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Madison-Kipp Corporation

Soil Vapor Extraction Pilot Test Summary and Phase I System Design

Madison-Kipp Corporation

Madison, Wisconsin

BRRTS No. 0213001569
Facility ID No. 113125320

February 2012

ARCADIS

Soil Vapor Extraction Pilot Test Summary and Phase I System Basis of Design

Madison-Kipp Corporation
Madison, Wisconsin

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Madison-Kipp Corporation

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Date:

February 27, 2012

Table of Contents

List of Acronyms and Abbreviations

CFM	Cubic Feet per Minute
ft bgs	Feet Below Ground Surface
in.H_2O	Inches of Water Column
lbs/hr	Pounds per hour
PVC	Polyvinyl Chloride
PVE	Pore volume exchanges
ROI	Radius of influence
scfm	Standard cubic feet per minute
SVE	Soil vapor Extraction
VMP	Vacuum Monitoring Point
VOC	Volatile Organic Compound
WDNR	Wisconsin Department of Natural Resources

Background

ARCADIS has been retained to assist the Madison-Kipp Corporation with environmental remediation activities at the facility located at 201 Waubesa Street in Madison, Wisconsin (Site) (Figure 1). Investigation and remediation activities at the Site are being conducted under the Wisconsin Department of Natural Resources (WDNR) Bureau for Remediation and Redevelopment Tracking System # 0213001569 and Facility ID # 113125320.

Chlorinated volatile organic compounds, including tetrachloroethene and trichloroethene, are present in soil and groundwater beneath the Site. Additionally, soil gas sampling results indicate vapor phase concentrations are present in the subsurface.

Soil vapor extraction (SVE) has been proposed to reduce the potential risk of vapor intrusion in nearby structures and to evaluate its application for mass reduction in the soil. This summary report has been prepared to describe the methods and results of the SVE pilot test that was conducted on February 9 and 10, 2012; and to outline the basis of design for the Phase I SVE system.

Site Geology

The subsurface at the Site is generally described as surficial asphalt overlying an approximately 4- to 10-foot thick clay layer. These clays have been classified as CH clays, meaning they are of low permeability. Beneath the clay, an approximately 15 to 20 foot fine to medium grained sand unit overlies sandstone bedrock. Fill, including foundry sand, has also been found at the Site.

Site Hydrogeology

The groundwater table is present from approximately 16.5 to 25 feet below ground surface (ft bgs) in either the sand unit or the sandstone. Groundwater monitoring indicates that the general direction of groundwater flow in the shallow soils is to the southwest with a southern flow direction in the deep aquifer.

Soil Vapor Extraction Technology Description

The SVE remedial technology involves inducing airflow in the subsurface with an applied vacuum extraction, enhancing the in-situ volatilization of contaminants and capture of soil vapors. The SVE process uses the volatility of the contaminants to allow mass transfer from adsorbed and dissolved phases in soil and groundwater to the vapor phase, where it is removed under vacuum and discharged to the atmosphere, or treated prior to discharge depending on vapor concentrations. At this site, the purpose of the SVE system is to capture soil vapors which may be present by inducing air flow within the vadose zone.

Airflow is induced in the subsurface by a pressure gradient applied through vertical extraction wells. The negative pressure inside the extraction well will be generated by a vacuum blower, which causes soil vapors to migrate toward the well. To design a SVE system, subsurface airflow pathways and extraction flow rates must be properly understood. The airflow field developed is dependent on many factors: the level of applied vacuum, available screen interval in the vadose zone, porosity, air permeability and its spatial variation, depth to groundwater, quantification of leakage from the ground surface, and subsurface conduits. A typical process flow diagram for the mobile SVE unit is shown in Figure 2.

Soil Vapor Extraction Pilot Test Results

A SVE Pilot Test Work Plan was submitted to the WDNR on February 8, 2012 for review and approval. The work plan was subsequently approved on February 9, 2012. As outlined in the work plan, the objectives of the SVE pilot test were to:

- Collect vacuum and flow rate data to determine full-scale design parameters for a SVE system;
- Determine the effective radius of influence (ROI) for the full-scale system design.
- Collect laboratory vapor samples to estimate the discharge and potential treatment and/or permitting requirements.

Extraction Wells and Monitoring Points

The existing SVE well (SVE-1) was used as the extraction point for the pilot test. Monitoring was conducted at four existing vapor monitoring points (VP-1N, VP-2N, VP-1S and VP-2S) (Figure 3).

Extraction Well

Extraction Well SVE-1, located to the east of the existing facility between the building and the property line, was used as the extraction point for the SVE pilot test. The extraction well was constructed using 2-inch diameter schedule 40 polyvinyl chloride (PVC) riser pipe, and a 2-inch diameter, 10-foot long, 0.010-inch slot, schedule 40 PVC screen. The screen is installed from approximately 4.5 to 14.5 ft bgs.

Vacuum Monitoring Points (VMP)

Four existing VMPs (VP-1N, VP-2N, VP-1S and VP-2S) located along the eastern boundary of the site were used for monitoring during the pilot test. The VMP network for the pilot test consisted of the following:

Table 1. SVE-1 Vacuum Monitoring Network

Point ID	Direction	Screened Interval (ft bgs)	Distance from SVE-1 (ft)
SVE-1	NA	4.5-14.5	---
VP-1N	Southeast	13-15	17.5
VP-2N	Southeast	6-8	18.5
VP-1S	Southeast	13-15	31.0
VP-2S	Southeast	6-8	33.0

Step Test and Constant Rate Test Summary

The SVE pilot testing consisted of three step tests, which were performed by incrementally closing the make-up air valve to determine the change in ROI at different applied vacuums and flow rates, followed by a constant rate test. Each step test was run until a minimum of three successive readings (taken on 15 minute intervals) were obtained which showed no significant change in operating conditions. Upon completion of the step test, the constant rate test began and was conducted until three successive readings (taken on 1 hour intervals) were obtained which showed no significant change in operating conditions. The following summarizes the operating conditions during the pilot testing:

- Step 1 – Vacuum of 20 inches of water column (in.H_2O) and a flow rate of less than 20 standard cubic feet per minute (scfm) (dilution air valve partially closed) was maintained at the Extraction Well SVE-1 wellhead for four consecutive reading (60 minutes). Note that the lowest increment on the wellhead flow meter is 20 scfm, thus an accurate measure of flow could not be obtained during the first and second steps.

- Step 2 – Vacuum of 40 in.H_2O and a flow rate of less than 20 scfm (dilution air valve partially closed) was maintained at the SVE-1 wellhead for three consecutive readings (45 minutes).

- Step 3 – Vacuum of 68 in.H_2O and a flow rate of 40 scfm (dilution air valve fully closed) was maintained at the SVE-1 wellhead for three consecutive readings (45 minutes).

- Constant Rate Test – Conducted under the same conditions as the third step test (68 in.H_2O and 40 scfm at SVE-1, with the dilution air valve fully closed) and was maintained for an additional 3 hours after the conclusion of the third step test.

Baseline differential pressure measurements were collected at Extraction Well SVE-1 and each VMP immediately prior to startup of the system for the first step test on February 9, 2012 and again on February 10, 2012 prior to initiation of the second step. During the step tests, vacuum measurements were taken at Extraction Well SVE-1 and each VMP on 15 minute intervals. During the constant rate test, vacuum measurements were taken at Extraction Well SVE-1 and each VMP at 1 hour intervals. The total flow rate, dilution air flow rate, and applied vacuum at the blower influent were also recorded. Data collected during the SVE pilot test is summarized in Appendix B. Measurement of system parameters during the pilot tests utilized the following equipment:

- Magnehelic vacuum gauges of varying sizes (0 to 10 in.H_2O, 0 to 20 in.H_2O, 0 to 50 in.H_2O, and 0 to100 in.H_2O) were used to monitor vacuum and pressure throughout the vacuum observation well network. The gauges were connected to air tight, valved ports connected to the top of each VMP.

- A flow manifold included an inline flowmeter, temperature gauge, sampling port, and valve. The sampling port on the flow manifold was utilized to obtain vacuum measurements and air stream vapor samples.

- A flow meter on the effluent line measured total system flow rate to account for any make up air used during the pilot study.

- A temperature gauge was used to measure the effluent temperature during operation.

- The SVE and VMP monitoring points were gauged with an electronic water level indicator prior to commencement of the pilot test. No water was detected in any of the points.

