Ott/Story/Cordova Superfund Site

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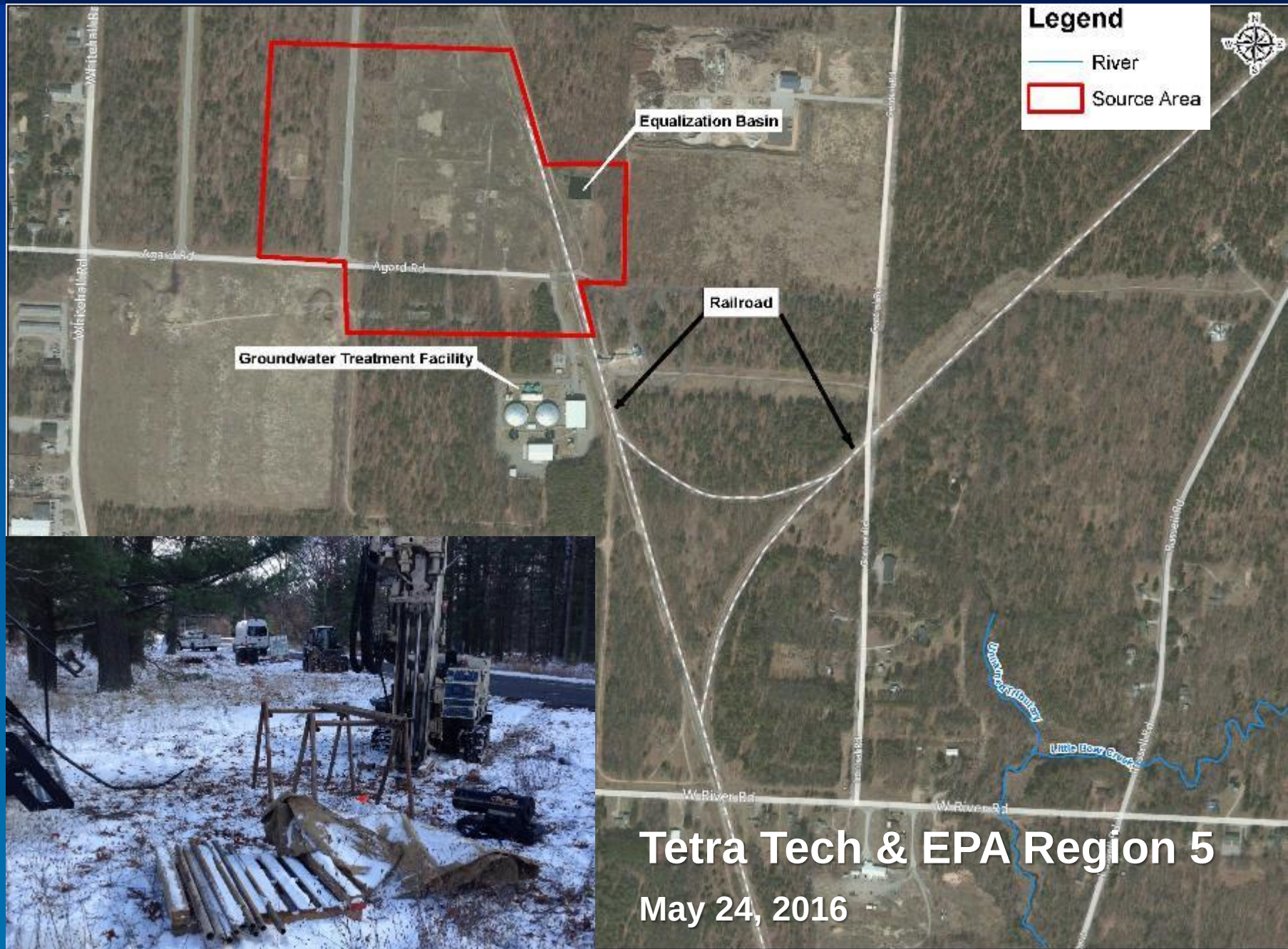


Tetra Tech

Outline

- Project Introduction
- Site History
- Goals of the Investigation/project
- High Resolution Site Characterization
- Investigation Results
- Next Steps for 2017

Project Introduction – Site Location

Site History

A Former Specialty Organic Chemical Production Facility that operated from about 1957 to 1985.

- Manufactured:
  - Pharmaceutical Intermediates
  - Veterinary Medicines
  - Agricultural Chemicals
  - Herbicides
  - Dyestuffs, and Others.

Site History

Waste by-products from the chemical manufacturing processes were placed in unlined lagoons or stored in drums on the property.

Site History

Site History

Site History

Site History

Principal Contaminants of Concern

- Vinyl Chloride
- Tetrachloroethene (PCE)
- Trichloroethene (TCE)
- Toluene
- Benzene
- 1,1-Dichloroethene (1,1-DCE)
- 1,2 Dichloroethane (1,2-DCA)
- 1,1,1-Trichloroethane

Site History

Site divided into 3 operable units (OU)

OU1 (ROD signed 1989)

- Installation of 11 extraction wells to protect downgradient stream and to restore the aquifer to drinking water quality

OU2 (ROD signed 1990)

- Construction and operation of Groundwater Treatment Facility (GWTF) and extraction wells
- 1996 GWTF started treating contaminated groundwater
- Collect quarterly groundwater samples

