



# **High Purge Volume Sub-Slab Sampling**

## **Former Paragon Electric Two Rivers, Manitowoc County**

**Part III, Case Study**

**Annette Weissbach, WDNR-Green Bay**

**Wisconsin's Vapor Intrusion Guidance**

**FET – March 2011**



Two Rivers

Paragon Electric

to Manitowoc

Lake Michigan



~27 acres

# History

- Manufacturer of electrical components (motors, timers, switches). Property vacant/mothballed since the late 1990s. TCE used as parts cleaner until 1991, Investigation began 1985, continued through 2000s
- Soils: 40 feet fine sand, 1-5 feet clay, fine sand 15+ feet, Silurian bedrock ~90 feet
- Groundwater 7-14 feet below grade
- 1993-2002 Source Remedy: soil vapor extraction with groundwater sparging (ceased in 93), and groundwater extraction.
- Estimated 1600 pounds (~ 123 gallons) of TCE removed.

# History

- 2006: Conditional closure granted w/GIS registry: soil and groundwater
- 2008: TA request for “clean” closure options
- 2008: joined the VPLE process
- 2009-2010: Phase I/Phase II
- 2009: VI Survey



Paragon Electric

successive  
plumes  
*(guesstimated!)*

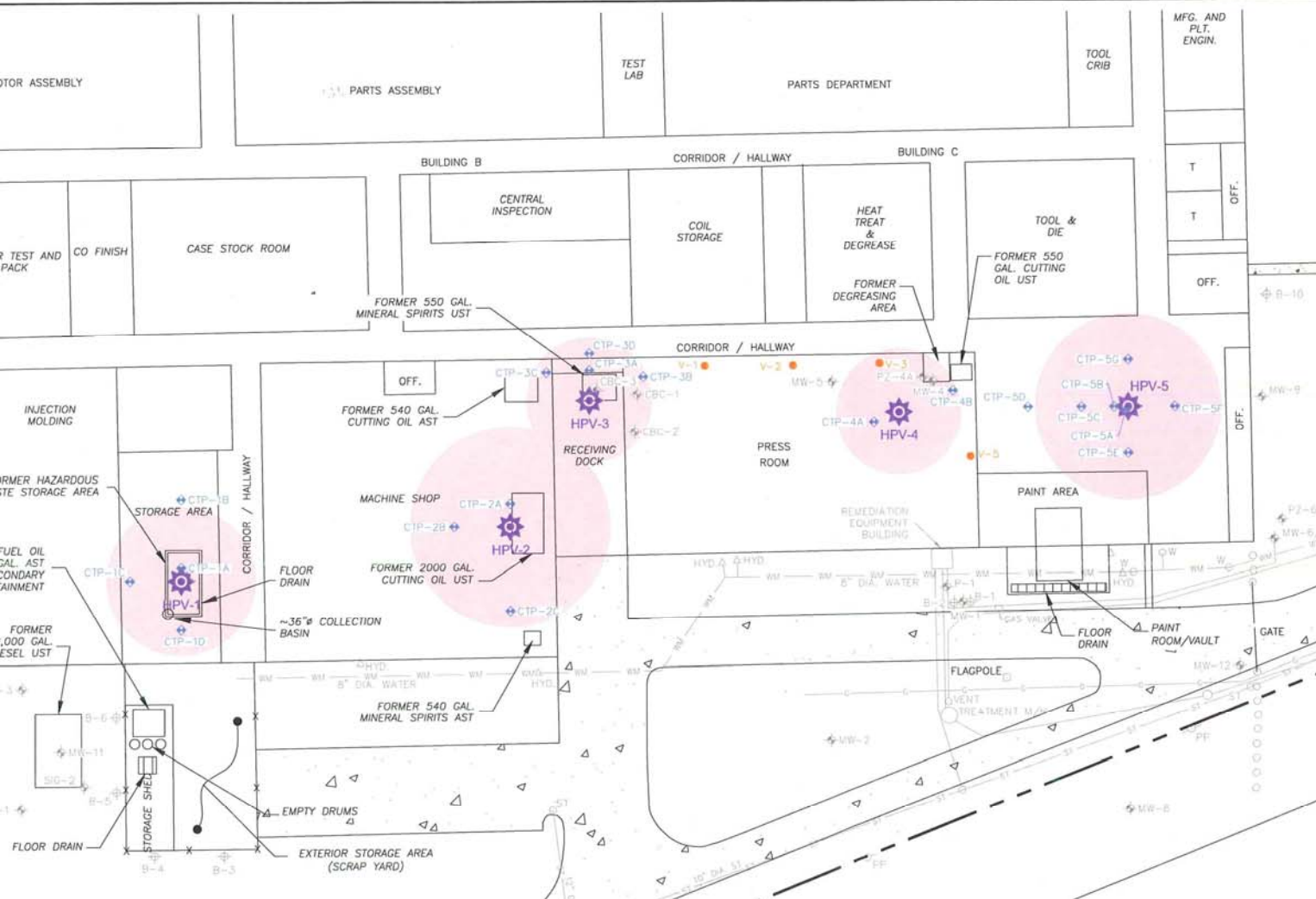
# High Purge Volume Sub-Slab Sampling

- Provides more information by removing a larger volume of soil gas
- Removes soil gas at a consistent rate, 25 to 100 scfm for a period of up to two hours.
- Removes sufficient volume of gas from a 6-inch gravel layer (30% porosity) to withdraw all soil gas within a radius of 25-50 feet.
- Concentration of extracted vapors monitored as a function of time