Vapor Sampling

Two vapor samples were collected during the pilot testing. The vapor samples were collected using summa canisters and submitted for laboratory analysis of volatile organic compound (VOCs) by United States Environmental Protection Agency Method TO-15. The first sample was collected on February 9, 2012, just prior to shutting down the system at the conclusion of the first step test (approximately 1 hour after startup of the test). The second sample was collected on February 10, 2012, just prior to shutting down the system at the conclusion of the constant rate test. The air make-up valve was fully closed during the collection of both samples to ensure that no dilution of the sample occurred. Analytical data collected during the SVE pilot test is summarized in Table C1 in Appendix C.

Summary of Pilot Study Data

A target vacuum of -0.01 in.H_2O measured at each VMP was selected as the minimum vacuum required to show adequate response from Extraction Well SVE-1. Based on the measured vacuums, all VMPs within 33 feet of the extraction well achieved at least -0.01 in.H_2O at an SVE-1 vacuum of 20, 40, and 68 in.H_2O.

During the pilot test a conservative average flow rate from the system is estimated to be 60 scfm. Based on this flow rate over a duration of 8 hours, and using the pilot test vapor sampling analytical data, the estimated mass of extracted vapors was approximately 0.35 pounds for the duration of the 8 hour pilot test, or an average of approximately 0.06 pounds per hour.

Calculations for the estimated mass of the extracted vapors are provided in Table C2 in Appendix C.

Phase I SVE System Design

Data collected from the pilot test was used to evaluate and calculate the design parameters for the Phase I SVE system, including the required flow rate, vacuum, and ROI of each SVE extraction well. The remedial equipment was sized to match the designed flow rate from each well and vacuum required during Phase I SVE system operation. In addition, analytical data obtained from vapor samples was used to determine if effluent air treatment is required.

The proposed Phase I SVE system has been designed based on the relationship between pore volume exchange rate, ROI, extraction well flow rate, and extraction well vacuum. The pore volume exchange rate determines the air flow rate which must be extracted to achieve design goals. Typical SVE systems operate at one to two pore volume exchanges per day. At a specified pore volume exchange rate, ROI is set based on the achievable flow rate and vacuum parameters. At a larger ROI, the required flow rate and vacuum requirements increase.

In order to provide an effective vapor control system, the Phase I SVE system has been designed to meet the following parameters:

- The basis of design is extraction of two pore volume exchanges (PVE) per day at a 35-foot ROI. Operational parameters to achieve these criteria are estimated to be 32 scfm at 6 in.H_2O at each of the extraction points.

The design calculation sheet for the PVE is included in Appendix D. Based on these design parameters, nine wells spaced 60 feet on center (35-foot ROI with overlap between points) are required to cover the area (Figure 4). Eight new SVE wells were installed the week of February 20, 2012; and will be used in conjunction with existing Extraction Well SVE-1. In general, all SVE wells are 2 inches in diameter and have 10- to 15-foot schedule 40 PVC, 0.010-inch slot, wire-wrapped screens installed approximately 2 to 5 feet above the water table.

In addition to utilizing properly designed ROIs for the soil conditions at the site, the following will be incorporated into the Phase I SVE system to maximize the efficiency of the system:

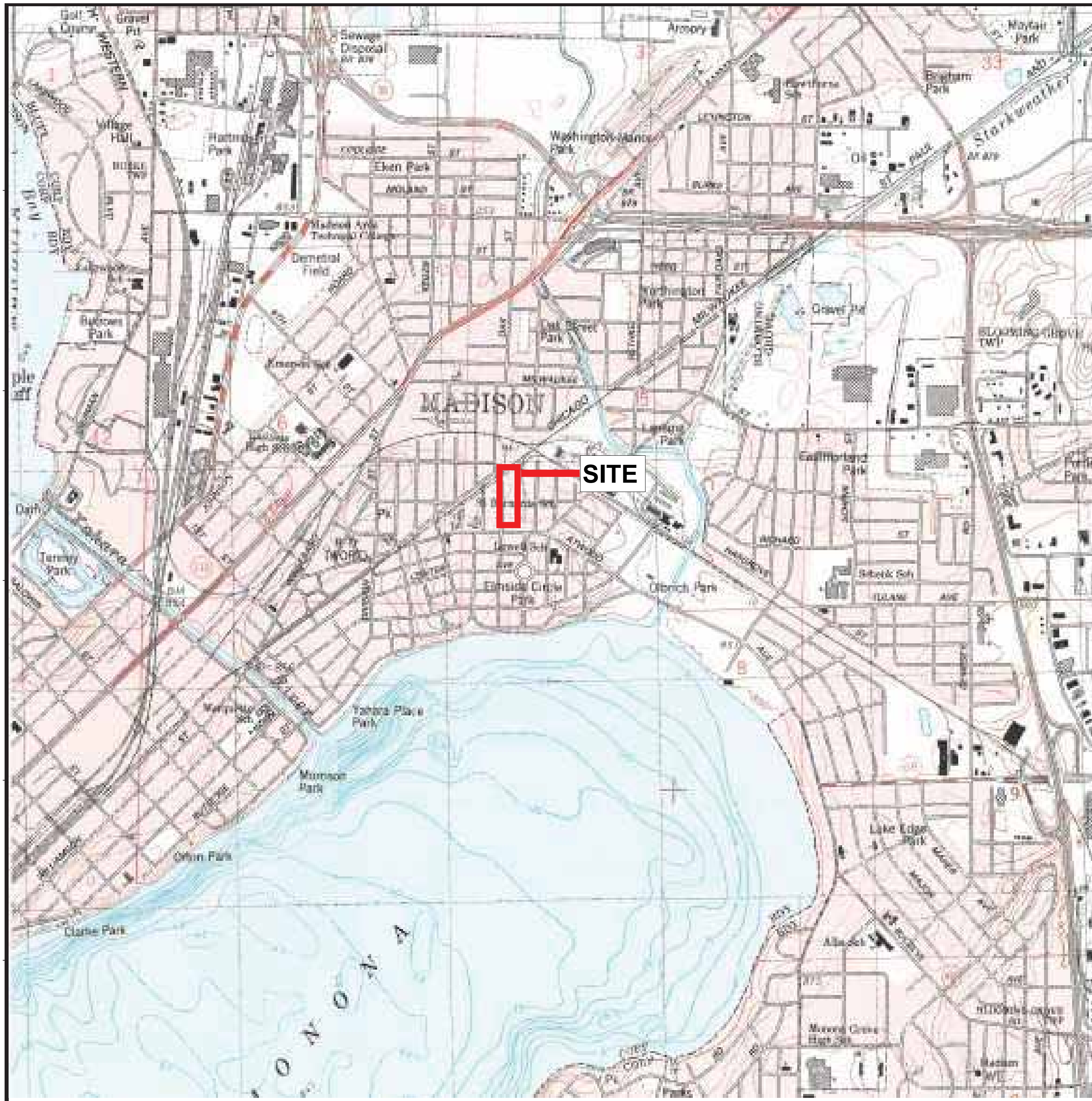
- Individual lines will be run to each extraction well rather than connecting the wells to a common extraction header. This will allow for maximum flow control and operational flexibility at each location.

- Strategies to minimize water in the extraction piping include sloping the conveyance lines toward the wells (where achievable) to allow gravity to drain the lines, in addition to a standard knock-out tank.

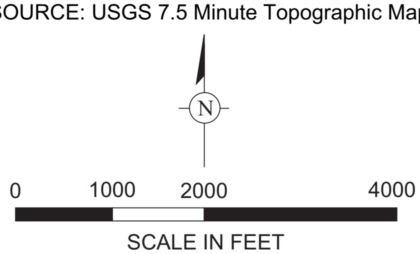
The proposed Phase I SVE system will be installed with permanent extraction wells and sub-grade piping, and a mobile SVE system trailer. The SVE trailer will be approximately 8 ft wide and 16 ft long, and will be placed south of the existing propane tanks in the area where the former propane tanks were located. The system will be fully automated and is designed to run continuously without operator oversight. The blower will be sized to provide a minimum design flow rate of 32 cfm at an applied vacuum of 6 in.H_2O at each SVE well to achieve a ROI of 35 feet and two PVE's per day. A majority of the site is paved and/or overlain by a shallow clay layer which provides a surface seal. This seal will enhance the effectiveness of SVE systems by forcing air to be drawn from greater distances and limiting barometric pressure interferences to the edges of the surface seal. In addition, the pavement will minimize infiltration from rainfall, and reduce the potential for interference from water within the SVE wells.