Site History – Site Layout

Site History – Site Layout

Site History

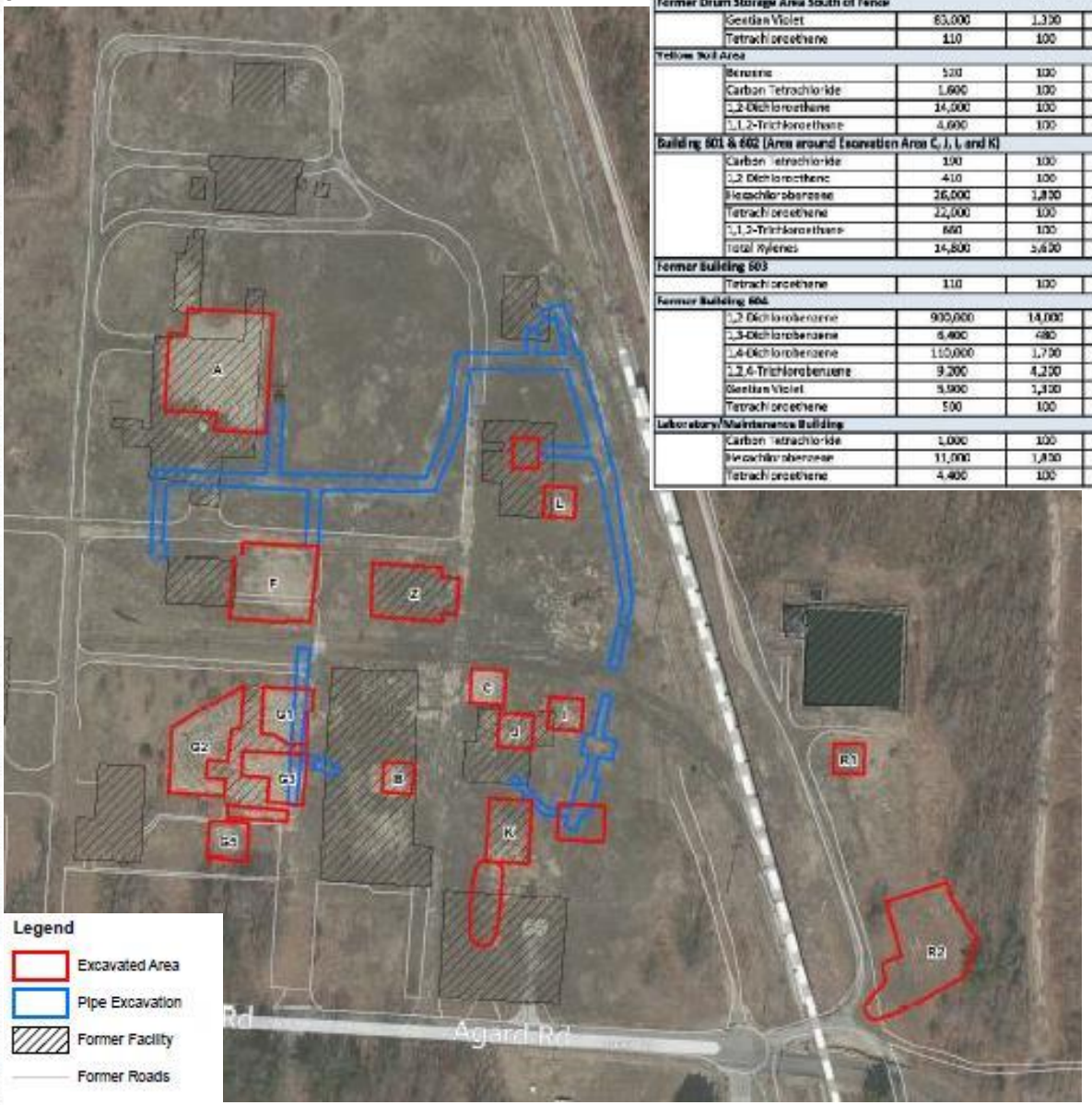
OU3 (ROD signed 1993, amended 1999)

- Primary remedial goal was to reduce downward migration of contaminants in soils and reduce human health and the environment associated with exposure to contaminated soils
- Excavated and disposed offsite approximately 16,000 tons of soil in the source area to just above shallow groundwater depths (approximately 4-5 feet)
- Demolished unusable structures
- Collected confirmatory samples after excavation

Site History

Area of Concern	Contaminant	Concentration (µg/kg)	MDEQ Clean-up Criteria	Depth (ft bgs)
Excavation Area A				
	Tetrachloroethene	1,100	100	5
Excavation Area B				
	Hexachlorobenzene	4,000	1,800	5
	Tetrachloroethene	760	100	5
Excavation Area C				
	Carbon Tetrachloride	120	100	5 and 2
	Tetrachloroethene	920	100	2
Excavation Area F				
	1,2-Dichlorobenzene	21,000	14,000	6
	1,3-Dichlorobenzene	520	480	6.5
	1,4-Dichlorobenzene	2,100	1,700	6
	Ethylbenzene	2,700	1,500	6
	Gentian Violet	150,000	1,300	4.5
	m,p-Xylene	14,000	5,500	6
	o-Xylene	8,000	5,600	6
	Tetrachloroethene	1,100	100	4.5
	1,1,1-Trichloroethane	5,000	4,000	9.5
Excavation Area G3				
	Aroclor-1248	70	20	2
Excavation Area I				
	Aroclor-1248	350	20	6
	Benzene	520	100	3
	1,2-Dichloroethene	460	130	3
	Tetrachloroethene	380	100	6
Excavation Area J				
	Hexachlorobenzene	1,900	1,800	unknown
	Tetrachloroethene	1,400	100	unknown
Excavation Area K				
	1,2-Dichloroethene	1,300	100	2
	Hexachlorobenzene	4,200	1,800	3-6
	Tetrachloroethene	7,400	100	2
	Trichloroethene	150	100	2
Excavation Area L				
	Tetrachloroethene	1,300	100	2
Excavation Area R1				
	Tetrachloroethene	450	100	2.5
Excavation Area R2				
	Benzene	14,000	100	2
	Carbon Tetrachloride	6,000	100	2
	1,2-Dichloroethene	9,800	100	2
	Tetrachloroethene	2,000	100	2
	Trichloroethene	340	100	2
	1,1,1-Trichloroethane	7,900	4,000	2
	1,1,2-Trichloroethane	13,000	100	2
	Total Xylenes	17,900	5,600	2
Sewer Near Excavation Area I & K				
	Benzene	13,000	100	2
	Carbon Tetrachloride	6,000	100	2
	1,2-Dichloroethene	9,800	100	2
	Tetrachloroethene	2,000	100	2
	1,1,1-Trichloroethane	7,900	4,000	2
	1,1,2-Trichloroethane	13,000	100	2
	Trichloroethene	340	100	2
	Total Xylenes	17,900	5,600	2
Sewer Near Excavation Area A				
	1,2-Dichloroethene	990	100	5
	Tetrachloroethene	990	100	5
Sewer Near Excavation Area F				
	1,3-Dichlorobenzene	820	480	6.5
	1,4-Dichlorobenzene	1,900	1,700	6
	Gentian Violet	82,000	1,300	6
	Tetrachloroethene	1,800	100	6.5
	1,1,2-Trichloroethane	170	100	6.5
	1,2,4-Trimethylbenzene	3,300	2,100	6.5
	1,3,5-Trimethylbenzene	4,300	1,800	6.5
	Total Xylenes	13,700	5,600	6.5
By-Product Storage Area				
	1,2-Dichloroethene	160	100	surface
	Tetrachloroethene	1,300	100	surface