# High Purge Volume Sub-Slab Sampling

- Field screening with slip-stream samples
- Communication test points (CTP)
- Applied vacuum measurements
- Gas velocity measurements
- Smoke tests (for leakage)
- 6-liter summa canister for 30-100 minutes
- Transient response tests





### LEGEND

- SAN — SANITARY SEWER
- ST — STORM SEWER
- G — GAS LINE
- W — WATER LINE
- CON — CONCRETE/ASPHALT PAVEMENT
- ⊕ MW-1 — MONITORING WELL LOCATION
- ⊕ B-1 — SOIL BORING LOCATION
- ⊕ V-1 — REMEDIATION SYSTEM SPARGE/SVE WELL
- ⊕ CTP-1A — COMMUNICATION TEST POINT
- ⊕ HPV-1 — HIGH PURGE VOLUME SUB-SLAB SAMPLE LOCATION (CALCULATED RADIUS OF GAS EXTRACTED)

**NOTE:**  
 BUILDING INTERIOR WALL, UTILITIES, AND PROPERTY BOUNDARIES ARE APPROXIMATE.

FORMER HAZARDOUS  
WASTE STORAGE AREA

FUEL OIL  
1050 GAL. AST  
TH SECONDARY  
CONTAINMENT

FORMER  
12,000 GAL.  
DIESEL UST

CTP-1B  
STORAGE AREA

CTP-1C

CTP-1A

HPV-1

CTP-1D

CORRIDOR / HALLWAY

FLOOR  
DRAIN

~36"Ø COLLECTION  
BASIN

MACHIN

FORM  
CU

WM

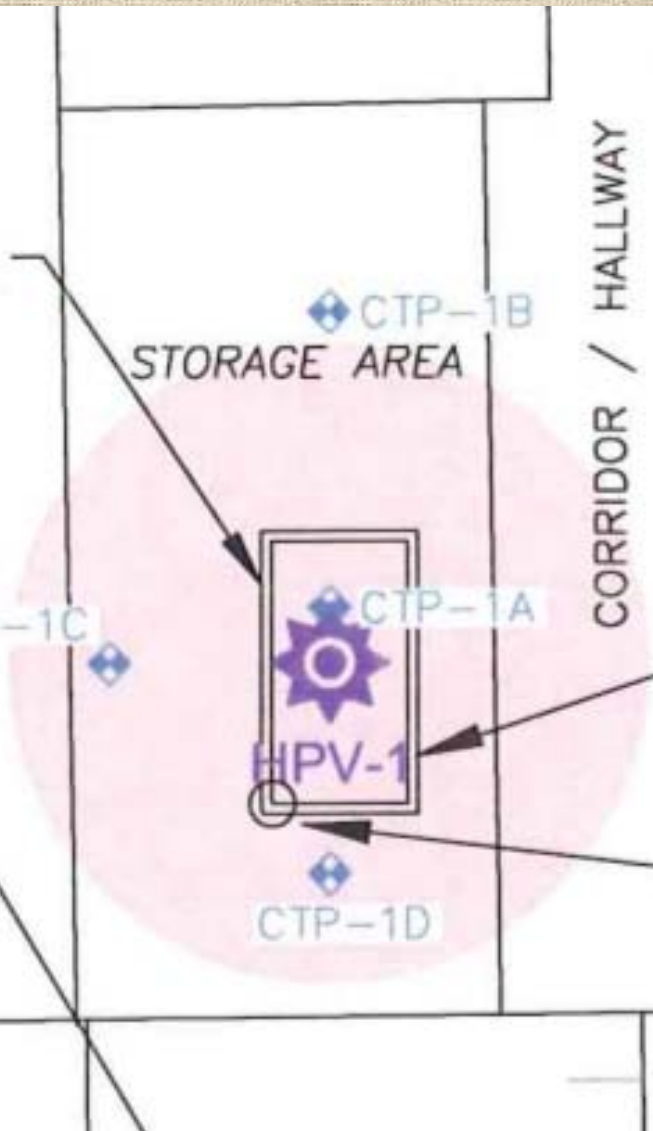
WM

WM

8" DIA. WA

△HYD.