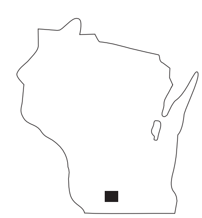
Laboratory data collected during the pilot test was used to estimate the air discharge and evaluate if air treatment is required. Based on the sum of all detected concentrations in the vapor sample collected during the first hour of SVE pilot testing activities (344,763 micrograms per cubic meter Total VOCs), and operation of nine SVE wells at the maximum expected flow rate (288 scfm), the maximum expected discharge from the Phase I SVE system is 0.37 pounds per hour (lbs/hr). VOC emissions estimated for the design flow rate and maximum vapor concentration is included in Table E1 in Appendix E. In accordance with Wisconsin Administrative Code NR406.04 (1)(m), the SVE system is exempt from air permit requirements and will not require air treatment based on the following.

- The potential to emit organic compounds from the site is less than 5.7 lbs/hr.

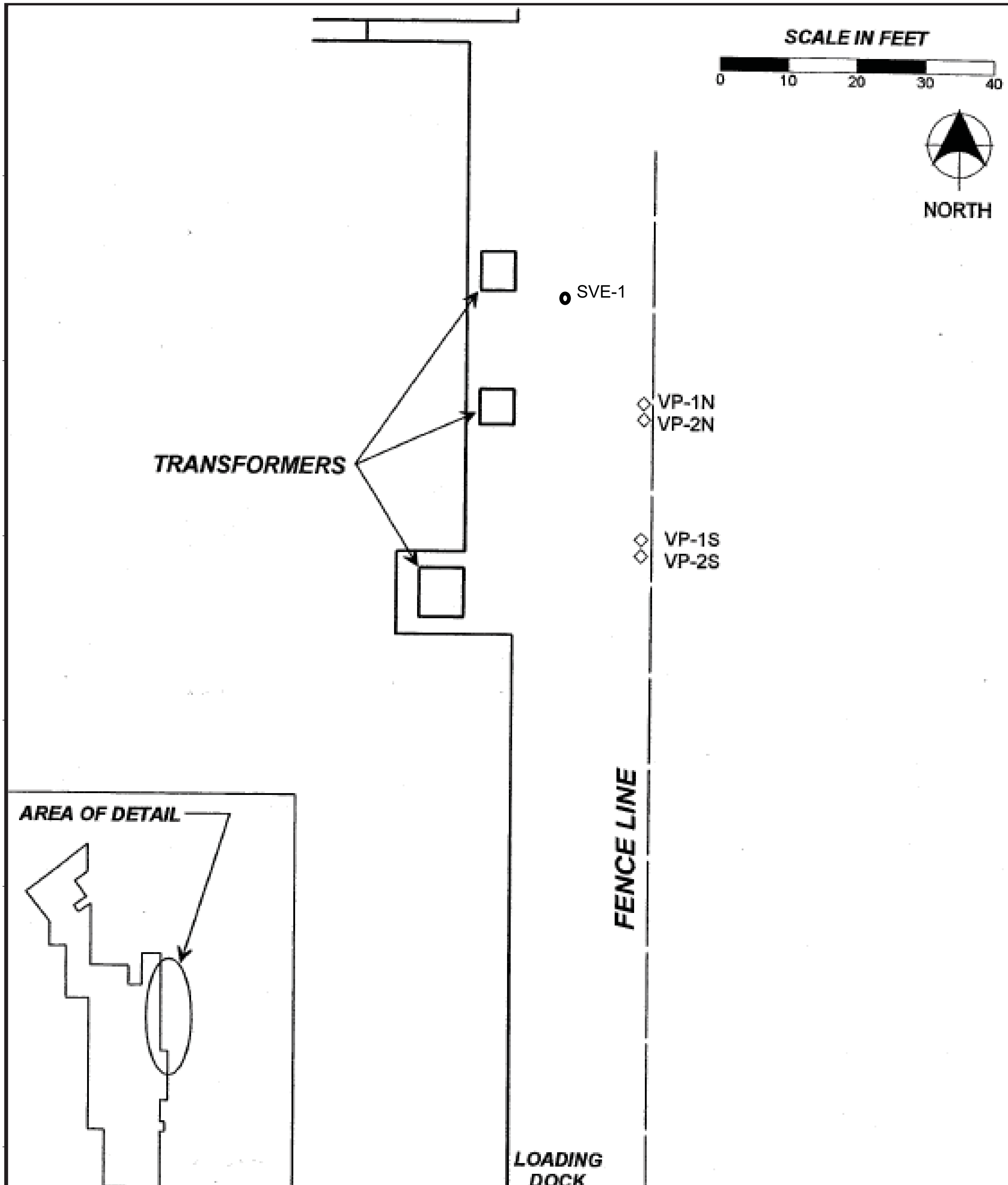


SOURCE: USGS 7.5 Minute Topographic Map, Madison East, Wisconsin Quadrangle, 1983





ARCADIS	**SITE LOCATION MAP** Madison-Kipp Corporation Madison, Wisconsin	FIGURE 1



Source: RSV Engineering Inc. Annual Soil and Groundwater Report 2007

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SITE LAYOUT

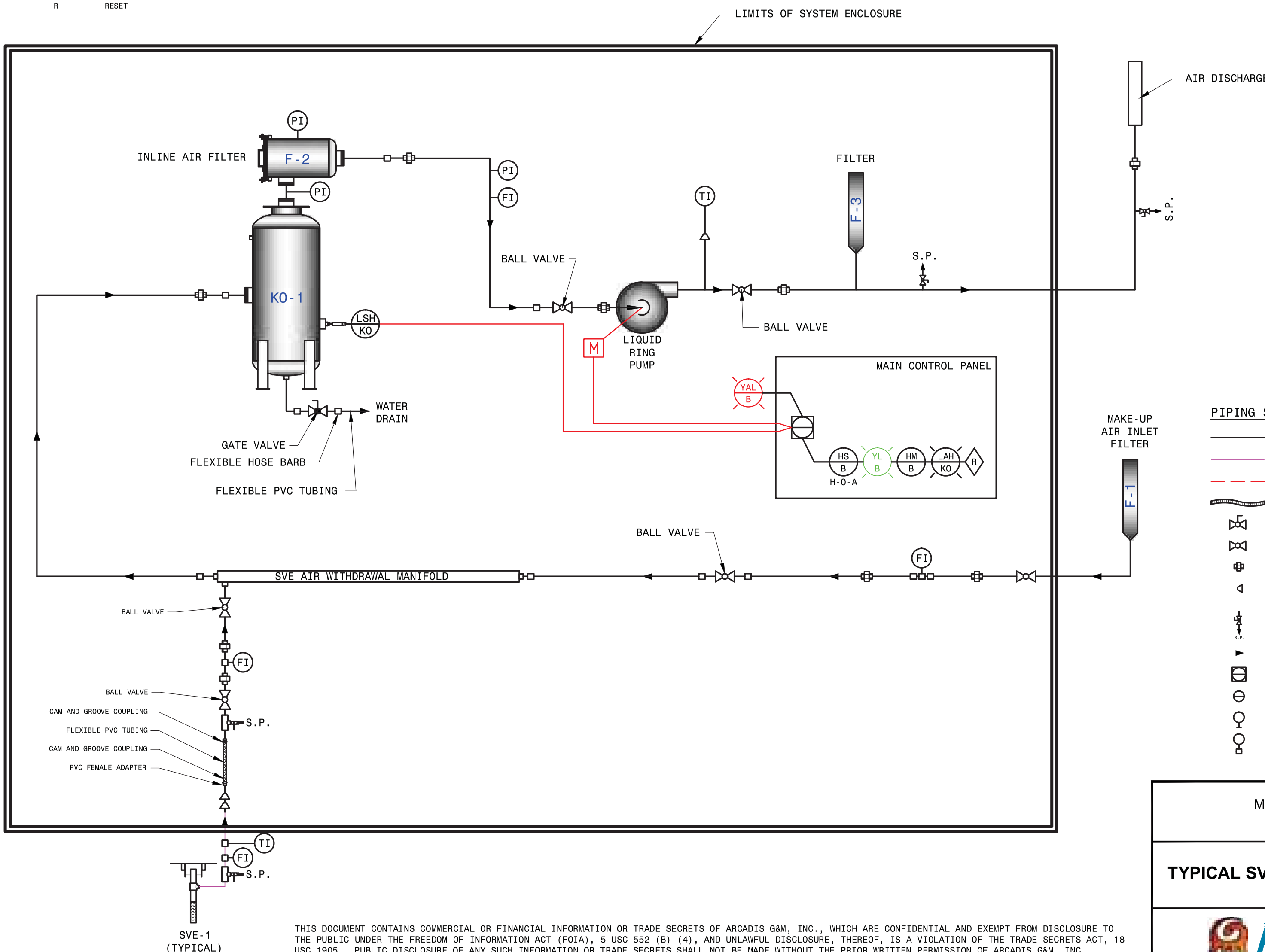
Madison-Kipp Corporation
Madison, Wisconsin