Area of Concern	Contaminant	Concentration (µg/kg)	MDEQ Clean-up Criteria	Depth (ft bgs)
Former Drum Storage Area South of Fence				
	Gentian Violet	83,000	1,300	2
	Tetrachloroethene	110	100	2
Yellow Soil Area				
	Benzene	520	100	2
	Carbon Tetrachloride	1,600	100	2
	1,2-Dichloroethene	14,000	100	2
	1,1,2-Trichloroethane	4,600	100	2
Building 601 & 602 (Area around Excavation Area C, J, L, and K)				
	Carbon Tetrachloride	190	100	surface
	1,2-Dichloroethene	410	100	surface
	Hexachlorobenzene	26,000	1,800	surface
	Tetrachloroethene	22,000	100	surface
	1,1,2-Trichloroethane	860	100	surface
	Total Xylenes	14,800	5,600	surface
Former Building 603				
	Tetrachloroethene	110	100	surface
Former Building 604				
	1,2-Dichlorobenzene	900,000	14,000	2
	1,3-Dichlorobenzene	6,400	480	2
	1,4-Dichlorobenzene	110,000	1,700	2
	1,2,4-Trichlorobenzene	9,200	4,200	2
	Gentian Violet	9,900	1,300	2
	Tetrachloroethene	500	100	2
Laboratory/Maintenance Building				
	Carbon Tetrachloride	1,000	100	surface
	Hexachlorobenzene	11,000	1,800	surface
	Tetrachloroethene	4,400	100	surface



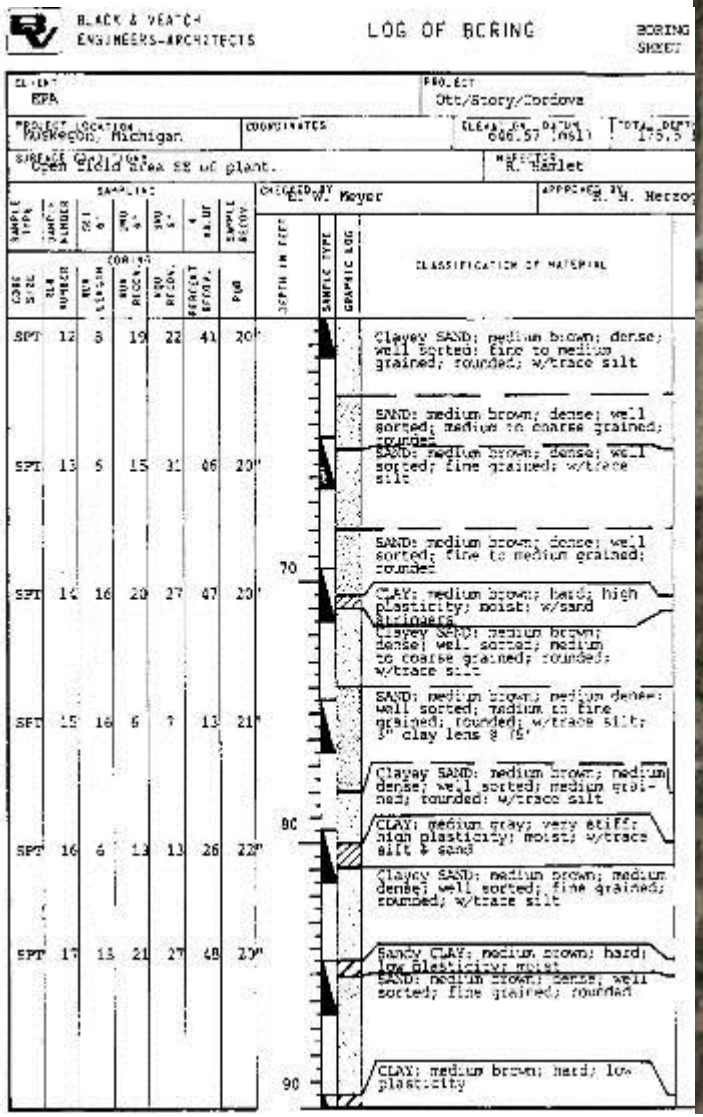
Environmental Issues/Goals of Investigation

- Characterize the nature and extent of contamination of the source area and downgradient areas
- Evaluate whether sources exist that may continue to impact the effectiveness of the site remedy
- Review and assess potential additional remedial technologies

Where to Start?

- Reviewed Over 20 Years of Data
  - Site Geology
  - Analytical Data
- Conducted 3D Visualization and Analysis
- Determined Data Gaps
- Conduct High Resolution Site Characterization (HRSC) to resolve data gaps
- Conduct 3D Visualization and Analysis (3DVA) to determine nature and extent of contamination

Review of Historical Data - Site Geology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ENGINEERS-ARCHITECTS

LOG OF BORING

BORING
SHEET

CLIENT
EPA

PROJECT
Ott/Story/Cordova

PROJECT LOCATION
Muskegon, Michigan.

COORDINATES

CLEAVAGE DATUM
606.57 (msl)

TOTAL DEPTH
175.5

SURFACE CONDITIONS
Open field area se of plant.

