOW GRADE
- ABOVE GRADE SHALLOW AND DEEP NESTED SVE WELL LOCATION
- BELOW GRADE SHALLOW AND DEEP NESTED SVE WELL LOCATION
- ABOVE GRADE SHALLOW SVE WELL LOCATION
- BELOW GRADE SHALLOW SVE WELL LOCATION
- ABOVE GRADE DEEP SVE WELL LOCATION
- BELOW GRADE DEEP SVE WELL LOCATION
- INDICATES ABOVE GRADE COMBINED SVE/AI WELL LOCATION
- INDICATES BELOW GRADE COMBINED SVE/AI WELL LOCATION
- ABOVE GRADE NESTED VAPOR PROBES
- BELOW GRADE NESTED VAPOR PROBES
- LOCATION OF VEHICLE ACCESS ROAD
- EXTENT OF SHALLOW TARGET TREATMENT AREA
- EXTENT OF DEEP TARGET TREATMENT AREA
- LOADING DOCK
- EXPANSION COUPLING LOCATION (SEE FIGURE 6F)

NOTES:

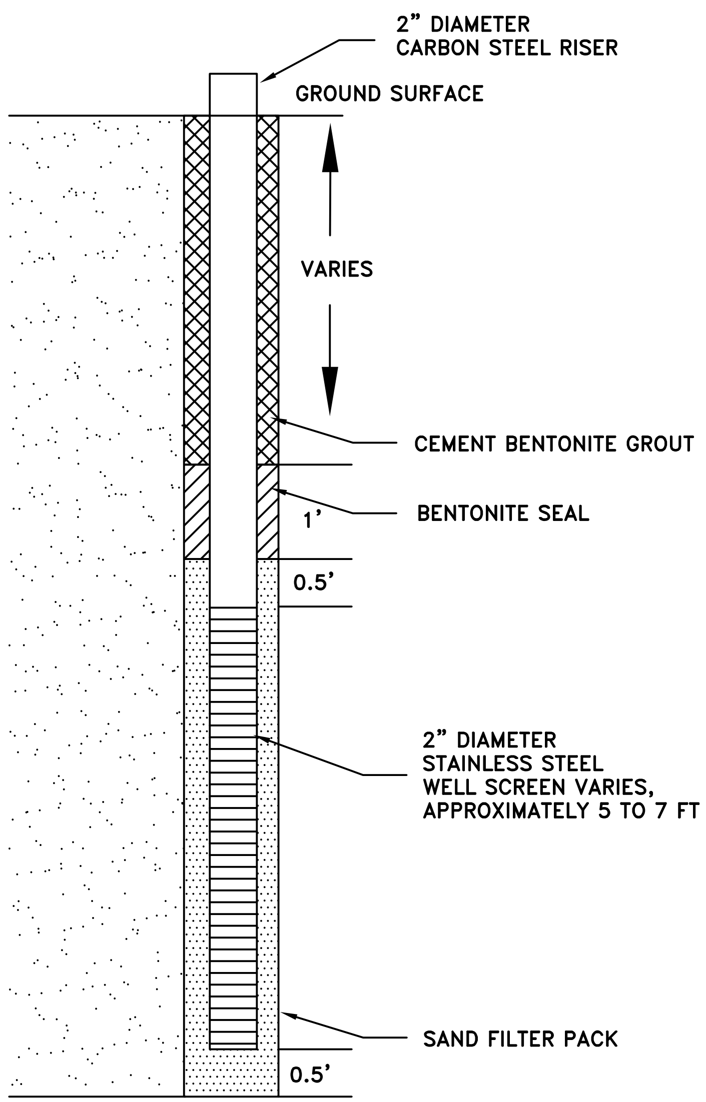
-REFER TO FIGURES 9A THROUGH 9G FOR PIPING MANIFOLD DETAILS A THROUGH G
-ALL ABOVE GRADE BRANCH AND MANIFOLD PIPING WILL BE INSULATED.
-CLEANOUTS WILL BE INSTALLED AT THE TERMINUS OF ALL BRANCH AND MAIN AI LINES (FIGURE 9H)

20' 0' 20' 40'

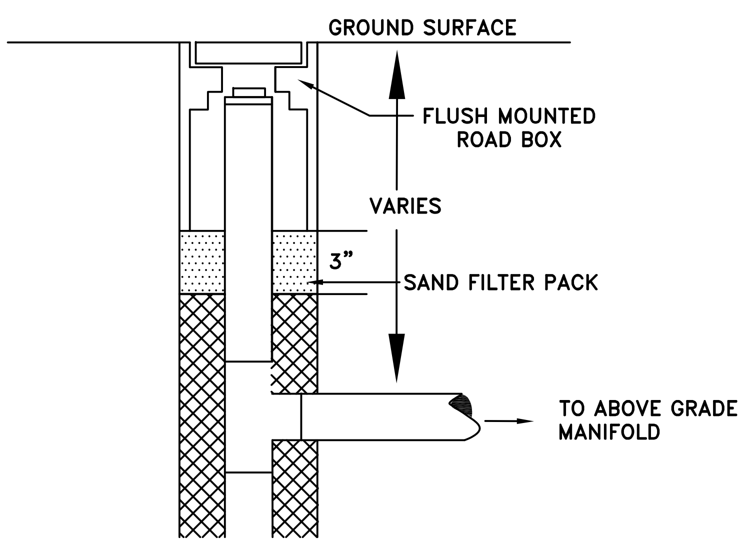
STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

SCALE: AS SHOWN	TITLE: AIR INJECTION PIPING LAYOUT W.G. KRUMMRICH FACILITY SAUGET, IL
DATE: SEPTEMBER 2011	
PROJECT NO.: 11002	
CLIENT: SOLUTIA INC.	
DRAWN BY: LBC	DRAWING NO.: FIGURE 6B
CHECKED BY: SCC	REV: 3
PROJ. MGMT. APPROVAL: SCC	

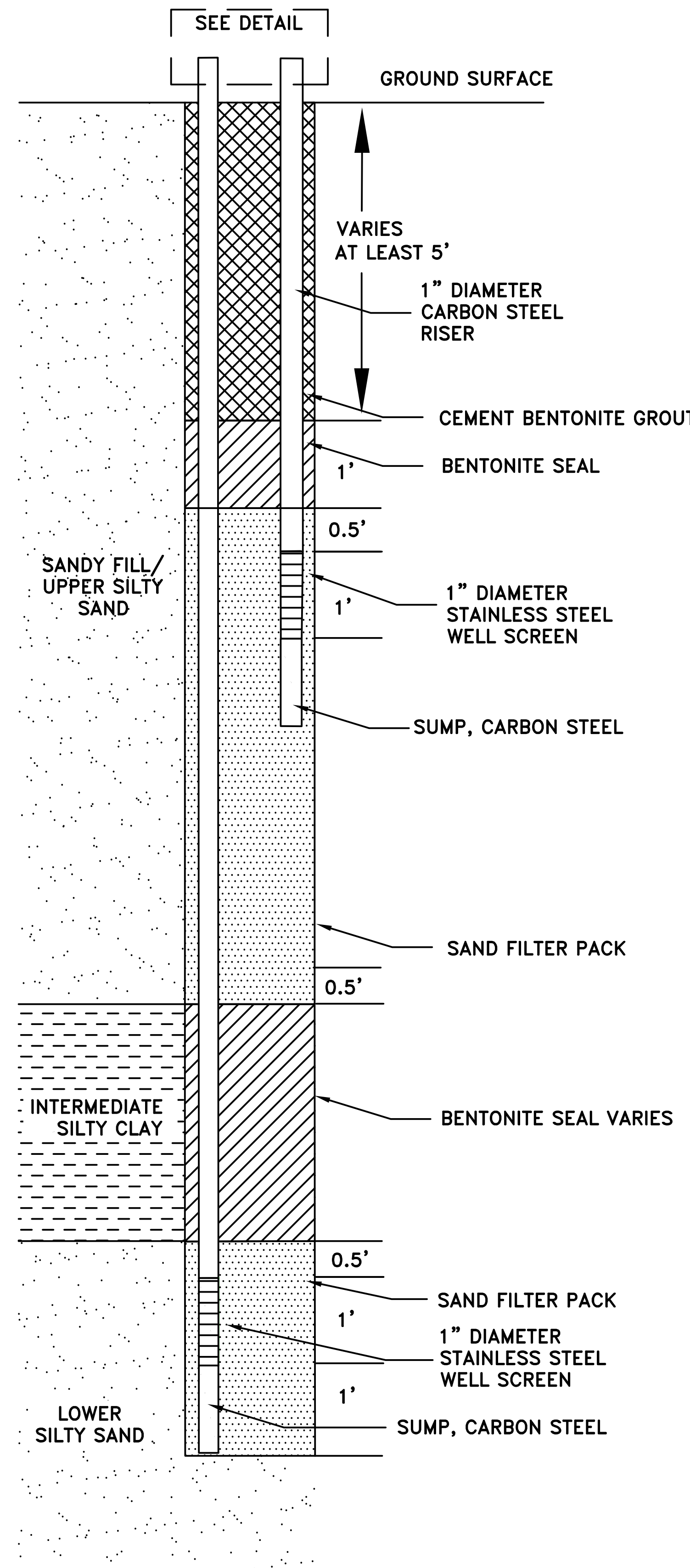
TYPICAL SVE/AI WELL



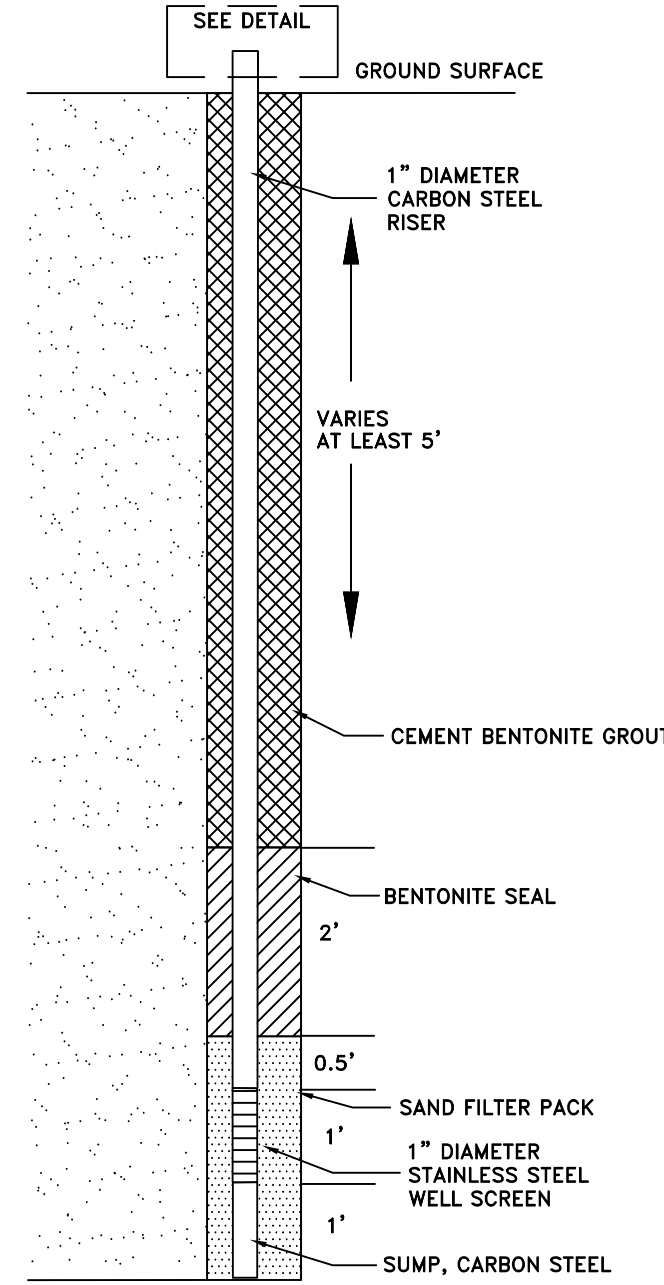
TYPICAL BELOW GRADE SVE/AI WELL COMPLETION DETAIL



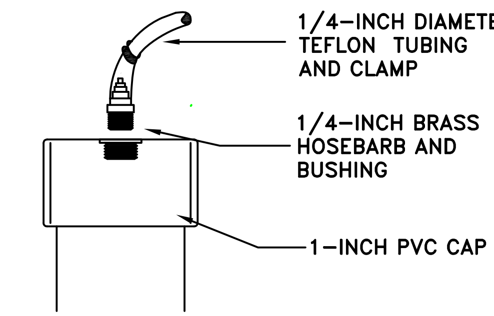
TYPICAL NESTED VAPOR PROBE



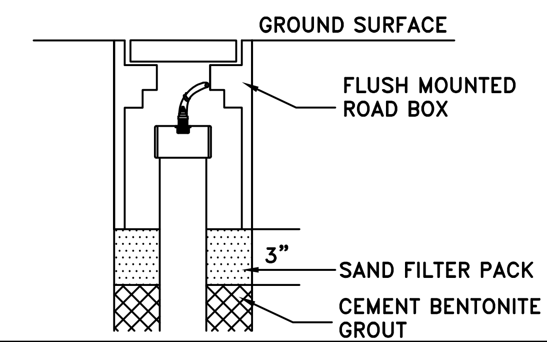
TYPICAL SINGLE VAPOR PROBE



TYPICAL ABOVE GRADE VAPOR PROBE COMPLETION DETAIL



TYPICAL BELOW GRADE VAPOR PROBE DETAIL



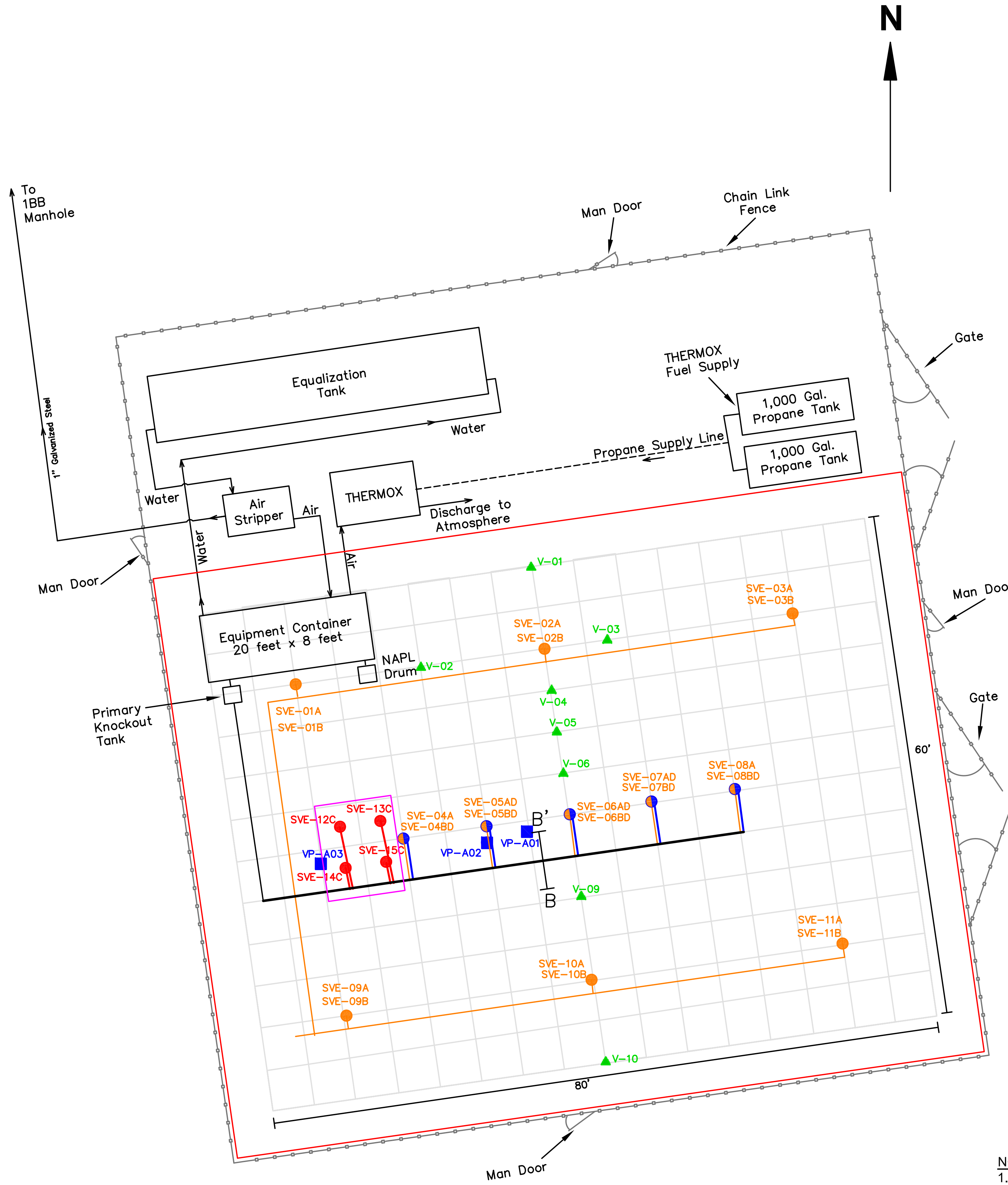
NOTE:

SVE = SOIL VAPOR EXTRACTION

XDD

STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

SCALE: NOT TO SCALE	TITLE: WELL AND VAPOR PROBE DESIGN CROSS-SECTION W.G. KRUMMRICH FACILITY SAUGET, IL
DATE: SEPTEMBER 2011	
PROJECT NO.: 11002	
CLIENT: SOLUTIA INC.	
DRAWN BY: MF	DRAWING NO.: FIGURE 7
CHECKED BY: ELS	REV: 1
PROJ. MGMT. APPROVAL: SC	



0' 15'

LEGEND:

- INTERMEDIATE SILTY CLAY LAYER SVE WELLS (C)
- FILL AND UPPER SILTY SAND (A) AND LOWER SILTY SAND (B) LAYERS NESTED SVE WELLS
- UPPER SILTY SAND (AD) AND LOWER SILTY SAND (BD) LAYERS NESTED COMBINATION SVE/AI WELLS
- VAPOR MONITORING POINTS
- VAPOR MONITORING PROBES
- = 5 FEET x 5 FEET GRID
- SVE / AI MANIFOLDING LINES A,B,C AND D
- SVE MANIFOLDING LINES A & B
- AI BRANCH LINE D
- SVE MANIFOLDING LINE C
- INTERMEDIATE SILTY CLAY PILOT TEST AREA
- EXTENT OF LOW PERMEABILITY RAIN COVER

NOTES:
1. SUFFIX ON WELL IDENTIFICATIONS INDICATES MANIFOLD CONNECTIONS.
2. AI - AIR INJECTION
3. CPVC - CHLORINATED POLYVINYLCHLORIDE
4. PVC - POLYVINYLCHLORIDE
5. SVE - SOIL VAPOR EXTRACTION
6. THERMOX - THERMAL OXIDIZER

XDD
STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

SCALE: AS SHOWN
DATE: SEPTEMBER 2011
PROJECT NO.: 08013.01
CLIENT: Solutia – Sauget
DRAWN BY: JTH
CHECKED BY: DK
PROJ. MGMT. APPROVAL: SCC

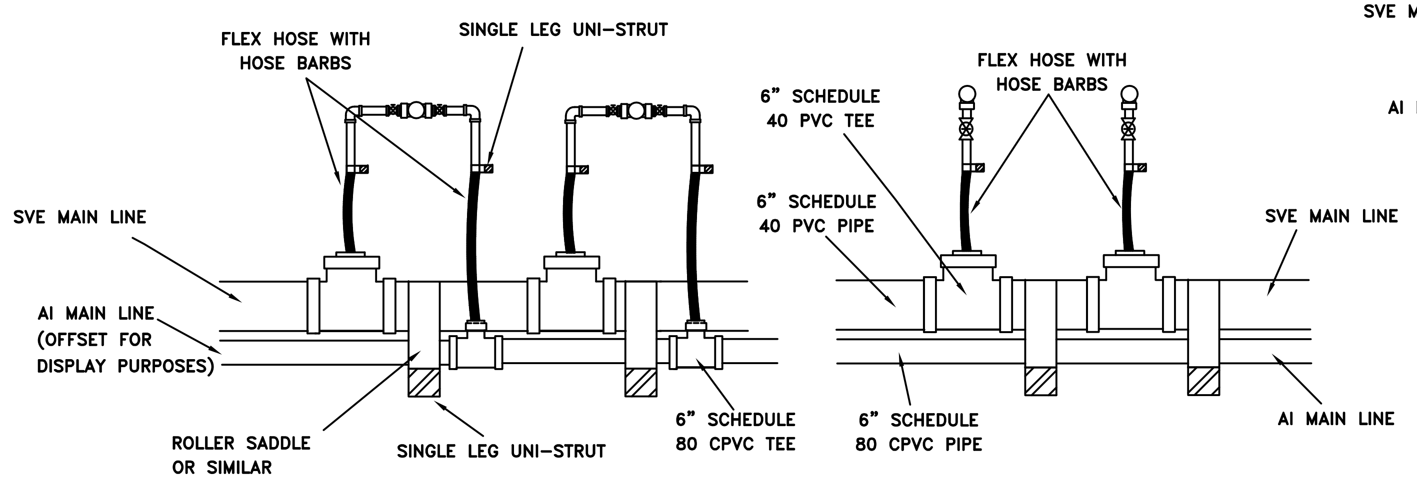
TITLE: PILOT TEST SITE PLAN
W.G. KRUMMRICH FACILITY
SAUGET, IL

DRAWING NO.: FIGURE 8
REV: 5

TOP VIEW

SVE/AI WELL LOCATIONS (SVE-84 S/D and SVE-80 S/D)

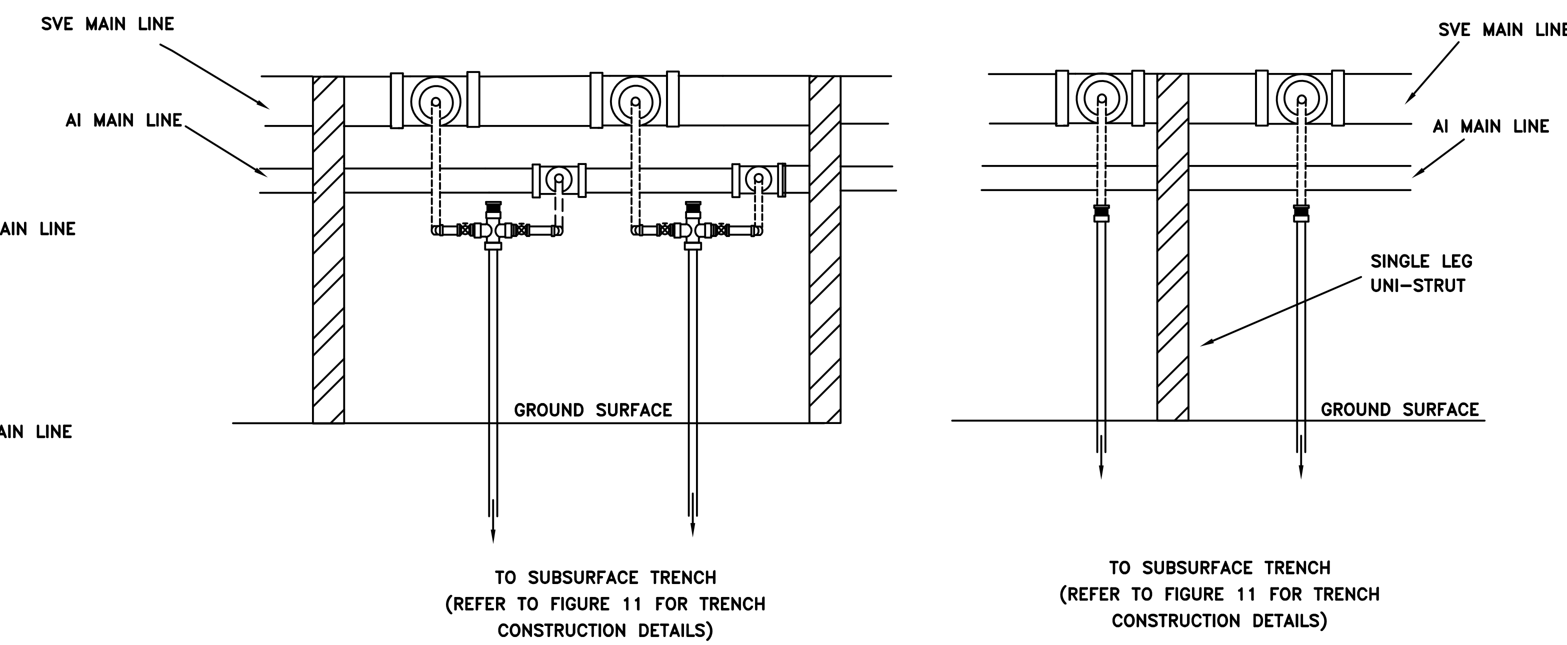
SVE WELL LOCATIONS (SVE-82 S/D and SVE-78 S/D)



FRONT VIEW

SVE/AI WELL LOCATIONS (SVE-84 S/D and SVE-80 S/D)

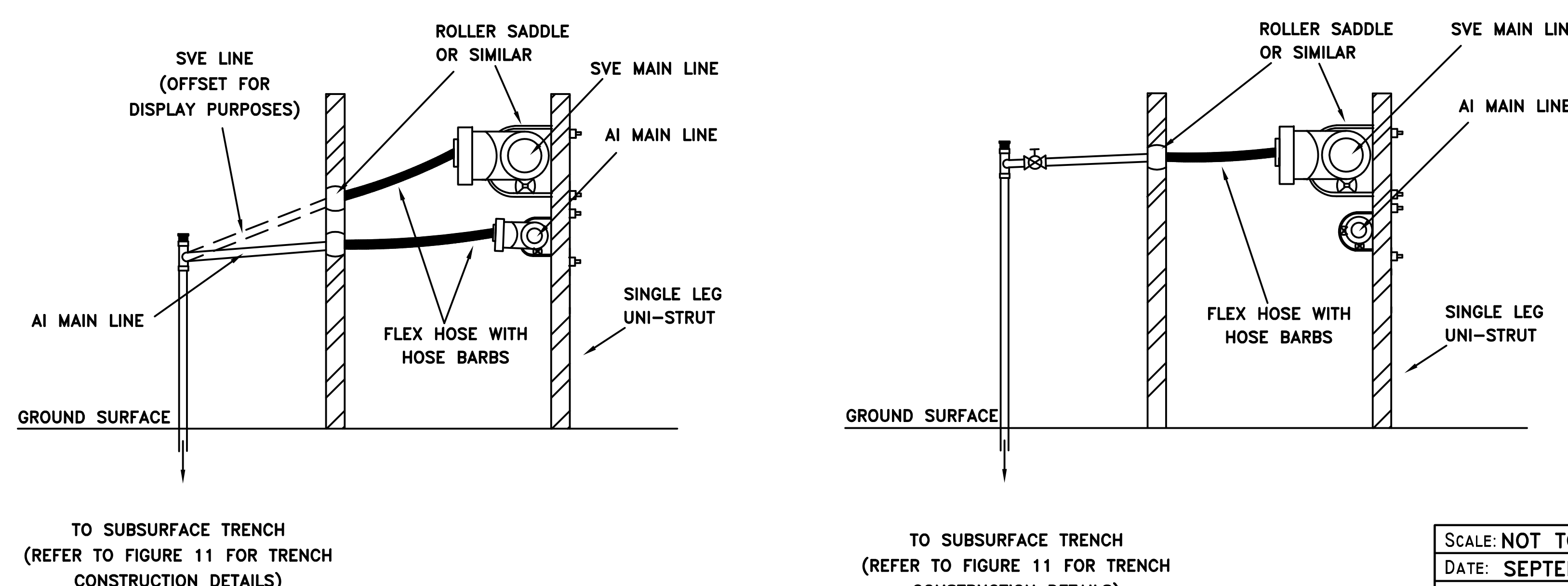
SVE WELL LOCATIONS (SVE-82 S/D and SVE-78 S/D)



SIDE VIEW

SVE/AI WELL LOCATIONS (SVE-84 S/D and SVE-80 S/D)

SVE WELL LOCATIONS (SVE-82 S/D and SVE-78 S/D)



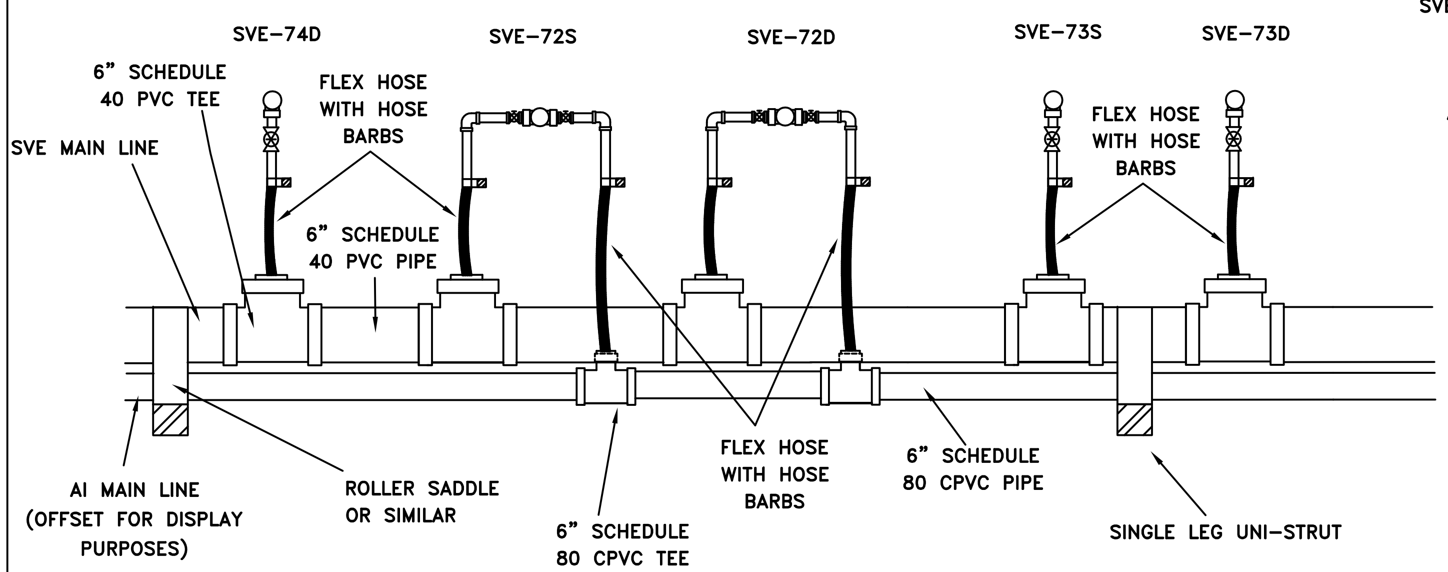
NOTES:

- AI = AIR INJECTION
- CPVC = CHLORINATED POLYVINYL CHLORIDE
- PVC = POLYVINYL CHLORIDE
- SVE = SOIL VAPOR EXTRACTION
- REFER TO FIGURE 6 FOR MANIFOLD DETAIL LOCATION.
- REFER TO FIGURES 12A AND 12B FOR SVE AND COMBINATION SVE/AI WELLHEAD DETAILS, RESPECTIVELY.
- SPACING OF PIPE FITTINGS AND UNI-STRUT SUPPORTS ARE FOR DISPLAY PURPOSES ONLY. ACTUAL SPACING WILL VARY BY LOCATION.
- ALL WELLHEADS (SVE AND SVE/AI) AND AI MANIFOLD PIPING WILL BE INSULATED.
- ALL SVE MANIFOLD PIPING WILL BE INSULATED AND HEAT TRACED FOR FREEZE PROTECTION.