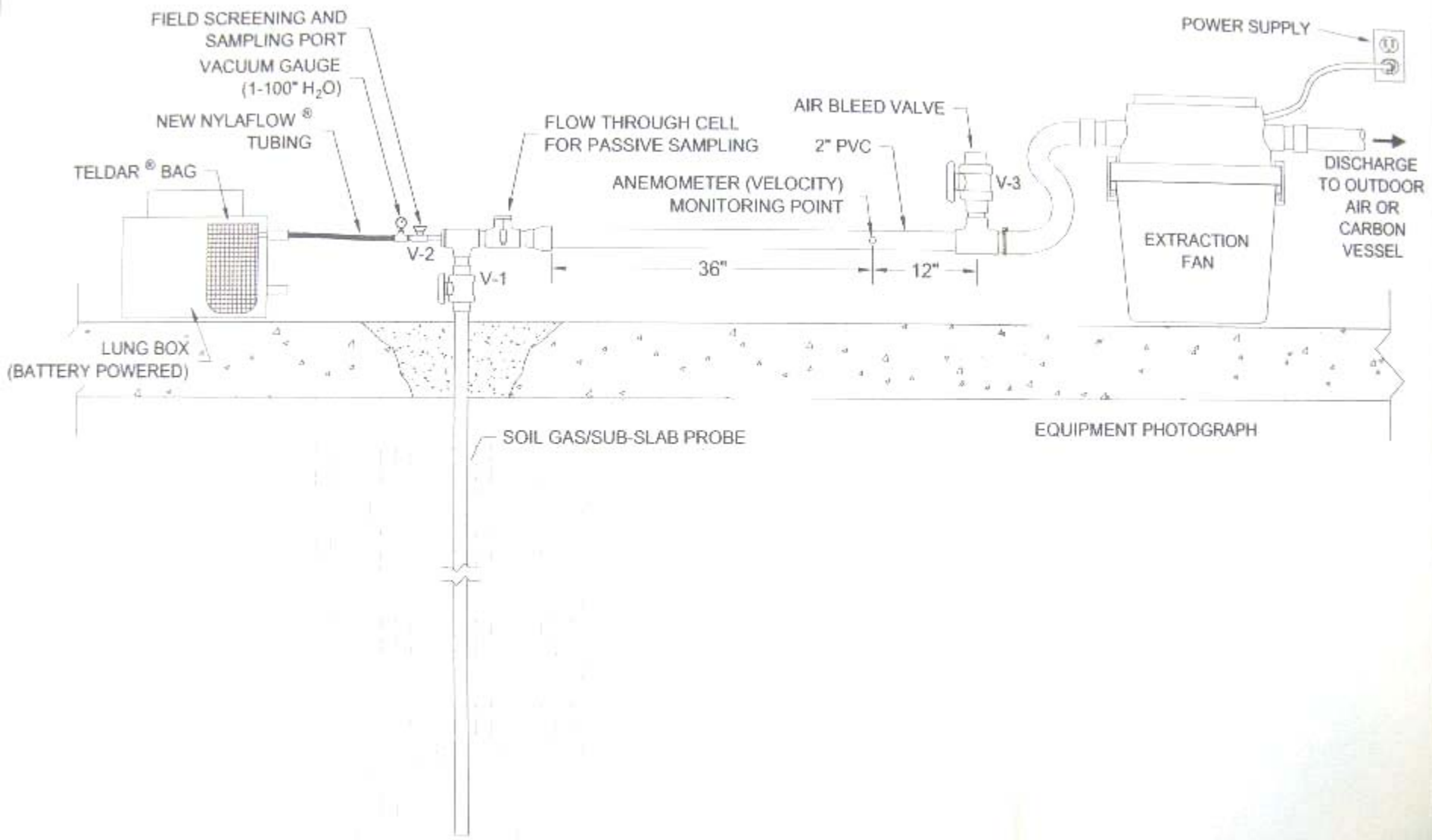
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# SUB-SLAB SAMPLING EQUIPMENT SCHEMATIC



REFERENCE: SCHEMATIC REPRODUCED FROM GEOSYNTEC CONSULTANTS FIGURE 1 (AUGUST 2009)