FIGURE

2

ABBREVIATIONS

ATCH	ATTACHMENT		KO	KNOCKOUT		S	SLIP
B	BLOWER		LSH	LEVEL SWITCH, HIGH		SCH	SCHEDULE
C.S.	CARBON STEEL		LAH	LEVEL ALARM, HIGH		SCFM	STANDARD CUBIC FEET PER MINUTE
CFM	CUBIC FEET PER MINUTE		M	MOTOR		S.P.	SAMPLE PORT
F	FILTER		MAG	MAGNEHELIC		SVE	SOIL-VAPOR EXTRACTION
FI	FLOW INDICATOR		MPT	MALE PIPE THREAD		T	THREAD
FPT	FEMALE PIPE THREAD		NEC	NATIONAL ELECTRICAL CODE		TI	TEMPERATURE INDICATOR
HDPE	HIGH-DENSITY POLYETHYLENE		NPT	NATIONAL PIPE THREAD		VRV	VACUUM RELIEF VALVE
HM	HOUR METER		PI	PRESSURE INDICATOR		YAL	ALARM INDICATOR LIGHT
H-O-A	HAND-OFF-AUTO		PSI	POUNDS PER SQUARE INCH		YL	EVENT LIGHT
HS	HAND SWITCH		PVC	POLYVINYL CHLORIDE		Ø	DIAMETER
IWG	INCHES WATER GAUGE		R	RESET			



PIPING SYMBOLS / INSTRUMENTATION LEGEND

- ABOVEGRADE SVE CONVEYANCE PIPING
- BELOWGRADE SVE CONVEYANCE PIPING
- ELECTRICAL SIGNAL
- FLEXIBLE PVC TUBING
- GATE VALVE
- BALL VALVE
- UNION
- REDUCING BUSHING
- SAMPLE PORT
- AIR FLOW DIRECTION
- SHARED DISPLAY
- PRIMARY PANEL MOUNTED
- FIELD-MOUNTED INSTRUMENT CONNECTED TO PROCESS LINE
- IN-LINE INSTRUMENT

Madison-Kipp Corporation
Madison, Wisconsin

TYPICAL SVE PROCESS FLOW DIAGRAM

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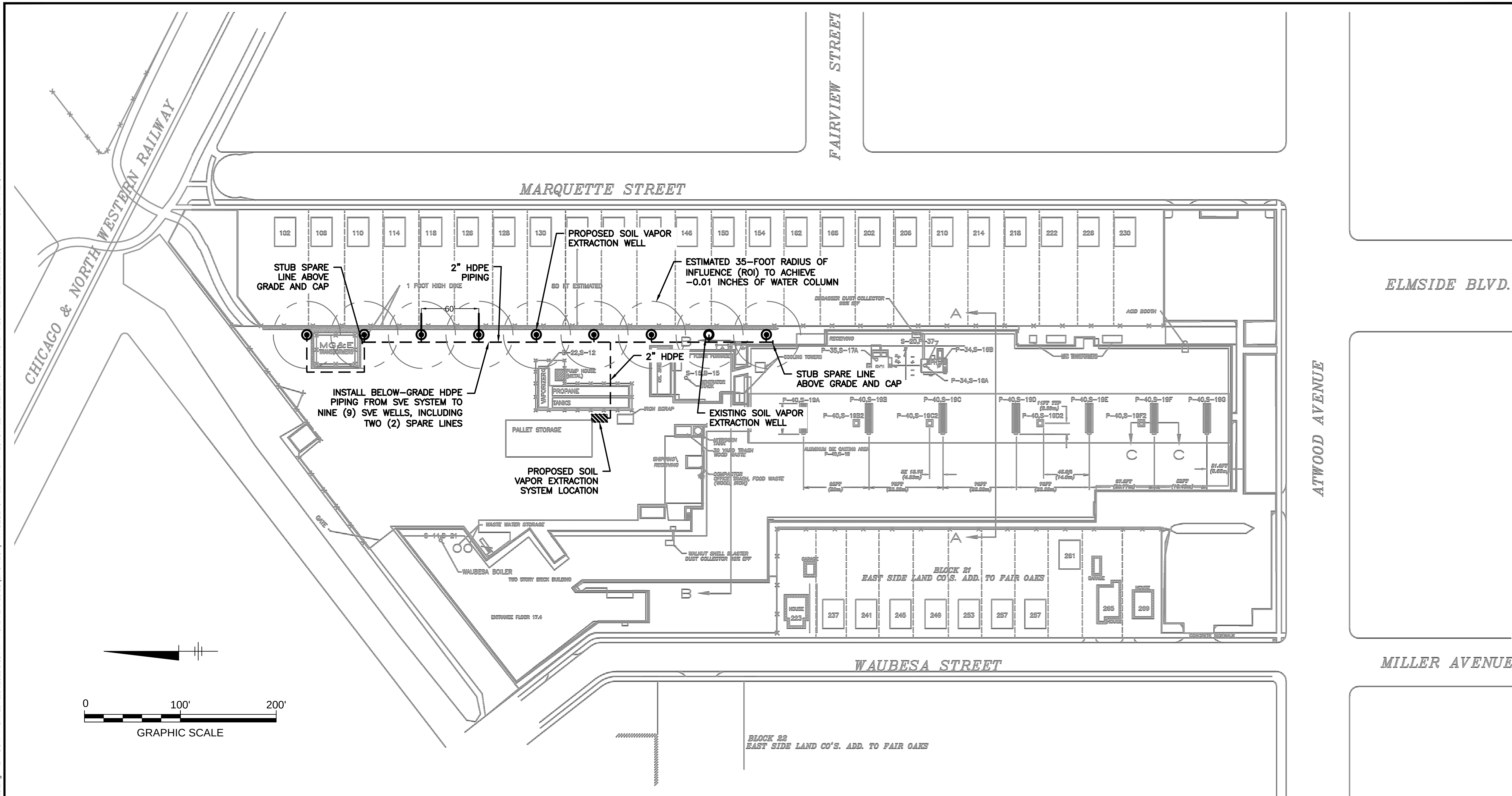
FIGURE 3



LEGEND:

- ○ EXISTING SOIL VAPOR EXTRACTION WELL
- ◉ PROPOSED SOIL VAPOR EXTRACTION WELL
- – – – PROPOSED SOIL VAPOR EXTRACTION PIPING (BELOW GRADE)
- ▨ PROPOSED SOIL VAPOR EXTRACTION SYSTEM LOCATION

NOTE: SVE WELLS PLACED ON 60-FOOT CENTERS.
SOURCE: MADISON KIPP CORPORATION

MADISON KIPP CORPORATION
201 WAUBESA STREET
MADISON, WISCONSIN

PROPOSED SVE SYSTEM LAYOUT

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FIGURE
4

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Appendix A

Soil Boring Logs

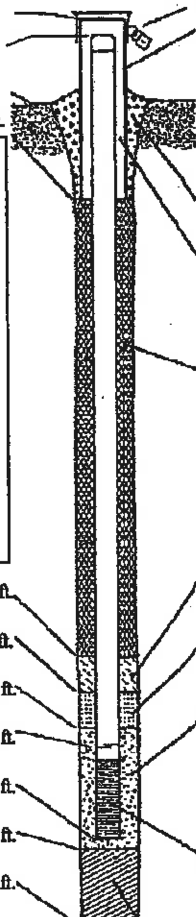
State of Wisconsin
Department of Natural Resources

Route to: Watershed/Wastewater ☐ Waste Management ☐ Remediation/Redevelopment ☐ Other ☐ ________