DRILLING
R. Hamlet

SAMPLING

CHECKED BY
E.W. Meyer

APPROVED BY
G.N. Herzo

SAMPLE TYPE	SAMPLE NUMBER	SILT %	SAND %	GRAVEL %	AS REC.	SAMPLE RECOV.	CORE SIZE	CORE RUN NUMBER	CORE RUN ELEVATION	CORE RUN RECOV.	CORE RUN RECOV.	PERCENT RECOV.	RQD
SPT	12	8	19	22	41	20"							
SPT	13	6	15	31	46	20"							
SPT	14	16	20	27	47	20"							
SPT	15	16	6	7	13	21"							
SPT	16	6	13	13	26	22"							
SPT	17	13	21	27	48	20"							

DEPTH IN FEET | SAMPLE TYPE | GRAPHIC LOG | CLASSIFICATION OF MATERIAL

Clayey SAND; medium brown; dense; well sorted; fine to medium grained; rounded; w/trace silt

SAND; medium brown; dense; well sorted; medium to coarse grained; rounded

SAND; medium brown; dense; well sorted; fine grained; w/trace silt

70

SAND; medium brown; dense; well sorted; fine to medium grained; rounded

CLAY; medium brown; hard; high plasticity; moist; w/sand stringers

Clayey SAND; medium brown; dense; well sorted; medium to coarse grained; rounded; w/trace silt

SAND; medium brown; medium dense; well sorted; medium to fine grained; rounded; w/trace silt; 3" clay lens @ 65'

Clayey SAND; medium brown; medium dense; well sorted; medium grained; rounded; w/trace silt

90

CLAY; medium gray; very stiff; high plasticity; moist; w/trace silt & sand

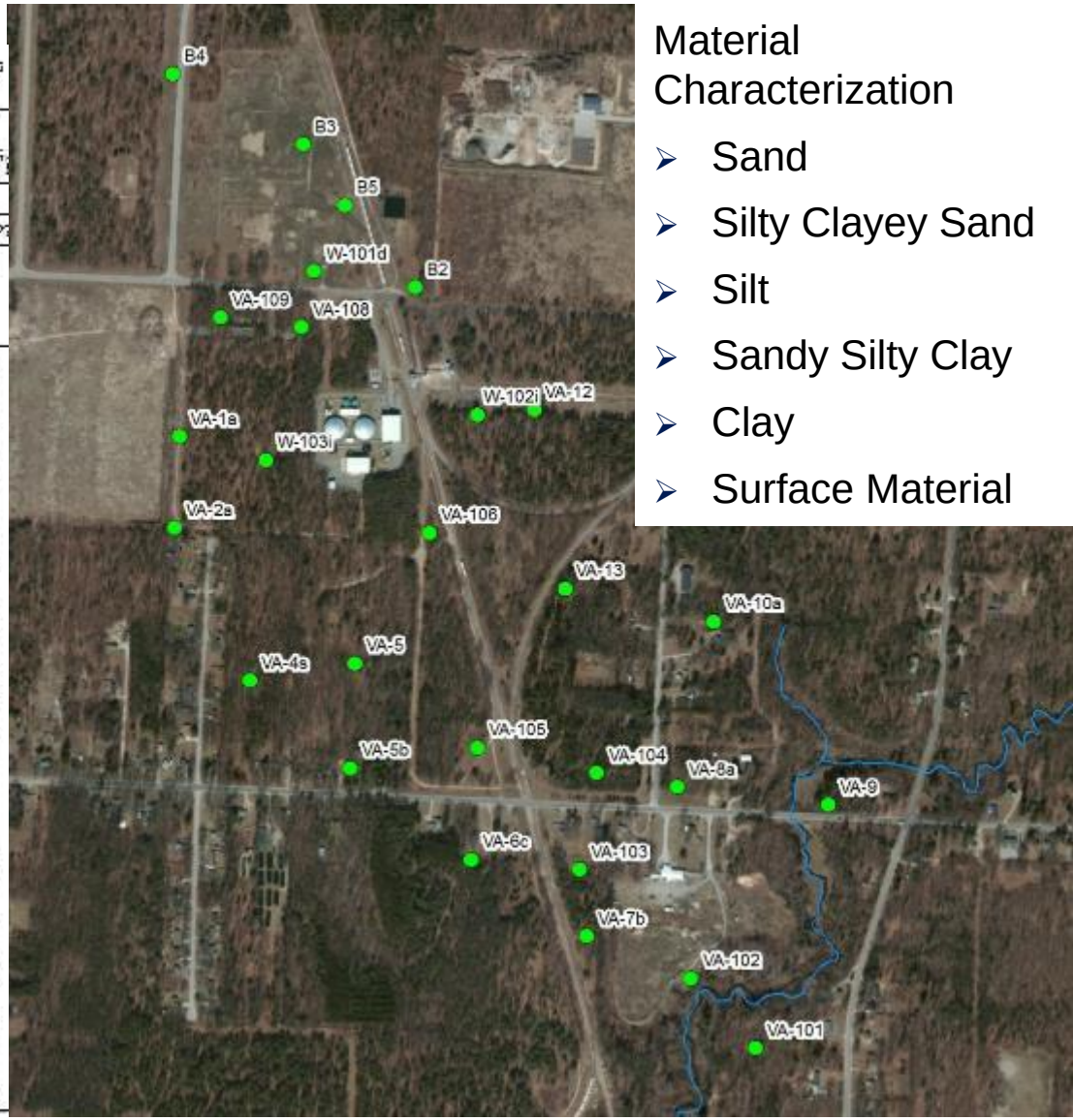
Clayey SAND; medium brown; medium dense; well sorted; fine grained; rounded; w/trace silt

