100% DESIGN
THERMALLY ENHANCED SOIL VAPOR EXTRACTION SYSTEM

AT

FORMER CHLOROBENZENE PROCESS AREA

W.G. KRUMMRICH FACILITY
SAUGET, ILLINOIS

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Executive Summary

XDD, LLC (XDD) has prepared this design document (*100% Design*) for Full-Scale Thermally Enhanced Soil Vapor Extraction for the remediation of unsaturated zone soil impacts at the former Chlorobenzene Process Area (CPA), at the Solutia Inc. (Solutia) W.G. Krummrich Facility in Sauget, Illinois (site). This *100% Design* contains the design basis for implementation and schedule for full-scale Thermally Enhanced Soil Vapor Extraction (T-SVE) treatment. A separate design document has been prepared for the Full-Scale Enhanced Aerobic Bioremediation (EABR) treatment of the saturated zone impacts in the CPA.

Treatment Areas: The area targeted for T-SVE treatment is an approximately 3.5 acre area within the CPA. The target treatment area is shown on **Figure ES-1**. The contaminants of concern (COCs) are volatile organic compounds (VOCs), primarily monochlorobenzene (MCB), 1,2-dichlorobenzene (1,2-DCB), 1,3-DCB, 1,4-DCB, 1,2,4-trichlorobenzene (1,2,4-TCB), and benzene. The total COC mass in the target treatment area is estimated at 440,000 pounds (lbs).

Geology and Hydrogeology: The target depth interval for the T-SVE treatment is within the unsaturated portion of the Shallow Hydrogeologic Unit (SHU), between ground surface and 15 feet below ground surface (feet bgs). The unsaturated zone consists of the three major layers:

- Sandy fill/upper silty sand layer: This layer generally extends down from ground surface to between 4 and 10 feet bgs.
- Intermediate silty clay layer: This layer generally ranges in thickness between 4 and 12 feet and the top of this layer is generally encountered at depths ranging from approximately 4 to 10 feet bgs.
- Lower silty sand layer: This layer is encountered below the intermediate silty clay and is encountered at depths ranging between approximately 10 and 18 feet bgs.

Groundwater levels in the treatment areas 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 in groundwater levels, it is anticipated that portions of the lower silty sand layer will be submerged seasonally.

Overview of T-SVE Design and Operational Strategy: T-SVE will be implemented using a dual-level SVE and Air Injection (AI) well network (i.e., shallow and deep well screens). The shallow SVE/AI wells will be designed to target the upper sandy fill/silty sand unit (referred to as the "**shallow**" zone). 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 (referred to as the "**deep**" zone). The intermediate silty clay layer will not be directly targeted by the T-SVE system because it has a low permeability and is not amenable to soil vapor extraction technology. All wells will be installed on an approximate 40-foot center-to-center grid spacing.

AI/Steam Injection System: A mixture of steam and air will be injected through the AI wells to heat the subsurface soils to a target temperature ranging between 40 and 60 degrees Celsius ($^{\circ}C$). This will increase the volatility of the target COCs and increase mass removal rates. The AI will also improve subsurface air flow distribution for more uniform treatment of the soils. The AI system will have the capacity to inject air at up to 50 standard cubic feet per minute (scfm) per well at pressures up to 60 inches of water (in. H_2O) up to a total capacity of approximately 2,000 scfm. The volume of steam added to the injection air will be optimized based on soil heating performance. An insulating concrete cap will be installed to reduce heat losses to the atmosphere.

SVE System: The SVE system will have the capacity to extract vapors at approximately 25 to 30 scfm per well (total capacity approximately 3,000 scfm). The SVE portion of the process will extract the heated vapors containing COCs, and the vapor stream will be treated using a thermal oxidizer unit prior to discharge to the atmosphere. During thermal oxidation of the COCs, acid-gas vapors will be formed. Therefore, an acid-gas scrubber unit will be included to remove the acid-gases that are created during the thermal oxidation of the target COCs.

Bioventing Mode: Upon completion of the T-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 T-SVE equipment will be modified as necessary to perform BV operations. The T-SVE design summary is presented in **Table ES-1**.

Table ES-1: T-SVE System Design Summary

Well	**Shallow Wells**	**Deep Wells**	**Nested Vapor Probes**	**Average Well Head Flow Rate**	**Average Well Head Vacuum / Pressure**	**Total System Flowrate**
	4-9 feet bgs	10-15 feet bgs	5-6 feet bgs 12-13 feet bgs	(scfm)	(in. H_2O)	(scfm)
SVE	39	43	23	25 to 30	-50	3,000
Combination SVE/AI	61	61		50	+60	2,000

Remediation Objectives: The remediation objective is to reduce the COC mass within the former CPA at the site. The primary indicator that the remediation objective has been achieved will be based on attainment of an asymptotic mass removal rate condition, defined as the COC mass removal rate being less than 10% of the observed peak rate for at least seven consecutive days. Annual soil sampling data to assess COC mass reduction on the soils, and the cumulative COC mass removal estimates from the T-SVE system will also be evaluated, and will be considered as lines of evidence in support of the remediation objective.

T-SVE Shutdown and Potential Transition to BV Mode: When the T-SVE system achieves an asymptotic mass removal condition, there will be little additional benefit of continuing T-SVE operations. At that 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:

- 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 shut down the T-SVE system.
- If the risk evaluations indicate the need for further action, and BV can potentially address the residual risk, then a transition to BV would be recommended.

A report will be prepared for the United States Environmental Protection Agency (USEPA) making the appropriate recommendation to either shut down the T-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 T-SVE system operations to evaluate overall vapor concentrations and track COC mass removal rates over time. The performance data (flowrates, vacuums/pressures, temperatures, VOCs concentrations, etc.) will be used to optimize the system operation. The system optimization strategies will include:

- Adjustment of steam injection ratios for the initial soil heating phase, and/or to maintain the desired subsurface temperatures during operation.
- Conducting static soil-gas rebound surveys to determine which portions of the treatment area have achieved adequate COC mass reduction.
- Maximizing VOC mass removal rates by focusing on T-SVE wells within areas of higher vapor concentration/vapor production.

Wellfield vapor concentrations will also be periodically evaluated (using vapor probes or the T-SVE wells under either dynamic [i.e., system on] or static [i.e., system off] conditions) to assess the progress of the remediation. Soil sampling will also be conducted annually during the operation for each area to assess the overall COC mass reduction.

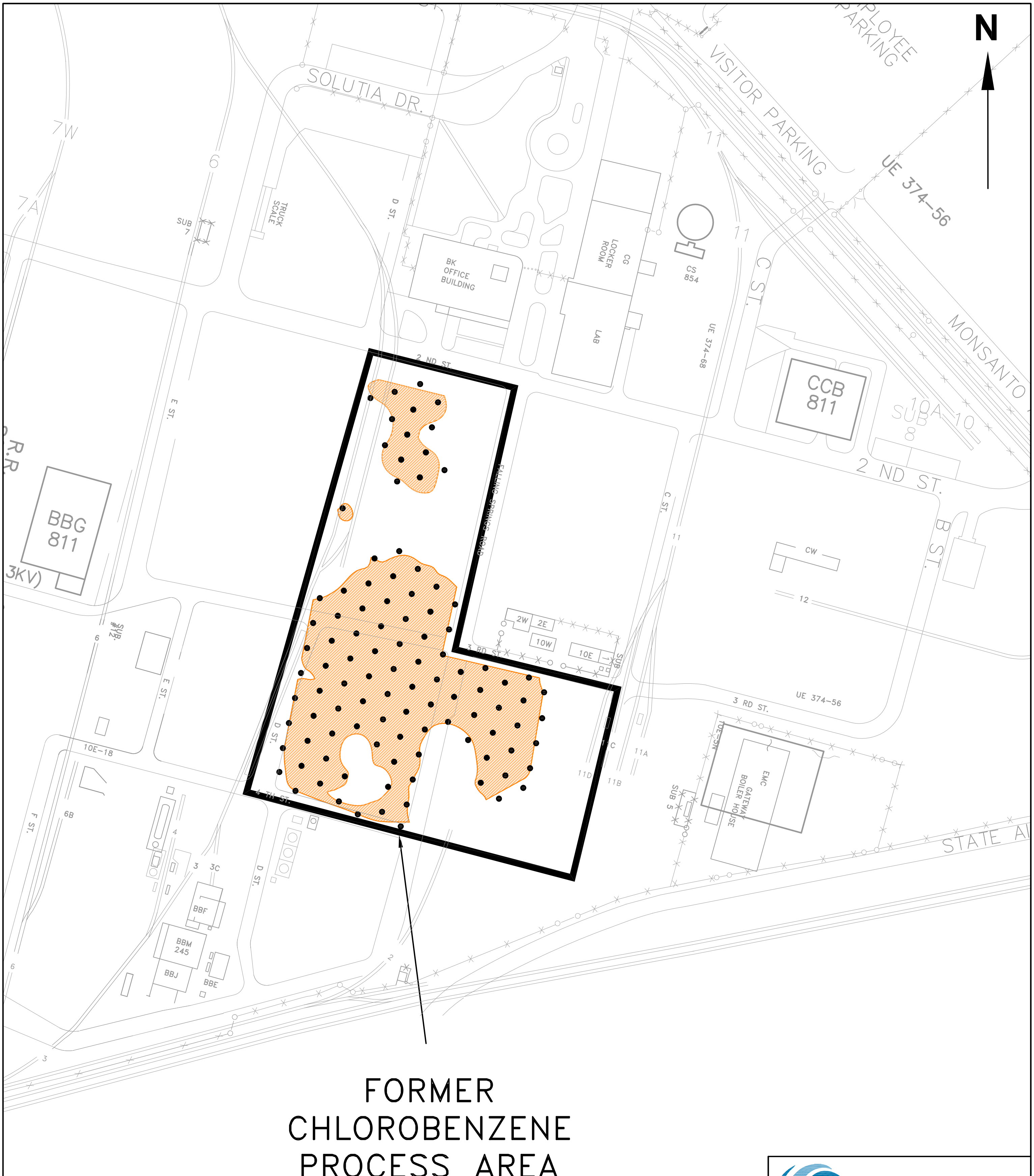
Another key aspect to the operation strategy of the T-SVE system will be performing regular monitoring of the site groundwater levels. The objective of this monitoring is to determine when water levels drop sufficiently to expose the lower silty sand layer, and then take the opportunity to reconfigure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

Schedule: The T-SVE system is anticipated to begin operation by the beginning of 2012 and operate for up to four years. The project schedule is summarized in **Table ES-2**.

Table ES-2: Summary of Project Schedule

Task Description	Dates
T-SVE Implementation	
• Design and Submittal of 100% Design to USEPA	Submittal November 2011
• Permitting	October-December 2011
• Construction	September-March 2012
• Construction Completion Report	Submittal April 2012
• T-SVE Operation	March 2012-July 2016
• Soil Sampling	March 2013-March 2016
• T-SVE Shutdown / Transition Evaluation	March 2016-May 2016
• T-SVE Shutdown / Transition Recommendation Report	Submittal May 2016
• USEPA Review of T-SVE Recommendation Report	May-July 2016
Transition to BV (if applicable)	
• BV Operation	August 2016-August 2020
• Soil Sampling	August 2017-August 2020
• BV Shutdown Evaluation	August 2020-December 2020
• BV Shutdown Evaluation Report	Submittal December 2020
Demobilization/Decommissioning	**December 2020-February 2021**

EXECUTIVE SUMMARY FIGURE



0–15 FOOT INTERVAL COC EXCEEDANCE AREA

SVE, SVE/AI WELL LOCATIONS

STRATEGIC. ENVIRONMENTAL. SOLUTIONS.

SCALE: AS SHOWN	TITLE: SITE PLAN W.G. KRUMMRICH FACILITY SAUGET, IL
DATE: OCTOBER 2011	
PROJECT NO.: 11003	
CLIENT: SOLUTIA INC.	
DRAWN BY: ELS	DRAWING NO.: FIGURE ES–1
CHECKED BY: DK	REV: 1
PROJ. MGMT. APPROVAL: SC	

1.0 INTRODUCTION

This design document (*100% Design*) provides the drawings and specifications for the Thermally Enhanced Soil Vapor Extraction (T-SVE) System for treatment of the former Chlorobenzene Process Area (CPA) at the W.G. Krummrich Facility in Sauget, IL (see **Figure 1**).

T-SVE will be applied to the unsaturated zone soils in the CPA. A separate technology, Enhanced Aerobic Bioremediation (EABR), will be used to treat the saturated portion of the CPA. A separate design document has been prepared for the full-scale EABR treatment.

The following information is including in this *100% Design* document:

- Site background information, including a summary of geology, hydrogeology, and distribution of the contaminants of concern (COCs) within the former CPA.
- Overview of the remediation approach, including the conceptual design basis, remedial goals, and shut-down protocols.
- Design drawings for the following components:
  - Subsurface well layouts, well construction details, and system manifolding.
  - Process equipment design details including extraction/injection blower skids, air controls, and water treatment equipment.
  - Utility specifications (electrical, water, sewer, steam and natural gas).
  - General infrastructure (equipment building, area barricading, insulating cap, etc.).
- General Operations, Maintenance, and Monitoring (OM&M) protocols.
- Anticipated project schedule.

1.1 SUMMARY OF REMEDIATION APPROACH

T-SVE will be implemented within the unsaturated portion of the Shallow Hydrogeologic Unit (SHU) (approximately 0 to 15 feet below ground surface [bgs]) using a dual-level SVE and Air Injection (AI) well network (i.e., shallow and deep well screens). 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 T-SVE system because it has a low permeability and is not amenable to soil vapor extraction technology. Refer to **Section 2.3** for a more detailed description of the geology within the T-SVE target interval.

A mixture of steam and air will be injected through the AI wells to heat the subsurface soils to a target temperature ranging between 40 and 60 degrees Celsius (°C) to increase the volatility of the target COCs[1]. A light-weight insulating concrete cap (12-inches thick) will be installed over the target area to reduce heat loss to atmosphere. The AI will also improve subsurface air flow distribution for more uniform treatment of the soils. The SVE portion of the process will extract the heated vapors containing COCs, and the vapor stream will be treated using a thermal oxidizer (ThermOx) prior to discharge to the atmosphere.

Upon completion of the T-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 the low permeability layers of the unsaturated zone.

[1] At ambient subsurface temperatures (typically 10°C), the volatility of MCB and DCB is relatively low (refer to **Appendix A** for contaminant properties). By adding heat to the subsurface, the volatility of MCB and DCB would increase, which improves the mass removal rates.

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

The remediation objective is to reduce COC mass within the former CPA at the site. Attainment of objectives will be based upon consideration of the following lines of evidence:

1. Asymptotic Mass Removal Rate: The primary indicator that the remediation objective has been achieved will be based on attainment of an asymptotic mass removal rate condition by the T-SVE system. An asymptotic condition will be based upon the observation that the COC vapor mass removal rate is less than 10% of the observed peak rate for a period of seven consecutive days.