MONITORING WELL CONSTRUCTION

Form 4400-113A Rev. 7-98

Facility/Project Name: Madison-Kipp 04-510	Local Grid Location of Well: ____ ft. ☐N. ☐S. ____ ft. ☐E. ☐W.	Well Name: VP-1S
Facility License, Permit or Monitoring No.	Local Grid Origin ☐ (estimated: ☐) or Well Location ☐ Lat. ° ' " Long. ° ' " or	Wis. Unique Well No. ________ DNR Well ID No. ________
Facility ID ________	St. Plane ________ ft. N, ________ ft. E. S/C/N	Date Well Installed 12 / 14 / 2004 (m m d d y y y y)
Type of Well: Well Code 99 / Ot	Section Location of Waste/Source: NW 1/4 of SW 1/4 of Sec. 5, T. 7 N, R. 10 ☒E ☐W	Well Installed By: Name (first, last) and Firm: Greg Kitson, Kitson Environmental Services
Distance from Waste/Source ________ ft. Enf. Stds. Apply ☐	Location of Well Relative to Waste/Source: u ☐ Upgradient s ☐ Sidegradient d ☐ Downgradient n ☐ Not Known	Gov. Lot Number



A. Protective pipe, top elevation ___3___ ft. MSL
B. Well casing, top elevation ______ ft. MSL
C. Land surface elevation ___0___ ft. MSL
D. Surface seal, bottom ______ ft. MSL or ___4___ ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☒
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☐

13. Sieve analysis performed? ☐ Yes ☒ No

14. Drilling method used: Rotary ☐ 5 0; Hollow Stem Auger ☐ 4 1; Other ☒ geoprobe

15. Drilling fluid used: Water ☐ 0 2; Air ☐ 0 1; Drilling Mud ☐ 0 3; None ☒ 9 9

16. Drilling additives used? ☐ Yes ☒ No

Describe ________

17. Source of water (attach analysis, if required): ________

E. Bentonite seal, top ______ ft. MSL or ___0.0___ ft.
F. Fine sand, top ______ ft. MSL or ______ ft.
G. Filter pack, top ______ ft. MSL or ___4.0___ ft.
H. Screen joint, top ______ ft. MSL or ___6.0___ ft.
I. Well bottom ______ ft. MSL or ___8.0___ ft.
J. Filter pack, bottom ______ ft. MSL or ___8.0___ ft.
K. Borehole, bottom ______ ft. MSL or ___8.0___ ft.
L. Borehole, diameter ___2.0___ in.
M. O.D. well casing ___1.33___ in.
N. I.D. well casing ___1.00___ in.

1. Cap and lock? ☒ Yes ☐ No
2. Protective cover pipe: Pop-up
a. Inside diameter: 4.0 in.
b. Length: 3.0 ft.
c. Material: Steel ☒ 0 4; Other ☐
d. Additional protection? ☐ Yes ☒ No
If yes, describe: ________
3. Surface seal: Bentonite ☒ 3 0; Concrete ☐ 0 1; Other ☐
4. Material between well casing and protective pipe: Bentonite ☒ 3 0; Other ☐
5. Annular space seal: a. Granular/Chipped Bentonite ☒ 3 3
b. ____ Lbs/gal mud weight . . . Bentonite-sand slurry ☐ 3 5
c. ____ Lbs/gal mud weight . . . . . Bentonite slurry ☐ 3 1
d. ____ % Bentonite . . . . . . Bentonite-cement grout ☐ 5 0
e. 1 bag ft³ volume added for any of the above
f. How installed: Tremie ☐ 0 1; Tremie pumped ☐ 0 2; Gravity ☒ 0 8
6. Bentonite seal: a. Bentonite granules ☐ 3 3
b. ☐ 1/4 in. ☒ 3/8 in. ☐ 1/2 in. Bentonite chips ☒ 3 2
c. ________ Other ☐
7. Fine sand material: Manufacturer, product name & mesh size
a. ________
b. Volume added ________ ft³
8. Filter pack material: Manufacturer, product name & mesh size
a. #40
b. Volume added 1 bag ft³
9. Well casing: Flush threaded PVC schedule 40 ☒ 2 3; Flush threaded PVC schedule 80 ☐ 2 4; Other ☐
10. Screen material: PVC
a. Screen type: Factory cut ☒ 1 1; Continuous slot ☐ 0 1; Other ☐
b. Manufacturer Timco
c. Slot size: 0.010 in.
d. Slotted length: 2 ft.
11. Backfill material (below filter pack): None ☒ 1 4; Other ☐

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: [signature] Firm: RSV Engineering, Inc., Jefferson, WI

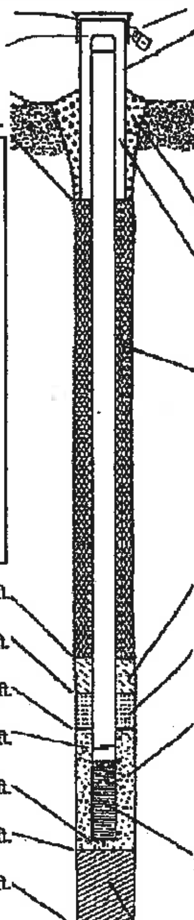
Please complete both Forms 4400-113A and 4400-113B and return them to the appropriate DNR office and bureau. Completion of these reports is required by chs. 160, 281, 283, 289, 291, 292, 293, 295, and 299, Wis. Stats., and ch. NR 141, Wis. Adm. Code. In accordance with chs. 281, 289, 291, 292, 293, 295, and 299, Wis. Stats., failure to file these forms may result in a forfeiture of between $10 and $25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on these forms is not intended to be used for any other purpose. NOTE: See the instructions for more information, including where the completed forms should be sent.

State of Wisconsin
Department of Natural Resources

Route to: Watershed/Wastewater ☐ Waste Management ☐ Remediation/Redevelopment ☐ Other ☐

MONITORING WELL CONSTRUCTION
Form 4400-113A Rev. 7-98

Facility/Project Name: Madison-Kipp 04-510	Local Grid Location of Well: ___ ft. ☐N. ☐S. ___ ft. ☐E. ☐W.	Well Name: VP-1D
Facility License, Permit or Monitoring No.	Local Grid Origin ☐ (estimated: ☐) or Well Location ☐ Lat. ___ Long. ___ or	Wis. Unique Well No. / DNR Well ID No.
Facility ID	St. Plane ___ ft. N, ___ ft. E. S/C/N	Date Well Installed 12/14/2004 (m m d d y y y y)
Type of Well: Well Code 99 / Ot	Section Location of Waste/Source: NW 1/4 of SW 1/4 of Sec. 5, T. 7 N, R. 10 ☒E ☐W	Well Installed By: Name (first, last) and Firm: Greg Kitson, Kitson Environmental Services
Distance from Waste/Source ___ ft. / Enf. Stds. Apply ☐	Location of Well Relative to Waste/Source: u ☐ Upgradient s ☐ Sidegradient d ☐ Downgradient n ☐ Not Known / Gov. Lot Number	



A. Protective pipe, top elevation ___3.___ ft. MSL
B. Well casing, top elevation ______ ft. MSL
C. Land surface elevation _____0 ft. MSL
D. Surface seal, bottom ______ ft. MSL or ___11 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☒
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☐

13. Sieve analysis performed? ☐ Yes ☒ No

14. Drilling method used: Rotary ☐ 50; Hollow Stem Auger ☐ 41; Other ☒ geoprobe

15. Drilling fluid used: Water ☐ 02; Air ☐ 01; Drilling Mud ☐ 03; None ☒ 99

16. Drilling additives used? ☐ Yes ☒ No

Describe ___

17. Source of water (attach analysis, if required): ___

E. Bentonite seal, top ______ ft. MSL or ___0.0 ft.
F. Fine sand, top ______ ft. MSL or ______ ft.
G. Filter pack, top ______ ft. MSL or ___11.0 ft.
H. Screen joint, top ______ ft. MSL or ___13.0 ft.
I. Well bottom ______ ft. MSL or ___15.0 ft.
J. Filter pack, bottom ______ ft. MSL or ___15.0 ft.
K. Borehole, bottom ______ ft. MSL or ___15.0 ft.
L. Borehole, diameter ___2.0 in.
M. O.D. well casing ___1.33 in.
N. I.D. well casing ___1.00 in.