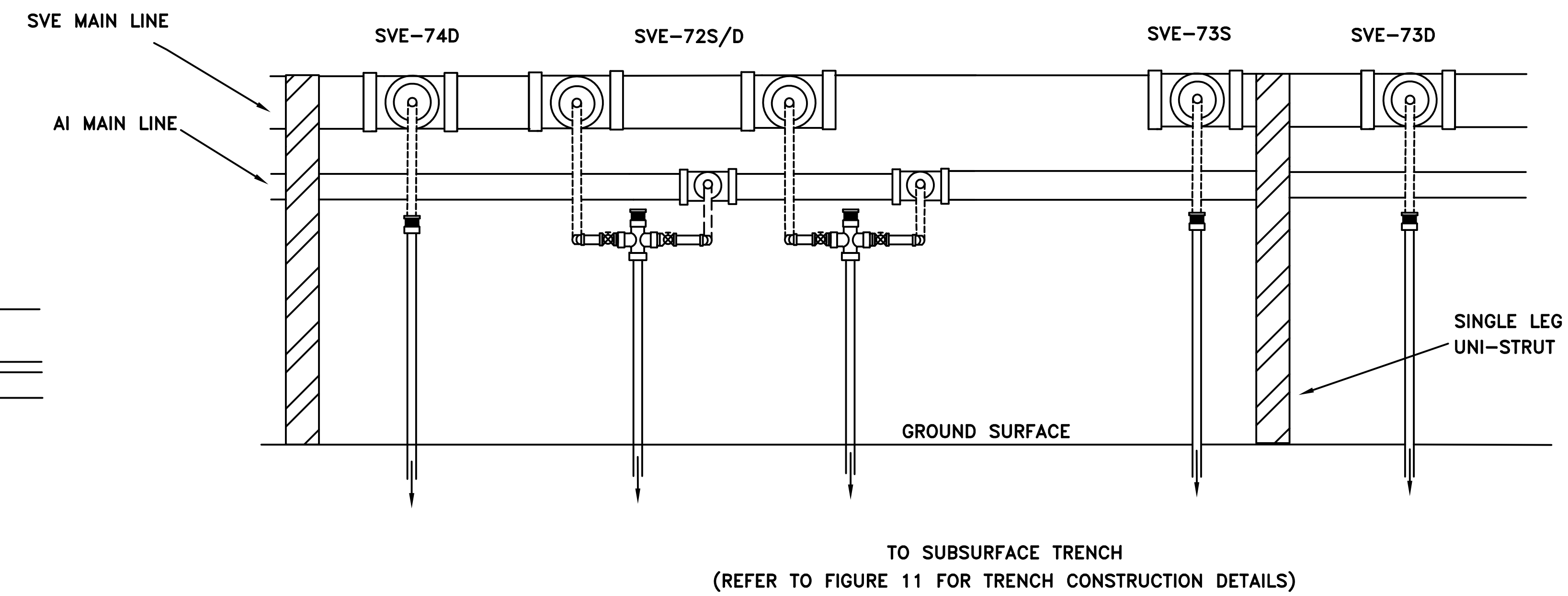
XDD — STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

SCALE: NOT TO SCALE	TITLE: BELOW GRADE WELLHEAD MANIFOLD DETAIL A
DATE: SEPTEMBER 2011	
PROJECT NO.: 11002	
CLIENT: SOLUTIA, INC.	
DRAWN BY: JWH	DRAWING NO.: FIGURE 9A
CHECKED BY: SC	REV: 2
PROJ. MGMT. APPROVAL: SC	

TOP VIEW

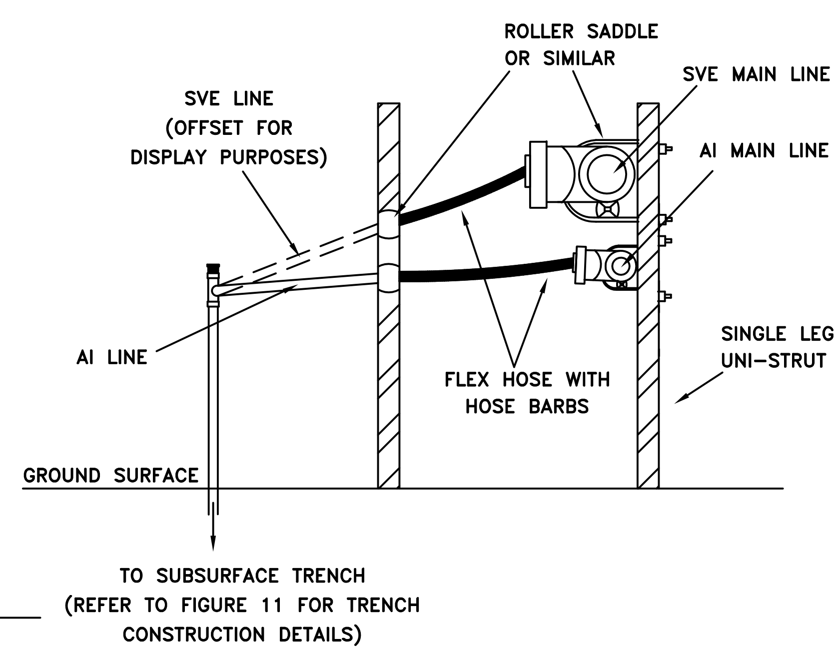


FRONT VIEW

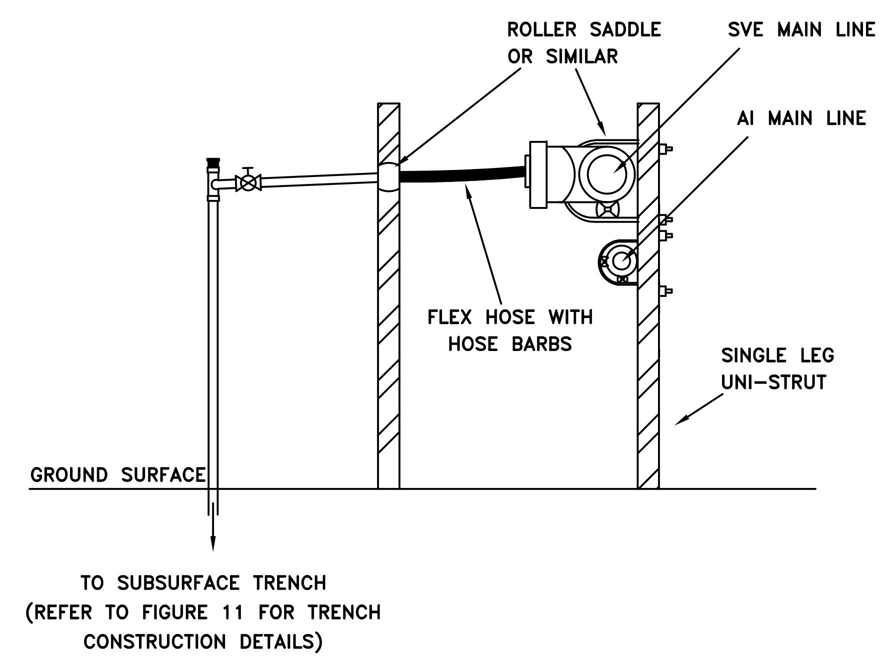


SIDE VIEW

SVE/AI WELL LOCATIONS (SVE-72 S/D)



SVE WELL LOCATIONS (SVE-74D and SVE-73 S/D)



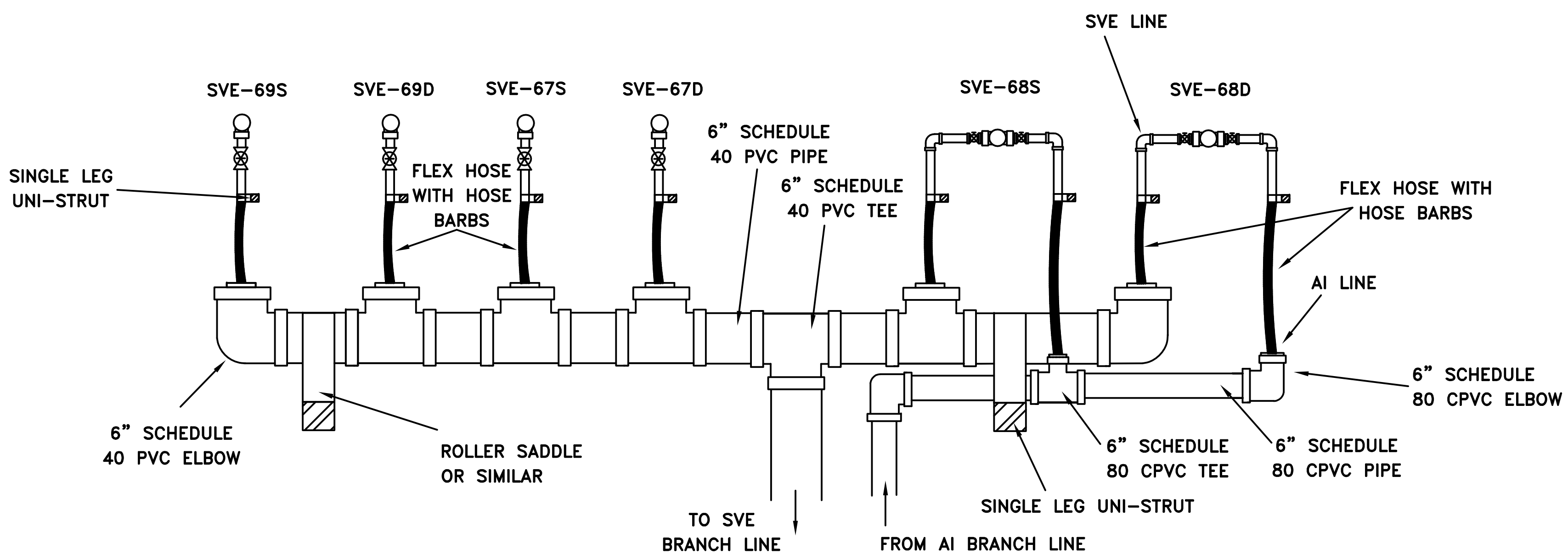
NOTES:

- AI = AIR INJECTION
- CPVC = CHLORINATED POLYVINYL CHLORIDE
- PVC = POLYVINYL CHLORIDE
- SVE = SOIL VAPOR EXTRACTION
- REFER TO FIGURE 6 FOR MANIFOLD DETAIL LOCATION.
- REFER TO FIGURES 12A AND 12B FOR SVE AND COMBINATION SVE/AI WELLHEAD DETAILS, RESPECTIVELY.
- SPACING OF PIPE FITTINGS AND UNI-STRUT SUPPORTS ARE FOR DISPLAY PURPOSES ONLY. ACTUAL SPACING WILL VARY BY LOCATION.
- ALL WELLHEADS (SVE AND SVE/AI) AND AI MANIFOLD PIPING WILL INSULATED.
- ALL SVE MANIFOLD PIPING WILL BE INSULATED AND HEAT TRACED FOR FREEZE PROTECTION.

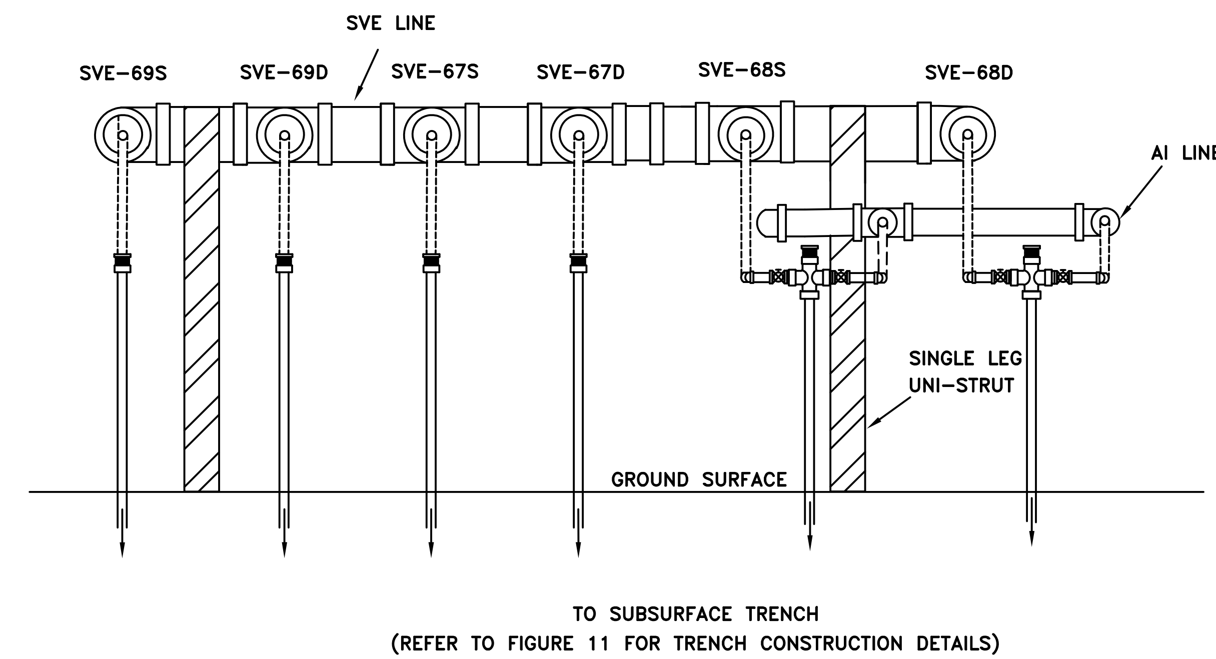
XDD
STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

SCALE: NOT TO SCALE	TITLE: BELOW GRADE WELLHEAD MANIFOLD DETAIL B
DATE: SEPTEMBER 2011	
PROJECT NO.: 11002	
CLIENT: SOLUTIA, INC.	
DRAWN BY: JWH	DRAWING NO.: FIGURE 9B
CHECKED BY: SC	REV: 2
PROJ. MGMT. APPROVAL: SC	

TOP VIEW

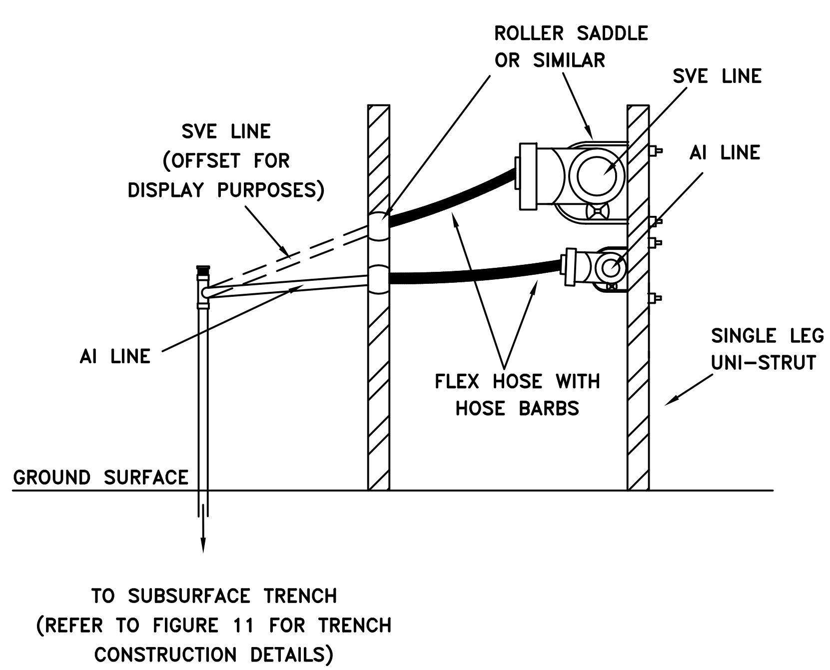


FRONT VIEW

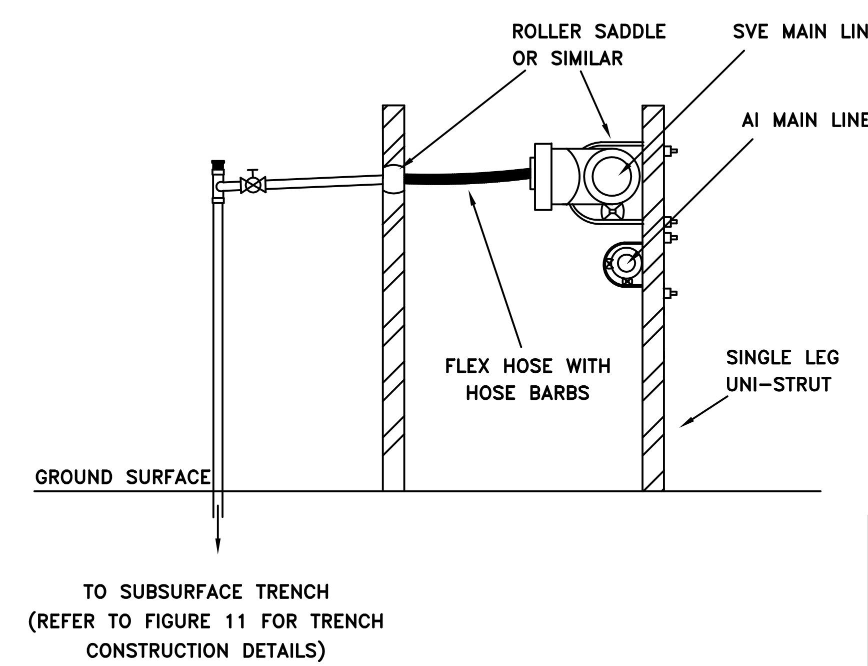


SIDE VIEW

SVE/AI WELL LOCATIONS (SVE-68 S/D)



SVE WELL LOCATIONS (SVE-69 S/D and SVE-67 S/D)



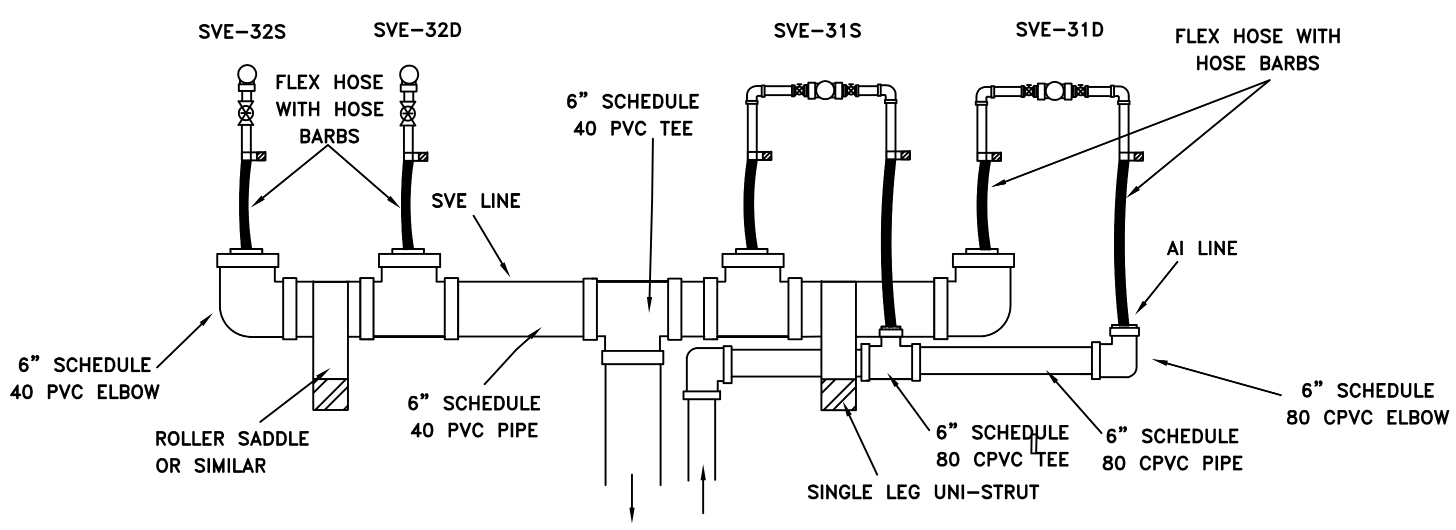
NOTES:

- AI = AIR INJECTION
- CPVC = CHLORINATED POLYVINYL CHLORIDE
- PVC = POLYVINYL CHLORIDE
- SVE = SOIL VAPOR EXTRACTION
- REFER TO FIGURES 6 FOR MANIFOLD DETAIL LOCATION.
- REFER TO FIGURES 12A AND 12B FOR SVE AND COMBINATION SVE/AI WELLHEAD DETAILS, RESPECTIVELY.
- SPACING OF PIPE FITTINGS AND UNI-STRUT SUPPORTS ARE FOR DISPLAY PURPOSES ONLY. ACTUAL SPACING WILL VARY BY LOCATION.
- ALL WELLHEADS (SVE AND SVE/AI) AND AI MANIFOLD PIPING WILL INSULATED.
- ALL SVE MANIFOLD PIPING WILL BE INSULATED AND HEAT TRACED FOR FREEZE PROTECTION.

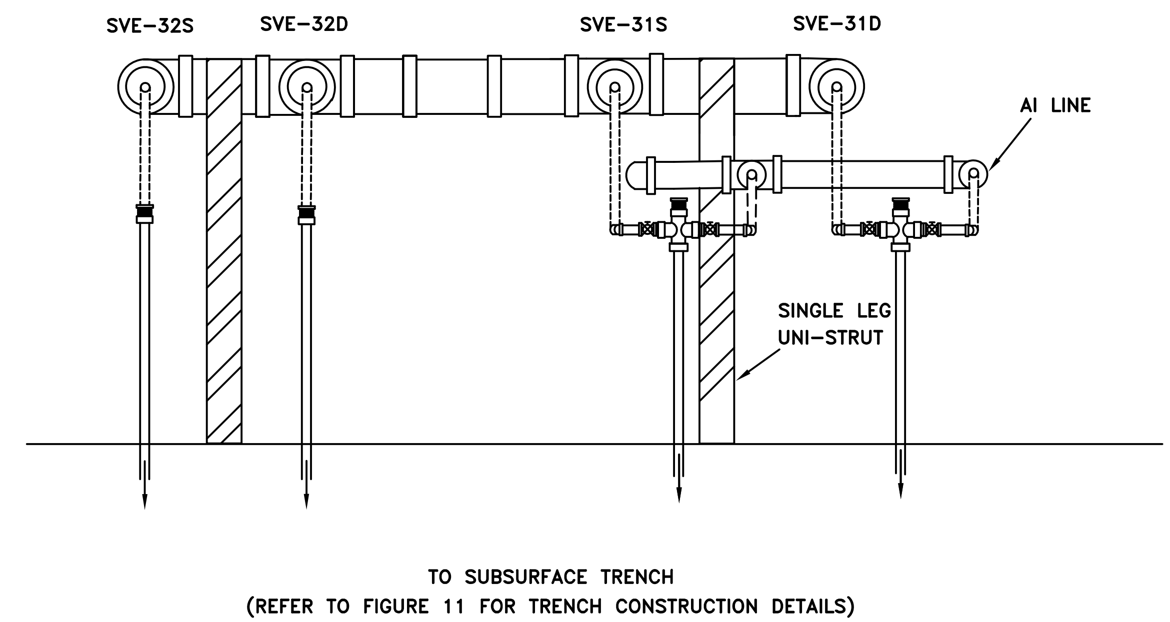
XDD
STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

SCALE: NOT TO SCALE	TITLE: BELOW GRADE WELLHEAD MANIFOLD DETAIL C
DATE: SEPTEMBER 2011	
PROJECT NO.: 11002	
CLIENT: SOLUTIA, INC.	
DRAWN BY: JWH	DRAWING NO.: FIGURE 9C — REV: 2
CHECKED BY: SC	
PROJ. MGMT. APPROVAL: SC	

TOP VIEW

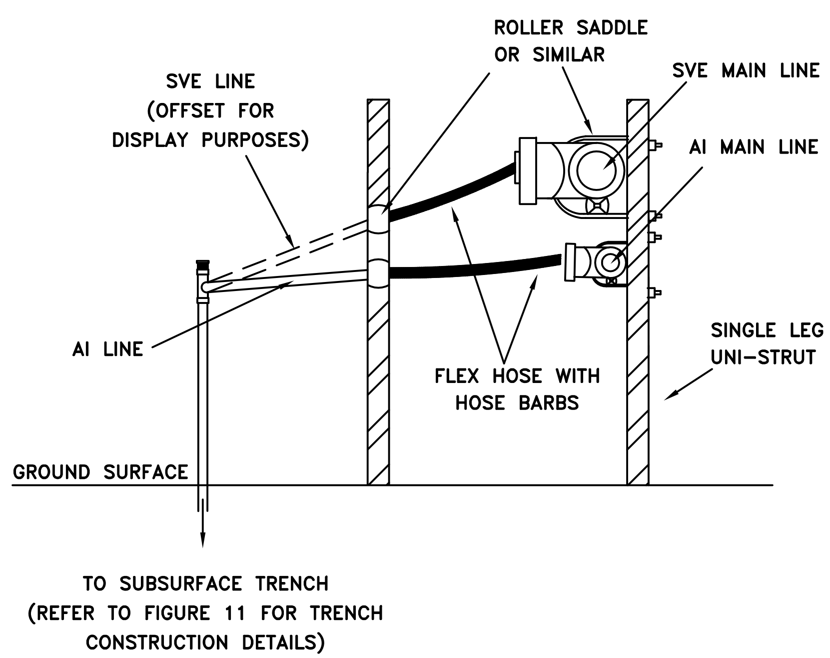


FRONT VIEW

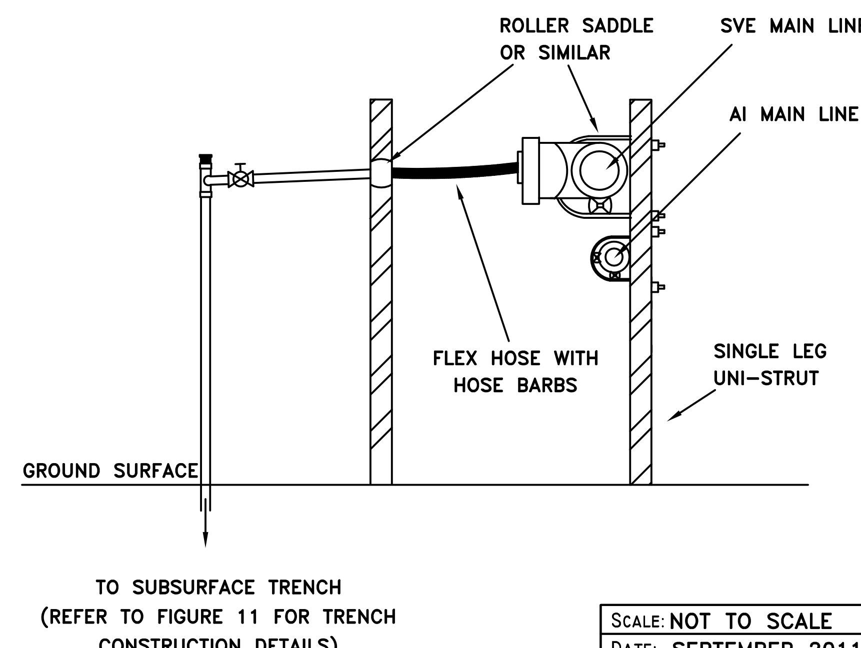


SIDE VIEW

SVE/AI WELL LOCATIONS (SVE-31 S/D)



SVE WELL LOCATIONS (SVE-32 S/D)



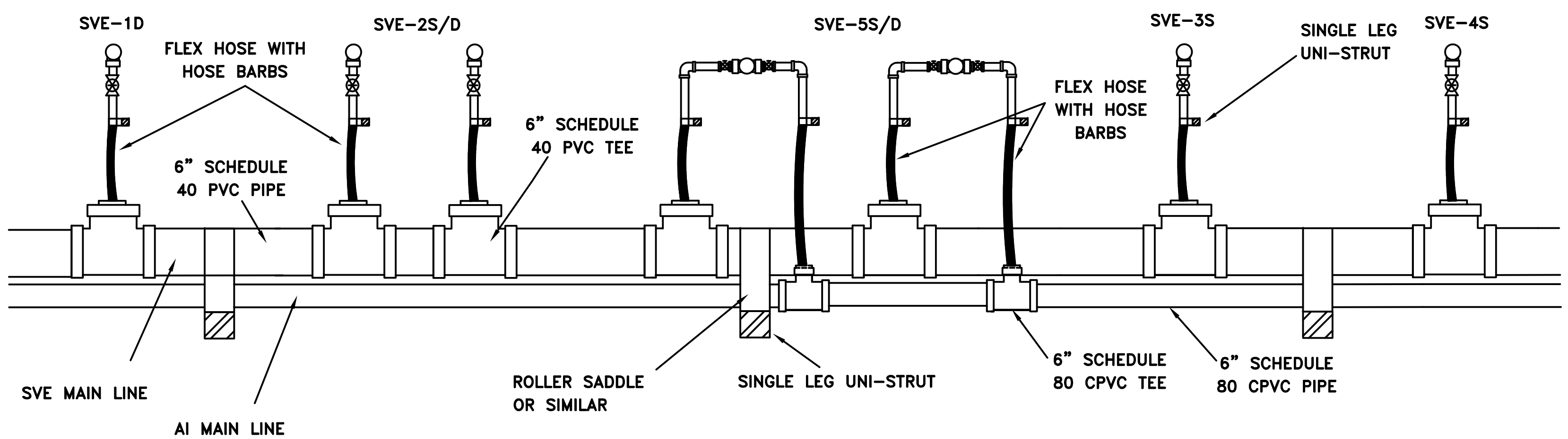
NOTES:

- AI = AIR INJECTION
- CPVC = CHLORINATED POLYVINYL CHLORIDE
- PVC = POLYVINYL CHLORIDE
- SVE = SOIL VAPOR EXTRACTION
- REFER TO FIGURE 6 FOR MANIFOLD DETAIL LOCATION.
- REFER TO FIGURES 12A AND 12B FOR SVE AND COMBINATION SVE/AI WELLHEAD DETAILS, RESPECTIVELY.
- SPACING OF PIPE FITTINGS AND UNI-STRUT SUPPORTS ARE FOR DISPLAY PURPOSES ONLY. ACTUAL SPACING WILL VARY BY LOCATION.
- ALL WELLHEADS (SVE AND SVE/AI) AND AI MANIFOLD PIPING WILL INSULATED.
- ALL SVE MANIFOLD PIPING WILL BE INSULATED AND HEAT TRACED FOR FREEZE PROTECTION.