2. Total COC Mass Removal Estimates: Once the T-SVE system has reached an asymptotic condition, it is anticipated that COC mass in the soils will have been reduced substantially. Reduction of COC mass in the soils will be estimated using two methods for comparison purposes only (a specific mass reduction target has not been established):

    a. Annual soil sampling data will be evaluated to assess COC mass reduction on the target soils as compared to baseline COC mass estimates.

    b. Cumulative COC mass removal will be estimated from the vapor mass removal rate as determined from the T-SVE operational data.

When the T-SVE system achieves an asymptotic mass removal condition, there will be little additional benefit of continuing T-SVE operations. At that 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:

- 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 shut down the T-SVE system.
- 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 shut down the T-SVE system or transition into a BV mode of operation. Upon USEPA's approval of either recommendation, the appropriate action would be taken.

Process and performance monitoring data will be used to track COC vapor mass removal rates (see **Section 17.1**). Well field vapor concentrations will be monitored and the T-SVE system will be regularly optimized to ensure that the system resources are focused within the areas that yield highest vapor removal rates (see **Section 17.2**). Soil data will also be collected on an annual basis (see **Section 17.3**) to assess remedial performance. The T-SVE shutdown/potential transition to BV protocol is included in **Section 17.6** and **Section 17.7**[2]. Note that it may be appropriate to recommend shutdown of portions of the T-SVE system in a phased manner if sub-areas and/or specific depth intervals meet the performance criteria.

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[2] The shutdown protocol is based upon the memorandum entitled "*Protocol for Completing Thermally Enhanced Soil Vapor Extraction Operations and Potential Transitioning to Bioventing Mode*", November, 2011, XDD, LLC.

1.3 ALTERNATIVE TECHNOLOGY SELECTION

The USEPA originally issued a Final Decision (dated February 26, 2008) requiring Solutia to implement In Situ Thermal Desorption (ISTD) within the CPA. ISTD was proposed to treat both the unsaturated and saturated interval between surface grade and 30 feet bgs. However, based on the results of the ISTD pilot-scale implementation and the preliminary full-scale design efforts conducted between 2009 and 2010, ISTD treatment technology was determined to be cost-prohibitive.

Therefore, the alternative remedy of T-SVE for the unsaturated zone and EABR for the saturated zone was proposed by Solutia. These alternative technologies were approved by USEPA in a letter to Solutia, dated March 11, 2011. An Explanation of Significant Difference (ESD) memorandum, dated April 26, 2011, was also completed by USEPA to document the decision to change the CPA remedy from ISTD to T-SVE/EABR.

2.0 SITE BACKGROUND INFORMATION

The W.G. Krummrich Facility is a 314-acre facility located at 500 Monsanto Avenue, Sauget, Illinois (**Figure 1**). 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.

The former CPA is located in the central portion of the facility (refer to **Figure 1**). The CPA was previously used for manufacturing monochlorobenzene (MCB) and dichlorobenzene (DCB) between approximately 1926 and 2004. Numerous process tanks and overhead piping runs were present in this area until 2009 when Solutia initiated and subsequently completed dismantlement/demolition of the former CPA unit and associated surface features. The former rail car loading/unloading area located directly east of and adjacent to the CPA (i.e., located directly east of Falling Springs Road) is considered part of the CPA.

The area targeted for T-SVE treatment is an approximately 3.5 acre area. The target treatment area is shown on **Figure 2.** The primary COCs that are targeted for treatment in the CPA include[3] MCB, 1,2-DCB, 1,3-DCB, and 1,4-DCB. Less significant levels of 1,2,4-trichlorobenzene (1,2,4-TCB) and benzene are also present in the CPA. The total COC mass in the target treatment area is estimated at 440,000 pounds (lbs). Refer to **Section 2.2** for a more detailed description of the COC distribution.

[3] URS Corporation, *Former Chlorobenzene Process Area Characterization Report*, February 2010.

2.1 TREATMENT AREA CHARACTERIZATION

Soil characterization was conducted by URS Corporation (URS) in 2009 and 2010 within the treatment area. Soil cores were geologically characterized and field screened using a photoionization detector (PID) for total volatile organic compounds (VOCs). Selected samples were then analyzed for VOCs by USEPA Method 8260B. The results of the soil characterization are presented in the *Former Chlorobenzene Process Area Characterization Report*, by URS, submitted to USEPA in February 2010 (*Characterization Report*).

For the purposes of this design document, the areas for T-SVE treatment are based on the characterization provided in the *Characterization Report*. The extent of the T-SVE treatment area is presented in **Figure 2**, and was based upon the characterization criteria shown below. Note that the saturated zone characterization criteria are shown for informational purposes only (refer to the EABR 100% Design for the saturated zone soil characterization):

COC	Characterization Criteria (mg/Kg)	
	Unsaturated Zone (0-15 feet bgs)	Saturated Zone (15-30 feet bgs)
Chlorobenzene	307	342
1,2-Dichlorobenzene	225	237
1,3-Dichlorobenzene	180	190
1,4-Dichlorobenzene	640	640
Benzene	77	77
1,2,4-Trichlorobenzene	13	13

Notes: mg/Kg = milligrams per kilogram

The treatment areas shown in **Figure 2** were based upon the detailed soil characterization, but areas that are inaccessible to T-SVE technology due to the presence of buildings, roads, railroad tracks, etc., are not proposed for treatment.

According to the *Characterization Report*, approximately 135,000 cubic yards (CY) of soil is impacted above the characterization criteria. This estimate includes saturated and unsaturated zone soils between 0 and 30 feet bgs.

2.2 CONTAMINANTS OF CONCERN

As previously discussed, the primary COCs are MCB, 1,2-DCB, 1,3-DCB, 1,4-DCB, 1,2,4-TCB, and benzene. Chemical properties of these COCs are provided in **Appendix A**.

2.2.1 MAXIMUM SOIL CONCENTRATIONS

The maximum soil concentrations (based on the 2009-2010 soil characterization) are presented in **Table 1**.

2.2.2 MASS ESTIMATES

The COC mass estimates are summarized in **Table 2**. Both the COC mass and the vertical distribution of the COC mass were estimated by URS using the soil characterization data and the Environmental Visualization System (EVC) software (EVS/MVS PRO Version 4.63). The unsaturated zone contaminant mass for T-SVE treatment was estimated over the 0-15 feet bgs interval. The saturated zone contaminant mass was estimated over two depth intervals (15-22 feet bgs and 22-30 feet bgs), and is shown for informational purposes only (refer to the EABR 100% Design for treatment of the saturated zone).

2.3 GEOLOGY AND HYDROGEOLOGY

The soil in the CPA consists of a mixture of silt, sand, and gravel with occasional clay layers, and is generally divided into three hydrogeologic units:

- The SHU (Shallow Hydrogeologic Unit), between the water table (typically 15 to 17 feet bgs) and 35 to 40 feet bgs. The unsaturated zone soils (0-15 feet bgs) above the water table are generally considered part of the SHU.
- The Middle Hydrogeologic Unit (MHU), beginning at approximately 35 to 40 feet bgs and extending down to approximately 55 feet bgs.
- The Deep Hydrogeologic Unit (DHU), between approximately 55 feet bgs and the top of the limestone bedrock at approximately 110 feet bgs. The final 5 feet above the bedrock is characterized as gravel with cobbles.

Three distinct soil units are observed in the upper unsaturated portion of the SHU (0-15 feet bgs):

- <u>Sandy fill/upper silty sand layer</u>. This layer generally extends down from ground surface to between 4 and 10 feet bgs.
- <u>Intermediate silty clay layer</u>. This layer generally ranges in thickness between 4 and 12 feet and the top of this layer is generally encountered at depths ranging from approximately 4 to 10 feet bgs. In at least one area, the intermediate silty clay layer is encountered at 2 feet bgs or less (e.g., in the vicinity of soil borings CPA-30/CPA-48). In some limited areas the intermediate silty clay layer is absent (e.g., near borings CPA-09 and CPA-55).
- <u>Lower silty sand layer</u>. This layer is encountered below the intermediate silty clay and is encountered at depths ranging between approximately 10 and 18 feet bgs. Note that in some areas, the top of the lower silty sand layer is below the average water table

elevation of 15 feet bgs (i.e., near CPA-48, CPA-63, etc.), and therefore, will not be targeted by T-SVE (EABR will be used to treat depths below 15 feet bgs).

The T-SVE system will be designed to target the sandy fill/upper silty sand and the lower silty sand layers. The intermediate silty clay will not be directly targeted with T-SVE technology.

The saturated portion of the SHU that is targeted for EABR treatment (i.e., 15 to 30 feet bgs) generally consists of soils similar to the lower silty sand layer, which transitions to fine/medium sands with depth. According to the CPA boring logs, there are indications of clay and silty clay layers (ranging from 2 to 7 feet thick) within the SHU. The top of these clay and silty clay layers are encountered at depths ranging from 18 to 26 feet bgs.

2.3.1 GEOLOGICAL CROSS-SECTIONS

Geological cross-sections for the treatment area are presented in the following figures:

- **Figure 3 –** Cross-Section A-A’
- **Figure 4 –** Cross-Section B-B’
- **Figure 5 –** Cross-Section C-C’

2.3.2 GROUNDWATER LEVEL TRENDS

Groundwater levels within the treatment areas are directly influenced by the Mississippi River, located approximately one mile west of the site. Since 2008, groundwater levels have been 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 drier conditions will occur that will allow T-SVE to be applied within the deeper target intervals ,up to 15 feet bgs[4].

As shown in **Table 3**, several of the existing monitoring wells in or near the CPA indicate that the water table elevation is between 6.2 and 13.8 feet bgs as of April 2011. The locations of the existing monitoring wells are shown on **Figure 2**.

Additional piezometers will be installed in the CPA as part of the EABR remedy. Refer to the EABR 100% Design for more details on the piezometers.

[4] XDD, LLC. *Work Plan for Full-Scale Soil Vapor Extraction,* November 2010.

3.0 T-SVE DESIGN BASIS

A description of T-SVE technology and the design parameters used to develop the full-scale design are provided in this section.

3.1 DESCRIPTION OF T-SVE TECHNOLOGY

The T-SVE remedy involves the use of standard SVE technology along with thermal enhancement (refer to **Section 3.3** for a discussion of thermal enhancement component of this remedy).

Standard SVE is an in-situ remediation process designed to remove VOCs from unsaturated zone soils by inducing air flow through the soil pores. Air flow is induced by creating a vacuum at the well screens within the target treatment interval(s). The VOCs partition into the air stream as it passes through the soil pores, and the air containing VOCs is subsequently extracted at the SVE well screens.

As air is extracted from the subsurface by the SVE system, air will be drawn down from the surface towards the well screens (i.e., infiltration of atmospheric air). Pore air will also be drawn laterally from the outer edges of the well field, but wells in the interior portions of the well field may receive mostly atmospheric air infiltration. The amount of air infiltration from the surface may be limited by low permeability soil layers (e.g., such as the intermittent silty clay layer above the lower silty sand unit in the CPA, and/or the insulating concrete cap). This can result in competition for air between the SVE wells in the interior of the well field. The competition for air between wells increases the required well head vacuums and decreases the overall flushing rate of air in the subsurface.

In this case, AI is used to supplement the SVE system to improve the subsurface air flow distribution, and provide fresh air to volatilize the target COCs. AI is particularly advantageous for the lower silty sand layer because the overlying intermediate silty clay unit could potentially limit the amount of surface air infiltration, and affect SVE performance[5].

The target COCs in the CPA are considered volatile; however, their volatility is somewhat low for standard SVE/AI technology. The low volatility of these compounds can result in lower mass removal rates, which can extend the expected remediation timeframe. Therefore, heat (i.e., using steam) will be added to the subsurface to increase the volatility of the target COCs. This will make the mass removal process more efficient and potentially reduce the timeframe to achieve the remedial goals (see **Section 3.3**).

3.2 SVE/AI CONCEPTUAL DESIGN BASIS

A SVE/AI (non-thermally enhanced) pilot test was conducted in the Big Mo area of the site in 2009-2010 (located southwest of CPA). For the purposes of this design, it was assumed that the subsurface air-flow characteristics in the CPA are similar to the Big Mo area of the site since their soil types are similar.

The SVE/AI well flowrates, wellhead vacuums/pressures, anticipated Radius of Influence (ROI) and well spacing is based upon the 2009-2010 SVE pilot test and the Big Mo SVE system design[6,7].

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[5] XDD, LLC. *Soil Vapor Extraction Pilot Test Report*, November 2010.

[6] XDD, LLC. *Soil Vapor Extraction Pilot Test Report*, November 2010.

[7] XDD, LLC. *Work Plan for Full-Scale Soil Vapor Extraction,* November 2010.

- Radius of Influence: The T-SVE well network is based upon an ROI of 20 feet at 25 to 30 standard cubic feet per minute (scfm) per well.

- Well Spacing: Using the above design ROI, the SVE/AI well grid was designed with an approximate 40-foot center-to-center well spacing.

- Target Depth Intervals: The T-SVE system is designed to treat the sandy fill/upper silty sand and lower silty sand layers (refer to **Section 2.3**). The sandy fill/upper silty sand layer is generally referred to as the "**shallow**" treatment interval. The lower silty sand layer is referred to as the "**deep**" treatment interval. The intermediate silty clay layer is a low permeability layer which will not be directly targeted during the T-SVE treatment. Separate SVE/AI wells (shallow and deep screen intervals) will be installed in the shallow and deep soil layers.

- Air Flow Capacity of SVE/AI Systems: The SVE/AI system is designed with a total air flow capacity to operate using up to one-half of the well screens at a given time (i.e., a combination of shallow/deep wells, each operating at the average wellhead design flowrates). As discussed in **Section 2.3.2**, seasonal fluctuations of the water table will likely allow only intermittent operation in the lower silty sand layer. Therefore, it is more cost effective to design the SVE/AI system with a capacity to generally focus on one target layer at a time (i.e., shallow versus deep zones), since approximately half of the well screens will be submerged during portions of the year.

- System Flexibility/Optimization: Even though the total capacity of the system is based on operating up to one-half of the well screens at a given time, the SVE/AI wellhead valve control system is designed to be flexible. The SVE/AI system can be configured using the wellhead valves to distribute system flow capacity into any combination of shallow and deep wells simultaneously, as water levels allow. As the system is optimized (refer to **Section 17.2**), the SVE/AI system resources can be focused on the shallow and/or deep soil hot-spots, as needed, to maximize treatment. As treatment progresses, those areas which have achieved cleanup can eventually be taken offline, and the system resources can then be refocused in other areas and/or depth intervals.

3.3 SOIL HEATING MODEL

The target subsurface temperature for the T-SVE treatment is between 40 to 60°C. This temperature range is designed to increase the volatility of the target compounds to an acceptable range (see **Appendix A** for COC properties).

A computer model simulation was performed to determine the minimum volume of steam required to achieve the desired soil heating range (refer to **Appendix B** for the results). The modeling was also designed to estimate the potential condensation levels from the steam injection.

- Initial Heating Phase: The soils are assumed to be at approximately 10°C initially, so a soil temperature rise of 30 to 50°C will be required. The specific-heat capacity of soils (i.e., heat required to raise the temperature by one degree) requires that a larger volume of steam will initially be required to supply enough heat energy to reach the desired temperature in a reasonable time period. Therefore, the AI/Steam manifold will be designed to allow use of a higher volume of steam (greater than 20% by volume) for the initial soil-heating phase. Heat losses will also be occurring from heat transfer to atmosphere, to the intermittent silty clay layer, and to the underlying groundwater flow below the target intervals. These potential heat sinks were included in the design estimates. An insulating concrete surface cap is included in the design to reduce heat loss to the atmosphere.