Sandy CLAY; medium brown; hard; low plasticity; moist

SAND; medium brown; dense; well sorted; fine grained; rounded

90

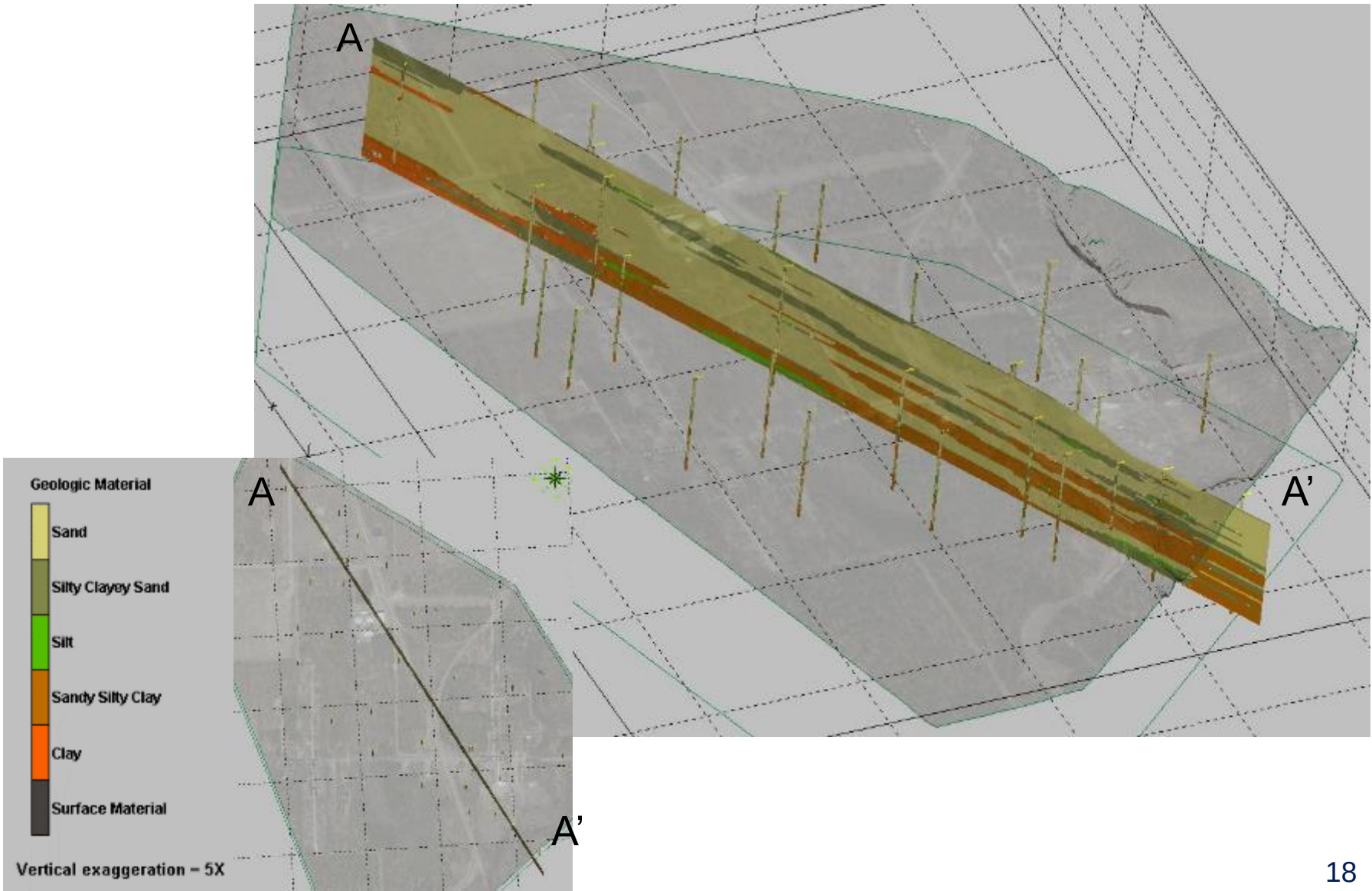
CLAY; medium brown; hard; low plasticity