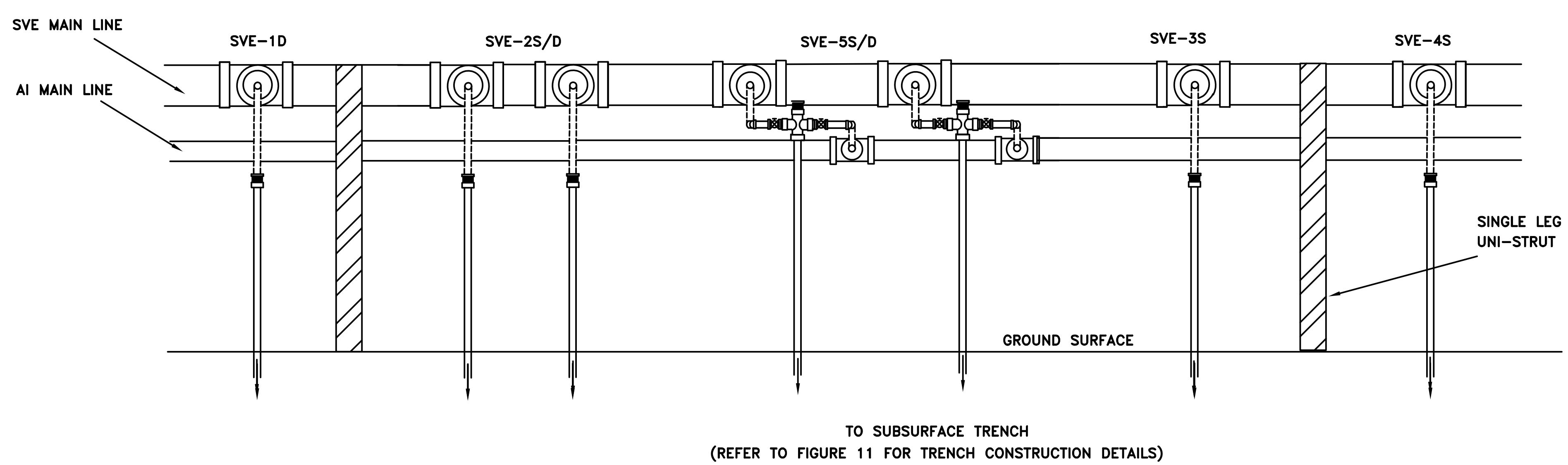
XDD
STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

SCALE: NOT TO SCALE	TITLE: BELOW GRADE WELLHEAD MANIFOLD DETAIL D
DATE: SEPTEMBER 2011	
PROJECT NO.: 11002	
CLIENT: SOLUTIA, INC.	
DRAWN BY: JWH	DRAWING NO.: FIGURE 9D
CHECKED BY: SC	REV: 2
PROJ. MGMT. APPROVAL: SC	

TOP VIEW

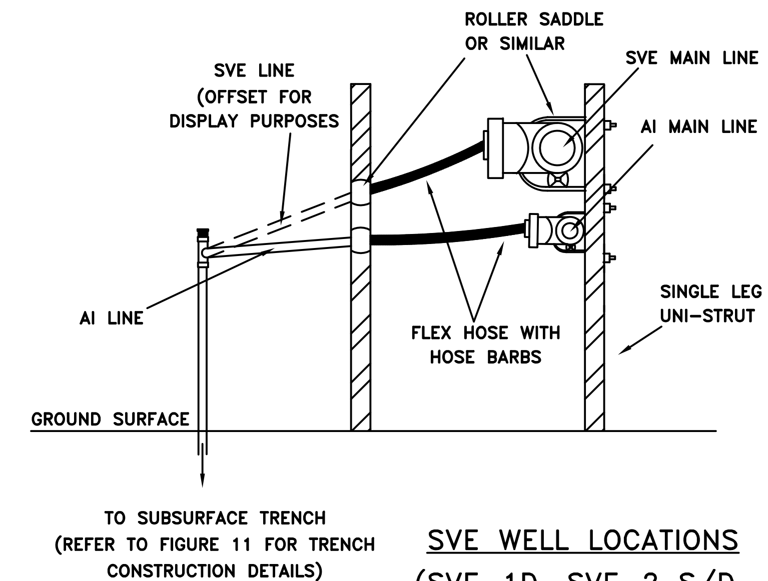


FRONT VIEW

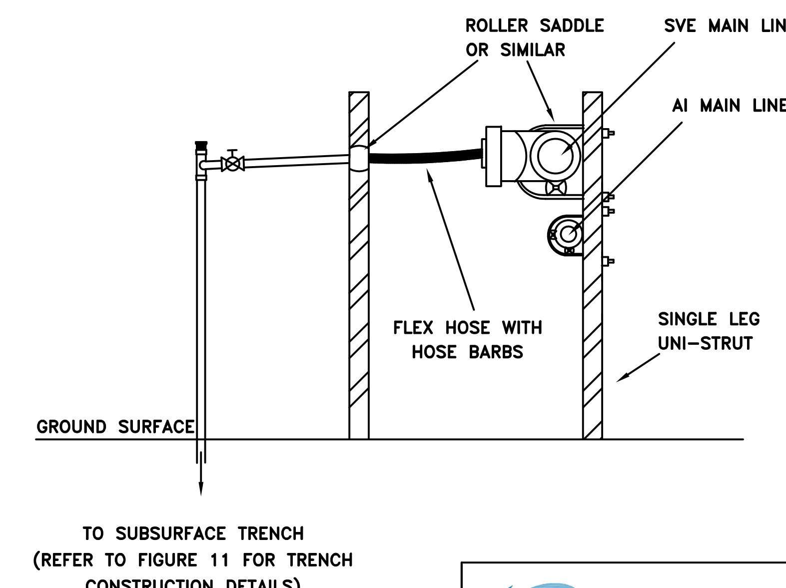


SIDE VIEW

SVE/AI WELL LOCATIONS
(SVE−5 S/D)



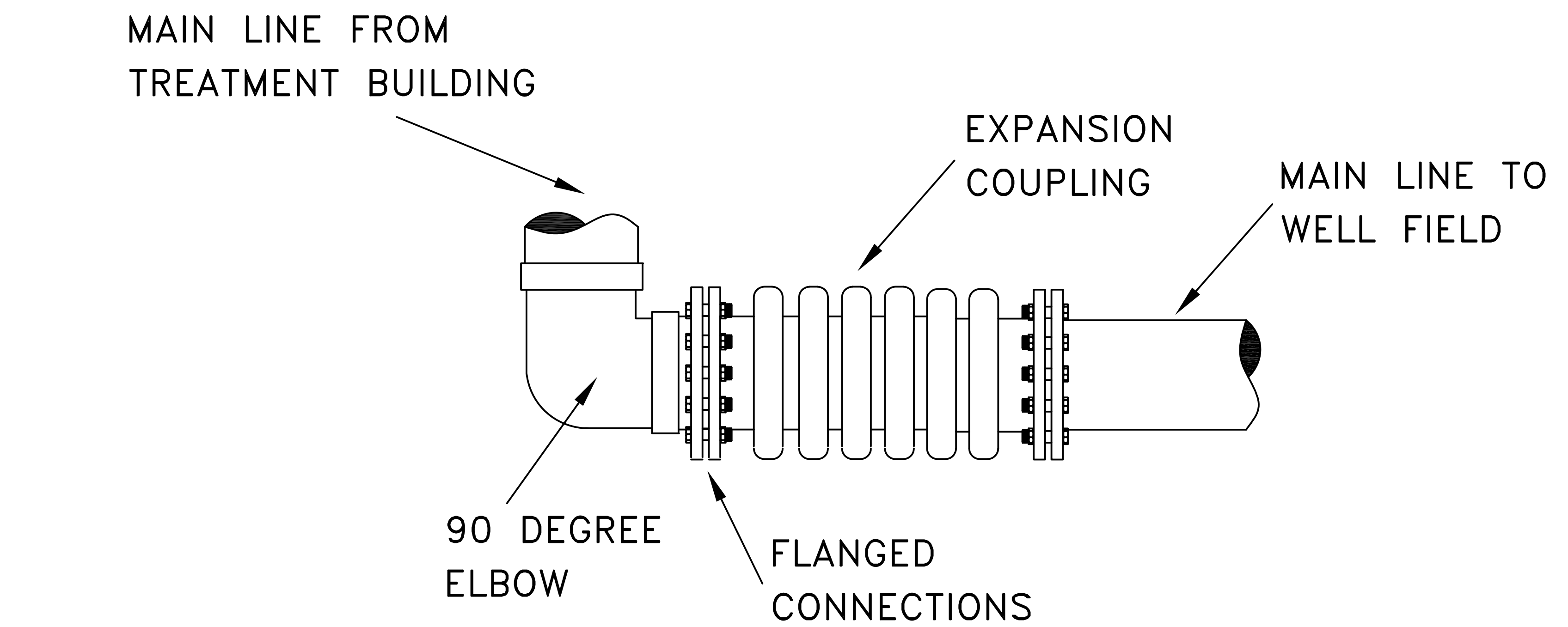
SVE WELL LOCATIONS
(SVE−1D, SVE−2 S/D,
SVE−3S, AND SVE−4S)

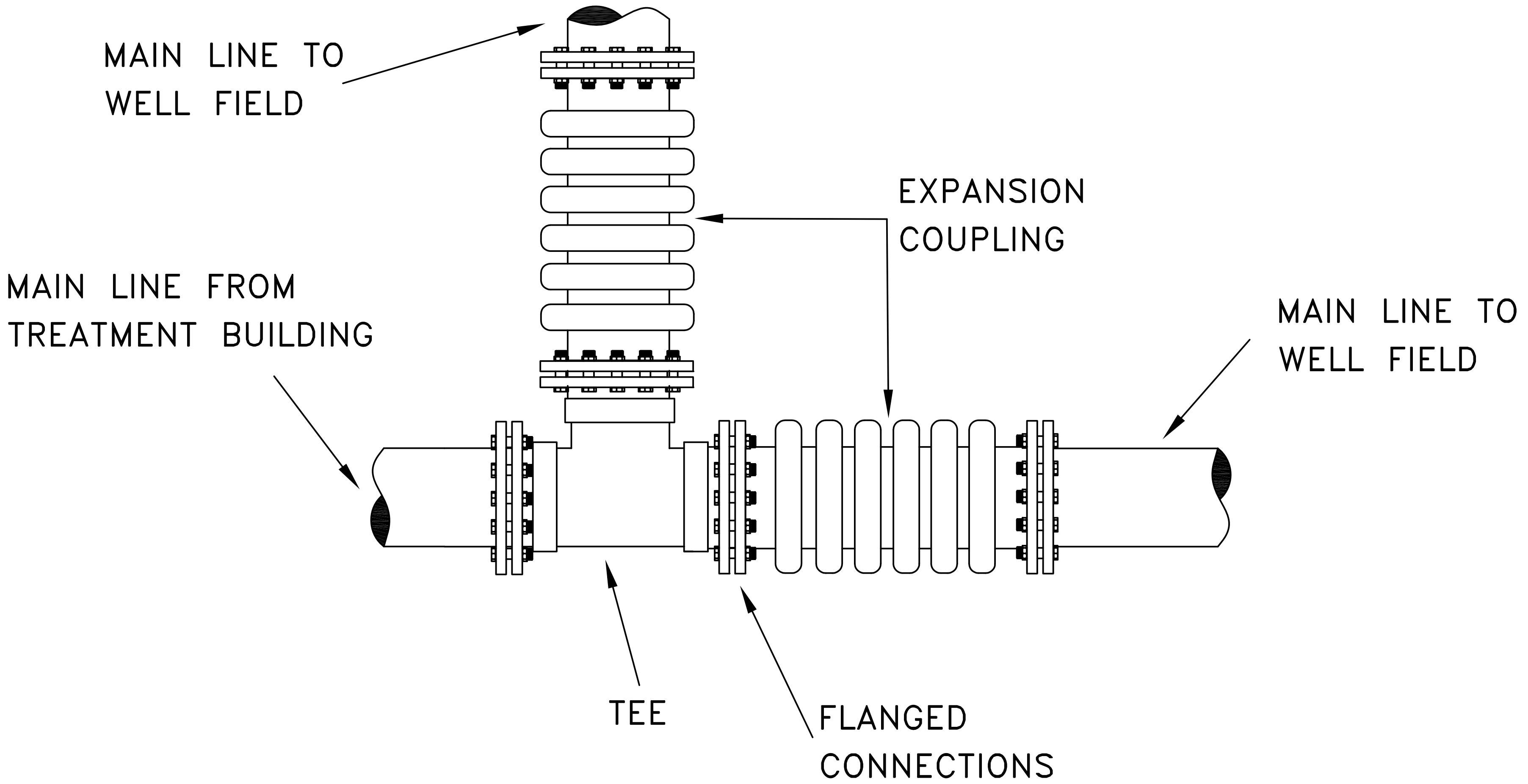


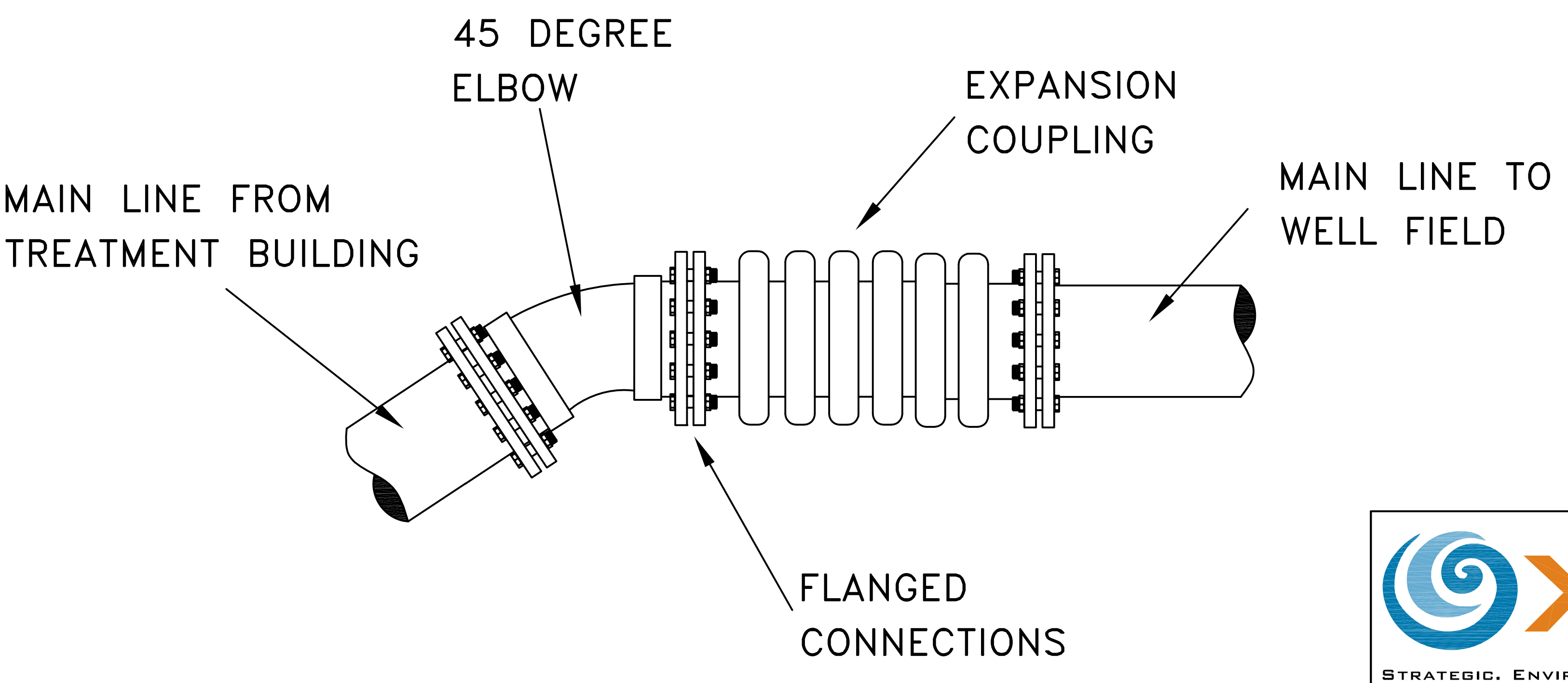
NOTES:
- AI = AIR INJECTION
- CPVC = CHLORINATED POLYVINYL CHLORIDE
- PVC = POLYVINYL CHLORIDE
- SVE = SOIL VAPOR EXTRACTION
- REFER TO FIGURE 6 FOR MANIFOLD DETAIL LOCATION.
- REFER TO FIGURES 12A AND 12B FOR SVE AND COMBINATION SVE/AI WELLHEAD DETAILS, RESPECTIVELY.
- SPACING OF PIPE FITTINGS AND UNI−STRUT SUPPORTS ARE FOR DISPLAY PURPOSES ONLY. ACTUAL SPACING WILL VARY BY LOCATION.
- ALL WELLHEADS (SVE AND SVE/AI) AND AI MANIFOLD PIPING WILL BE INSULATED.
- ALL SVE MANIFOLD PIPING WILL BE INSULATED AND HEAT TRACED FOR FREEZE PROTECTION.

XDD
STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

SCALE: NOT TO SCALE	TITLE: BELOW GRADE WELLHEAD MANIFOLD DETAIL E
DATE: SEPTEMBER 2011	
PROJECT NO.: 11002	
CLIENT: SOLUTIA, INC.	
DRAWN BY: JWH	DRAWING NO.: FIGURE 9E
CHECKED BY: SC	REV: 2
PROJ. MGMT. APPROVAL: SC	



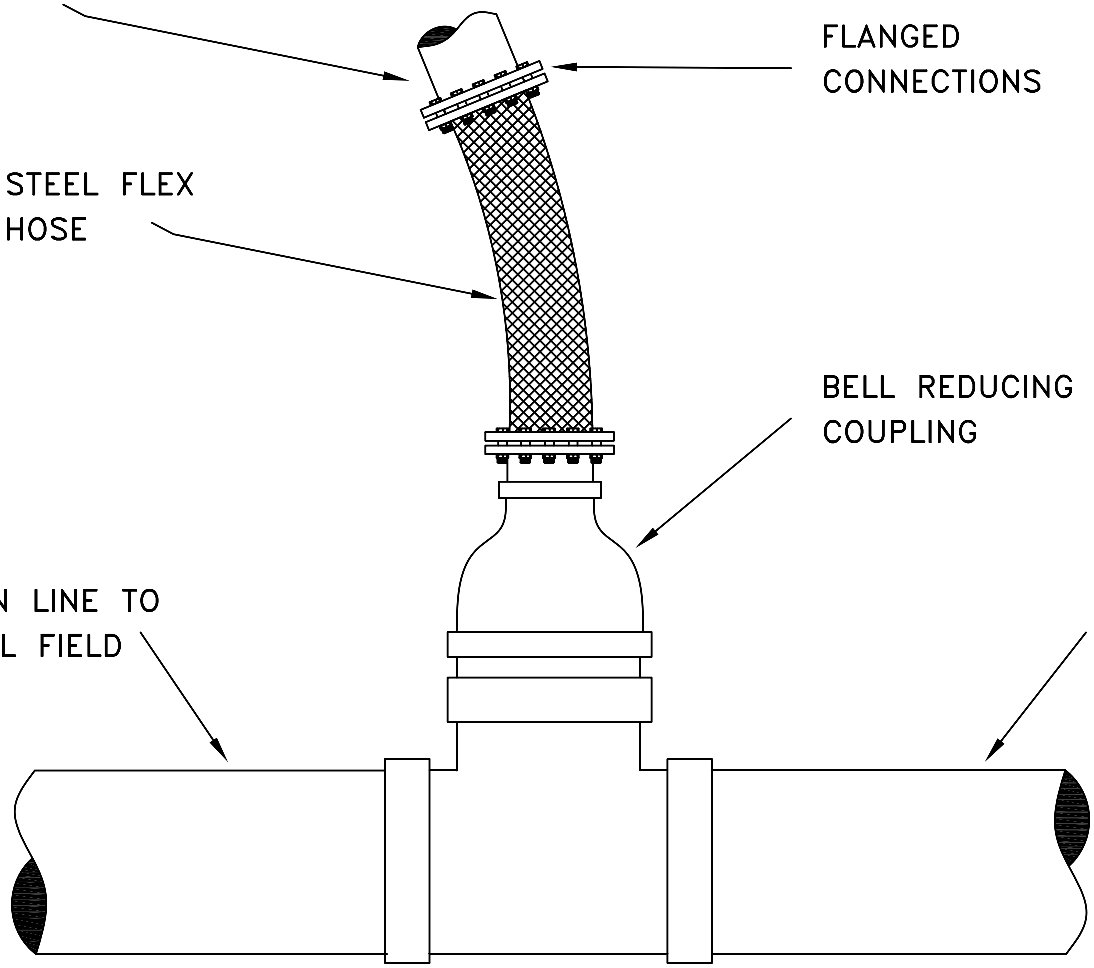




XDD
STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

SCALE: NOT TO SCALE	TITLE: EXPANSION COUPLING DETAIL W.G. KRUMMRICH FACILITY SAUGET, IL
DATE: SEPTEMBER 2011	
PROJECT NO.: 11002	
CLIENT: SOLUTIA INC.	
DRAWN BY: MAW	DRAWING NO.: FIGURE 9F — REV: 1
CHECKED BY: DK	
PROJ. MGMT. APPROVAL: DK	

NOTE:
–REFER TO FIGURES 6A AND 6B FOR SOIL VAPOR EXTRACTION AND AIR INJECTION PIPING SPECIFICATIONS, RESPECTIVELY.

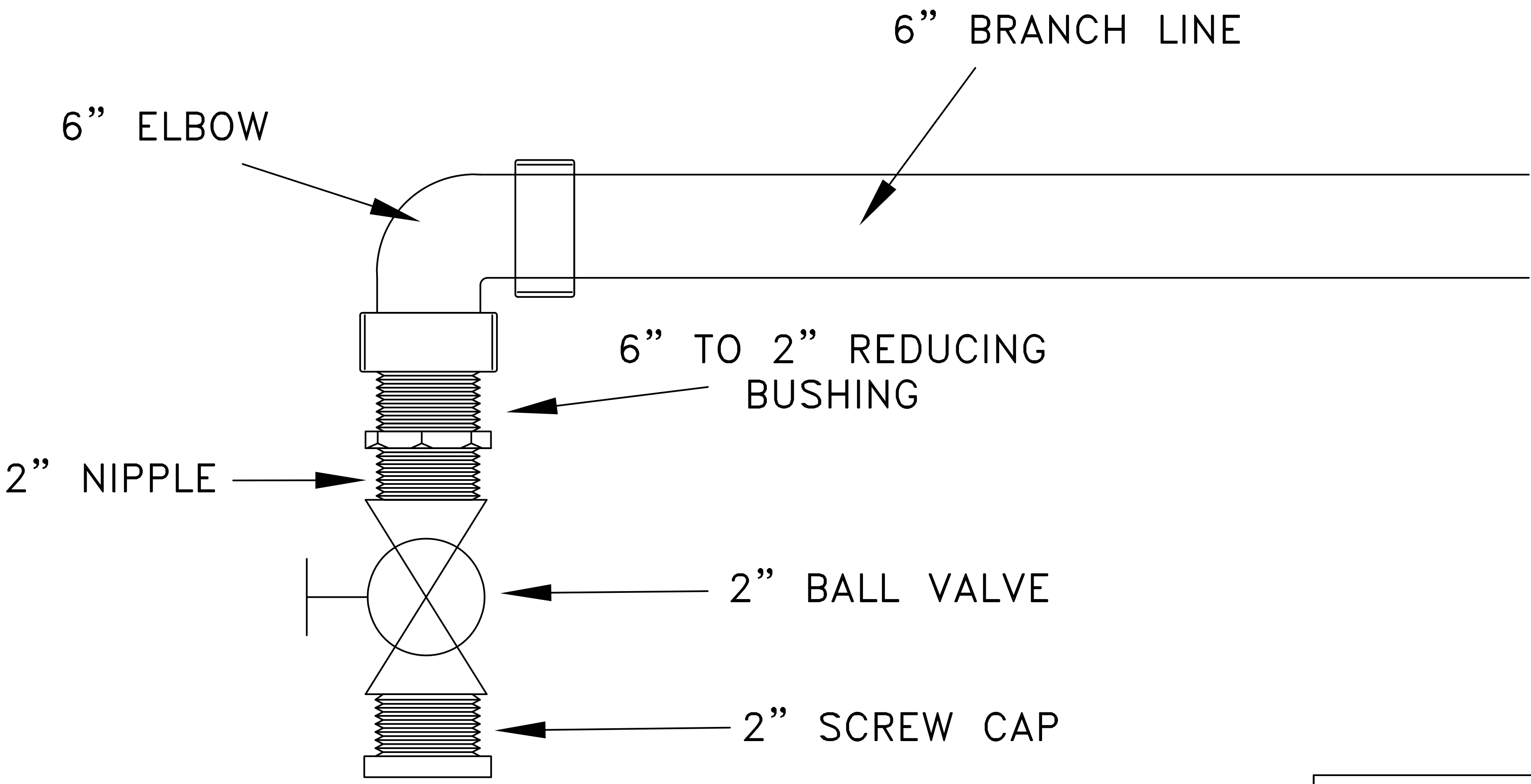


NOTES:

- REFER TO FIGURE 6A AND 6B FOR SOIL VAPOR EXTRACTION AND AIR INJECTION PIPING SPECIFICATIONS, RESPECTIVELY.
- BRANCH LINES WILL HAVE AN APPROXIMATE ANGLE OF 105 DEGREES FROM THE MAIN LINES

XDD
STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

SCALE: NOT TO SCALE	TITLE: MAIN LINE TO BRANCH LINE FLEX HOSE CONNECTION W.G. KRUMMRICH FACILITY SAUGET, IL
DATE: SEPTEMBER 2011	
PROJECT NO.: 11002	
CLIENT: SOLUTIA INC.	
DRAWN BY: MAW	DRAWING NO.: FIGURE 9G
CHECKED BY: DK	REV: 1
PROJ. MGMT. APPROVAL: DK	

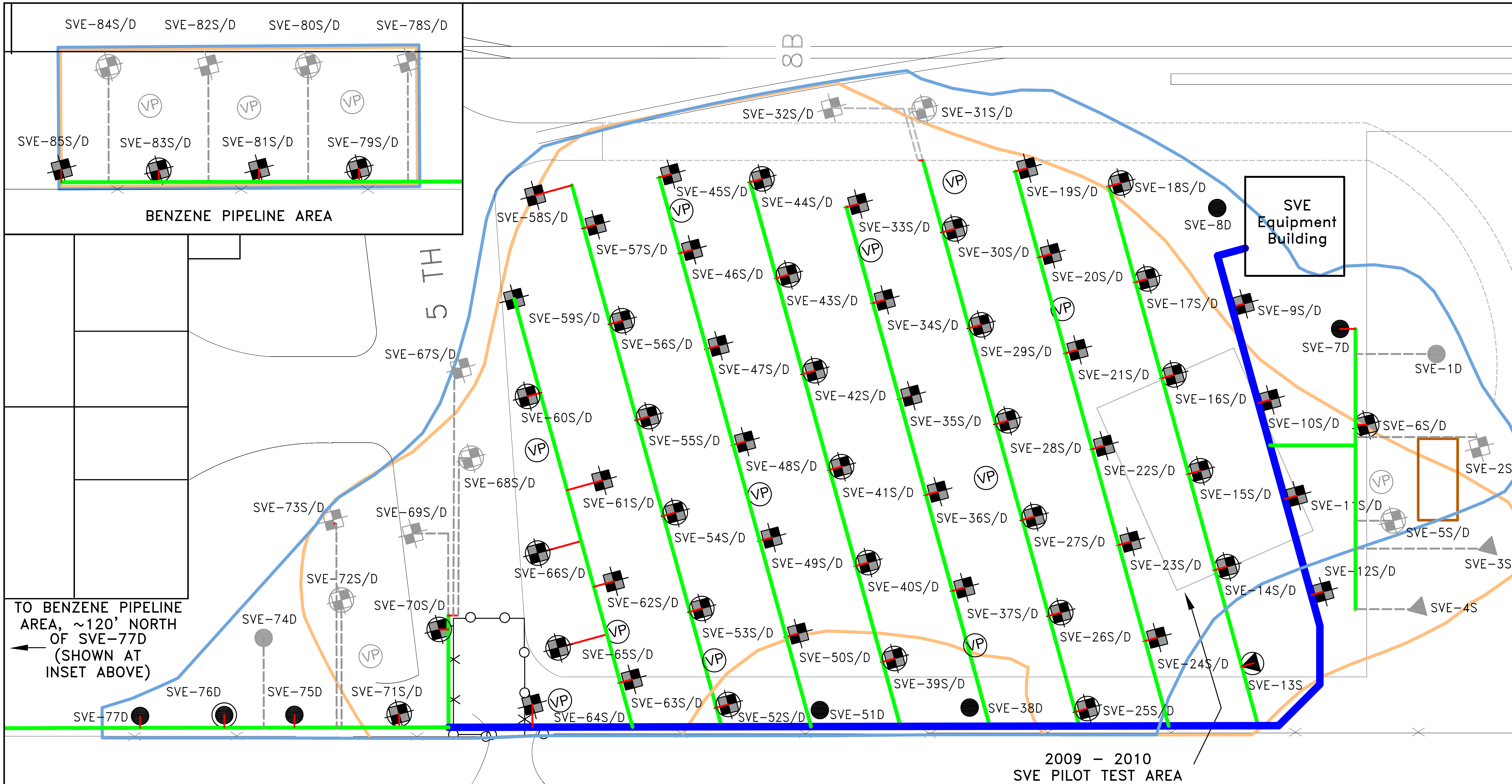


NOTES:

- AIR INJECTION (AI) CLEAN OUT WILL BE CONSTRUCTED OF SCHED. 80 CHLORINATED POLYVINYL CHLORIDE (CPVC) PIPING
- SOIL VAPOR EXTRACTION (SVE) WILL BE CONSTRUCTED OF SCHED. 40 POLYVINYL CHLORIDE (PVC) PIPING

XDD
STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

SCALE: NOT TO SCALE	TITLE: SVE AND AI PIPING CLEAN OUTS W.G. KRUMMRICH FACILITY SAUGET, IL
DATE: SEPTEMBER 2011	
PROJECT NO.: 11002	
CLIENT: SOLUTIA INC.	
DRAWN BY: JTH	DRAWING NO.: FIGURE 9H
CHECKED BY: ELS	REV: 1
PROJ. MGMT. APPROVAL: SCC	