- Temperature Maintenance Phase: When the subsurface reaches the desired temperature, the AI system will be reconfigured to use less steam (less than 20% by volume) to maintain subsurface temperatures. The maintenance heat requirement is based upon providing enough heat energy to balance the potential heat-losses (i.e., heat loss across the insulating cap to atmosphere, etc.). This will be optimized during operation of the system to maintain the subsurface temperatures within the target 40 to 60^{o}C range.

4.0 SYSTEM DESIGN OVERVIEW

The remediation approach consists of soil heating to enhance the volatility of the target COCs (via injection of a mixture of steam and air through injection wells), and SVE to remove the heated contaminant vapors. The extracted vapors will be treated using a thermal oxidizer (ThermOx). The effluent vapor discharge from the ThermOx will contain hydrogen chloride (HCl gas) from the combustion of the chlorinated COCs, which will require additional treatment using an acid-gas wet-scrubber unit. Condensate generated by the SVE system will be treated using an air stripper (AS) unit prior to discharge to the on-site sewer system. 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 PROCESS FLOW

The T-SVE Process Flow Diagram (PFD) is shown in **Figure 6**, and the key design elements of are outlined below:

- T-SVE Wells: The system will include a dual-level SVE and AI well network (i.e., shallow and deep well screens). Some wells are designed to operate as combination SVE/AI wells (i.e., can be operated in either vapor extraction or air injection modes by configuring the gate valves provided for each well head). By configuring the combination SVE/AI wells in either mode, subsurface air flow patterns can be modified. The SVE and AI systems will be connected to the respective process equipment using two separate manifold piping systems.

  The SVE/AI well grid was designed with an approximate 40-foot center-to-center well spacing (refer to **Figure 7** for the well layout). A summary of the well design is presented in the following table (also refer to **Table 4**).

T-SVE System Wellhead Operating Parameters

Well	Shallow Wells	Deep Wells	Nested Vapor Probes	Average Well Head Flow Rate	Average Well Head Vacuum / Pressure	Total System Flowrate
	4-9 feet bgs	10-15 feet bgs	5-6 feet bgs 12-13 feet bgs	(scfm)	(in. H_2O)	(scfm)
SVE	39	43	23	25 to 30	-50	3,000
Combination SVE/AI	61	61		50	+60	2,000

Notes: scfm = standard cubic feet per minute in. H_2O = inches of water vacuum (-) or pressure (+)
Steam will be added to the AI process stream.

- Air/Steam Injection System: The AI system will include air injection blowers to provide a source of clean air to the subsurface to improve the overall air flushing performance. The AI system will also be used to inject a steam-air mixture to heat the subsurface to a target temperature ranging between 40 and 60 °C to increase the volatility of the target COCs. The steam will be supplied by the existing W.G. Krummrich facility steam conveyance system and will be mixed with the AI process air flow prior to subsurface injection.

  The AI system will have the capacity to inject air at an average flowrate of 50 scfm per well, at pressures of 60 inches of water (in. H_2O). The total system flowrate capacity will be approximately 2,000 scfm. The volume of steam that will be used will be minimized to reduce potential condensation in the soils and to reduce energy usage (actual steam volumes will be optimized to achieve the target soil temperature, and will depend on the quality of steam from the plant supply). An insulating surface cap will be installed to reduce heat losses to the atmosphere. General system operating parameters are summarized in **Table 5**.

- SVE System: The SVE portion of the process will extract the heated vapors containing COCs, and the vapor stream will be treated using a ThermOx unit prior to discharge to the atmosphere. The SVE system will have the capacity to extract vapors at approximately 25 to 30 scfm per well (total capacity approximately 3,000 scfm). General system operating parameters are summarized in **Table 5**.

- Vapor Treatment System – Oxidizer/Scrubber Unit: Air flow from the discharge of the SVE system will be routed to a ThermOx. The ThermOx unit will be used to destroy COCs in the air stream prior to discharge to the atmosphere.

  During thermal oxidation of the COCs, acid-gas vapors (HCl) will be formed. Therefore, an acid-gas wet scrubber unit will be included to remove acid-gases from the process air stream. Blow-down water from the scrubber will be discharged to the facility sewer under permit. A water softener system may be used, if needed, to treat the incoming feed water to the scrubber to reduce water hardness for maintenance purposes.

- Condensate/NAPL Handling System: Condensation that is collected by the SVE system will be separated from the process stream using air-moisture separators (AMS). The condensate will be pumped from the air-moisture separators into an oil-water separator (OWS) to remove potential NAPL from the condensate.

  The condensate water will be pumped to an equalization tank (ET) for subsequent batch treatment using an air stripper (AS) system. The treated condensate will be discharged under permit to the plant sewer system (under permit with the American Bottoms Regional Waste Water Treatment Facility [ABRTF]). The vapor stream from the AS will be routed to the ThermOx unit for treatment.

The NAPL that is separated by the OWS will be collected in the NAPL Tank (NT). The NAPL will then be manually pumped to approved containers (with secondary containment) for characterization and disposal.

4.2 SYSTEM CONTROLS

A programmable logic controller (PLC) will control all automated functions of the T-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.

Other monitoring devices that will be integrated with the PLC program and T-SVE operation will include:

- Vapor Probe Temperature Sensors: Temperature probes/transmitters will be provided for real-time monitoring of subsurface temperatures at selected vapor probe locations. Manual temperature readings will also be collected periodically from the vapor probe networks for optimization purposes (refer to **Figure 7** for the vapor probe locations).

- Water Level Transducers: Because the operation of the T-SVE in the lower silty sand unit will be contingent upon the seasonal fluctuations of the water table, water level transducers will be provided for real-time monitoring of groundwater elevations. This will allow forecasting of conditions and prompt re-configuration of the T-SVE to optimize treatment in the lower silty sand unit. Manual water level readings will also be collected from the piezometer network in the area and will be used for the same purpose (refer to **Figure 7** for the piezometer locations).

- Dissolved Oxygen (DO) Probes/Data Loggers: DO probes/data loggers will be provided for real-time monitoring of aerobic conditions using selected piezometer locations (**Figure 7**). DO readings will be accessible through the PLC and remote monitoring telemetry system.

- LEL Meter: The ThermOx unit will be equipped with a process inlet lower explosive limit (LEL) meter which is set at a maximum of 20% of the LEL for monochlorobenzene (0.26%; 2,600 parts per million by volume [ppmv]). If the process vapor exceeds 20% LEL, the ThermOx unit will shut down, followed by shutdown of the SVE/AI system

- Oxygen Sensors: The EABR system will be introducing pure oxygen into the saturated zone at the same time that the T-SVE system is operating. Oxygen sensors will be provided on the inlet to the T-SVE system to detect if elevated levels of oxygen are entering the system. Elevated oxygen levels could affect the ThermOx unit operation and could be a compatibility issue for the T-SVE equipment. If elevated oxygen levels (i.e., >23.5%) are detected, the entire T-SVE (and EABR) system would be shut down. This alarm will also trigger the audio/visual alarm beacons (one located inside the equipment building, and one located on the exterior of the building) and will send an autodialer alarm message to the appropriate responders.

- Building VOC Monitor and Seismic Monitor: The T-SVE equipment building will be equipped with a PID monitor to detect potential COC vapors within the atmosphere of the building that could result in potential leaks in the system. If vapor concentrations begin to approach 10% of the Immediately Dangerous to Life and Health (IDLH) concentration for dichlorobenzene (10% of IDLH = 15 ppmv), the entire T-SVE (and EABR) system will be shut down. This alarm will also trigger the audio/visual alarm beacons (one located inside the equipment building, and one located on the exterior of the building) and will send an autodialer alarm message to the system operators.

A seismic monitor will also be installed and will shut down the entire system in the event of a significant earthquake.

- Building Smoke Alarm: The T-SVE equipment building will be equipped with a heat/smoke alarm to detect potential fire. If smoke is detected, the entire T-SVE (and EABR) system would be shut down. This alarm will also trigger the audio/visual alarm beacons (one located inside the equipment building, and one located on the exterior of the building) and will send an autodialer alarm message to the appropriate responders.

4.3 SYSTEM CAPACITY AND WELL FIELD FLOW DISTRIBUTION

The SVE/AI system is designed with a total air flow capacity to operate using up to one-half of the well screens at a given time (i.e., using a combination of shallow and/or deep wells, each operating at the average wellhead design flowrates as shown in **Table 5**). This is because seasonal fluctuations of the water table will likely allow only intermittent operation in the lower silty sand layer. Therefore, it is more cost effective to design the SVE/AI blower systems with a capacity to generally focus on one target layer at a time (i.e., shallow versus deep zones), since approximately half of the well screens will be submerged during portions of the year.

Although the total capacity of the system is based on operating up to one-half of the well screens at a given time, the SVE/AI wellhead valve control system is designed to be flexible. The SVE/AI system can be configured using the wellhead valves to distribute system flow capacity into any combination of shallow and deep wells simultaneously, as water levels allow. It is anticipated that the system will be initially started up to focus on the shallow treatment interval. As the water table fluctuates and the lower silty sand layer is exposed, the system can be reconfigured to target the deep interval.

4.4 GENERAL DESIGN CONSIDERATIONS

The following additional considerations were incorporated into the T-SVE system design:

- Freeze protection (heaters and heat trace/insulation on process piping, etc.) for year-round operation.
- Automated systems to decrease operation and maintenance costs.
- Alarm schedule built into the PLC to protect equipment and personnel.
- Chemical compatibility with the COCs and temperature ranges encountered.
- 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.
- Compliance with Solutia safety standards and Occupational Safety and Hazard Administration (OSHA) regulations.

4.5 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 shall 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 DETAILS

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

- T-SVE well and vapor probe locations (**Figure 7**).
- Typical SVE/AI well construction details (**Figure 8**).
- Typical single and nested vapor probe details (**Figure 9**).
- Detailed well construction tables (including well depth and well screen lengths, see **Table 6 and Table 7**).

5.1 T-SVE WELL AND VAPOR PROBE LAYOUTS

The dual-level SVE/AI well layout is based on a 40-foot on center spacing, designed to cover the extent of the COC exceedances within the CPA (**Figure 7**). There is one area where only the deep treatment interval is targeted (near the corner of 4th Street and Falling Springs Road); therefore, only four deep-screened wells will be installed to treat this specific area. A summary of the total number of wells and vapor probes is presented below:

Well Summary

Treatment Interval	**T-SVE Wells**			**Nested Vapor Probes**	
	Screen Interval[1]	**SVE**	**Combination SVE/AI**		
		Well Count	Well Count	Screen Interval[1]	Well Count
Shallow	3-8 feet bgs	39	61	5-6 feet bgs	23
Deep	10-15 feet bgs	43	61	12-13 feet bgs	23

Notes: [1] = Average screen intervals are shown, actual screen intervals will vary depending on actual geology.

Combination SVE/AI Wells: Approximately 60% of the SVE wells will be configured to allow for AI/steam injection. Note that the placement of the combination SVE/AI wells was selected to provide additional heating capability, and to provide flexibility to optimize the injection and/or extraction flow patterns in those areas which exhibit the highest DCB concentrations (i.e., specifically, within the center portion of the CPA which is bisected by 3rd Street).

Vapor Probes: In addition to the T-SVE wells, shallow and deep vapor probes will be installed (see **Figure 7**). The vapor probes will be installed in the shallow and deep target zones to monitor vacuum/pressure distribution, temperature distribution, and soil vapor concentrations. Vapor probe placement was optimized based on the COC distribution to target the most elevated concentrations, and to provide complete coverage of the target area. In addition, several vapor probes are installed as “near” and “far” radius monitoring points from selected SVE/AI locations, to monitor vacuum distribution/heat distribution as a function of radial distance from the SVE/AI wells.

5.2 WELL CONSTRUCTION DETAILS

Typical construction details for the shallow and deep SVE/AI wells and vapor probes are presented on **Figures 8 and 9**. Construction and installation details are presented in **Tables 6 through 8**. Well screen placement will be refined during installation based upon actual geological conditions and COC distribution (to be verified by geological characterization and field PID screening results, refer to **Section 5.3**).

5.2.1 T-SVE WELL CONSTRUCTION DETAILS

In general, shallow well screen lengths will vary between 1 and 7 feet and will be screened from approximately 3 feet bgs to the top of the intermediate silty clay layer targeting the sandy fill/upper silty sand layer, as shown in **Table 6**. Deep well screen lengths will vary between 3 and 5 feet, and will extend from below the intermediate silty clay to approximately 15 feet bgs targeting the lower silty sands.

As shown on **Figure 8**, the SVE wells will be constructed of 2-inch inside diameter (ID), 0.02-inch slotted stainless steel (SS) well screens. The wells will be completed to surface with solid 2-inch carbon steel riser. The filter pack will consist of a #002 sand, or equivalent, which extends a minimum of 0.5 feet above the well screen. A minimum 1-foot granular bentonite seal will be placed above the sand pack. All boreholes will be completed to surface grade with a high temperature compatible cement grout mixture. Well construction materials have been selected to be compatible with the COCs and the elevated temperatures that will be present. All wells will be installed using rotosonic drilling techniques.

5.2.2 VAPOR PROBE CONSTRUCTION DETAILS

The shallow and deep vapor probes will be installed with a 1-foot screened interval. The screened intervals of the shallow and deep vapor probes will generally be installed at the midpoint elevation of the adjacent shallow and deep T-SVE wells.

As shown on **Figure 9**, the vapor probes will be constructed of 1-inch ID, 0.02-inch slotted SS well screens with a one-foot carbon steel sump. The vapor probes will be completed to surface with 1-inch ID carbon steel riser. The filter pack will consist of a #002 sand, or equivalent, which extends a minimum of 0.5 ft above the well screen. A minimum 1-foot granular bentonite seal will be placed above the sand pack. All boreholes will be completed to surface grade with a high temperature compatible cement grout mixture. Well construction materials have been selected to be compatible with the COCs and the elevated temperatures that will be present. All wells will be installed by Boart using rotosonic drilling techniques.

5.2.3 *WELL SURFACE COMPLETIONS*

The wells and vapor probes will be completed to a minimum of 2 feet above surface grade with carbon steel riser pipes. The T-SVE well riser pipes will be completed with 2-inch Female National Pipe Thread (FNPT) adapters.

5.3 GEOLOGICAL CHARACTERIZATION

The placement of the well screen intervals for the T-SVE wells and the vapor probes is based upon prior soil borings conducted within the CPA, and a summary of the depths is provided in **Tables 6 and 7**. The well screen placements will be refined based on the profiles determined from the soil cores obtained during the drilling program.

Continuous soil cores will be collected directly from the rotosonic core barrels from each well location. Soil cores will be examined visually for geological characteristics and logged, and will be compared to existing CPA boring logs by the Project Geologist. The headspace vapors from the soils cores will be analyzed with a PID and will also be recorded.