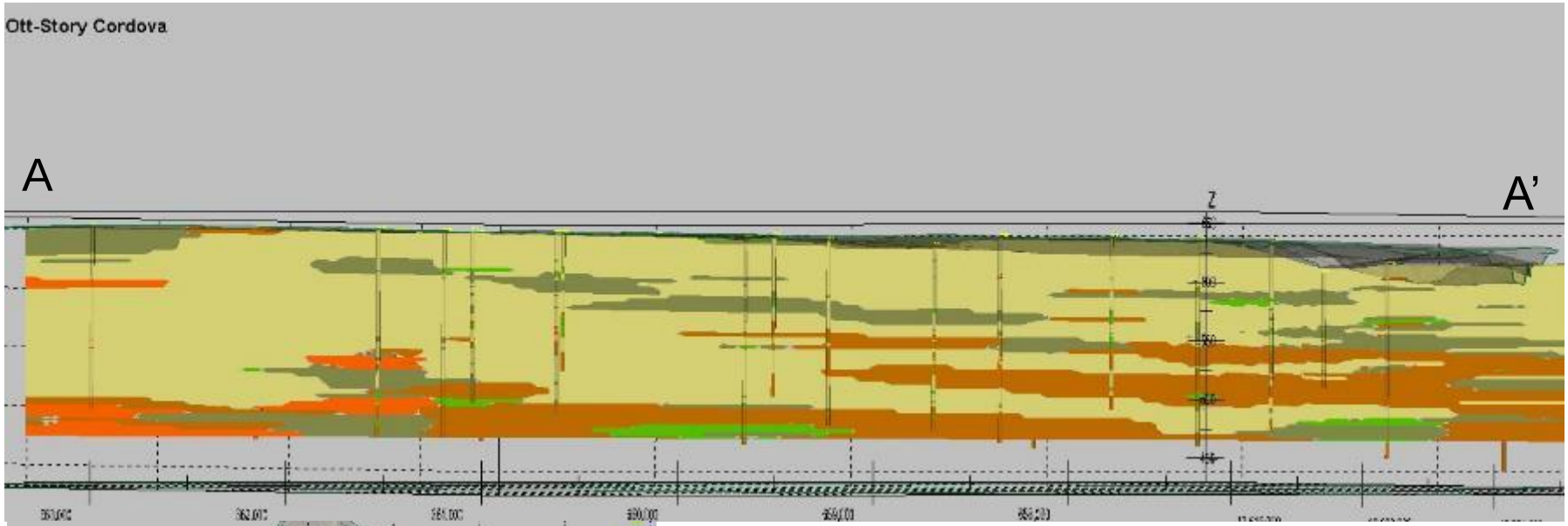
Material Characterization

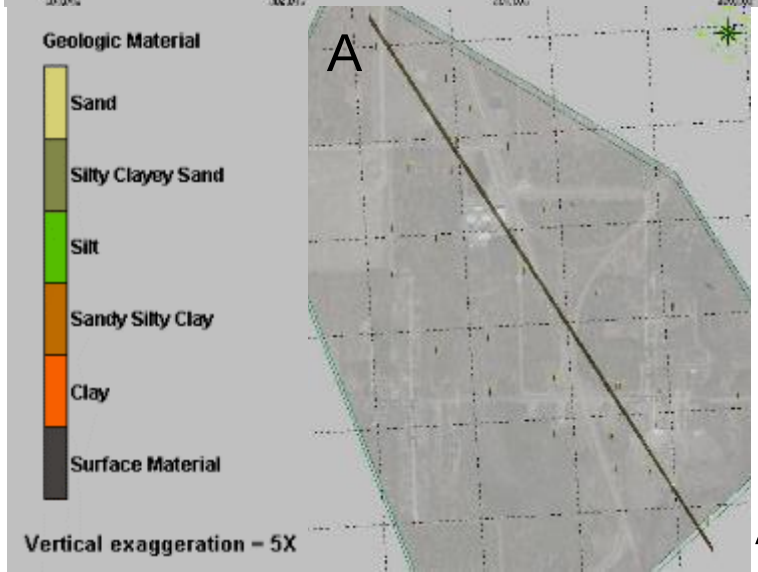
- Sand
- Silty Clayey Sand
- Silt
- Sandy Silty Clay
- Clay
- Surface Material