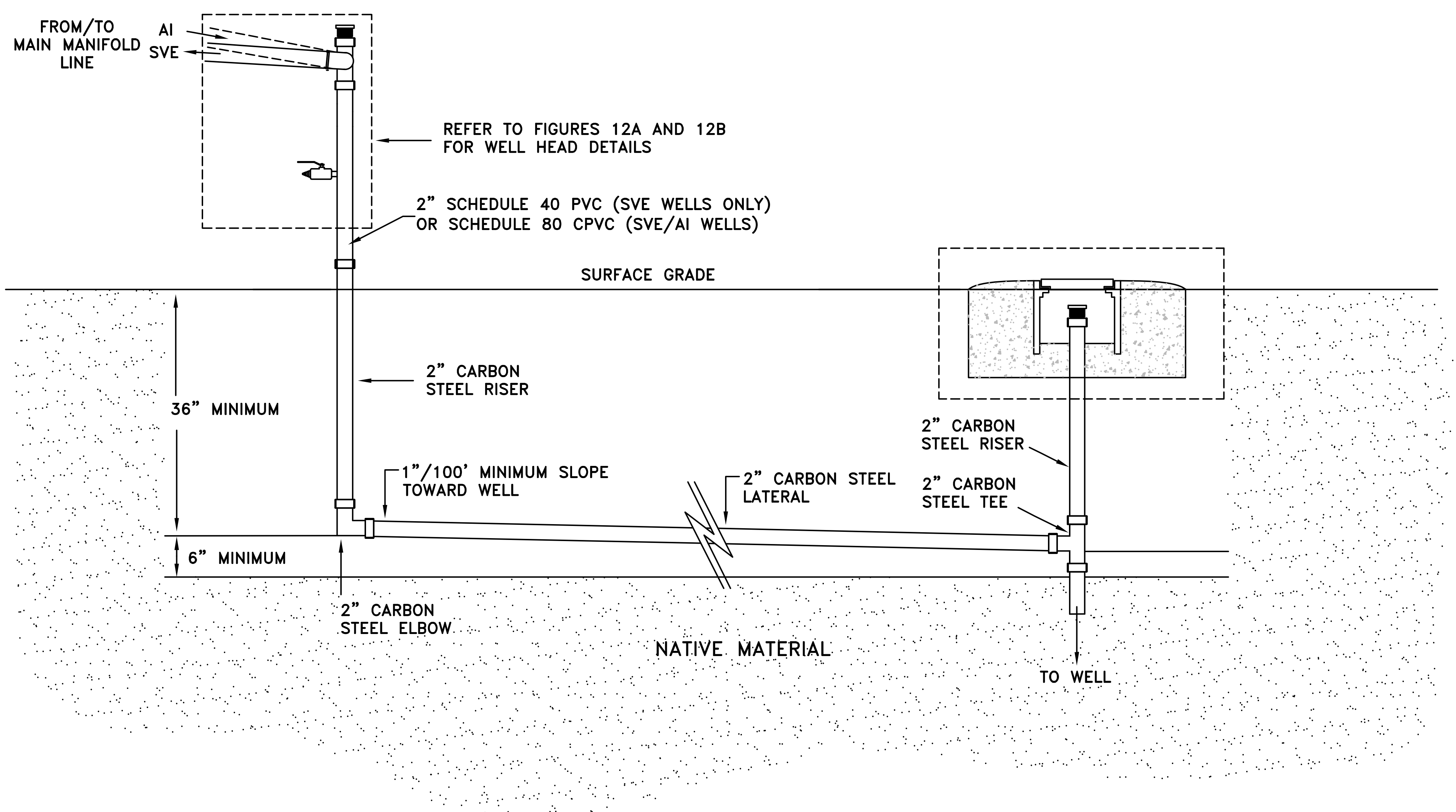
LEGEND:

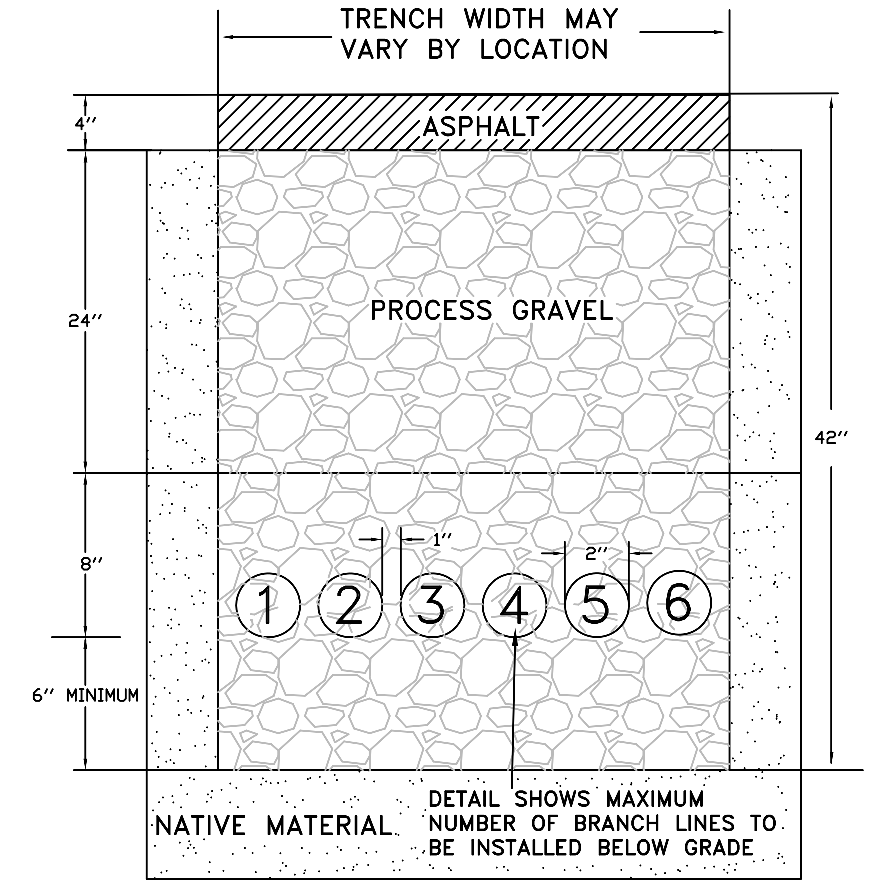
Red line	2-INCH PIPING (SUPPORTS TO HAVE A MAXIMUM SPACING INTERVAL OF 5 FEET)
Green line	6-INCH PIPING (SUPPORTS TO HAVE A MAXIMUM SPACING INTERVAL OF 6.5 FEET)
Blue line	12-INCH PIPING (SUPPORTS TO HAVE A MAXIMUM SPACING INTERVAL OF 8 FEET)
Gray dashed line	ALL PIPING IS GRAY & DASHED WHERE PROPOSED TO BE INSTALLED BELOW GRADE
	ABOVE GRADE SHALLOW AND DEEP NESTED SVE WELL LOCATION
	BELOW GRADE SHALLOW AND DEEP NESTED SVE WELL LOCATION
	ABOVE GRADE SHALLOW SVE WELL LOCATION
	BELOW GRADE SHALLOW SVE WELL LOCATION
	ABOVE GRADE DEEP SVE WELL LOCATION
	BELOW GRADE DEEP SVE WELL LOCATION
	INDICATES ABOVE GRADE COMBINED SVE/AI WELL LOCATION
	INDICATES BELOW GRADE COMBINED SVE/AI WELL LOCATION
VP	ABOVE GRADE NESTED VAPOR PROBES
VP	BELOW GRADE NESTED VAPOR PROBES
	LOCATION OF VEHICLE ACCESS ROAD
	EXTENT OF SHALLOW TARGET TREATMENT AREA
	EXTENT OF DEEP TARGET TREATMENT AREA
	LOADING DOCK

20' 0' 20' 40'

XDD
STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

SCALE: AS SHOWN	TITLE: PIPE SUPPORT SPACING DETAILS W.G. KRUMMRICH FACILITY SAUGET, IL
DATE: SEPTEMBER 2011	
PROJECT NO.: 11002	
CLIENT: SOLUTIA INC.	
DRAWN BY: LBC	DRAWING NO.: FIGURE 10
CHECKED BY: SCC	REV: 3
PROJ. MGMT. APPROVAL: SCC	



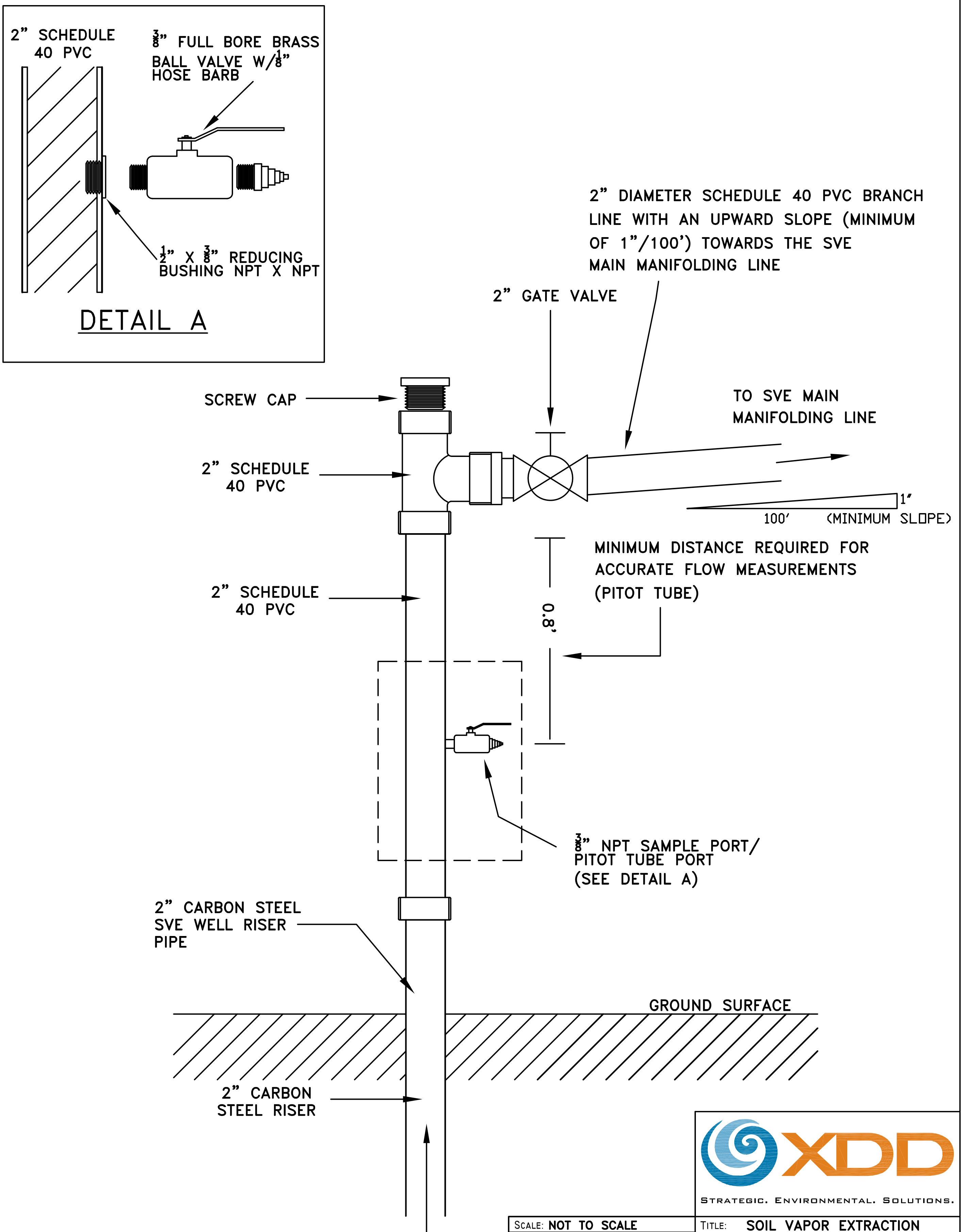


NOTES:

- AI = AIR INJECTION
- CPVC = CHLORINATED POLYVINYL CHLORIDE
- PVC = POLYVINYL CHLORIDE
- SVE = SOIL VAPOR EXTRACTION

XDD
STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

SCALE: NOT TO SCALE	TITLE: BELOW GRADE TRENCHING DETAIL W.G. KRUMMRICH FACILITY SAUGET, IL
DATE: SEPTEMBER 2011	
PROJECT NO.: 11002	
CLIENT: SOLUTIA INC.	
DRAWN BY: LBC/JWH	DRAWING NO.: FIGURE 11 — REV: 3
CHECKED BY: DK	
PROJ. MGMT. APPROVAL: DK	

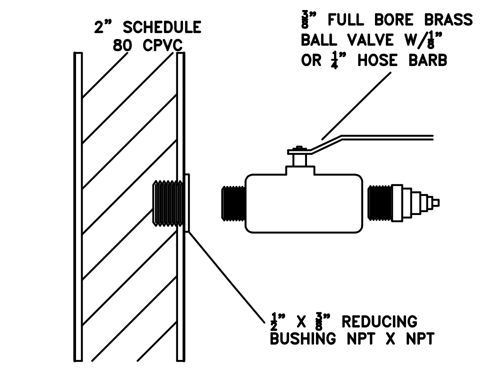


XDD
STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

SCALE: NOT TO SCALE	TITLE: SOIL VAPOR EXTRACTION WELLHEAD DETAIL W.G. KRUMMRICH FACILITY SAUGET, IL
DATE: SEPTEMBER 2011	
PROJECT NO.: 11002	
CLIENT: SOLUTIA INC.	
DRAWN BY: LBC	DRAWING NO.: FIGURE 12A
CHECKED BY: SCC	REV: 2
PROJ. MGMT. APPROVAL: SCC	

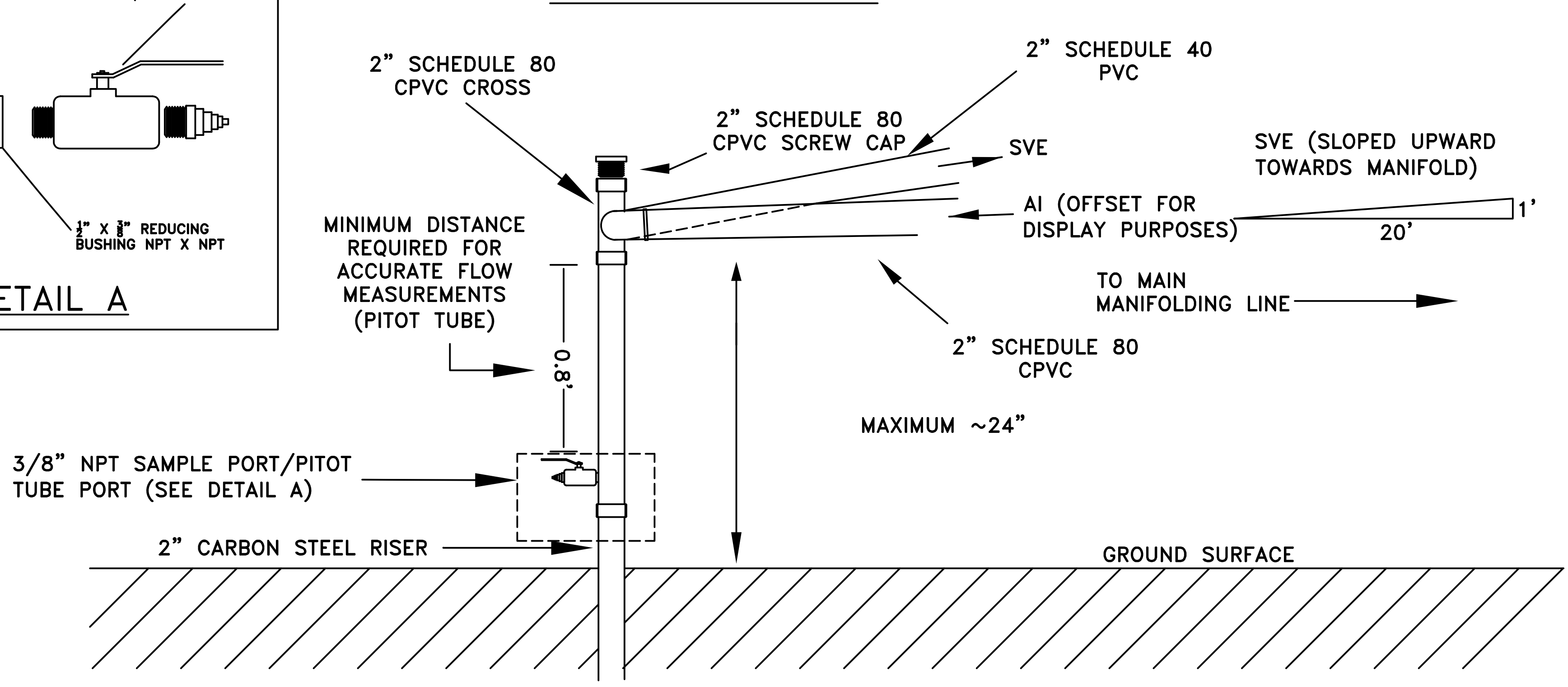
NOTES:

- PVC = POLYVINYL CHLORIDE
- SVE = SOIL VAPOR EXTRACTION
- ALL SVE WELLHEADS WILL BE INSULATED
- FLEX HOSE LOCATED AT THE BRANCH LINE

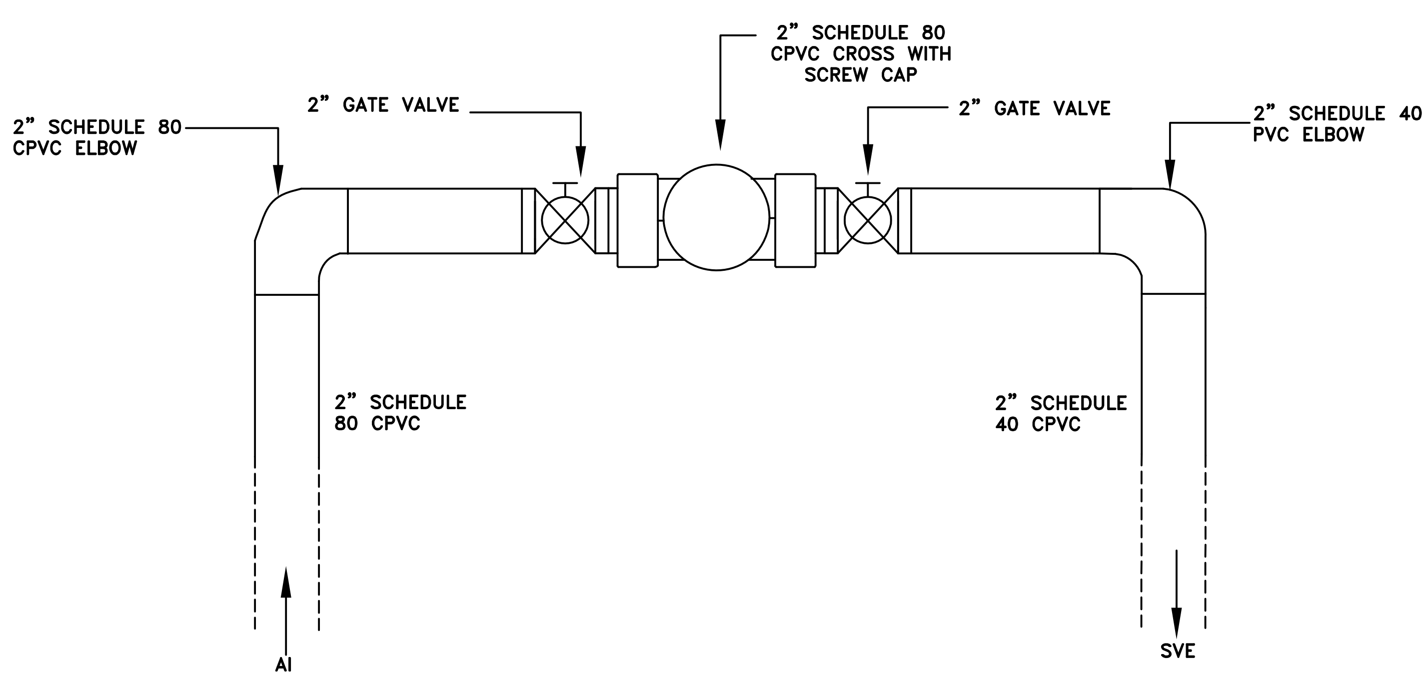


DETAIL A

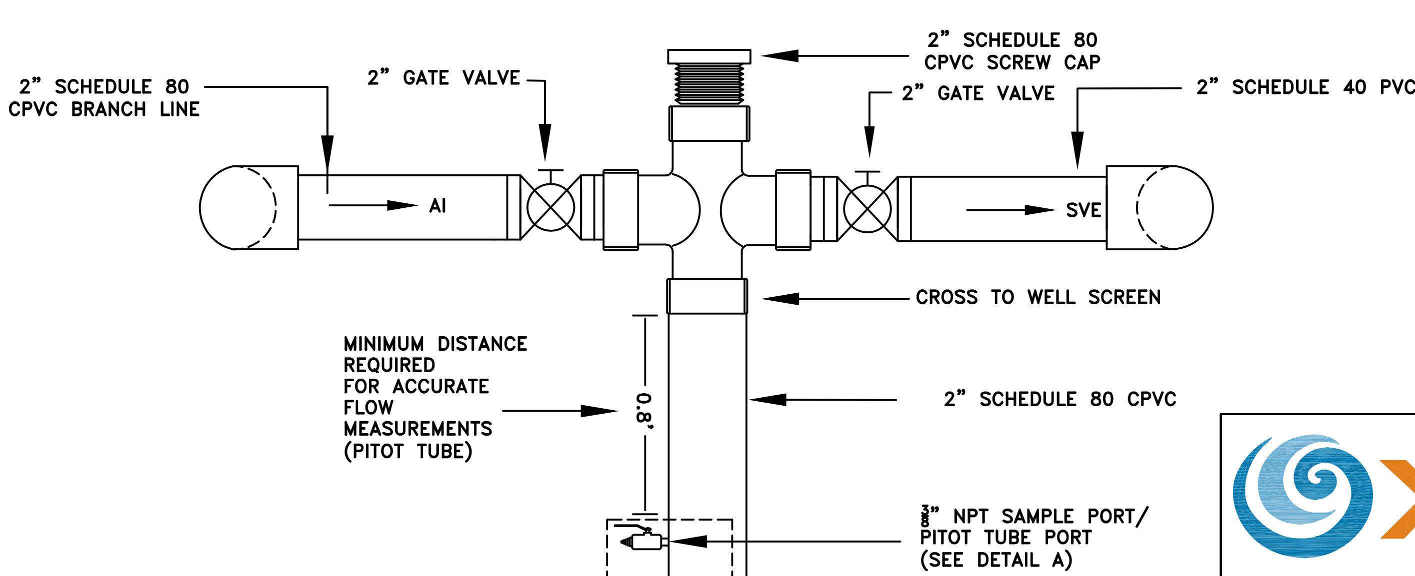
SIDE VIEW



TOP VIEW



FRONT VIEW

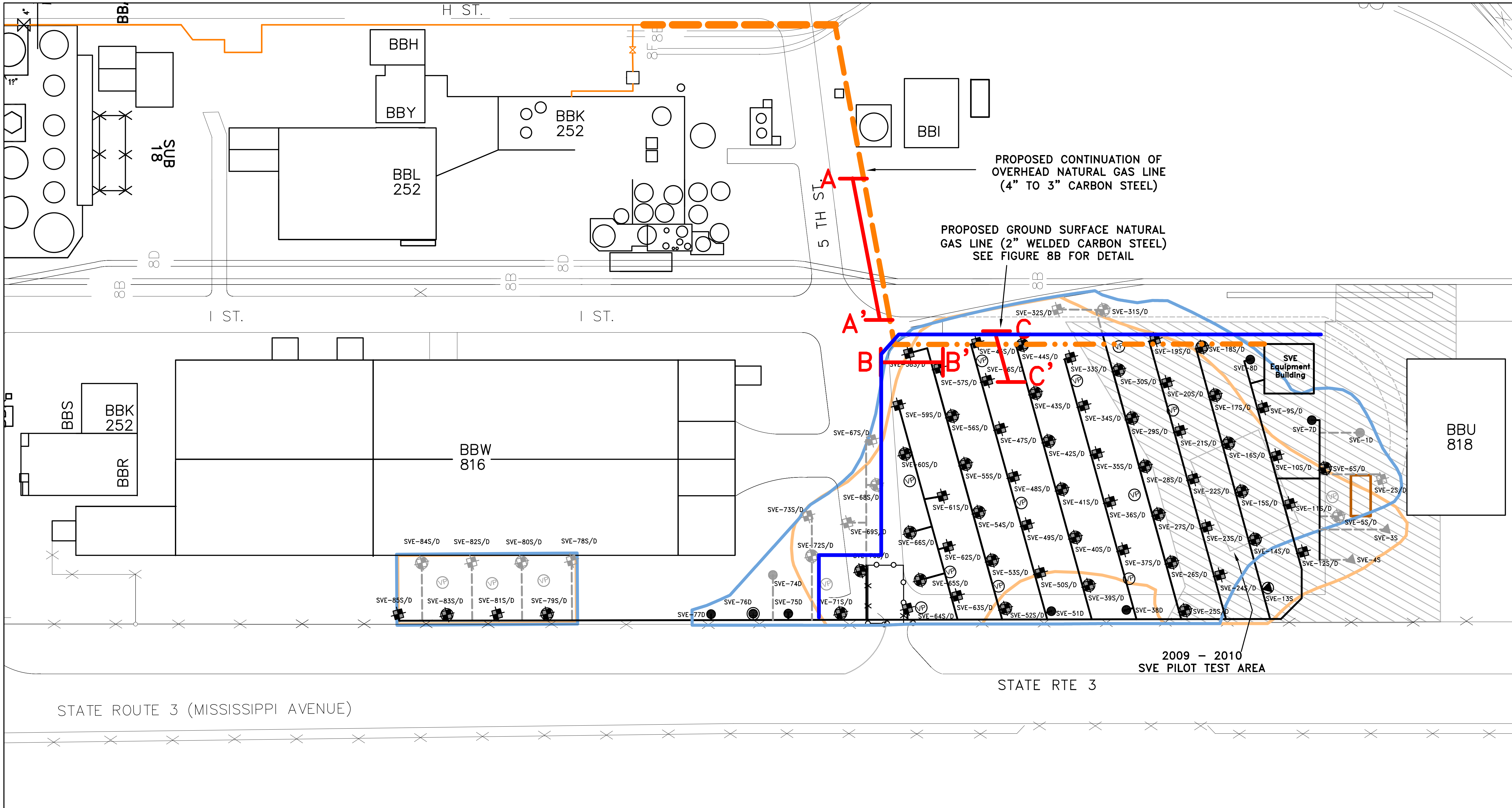


NOTES:

- AI = AIR INJECTION
- CPVC = CHLORINATED POLYVINYL CHLORIDE
- PVC = POLYVINYL CHLORIDE
- SVE = SOIL VAPOR EXTRACTION
- ALL SVE/AIR COMBINATION WELLHEADS WILL BE INSULATED.
- FLEX HOSE LOCATED AT THE BRANCH LINES.