5.4 WELL DEVELOPMENT

Piezometers will be installed as part of the EABR system monitoring well network (refer to the EABR design document for piezometer locations), and these piezometers will be used to monitor water level elevations to aid configuration of the T-SVE system. Saturated zone wells will be developed using surge block and pumping until the effluent is clear or until five times the borehole volume has been evacuated. Water, sediment, and potential NAPL generated during well development will be handled in accordance with the waste management procedures provided in **Section 5.6**.

5.5 WELL INSTALLATION LOGISTICS

5.5.1 Utility Clearance

The W.G. Krummrich facility utility maps were used to identify the locations of known existing and/or abandoned utilities within the CPA. Well locations/excavation locations have been adjusted to be clear of known subsurface utilities. Hand digging and air-knifing techniques will be used to verify utility clearance in areas of any uncertainty.

5.5.2 Pre- and Post-Drilling Surveying

T-SVE and vapor probe locations will be marked using a flag/stake by a surveyor prior to the start of the drilling program. 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., drilling refusal due to concrete, cobbles, etc.).

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

5.6 DECONTAMINATION AND WASTE HANDLING/DISPOSAL

Soil, groundwater and decontamination fluids will be generated during the work 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 materials will be characterized and 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 an on-site hydrant (requires 24-hour notice to the plant), and will be staged in close vicinity to the decontamination area. Tanks, water handling equipment, and all decontamination supplies will be provided by the drilling contractor.

Primary Decontamination Area: A primary decontamination area will be constructed by the drilling contractor within the CPA, and will include a bermed area with a polyethylene liner, 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 shall 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 and/or roll-offs (e.g., a sump area with pump, etc.).

Temporary Decontamination Area(s): Small pieces of drilling equipment (core barrels, etc.), hand tools, and other miscellaneous equipment that come in contact with soils or groundwater will be decontaminated within a temporary decontamination area. The temporary decontamination areas may be located adjacent to the active drilling operations, and may include 6-mil polyethylene liners/berms, plastic trays, or equivalent. Decontamination of small pieces of equipment will be performed using two water buckets (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 and drums will be staged in the designated area within the CPA. 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 day's activities. Drums will be United States Department of Transportation (USDOT)/United Nations (UN) 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 to the existing waste storage warehouse (BBU Building) located to the 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 lined/covered roll-off containers provided by Solutia. 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.

- Groundwater and Decontamination Water: Impacted liquids from decontamination of equipment and impacted groundwater from well purging/sampling will be contained in 55-gallon USDOT/UN rated 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.

- 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.

- NAPL Segregation: NAPL liquids will be segregated to the extent possible during waste accumulation, and transferred to separate 55-gallon USDOT/UN rated 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.

6.0 MANIFOLD PIPING DESIGN

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

- SVE manifold piping layouts and specifications.
- AI manifold piping layouts and specifications.
- Pipe supports and pipe saddles.
- Expansion joints, clean-outs, sumps, etc. details.
- Condensate traps.
- Pipe head loss calculations.
- Pressure testing requirements.

The layout of the SVE/AI piping is presented in **Figures 10 and 11**. Construction details, including pipe supports, expansion/flex joints, cleanouts and sump details, and steam traps/condensate traps, are presented in **Figures 12 through 15**. Note that process piping inside the equipment buildings and/or connections between the SVE/AI equipment skids and other components are not included in this section.

6.1 SVE AND AI MANIFOLD DESIGN

The SVE and AI manifold piping will provide the connection between the wellhead laterals (see **Section 7.0**) and the process equipment, using two separate manifold piping systems:

- The SVE manifold consists of a single pipeline to connect all of the shallow and deep zone SVE wells.

- Similarly, the AI system consists of a single pipeline to connect to all of the shallow and deep zone combination SVE/AI wells.

Both manifold piping systems include large diameter trunk-lines (12-inch ID and 8-inch ID), and 4-inch ID branch or lateral lines, as shown in **Figures 10 and 11**. The branch lines are labeled as **Legs A through Q**. A summary of the piping headloss calculations are provided in **Table 9**. Piping specifications are listed in **Table 10**. All manifold piping will be installed above ground surface and will be supported by the pipe supports (see **Figure 12**, and **Section 6.2** for more details).

6.1.1 GENERAL MATERIAL COMPATIBILITY SPECIFICATIONS

In general, the SVE and AI manifold piping will be constructed of carbon steel and temperature-rated hoses, since temperatures generated by the aerated steam will exceed 212 degrees Fahrenheit ($^{\circ}$F). Refer to **Table 10** for piping specifications.

General materials of construction are as follows:

- Steel piping will be of carbon steel (minimum Schedule 10) with either butt-weld, threaded, or flanged fittings. Any piping requiring threaded fittings will be Schedule 40.
- Control valves will be of brass body construction with polytetraflouroethylene (PTFE) or Viton® seats/gaskets.
- Seals, gaskets, and seating materials in contact with the target COCs will be of compatible fluoroelastomer (FKM/FFKM) materials (e.g., Viton®, Kalrez®) or PTFE materials (e.g., Teflon®), etc. Thread sealants, including pastes and tapes, will also be of compatible PTFE formulations.
- Flexible hoses will consist of inner tubes of Modified Cross-Linked Polyethylene (XLPE), Ultra High Molecular Weight Polyethylene (UHMWPE), PTFE, or other

chemically compatible material for use with the target COCs. The outer protective tube cover will be Ethylene Propylene Diene Monomer (EPDM), or equivalent protective covering.

- Hose fittings will be of 316 SS construction with PTFE or Viton® seats/gaskets, or carbon steel, as needed.
- Wetted parts of sensors, transducers, transmitters, pressure gauges, flow meters, or any other in-line instrumentations shall be of chemically compatible/temperature compatible materials (brass, SS, PTFE, FKM/FFKM, or approved equivalents).

6.1.2 *GENERAL FITTING ASSEMBLY SPECIFICATIONS*

General Piping Assembly: The piping shall be constructed to the following specifications:

- Flanges shall be equipped with full-faced Viton® or equivalent chemical/temperature compatible gaskets.
- Piping assemblies may be partially pre-fabricated using threaded, flanged, or butt-welded fittings.
- Piping assemblies shall be air-tight.
- Pipe lengths will need to be adjusted in the field to accommodate the actual dimensions of the field assembly.
- Tee connections from the main mainline pipes to the flex-hose connections may be pre-fabricated using flanged, threaded, or butt-weld fittings.
- Straight pipe sections may be joined using butt-welded, socket-welded, or flanged connections.

Control valves and sample ports: The control valves and sample ports will be constructed to the following specifications:

- Control valves/sample ports shall be brass with PTFE or Viton® seats/gaskets. Valves may be threaded, flanged, butt-welded, or socket-brazed connection.
- Sample ports shall be joined to the well riser using a threaded bushing installed in the riser pipe (bushing will be threaded or welded to the pipe).

Pipe Reducers: Pipe size reducers (for transition from large to smaller diameter pipe) will be of eccentric design for the AI manifold. Concentric reducers will be acceptable for the SVE manifold.

Flex Hoses: Refer to **Section 7.1.2** for details of the flex hose expansion/flex joint assemblies.

6.1.3 MANIFOLD PRESSURE TESTING REQUIREMENTS

All manifold piping shall be pressure tested at the completion of the field assembly. The pressure testing requirements are summarized in **Table 11**.

All utility piping and connections (discussed in **Section 15.0**) which are fabricated and installed per Solutia standards (Solutia PMS B3CS2 for the steam line, B1CS2 for the natural gas line, and D1CS1 for the water line) will be inspected and tested as specified in the standard (i.e., Solutia Standard Procedure ESHS 507.11 for pressure and leak testing).

6.2 PIPE SUPPORTS

Pipe supports for the piping sections are detailed in **Figure 12**. Pipe supports will be constructed in accordance with ASME B31.1-2011. Pipe supports will be height-adjustable to account for required pipe slope specifications, and to account for the variable surface elevation of the final site cover (i.e., insulating cap).

Strut channels will be P1000 or P1001-type Unistrut® (1 5/8-inch, 12 gauge steel, green enamel painted), or equivalent.

6.2.1 SUPPORT LOAD CAPACITY

Pipe supports will be of channel strut design (or approved equivalent), and will be fabricated to support the cumulative weight of the T-SVE piping (SVE/AI manifolds), the EABR piping (detailed in the EABR design document), electrical conduit piping, and other utility piping (steam, natural gas, water, etc.).

Horizontal Span Load Capacity: A horizontal span Unistrut® can support up to 1,690 (P1000-type) and 3,130 (P1001-type) pounds (lbs), assuming a uniformly distributed load. This maximum load is based on allowable strut deflection, and assumes a 24-inch maximum horizontal span (load capacity decreases with increasing horizontal span length). This maximum load rating is reduced by a factor of 0.5 for a single concentrated load in the center of the span (e.g., single pipe run). Assuming two concentrated loads (i.e., two pipe runs), which are placed at one-quarter of the horizontal span length from each end (i.e., 6 inches from either end of the maximum 24-inch long span), the load de-rating factor is 1.0.

Vertical Load Capacity (Columns): The maximum vertical load (column orientation) capacity is 3,000 (P1000-type) and 6,190 (P1001-type) lbs.

Hardware/Bracket Load Capacity: Actual pipe support capacity may be limited by hardware load capacity (i.e., slip resistance of channel nut/bolt and type of support bracket), or for welded assemblies, the shear strength of the welds. A ½-inch-#13 thread channel nut/bolt fitting is rated at up to 1,500 lbs vertical load (per the Unistrut® manual).

For bolt/bracket assemblies (assumes supported at both ends of the horizontal span):

- A 90-degree angle, single bolt fitting (P1026-type) will support up to 1,500 lbs (a 0.5 load de-rating factor must be applied for a single, central concentrated load).
- A double bolt gusset type fitting (P2484-type) will support up to 3,000 lbs (a 0.5 load de-rating factor must be applied for a single, central concentrated load).

6.2.2 PIPE SUPPORT SPACING

Approximate pipe support locations are shown on **Figures 7 and 8** (locations may require field adjustment depending on actual construction and surface topography). The recommended maximum pipe support spacing (per ASME B31.1-2001) is presented in the following table:

Maximum Pipe Support Spacing

Pipe Section	**Pipe Size**	**Pipe Weight**[1] (lbs/ft)	**Maximum Support Spacing for Pipe Sag**[2]	**Max. Design Support Spacing**[3] (ft)
Main Trunk Lines	12-inch	24.2	30 feet (23 feet)	20
Main Trunk Lines	8-inch	13.4	24 feet (19 feet)	18[4]
Lateral Lines	4-inch	5.6	17 feet (14 feet)	14[4]
Other Steel Lines	2-inch	2.6	13 feet (10 feet)	10[4]

Notes:
lbs/ft = Pounds per foot.
[1] = Schedule 10, carbon steel pipe.
[2] = Support spacing is carbon steel piping for air, steam, and gas service. Value in parentheses is for carbon steel piping for water/liquid service. Based on recommended spacing per ASME B31.1-2011
[3] = Based on 750 lb capacity, per horizontal support member. Calculated by: L (max. support spacing) = 750 lbs / [1 pipe x pipe weight per foot (lb/ft)] x 0.66 safety factor. Safety factor is for additional allowance for added for weight of fittings, electrical conduits, EABR piping, etc.
[4] = Allowable support spacing based on pipe weight is greater than recommended maximum support spacing for pipe deflection. Therefore, the more conservative support spacing was selected per ASME B31.1-2001.

For purposes of supporting the actual weight of the pipes, and for minimizing pipe sag, the pipe support spacing is based on the following assumptions. A conservative load bearing capacity of 750 lbs, per horizontal support, is based upon the hardware support bracket maximum load capacity of 1,500 lbs, with a 0.5 de-rating factor to account for centered point loads (worst case scenario). An additional safety factor of 0.66 was used to account for fittings, heat trace/insulation, EABR piping, and other ancillary piping (electrical conduits, etc.) that will be supported on the pipe supports. Note that electrical conduits of polyvinyl chloride (PVC) construction will require additional support to prevent excessive sag.

6.2.3 PIPE SADDLES AND ROLLER SUPPORTS

The design of the pipe saddles are shown in **Figure 12**. Pipe supports will be roller-type. Pipe supports include pipe saddles to protect insulation/heat trace from crushing and allow for pipe movement due to thermal expansion/contraction. Pre-insulated saddles may be used.

6.3 MANIFOLD PIPING DETAILS

6.3.1 EXPANSION/FLEX JOINTS

At the connection between the primary trunk lines and the lateral lines (**Legs A-Q**), an expansion/flex joint will be provided to allow for thermal expansion/contraction. The expansion joint design is presented in **Figure 13**.

Flex hoses will be compatible with the COCs and anticipated service temperatures:

- Inner tube will be 4-inch ID and will be of XLPE, UHMWPE, PTFE, or other chemically compatible material for use with the target COCs. Outer protective tube cover will be EPDM, or equivalent protective covering.

- Hoses will be rated for a minimum of 200 psig (at standard operating conditions).
- Hoses will be rated for a minimum of 250 °F service temperature. (Typical pressure de-rating values are 30% for 150 to 225 °F and 50% for > 225 °F).
- Hose fittings may be SS or carbon steel. Hose shank fittings will be double band clamped/crimped with 316SS bands.

6.3.2 CLEANOUTS AND SUMPS

A clean-out access and sump assembly will be located at the terminus of each primary trunk line, and lateral line, as show on **Figure 14**.

6.3.3 CONDENSATE HANDLING SYSTEM

At the terminus of each primary trunk line and lateral line on the AI piping system, a sump, condensate trap-set, and drain will be installed (see **Figure 15**).

The condensate trap set will be of a mechanical float design (Spirax Sarco Model TD52, or equivalent, refer to **Table 10**), and is sized for the anticipated steam condensation rate. Steam condensate will be drained to shallow wells. Steam traps will be heat traced and insulated (per **Section 8.0**, Piping Heat Trace and Insulation).

6.4 WINTERIZATION

The SVE manifold will be heat traced and insulated. The AI manifold will be insulated only. Condensate traps and drain lines on AI manifold will be heat traced and insulated. Refer to **Section 8.0** (Piping Heat Trace and Insulation) for the heat trace and insulation design and specifications.

7.0 WELLHEAD CONSTRUCTION DETAILS

All T-SVE wellheads are designed with valves and sampling ports to allow for flow adjustment and well field optimization. In addition, selected wells are equipped with valves which will allow configuration as either SVE or AI wells (i.e., combination SVE/AI wells). The following construction and installation details are included in this section:

- SVE wellhead design and specifications.
- Combination SVE/AI wellhead design and specifications.
- Lateral piping details for the SVE and combination SVE/AI wells.

Typical construction details for the SVE and SVE/AI wellhead assemblies are described below and presented on **Figure 16**. Specifications are listed in **Table 10**.