NOT TO SCALE











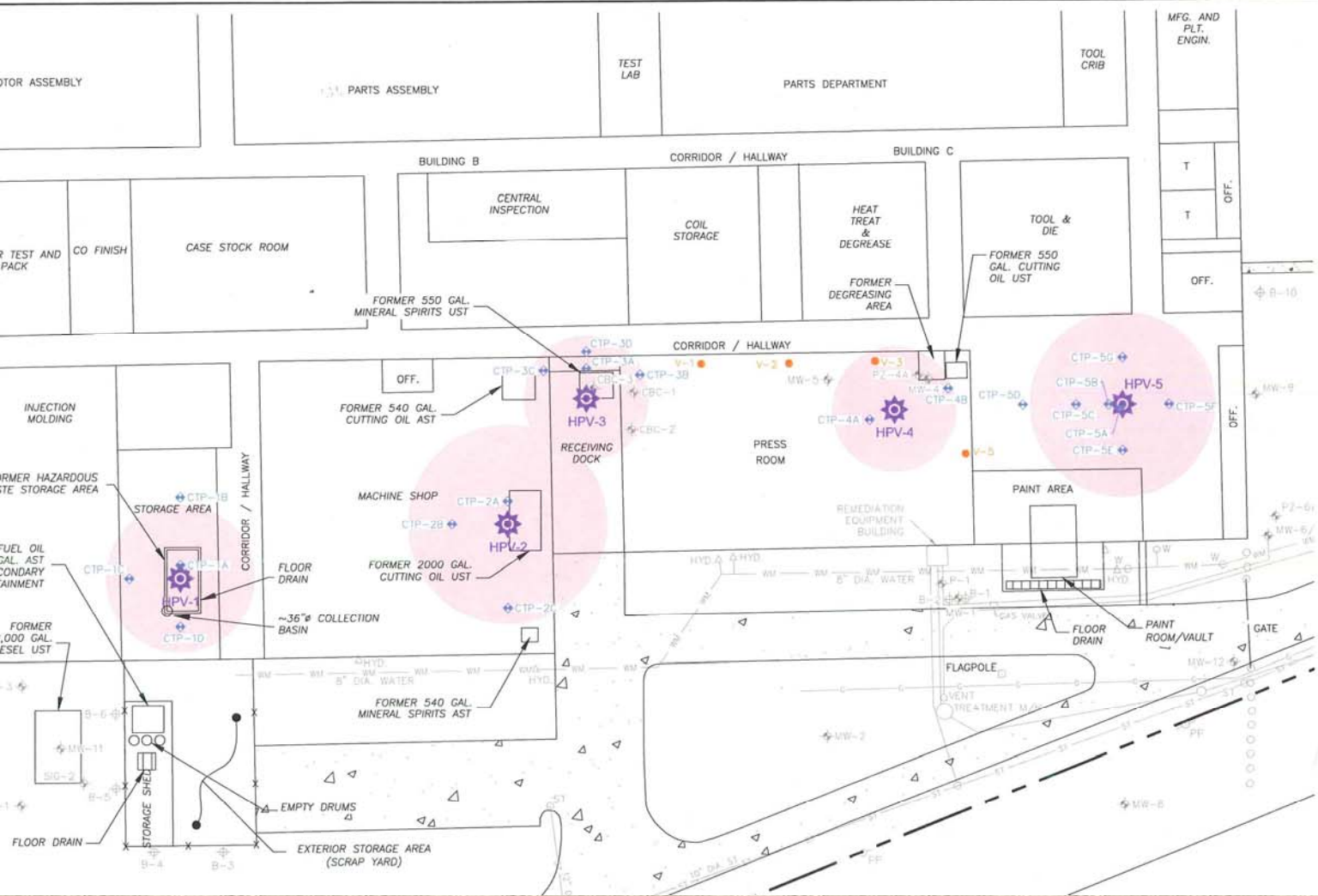












### LEGEND

- SAN — SANITARY SEWER
- ST — STORM SEWER
- GAS — GAS LINE
- WATER — WATER LINE
- CONCRETE/ASPHALT PAVEMENT
- MW-1 — MONITORING WELL LOCATION
- B-1 — SOIL BORING LOCATION
- V-1 — REMEDIATION SYSTEM SPARGE/SVE WELL
- CTP-1A — COMMUNICATION TEST POINT
- HPV-1 — HIGH PURGE VOLUME SUB-SLAB SAMPLE LOCATION (CALCULATED RADIUS OF GAS EXTRACTED)

**NOTE:**  
 BUILDING INTERIOR WALL, UTILITIES, AND PROPERTY BOUNDARIES ARE APPROXIMATE.

**Table 4: Field Screening Readings on Samples of Extracted Gas***(Data provided by Geosytec Consultants)*

VPLE Phase II ESA - Former Paragon Electric Site

Two Rivers, Wisconsin

AECOM Project No. 60139878

Location	Time	Elapsed Time (min)	Cumulative Volume Removed (L)	VOCs by PID (ppm <sub>v</sub> )	O <sub>2</sub> (%)	CO <sub>2</sub> (%)
HPV-1	10:15	0.3	155	12.3	18.5	2.5
	10:23	8	4,952	10.9	18.7	2.4
	10:30	15	9,286	10.7	19.0	2.2
	10:50	35	21,667	7.5	19.5	1.6
	11:05	50	30,953	5.8	19.5	1.4
HPV-2	9:50	0.3	171	1.7	-	-
	9:55	5	3,430	1.8	-	-
	10:00	10	6,859	1.8	-	-
	10:10	20	13,718	1.8	11.2	8.4
	10:25	35	24,007	1.7	11.0	8.2
	11:05	75	51,443	1.5	10.1	8.8
	11:30	100	68,591	1.7	11.0	8.0
HPV-3	8:18	3	2,605	0.0	18.6	2.7
	8:30	12	10,419	0.0	19.1	2.4
	8:40	22	19,101	0.0	19.4	2.1
	9:00	45	39,070	0.0	19.4	1.8
HPV-4	12:50	0.5	301	1.8	19.4	1.7
	12:58	8	4,808	1.6	19.5	1.7
	13:03	13	7,813	1.5	19.7	1.5
	13:15	25	15,025	1.1	20.1	1.3
	13:30	40	24,041	1.6	19.8	1.6
	14:25	95	57,096	1.3	20.1	1.0
HPV-5	15:32	2	1,259	1.9	20.0	1.3
	15:43	13	8,185	1.7	20.1	1.3
	16:05	35	22,037	1.6	20.1	1.4
	16:30	60	37,778	1.8	20.0	1.3
	16:55	85	53,519	1.8	20.1	1.3

**Notes:**

- measurement not collected

min - minutes

L - liters

PID - photoionization detector

ppm<sub>v</sub> - parts per million by volumein H<sub>2</sub>O - inches of water

scfm - standard cubic feet per minute

ft/min - feet per minute

VOCs - volatile organic compounds

O<sub>2</sub> - oxygenCO<sub>2</sub> - carbon dioxide



**Table 5: Vacuum and Field Screening Readings at Communication Test Points***(Data provided by Geosytec Consultants)*

VPLE Phase II ESA - Former Paragon Electric Site

Two Rivers, Wisconsin

AECOM Project No. 60139878

Location	Distance from Point of Extraction (ft)	Vacuum (in H <sub>2</sub> O)	VOCs by PID (ppm <sub>v</sub> )	O <sub>2</sub> (%)	CO <sub>2</sub> (%)
CTP-1A	5.5	0.125	11.5	19.7	1.4
CTP-1B	35	0.012	6.1	17.6	2.4
CTP-1C	22	0.020	4.2	19.8	0.4
CTP-1D	21	0.015	4.2	19.0	1.4
CTP-2A	10	0.300	3.1	-	-
CTP-2B	24	0.122	4.0	3.4	16.1
CTP-2C	36	0.022	24.0	21.0	0.2
CTP-3A	12.8	0.115	44.0	16.6	3.0
CTP-3B	25	0.021	2.0	17.3	1.8
CTP-3C	22	0.022	1.0	20.9	0.0
CTP-3D	20	0.016	1.3	17.1	2.9
CTP-4A	11.5	0.264	0.3	20.8	0.6
CTP-4B	25	0.009	6.0	20.3	0.9
CTP-5A	2	-	-	-	-
CTP-5B	6	0.570	1.8	20.4	0.6
CTP-5C	20	0.133	1.7	21.0	0.0
CTP-5D	43	0.020	3.6	20.1	0.2
CTP-5E	20	0.035	0.8	20.7	0.4
CTP-5F	20	0.015	0.6	20.7	0.3
CTP-5G	20	0.118	0.6	21.0	0.0