Review of Historical Data – 3DVA

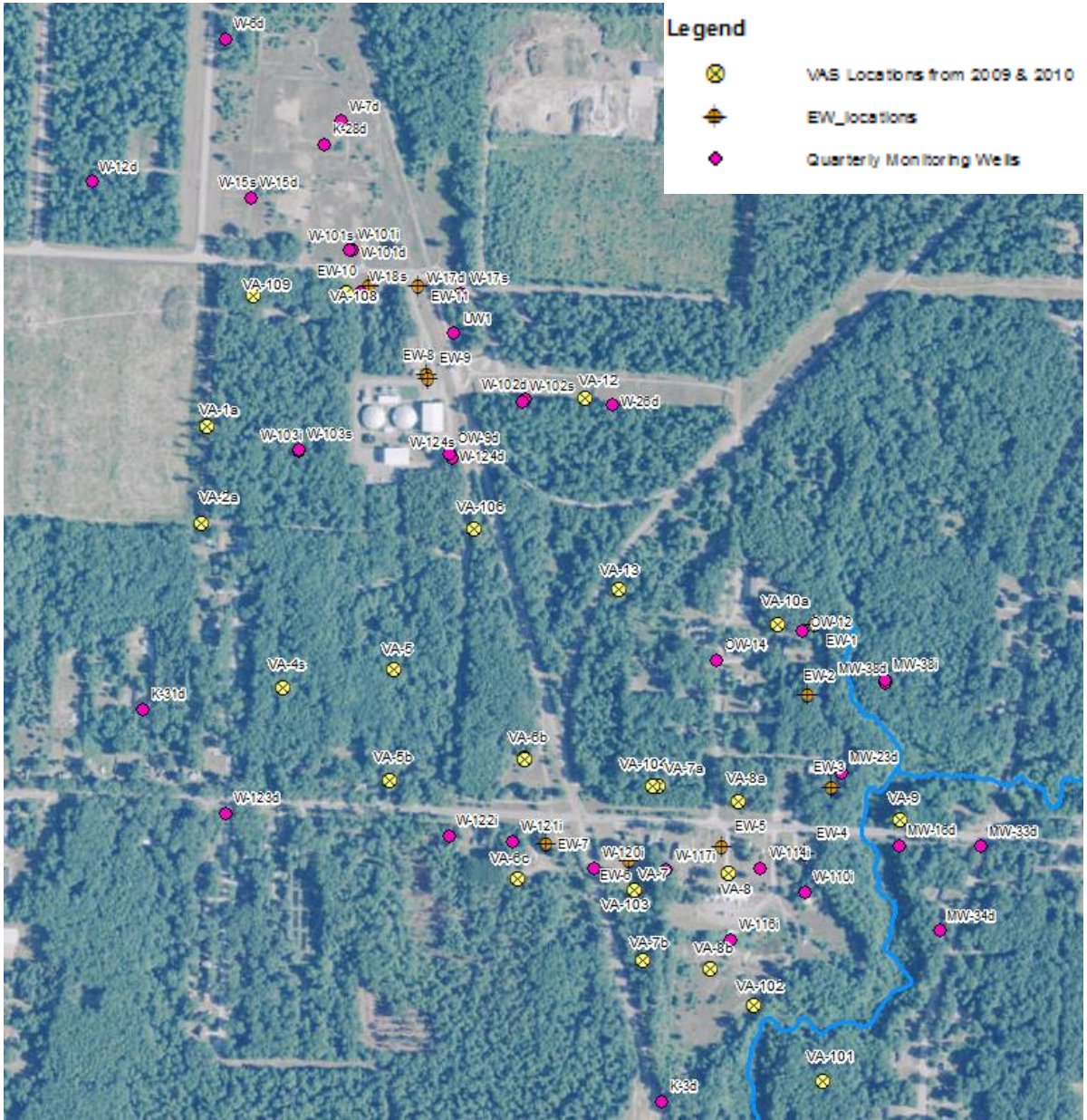


Review of Historical Data – 3DVA





Review of Historical Data - Groundwater Analysis



High Resolutions Site Characterization

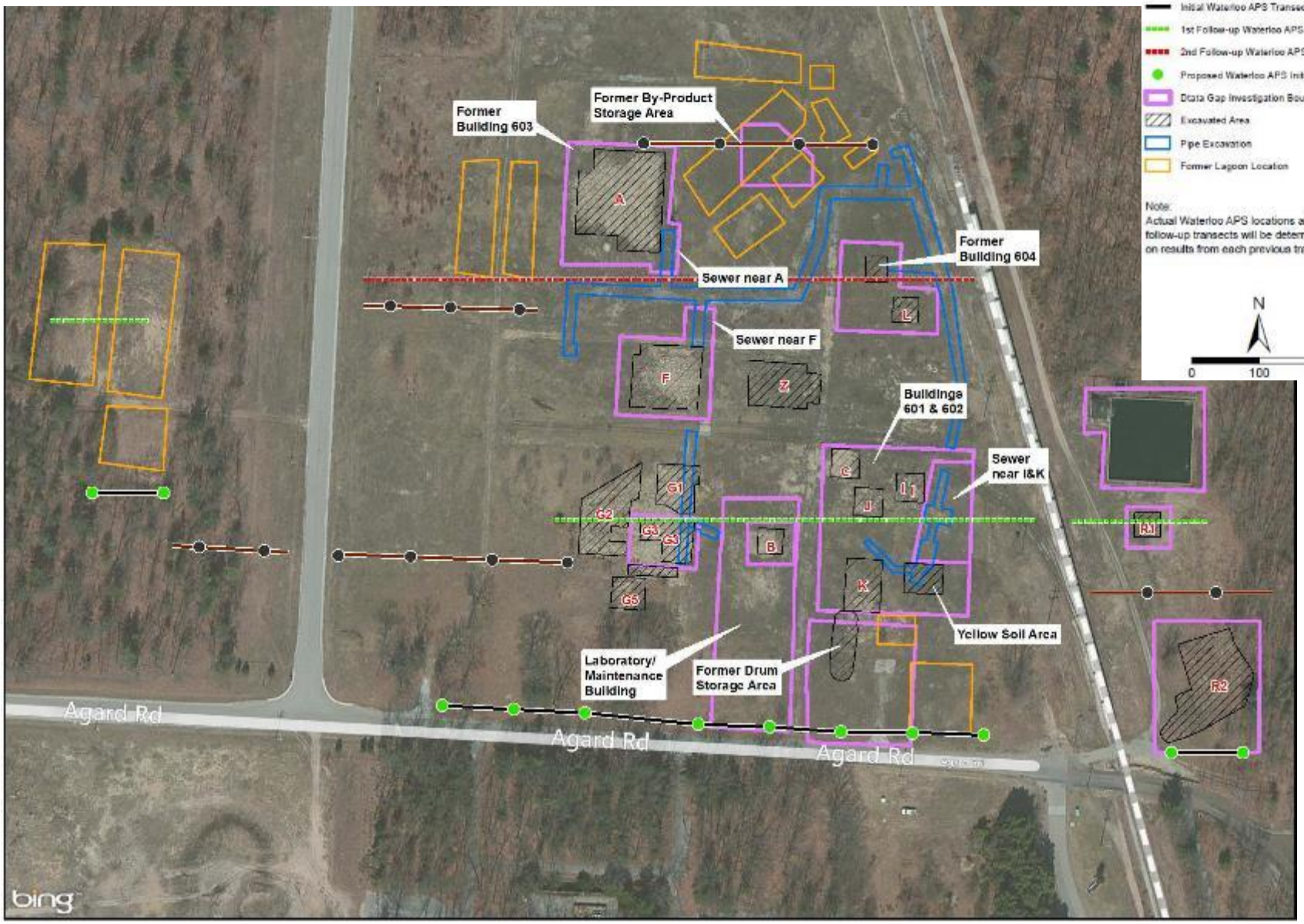
Design Site Investigation

- Initial Investigation Focused on Source Area
- Transect based approach
- MIP (Membrane Interface Probe)
- Waterloo APS (Continuous Vertical Profile)
- Onsite Mobile Laboratory
- Real- Time Decisions
- 3D Visualization and Analysis

Field investigation performed in three phases:

- Phase I – Fall 2014 (MIP and Waterloo)
- Phase II – Summer 2015 (Additional Waterloo)
- Phase III – Spring 2016 (Deep VAS)

Source Area Investigation



Phase I and II Investigation Summary

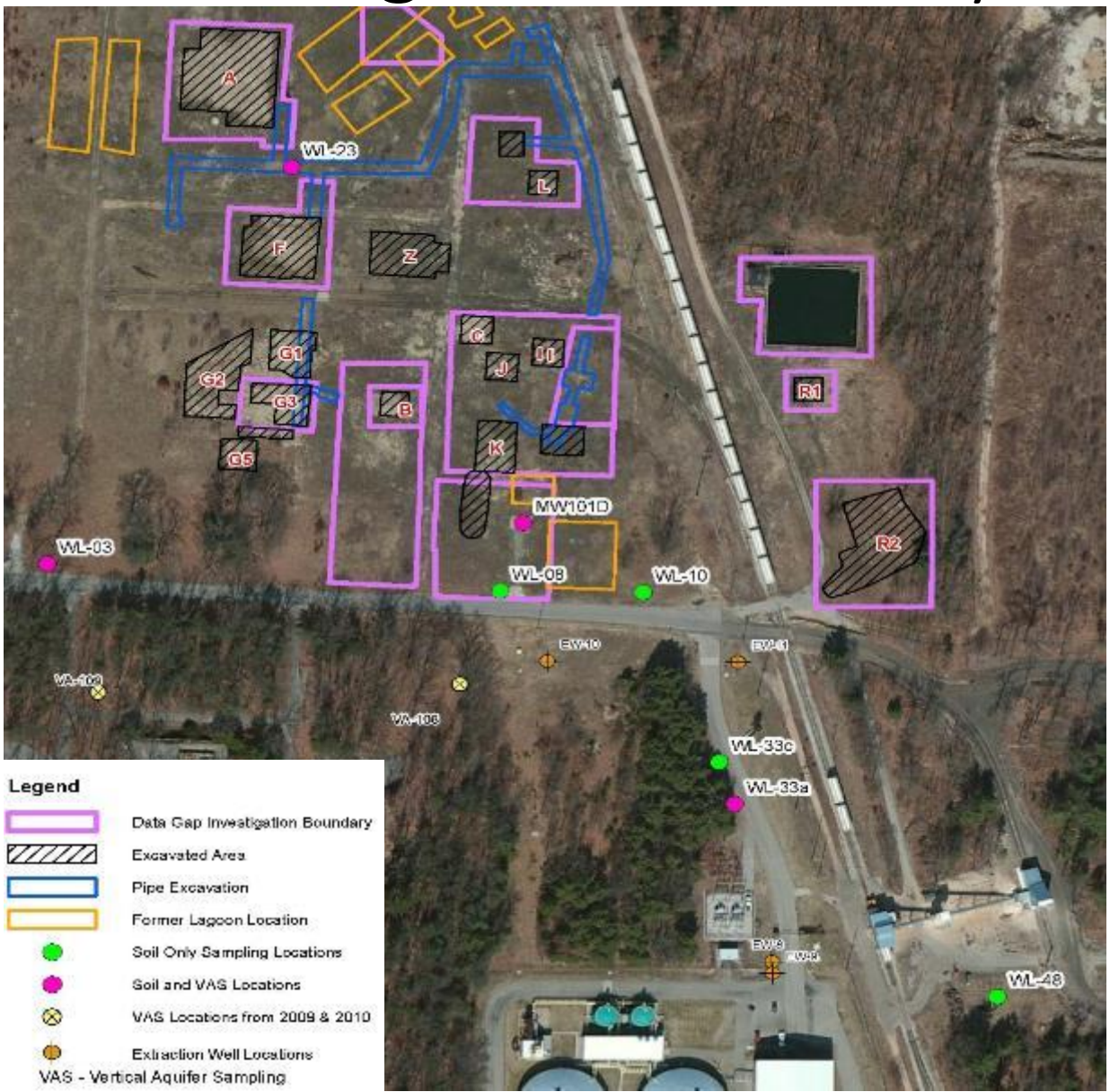
- Conducted MIP at 13 locations to primarily set edges of Waterloo transects
- Conducted Waterloo profiling at 52 locations collecting over 1,000 groundwater samples and generating 52 continuous Index of Hydraulic Conductivity (relative IK) geologic logs
- Analyzed all groundwater samples with an on-site mobile laboratory