7.1 SVE AND SVE/AI WELLHEAD DESIGN

The wellhead assemblies for the SVE and combination SVE/AI wells are shown in **Figure 16**. Lateral piping from the SVE and SVE/AI wellheads to the main manifold piping will be constructed of 2-inch ID carbon steel. Carbon steel will be utilized since it can withstand the anticipated operating temperatures of the air-steam mixture (greater than 212 °F). High temperature-rated flex hose will be used to connect the wellhead laterals to the main manifold, which will allow for thermal expansion/contraction. The SVE lateral connection will be sloped slightly downward towards the main piping manifold to allow condensation to drain, and be collected by the condensate removal systems. The AI lateral connection will be sloped upward, and the flex hose orientation is designed to prevent steam condensate accumulated within the AI main line from flowing into the wellheads.

7.1.1 *GENERAL MATERIAL COMPATIBILITY SPECIFICATIONS*

In general, the SVE and AI well heads and lateral piping will be constructed of carbon steel and temperature rated hoses, since temperatures generated by the aerated steam will exceed 212 °F. General materials of construction are as follows (refer to **Table 10**):

- Steel piping will be constructed of carbon steel (minimum Schedule 10) with either butt-weld, threaded, or flanged fittings. Any piping requiring threaded fittings will be Schedule 40.
- Control valves will be of brass body construction with PTFE or Viton® seals/gaskets.
- Seals, gaskets, and seating materials in contact with the target COCs will be of compatible FKM/FFKM materials (e.g., Viton®, Kalrez®) or PTFE materials (e.g., Teflon®), etc. Thread sealants, including pastes and tapes, will also be of compatible PTFE formulations.
- Flexible hoses will consist of inner tubes of XLPE, UHMWPE, PTFE, or other chemically compatible material for use with the target COCs. The outer protective tube cover will be EPDM, or equivalent protective covering.
- Hose fittings will be of 316SS construction with PTFE or Viton® seats/gaskets, as needed.

7.1.2 *FITTING ASSEMBLY SPECIFICATIONS*

<u>Wellheads and lateral piping</u>: The wellheads shall be constructed to the following specifications:

- If flanged connections are used, the flanges shall be equipped with full-faced Viton® or equivalent chemical/temperature compatible gaskets.
- Wellhead riser/tee/sample-port and steel lateral assembly may be partially pre-fabricated using threaded, flanged, or butt-welded fittings. Steel lateral lengths and riser height will

need to be adjusted in the field to accommodate the actual dimensions of the field assembly.

- Tee connections from the main pipes to the flex-hose connections may be pre-fabricated using threaded, flanged, or butt-weld fittings.
- Wellhead assemblies shall be air-tight.
- Wellheads may be socket brazed or butt-welded to the well risers.

Wellhead valves and sample ports: The control valves and sample ports will be constructed to the following specifications:

- Control valves/sample ports shall be brass with PTFE or Viton® seats/gaskets. Valves may be threaded, flanged, butt-weld, or socket-brazed connection. If flanged connections are used, the flanges will be equipped with full-faced Viton® or equivalent chemical/temperature compatible gaskets.
- The sample ports will be joined to the well riser using a threaded bushing installed in the riser pipe (bushing will be threaded or welded to the pipe).

Flex Hoses: Flex hoses will be compatible with the COCs and anticipated service temperatures:

- Inner tube will be 2-inch ID and will be of XLPE, UHMWPE, PTFE, or other chemically compatible material for use with the target COCs.
- Outer protective tube cover will be EPDM, or equivalent protective covering.
- Hoses will be rated for a minimum of 200 psig (at standard operating conditions).
- Hoses will be rated for a minimum of 250 °F service temperature. (Typical pressure de-rating values are 30% for 150 to 225 °F and 50% for > 225 °F).
- All hose fittings will be 316SS with Viton® gaskets. Hose shank fittings will be double band clamped/crimped with 316SS bands.

7.1.3 PRESSURE TESTING REQUIREMENTS

All wellheads and laterals will be pressure tested at the completion of the field assembly. The pressure testing requirements are summarized in **Table 11**. The mechanical contractor will provide the compressed air supply, temporary fittings, valves, and pressure gauges to conduct the pressure testing.

7.2 WINTERIZATION

The wellheads and lateral assemblies will be heat traced and insulated. The well riser pipe (i.e., from the wellhead tee down to surface grade) will be insulated only. Refer to **Section 8.0** (Piping Heat Trace and Insulation) for the heat trace and insulation design and specifications.

8.0 PIPING HEAT TRACE AND INSULATION

The SVE manifold will be heat traced and insulated. The AI manifold will be insulated only. Condensate traps and drain lines on the AI manifold will be heat traced and insulated. The wellheads and lateral assemblies will be heat traced and insulated. The well riser pipe (i.e., from the wellhead tee down to surface grade) will be insulated only. The water line and sewer line (refer to **Section 15.0**) will also be heat traced and insulated (i.e., portions that are installed above ground).

8.1.1 HEAT TRACE

The heat trace will be self-regulating (SR), thermostatically controlled and consist of industrial series 240 volt (V) or 277 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 °F with a 5 ºF temperature differential. Conductive aluminum heat tape 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 NEMA 3R rating (if installed on the exterior of equipment building). All electrical connections and fittings must comply with the Class I, Division II specification. Light Emitting Diode (LED) trouble lights will be installed at the termination of each strand of heat-trace to indicate a potential electrical fault.

The approximate lengths of the heat tracing for the primary SVE lines are shown on **Figure 17**. Changes in heat trace length may be necessary to account for variation in pipe lengths due to field construction variations.

Water lines and condensate trap assemblies will be heat traced according to manufacturer's recommendations (i.e., number of stands and fitting/valve wrapping specifications will be specified on the size of the respective piping system).

8.1.2 PIPE INSULATION

Insulation and protective jacketing material shall be resistant to long-term exposure to outdoor factors such as cold, heat, and sun exposure.

- Fiberglass Pipe Insulation: Pre-formed tubular fiberglass pipe insulation will comply with ASTM C 547 and will be Class 3 (to 850 °F [454 °C]), rigid, molded pipe insulation, and noncombustible. 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.

- Mineral Wool Pipe Insulation (Steam Lines): Pre-formed tubular mineral wool pipe insulation will comply with ASTM C 547, high temperature insulation (k value of 0.35 at 300 °F. Insulation thickness will be 1.5-inch minimum. Mineral wool insulation will be jacketed with aluminum (0.016" Type T-23003 H-14 sheeting, in accordance with ASTM B209).

9.0 T-SVE SYSTEM DESIGN AND SPECIFICATIONS

The T-SVE system is comprised of the SVE and AI process equipment (refer to **Section 4.0** for a description of the process design). The process equipment is divided into five main components:

- The SVE system to extract heated vapors from the SVE wells.
- The AI system to inject air/steam into AI wells for soil heating.
- The condensate handling system, designed to separate moisture (and potential LNAPL/DNAPL) from the SVE vapor stream, and to provide treatment/discharge of the accumulated condensate.
- PLC and instrumentation specifications, including the control/interlock and input-output schedule for the PLC (discussed separately in **Section 10.0**).
- The vapor treatment system, designed to treat the extracted soil vapor prior to atmospheric discharge (discussed separately in **Section 11.0**).

The following design details and equipment specifications are included in this section:

- Process and instrumentation diagrams (P&IDs) for the SVE and AI systems, including the condensate handling systems, oil water separator, and the air stripper.
- Steam addition/air heating components.
- List of process parts and equipment specifications.
- PLC control logic/interlock tables.

9.1 SVE SYSTEM EQUIPMENT

The SVE system is a high flow, low vacuum system designed to extract the heated soil vapors from the sandy fill/upper silty sand (shallow zone) and lower silty sand layers (deep zone). The system is designed to provide an average of between 25 and 30 scfm per well at up to 50 in. H_2O vacuum at the wellhead (not including piping headloss). The total SVE system design capacity is 3,000 scfm.

The P&ID of the SVE system is presented on **Figure 18** and specifications are provided in **Table 12**. The SVE system will be designed to use three positive displacement blowers (PDB) installed in a parallel configuration. Dividing the total system flow between three blowers has several design advantages:

- Provides redundancy - If a blower requires maintenance or fails, the SVE system can still operate on the remaining blowers.
- Reduces the size of process piping and equipment – At the lower flowrate (approximately 1,000 scfm per blower) individual process piping size is reduced. Additionally, at the lower flowrates (i.e., ~1,000 scfm per blower), standard equipment can be used instead of custom fabricated high volume equipment, reducing capital costs and equipment fabrication lead times.
- Provides long-term cost savings - As overall system flowrates decrease as remedial goals are achieved in portions of the treatment area, some of the blowers can be taken off-line as appropriate, reducing operation and monitoring (O&M) costs.

Each of the three SVE blower skids will include an in-line air particulate filter (APF) and necessary associated valves, fittings, gauges, and sample ports (**Figure 18**). The primary components of the SVE system are described below. All process piping will be constructed of carbon steel or stainless steel.

- Vacuum Blowers – The soil vapor stream will be extracted using PDBs. The PDBs will be designed to extract a total of approximately 3,000 scfm. Each SVE Blower will be a ROOTS™ Rotary Positive Blower (rotary lobe type), rated for 1,000 scfm at 10 inches of mercury (in. Hg) of total dynamic head measured at the enclosure inlet and 0 in. Hg at the enclosure outlet. The electric motors will be totally enclosed, fan cooled (TEFC) motors. The motor will operate at 460 volts, 3-phase power. Each blower is equipped with a muffler/silencer to reduce noise.

- Ambient Air Intake Air Filters/Silencers – A Stoddard, ambient air intake air filter/silencer will be used for each soil vapor stream and will be rated for the flows and vacuums of the blowers.

- In-Line Air Particulate Filters – A Stoddard, high-efficiency APF will be used for each soil vapor stream prior to the downstream blower to remove fine particle solids that could damage the blowers.

- Vacuum Relief Valves – A Kunkle, or equivalent, vacuum relief valve will be installed and set at 16 in. Hg vacuum for each soil vapor stream to prevent excessive system vacuum build-up.

- Pressure Relief Valves – Kunkle, or equivalent, pressure relief valves will be installed on the discharge side of each SVE blower, and will be routed to a vent line equipped with carbon filters and flame arrestors (refer to **Section 9.2.6**). The vent will discharge on the outside of the equipment building.

The final SVE process equipment specifications will be provided by the equipment fabricator, (including blower/compressor model numbers, pump curves, motor specifications, etc.). General specifications are provided in **Table 12**.

9.2 SVE CONDENSATE HANDLING SYSTEM

Condensation that is collected by the SVE system will be separated from the process stream using three separate AMS units in parallel. Condensate (soil moisture and potentially NAPL) collected in the AMS will be automatically transferred to the OWS using float-switch actuated transfer pumps. NAPL will be separated from the condensate and held in an internal storage tank within the OWS. The OWS will be equipped with an LNAPL and DNAPL tank. When the internal NAPL storage tanks in the OWS reaches normal capacity, the DNAPL will be manually transferred into USDOT/UN-approved 55-gallon drums to be disposed of by Solutia. Water from the OWS will be pumped into the ET, and then through the AS unit. After water is treated by the AS unit, it will be discharged to the facility sewer under permit with the ABRTF.

The P&ID for the condensate handling system is presented on **Figure 18** and specifications are provided in **Table 12**. A summary of the design of each primary component of the condensate handling system is described in the following sections.

9.2.1 AIR MOISTURE SEPARATORS

Each SVE process stream will pass through a dedicated AMS. Each AMS is designed with a 240-gallon capacity and is capable of a maximum 10 gallon per minute (gpm) discharge rate to the OWS. All three AMS units are equipped with low-level, high-level, and high-high level sensor switches. The low-level and high-level switches operate their corresponding transfer pumps. The high-high level float is designed to prevent overfilling of the AMS units; and if any of these switches are actuated, they trigger a controlled shutdown of the entire system.

9.2.2 *Oil Water Separator*

The condensate from the AMS units will be pumped through the OWS. The OWS unit is designed to separate potential LNAPL/DNAPL from the condensate collected by the AMS units. The OWS will have a maximum treatment flow capacity of 30 gpm (intermittent/batch flow; 12 gpm continuous flow). The OWS will have a 73-gallon, effluent pump out compartment and integral NAPL storage compartment.

The coalesced NAPL, if any, will be collected in internal LNAPL/DNAPL Tanks. The NAPL Tanks are equipped with high-level sensors that will send an autodialer signal to the system operator when either of the internal NAPL Tanks has reached a pre-determined level (and needs to be drained). A high-high level sensor will detect if the NAPL Tanks have reached maximum capacity and will trigger a full shut-down of the SVE/AI systems, including the ThermOx unit. The NAPL will be drained manually as needed, and will be pumped to an external NAPL storage drum with secondary containment (refer to **Section 9.2.5**).

The OWS will have a passive venting system which will be routed to a vent line equipped with carbon filters and flame arrestors (refer to **Section 9.2.6**). The vent will discharge on the outside of the equipment building.

9.2.3 *Equalization Tank*

A 300-gallon, SS equalization tank will be used to store water discharged from the OWS, and will allow for batch treatment of the accumulated condensate when necessary. The ET will be equipped with low-level, high-level, and high-high level sensor switches which will be interlocked with the AS unit and will control pump on/off status. The high-high level float is designed to prevent overfilling of the tank, and when actuated, this switch signals a controlled shutdown of the entire system. The ET will have a passive venting system which will be routed to a vent line equipped with carbon filters and flame arrestors (refer to **Section 9.2.6**). The vent will discharge on the outside of the equipment building.

9.2.4 AIR STRIPPER UNIT

The water accumulated in the ET will be transferred to the AS system for batch treatment. The treated condensate will be discharged to the sewer in accordance with applicable discharge permits. VOC-impacted air from the AS will be combined with the SVE vapor stream and treated via the ThermOx unit (refer to **Section 11.0**).

The unit will be a NEEP Systems, Inc. (NEEP) Model 2321-P, high density polyethylene (HDPE) Shallow Tray Air Stripper, equipped with two SS stripping trays, and a 3 Hp 460V TEFC electric motor. This model is designed to treat up to 50 gpm with a minimum of 98% removal of chlorobenzenes from the condensate. A flow totalizer unit is installed on the discharge side of transfer pump to monitor the total treated water discharge from the AS system.

9.2.5 NAPL STORAGE DRUM

The NAPL storage drum will be a standard USDOT/UN rated 55-gallon steel drum with two bung openings. The NAPL storage drum will be placed on a secondary containment unit. This assembly is show on **Figure 18**.

The outlet from the OWS internal NAPL tanks are connected to a chemical transfer pump, which will discharge through a chemical-compatible hose system (Transfer Hose) into the NAPL storage drum. The Transfer Hose system will be equipped with ball-valves on each end. The Transfer Hose system will only be connected to the NAPL drum during the actual transfer. During filling of the NAPL storage drum, the drum will be vented using the second bung opening with a flexible piping system connected to a carbon filter vent unit (refer to **Section 9.2.6**). The drum will be supplied with a dedicated electrical grounding clamp, and grounding rod installed by a qualified electrician.

9.2.6 *CARBON FILTER VENTILATION SYSTEM*

The OWS and ET units will be passively vented through a 30-pound granular activated carbon (GAC) drum via flexible hose connections. The discharge of the GAC drum is equipped with a flame arrestor and a PVC pipe discharge stack.

The vent (bung) of the NAPL storage drum will also be temporarily connected to this GAC drum via flexible hose connections (but only during the process of manually filling of the drum) for passive ventilation purposes (see **Section 9.2.5**).