XDD
STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

SCALE: NOT TO SCALE	TITLE: SOIL VAPOR EXTRACTION/ AIR INJECTION WELLHEAD DETAIL W.G. KRUMMRICH FACILITY SAUGET, IL
DATE: SEPTEMBER 2011	
PROJECT NO.: 11002	
CLIENT: SOLUTIA INC.	
DRAWN BY: LBC	DRAWING NO.: FIGURE 12B
CHECKED BY: ELS	REV: 2
PROJ. MGMT. APPROVAL: SCC	



LEGEND:

- EXISTING ABOVE GRADE NATURAL GAS PIPING
- JERSEY BARRIERS
- OVERHEAD NATURAL GAS LINE
- GROUND SURFACE NATURAL GAS LINE PROTECTED WITH JERSEY BARRIERS OR SIMILAR
- ABOVE GRADE SVE/AI PIPING
- BELOW GRADE SVE/AI PIPING
- ABOVE GRADE SHALLOW AND DEEP NESTED SVE WELL LOCATION
- BELOW GRADE SHALLOW AND DEEP NESTED SVE WELL LOCATION
- ABOVE GRADE SHALLOW SVE WELL LOCATION
- BELOW GRADE SHALLOW SVE WELL LOCATION
- ABOVE GRADE DEEP SVE WELL LOCATION
- BELOW GRADE DEEP SVE WELL LOCATION
- INDICATES ABOVE GRADE COMBINED SVE/AI WELL LOCATION
- INDICATES BELOW GRADE COMBINED SVE/AI WELL LOCATION
- ABOVE GRADE NESTED VAPOR PROBES
- BELOW GRADE NESTED VAPOR PROBES
- LOCATION OF VEHICLE ACCESS ROAD
- EXTENT OF SHALLOW TARGET TREATMENT AREA
- EXTENT OF DEEP TARGET TREATMENT AREA
- LOADING DOCK
- PAVED AREA

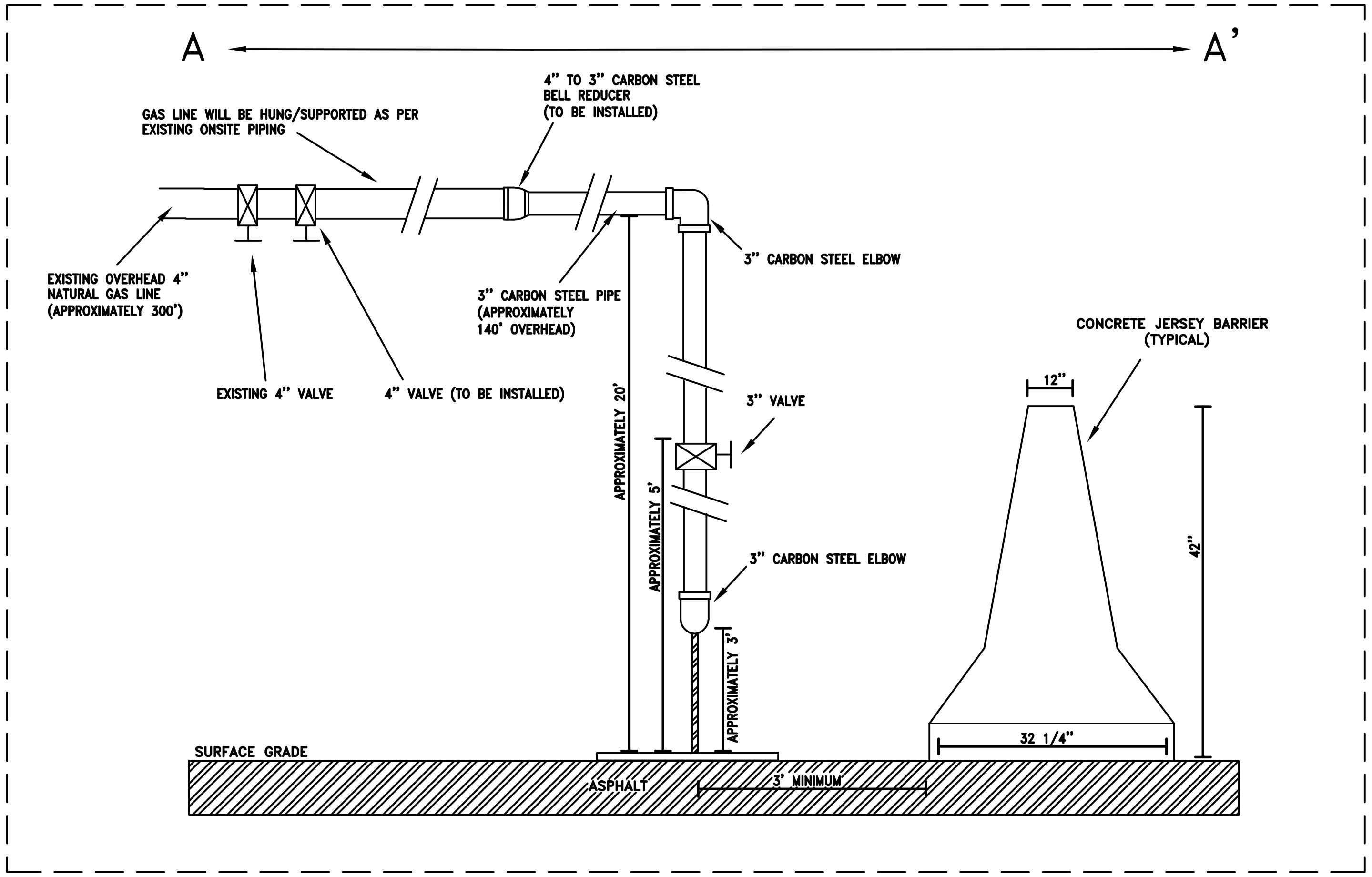
NOTES:

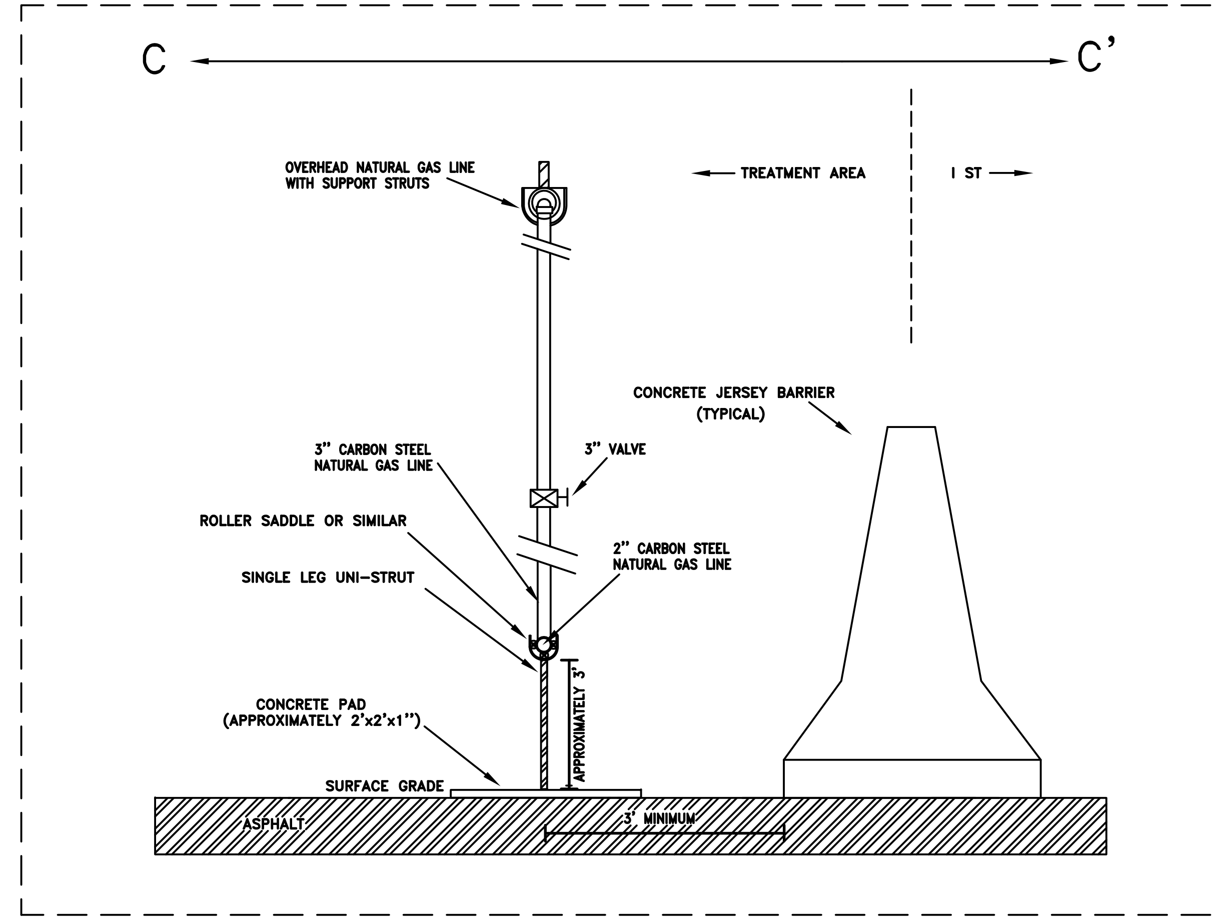
– BASE MAP PROVIDED BY W.G. KRUMMRICH FACILITY.
– CROSS SECTIONS A–A', B–B', AND C–C' PRESENTED ON FIGURE 13B.

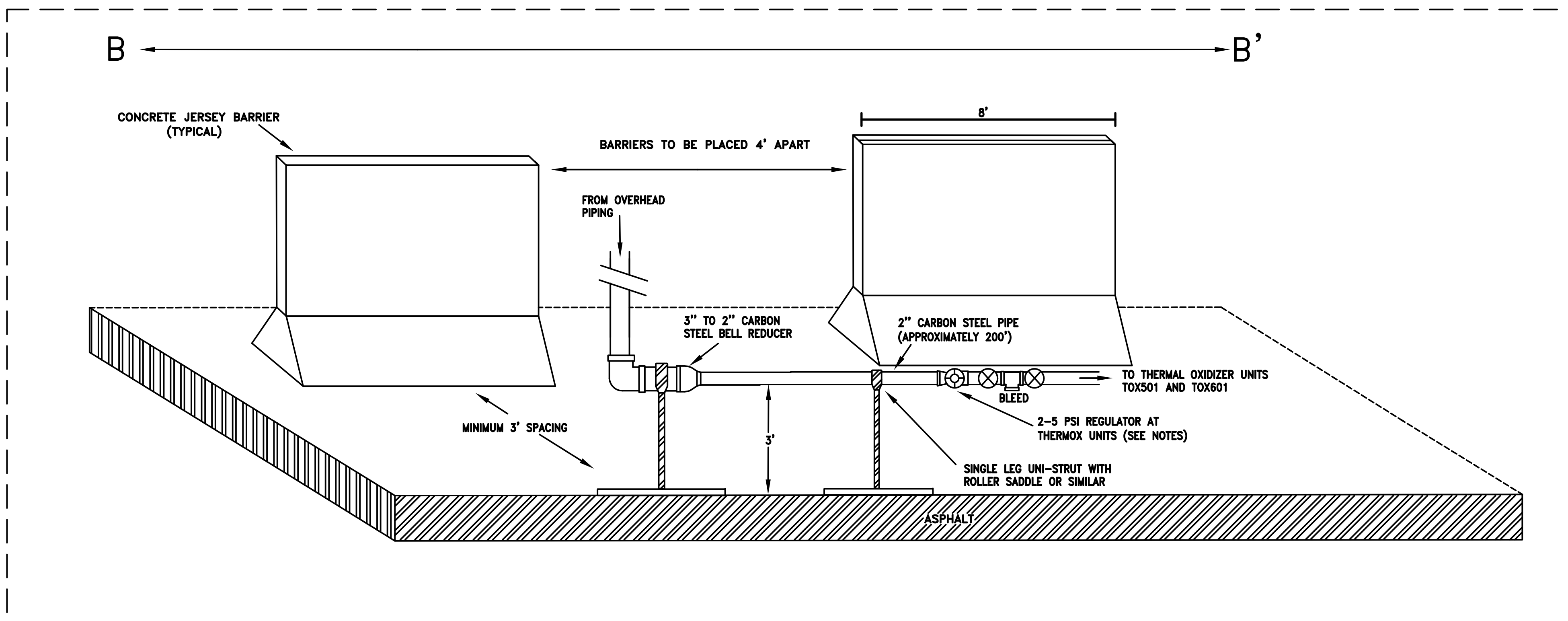
40' 0' 40' 80'

XDD
STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

SCALE: AS SHOWN	TITLE: NATURAL GAS UTILITIES MAP W.G. KRUMMRICH FACILITY SAUGET, IL
DATE: SEPTEMBER 2011	
PROJECT NO.: 11002	
CLIENT: SOLUTIA INC.	
DRAWN BY: LBC	DRAWING NO.: FIGURE 13A
CHECKED BY: SCC	REV: 3
PROJ. MGMT. APPROVAL: SCC	







NOTES:

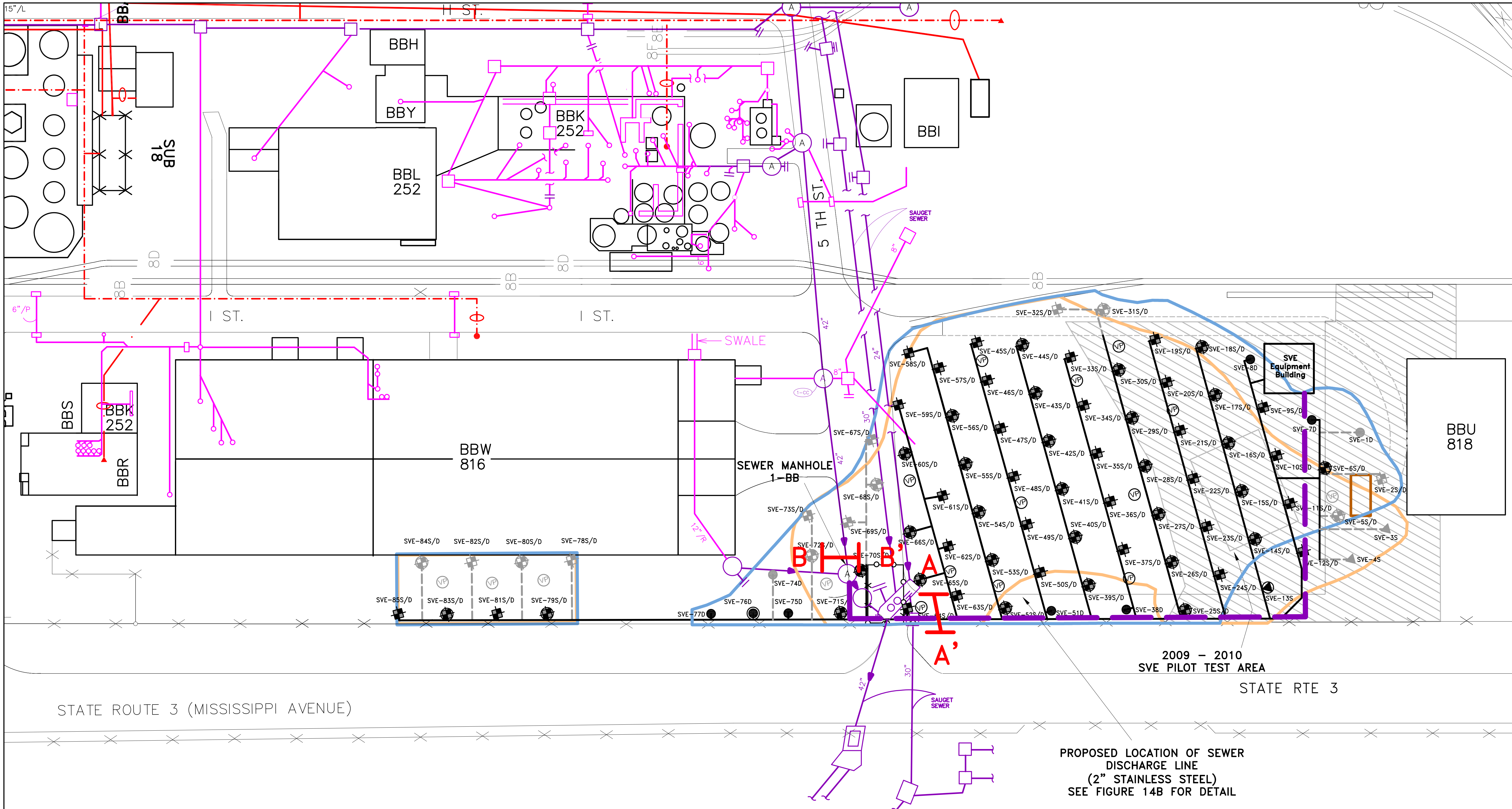
- ALL PIPE AND FITTING CONNECTIONS TO BE WELDED.
- ACTUAL REGULATOR SIZE AND SPECIFICATIONS WILL BE DETERMINED BASED ON THE THERMAL OXIDIZER UNIT FLOW AND PRESSURE REQUIREMENTS. TYPICAL OPERATING RANGE FOR NATURAL GAS IS 2 TO 5 PSI.
- HORIZONTAL OVERHEAD PIPING WILL BE BRACED TO THE EXISTING PROCESS PIPING SUPPORTS.
- VERTICAL PIPING WILL BE BRACED TO A PROCESS PIPING SUPPORT STAND AT APPROXIMATELY 8' SPACING.
- JERSEY BARRIERS WILL BE PLACED AROUND THE LINE, BUTTERFLY VALVE, AND REGULATOR.

XDD
STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

SCALE: NOT TO SCALE
DATE: SEPTEMBER 2011
PROJECT NO.: 11002
CLIENT: SOLUTIA INC.
DRAWN BY: JWH
CHECKED BY: DK
PROJ. MGMT. APPROVAL: DK

TITLE: NATURAL GAS CONNECTION DETAILS
W.G. KRUMMRICH FACILITY
SAUGET, IL

DRAWING NO.: FIGURE 13B
REV: 1



LEGEND:

- MAIN SEWER LINE
- SECONDARY SEWER LINE
- JERSEY BARRIERS
- TREATMENT WATER DISCHARGE LINE
- SOLID SEWER LID
- GRATED SEWER LID
- SEWER
- DRAIN
- PLUG OR CAP
- ABOVE GRADE SVE/AI PIPING
- BELOW GRADE SVE/AI PIPING
- ABOVE GRADE SHALLOW AND DEEP NESTED SVE WELL LOCATION
- BELOW GRADE SHALLOW AND DEEP NESTED SVE WELL LOCATION
- ABOVE GRADE SHALLOW SVE WELL LOCATION
- BELOW GRADE SHALLOW SVE WELL LOCATION
- ABOVE GRADE DEEP SVE WELL LOCATION
- BELOW GRADE DEEP SVE WELL LOCATION
- INDICATES ABOVE GRADE COMBINED SVE/AI WELL LOCATION
- INDICATES BELOW GRADE COMBINED SVE/AI WELL LOCATION
- VP ABOVE GRADE NESTED VAPOR PROBES
- VP BELOW GRADE NESTED VAPOR PROBES
- LOCATION OF VEHICLE ACCESS ROAD
- EXTENT OF SHALLOW TARGET TREATMENT AREA
- EXTENT OF DEEP TARGET TREATMENT AREA
- LOADING DOCK
- PAVED AREA

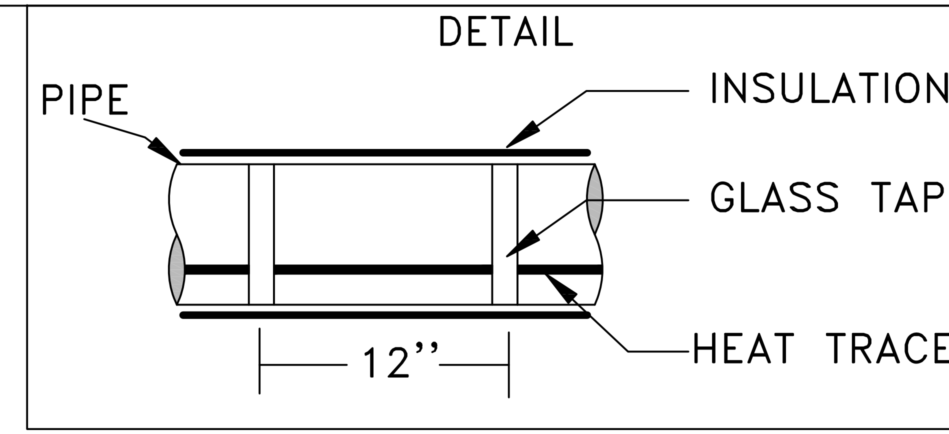
NOTES:

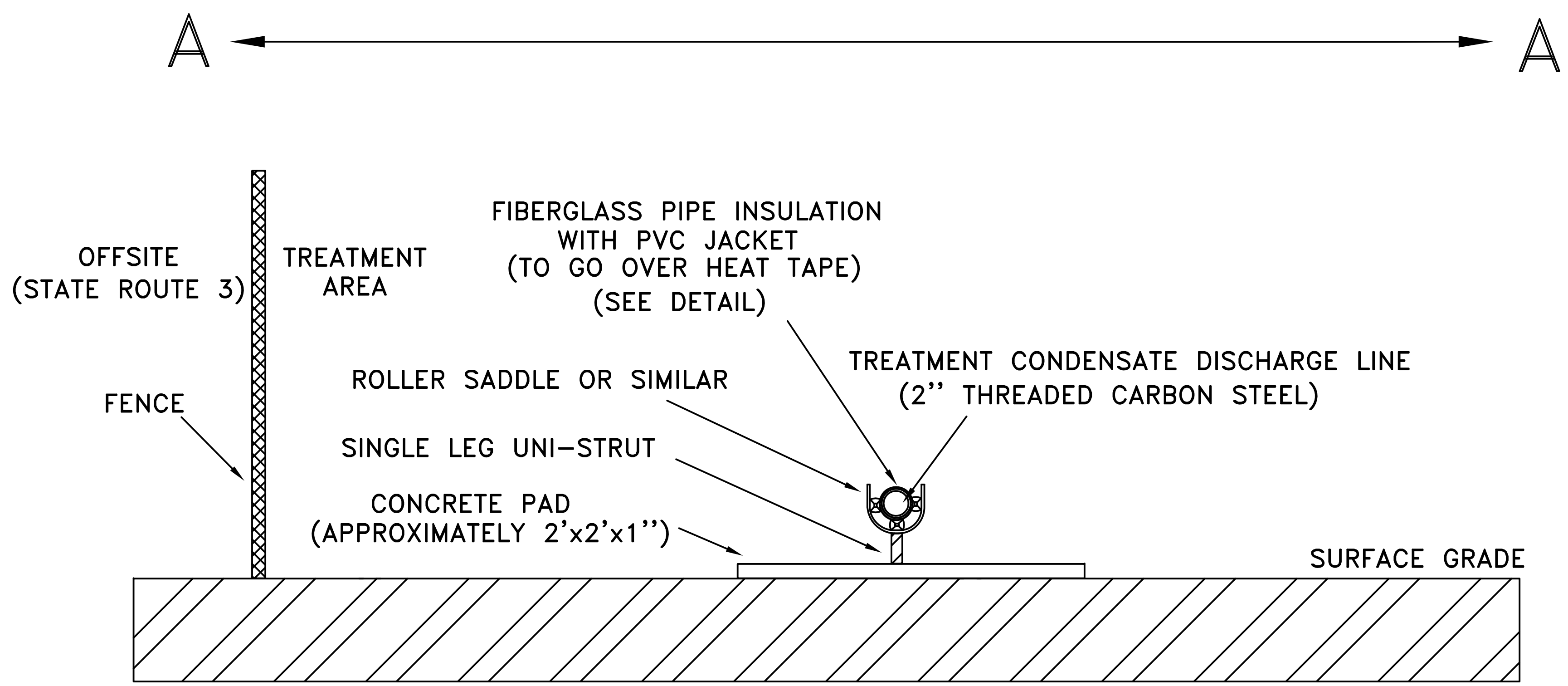
- BASE MAP PROVIDED BY W.G. KRUMMRICH FACILITY.
- CROSS SECTIONS A–A' AND B–B' PRESENTED ON FIGURE 14B.

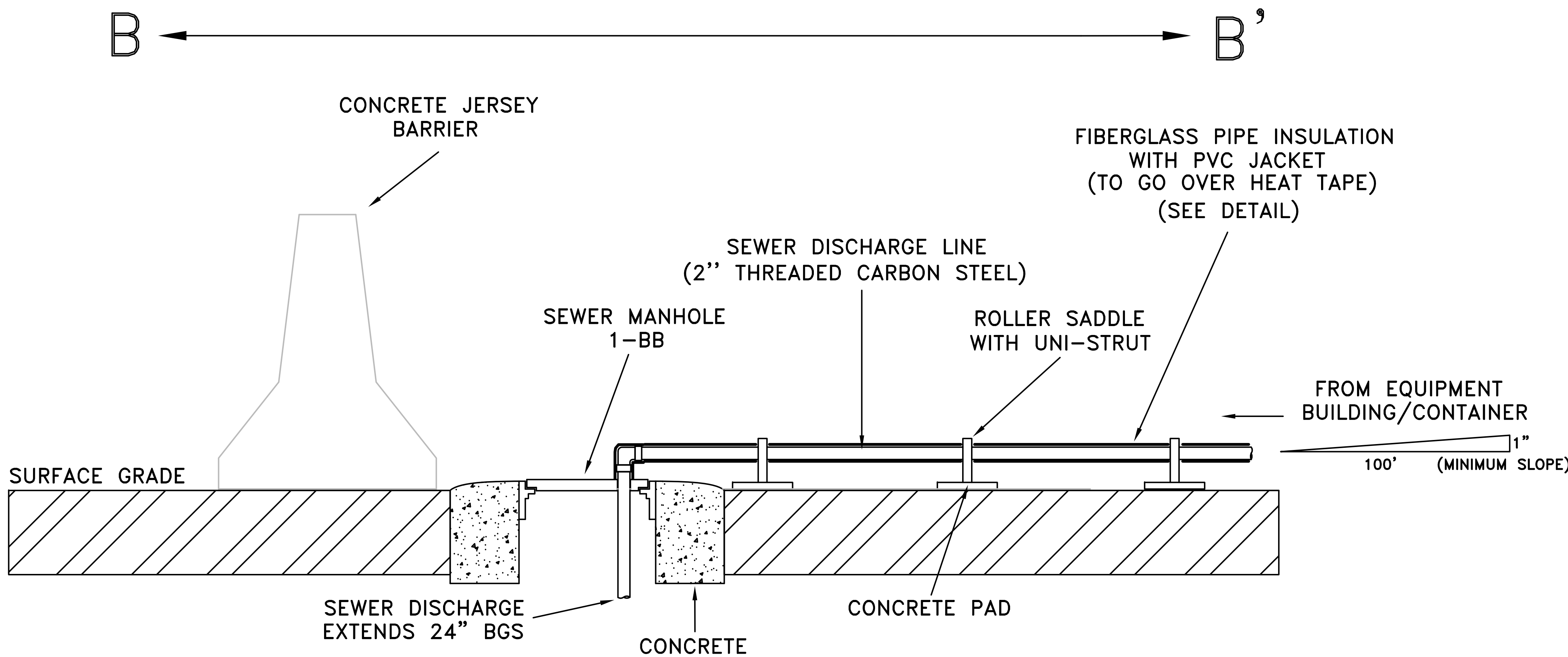
40' 0' 40' 80'

XDD
STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

SCALE: AS SHOWN	TITLE: SEWER UTILITIES MAP W.G. KRUMMRICH FACILITY SAUGET, IL
DATE: SEPTEMBER 2011	
PROJECT NO.: 11002	
CLIENT: SOLUTIA INC.	
DRAWN BY: LBC	DRAWING NO.: FIGURE 14A
CHECKED BY: SCC	REV: 3
PROJ. MGMT. APPROVAL: SCC	







NOTES:

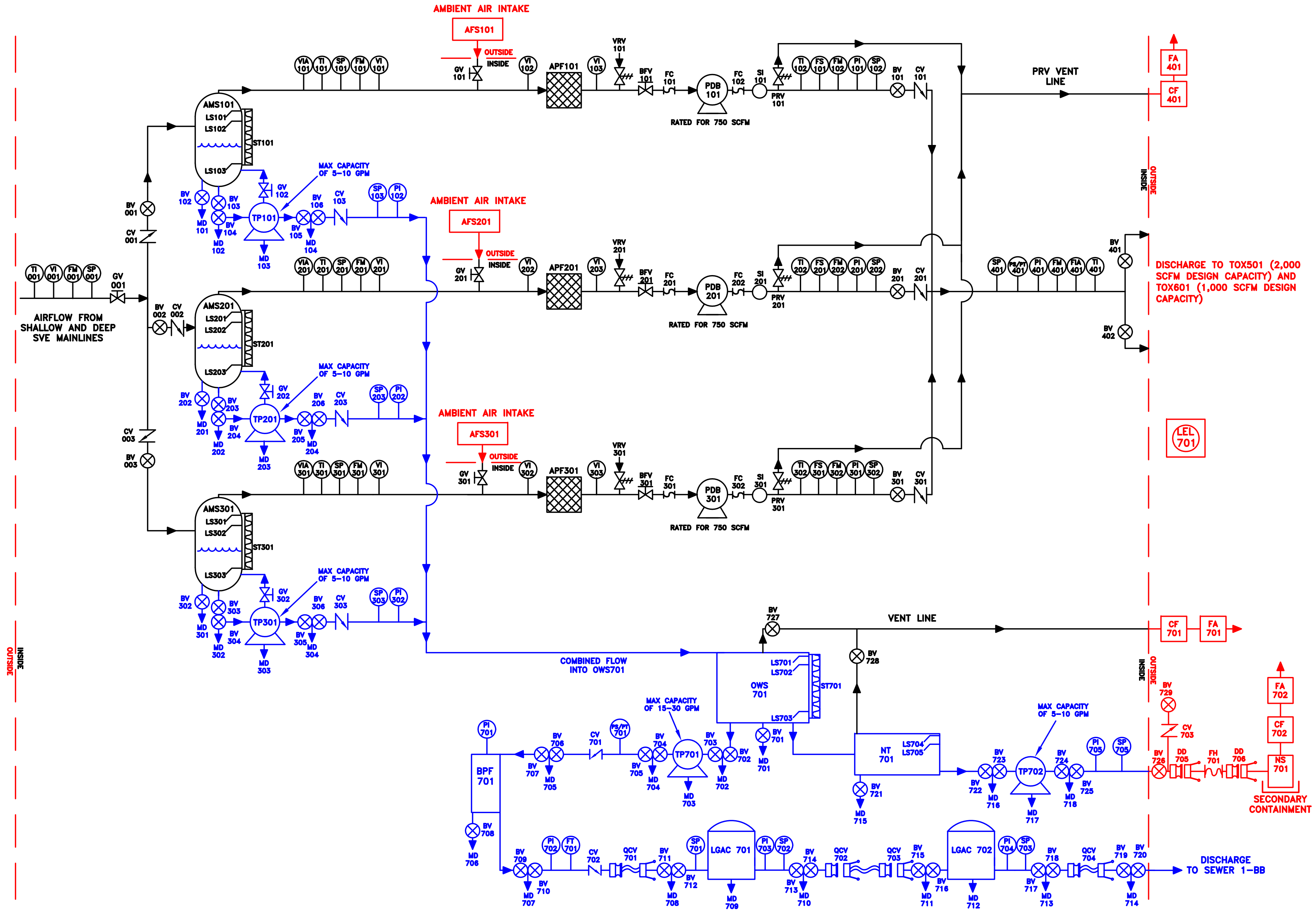
- BGS = BELOW GROUND SURFACE
- PVC = POLYVINYL CHLORIDE
- SEWER DISCHARGE LINE WILL BE MARKED WITH HIGH VISIBILITY AND REFLECTIVE PAINT OR TAPE TO PREVENT POTENTIAL COLLISIONS AND SLIPS/TRIPS/FALLS.
- JERSEY BARRIERS WILL BE PLACED AROUND THE SEWER DISCHARGE LINE CONNECTION TO SEWER MANHOLE 1-BB.
- SEWER DISCHARGE PIPING SLOPES A MINIMUM OF 1"/100' DOWNWARD FROM THE EQUIPMENT BUILDING/CONTAINER TOWARD THE SEWER MANHOLE, 1-BB.

XDD

STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

SCALE: NOT TO SCALE	TITLE: SEWER DISCHARGE CONNECTION DETAILS W.G. KRUMMRICH FACILITY SAUGET, IL
DATE: SEPTEMBER 2011	
PROJECT NO.: 11002	
CLIENT: SOLUTIA INC.	
DRAWN BY: JWH	DRAWING NO.: FIGURE 14B
CHECKED BY: SCC	REV: 2
PROJ. MGMT. APPROVAL: SCC	

SVE SYSTEM



LEGEND:

AC	Air Compressor
AI	Air Injection
AFS	Air Filter/Silencer
AMS	Air Moisture Separator
APF	Air Particulate Filter
BFV	Butterfly Valve
BPF	Bag Particulate Filter
BV	Ball Valve
CF	Carbon Filter
CO	Clean Out
CV	Check Valve
FA	Flame Arrester
FC	Flex/Flange Coupling
FH	Flexible Hose
FIA	Flow Indicator Analog
FM	Differential Flow Meter
FS	Flow Switch
FT	Flow Totalizer
GPM	Gallons Per Minute
GV	Gate Valve
HM	Hour Meter
LEL	Lower Explosive Limit
LGAC	Liquid-Phase Granular Activated Carbon
LS	Level Switch
MBFV	Motorized Butterfly Valve
MD	Manual Drain
NS	Non-Aqueous Phase Liquid (NAPL) Storage
NT	NAPL Tank
OWS	Oil/Water Separator
PDB	Positive Displacement Blower
PI	Pressure Indicator
PIA	Pressure Indicator Analog
PRV	Pressure Relief Valve
PS	Pressure Switch
PSI	Pounds Per Square Inch
PT	Pressure Transducer
QCV	Quick Connect Valve
SCFM	Standard Cubic Feet Per Minute
SI	Silencer
SP	Sample Port
ST	Sight Tube
SVE	Soil Vapor Extraction
TI	Temperature Indicator
TIA	Temperature Indicator Analog
TOX	Thermal Oxidizer Unit
TP	Transfer Pump
VI	Vacuum Indicator
VIA	Vacuum Indicator Analog
VRV	Vacuum Relief Valve

NOTES:

- Equipment to be placed/installed outside the equipment container/building shown in red.
- Liquid stream line shown in blue.
- Air stream line shown in black.
- All manual drain ball valves will be normally closed with threaded plug.
- Actual location of NS701 will be determined following vendor selection of equipment containers/building.
- Pressure relief valves (PRVs) may be added to vents to prevent pressure buildup if ball valves BV714, BV715, and/or BV716 are accidentally closed.
- FT801 will be used to measure discharge totals and will be monitored via programmable logic controller (PLC) telemetry.
- All process piping will be black iron steel.
- HM 101, HM 102, HM 201, HM 202, HM 301, HM 302, HM 701, HM 702, HM 901 and HM 1001 Total Runtime Meters are for PDB 101, TP 101, PDB 201, TP 201, PDB 301, TP 301, TP 701, TP 702, AC 901 and AC 1001, respectively.
- Refer to Table 14 for system valves normally open/normally closed operational status.
- LEL 701 will be mounted on the outside of the equipment building/container to monitor ambient air conditions inside.