**Notes:**

- measurement not collected

ft - feet

min - minutes

in H<sub>2</sub>O - inches of water

PID - photoionization detector

ppm<sub>v</sub> - parts per million by volume

VOCs - volatile organic compounds

O<sub>2</sub> - oxygenCO<sub>2</sub> - carbon dioxide

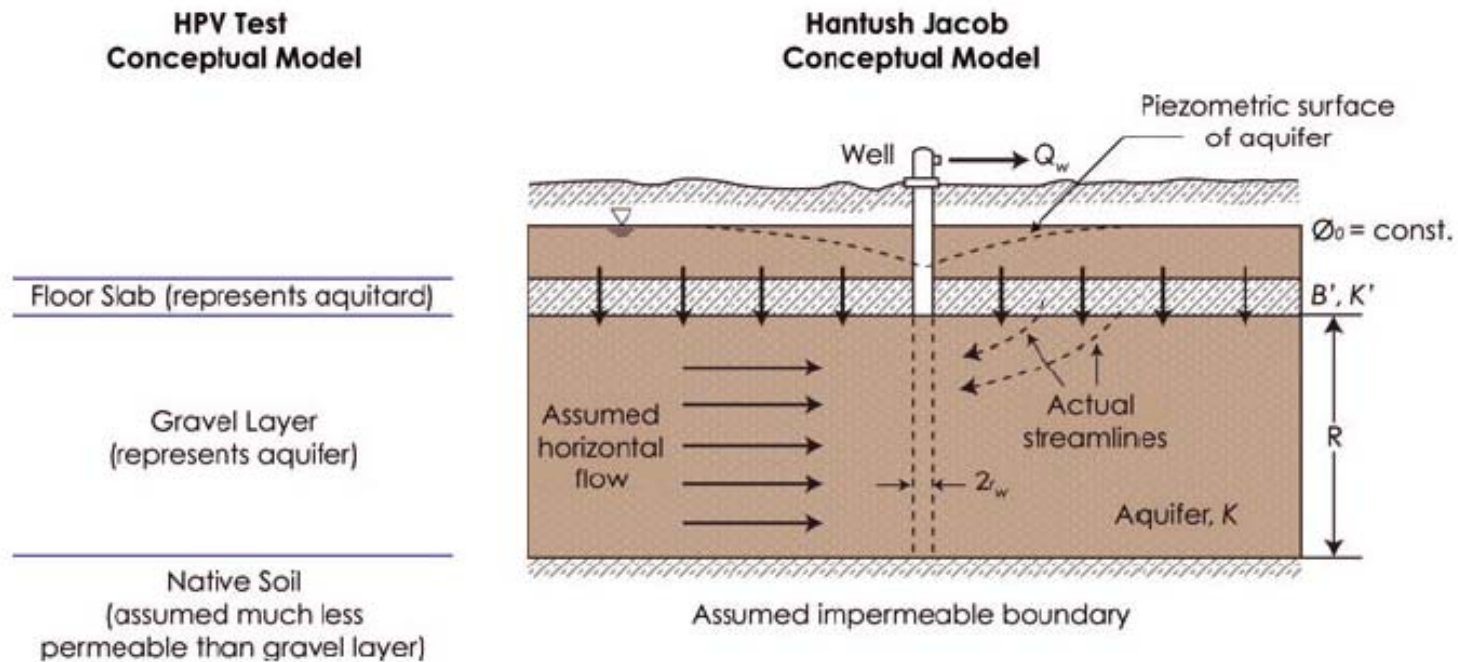


Figure 1. Conceptualization of the Hantush-Jacob leaky aquifer model—for application to HPV transient vacuum data, the “semi-pervious layer” represents the floor slab, “aquifer” represents the granular fill layer beneath the slab, and native soil is present below the bottom of the aquifer layer.

**Table 7: Summary of Transient Response Analysis***(Data provided by Geosytec Consultants)*

VPLE Phase II ESA - Former Paragon Electric Site

Two Rivers, Wisconsin

AECOM Project No. 60139878

Test Location	Monitored CTP	Distance Between CTP and HPV (ft)	HPV Test Duration (min)	HPV Flow Rate (scfm)	Calculated Leakance (B) Value (ft)	Radius of Gas Extracted During Test (ft)	Theoretical Test Extraction Radius1 (ft)	% of model	% Leakage Modeled	% of Sub-slab Soil Gas Collected in the Sample
HPV-1	CTP-1A	5.5	50	22.10905	13.1578947	32	57	0.561404	0.438596	0.61
HPV-2	CTP-2A	10	100	24.49689	16.1290323	45	88	0.511364	0.488636	0.65
HPV-3	CTP-3A	12.75	45	31.00764	7.65765766	26	60	0.433333	0.566667	0.5
HPV-4	CTP-4A	11.5	95	21.46484	6.1827957	27	73	0.369863	0.630137	0.5
HPV-5	CTP-5B	6	85	22.48698	12.9440096	38	75	0.506667	0.493333	0.61
HPV-5	CTP-5-D	43	--	27	13.6363636	--				

**Notes:**

Refer to Appendix C for detailed analyses.