1. Cap and lock? ☒ Yes ☐ No
2. Protective cover pipe: Pop-up
   a. Inside diameter: 4.0 in.
   b. Length: 3.0 ft.
   c. Material: Steel ☒ 04; Other ☐
   d. Additional protection? ☐ Yes ☒ No; If yes, describe: ___
3. Surface seal: Bentonite ☒ 30; Concrete ☐ 01; Other ☐
4. Material between well casing and protective pipe: Bentonite ☒ 30; Other ☐
5. Annular space seal: a. Granular/Chipped Bentonite ☒ 33
   b. ___ Lbs/gal mud weight . . . Bentonite-sand slurry ☐ 35
   c. ___ Lbs/gal mud weight . . . . . Bentonite slurry ☐ 31
   d. ___ % Bentonite . . . . . . Bentonite-cement grout ☐ 50
   e. 1 bag ft³ volume added for any of the above
   f. How installed: Tremie ☐ 01; Tremie pumped ☐ 02; Gravity ☒ 08
6. Bentonite seal: a. Bentonite granules ☐ 33
   b. ☐1/4 in. ☒3/8 in. ☐1/2 in. Bentonite chips ☒ 32
   c. ___ Other ☐
7. Fine sand material: Manufacturer, product name & mesh size
   a. ___
   b. Volume added ___ ft³
8. Filter pack material: Manufacturer, product name & mesh size
   a. #40
   b. Volume added 1 bag ft³
9. Well casing: Flush threaded PVC schedule 40 ☒ 23; Flush threaded PVC schedule 80 ☐ 24; Other ☐
10. Screen material: PVC
   a. Screen type: Factory cut ☒ 11; Continuous slot ☐ 01; Other ☐
   b. Manufacturer Timco
   c. Slot size: 0.010 in.
   d. Slotted length: 2 ft.
11. Backfill material (below filter pack): None ☒ 14; Other ☐

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature	Firm
[signature]	RSV Engineering, Inc., Jefferson, WI

Please complete both Forms 4400-113A and 4400-113B and return them to the appropriate DNR office and bureau. Completion of these reports is required by chs. 160, 281, 283, 289, 291, 292, 293, 295, and 299, Wis. Stats., and ch. NR 141, Wis. Adm. Code. In accordance with chs. 281, 289, 291, 292, 293, 295, and 299, Wis. Stats., failure to file these forms may result in a forfeiture of between $10 and $25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on these forms is not intended to be used for any other purpose. NOTE: See the instructions for more information, including where the completed forms should be sent.

State of Wisconsin
Department of Natural Resources

Route to: Watershed/Wastewater ☐ Waste Management ☐ Remediation/Redevelopment ☐ Other ☐

MONITORING WELL CONSTRUCTION
Form 4400-113A Rev. 7-98

Facility/Project Name: Madison-Kipp 04-510	Local Grid Location of Well ____ ft. ☐N. ☐S. ____ ft. ☐E. ☐W.	Well Name: VP-2S
Facility License, Permit or Monitoring No.	Local Grid Origin ☐ (estimated: ☐) or Well Location ☐ Lat. ___ Long. ___ or	Wis. Unique Well No. / DNR Well ID No.
Facility ID	St. Plane ____ ft. N, ____ ft. E. S/C/N	Date Well Installed 12/14/2004 (m m d d y y y y)
Type of Well: Well Code 99 / Ot	Section Location of Waste/Source: NW 1/4 of SW 1/4 of Sec. 5, T. 7 N, R. 10 ☒E ☐W	Well Installed By: Name (first, last) and Firm: Greg Kitson, Kitson Environmental Services
Distance from Waste/Source ____ ft. / Enf. Stds. Apply ☐	Location of Well Relative to Waste/Source: u ☐ Upgradient s ☐ Sidegradient d ☐ Downgradient n ☐ Not Known / Gov. Lot Number	

A. Protective pipe, top elevation ___3___ ft. MSL
B. Well casing, top elevation _______ ft. MSL
C. Land surface elevation ___0___ ft. MSL
D. Surface seal, bottom ______ ft. MSL or ___4___ ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☒
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☐

13. Sieve analysis performed? ☐ Yes ☒ No

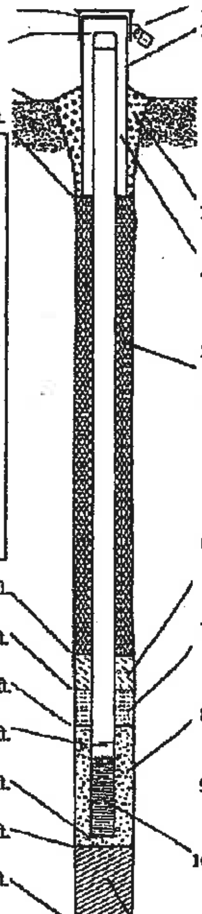
14. Drilling method used: Rotary ☐ 50; Hollow Stem Auger ☐ 41; Other ☒ geoprobe

15. Drilling fluid used: Water ☐ 02; Air ☐ 01; Drilling Mud ☐ 03; None ☒ 99

16. Drilling additives used? ☐ Yes ☒ No
Describe ____

17. Source of water (attach analysis, if required): ____

E. Bentonite seal, top ______ ft. MSL or ___0.0___ ft.
F. Fine sand, top ______ ft. MSL or ______ ft.
G. Filter pack, top ______ ft. MSL or ___4.0___ ft.
H. Screen joint, top ______ ft. MSL or ___6.0___ ft.
I. Well bottom ______ ft. MSL or ___8.0___ ft.
J. Filter pack, bottom ______ ft. MSL or ___8.0___ ft.
K. Borehole, bottom ______ ft. MSL or ___8.0___ ft.
L. Borehole, diameter ___2.0___ in.
M. O.D. well casing ___1.33___ in.
N. I.D. well casing ___1.00___ in.



1. Cap and lock? ☒ Yes ☐ No
2. Protective cover pipe: Pop-up
   a. Inside diameter: 4.0 in.
   b. Length: 3.0 ft.
   c. Material: Steel ☒ 04; Other ☐
   d. Additional protection? ☐ Yes ☒ No
   If yes, describe: ____
3. Surface seal: Bentonite ☒ 30; Concrete ☐ 01; Other ☐
4. Material between well casing and protective pipe: Bentonite ☒ 30; Other ☐
5. Annular space seal: a. Granular/Chipped Bentonite ☒ 33
   b. ____ Lbs/gal mud weight . . . Bentonite-sand slurry ☐ 35
   c. ____ Lbs/gal mud weight . . . . . Bentonite slurry ☐ 31
   d. ____ % Bentonite . . . . . . Bentonite-cement grout ☐ 50
   e. 1 bag Ft³ volume added for any of the above
   f. How installed: Tremie ☐ 01; Tremie pumped ☐ 02; Gravity ☒ 08
6. Bentonite seal: a. Bentonite granules ☐ 33
   b. ☐1/4 in. ☒3/8 in. ☐1/2 in. Bentonite chips ☒ 32
   c. ____ Other ☐
7. Fine sand material: Manufacturer, product name & mesh size
   a. ____
   b. Volume added ____ ft³
8. Filter pack material: Manufacturer, product name & mesh size
   a. #40
   b. Volume added 1 bag ft³
9. Well casing: Flush threaded PVC schedule 40 ☒ 23; Flush threaded PVC schedule 80 ☐ 24; Other ☐
10. Screen material: PVC
   a. Screen type: Factory cut ☒ 11; Continuous slot ☐ 01; Other ☐
   b. Manufacturer Timco
   c. Slot size: 0.010 in.
   d. Slotted length: 2 ft.
11. Backfill material (below filter pack): None ☒ 14; Other ☐

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature: [signature] Firm: RSV Engineering, Inc., Jefferson, WI

Please complete both Forms 4400-113A and 4400-113B and return them to the appropriate DNR office and bureau. Completion of these reports is required by chs. 160, 281, 283, 289, 291, 292, 293, 295, and 299, Wis. Stats., and ch. NR 141, Wis. Adm. Code. In accordance with chs. 281, 289, 291, 292, 293, 295, and 299, Wis. Stats., failure to file these forms may result in a forfeiture of between $10 and $25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on these forms is not intended to be used for any other purpose. NOTE: See the instructions for more information, including where the completed forms should be sent.