SCALE: NOT TO SCALE	
DATE: SEPTEMBER 2011	
PROJECT NO.: 11002	
CLIENT: SOLUTIA INC.	
DRAWN BY: MAW	
CHECKED BY: DK	
PROJ. MGMT. APPROVAL: SCC	

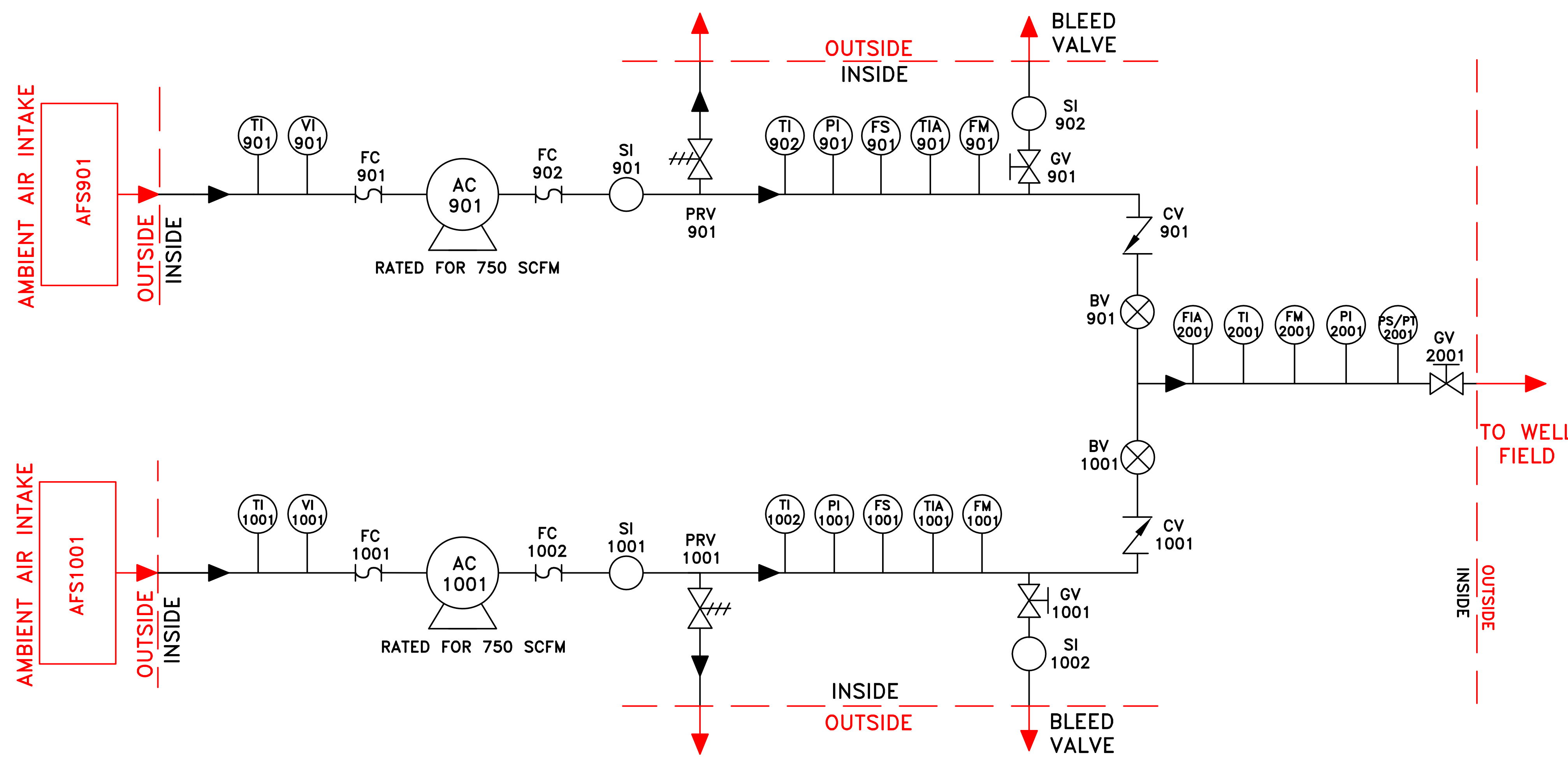
XDD
STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

TITLE:
SOIL VAPOR EXTRACTION PIPING AND INSTRUMENTATION DIAGRAM
W.G. KRUMMRICH FACILITY
SAUGET, IL

DRAWING NO.: FIGURE 15A

REV: 3

AI SYSTEM



LEGEND:

AC	Air Compressor
AI	Air Injection
AFS	Air Filter/Silencer
AMS	Air Moisture Separator
APF	Air Particulate Filter
BFV	Butterfly Valve
BPF	Bag Particulate Filter
BV	Ball Valve
CF	Carbon Filter
CO	Clean Out
CV	Check Valve
FA	Flame Arrester
FC	Flex/Flange Coupling
FH	Flexible Hose
FIA	Flow Indicator Analog
FM	Differential Flow Meter
FS	Flow Switch
FT	Flow Totalizer
GPM	Gallons Per Minute
GV	Gate Valve
HM	Hour Meter
LEL	Lower Explosive Limit
LGAC	Liquid-Phase Granular Activated Carbon
LS	Level Switch
MBFV	Motorized Butterfly Valve
MD	Manual Drain
NS	Non-Aqueous Phase Liquid (NAPL) Storage
NT	NAPL Tank
OWS	Oil/Water Separator
PDB	Positive Displacement Blower
PI	Pressure Indicator
PIA	Pressure Indicator Analog
PRV	Pressure Relief Valve
PS	Pressure Switch
PSI	Pounds Per Square Inch
PT	Pressure Transducer
QCV	Quick Connect Valve
SCFM	Standard Cubic Feet Per Minute
SI	Silencer
SP	Sample Port
ST	Sight Tube
SVE	Soil Vapor Extraction
TI	Temperature Indicator
TIA	Temperature Indicator Analog
TOX	Thermal Oxidizer Unit
TP	Transfer Pump
VI	Vacuum Indicator
VIA	Vacuum Indicator Analog
VRV	Vacuum Relief Valve

NOTES:

- Equipment to be placed/installed outside the equipment container/building shown in red.
- Liquid stream line shown in blue.
- Air stream line shown in black.
- All manual drain ball valves will be normally closed with threaded plug.
- Actual location of NS701 will be determined following vendor selection of equipment containers/building.
- Pressure relief valves (PRVs) may be added to vents to prevent pressure buildup if ball valves BV714, BV715, and/or BV716 are accidentally closed.
- FT801 will be used to measure discharge totals and will be monitored via programmable logic controller (PLC) telemetry.
- All process piping will be black iron steel.
- HM 101, HM 102, HM 201, HM 202, HM 301, HM 302, HM 701, HM 702, HM 901 and HM 1001 Total Runtime Meters are for PDB 101, TP 101, PDB 201, TP 201, PDB 301, TP 301, TP 701, TP 702, AC 901 and AC 1001, respectively.
- Refer to Table 14 for system valves normally open/normally closed operational status.
- LEL 701 will be mounted on the outside of the equipment building/container to monitor ambient air conditions inside.

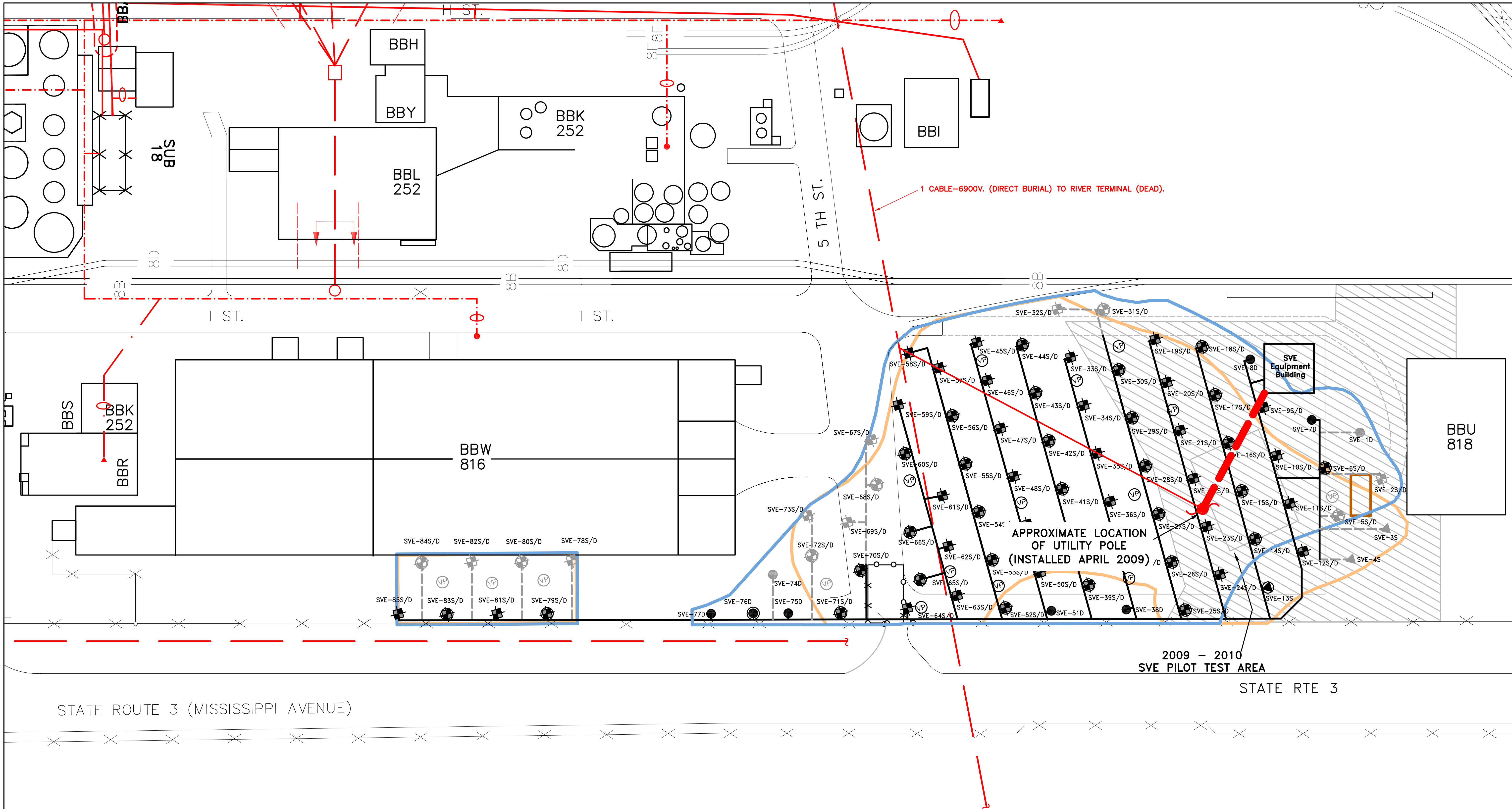
SCALE: NOT TO SCALE
DATE: SEPTEMBER 2011
PROJECT NO.: 11002
CLIENT: SOLUTIA INC.
DRAWN BY: MAW
CHECKED BY: DK
PROJ. MGMT. APPROVAL: SCC

XDD
STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

TITLE: AIR INJECTION PIPING AND INSTRUMENTATION DIAGRAM
W.G. KRUMMRICH FACILITY
SAUGET, IL

DRAWING NO.: FIGURE 15B

REV: 3



LEGEND:

- 480 VOLT OVERHEAD ELECTRICAL LINE
- 13.8/2.3 KILOVOLT OVERHEAD ELECTRICAL LINE
- UNDERGROUND ELECTRICAL DUCTS & CABLES
- PROPOSED ELECTRICAL LINE
- ABOVE GRADE SVE/AI PIPING
- BELOW GRADE SVE/AI PIPING
- ABOVE GRADE SHALLOW AND DEEP NESTED SVE WELL LOCATION
- BELOW GRADE SHALLOW AND DEEP NESTED SVE WELL LOCATION
- ABOVE GRADE SHALLOW SVE WELL LOCATION
- BELOW GRADE SHALLOW SVE WELL LOCATION
- ABOVE GRADE DEEP SVE WELL LOCATION
- BELOW GRADE DEEP SVE WELL LOCATION
- INDICATES ABOVE GRADE COMBINED SVE/AI WELL LOCATION
- INDICATES BELOW GRADE COMBINED SVE/AI WELL LOCATION
- ABOVE GRADE NESTED VAPOR PROBES
- BELOW GRADE NESTED VAPOR PROBES
- LOCATION OF VEHICLE ACCESS ROAD
- EXTENT OF SHALLOW TARGET TREATMENT AREA
- EXTENT OF DEEP TARGET TREATMENT AREA
- LOADING DOCK
- PAVED AREA

NOTES:

- BASE MAP PROVIDED BY W.G. KRUMMRICH FACILITY.
- ONLY 480 VOLT POWER FEEDERS ARE INDICATED, NOT ALL 480 VOLT CABLES.

40' 0' 40' 80'

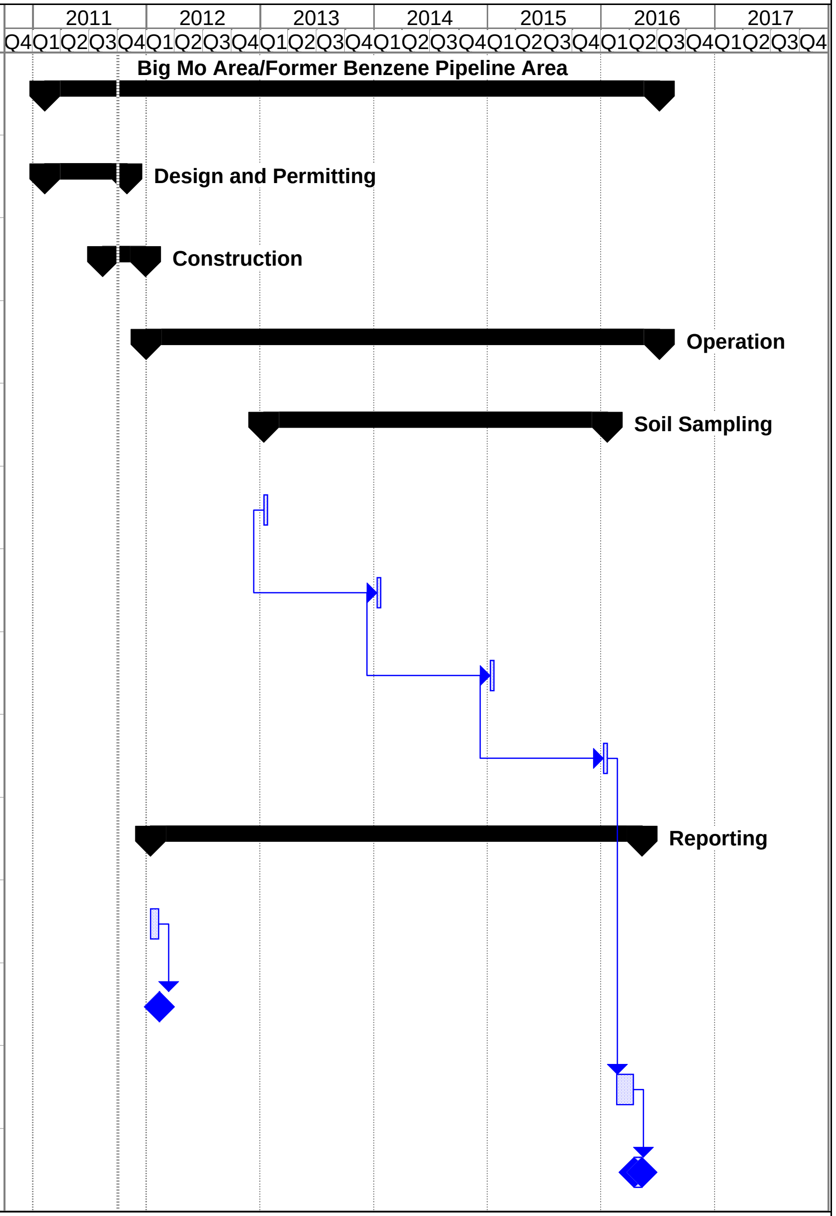
XDD

STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

SCALE: AS SHOWN	TITLE: ELECTRICAL UTILITIES MAP W.G. KRUMMRICH FACILITY SAUGET, IL
DATE: SEPTEMBER 2011	
PROJECT NO.: 11002	
CLIENT: SOLUTIA INC.	
DRAWN BY: LBC	DRAWING NO.: FIGURE 16
CHECKED BY: SCC	REV: 2
PROJ. MGMT. APPROVAL: SCC	

FIGURE 17
PROJECT SCHEDULE
100% Soil Vapor Extraction System Design - Big Mo & Former Benzene Pipeline Areas
W.G. Krummrich Facility, Sauget, Illinois

ID	Task Name	Start	Finish
1	Big Mo Area/Former Benzene Pipeline Area	Thu 2/10/11	Fri 7/8/16
2	Design and Permitting	Thu 2/10/11	Mon 10/31/11
5	Construction	Mon 8/15/11	Fri 12/30/11
11	Operation	Mon 1/2/12	Fri 7/8/16
15	Soil Sampling	Mon 1/14/13	Fri 1/22/16
16	Soil Sampling (Year 1)	Mon 1/14/13	Fri 1/25/13
17	Soil Sampling (Year 2)	Mon 1/13/14	Fri 1/24/14
18	Soil Sampling (Year 3)	Mon 1/12/15	Fri 1/23/15
19	Final Soil Sampling (Year 4)	Mon 1/11/16	Fri 1/22/16
20	Reporting	Mon 1/16/12	Fri 5/13/16
21	Construction Completion Report	Mon 1/16/12	Fri 2/10/12
22	Submittal to USEPA	Mon 2/13/12	Mon 2/13/12
23	Interim Completion Report	Mon 2/22/16	Fri 4/15/16
24	USEPA Review & Approval	Mon 4/18/16	Fri 5/13/16



Appendix A

Groundwater and River Elevation Data

TABLE A-1

Judith Lane Containment Cell Groundwater Levels
W.G. Krummrich Facility, Sauget, Illinois

Date	TCMW-1S***		TCMW-2[S]		TCMW-3S		TCMW-4[S]		TCMW-5S		TCMW-6S		AVERAGE***	
	ft bgs	ft msl	ft bgs	ft msl	ft bgs	ft msl	ft bgs	ft msl	ft bgs	ft msl	ft bgs	ft msl	ft bgs	ft msl
09/19/01	6.60	398.00	10.09	397.51	11.14	397.36	11.88	396.32	11.29	396.91	10.88	396.62	11.06	396.94
12/19/01	7.19	397.41	11.30	396.30	12.30	396.20	12.55	395.65	12.60	395.60	11.59	395.91	12.07	395.93
03/30/02	7.22	397.38	11.23	396.37	12.26	396.24	12.60	395.60	12.56	395.64	12.44	395.06	12.22	395.78
06/21/02	3.03	401.57	6.25	401.35	7.19	401.31	6.82	401.38	6.86	401.34	6.06	401.44	6.64	401.36
09/25/02	6.60	398.00	10.20	397.40	11.14	397.36	11.28	396.92	11.29	396.91	10.97	396.53	10.98	397.02
12/18/02	8.22	396.38	12.04	395.56	13.08	395.42	13.31	394.89	13.37	394.83	13.19	394.31	13.00	395.00
03/27/03	10.05	394.55	14.22	393.38	15.27	393.23	15.73	392.47	15.72	392.48	15.76	391.74	15.34	392.66
06/17/03	6.96	397.64	11.10	396.50	12.04	396.46	12.15	396.05	12.18	396.02	11.75	395.75	11.84	396.16
09/19/03	7.57	397.03	11.44	396.16	12.52	395.98	12.68	395.52	12.73	395.47	12.61	394.89	12.40	395.60
12/18/03	12.23	392.37	13.30	394.30	14.33	394.17	14.71	393.49	14.81	393.39	14.63	392.87	14.36	393.64
03/18/04	8.84	395.76	13.02	394.58	14.02	394.48	14.39	393.81	14.47	393.73	14.31	393.19	14.04	393.96
06/29/04	5.48	399.12	9.03	398.57	9.92	398.58	9.97	398.23	10.00	398.20	9.38	398.12	9.66	398.34
09/21/04	5.90	398.70	9.65	397.95	10.62	397.88	10.77	397.43	10.81	397.39	10.50	397.00	10.47	397.53
12/21/04	4.99	399.61	8.92	398.68	9.87	398.63	10.28	397.92	10.30	397.90	10.06	397.44	9.89	398.11
03/14/05	3.65	400.95	7.42	400.18	8.43	400.07	8.12	400.08	8.57	399.63	8.32	399.18	8.17	399.83
06/23/05	5.78	398.82	9.46	398.14	10.38	398.12	10.44	397.76	10.34	397.86	9.99	397.51	10.12	397.88
09/26/05	8.07	396.53	12.12	395.48	13.13	395.37	13.43	394.77	13.49	394.71	13.29	394.21	13.09	394.91
12/19/05	9.58	395.02	13.62	393.98	14.66	393.84	15.04	393.16	15.11	393.09	14.98	392.52	14.68	393.32
03/07/06	10.73	393.87	14.70	392.90	15.72	392.78	16.13	392.07	16.26	391.94	16.10	391.40	15.78	392.22
06/28/06	9.48	395.12	13.19	394.41	14.18	394.32	14.27	393.93	14.32	393.88	13.96	393.54	13.98	394.02
09/26/06	16.19	388.41	15.05	392.55	16.06	392.44	16.40	391.80	16.46	391.74	11.22	396.28	15.04	392.96
12/20/06	11.80	392.80	15.89	391.71	16.91	391.59	17.31	390.89	17.37	390.83	17.12	390.38	16.92	391.08
03/27/07	10.14	394.46	14.11	393.49	15.05	393.45	15.30	392.90	15.34	392.86	14.98	392.52	14.96	393.04
06/21/07	6.44	398.16	9.67	397.93	10.60	397.90	10.46	397.74	10.46	397.74	9.81	397.69	10.20	397.80
09/24/07	7.88	396.72	11.26	396.34	12.22	396.28	12.24	395.96	12.24	395.96	11.83	395.67	11.96	396.04
12/18/07	9.03	395.57	12.69	394.91	13.64	394.86	13.80	394.40	13.85	394.35	13.58	393.92	13.51	394.49
03/27/08	6.62	397.98	10.36	397.24	11.26	397.24	11.47	396.73	11.47	396.73	11.04	396.46	11.12	396.88
06/17/08	1.09	403.51	4.40	403.20	5.18	403.32	4.89	403.31	4.82	403.38	3.99	403.51	4.66	403.34
09/22/08	1.74	402.86	5.36	402.24	6.26	402.24	6.12	402.08	6.13	402.07	5.55	401.95	5.88	402.12
12/11/08	5.40	399.20	10.05	397.55	10.02	398.48	10.17	398.03	10.18	398.02	9.92	397.58	10.07	397.93
03/27/09	5.76	398.84	9.41	398.19	10.33	398.17	10.41	397.79	10.45	397.75	9.97	397.53	10.11	397.89
06/15/09	1.59	403.01	5.04	402.56	5.86	402.64	5.57	402.63	5.62	402.58	4.67	402.83	5.35	402.65
08/31/09	3.96	400.64	7.54	400.06	8.49	400.01	8.55	399.65	8.58	399.62	8.22	399.28	8.28	399.72
12/08/09	1.40	403.20	4.91	402.69	5.83	402.67	5.76	402.44	5.82	402.38	5.34	402.16	5.53	402.47
03/22/10	2.59	402.01	6.10	401.50	7.03	401.47	7.05	401.15	7.13	401.07	6.52	400.98	6.77	401.23
06/14/10	0.31	404.29	3.50	404.10	4.24	404.26	4.03	404.17	3.97	404.23	3.17	404.33	3.78	404.22

ft = feet
bgs = below ground surface
msl = mean sea level

*** NOTE: Averages excludes TCMW-1S (ground surface = 404.60 vs. average ground surface at 2 - 6 = 408.00)

TABLE A-2

On-Site Well BSAMW01S Groundwater Levels
W.G. Krummrich Facility, Sauget, Illinois

Date	BSAMW01S	
	ft bgs	ft msl
03/23/06	20.62	388.87
06/20/06	17.75	391.74
08/28/06	20.03	389.46
11/06/06	21.36	388.13
02/12/07	20.23	389.26
05/21/07	13.46	396.03
09/06/07	15.13	394.36
12/06/07	17.33	392.16
03/12/08	16.45	393.04
06/09/08	6.89	402.60
08/18/08	8.80	400.69
11/17/08	13.18	396.31
02/23/09	15.00	394.49
05/29/09	7.66	401.83
08/17/09	12.02	397.47
11/13/09	9.75	399.74
02/12/10	10.40	399.09
05/14/10	8.23	401.26
09/22/10	11.62	397.87

ft = feet
bgs = below ground surface
msl = mean sea level

TABLE A-3
Mississippi River Surface Water Levels
W.G. Krummich Facility, Sauget, Illinois

Date	Mississippi River	
	Gauge Height[1]	Surface Elevation
	ft	ft msl
09/19/01	3.19	**383.13**
12/19/01	9.61	**389.55**
03/30/02	9.67	**389.61**
06/21/02	21.25	**401.19**
09/16/02	5.1	**385.04**
10/01/02	2.21	**382.15**
12/18/02	-0.28	**379.66**
03/27/03	4.92	**384.86**
06/17/03	13.29	**393.23**
09/19/03	-0.34	**379.6**
12/18/03	5.44	**385.38**
03/18/04	12.49	**392.43**
06/29/04	23.43	**403.37**
09/21/04	4.13	**384.07**
12/21/04	8.81	**388.75**
03/14/05	7.22	**387.16**
06/23/05	13.93	**393.87**
09/26/05	2.72	**382.66**
12/19/05	-1.09	**378.85**
03/07/06	-0.05	**379.89**
03/23/06	6.35	**386.29**
06/20/06	3.42	**383.36**
06/28/06	4.15	**384.09**
08/28/06	0.71	**380.65**
09/26/06	1.37	**381.31**
11/06/06	-2.01	**377.93**
12/20/06	4.19	**384.13**
02/12/07	-1.29	**378.65**
03/27/07	20.3	**400.24**
05/21/07	20.95	**400.89**
06/21/07	11.91	**391.85**
09/06/07	15.3	**395.24**
09/24/07	4.22	**384.16**
12/06/07	-0.14	**379.8**
12/18/07	7.17	**387.11**
03/12/08	16.79	**396.73**
03/27/08	23.22	**403.16**
06/09/08	30.44	**410.38**
06/17/08	35.53	**415.47**
08/18/08	8.3	**388.24**
09/22/08	28.12	**408.06**
11/17/08	6.38	**386.32**
12/11/08	1.84	**381.78**
02/23/09	9.68	**389.62**
03/27/09	21.5	**401.44**
05/29/09	24.89	**404.83**
06/15/09	22.91	**402.85**
08/17/09	6.95	**386.89**
08/31/09	17.79	**397.73**
11/13/09	20.55	**400.49**
12/08/09	11.75	**391.69**
02/12/10	12.01	**391.95**
03/22/10	28.78	**408.72**
05/14/10	26.99	**406.93**
06/14/10	26.83	**406.77**
07/15/10	31.28	**411.22**
08/15/10	26.36	**406.30**
09/15/10	15.78	**395.72**

ft = feet
msl = mean sea level

Note:
1. Gauge height 0 = surface elevation of 379.94 ft msl.