A separate GAC drum unit (with flame arrestor and discharge stack) will be provided for the discharge side of the three SVE system pressure relief valves. This vent system will be completely independent of the vent system used for the OWS, ET and NAPL drums.

9.3 AI SYSTEM EQUIPMENT

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. In addition, the AI system will be used to inject a steam-air mixture to heat the subsurface soils to a target temperature ranging between 40 and 60 $^{\circ}$C. The steam will be supplied by the existing W.G. Krummrich facility steam conveyance system and will be mixed with the AI process air flow prior to subsurface injection. The AI system will have the capacity to inject air at an average of 50 scfm per well at pressures of 60 in. H_2O. The total AI system design capacity is 2,000 scfm.

The P&ID of the AI system is presented in **Figure 19** and specifications are shown in **Table 13**. The AI system will use two compressors installed in a parallel configuration. Two compressors will provide redundancy, reduce the size of associated process piping on each skid, and potentially provide long-term O&M cost savings. Each of the AI process streams will be constructed with the necessary components for independent operation, including an ambient air intake and all associated valves, fittings, and gauges.

The major components of the air/steam injection process equipment are described below. All process piping will be constructed of carbon steel or SS construction.

- Air Compressors – Two PDBs with a total capacity of up to 2,000 scfm will be provided. The pressure capacity will be based upon an estimated wellhead pressure requirement of up to 60 in. H_2O. The electric motor will be TEFC and will operate at 460 volts, 3-phase power. Each blower is equipped with a muffler/silencer to reduce noise.

- In-Line Air Particulate Filter (APF) – A Solberg, high-efficiency APF will be used to remove fine particle solids to prevent damage to the compressor.

- Pressure Relief Valves (air component) – Kunkle, or equivalent, pressure relief valves will be installed on the air injection lines to prevent excessive pressure build-up in the system, and to regulate injection pressure to avoid creating preferential pathways for air movement.

- Pressure Relief Valves (steam component) – Spirax Sarco, or equivalent, pressure relief valves will be installed on the steam injection lines to prevent excessive pressure build-up in the system.

- Steam Inlet – Steam will be blended with the AI process air at variable air-to-steam volume ratios. The steam will be obtained from the existing W.G. Krummrich steam conveyance piping system. A motorized valve will be provided to control the addition of steam, which will be controlled by a temperature transmitter located downstream of the air/steam mixing point. A solenoid shutoff valve (normally closed) will also be included on the steam inlet to shut off the supply in the event of a system shutdown or power failure.

- Steam Condensate System: Some steam will condense within the AI manifold prior to reaching the injection wells. The AI manifold system will be equipped with appropriate condensate traps, drains, and controls to remove condensate from the system to prevent water accumulation and potential pipe blockage. This condensate will not require treatment as it will be clean coming from the W.G. Krummrich plant steam conveyance system.

AI process equipment specifications will be provided by the equipment fabricators (including blower/compressor model numbers, pump curves, motor specifications, etc.). General specifications are provided in **Table 13**.

9.4 SYSTEM INSTRUMENTATION

System instrumentation includes various process indicators, such as flow meters, pressure/vacuum gauges, temperature meters, etc.

9.4.1 MANUAL READ INSTRUMENTATION

Miscellaneous air flow meters, vacuum/pressure, and temperature gauges are located along the system manifold, wellheads and process piping to monitor these operating parameters. In addition, liquid totalizers and sample ports for vapor/liquids are provided in key locations. Instrumentation specifications (e.g., sample ports, direct read vacuum/pressure and flow gauges, temperature gauges, etc.) are presented in **Tables 12 and 13**.

- **Flow Totalizer** (FT) **–** Direct-read water totalizer units to measure total water/condensate discharge from the process (FT 701 is located at the discharge of the AS system).
- **Flow Meters** (FM) – Direct read instruments for measuring vapor flow rates at the specific process location.

- **Hour Meters** (HM) **–** Indicates run time of the associated equipment, and can be used for tracking maintenance schedules or evaluating operational/shutdown time periods.
- **Pressure Indicators** (PI) **–** Direct read instruments for measuring pressure at the specific process location.
- **Sample Ports** (SP) **–** Used to sample liquid or vapor at the specific process location. Some sample ports (such as on the individual wellheads) serve multiple purposes and can be used to measure vacuum or pressures, or can be used to measure wellhead flow rates with portable instrumentation. Selected sample ports on the discharge side of the SVE system and the condensate handling system are spring-loaded/self-closing types to prevent accidental releases due to sample ports left open.
- **Temperature Indicators** (TI) **–** Direct read instruments for measuring temperature at the specific process location.
- **Vacuum Indicators** (VI) **–** Direct read instruments for measuring vacuum at the specific process location.

9.4.2 ANALOG/DIGITAL INSTRUMENTATION

The system will be equipped with electronic sensors to monitor the various systems, and to ensure that the system is operating within design specifications. A summary of the SVE and AI input-output schedule is included in **Table 14**.

The following controls provide measurement of various operational parameters, and transmit these readings (electronically) to the control panel/telemetry system for remote readings.

- **Flow Indicators, Analog** (FIA) **–** These controls are designed to provide an air flow rate measurement and readout (on a digital or analog meter) in the various process piping systems. These controls also transmit the air flow readings to the control panel/telemetry system for remote readings.

- **Flow Sensors** (FS) – These sensors are located on the discharge of the SVE and AI Systems. They are designed to indicate an alarm condition of minimal flow/no flow (due to shutdown of the blowers, break/blockage of the process piping, or improper valve settings). These are flow vane type switches, actuated by the momentum of the air flow within the process piping, and deactivated when the air flow ceases within the respective piping system. These are set with a 30-second delay before arming, to allow the SVE/AI systems to come up to speed when initially started.
- **Temperature Indicators, Analog** (TIA) – These controls are designed to provide a temperature measurement and readout (on a digital or analog meter) in the various process piping systems. These controls also transmit the temperature readings to the control panel/telemetry system for remote readings.
- **Vacuum Indicators, Analog** (VIA) – These controls are designed to provide vacuum measurement and readout (on a digital or analog meter) in the various process piping systems. These controls also transmit the vacuum readings to the control panel/telemetry system for remote readings.
- **Pressure Transmitters/Pressure Switches** (PT/PS) – These are located on the discharge side of the SVE and AI blower systems. These controls are designed to transmit a pressure reading to the control panel/telemetry system, and also to detect over-pressure conditions (due to pipe blockage or improper valve settings in the process piping), which would trigger a system shutdown.

9.4.3 AUTOMATION CONTROLS

Automation controls trigger equipment responses, such as turning liquid transfer pumps on or off, or indicate alarm conditions, such as high liquid levels in tanks. Alarm conditions triggered by these controls are presented in **Table 14**. The status of these sensors can be observed from the control panel/telemetry system for remote tracking purposes.

- **Level Sensors** (LS) - Located on AMSs, OWS/NT, ET, and AS systems. These sensors are designed to trigger the transfer pump cycles (on and off), and to sense liquid levels to prevent overfilling of the various tanks.
- **Motorized Valves/Solenoid Valves** (MV, MBFV, SV) – Motorized valves and solenoid valves will be used to control flow rates and/or provide shut-down of critical portions of the process flow in the event of alarm conditions.

9.5 MATERIAL COMPATIBILITY AND ASSEMBLY SPECIFICATIONS

9.5.1 MATERIALS OF CONSTRUCTION

General materials of construction are as follows:

- Steel piping will be constructed of carbon steel (minimum Schedule 10) with either butt-weld, threaded, or flanged fittings. Any piping requiring threaded fittings will be Schedule 40. Steam piping will be Schedule 80 carbon steel.
- Control valves will be constructed of brass body construction with PTFE or Viton® seats/gaskets.
- Seals, gaskets, and seating materials in contact with the target COCs will be constructed of compatible FKM/FFKM materials (e.g., Viton®, Kalrez®) or PTFE materials (e.g., Teflon®), etc. Thread sealants, including pastes and tapes, will also be constructed of compatible PTFE formulations.
- Flexible hoses, if used, will consist of inner tubes of XLPE, UHMWPE, PTFE, or other chemically compatible material for use with the target COCs. The outer protective tube cover will be EPDM, or SS (for high pressure), or equivalent protective covering.
- Hose fittings will be constructed of 316SS construction with PTFE or Viton® seats/gaskets, as needed.

- Wetted parts of sensors, transducers, transmitters, pressure gauges, flow meters, or any other in-line instrumentations will be constructed of chemically compatible/temperature compatible materials (brass, SS, PTFE, FKM/FFKM, or approved equivalents).

9.5.2 ASSEMBLY SPECIFICATIONS

General Process Piping Assembly: The process piping shall be constructed to the following specifications:

- Process pipes may be joined using butt-welded, socket-welded, or flanged connections.
- Outlets of process piping from each major equipment skid will be threaded or flanged to allow field connection to the field piping at the equipment building. Flanged connections will be equipped with Viton® or equivalent chemical/temperature compatible gaskets.
- Piping assemblies will be air-tight. Equipment will be leak-tested prior to delivery.

Control valves and sample ports: The control valves and sample ports will be constructed to the following specifications:

- Control valves/sample ports will be brass with PTFE or Viton® seats/gaskets. Valves may be threaded or socket-brazed connection.
- The sample ports will be joined to the well riser using a threaded bushing installed in the riser pipe (threaded or welded).

Flex Hoses: Flex hoses will be compatible with the COCs and anticipated service temperatures:

- Inner tube will be 2-inch ID and will be of XLPE, UHMWPE, PTFE, or other chemically compatible material for use with the target COCs.
- Outer protective tube cover will be EPDM, or equivalent protective covering.
- Hoses will be rated for a minimum of 200 psig (at standard operating conditions).

- Hoses will be rated for a minimum of 250 °F service temperature. (Typical pressure de-rating values are 30% for 150 to 225 °F and 50% for > 225 °F).
- All hose fittings will be 316SS with Viton® gaskets. Hose shank fittings will be double band clamped/crimped with 316SS bands.

Pipe Reducers: Pipe size reducers (for transition from large to smaller diameter pipe) will be of eccentric design for the AI manifold. Concentric reducers will be acceptable for the SVE manifold.

10.0 PROGRAMMABLE LOGIC CONTROLLER AND INTERLOCKS

Automated functions of the T-SVE system (specifically the SVE and AI systems shown in **Figures 18 and 19**) will be controlled using a PLC. The system control input/output schedule is provided in **Table 15**. The PLC will control appropriate system responses to alarm conditions, and will use an autodialer to send alarm messages to the system operators.

The vapor treatment system (see **Section 11.0**) will include separate, dedicated PLC systems specifically designed to control the ThermOx and acid-gas scrubber units (supplied by the equipment manufacturer to control the respective units). These dedicated PLCs will be interlocked with the T-SVE system PLC, and will trigger appropriate alarm responses. The EABR system will also have a dedicated PLC to control automated functions, and will be interlocked with the T-SVE system (refer to the EABR design document for more details of the EABR PLC).

10.1 SYSTEM CONTROL SPECIFICATIONS

The main control panel for the T-SVE system will be constructed to NEMA 4X standards. All lights, selector switches, push buttons, and all other panel face-mounted devices will be clearly and properly labeled with white letters engraved on black metal labels. 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.

10.1.1 PROGRAMMABLE LOGIC CONTROLLER

System operation and responses to instrumentation and alarm conditions will be controlled via a High Safety PLC interface (Allen-Bradley Compact GuardLogix or equivalent), which provides redundant processors in the event of a primary system hang-up.

The interlock wiring between the T-SVE, EABR, and ThermOx/Scrubber PLCs, and other external sensors, is shown on **Figure 20.** The seismic switch (SS 701) and two oxygen sensors (OS/OT 001 and 401) will be installed in the T-SVE Equipment Buildings and will be wired to both the EABR and T-SVE PLCs to cause a complete system shut-down if tripped. Additional field wiring will include eleven (11) temperature probes and four (4) water level transducers which will be accessible via the system telemetry (refer to **Figure 21**).

10.1.2 GRAPHICAL USER INTERFACE AND REMOTE TELEMETRY SYSTEM

A Graphical User Interface (GUI) will be used to monitor flows, pressures, and operating temperatures, as well as the position of safety sensors and controls (e.g., pressure switches, level sensors, solenoid valves, etc.). The GUI is a C-More EA7 Touch Panel unit, or equivalent.

A telemetry system will be incorporated to allow remote monitoring of the operational status and process data (i.e., air flowrates, vacuums, pressures, and temperatures, oxygen levels, etc.). A cellular connection will be installed with the PLC for telemetry access. If the telephone connection is lost, the entire system will be shut off and a local light or siren alarm will activate.

10.1.3 AUTODIALER

An autodialer system with battery backup is used to transmit specific system status and alarm conditions to the system operator (per **Table 15**). A cellular autodialer/telemetry line will be installed with the PLC for communications. If the telephone connection is lost, the entire system will be shut off and a local light or siren alarm must activate.

10.1.4 EMERGENCY STOP BUTTONS

Emergency Stop buttons will be provided at the system PLC control panels (1 button), within the building (1 location), and outside the building (1 location). Shutting off the SVE/AI will automatically send a control signal to shut off the ThermOx unit.

10.1.5 THERMAL OXIDIZER LEL METER

The ThermOx unit will be equipped with an inlet LEL meter which is set at a maximum of 20% of the LEL for monochlorobenzene (0.26%; 2,600 ppmv). If the process vapor exceeds 20% LEL, the ThermOx will shut down, followed by shutdown of the SVE/AI system.

10.1.6 BUILDING VOC MONITOR AND SEISMIC MONITOR

A photoionization detector (PID 701) VOC monitor will be provided to monitor the atmosphere within the equipment building. In general, if a PID measurement greater than 1 ppmv is detected, this could indicate a minor vapor or liquid leak within the trailer. If vapor concentrations begin to approach 10% of the Immediately Dangerous to Life and Health (IDLH) for dichlorobenzene (10% of IDLH = 15 ppmv), the system will shut down and the system operators will be notified.

If the VOC monitor detects VOC concentrations in the building, a beacon light/alarm siren will sound to notify personnel of this condition so that proper procedures can be followed.

A seismic monitor (SS701) will also be supplied and will shut down the entire system in the event of a significant earthquake.

10.1.7 AUDIO/VISUAL ALARM BEACONS

Two audio/visual alarm beacons will be installed in the equipment building. One will be inside the building and one will be outside. If a general shutdown/alarm occurs, the strobe light beacon will turn on. If a serious alarm condition occurs (smoke alarm, or VOCs detected in the building, etc.) the strobe and audio siren will turn on, and the system will shut down.

10.1.8 OXYGEN SENSORS

The EABR system (refer to the EABR design document) will be introducing pure oxygen into the saturated zone at the same time that the T-SVE system is operating. Oxygen sensors will be provided on the inlet to the T-SVE system to detect if elevated levels of oxygen are entering the system. Elevated oxygen levels could affect the ThermOx unit operation and could be a compatibility issue for the T-SVE equipment. If elevated oxygen levels are detected, the entire T-SVE (and EABR) system will shut down.