CTP - communication test point

HPV - high purge volume

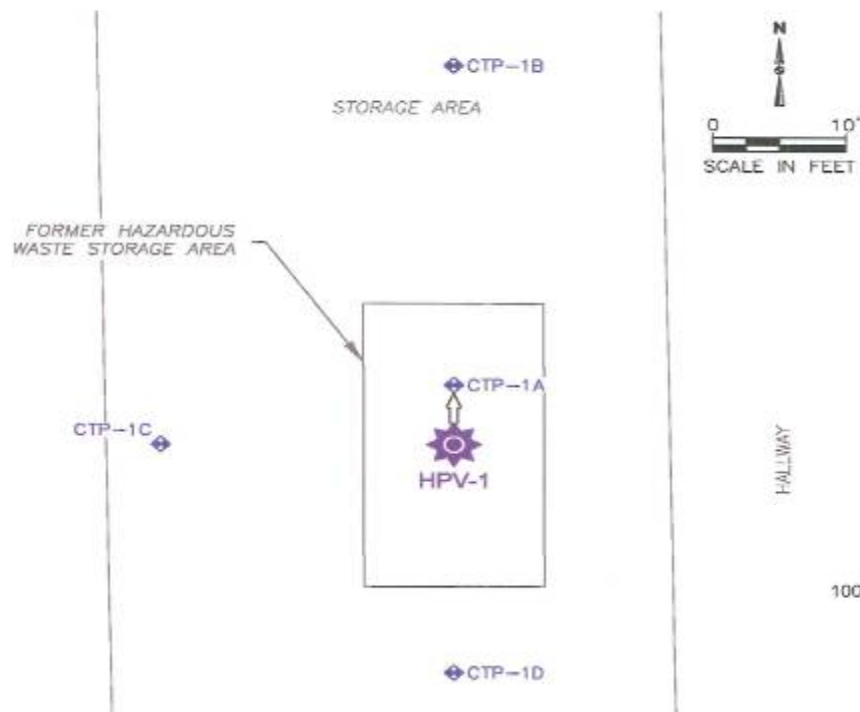
ft - feet

min - minutes

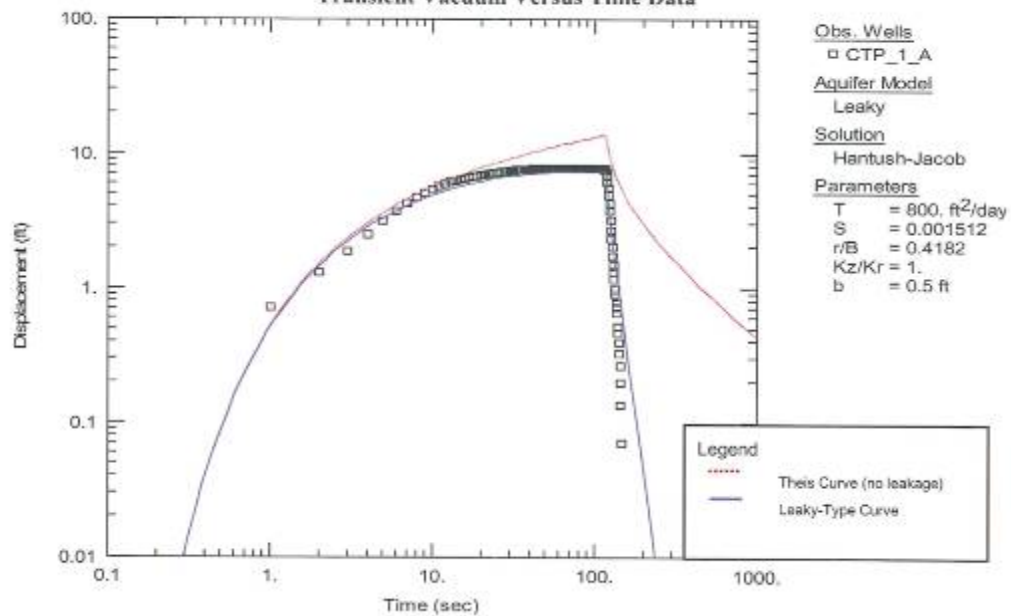
scfm - standard cubic feet per minute

% - percent

**Figure 1: Plan View Map of High Purge Volume (HPV) Test Point and Communication Test Points (CTP)**

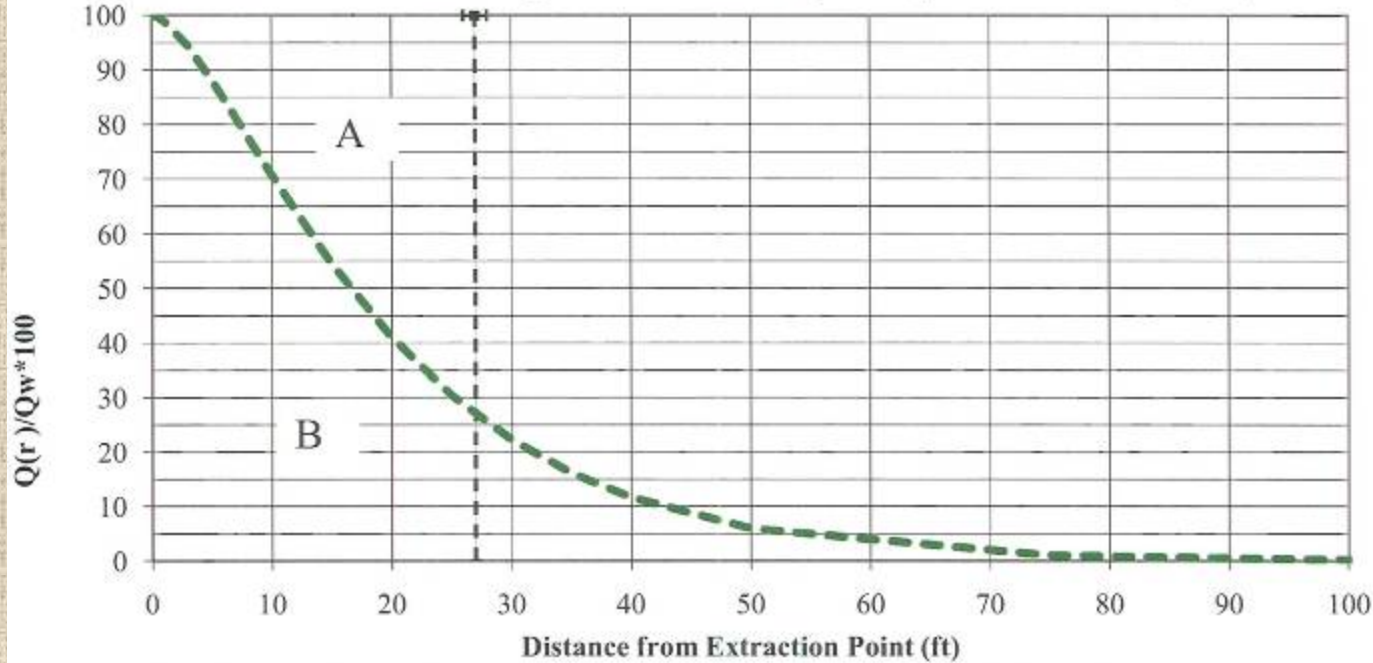


**Figure 3: Graphical Output of Hantush-Jacob Model Fit to Transient Vacuum Versus Time Data**



**Figure 7: Percentage of Total Flow Originating below the Slab vs. Radius**

- CTP-1A Leaky Model Curve
- |- Distance from which gas was extracted during the sample collection interval (27 ft)



A - Area intergrated above the curve represents leakage during sample collection interval  
 B - Area intergrated below the curve represents soil gas extracted from subslab region during the sample collection interval  
 Proportion of sample consisting of soil gas =  $B/(B+A)$

**Table 8: Soil Gas Analytical Results**  
 VPLE Phase II ESA - Former Paragon Electric Site  
 Two Rivers, Wisconsin  
 AECOM Project No. 60139678

Sample I.D.	EPA Region III RBC Residential Sub-slab Soil Gas Screening Level	EPA Region III RBC Industrial Sub-slab Soil Gas Screening Level	HPV-1 10/8/2009 10:22 - 10:52 10/13/2009	Corrected for leakage 39%	HPV-4 10/7/2009 12:52 - 13:17 10/13/2009	Corrected for leakage 50%	HPV-5 10/7/2009 16:00 - 16:30 10/13/2009	Corrected for leakage 39%	CTP-3A 10/8/2009 10:10 - 10:45 10/13/2009	V-5 10/8/2009 07:43 - 08:12 10/13/2009
<i>Volatile Organic Compounds (µg/m<sup>3</sup>)</i>										
Acetone	3,200,000	14,000,000	<122 U		0.87	1.74	0.32 U		5.6	0.82
Benzene	31	160	<165 U		0.44 U		0.44 U		0.68 U	0.44 U
Bromodichloromethane	6.6	33	<256 U		0.94 U		0.94 U		1.3 U	0.94 U