Appendix B
Soil Concentration Data

TABLE B-1

Soil Concentration Data - Big Mo Area

W.G. Krummrich Facility, Sauget, Illinois

Location	Depth (ft bgs)	Benzene (mg/kg)	Chlorobenzene (mg/kg)	1,2-Dichlorobenzene (mg/kg)	2-Hexanone (mg/kg)	1,4-Dichlorobenzene (mg/kg)	Ethylbenzene (mg/kg)	Xylenes, Total (mg/kg)
Delineation Criteria (mg/Kg)		29	169	2,600	2,610	61.4	2,830	151
Sandy Fill / Upper Silty Sand								
WGK-SVE-82	0 - 2 ft	<0.45	<0.45	<0.45	<2.2	<0.45	<0.45	<0.9
WGK-SVE-60	1 - 2 ft	**0.0039 J**	<0.0049	<0.0049	<0.025	<0.0049	<0.0049	<0.0099
WGK-SVE-66	2 - 3 ft	**0.04**	<0.0058	<0.0058	<0.029	<0.0058	<0.0058	<0.012
WGK-SVE-30	3 - 4 ft	**0.002 J**	<0.0049	<0.0049	<0.024	<0.0049	<0.0049	<0.0098
WGK-SVE-32	3 - 4 ft	<0.0056	<0.0056	<0.0056	<0.028	<0.0056	<0.0056	<0.011
WGK-SVE-34	3 - 4 ft	**0.0019 J**	<0.0055	<0.0055	<0.028	<0.0055	<0.0055	<0.011
WGK-SVE-36	3 - 4 ft	**1,100**	<76	<76	<380	<76*	<76	<150
WGK-SVE-39	3 - 4 ft	**180**	<7.5	<7.5	<38	**5.7J**	<7.5	<15
WGK-SVE-61	3 - 4 ft	**0.0022 J***	**0.0026 J***	<0.0057	<0.029	<0.0057	<0.0057	<0.011
WGK-SVE-62	3 - 4 ft	<0.0064*	<0.0064*	<0.0064	<0.032	**0.0015 J**	<0.0064	<0.013
WGK-SVE-63	3 - 4 ft	**55**	**97**	<27	<130	**220**	<27	<53
WGK-SVE-67	3 - 4 ft	**0.029***	**0.0093***	**0.015**	<0.035	**0.2**	<0.0071	<0.014
WGK-SVE-68	3 - 4 ft	**620**	<45	<45	<220	<45	<45	<89
WGK-SVE-70	3 - 4 ft	**0.73**	**2.4**	**1.9**	<4.6	**24**	<0.92	<1.8
WGK-SVE-71	3 - 4 ft	**30**	<2.1	<2.1	<11	0.69 J	<2.1	<4.2
WGK-SVE-72	3 - 4 ft	**0.23 J**	**0.69 J**	**4.9**	<4.4	**24**	<0.89	<1.8
WGK-SVE-73	3 - 4 ft	<0.0097*	<0.0097*	**0.0041 J**	<0.048	**0.0073 J**	<0.0097	<0.019
WGK-SVE-80	3 - 4 ft	**66**	**140**	<3.9	<19	<3.9	<3.9	<7.7
WGK-SVE-81	3 - 4 ft	<0.0053	<0.0053	<0.0053	<0.026	<0.0053	<0.0053	<0.011
WGK-SVE-33	4 - 5 ft	**0.0019 J**	<0.0054	<0.0054	<0.027	<0.0054	<0.0054	<0.011
WGK-SVE-35	4 - 5 ft	<0.0054	<0.0054	<0.0055	<0.028	<0.0054	<0.0054	<0.011
WGK-SVE-38	4 - 5 ft	**0.19**	**0.0014 J**	**0.0019 J**	<0.028	**0.016**	<0.0055	<0.011
WGK-SVE-60A	4 - 5 ft	**0.0023 J**	**0.0058**	<0.0052	<0.026	<0.0052	**0.07**	**0.27**
WGK-SVE-60A-DUP	4 - 5 ft	<0.2	**0.047 DJ**	<0.2	<1	<0.2	<0.2	<0.4
WGK-SVE-64	4 - 5 ft	**720**	<33	<33	<160	<33	<33	<65
WGK-SVE-65	4 - 5 ft	**1**	<0.19	<0.19	<0.95	<0.19	<0.19	<0.38
WGK-SVE-69	4 - 5 ft	**0.22**	<0.0044	<0.0044	<0.022	**0.0015 J**	<0.0044	<0.0088
WGK-SVE-69-DUP	4 - 5 ft	**0.24 D**	<0.2	<0.2	<1	<0.2	<0.2	<0.4
WGK-SVE-70	5 - 6 ft	**81**	**2.5**	**1.9**	<4.6	**24**	<2.5	<5
WGK-SVE-62	7 - 8 ft	**0.0019 J***	<0.0056*	<0.0056	<0.028	<0.0056	<0.0056	<0.011
WGK-SVE-69	7 - 8 ft	**630**	<48	<48	<240	<48	<48	<96
WGK-SVE-34	8 - 9 ft	**1.8**	<0.52	<0.52	<2.6	<0.52	<0.52	<1
WGK-SVE-61	8 - 9 ft	**0.96 J**	**75**	<2	<10	<2	<2	<4
WGK-SVE-80	8 - 9 ft	**180**	**420**	<11	<57	<11	<11	<23
WGK-SVE-80-DUP	8 - 9 ft	**180**	**480**	<19	<94	<19	<19	<37
WGK-SVE-60	9 - 10 ft	**0.39**	**7.4**	<0.23	<1.1	<0.23	<0.23	<0.45
Average:		**366**	**NA**	**no exceedences**	**no exceedences**	**NA**	**no exceedences**	**no exceedences**
Maximum (not including Hot Spots):		**1,100**	**480**	**5**	**NA**	**220**	**NA**	**NA**
Hot Spot (averaged, if applicable):		**NA**	**NA**	**no exceedences**	**no exceedences**	**NA**	**no exceedences**	**no exceedences**
Intermediate Silty Clay								
WGK-SVE-79	3 - 4 ft	**250**	**48**	<19	<97	<19	<19	<39
WGK-SVE-37	4 - 5 ft	**140**	<12	<12	<59	<12	<12	<24
WGK-SVE-78	4 - 5 ft	<0.0051	<0.0051	<0.0051	<0.025	<0.0051	<0.0051	<0.01
WGK-SVE-83	4 - 5 ft	<0.38	**1.6**	<0.38	<1.9	**0.066 J**	<0.38	<0.76
WGK-SVE-38	6 - 7 ft	**3.2**	<0.52	<0.52	<2.6	<0.52	<0.52	<1
WGK-SVE-64	6 - 7 ft	**390**	<28	<28	<140	<28	<28	<56
WGK-SVE-72	6 - 7 ft	**0.61**	**12**	**1**	<2.8	**2.4**	<0.57	<1.1
WGK-SVE-39	7 - 8 ft	**30**	<1.2	<1.2	<6.1	<1.2	<1.2	<2.5
WGK-SVE-67	7 - 8 ft	**0.0023 J***	**0.032***	**0.015**	<0.03	**0.086**	<0.006	<0.012
WGK-SVE-68	7 - 8 ft	**3,900**	**49**	<250	<1,200	<250	<250	<500
WGK-SVE-73	7 - 8 ft	**0.0042 J***	**0.01***	**0.012**	<0.034	**0.029**	<0.0067	<0.013
WGK-SVE-83	7 - 8 ft	**0.086 J**	**2.6**	<0.5	<2.5	<0.5	<0.5	<1
WGK-SVE-60A	8 - 9 ft	**0.064**	<0.0062	<0.0062	<0.031	<0.0062	<0.0062	<0.012
WGK-SVE-66	8 - 9 ft	**0.011**	**0.51 E**	**0.0023 J**	<0.028	**0.017**	<0.0057	<0.011
WGK-SVE-66-DUP	8 - 9 ft	**0.083 JD**	**2.3 D**	<0.23	<1.1	**0.34 D**	<0.23	<0.45
WGK-SVE-81	8 - 9 ft	<0.0077	<0.0077	<0.0077	<0.039	<0.0077	<0.0077	<0.015
WGK-SVE-82	8 - 9 ft	<0.0058	<0.0058	<0.0058	<0.029	<0.0058	<0.0058	<0.012
WGK-SVE-30	9 - 10 ft	<0.0051	<0.0051	<0.0051	<0.025	<0.0051	<0.0051	<0.01
WGK-SVE-33	9 - 10 ft	**190**	<12	<12	<58	<12	<12	<23
WGK-SVE-36	9 - 10 ft	**1,100**	<53	<53	<260	<53	<53	<110

TABLE B-1

Soil Concentration Data - Big Mo Area

W.G. Krummrich Facility, Sauget, Illinois

Location	Depth (ft bgs)	Benzene (mg/kg)	Chlorobenzene (mg/kg)	1,2-Dichlorobenzene (mg/kg)	2-Hexanone (mg/kg)	1,4-Dichlorobenzene (mg/kg)	Ethylbenzene (mg/kg)	Xylenes, Total (mg/kg)
	Delineation Criteria (mg/Kg)	29	169	2,600	2,610	61.4	2,830	151
Intermediate Silty Clay								
WGK-SVE-37	9 - 10 ft	**400**	<31	<31	<160	<31	<31	<62
WGK-SVE-65	9 - 10 ft	**29,000**	<6,000	<6,000	<30,000	<6,000	<6,000	<12,000
WGK-SVE-65-DUP	9 - 10 ft	**25,000**	<5,800	<5,800	<29,000	<5,800	<5,800	<12,000
WGK-SVE-71	9 - 10 ft	**330**	<11	<11	<55	<11	<11	<22
WGK-SVE-78	9 - 10 ft	<0.006	<0.006	<0.006	<0.03	**0.0029 J**	<0.006	<0.012
WGK-SVE-70	12 - 13 ft	**16**	**2.1**	**1.4**	<3	**11**	<0.59	<1.2
Average:		**748**	**no exceedences**	**no exceedences**	**no exceedences**	**no exceedences**	**no exceedences**	**no exceedences**
Maximum (not including Hot Spots):		**3,900**	**49**	**1**	**NA**	**NA**	**NA**	**NA**
Hot Spot (averaged, if applicable):		**29,000**	**no exceedences**	**no exceedences**	**no exceedences**	**no exceedences**	**no exceedences**	**no exceedences**
Lower Silty Sand								
WGK-SVE-32	8 - 9 ft	**0.0036 J**	<0.0061	<0.0061	<0.031	<0.0061	<0.0061	<0.012
WGK-SVE-32-DUP	8 - 9 ft	<0.0056	<0.0056	<0.0056	<0.028	<0.0056	<0.0056	<0.011
WGK-SVE-35	8 - 9 ft	<0.0055	<0.0055	<0.0055	<0.027	<0.0055	<0.0055	<0.011
WGK-SVE-35-DUP	8 - 9 ft	<0.0052	<0.0052	<0.0052	<0.026	<0.0052	<0.0052	<0.01
WGK-SVE-63	9 - 10 ft	**370**	**15 J**	<26	<130	<26	<26	<51
WGK-SVE-79	9 - 10 ft	**680**	**620**	<60	<300	<60	<60	<120
WGK-SVE-71	10 - 11 ft	**42,000**	<4,800	<4,800	<24,000	<4,800	<4,800	<9,600
WGK-SVE-72	10 - 11 ft	**0.0037 J***	**0.021***	**0.0024 J**	<0.028	**0.019**	<0.0056	<0.011
WGK-SVE-78	10 - 11 ft	<0.005	**0.027**	<0.005	<0.025	**0.0062**	<0.005	<0.0099
WGK-SVE-78-DUP	10 - 11 ft	**0.0013 J**	**0.032**	<0.0049	<0.025	**0.0085**	<0.0049	<0.0098
WGK-SVE-33	11 - 12 ft	**15,000**	<570	<570	<2,800	<570	<570	<1,100
WGK-SVE-60	11 - 12 ft	**0.35 J**	**28**	<1.9	<9.5	<1.9	<1.9	<3.8
WGK-SVE-61	11 - 12 ft	**47**	**200**	<26	<130	<26	<26	<52
WGK-SVE-61-DUP	11 - 12 ft	**47**	**230**	<27	<130	<27	<27	<54
WGK-SVE-66	11 - 12 ft	**29**	**2.9**	<2	<10	**0.58 J**	<2	<4.1
WGK-SVE-69	11 - 12 ft	**610**	<30	<30	<150	<30	<30	<60
WGK-SVE-60A	12 - 13 ft	**0.0033 J**	**0.0027 J**	<0.0054	<0.027	<0.0054	<0.0054	<0.011
WGK-SVE-79	12 - 13 ft	**680**	**810**	<26	<130	<26	<26	<52
WGK-SVE-80	12 - 13 ft	**3**	**15**	<0.44	<2.2	**0.077 J**	<0.44	<0.88
WGK-SVE-82	12 - 13 ft	<0.0064	**0.0077**	<0.0064	<0.032	<0.0064	<0.0064	<0.013
WGK-SVE-32	13 - 14 ft	**0.0015 J**	<0.0056	<0.0056	<0.028	<0.0056	<0.0056	<0.011
WGK-SVE-34	13 - 14 ft	**38**	**0.89**	<1.4	<7.1	<1.4	<1.4	<2.8
WGK-SVE-36	13 - 14 ft	**7,000**	<560	<560	<2,800	<560*	<560	<1,100
WGK-SVE-38	13 - 14 ft	**1,500**	**21**	<58	<290	<58	<58	<120
WGK-SVE-39	13 - 14 ft	**2,300**	<110	<110	<570	<110	<110	<230
WGK-SVE-63	13 - 14 ft	**1,100**	**41**	<52	<260	<52	<52	<100
WGK-SVE-63-DUP	13 - 14 ft	**1,400**	**56**	<46	<230	<46	<46	<91
WGK-SVE-64	13 - 14 ft	**820**	<28	<28	<140	<28	<28	<56
WGK-SVE-67	13 - 14 ft	**19**	**2.2**	**3.3**	<5.8	**15**	<1.2	<2.3
WGK-SVE-68	13 - 14 ft	**5,900**	<260	<260	<1,300	<260	<260	<520
WGK-SVE-73	13 - 14 ft	**0.004 J***	**0.084***	**0.019**	<0.036	**0.26**	<0.0072	<0.014
WGK-SVE-30	14 - 15 ft	<3.2	**81**	**1.4 J**	<16	<3.2	<3.2	<6.5
WGK-SVE-35	14 - 15 ft	**5.3**	**3.6**	<0.44	<2.2	**0.12 J**	<0.44	<0.89
WGK-SVE-37	14 - 15 ft	**2,600**	<110	<110	<570	**29 J**	<110	<230
WGK-SVE-62	14 - 15 ft	**8.7**	**0.092 J**	<0.22	<1.1	**0.081 J**	<0.22	<0.44
WGK-SVE-65	14 - 15 ft	**6,500**	<270	<270	<1,400	<270	<270	<540
WGK-SVE-83	14 - 15 ft	**140**	**3.5 J**	<9.5	<47	<9.5	<9.5	<19
WGK-SVE-81	14 - 15 ft	**0.0022 J**	**0.11**	<0.0051	<0.026	**0.0093**	<0.0051	<0.01
Average:		**1,976**	**NA**	**no exceedences**	**no exceedences**	**no exceedences**	**no exceedences**	**no exceedences**
Maximum (not including Hot Spots):		**7,000**	**810**	**3**	**NA**	**15**	**NA**	**NA**
Hot Spot (averaged, if applicable):		**42,000**	**NA**	**no exceedences**	**no exceedences**	**no exceedences**	**no exceedences**	**no exceedences**

Notes:

NA = Not Applicable

Duplicates are not included in the averages.

[yellow] = Exceeds delineation criteria

[green] = Indicates an elevated concentration relative to the other soil concentrations corresponding to contaminant hot spots.

ft bgs = feet below ground surface

mg/kg = milligrams per Kilogram

TABLE B-2

Soil Concentration Data - Former Benzene Pipeline Area
W.G. Krummrich Facility, Sauget, Illinois

Location	Depth (ft bgs)	Benzene (mg/kg)	Chlorobenzene (mg/kg)	1,2-Dichlorobenzene (mg/kg)	2-Hexanone (mg/kg)	1,4-Dichlorobenzene (mg/kg)	Ethylbenzene (mg/kg)	Xylenes, Total (mg/kg)
Delineation Criteria (mg/Kg)		29	169	2,600	2,610	61.4	2,830	151
Sandy Fill / Upper Silty Sand								
WGK-SVE-27	3 - 4 ft	**10**	<3.7	<3.7	<18	<3.7	<3.7	<7.3
WGK-SVE-28	9 - 10 ft	**520**	**1,900**	<100	<500	<100*	<100	<200*
WGK-SVE-29	4 - 5 ft	<0.0045	<0.0045	<0.0045	<0.023	<0.0045	<0.0045	<0.009
WGK-SVE-28	9 - 10 ft	**160**	**590**	<1	<5	**1.4**	<1	<2
WGK-SVE-28-DUP	9 - 10 ft	**31**	**130**	<1.1	<290	<1.1	<1.1	<2.2
WGK-SVE-28-DUP DL	9 - 10 ft	**33**	**150**	<5.5	<5.5	<5.5	<5.5	<11*
Average:		**340**	**1,245**	**no exceedances**	**no exceedances**	**no exceedances**	**no exceedances**	**no exceedances**
Maximum:		**520**	**1,900**	**NA**	**NA**	**NA**	**NA**	**NA**
Intermediate Silty Clay								
WGK-SVE-26	3 - 4 ft	<0.0054	<0.0054	<0.0054	<0.027	<0.0054	<0.0054	<0.011
WGK-SVE-29	7 - 8 ft	<0.0054	<0.0054	<0.0045	<0.023	<0.0054	<0.0054	<0.011
WGK-SVE-27	8 - 9 ft	**990**	**2,000**	<54	<270	<54	<54	<110
Average:		**990**	**2,000**	**no exceedances**	**no exceedances**	**no exceedances**	**no exceedances**	**no exceedances**
Maximum:		**990**	**2,000**	**NA**	**NA**	**NA**	**NA**	**NA**
Lower Silty Sand								
WGK-SVE-26	9 - 10 ft	<0.0065	<0.0065	<0.0065	<0.032	<0.0065	<0.0065	<0.013
WGK-SVE-28	11 - 12 ft	**400**	**1,300**	<57	<27	<57	<57	<110
WGK-SVE-26	14 - 15 ft	<0.0059	<0.0059	<0.0059	<0.03	<0.0059	<0.0059	<0.012
WGK-SVE-27	14 - 15 ft	**68**	**16**	<3	<15	<3	<3	<6
WGK-SVE-29	14 - 15 ft	<0.0054	<0.0054	<0.0054	<0.027	<0.0054	<0.0054	<0.011
Average:		**234**	**1,300**	**no exceedances**	**no exceedances**	**no exceedances**	**no exceedances**	**no exceedances**
Maximum:		**400**	**1,300**	**NA**	**NA**	**NA**	**NA**	**NA**

Notes:

NA = Not Applicable

Duplicates are not included in the averages.

[yellow] = Exceeds delineation criteria

[green] = Indicates an elevated concentration relative to the other soil concentrations corresponding to contaminant hot spots.

ft bgs = feet below ground surface

mg/kg = milligrams per Kilogram

Appendix C
Soil Saturation Limit Calculations

TABLE C-1

Soil Saturation Limit (Csat) Calculations (10% NAPL Saturation Assumption)

W.G. Krummrich Facility, Sauget, Illinois

Compound	Molecular Wt.	Solubility Limit (Csol)	Henry's Law Contant (H')	Organic Carbon Partitioning Coefficient (Koc)	Density	Soil Partitioning Coefficient (Kd)	Max Soil Conc.	Max. Pore Water Conc. (Cwater)	Max. Pore Air Conc. (Cair)	Soil Saturation Limit (Csat)	Max NAPL Content Based on Pore NAPL Saturation (C_{NAPL})	Maximum Soil Conc.
						Kd = Koc * foc	Eq. 1	Eq. 2	Eq. 3	Eq. 4	Eq. 5	Eq. 6
	g/Mol	mg/L	V/V unitless	L/Kg	Kg/L	L/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
Benzene	78.11	1800	0.228	98	0.879	0.49	882	84	50.0	1,016	16,462	17,478
Chlorobenzene	112.56	466.3	0.152	126	1.1058	0.63	294	22	8.6	324	20,710	21,034

Constants						
Soil Bulk Density	Total Porosity	NAPL Sat.	Water Sat.	Air Sat.	Freundlich "N"	Foc
LBs/CF	n	%	%	%		Fraction
100	0.3	10%	25%	65%	1	0.005

LBs = pounds

foc = Fraction of Organic Carbon

CF = Cubic Feet

g = grams

Mol = Moles

mg = milligrams

L= liters

V/V = Volume/Volume basis

Kg = Kilograms

Equations:

Eq. 1: Csoil=(Kd*Csol)^(1/N) (Freundlich Isotherm)

Eq. 2: Cwater = Csol * Water Sat. * n / Bulk Density

Eq. 3: Cair = Csol * H' * Air Sat. * n / Bulk Density

Eq. 4: Csat = Csoil + Cwater + Cair

Eq. 5: CNAPL = Density * n * NAPL Sat. / Bulk Density

Eq. 6: Csat + CNAPL

TABLE C-2

Soil Saturation Limit (Csat) Calculations (100% NAPL Saturation Assumption)

W.G. Krummrich Facility, Sauget, Illinois

Compound	Molecular Wt.	Solubility Limit (Csol)	Henry's Law Contant (H')	Organic Carbon Partitioning Coefficient (Koc)	Density	Soil Partitioning Coefficient (Kd)	Max Soil Conc.	Max. Pore Water Conc. (Cwater)	Max. Pore Air Conc. (Cair)	Soil Saturation Limit (Csat)	Max NAPL Content Based on Pore NAPL Saturation (C_{NAPL})	Maximum Soil Conc.
						Kd = Koc * foc	Eq. 1	Eq. 2	Eq. 3	Eq. 4	Eq. 5	Eq. 6
	g/Mol	mg/L	V/V unitless	L/Kg	Kg/L	L/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
Benzene	78.11	1800	0.228	98	0.879	0.49	882	0	0.0	882	164,620	165,502
Chlorobenzene	112.56	466.3	0.152	126	1.1058	0.63	294	0	0.0	294	207,095	207,389

Constants						
Soil Bulk Density	Total Porosity	NAPL Sat.	Water Sat.	Air Sat.	Freundlich "N"	Foc
LBs/CF	n	%	%	%		Fraction
100	0.3	100%	0%	0%	1	0.005

LBs = pounds
foc = Fraction of Organic Carbon
CF = Cubic Feet

g = grams
Mol = Moles
mg = milligrams

L= liters
V/V = Volume/Volume basis
Kg = Kilograms

Equations:

Eq. 1: Csoil=(Kd*Csol)^(1/N) (Freundlich Isotherm)

Eq. 2: Cwater = Csol * Water Sat. * n / Bulk Density

Eq. 3: Cair = Csol * H' * Air Sat. * n / Bulk Density

Eq. 4: Csat = Csoil + Cwater + Cair

Eq. 5: CNAPL = Density * n * NAPL Sat. / Bulk Density

Eq. 6: Csat + CNAPL

Appendix D

Mass Estimates

TABLE D-1

BIG MO - Mass Estimates

W.G. Krummrich Facility, Sauget, Illinois

Impacted Area Description	Sandy Fill/Upper Silty Sand		Intermediate Silty Clay			Lower Silty Sand			
	Average Over Majority of Area[1]	SVE Pilot Test Area[2]	Average Over Majority of Area[1]	SVE Pilot Test Area[2]	SVE-65 Hot Spot	Average Over Majority of Area[1]	SVE Pilot Test Area[2]	SVE-71 Hot Spot	SVE-33 Hot Spot
Avg. Conc. (mg/Kg) - BENZENE	366	2,059	748	2,731	29,000	1,976	3,083	42,000	15,000
Avg. Conc. (mg/Kg) - CHLOROBENZENE	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Conc. (mg/Kg)	366	2,059	748	2,731	29,000	1,976	3,083	42,000	15,000
Area (SF)	78,900	4,800	76,000	4,800	2,900	80,600	4,800	5,400	7,200
Thickness (Feet)	6	7	5	5	5	5	5	5	5
Soil Volume (CY)	17,600	1,300	14,100	900	600	15,000	900	1,000	1,400
Soil Mass (LBs)[3]	47,340,000	3,360,000	38,000,000	2,400,000	1,450,000	40,300,000	2,400,000	2,700,000	3,600,000
COC Mass Adsorbed To Soil (LBs)	17,000	7,000	28,000	7,000	42,000	80,000	7,000	113,000	54,000
Assumed NAPL Mass (LBs)[4,5]	NA	55,000	NA	39,000	NA	NA	39,000	NA	NA
Subtotal Mass (LBs)	17,000	62,000	28,000	46,000	42,000	80,000	46,000	113,000	54,000
Subtotal Mass in Layer (LBs)	80,000		120,000			290,000			
% of Total COC Mass Layer	16%		24%			59%			
Total COC Mass (LBs)	490,000								

Notes:

Soil COC concentration data is presented in Appendix B

COC = Contaminant of Concern

NA = Not Applicable

1. The surface area of the entire treatment area is used, minus the SVE pilot test area and specific hot spot areas, as applicable.
2. The SVE pilot test area mass estimate is based on soil samples collected during the baseline and intermediate sampling events during the SVE pilot test.
3. Soil Bulk Density (LBs/CF) = 100
4. A 10% saturation of NAPL was assumed for the SVE pilot test area based on field observations and SVE performance during the pilot test.
5. NAPL mass calculation: (10% Sat. NAPL)*0.30 (porosity)*Soil Volume (ft3)*7.48 gal/ft3*879 g/L (benzene density)*3.785 L/gal* 1 lb/454 g

   Density of benzene = 879 g/L

   Porosity = 0.30

Exceeds Csat + 10% NAPL Saturation

TABLE D-2

FORMER BENZENE PIPELINE AREA - Mass Estimates

W.G. Krummrich Facility, Sauget, Illinois

Impacted Area Description	Sandy Fill/Upper Silty Sand	Intermediate Silty Clay	Lower Silty Sand
	Average Over Majority of Area[1]	Average Over Majority of Area[1]	Average Over Majority of Area[1]
Avg. Conc. (mg/Kg) - BENZENE	340	990	234
Avg. Conc. (mg/Kg) - CHLOROBENZENE	1,245	2,000	1,300
Total Conc. (mg/Kg)	1,585	2,990	1,534
Area (SF)	8,500	8,500	8,500
Thickness (Feet)	7	4	6
Soil Volume (CY)	2,300	1,300	1,900
Soil Mass (LBs)[2]	5,950,000	3,400,000	5,100,000
COC Mass Adsorbed To Soil (LBs)	9,000	10,000	8,000
Assumed NAPL Mass (LBs)[3]	NA	NA	NA
Subtotal Mass (LBs)	9,000	10,000	8,000
Subtotal Mass in Layer (LBs)	9,000	10,000	8,000
% of Total COC Mass Layer	33%	37%	30%
Total COC Mass (LBs)		**27,000**	

Notes:
Soil COC concentration data is presented in Appendix B
COC = Contaminant of Concern
NA = Not Applicable
1. The surface area of the entire treatment area is used, minus the SVE Pilot Test area and specific hot spot areas, as applicable.
2. Soil Bulk Density (LBs/CF) = 100
3. NAPL mass calculation: (10% Sat. NAPL)*0.30 (porosity)*Soil Volume (ft3)*7.48 gal/ft3*879 g/L (benzene density)*3.785 L/gal* 1 lb/454 g
   Density of benzene = 879 g/L
   Porosity = 0.30

Appendix E

Radius of Influence Design Calculations

TABLE E-1

SVE OPERATION TIME ANALYSIS - ESTIMATED TOTAL PORE VOLUME EXCHANGES AFTER MULTIPLE YEARS OF OPERATION

W.G. Krummrich Facility, Sauget, Illinois

ROI	Center-to-Center Well Spacing	Pore Volume Exchange Rate (PV/Year)[1]		Total Pore Volume Exchanges at Midpoint Between Wells[2]					
				Years of Operation Required @ 25 SCFM			Years of Operation Required @ 30 SCFM		
Feet	Feet	25 SCFM	30 SCFM	1.2	2.6	4.8	1.0	2.1	4.0
10.1	20	6,064	7,280	7,276	15,765	29,105	7,280	15,288	29,119
10.6	21	5,360	6,435	6,432	13,936	25,728	6,435	13,514	25,740
11.1	22	4,764	5,719	5,717	12,386	22,866	5,719	12,010	22,876
11.6	23	4,255	5,108	5,106	11,063	20,423	5,108	10,727	20,432
12.1	24	3,817	4,583	4,581	9,925	18,323	4,583	9,623	18,330
12.6	25	3,439	4,128	4,126	8,941	16,506	4,128	8,669	16,512
13.1	26	3,109	3,733	3,731	8,084	14,925	3,733	7,838	14,930
13.6	27	2,821	3,387	3,385	7,335	13,542	3,387	7,112	13,547
14.1	28	2,568	3,082	3,081	6,676	12,326	3,082	6,473	12,330
14.6	29	2,344	2,814	2,813	6,095	11,252	2,814	5,909	11,255
15.1	30	2,146	2,576	2,575	5,579	10,299	2,576	5,409	10,302
15.6	31	1,969	2,363	2,363	5,119	9,450	2,363	4,963	9,453
16.1	32	1,811	2,174	2,173	4,708	8,692	2,174	4,565	8,694
16.6	33	1,669	2,003	2,003	4,340	8,011	2,003	4,207	8,014
17.1	34	1,541	1,850	1,850	4,008	7,399	1,850	3,886	7,401
17.6	35	1,426	1,712	1,712	3,708	6,846	1,712	3,595	6,848
18.1	36	1,322	1,587	1,586	3,437	6,346	1,587	3,332	6,347
18.6	37	1,227	1,473	1,473	3,191	5,891	1,473	3,094	5,893
19.1	38	1,141	1,370	1,370	2,967	5,478	1,370	2,877	5,479
19.6	39	1,063	1,276	1,275	2,763	5,101	1,276	2,679	5,102
20.1	40	991	1,189	1,189	2,576	4,756	1,189	2,498	4,757
20.6	41	925	1,110	1,110	2,405	4,441	1,110	2,332	4,442
21.1	42	865	1,038	1,038	2,248	4,151	1,038	2,180	4,152
21.6	43	809	971	971	2,104	3,884	971	2,040	3,885
22.1	44	758	910	910	1,971	3,639	910	1,911	3,640
22.6	45	711	853	853	1,848	3,412	853	1,792	3,413
23.1	46	667	801	801	1,735	3,203	801	1,682	3,204
23.6	47	627	752	752	1,630	3,009	752	1,580	3,010
24.1	48	590	708	707	1,533	2,830	708	1,486	2,830
24.6	49	555	666	666	1,443	2,663	666	1,398	2,664
25.1	50	523	627	627	1,359	2,508	627	1,317	2,509
25.6	51	493	591	591	1,281	2,364	591	1,242	2,365
26.1	52	465	558	558	1,208	2,230	558	1,171	2,231
26.6	53	439	526	526	1,140	2,105	526	1,105	2,105
27.1	54	414	497	497	1,077	1,988	497	1,044	1,989
27.6	55	392	470	470	1,018	1,879	470	987	1,880
28.1	56	370	444	444	963	1,777	444	933	1,778
28.6	57	350	421	420	911	1,682	421	883	1,682
29.1	58	332	398	398	862	1,592	398	836	1,592
29.6	59	314	377	377	817	1,508	377	792	1,509
30.1	60	298	357	357	774	1,430	357	751	1,430

Notes:

ROI = Radius of Influence

PV/Year = Pore Volume Exchange Rate per Year

SCFM = Standard Cubic Feet per Minute

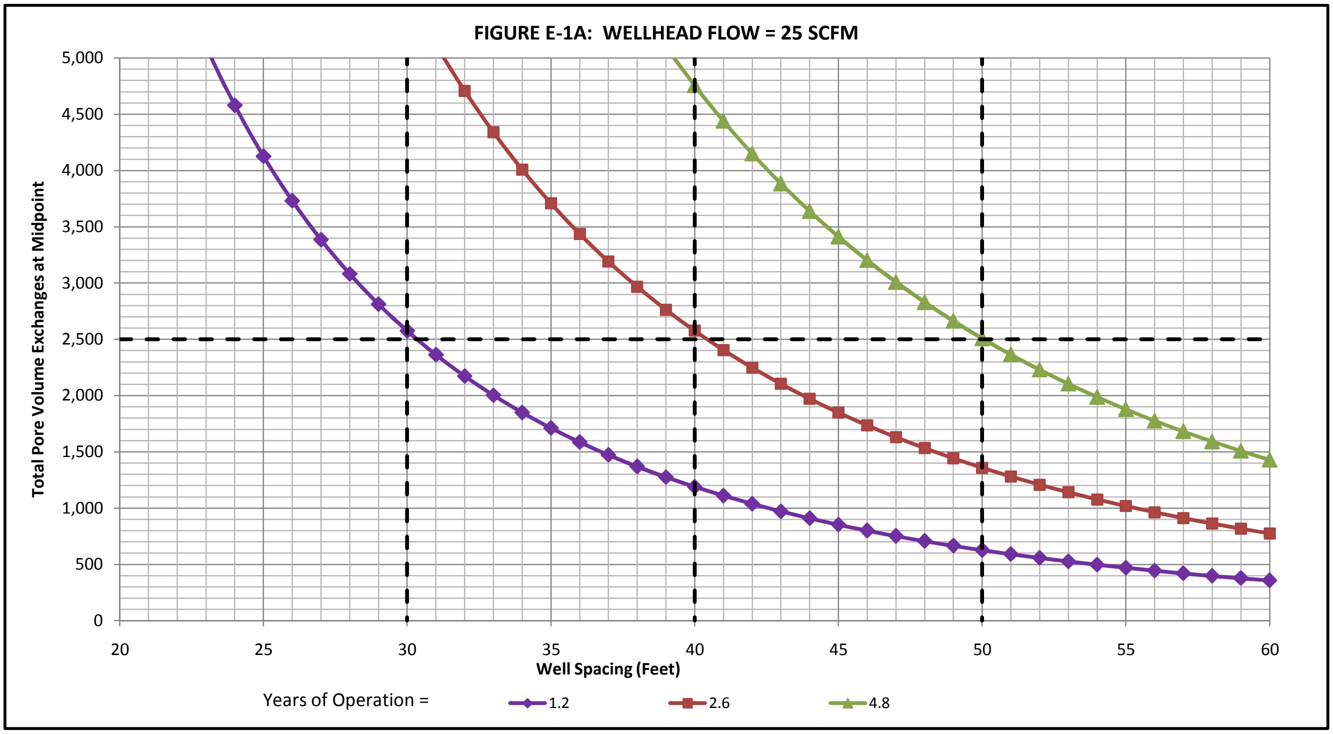
[1] = PV/Year represents the pore volume exchange rate at the SVE well ROI, as based on SVE Pilot Test Report air flow modeling simulations at 25 and 30 SCFM.