State of Wisconsin
Department of Natural Resources

Route to: Watershed/Wastewater ☐ Waste Management ☐ Remediation/Redevelopment ☐ Other ☐ ________

MONITORING WELL CONSTRUCTION
Form 4400-113A Rev. 7-98

Facility/Project Name: Madison-Kipp 04-510	Local Grid Location of Well ______ ft. ☐N. ☐S. ______ ft. ☐E. ☐W.	Well Name: VP-2D
Facility License, Permit or Monitoring No.	Local Grid Origin ☐ (estimated: ☐) or Well Location ☐ Lat. ___ ° ___ ' ___ " Long. ___ ° ___ ' ___ " or	Wis. Unique Well No. ______ DNR Well ID No. ______
Facility ID ________	St. Plane ______ ft. N, ______ ft. E. S/C/N	Date Well Installed 12 / 14 / 2004 (m m d d y y y y)
Type of Well — Well Code 99 / Ot	Section Location of Waste/Source: NW 1/4 of SW 1/4 of Sec. 5, T. 7 N, R. 10 ☒E ☐W	Well Installed By: Name (first, last) and Firm: Greg Kitson, Kitson Environmental Services
Distance from Waste/Source ______ ft. Enf. Stds. Apply ☐	Location of Well Relative to Waste/Source: u ☐ Upgradient s ☐ Sidegradient d ☐ Downgradient n ☐ Not Known — Gov. Lot Number ______	

A. Protective pipe, top elevation ___3.___ ft. MSL

B. Well casing, top elevation ______ ft. MSL

C. Land surface elevation ______0 ft. MSL

D. Surface seal, bottom ______ ft. MSL or ___11 ft.

12. USCS classification of soil near screen:
GP ☐ GM ☐ GC ☐ GW ☐ SW ☐ SP ☒
SM ☐ SC ☐ ML ☐ MH ☐ CL ☐ CH ☐
Bedrock ☐

13. Sieve analysis performed? ☐ Yes ☒ No

14. Drilling method used: Rotary ☐ 5 0; Hollow Stem Auger ☐ 4 1; geoprobe Other ☒

15. Drilling fluid used: Water ☐ 0 2 Air ☐ 0 1 Drilling Mud ☐ 0 3 None ☒ 9 9

16. Drilling additives used? ☐ Yes ☒ No

Describe ________

17. Source of water (attach analysis, if required): ________

E. Bentonite seal, top ______ ft. MSL or ___0.0 ft.

F. Fine sand, top ______ ft. MSL or ______ ft.

G. Filter pack, top ______ ft. MSL or ___11.0 ft.

H. Screen joint, top ______ ft. MSL or ___13.0 ft.

I. Well bottom ______ ft. MSL or ___15.0 ft.

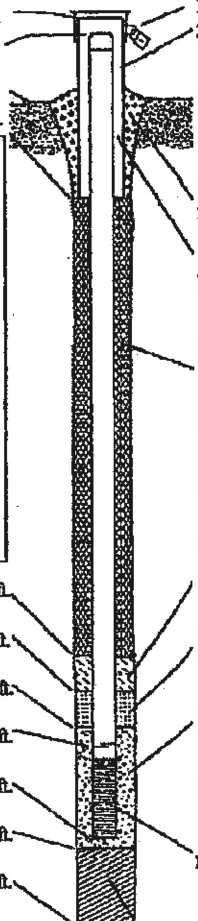
J. Filter pack, bottom ______ ft. MSL or ___15.0 ft.

K. Borehole, bottom ______ ft. MSL or ___15.0 ft.

L. Borehole, diameter ___2.0 in.

M. O.D. well casing ___1.33 in.

N. I.D. well casing ___1.00 in.



1. Cap and lock? ☒ Yes ☐ No

2. Protective cover pipe: Pop-up
a. Inside diameter: 4.0 in.
b. Length: 3.0 ft.
c. Material: Steel ☒ 0 4; Other ☐
d. Additional protection? ☐ Yes ☒ No
If yes, describe: ________

3. Surface seal: Bentonite ☒ 3 0; Concrete ☐ 0 1; Other ☐

4. Material between well casing and protective pipe: Bentonite ☒ 3 0; Other ☐

5. Annular space seal: a. Granular/Chipped Bentonite ☒ 3 3
b. ____ Lbs/gal mud weight . . . Bentonite-sand slurry ☐ 3 5
c. ____ Lbs/gal mud weight . . . . . Bentonite slurry ☐ 3 1
d. ____ % Bentonite . . . . . . Bentonite-cement grout ☐ 5 0
e. 1 bag Ft^3 volume added for any of the above
f. How installed: Tremie ☐ 0 1; Tremie pumped ☐ 0 2; Gravity ☒ 0 8

6. Bentonite seal: a. Bentonite granules ☐ 3 3
b. ☐1/4 in. ☒3/8 in. ☐1/2 in. Bentonite chips ☒ 3 2
c. ________ Other ☐

7. Fine sand material: Manufacturer, product name & mesh size
a. ________
b. Volume added ________ ft^3

8. Filter pack material: Manufacturer, product name & mesh size
a. #40
b. Volume added 1 bag ft^3

9. Well casing: Flush threaded PVC schedule 40 ☒ 2 3; Flush threaded PVC schedule 80 ☐ 2 4; Other ☐

10. Screen material: PVC
a. Screen type: Factory cut ☒ 1 1; Continuous slot ☐ 0 1; Other ☐
b. Manufacturer Timco
c. Slot size: 0.010 in.
d. Slotted length: 2 ft.

11. Backfill material (below filter pack): None ☒ 1 4; Other ☐

I hereby certify that the information on this form is true and correct to the best of my knowledge.

Signature [signature] Firm RSV Engineering, Inc., Jefferson, WI

Please complete both Forms 4400-113A and 4400-113B and return them to the appropriate DNR office and bureau. Completion of these reports is required by chs. 160, 281, 283, 289, 291, 292, 293, 295, and 299, Wis. Stats., and ch. NR 141, Wis. Adm. Code. In accordance with chs. 281, 289, 291, 292, 293, 295, and 299, Wis. Stats., failure to file these forms may result in a forfeiture of between $10 and $25,000, or imprisonment for up to one year, depending on the program and conduct involved. Personally identifiable information on these forms is not intended to be used for any other purpose. NOTE: See the instructions for more information, including where the completed forms should be sent.

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Appendix B

SVE Pilot Test Field Data

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Table B1. Soil Vapor Extraction Pilot Test Field Data, Madison-Kipp Corporation, Madison, Wisconsin.

Day 1

Date: 2/9/2012 **Pilot Test Start Time:** 17:10 PM **Ambient Temperature:** 35°F
Personnel: T.Alessi / W. May **Weather:** Partly Cloudy **Barometric Pressure:** 30.06 in

		Extraction Point	Monitoring Point				Extraction System				
Test Designation	Date/Time	SVE-1 (in H_2O) (1)	VP-1N (17.5' from EW) (in H_2O) (1)	VP-2N (18.5' from EW) (in H_2O) (1)	VP-1S (31' from EW) (in H_2O) (1)	VP-2S (33' from EW) (in H_2O) (1)	Blower Inlet Vacuum (in H_2O) (1)	Extraction Well Flow Rate (cfm)	Dilution Air Flowrate (cfm)	Blower Outlet Flow Rate (cfm)	Blower Outlet Temperature (°F)
Pre-Startup	2/9/2012 17:10	-0.01	0.01	-0.01	-0.01	0.00	--	--	--	--	--
Step 1	2/9/2012 17:25	-20	-0.29	-0.05	-0.05	-0.02	-21	<20 (2)	>60 (2)	80	60°F
Step 1	2/9/2012 17:40	-20	-0.30	-0.06	-0.06	-0.02	-20	--	--	--	--
Step 1	2/9/2012 17:55	-20	-0.28	-0.06	-0.06	-0.02	-20	--	--	--	--
Step 1	2/9/2012 18:10	-20	-0.30	-0.06	-0.06	-0.01	-20	<20 (2)	>60 (2)	80	70°F

Day 2

Date: 2/10/2012 **Pilot Test Start Time:** 8:05 AM **Ambient Temperature:** 25°F
Personnel: T.Alessi **Weather:** Snow **Barometric Pressure:** 29.89 in

		Extraction Point	Monitoring Point				Extraction System				
Test	Date/Time	SVE-1 (in H_2O) (1)	VP-1N (17.5' from EW) (in H_2O) (1)	VP-2N (18.5' from EW) (in H_2O) (1)	VP-1S (31' from EW) (in H_2O) (1)	VP-2S (33' from EW) (in H_2O) (1)	Blower Inlet Vacuum (in H_2O) (1)	Extraction Well Flow Rate (cfm)	Dilution Air Flowrate (cfm)	Blower Outlet Flow Rate (cfm)	Blower Outlet Temperature (°F)
Pre-Startup	2/10/2012 8:05	-0.01	-0.01	-0.01	-0.01	0.00	--	--	--	--	--
Step 2	2/10/2012 8:30	-40	-0.50	-0.10	-0.11	-0.02	-40	<20 (2)	>40 (2)	60	68°F
Step 2	2/10/2012 8:45	-40	-0.50	-0.10	-0.11	-0.02	-40	<20 (2)	>40 (2)	60	74°F
Step 2	2/10/2012 9:00	-40	-0.50	-0.10	-0.11	-0.02	-40	<20 (2)	>40 (2)	60	74°F
Step 3	2/10/2012 9:15	-68	-0.80	-0.18	-0.18	-0.05	-68	40	0.0	40	92°F
Step 3	2/10/2012 9:30	-68	-0.80	-0.19	-0.18	-0.04	-68	40	0.0	40	98°F
Step 3	2/10/2012 9:45	-68	-0.80	-0.18	-0.18	-0.05	-68	40	0.0	40	100°F
Extended Test	2/10/2012 10:00	-68	-0.90	-0.19	-0.18	-0.05	-69	40	0.0	40	98°F
Extended Test	2/10/2012 11:00	-69	-0.90	-0.18	-0.18	-0.05	-70	40	0.0	40	98°F
Extended Test	2/10/2012 12:00	-70	-0.90	-0.18	-0.18	-0.06	-70	40	0.0	40	98°F
Extended Test	2/10/2012 13:00	-70	-0.90	-0.19	-0.18	-0.05	-70	40	0.0	40	96°F