Mini HPV test on former SVE well

Former hazardous waste storage area

Former TCE Vault area

n-Heptane	-	-	211 U		0.56 U		0.56 U		0.75 U	0.56 U
Hexachloro-1,3-butadiene	-	-	560 U		1.5 U		1.5 U		2.0 U	1.5 U
n-Hexane	73,000	310,000	183 U		0.48 U		0.48 U		0.65 U	0.48 U
2-Hexanone	-	-	211 U		0.56 U		0.56 U		0.75 U	0.56 U
Methylene Chloride	520	2,600	161 U		0.48 U		0.48 U		0.64 U	0.48 U
4-Methyl-2-pentanone (MIBK)	-	-	211 U		0.56 U		0.56 U		0.75 U	0.56 U
Methyl-tert-butyl ether	940	4,700	186 U		0.49 U		0.49 U		0.66 U	0.49 U
Naphthalene	7.2	36	667 U		1.8 U		1.8 U		2.4 U	1.8 U
2-Propanol	-	-	636 U		1.7 U		1.7 U		2.2 U	1.7 U
Propylene	-	-	89.0 U		0.23 U		0.23 U		0.32 U	0.23 U
Styrene	100,000	440,000	221 U		0.58 U		0.58 U		0.78 U	0.58 U
1,1,2,2-Tetrachloroethane	4.2	21	356 U		0.94 U		0.94 U		1.3 U	0.94 U
Tetrachloroethene	41	210	15,000	24,600	10		26.9		1.3 U	30.9
Tetrahydrofuran	-	-	183 U		0.40 U		0.40 U		0.54 U	0.40 U
Toluene	520,000	2,200,000	196 U		1.3		1.3		0.69 U	0.52 U
1,2,4-Trichlorobenzene	210	1,800	252 U		0.66 U		0.66 U		0.89 U	0.66 U
1,1,1-Trichloroethane	520,000	2,200,000	280 U		0.74 U		0.74 U		0.99 U	0.74 U
1,1,2-Trichloroethane	15	77	280 U		0.74 U		0.74 U		0.99 U	0.74 U
Trichloroethene	120	610	30,200	49,500	114		228	182	298	34.6
Trichlorofluoromethane	73,000	310,000	280 U		0.74 U		0.74 U		0.99 U	0.74 U
1,1,2-Trichlorotrifluoroethane	-	-	407 U		1.1 U		1.1 U		1.4 U	1.1 U
1,2,4-Trimethylbenzene	730	3,100	636 U		1.7 U		1.7 U		71.4	1.7 U
1,3,5-Trimethylbenzene	-	2,600	636 U		1.7 U		1.7 U		18.3	1.7 U
Vinyl acetate	21,000	88,000	161 U		0.48 U		0.48 U		0.64 U	0.48 U
Vinyl chloride	16	280	132 U		0.35 U		0.35 U		0.47 U	0.35 U
m&p-Xylene	73,000	310,000	448 U		1.2 U		1.2 U		35.7	1.2 U
o-Xylene	73,000	310,000	224 U		0.59 U		0.59 U		14.2	0.59 U