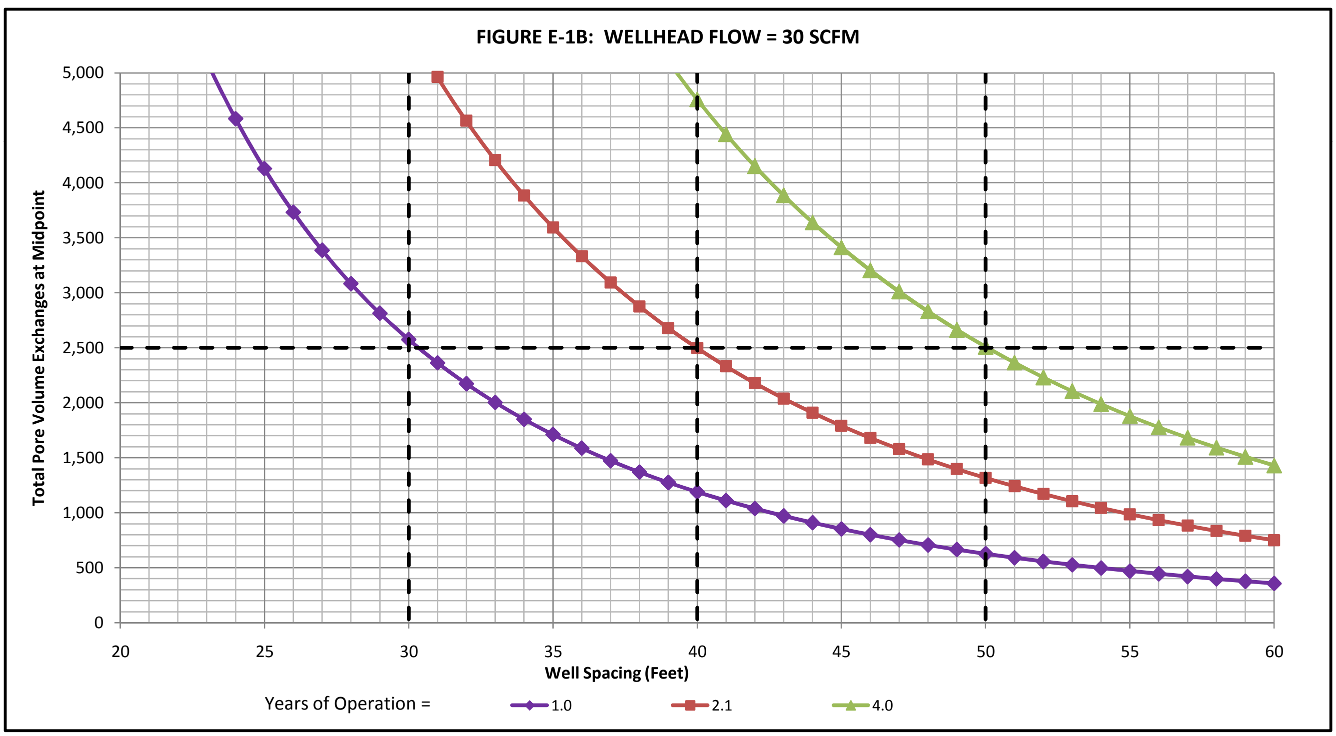
[2] = Total Pore Volume Exchanges occuring at the midpoint between two SVE wells after the specified years of operation, at the specified flowrate. For example, at a well spacing of 40 feet, approximately 2,500 pore volume exchanges will occur at the midpoint between wells after 2.6 years of operation at a wellhead flowrate of 25 SCFM.

FIGURE E-1

SVE OPERATION TIME ANALYSIS - TOTAL PORE VOLUME EXCHANGES AFTER MULTIPLE YEARS OF OPERATION

W.G. Krummrich Facility, Sauget, Illinois





Notes:

SCFM = Standard Cubic Feet per Minute

The Total Pore Volume Exchanges (PV) that occurs at the midpoint between two SVE wells is plotted as a function of the center-to-center wellhead spacing. For example: At a 40 foot well spacing, approximatley 2,500 PV exchanges will occur at the midpoint between the wells after 2.1 years of operation at 30 SCFM per well.

Appendix F

Three-Dimensional Air Flow Modeling

Appendix F

Three-Dimensional Air Flow Modeling

W.G. Krummrich Facility, Sauget, Illinois

Introduction: Two-dimensional (2-D) and three-dimensional (3-D) computer air flow models were used to design the soil vapor extraction (SVE) well grid spacing. The 2-D model[1] was used to determine the radius of influence (ROI) of a single SVE well (refer to the *Soil Vapor Extraction Pilot Test Report*, November 2010). The ROI of a single SVE well was based upon achieving 500 to 1,000 pore volume exchanges per year (PV/year) at a wellhead flowrate of 25 to 30 standard cubic feet per minute (scfm). The ROI was estimated to be 20 feet using the 2-D model.

When multiple SVE wells are operated together, there is some competition for the available pore air in the subsurface. In addition, the presence of the intermediate silty clay layer could further limit surface air infiltration to the lower silty sand layer, thus affecting the net pore volume exchange rate.

Therefore, a 3-D air flow simulation using the American Petroleum Institute [API] AIR3D[2] computer model was performed. This model accounts for the superposition effect of multiple wells, and estimates the air-flow pore velocity vectors within a 3-D model grid. A pore air velocity of 0.01 centimeters per second (cm/s) is a typical minimum air velocity target[3] that will provide adequate pore volume exchanges within the target layers.

---

[1] Baehr, A.L. and Joss, C.J. 1995. "An updated model of induced air flow in the unsaturated zone," Water Resources Research Vol 31, n 2, pp 417-421.
[2] AIR-3D: A Three-Dimensional Model of Air Flow in the Unsaturated Zone. American Petroleum Institute. 1994
[3] DiGiulio, D.C. and R. Varadhan. 2001. Development of Recommendations and Methods to Support Assessment of Soil Venting Performance and Closure. USEPA Office of Research and Development (EPA/600/R-01/070).

The 3-D air flow model results confirmed that superposition of multiple vapor extraction/air injection wells will provide adequate air velocities in the target layers.

Model Set-Up: A portion of the proposed SVE well grid was simulated to demonstrate that the minimum air flushing velocities are occurring throughout the target layers. The model grid is presented in **Figure F-1**. A well grid of 11 SVE wells with 2 Air Injection (AI) wells was created to represent a typical portion of the SVE well grids for the treatment areas.

Seven layers were defined for the model. Layer depths and thicknesses were based upon on the general geological conditions observed in the four target treatment areas.

The model was designed with the following layers:

- **Layer 1**: This layer represents ground surface, and was assumed to be 1 foot thick.
- **Layer 2**: This layer represents the upper portion of the sandy fill/upper silty sand layer, and was assumed to be 3 feet thick. No SVE/AI well screens are in this layer.
- **Layers 3 and 4**: Layer 3 (3 feet thick) and Layer 4 (2 feet thick) represent the target impacted interval of the sandy fill/upper silty sand layer (i.e., 5 feet thick in total). The shallow SVE/AI wells span these two layers in the model (i.e., 5-foot-long well screens). While the impacted interval of the sandy fill/upper silty sand layer could have been modeled as a single layer, using multiple layers in this model provides more refined pore velocity estimates. Also, using two layers instead of a single layer allows an interpretation of the change of air flow patterns with depth.
- **Layer 5**: Intermediate Silty Clay Layer (assumed to be 3 feet thick).
- **Layers 6 and 7**: Layer 6 (3 feet thick) and Layer 7 (2 feet thick) represent the target impacted interval of the lower silty sand layer (i.e., 5 feet thick in total). The deep SVE/AI wells span these two layers in the model (i.e., 5-foot-long well screens). Two

layers were used to represent the deep target interval for the same reasons noted above for the shallow target interval.

A SVE extraction rate of 25 standard cubic feet per minute (scfm) was assumed for the SVE wells. An AI injection rate of 60 scfm was assumed for the AI wells. The model predicted wellhead vacuums to achieve these air flow rates are within 20% of the actual vacuums/pressures observed during the pilot test. Therefore the model was considered calibrated to field conditions.

Soil Permeabilities: The intrinsic soil permeabilities were previously estimated using the 2-D air flow model (refer to the *Soil Vapor Extraction Pilot Test Report*, November 2010). Model simulations provided an estimate of the soil permeability in both the radial and vertical directions(K_r and K_z respectively), as follows:

- The sandy fill/upper silty sand layer was estimated at $K_r = K_z = 3.94 \times 10^{-7}$ centimeters squared (cm^2) (isotropic conditions). Permeabilities could not be estimated for the lower silty sand layer due to water saturation, but were assumed to be similar to the sandy fill/upper silty sand layer based on prior point permeability testing.

- Permeabilities were not estimated for the intermediate silty clay layer because air flow could not be induced in this unit during the SVE pilot test (refer to the *SVE Pilot Test Report*, November 2010). However, the original point permeability testing for this area indicated that the intermediate silty clay layer had a $K_r = K_z = 3.9 \times 10^{-9}$ cm^2. This value was not used in the model[4] because the actual permeability of this unit is likely to be lower. A range of assumed values of 1×10^{-10} cm^2 to 1×10^{-11} cm^2 were used for the 3-D modeling simulations for conservatism.

---

[4] Field observations suggest that the intermediate silty clay layer of low intrinsic permeability. However, the point permeability testing and modeling results for this layer yielded a higher permeability than anticipated. This higher estimated permeability is likely due to short-circuiting of air flow between the silty clay layer and the upper and lower silty sand layers.

- The effective ground surface permeability, K_c/B_c[5], was estimated at 3.58×10^{-10} cm^2, which represents the conditions in the pilot test area (gravel and asphalt paved area). Note that some of the other treatment areas do not have surface covers. However, the effect of the surface cover is negligible when AI wells are used, and so the model simulation is valid for the other areas without a surface cover.

Results: After the model was calibrated, minimum velocity vector plots (minimum pore velocities of 0.01 cm/s) were estimated for each appropriate model layer (i.e., layers containing SVE and AI well screens). The model estimates an average air velocity and direction in each model cell. The pore air velocity vectors are then plotted for each layer, and the length of the vector in each cell is relative to the magnitude of the air velocity (i.e., the long vectors represent higher air velocities, and will be observed closer to SVE wells or AI wells). If the air velocity in a cell is less than the selected minimum velocity of 0.01 cm/s, then an empty cell is plotted.

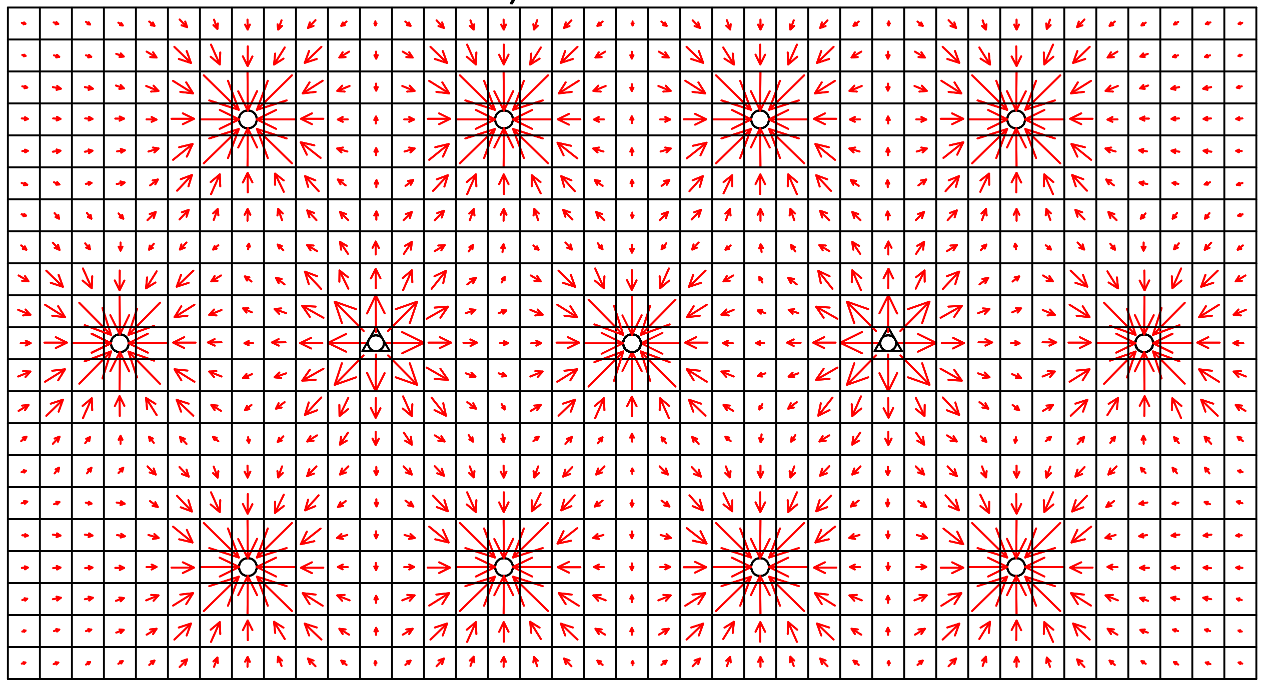
The minimum velocity vector plots are presented in **Figure F-1**. As shown in **Figure F-1**, the pore air velocity is greater than 0.01 cm/s throughout the target treatment intervals (i.e., Layers 3, 4, 6, and 7). Therefore, this modeling simulation indicates that the SVE/AI well design spacing of 40-feet, under the site-specific geological conditions, will achieve the minimum pore air velocity and minimum target flushing rates.

[5] The computer model assumes that the surface cover is 10 cm thick (represented by B_c), and the overall permeability of this surface cover is a function of its thickness (i.e., K_c/B_c).

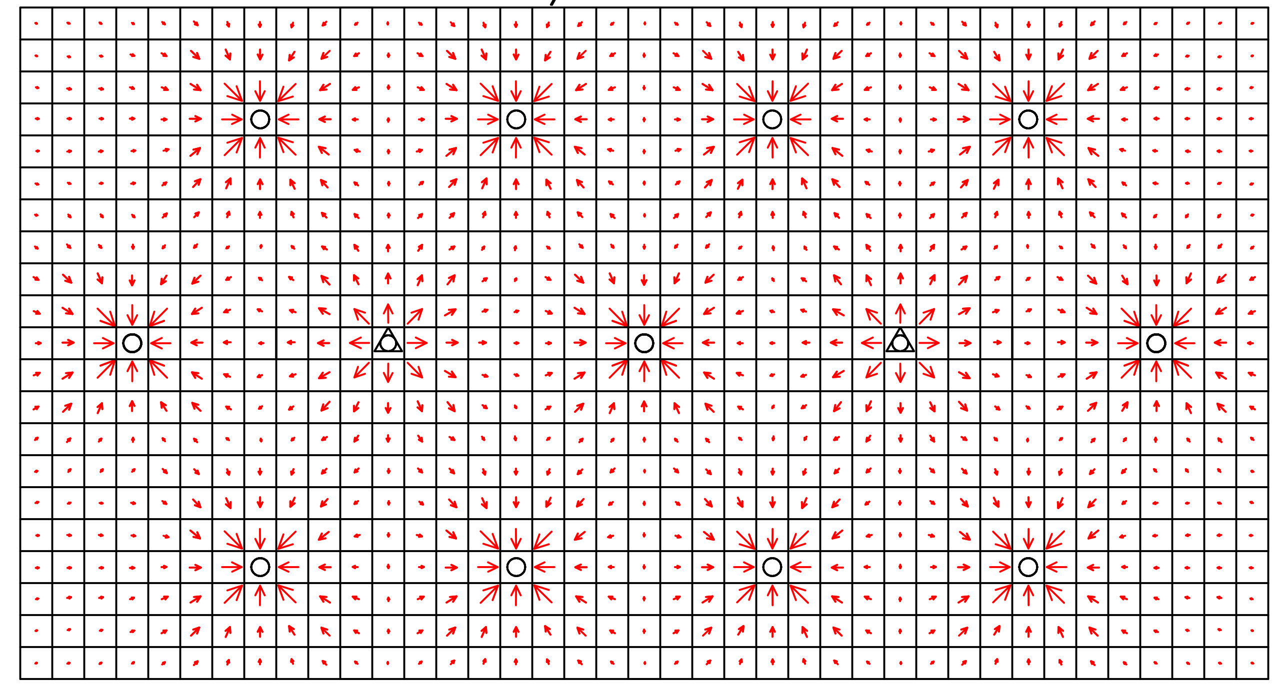
Appendix F

Figure

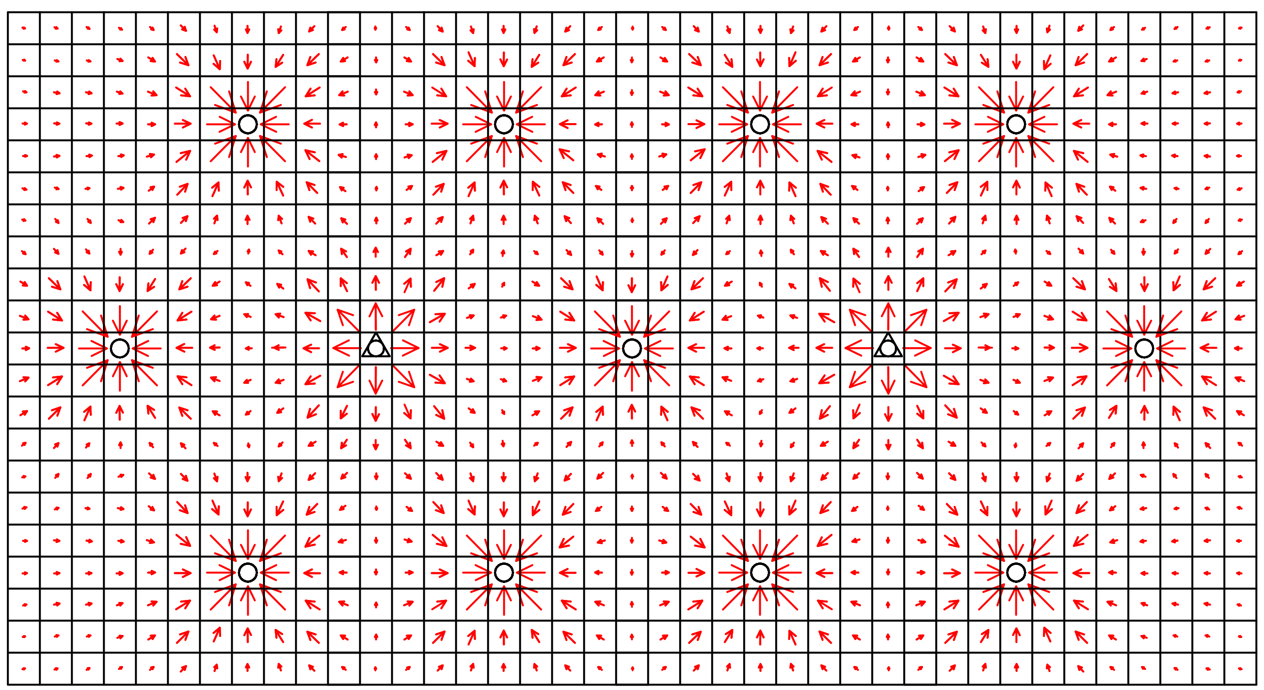
LAYER 3 – SANDY FILL/UPPER SILTY SAND



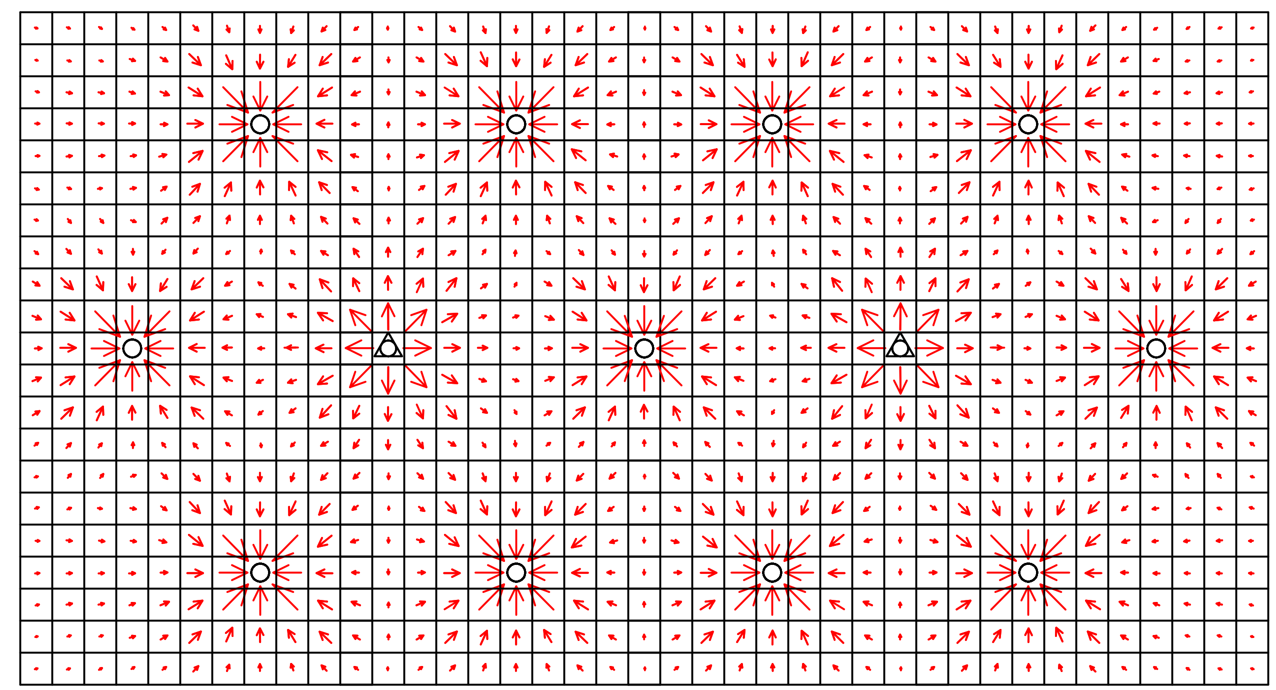
LAYER 4 – SANDY FILL/ UPPER SILTY SAND



LAYER 6 – LOWER SILTY SAND



LAYER 7 – LOWER SILTY SAND



LEGEND

○ SVE Well

△ Air Injection Well

→ Red arrows represent air velocity vectors. Air velocity is proportional to arrow length. All air velocity vectors plotted are equal to or greater than 0.01 centimeters per second (cm/sec)

15' 0' 15' 30'

XDD

STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

SCALE: AS SHOWN	TITLE: SOIL VAPOR EXTRACTION/AIR INJECTION 3-D MODEL GRID
DATE: SEPTEMBER 2011	
PROJECT NO.: 11002	
CLIENT: SOLUTIA	
DRAWN BY: LBC	DRAWING NO.: FIGURE F-1
CHECKED BY: SCC	REV: 1
PROJ. MGMT. APPROVAL: SCC	

Appendix G
SVE Shutdown Protocol Memorandum

To:	Bill Johnson (Solutia)	Date:	April 14, 2011
From:	Scott Crawford (XDD)	Cc:	Jerry Rinaldi (Solutia) Mike Marley (XDD) XDD File (10022)
RE:	**Protocol for Completing Soil Vapor Extraction Operations and Potential Transitioning to Bioventing Mode** **Solutia Inc., W.G. Krummrich Facility, Sauget, Illinois**		

Dear Mr. Johnson,

XDD, LLC (XDD) has prepared this protocol to determine when it is appropriate to cease Soil Vapor Extraction (SVE) operations in each treatment area at the Solutia Inc. (Solutia) W.G. Krummrich facility. The objective will be to assess whether it is necessary to address any residual impacts remaining within silty sand and intermediate silty clay units at the completion of the SVE operations.

The steps in this protocol will provide the basis for making the recommendation, which will be approved by the United States Environmental Protection Agency (U.S. EPA), for shutdown of SVE or making the transition to bioventing (BV). SVE operations will continue in each treatment area until U.S. EPA approval of the corresponding recommendation to shut down or transition to BV.

It was originally proposed in Section 1.2 of the *Work Plan for Full-Scale SVE* (November 2010) that SVE operations would be considered complete when the mass removal rate of the SVE system reaches an asymptotic condition. Asymptotic conditions would be based upon the observation that the contaminant of concern (COC) vapor mass removal rate is less than 10% of the observed baseline rate for at least seven consecutive calendar days.

The decision to shut down SVE operations and potentially transition to the BV mode is now recommended to be based upon the following steps:

1. **<u>Process Vapor Monitoring</u>** - Conduct performance monitoring of SVE operations to assess the COC mass removal rate and cumulative COC mass removal in the vapor phase. This includes:
    a. Measurement of COC concentrations in the SVE well field vapor stream.
    b. Measurement of the total SVE well field flowrate.
    c. The COC mass removal rates for each monitoring event will be calculated based upon the COC vapor concentration and the SVE flowrate.

   d. The cumulative COC mass removed will be calculated based upon the average COC mass removal rate and the length of time elapsed between each monitoring event.
   e. Process vapor monitoring would be conducted initially on a weekly basis, and this frequency would be reduced as vapor concentrations and mass removal rates stabilize.
   f. The cumulative COC mass removed as vapor will be plotted and provided to U.S. EPA in quarterly status updates.

2. **<u>Assess Asymptotic Conditions</u>** - Identify when asymptotic mass removal rate conditions are achieved:
   a. The initial peak COC vapor concentrations observed at start-up of the SVE system will be associated with the flushing of "static-equilibrium" soil gas concentrations. These initial peak level concentrations tend to decline rapidly after start-up as the initial pore volumes of soil gas are removed.
   b. For the purposes of establishing a representative baseline mass removal rate for the SVE system, an average mass removal rate will be calculated based on the first month of SVE operation.
   c. As previously discussed, SVE operations will be considered to have achieved asymptotic conditions when mass removal rates have been reduced to 10% of the baseline mass removal rates and remain at this level for a period greater than seven consecutive calendar days.
   d. The mass removal rate will not be considered to be "asymptotic" if the reason for the decrease in mass removal rates appears to be related to groundwater table elevations rising and blocking the SVE well screen.
   e. In addition, "rebound" monitoring of COC concentrations in soil vapor under "static" conditions (i.e., SVE system temporarily turned off for a period of two to four weeks) will be evaluated periodically for system optimization as "asymptotic" mass removal conditions are achieved within portions of the wellfield. Monitoring results will be evaluated to determine if significant additional mass removal can achieved by further SVE operation (either in continuous or "pulsed" mode). The potential mass removal that can be achieved with continued operation of SVE will be compared to that associated with a transition to BV mode to determine the most effective strategy.

3. **<u>Soil Sampling</u>** - Conduct soil sampling to assess reductions in soil concentrations and soil COC mass during SVE operations:
   a. Soil sampling is to be conducted on an annual basis (except within the intermediate silty clay which is proposed to be conducted once near the completion of SVE operations). The final soil sampling event would be conducted after asymptotic COC mass removal rates are achieved (see Step #2 above).

b. Initial COC mass estimates based on baseline soil data have been developed for each target area (refer to Table 2[1] of the *Work Plan for Full-Scale SVE*). The initial estimated mass of benzene and/or chlorobenzene is 490,000 pounds at the Big Mo Area, 27,000 pounds at the Former Benzene Pipeline Area, 250,000 pounds at the North Tank Farm Area, and 25,000 pounds at the Near Little Mo Area.
c. Soil COC mass remaining will be calculated following each annual soil sampling event and compared to the initial mass estimates to estimate percent mass reduction.
d. The COC mass reduction on the soils will also be compared to the cumulative COC mass removed based on vapor concentration data (see Step #1 above).

4. **Assess COC Mass Remaining on Soils** – Upon reaching an asymptotic condition, evaluate the impact, if any, of residual COC mass remaining on soils :
   a. Modeling will be conducted to evaluate potential impact to groundwater posed by the remaining COC mass in the unsaturated zone.
   b. Residual soil concentrations will also be evaluated to determine if there are any potential human health risks and if these are addressed by institutional controls.
   c. If a. or b. above suggest the need for further action, an evaluation to determine if BV will address the residual soil concentrations will be conducted.

5. **Recommendation for Shutdown or Transition to BV** – Prepare a report for U.S. EPA to recommend whether to shut down or transition from SVE to BV:
   a. Based on the data collection and evaluations conducted in Step #1 through #4, prepare a report for U.S. EPA to confirm that asymptotic conditions have been achieved and residual COC mass remaining does not pose unacceptable risk to groundwater or human health.
   b. Upon U.S. EPA's agreement, the SVE system would be either shut down or transitioned into the BV phase of operations (Step #6 below). Note that it will be appropriate to recommend shutdown of portions of the SVE system in a phased manner as sub-areas and/or specific depth intervals meet the performance criteria. This will be evaluated during regular system optimization events.

6. **Transition to BV Operations** – In accordance with Step #5 above, after shutdown of SVE operations, BV may be conducted to address COC mass flux from the intermediate silty clay unit. If so, BV will provide some additional reduction of the residual COC mass remaining within the upper and lower silty sand units. Annual sampling will be conducted within the intermediate silty clay unit to assess COC mass reduction (as compared to "baseline" soil concentrations at the completion of the SVE phase of operations).

[1] Table 2 of the Work Plan for Soil Vapor Extraction (SVE) was most recently updated on April 4, 2011, to include the results of four additional soil borings that were conducted in the North Tank Farm area on January 19, 2011.

7. **Completion of BV Operations** - Based on the performance of BV within the intermediate silty clay unit, a recommendation will be made to U.S. EPA regarding shutdown of BV operations.
    a. BV is not expected to yield appreciable results after one year. If, after two years of BV, no significant reduction in COC mass has occurred within the intermediate silty clay, it will be recommended to shut down the BV operations.
    b. COC mass reduction in the intermediate silty clay unit will be assessed annually using the soil sampling data. An assessment will be made regarding the benefit, if any, of ongoing BV operation.
    c. Prior to shutdown of BV operations, the impact, if any, of residual COC mass will be assessed:
        i. Modeling will be conducted to evaluate potential impact to groundwater posed by the remaining COC mass in the intermediate silty clay zone.
        ii. Residual soil concentrations will also be evaluated to determine if there are any potential human health risks and if these are addressed by institutional controls.
    d. If either c.i. or c.ii. above suggests the need, an evaluation will be conducted to determine additional actions to address the remaining residual risks. Additional actions may include monitored natural attenuation (MNA) or additional institutional controls.
    e. Upon approval by U.S. EPA, the BV operations will be shut down. Note that it will be appropriate to recommend shutdown of portions of the BV system in a phased manner as sub-areas and/or specific depth intervals meet the performance criteria.