The oxygen sensors will be installed on a sampling loop within the process piping, which will allow vapors to cool and allow for maintenance/calibration operations (refer to **Figure 18 and Table 12**).

10.1.9 VAPOR PROBE TEMPERATURE SENSORS

Eleven temperature probes/transmitters will be provided for real-time monitoring of subsurface temperatures at selected vapor probe locations. The temperature probes will be AquiStar® T16 Smart Sensors, or equivalent. Manual temperature readings will also be collected periodically from the vapor probe networks for optimization purposes. The location of the temperature probes are shown on **Figure 21**.

10.1.10 WATER LEVEL TRANSDUCERS

Because the operation of the T-SVE in the lower silty sand unit will be contingent upon the seasonal fluctuations of the water table, water level transducers will be provided for real-time monitoring of groundwater elevations. Four water level transducers will be provided for real-time monitoring of groundwater elevations and will require an external input for the system PLC (**Table 14**). Inputs to the PLC will be provided for these transducers. This will allow forecasting of conditions and prompt re-configuration of the T-SVE to optimize treatment in the lower silty sand unit. Manual water level readings will also be collected from the piezometer network in the area and will be used for the same purpose. The location of the water level transducers are shown on **Figure 21**.

10.1.11 DISSOLVED OXYGEN PROBES/DATA LOGGERS

DO probes/data loggers will be provided for real-time monitoring of aerobic conditions at 10 selected piezometer locations. DO readings will be accessible through the PLC and remote monitoring telemetry system.

10.2 PROCESS CONTROL STANDARDS

Solutia requires that all controllers, sensors, and electro-mechanical actuated valves which are used to control a process be evaluated and classified in a Level of Protection Analysis (LOPA).

The purpose of the LOPA is to ensure that safety-critical instruments and controls are designed, tested, and/or certified to perform with a required level of reliability (i.e., “Integrity Level” or “IL”). The LOPA evaluation is conducted to assess the safety of the system due to environmental, and/or property damage that could occur as a result of a potential failure of each control/interlock. Based on this assessment, the required IL classification of each control/interlock is determined. A LOPA analysis has already been conducted by Solutia for this system and all of the system controls and interlocks have been classified.

Based on the LOPA assessment, the following requirements are part of this *100% Design*:

Sensors: Sensors include flow, level, temperature, etc. switches and transmitters that are used as part of a Basic Process Control System (BPCS) interlock.

1. Sensor failure must not initiate the hazard, which means the sensor is separate and independent of control functions.
2. The sensor should be certified to IEC61508 with an integrity level claim limit that matches the classification. A BPCS requires an "IL-1". Sensor manufacturers may have certifications other than IEC that may be satisfactory and will be evaluated on a case by case basis.

Final Elements: Final elements include solenoid valves, process valves, dampers, etc. that are used as part of a BPCS interlock.

1. Final element failure must not initiate the hazard, which means the final element is separate and independent of control functions.
2. The final element should be certified to IEC61508 with an integrity level claim limit that matches the classification. A BPCS requires an "IL-1". Final element manufacturers may have certifications other than IEC that may be satisfactory and will be evaluated on a case by case basis.

Controllers: Controllers are programmable controllers that run the system, including the processor and input/output modules.

1. The controller must have redundancy or on-line diagnostics to achieve a PFD (Probability of Failure on Demand Final) = 0.01 and have the program logic and set points password protected.

General Requirements: Sensors, final elements and controllers must fail to a safe state on loss of signal, power or instrument air.

11.0 VAPOR TREATMENT SYSTEM SPECIFICATIONS

The vapor treatment system is designed to treat the extracted soil vapor prior to atmospheric discharge. Air flow from the discharge of the soil vapor extraction (SVE) system will be routed through a ThermOx and acid-gas scrubber prior to discharge to the atmosphere. Refer to **Figures 22 and 23** for a general process schematic diagram of the ThermOx and acid-gas scrubber unit. Refer to **Table 16** for a summary of the ThermOx operating specifications.

The following details and specifications are included in this section:

- P&ID for the ThermOx and acid-gas scrubber unit.
- List of oxidizer/scrubber unit(s) design specifications.
- Estimated natural gas consumption rates.

11.1 THERMOX SYSTEM

The ThermOx vapor treatment system is designed for an initial process flow rate of 4,000 scfm, and will oxidize volatile organic compounds in SVE discharge prior to release. Treated vapors will be discharged under an Illinois Environmental Protection Agency (IEPA) air discharge permit.

The ThermOx design specifications are summarized below:

- One Regenerative Thermal Oxidizer (RTO).
- The ThermOx unit will have a total flow rate capacity of 4,000 scfm.
- The ThermOx unit will be capable of achieving a 98% minimum destruction and removal efficiency (DRE).

- The ThermOx will be equipped with an inlet LEL meter which is set at a maximum of 20% of the LEL for monochlorobenzene (0.26%; 2,600 ppmv). If the process vapor exceeds 20% LEL for chlorobenzene, the ThermOx system will shut down, followed by shutdown of the entire SVE/AI system. The LEL meter will be located on the ThermOx inlet, after the air dilution valve (**Figure 22**).
- The ThermOx unit will be designed to withstand an internal deflagration within the combustion chamber without rupturing through to the exterior of the equipment materials and passing the resultant pressure wave through the discharge stack.
- The ThermOx unit will induce draft, which allows for any leaks in the system to be inward, eliminating any fugitive emissions and making routine operation and maintenance safer.
- Natural gas will be piped from an on-site supply line to fuel the ThermOx unit (refer to **Section 15.1** for utility connection information).
- The ThermOx unit will be constructed with materials compatible with acid-gas vapors.
- Oxygen sensors will be installed in the SVE and ThermOx unit inlets to detect potential elevated oxygen levels resulting from the EABR treatment of the saturated zone. If excess oxygen is present, this will signal the entire SVE/AI system to shut down.
- The ThermOx unit will be designed, built and installed to be in compliance with all applicable NFPA codes.

The ThermOx unit will operate at a temperature of at least 1,500 °F whenever the affected system is generating vapors.

11.2 ACID GAS SCRUBBER

Hydrogen chloride (HCl) is a corrosive gas formed during thermal oxidation of chlorinated organic compounds. Therefore, a wet-scrubber unit will be used to strip the acid-gases that are created during the thermal oxidation of the target COCs. Hydrogen chloride scrubbers incorporate a variety of gas-liquid contacting techniques, including packed beds, spray chambers and water jets. The exhaust of the ThermOx unit will be routed to the wet-scrubber and a water spray (up to 20 gallons per minute) will be used to strip the acid-gas from the air stream. Hydrochloric acid is formed when HCl gas is dissolved in spray water. This water will be discharged to the site sewer under the appropriate permit.

Refer to **Figure 23** for a general process schematic diagram of the acid-gas scrubber unit. The acid-gas scrubber unit will be fitted to the air discharge process stream from the ThermOx unit. Blow-down water from the wet-scrubber will be discharged to the facility sewer under permit.

The general acid-gas scrubber design specifications are summarized below:

- The acid-gas scrubber will be a vertical scrubber with a design capacity of 4,000 scfm.
- The scrubber unit will achieve a 99% minimum hydrochloric acid (HCl) removal efficiency, based on the concentrations estimated below:

Estimated Pre-Treatment HCl Values

Compound	Estimated Maximum Concentration (ppmv)	Estimated HCl Load (pounds per hour)
HCl	2,300	40

- The scrubber unit will be constructed of materials able to withstand acid vapor and be compatible with the temperatures expected to be encountered for a minimum five-year design life.
- The scrubber unit will be winterized with a scrubber heater, heat trace, and insulation.

12.0 EQUIPMENT BUILDING

12.1 EQUIPMENT BUILDING AND EQUIPMENT LAYOUT

The process equipment and components associated with the T-SVE system will be housed in two prefabricated steel shipping containers: one will house the SVE equipment and the other the AI system. The containers and major equipment will be installed west of Falling Springs Road between 2nd and 3rd Streets, as shown on **Figure 25**. Other general specifications are provided in **Table 17**. Refer to **Section 14.0** for electrical details of the containers.

The equipment enclosure will require, at a minimum, the following specifications (**Table 17**):

- Building dimensions: 16 feet wide x 45 feet long x 10-11 feet high
- Conformance to all state (Illinois) and local (Sauget) building and safety codes, as applicable.
- A photoionization detector (PID 701 on **Figure 18** and **Table 12**) VOC monitor will be mounted on the exterior of the housing to monitor the atmosphere within the equipment container/building and will result in a system shutdown and alarm condition should atmospheric concentrations exceed 15 parts per million by volume (ppmv) as chlorobenzene.
- A seismic monitor (SS701) will be installed in one of the enclosures.
- Smoke alarms with audio and visual indicators on the interior and exterior of the housing. The smoke alarms/alarm beacons will be provided as a loose part for the skid option.
- A minimum of two (2) 36" man doors. Man doors will be lockable, capable of fully opening with holdbacks, and 36 inches wide per NFPA 101, Section 7.3.4.1(2) (**Table 17**). The egress must be unobstructed, clearly visible and marked and lighted as needed.
- A minimum of one 72-inch double wide access door with entry sweep and lock.

- 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.
- Two audio/visual alarm beacons will be installed in the equipment building. One will be inside the building and one will be outside. If a general shutdown/alarm occurs, the strobe light beacon will turn on. If a serious alarm condition occurs (smoke alarm, or VOCs detected in the building, etc.) the strobe and audio siren will turn on, and the system will be shut down.
- Interior framed and insulated (R-13), rain/sound insulated hoods for vent fans and fresh air intakes.
- Connections for electrical, natural gas, sewer, water, steam, and phone line systems.
- Interior temperature switch/heat detector/alarm (TSH) is also provided in the event that temperatures exceed design parameters within the building. If the set point is reached inside the building, the entire system will shut down.
- Interior and exterior emergency (E-stop) switches.

12.1.1 *ELECTRICAL SPECIFICATIONS*

Electrical service at 480V will be supplied to the trailer. All circuit breakers, disconnects, and transformers, will be constructed Class I, Division II Standards and will be indicated as such. Electrical schematic drawings detailing proper labeling of all wires, terminals, and all internal and external panel devices will be provided by the fabricator. The following are additional specifications.

- Electrical wiring will meet Class I, Division II standards/NFPA 85.
- Fabrication of electrical panels and connections for 480V power service. A transformer to accommodate the system's 120V electrical needs, and additional 20 amperes of 120V to be wired to the oxygen supply tank.

- Exterior grounding and lightning rod protection to be specified by the contractor and installed in the field by others.
- Fluorescent overhead lighting in accordance with National Electric Code (NEC) illumination requirements.
- Two GFI outlets on each main wall.

12.1.2 *VENTILATION SPECIFICATIONS*

- Thermostatically controlled ventilation with a minimum of 10 building exchanges per hour capacity. During summer months, the interior temperature of the enclosure will be thermostatically controlled with ventilation fan(s) capable of ventilating at a minimum capacity of 10 building exchanges per hour, or a similarly adequate means. The ventilation system must be capable of keeping the interior temperature within the operating limits of all equipment, not to exceed 140 °F.
- Thermostatically controlled electrical heater(s) for thermal protection of the building. The Site location frequently experiences temperatures below freezing (32 °F). Since the enclosure will contain equipment that is temperature-sensitive, a thermostatically controlled heating system will be installed keeping the interior temperature within the operating limits of all equipment as specified, but not below 60 °F. The electrical connection associated with the heater will be pre-wired so it can be easily connected to the electrical breaker panel in the field.
- Vents will be located to discharge above the roofline of the building with sufficient stack height to allow dispersion. Vents will be equipped with rain hats and screens (to prevent animal entry/nesting). All equipment will be leak tested to ensure that oxygen/nitrogen is not leaking into the enclosed building.

12.1.3 *ENCLOSURE NOISE REQUIREMENTS*

The equipment enclosure must include noise dampening materials as required to prevent nuisance noise and provide less than 85 dBA at 10 feet distance where possible. Additionally, all external points of ventilation on the enclosure will be fitted with sound dampening louvers to minimize noise transmission at the Site.

12.1.4 EMERGENCY EYEWASH STATION

One emergency eyewash station will be provided in each equipment container. The eyewash stations will be mounted on one of the two man doors in each container.

12.1.5 FIRE EXTINGUISHERS AND FIRST AID KITS

Multipurpose fire extinguishers (for Class A, B, and C fires) will be maintained within the equipment containers and carried on personnel vehicles at all times. These extinguishers will be capable of extinguishing ordinary combustibles, flammable liquids and gases, and electrical equipment fires. Three 20-pound ABC fire extinguishers will be maintained (one inside each equipment container and one mounted on the power pole closest to the Main Power Panel). Fire extinguishers will be inspected on a periodic basis (per manufacturer’s requirements).

A first aid kit will also be maintained within the equipment containers and will be inspected on a periodic basis to ensure the contents are current.

13.0 INSULATING CONCRETE SURFACE COVER

A light-weight concrete surface cover will be installed at the site to provide thermal insulation and reduce heat losses to atmosphere during the soil heating operations.

13.1 SITE GRADING

The Site will be graded to an approximate 2.0% to 2.5% surface grade to prepare the surface for the installation of the insulating concrete cap. Additional fill material will be used, as necessary, to achieve the required grade elevations in low areas. A 12-inch gravel/crushed stone berm will be built around the perimeter of the treatment areas to be used as a form for the insulating concrete cap installation.

13.2 CONCRETE SURFACE COVER

A concrete surface cover will be installed over the target area, as shown in **Figure 25**. The surface cover will be designed to provide a minimum R-value of 18. The surface cover design calls for a lightweight, cellular concrete mix (25 to 30 pounds per cubic foot [pcf]) material at a minimum of 12 inches thick.

14.0 ELECTRICAL DESIGN

The electrical service for the entire system will originate from the substation to the east of Falling Springs Road (refer to **Figure 26**). Electrical cables will be connected to Substation #1, and will be installed using the existing overhead pipe rack and cable trays, and utility poles, as necessary. A single 13.8 kilovolt (kV) feeder cable will feed a transformer to provide 480 V service for all the equipment. Three power poles will be installed (as shown in **Figure 26**) to provide a drop to the main system power panel (PP-1).

14.1 ELECTRICAL SYSTEM DETAILS

The majority of equipment at the site will operate at 480 V. All equipment inside the containers will be Class I Division II specification (with the exception of some of the AI equipment which may be segregated and electrically non-classified). The electrical loads for the SVE/AI system components are summarized on **Table 18**.

14.1.1 MAIN POWER AND SUB-PANEL LAYOUT

The locations of the main power and transformers to feed all the equipment is shown on **Figure 27**. The main power panel (PP-1) will provide power to various breakers, as shown in the electrical line diagram on **Figure 28**.

14.1.2 SENSORS AND INTERLOCKS WIRING DIAGRAM

The PLC computers for each of the main systems will be interlocked with one another to provide automated control/alarm/shutdown functions. Interlock wiring is shown on **Figure 20** and will include:

- T-SVE PLC connection with the ThermOx PLC.
- T-SVE PLC connection with the Scrubber PLC.
- T-SVE PLC connection with the EABR PLC.