**Notes:**

µg/m<sup>3</sup> - micrograms per cubic meter

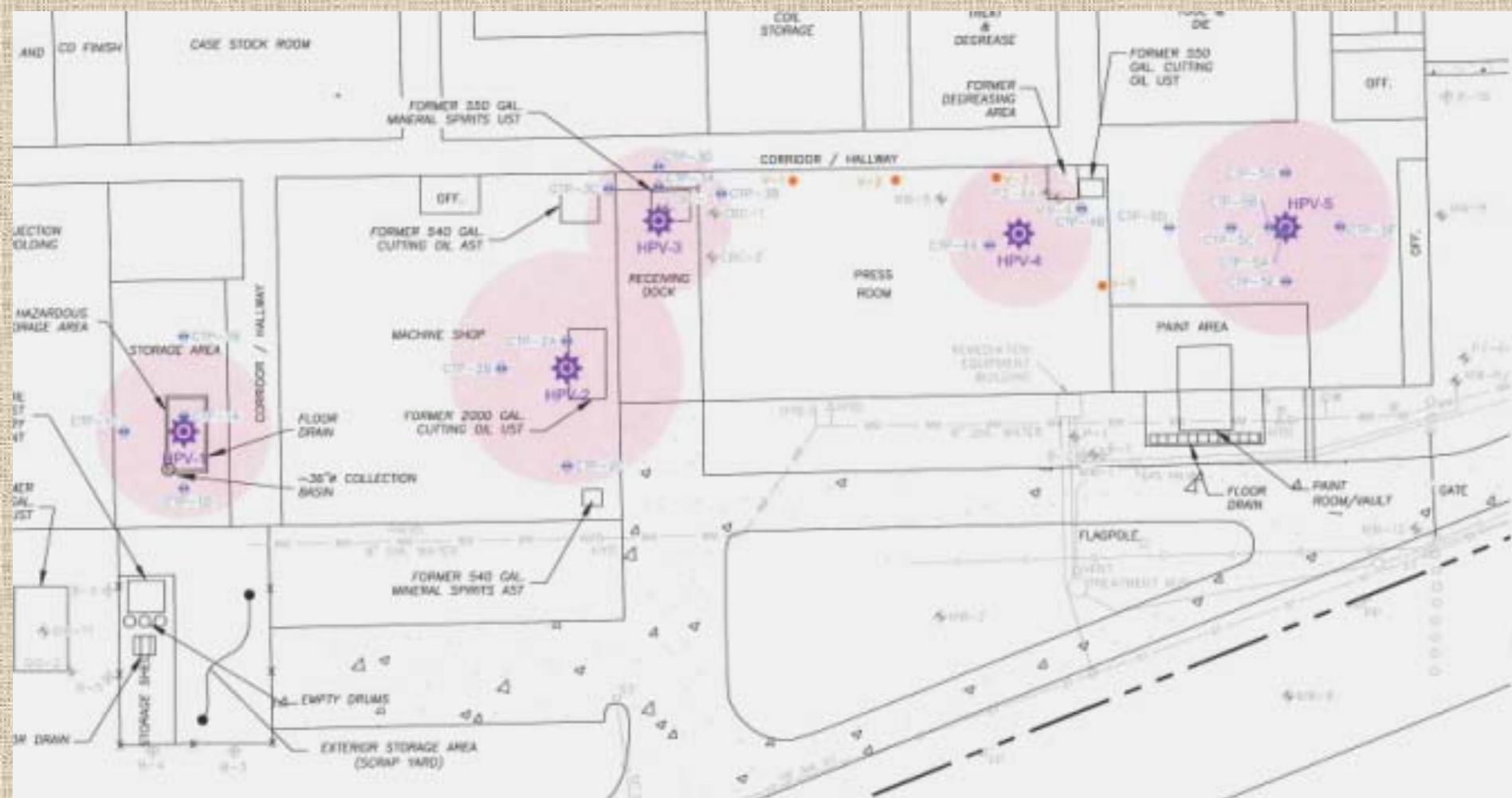
I.D. - identification

J - Analyte recovery in the laboratory control sample (LCS) was above QC limits. Result may be biased high.

U - Analyte not detected, associated value is reporting limit.

<sup>1</sup> Sub-slab soil gas screening levels based on EPA Region III Risk Based Concentrations with a cancer risk of 1 x 10<sup>-6</sup> and and at

55 indicates that analyte was detected above soil gas screening level





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