(1) Vacuum measured with a Magnehelic gauge.
(2) Flow meter low increment is 20 CFM and flow rates from extraction well at less than 20 CFM were unable to be recorded.

in H_2O inches of water column
fpm feet per minute
cfm cubic feet per minute
-- Not monitored

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Appendix C

SVE Pilot Test Analytical Data and
Estimate of Mass Removed

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Table C1. Soil Vapor Extraction Pilot Test Analtyical Data, Madison-Kipp Corporation, Madison, Wisconsin.

Vapor Phase Constituent		Effluent Concentration (EFF-1) µg/m³	Effluent Concentration (EFF-2) µg/m³
Tetrachloroethene		**325,000**	**163,000**
Trichloroethene		**4,600**	**2,880**
trans-1,2-Dichloroethene		**563**	**120**
cis-1,2-Dichloroethene		**14,600**	**9,320**
Acetone	<	*258*	**11.4**
Benzene	<	*175*	**3.4**
2-Butanone	<	*323*	**4.5**
Chloroform	<	*532*	**13.1**
Cyclohexane	<	*366*	**1.5**
Dichlorodifluoromethane	<	*538*	**1.7**
Ethanol	<	*1,020*	**7.3**
Ethylbenzene	<	*473*	**2.7**
n-Hexane	<	*387*	**4.3**
Methylene Chloride	<	*382*	**16.3**
Naphthalene	<	*1,450*	**7.7**
Tetrahydrofuran	<	*323*	**3.0**
Toluene	<	*414*	**8.1**
1,2,4-Trimethylbenzene	<	*537*	**5.3**
Vinyl Chloride	<	*140*	**13.4**
m&p-Xylene	<	*946*	**6.6**
o-Xylene	<	*473*	**2.8**
Total VOCs		**349,132**	**175,433**

< Constituent not detected above the laboratory reporting limit.
Bold Constituent detected above the laboratory reporting limit.
cfm Cubic feet per minute.
ppbv Parts per billion by volume.
µg/m³ Micrograms per cubic meter.
lb/hr Pounds per hour.

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Table C2. Estimate of Mass Removed during Soil Vapor Extraction Pilot Test, Madison-Kipp Corporation, Madison, Wisconsin.

Date	Total VOC Concentration [1]	System Flow Rate	Dilution Air Valve Position	Emission Rate [2]	Mass Removed [3]	Cumulative Mass Removed
	$\mu g/m^3$	cfm	percent open	lb/hr	lb/day	lb
2/9/2012 18:10	349,132	60	0	0.08	0.08	0.08
2/10/2012 13:00	175,433	60	0	0.04	0.28	0.35
			Average Emission Rate	**0.06**	**0.18**	

[1] Total VOC concentration was based on the sum of all detected analyte concentrations in Samples EFF-1 and EFF-2.

[2] Emission rates were determined using the following equation:

$$\text{Emission Rate} = \text{Influent Conc.} * \text{Flow Rate} * 60\ \text{min/hr} * (1\ m^3/35.31\ ft^3) * (1\ \text{lb}/4.54\text{x}108\ \text{mg})$$

[3] Mass removed is calculated based on the average emission rate for two consecutive sample dates multiplied by the operating time between those sample date.

$$\text{Mass Removed} = [(\text{Emission Rate}_1 + \text{Emission Rate}_2) / 2] * [(\text{Date}_2 - \text{Date}_1) * 24]$$

[4] Emission factors were determined from detected soil gas vapor concentrations collected after completion of pilot test (Sample EFF-2).

[5] When compounds are not detected above the laboratory reporting limit, emissions are calculated using 1/2 the reporting limit.

cfm Cubic feet per minute.
lb/day Pounds per day.
lb/hr Pounds per hour.
$\mu g/m^3$ Micrograms per cubic meter.

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Appendix D

Soil Vapor Extraction System Design Calculations

Madison Kipp Corporation
Soil Vapor Extraction System Design Calculations

PHYSICAL PROPERTIES OF THE SOIL AND AIR

Soil Porosity
The total porosity is described by the variable η.

$$? := 0.3 \frac{cm^3}{cm^3}$$

Air Density

Density for air is given for a soil temperature of 10 C.

$$?_{air} := 1.27 \cdot 10^{-3} \frac{g}{cm^3}$$

VAPOR EXTRACTION SYSTEM DESIGN SPECIFICATIONS

Vadose Zone Thickness

The value for vadose zone thickness in feet.

$h := 20$ ft

$h := h \cdot 30.48$ cm

$h = 610$ cm

Vapor Extraction Well Radius

The value for the SVE well radius in feet, including filter pack.

$a := 0.25$ ft

$a := a \cdot 30.48$ cm

$a = 7.6$ cm

Pore Volume Exchange Rate

The pore volume exchange rate determines the air flow which must be applied to any soil volume, to achieve design goals. Typical vapor extraction systems achieve 1 to 2 pore volume exchanges per day.

$ER := 2$ Pore Volume Exchanges per day

RADIAL FLOW DESIGN FUNCTIONS

The soil vapor extraction method relies on two principal design functions. The first relates the mass air flow required to achieve the design pore volume exchange rate as a function of the soil pore volume between the well radius and the variable, outer radius, b. The second function calculates the pressure drop required to drive air flow at the design pore volume exchange rate, over the soil volume which lies between the outer radius, b, and the well bore radius, a. The data collected during the SVE pilot test have been used to determine the pressure drop in the system. The mass flow needed to meet the design specifications is calculated below.

The Mass Flow Function

The mass flow function was developed to express the air flow required through a target soil volume, as a function of the outer radius, b, of the target volume, and the selected pore volume exchange rate, ER. The values for vadose zone thickness, h, total porosity, η, and air density, ρ_{air}, were all specified above.

$$Q(b) := \frac{ER \cdot p \cdot \left(b^2 - a^2\right) \cdot h \cdot ? \cdot ?_{air}}{1440 \cdot 60} \qquad \frac{g}{sec}$$

Estimates of Per Well Flow Rate to Achieve Specified PVE

For the mass flow point estimate, a revised function, $Q_1(b)$ is defined, to provide a result in conventional air flow units (ft^3/min). The function calcaulates the minimum flow rate needed to obtain the specified PVE at an ROI (b) of 35 feet.

$$b := 35 \qquad ft$$

$$b := b \cdot 30.48$$

$$b = 1067 \qquad cm$$

Estimated flow rate in cubic feet per minute (CFM) needed from a single well to achieve two (2) PVE's per day at a ROI of 35 feet and a vadose zone thickness of 20 feet.

$$Q_1(b) = 32 \qquad \frac{ft^3}{min}$$

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Appendix E

Maximum Organic Compound Emission Rate Estimated for Phase 1 SVE System

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Table E1. Maximum Estimated Organic Compound Emission Rate, Phase I Soil Vapor Extraction System, Madison-Kipp Corporation, Madison, Wisconsin.

Vapor Phase Constituent	Highest Estimated Effluent Concentration µg/m^3	Estimated Emission Rate lb/hr
Vent System Flow Rate (cfm)		**288**
Tetrachloroethene	325,000	0.350
Trichloroethene	4,600	0.005
trans-1,2-Dichloroethene	563	0.001
cis-1,2-Dichloroethene	14,600	0.016
	Maximum Estimated Organic Compound Emission Rate	***0.372***

1. Calculations based on an air flow rate of 32 CFM per well (9 wells total).
2. Emission factors were determined from detected soil gas vapor concentrations collected during first hour of pilot test (sample EFF-1).

cfm Cubic feet per minute.
µg/m^3 Micrograms per cubic meter.
lb/hr Pounds per hour.