In addition, sensors will be installed in the vapor probes and piezometers within the well field (refer to **Figure 21**) and will be interlocked with the T-SVE PLC, including:

- Eleven temperature probes.
- Ten DO probes.
- Four water level pressure transducers.

14.1.3 MISCELLANEOUS ELECTRICAL CONNECTIONS

Miscellaneous electrical connections are shown in **Figure 27**, and include:

- Lightning rod protection for the ThermOx/Scrubber discharge stack.
- Grounding rods for the panels/subpanels and NAPL drum.

The NAPL drum will require a dedicated grounding rod and clamping system to ground the drum during transfer operations.

15.0 UTILITY SPECIFICATIONS

The following utility services will be installed in the CPA:

- Natural Gas Line: Natural gas is required to operate the ThermOx units. A natural gas connection and pipeline will be tied into the existing plant natural gas supply system.
- Sewer Line: A sewer pipeline and connection to the facility sewer will be installed for discharge of the treated SVE condensate.
- Water Line: A water pipeline and connection to the facility water supply will be installed for operation of the acid-gas scrubber.
- Steam Line: Steam is required to supply the thermal component of the T-SVE system. A steam connection and pipeline will be tied into the existing plant 200-pound steam supply system.

15.1 UTILITY CONNECTIONS

Location of the facility utilities (fire protection systems, natural gas, sewer, water, and steam) and the connections to the T-SVE system are shown in **Figures 29 through 37**. The approximate location of the process equipment building/container is also shown in these figures.

15.1.1 FIRE PROTECTION WATER SYSTEM

As shown on **Figure 29**, there is a fire hydrant located approximately 60 feet from the northeast corner of the equipment area.

15.1.2 NATURAL GAS LINE DETAILS

The ThermOx unit system will be connected to the plant's natural gas supply (connection will be to the MRT gas line and a 2-inch connection will be provided). The location of the connection to the plant's natural gas supply is shown on **Figure 30**. The natural gas pipeline controls/valves and other equipment is shown on the figure. The gas line will be constructed of 2-inch Schedule 40 carbon steel pipe and will be welded construction. Piping materials, specifications, and construction will be in accordance with Solutia's PMS B1CS2 standard**,** and will be pressure/leak tested per Solutia Standard Procedure ESHS 507.11. Materials and construction specifications are provided on **Figure 31**.

The pipeline will be supported on the existing overhead pipe supports running along Falling Springs Road and will be connected at an available tie point near the southern fence line of the property. Portions of the pipeline that will be installed ground level will be protected by 8-foot concrete jersey barriers spaced 4 feet apart.

15.1.3 SEWER LINE DETAILS

The sewer pipeline will connect to the plant's existing sewer 4-F, as shown on **Figures 32 and 33**. The pipeline will carry a maximum flow of up to 35 gpm. The above ground portions of the sewer line will be heat traced and insulated. A sewer pipeline and connection to the facility sewer will be installed for discharge of the treated condensate and for the scrubber discharge. The sewer pipeline will be installed above grade and will be constructed of 2-inch and 3-inch ID, Schedule 80, CPVC, for compatibility with HCl generated by the scrubber system. The sewer line will be labeled with "HYDROCHLORIC ACID" with an adhesive backed weather/UV resistant label.

The sewer line will discharge to the 4-F manhole. The manhole is constructed of concrete and lined with acid brick and vinyl ester (epoxy) coating.

15.1.4 *WATER LINE DETAILS*

The acid-gas scrubber unit requires a water supply for scrubber operations. Water will be supplied from a plant water supply connection shown on **Figure 34**. The water line will be constructed of 2-inch ID carbon steel, and will be heat traced and insulated. The plant water line (6 inch ID) is installed below ground (estimated to be less than 3 feet below grade). A tee connection with a key operated valve will be tapped into the existing line and extended upward above grade. The water line piping details are shown on **Figure 35**.

Piping materials, specifications, and construction will be in accordance with Solutia's PMS D1CS1 standard**,** and will be pressure/leak tested per Solutia Standard Procedure ESHS 507.11.

15.1.5 *STEAM LINE DETAILS*

The thermal component of the T-SVE system will require a mixture of air and steam ("aerated steam").

A steam connection and pipeline will be tied into the existing plant 200-pound steam supply system. The existing plant connection and the steam line piping details are shown on **Figures 36 and 37**. The steam line will be constructed of 2-inch ID, carbon steel piping and will be constructed in accordance with W.G. Krummrich plant requirements.

Piping materials, specifications, and construction will be in accordance with Solutia's PMS B3CS2 standard**,** and will be pressure/leak tested per Solutia Standard Procedure ESHS 507.11.

15.2 PRESSURE TESTING REQUIREMENTS

All utility piping and connections (discussed in **Section 15.1**) which are fabricated and installed per Solutia standards (Solutia PMS B3CS2 for the steam line, B1CS2 for the natural gas line, and

D1CS1 for the water line) will be inspected and tested as specified in the standard (i.e., Solutia Standard Procedure ESHS 507.11 for pressure and leak testing).

15.3 BARRICADES

Concrete barriers will be placed in key areas to protect critical utilities (such as natural gas or steam lines), if required.

16.0 IMPLEMENTATION TASKS

16.1 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.

16.1.1 AIR QUALITY CONSTRUCTION PERMIT AND AIR QUALITY OPERATING PERMIT

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

16.1.2 WATER DISCHARGE PERMIT

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

16.1.3 UNDERGROUND INJECTION CONTROL NOTIFICATION

Injection of steam into the subsurface is subject to the IEPA's Underground Injection Control (UIC) Program. A Class V notification will be submitted for this activity.

16.2 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.

16.2.1 *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.

16.2.2 *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 how to determine when operations are complete.

16.2.3 *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.

16.2.4 *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.

16.3 MOBILIZATION

Staff, materials, and equipment will be mobilized to the site to implement the remediation system, per the schedule as discussed in **Section 18.0**. Basic mobilization and site preparation activities include the following tasks:

- Fabrication of necessary components (blowers, ThermOx unit, AS 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 include a Construction Manager and up to two field technicians. Local subcontractors may also be contracted to perform site construction tasks, as required.

16.4 SITE SECURITY

Portions of the treatment area will be barricaded with concrete barriers, and the equipment buildings will have locking doors. The W.G. Krummrich Plant's Security will be provided with keys to the locks for all gates.

16.5 WELL INSTALLATION

Installation of all SVE/AI wells and vapor probes will be conducted using rotosonic drilling technology. Refer to **Sections 5.1** and **5.2** for a description of the SVE/AI wells and vapor probe construction details.

Drill cuttings will be transferred to appropriate containers, analyzed, and disposed of off-site at an appropriate disposal facility.

16.6 INSULATING CAP INSTALLATION

The insulating concrete cap will be installed by a qualified contractor. The insulating cap will be installed in phases after various sections of wells/vapor probes are installed.

The insulating cap design calls for a lightweight, cellular concrete mix (25-30 pounds pcf) material approximately 12 inches thick.

16.7 MANIFOLD INSTALLATION

A mechanical piping subcontractor will be contracted to install the manifold systems (including all connections between the ThermOx, Scrubber, and other SVE/AI equipment as necessary), and wellhead controls.

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

16.8 EQUIPMENT INSTALLATION

The SVE/AI equipment installation will include set-up and field connections of equipment that has been pre-fabricated by the equipment manufacturer. A mechanical and electrical contractor will be subcontracted for the field piping and electrical connections, respectively.

16.9 SYSTEM START-UP/EQUIPMENT SHAKEDOWN

Equipment shakedown will be performed to ensure all automation and safety controls are fully functional. The equipment shakedown will be performed with the SVE/AI wellfield shut off from the system so that there is no potential discharge during the pre-start testing. The system shake-down activities will include:

- A pre-startup safety review meeting to confirm that the system construction and final installation satisfies the Solutia Process Hazard Analysis (PHA) review.
- Pressure test all major piping.
- Leak-check vapor, liquid, and steam transfer lines.
- Test liquid and vapor treatment systems with clean water and 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, temperature, and water level data.

16.10 SYSTEM OPERATION

The system operation phase will include general operation, monitoring, and maintenance which is discussed in **Section 17.0**.

16.11 SYSTEM DEMOBILIZATION

After completion of T-SVE operations and/or BV operations (refer to **Sections 17.6** and **17.7**), the T-SVE/BV system will be either demobilized/decommissioned.

Well Abandonment: As treatment in each area is completed, the SVE/AI wells and vapor probes will be abandoned per 35 Illinois Administrative Code 920 and other applicable IEPA regulations and guidelines.

Equipment Removal/Salvage: Equipment will be removed and/or salvaged at the end of active operations.

Site Restoration: Prior to demobilizing, rough grading will be performed as needed to maintain adequate drainage, berms or swales constructed for the project will be removed, and the site will be returned to a condition substantially similar to its condition prior to the start of construction.

17.0 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 (refer to **Section 16.2.2**).

The schedule and operational sequence for treatment of the CPA is provided in **Section 18.0**.

17.1 GENERAL SYSTEM MONITORING

The general system operations include routine process monitoring, performance monitoring, and compliance monitoring. The goal of monitoring is to record T-SVE system data to assess the progress towards the remediation objectives. Additional details regarding the system monitoring activities will be included in the OM&M manual (refer to **Section 16.2.2**).

17.1.1 PROCESS MONITORING

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

The process monitoring data will be used to evaluate the mechanical performance of the system to ensure that 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.

17.1.2 *Performance Monitoring*

Performance monitoring data generally includes:

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

The performance monitoring data is used in conjunction with the process monitoring data to estimate the vapor mass removal rates, total mass removed by the T-SVE system, and provide data regarding vapor concentrations remaining in the subsurface.

17.1.3 *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 T-SVE system vapor concentrations to confirm treatment efficiency of the ThermOx, and ensure air permit compliance.
2. Sampling the AS influent/effluent water concentrations, to confirm treatment efficiency of the AS, and ensure water discharge permit compliance.

17.1.4 *Groundwater Level Monitoring*

A key aspect to the operation strategy will be regular monitoring of the site groundwater levels. As of May 2011, water table elevations have been at a historical high, which has submerged the lower silty sand layer. Part of the 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 T-SVE to operate in that zone for as long as possible.

Groundwater levels will be monitored in the treatment areas using nearby monitoring wells during routine site checks (or using remote data-loggers, if desired). Several piezometers will be installed in the vicinity of the treatment area for the EABR system operation which will be used for this purpose. In addition, four pressure transducers equipped with remote telemetry will be installed four monitoring wells to allow for real time monitoring of the water levels by the engineering and project management.

17.2 WELL FIELD OPTIMIZATION

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

- Adjustment of steam injection ratios for the initial soil heating phase, and/or to maintain the desired subsurface temperatures during operation.
- Conduct static soil-gas rebound surveys to determine which portions of the treatment area have achieved adequate COC mass reduction (which would be quantified with soil sampling).
- Maximizing VOC mass removal rates as much as possible by focusing on T-SVE wells within areas of higher vapor concentration/vapor production.

Details and the anticipated intervals of optimization events will be included in the OM&M manual (refer to **Section 16.2.2**).

17.3 SOIL SAMPLING

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 COC mass reduction on the soils over the course of the remediation process. A brief description of the soil sampling program is included in this section. A more detailed soil sampling program, with soil sample counts, depths, locations, and selection criteria, will be discussed in the SAP (refer to **Section 16.2.3**). Soil sampling will be conducted annually.

17.3.1 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 COC mass in each treatment area was based on this data and was discussed in **Section 2.2.2**.

17.3.2 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/AI system, as applicable (refer to the schedule in **Section 18.0**).

17.3.3 FINAL SOIL SAMPLING

Based on process and performance monitoring data, when the SVE/AI system has reached an asymptotic mass removal condition (refer to **Section 1.4**), a final soil sampling event will be conducted to determine the overall level of COC mass reduction on the soils.

17.4 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. Contaminant mass removal rates and totals (as vapor, water, and NAPL).
2. Soil heating performance.
3. Changes in operational parameters of system process equipment (such as increasing or decreasing flowrates, vacuums/pressures, temperatures, etc.) that may indicate changes in the remedial process, or impending maintenance issues.
4. 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.
5. Groundwater level assessment to determine when to configure the systems for operation in the lower silty sandy layers.

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

17.5 STATUS REPORTING

A *Construction Completion Report* will be generated upon completion of the construction phase of the T-SVE system.

In addition, general status reporting will be conducted on a quarterly basis. The 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.
- Soil temperatures and heating performance.
- 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 T-SVE system attains the remedial objectives, an assessment will be conducted to determine if the T-SVE system should be shut down and/or transitioned into a bioventing mode. This is discussed in **Sections 17.6** and **17.7**. A final completion report will be provided to USEPA upon completion of T-SVE/BV operations.

17.6 T-SVE SHUTDOWN PROTOCOL

The T-SVE shutdown protocol is provided in **Appendix C**. The steps in the protocol will provide the basis for a recommendation to USEPA to shutdown the T-SVE system or make the transition to bioventing (see **Section 17.7** for details of the BV transition and conditions for the eventual shut down of the BV operations). T-SVE operations will continue in the CPA until USEPA approval of the corresponding recommendation to shut down or transition to BV.

When the T-SVE system achieves an asymptotic mass removal condition, there will be little additional benefit of continuing T-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.

Upon reaching an asymptotic mass removal condition (as supported by the protocol), the impact (if any) of residual COC mass remaining on soils will be evaluated. These evaluations will include:

1. Modeling to evaluate potential impact to groundwater posed by the remaining COC mass in the unsaturated zone. Note that potential impacts to groundwater from COC mass within the underlying saturated zone (15 to 30 foot interval) will be evaluated concurrently during the EABR performance evaluations.
2. 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.

Based on the results of the above 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 shut down the T-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 USEPA making the appropriate recommendation to either shut down the T-SVE system or transition into a BV mode of operation. Upon USEPA's approval of either recommendation, the appropriate action would be taken.

17.7 TRANSITION TO BIOVENTING

If required, the system will be transitioned to a bioventing mode. The protocol for the potential transition to BV mode, and the evaluation for the eventual shut down of the BV operations, is provided in **Appendix C**.

If the T-SVE system is transitioned to BV, the operations and monitoring of the BV system will be conducted for a minimum of two years (per the protocol), and annual sampling will be conducted within the intermediate silty clay unit to assess COC mass reduction in this unit.

Based on performance of BV within the intermediate silty clay unit, a recommendation will be made to USEPA regarding shutdown of BV operations. If no significant mass reduction is observed in the intermediate silty clay unit after two years of operation, the impact (if any) of residual COC mass remaining on soils will be evaluated. These evaluations will include:

1. Modeling to evaluate potential impact (if any) to groundwater posed by the remaining COC mass in the intermediate silty clay zone.
2. 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.

If either of the above evaluations 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. Otherwise, upon approval by USEPA, the BV operations will be shut down.

18.0 SCHEDULE

This section outlines the anticipated project schedule. The schedule will be dependent upon actual T-SVE system performance. The proposed project schedule is presented in **Figures 38A and 38B**.

In general, it is anticipated that operation will begin in the sandy fill/upper silty sand layers. However, when groundwater levels allow, the systems will be reconfigured to operate in the lower silty sand layer. Refer to **Section 2.3.2** for a discussion of the water level trends in the treatment areas.