Phase I and II Investigation Summary

Phase III Investigation Summary

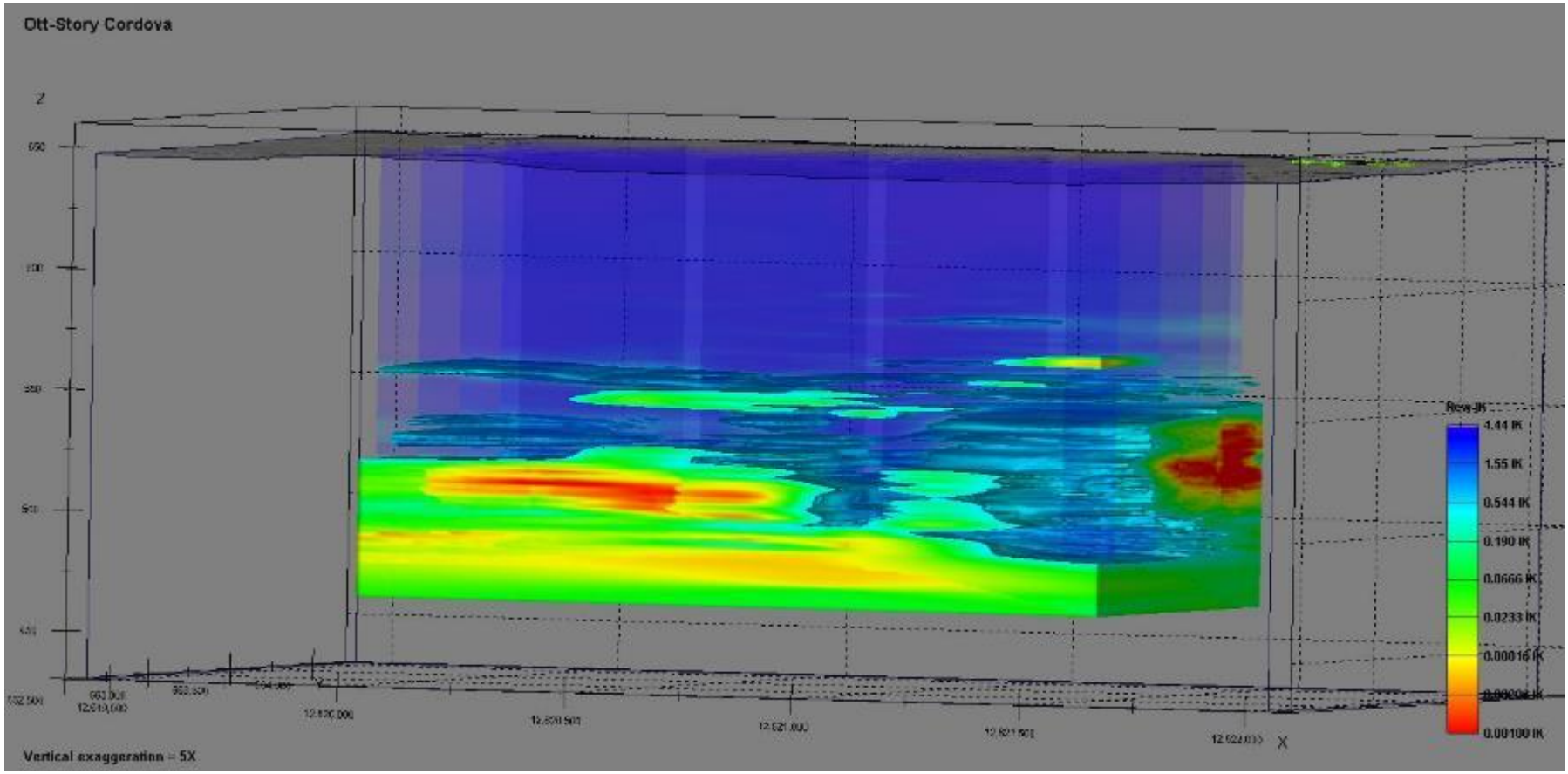
- Paired up with 4 Waterloo boring locations to conduct deeper VAS using sonic drilling and packer sampling to collect soil and groundwater samples from discrete depths
- Collected soil samples at discrete depths at 4 additional Waterloo boring locations
- Conducted field screening for NAPL using visual observations, PID, and field test kits (Oil-in-Soil shake tests)

Phase III Investigation Summary



Summary of Field Investigation Activities

Site Geology Results



Summary of Field Investigation Activities

Contamination Results

Nature of Contamination:

- Numerous organic compounds detected in groundwater including chlorinated ethenes, chlorinated ethanes, aromatic hydrocarbons, and other "miscellaneous" compounds (aniline, THF)
- Parent as well as degradation compounds were detected

Extent of Contamination:

- Contamination was detected in groundwater samples throughout OU3 and in the samples from transects located south of Agard Road
- The presence and extent of contamination varies for each compound (not a single release event/location)

Summary of Field Investigation Activities

Contamination Results Continued

Magnitude of Contamination:

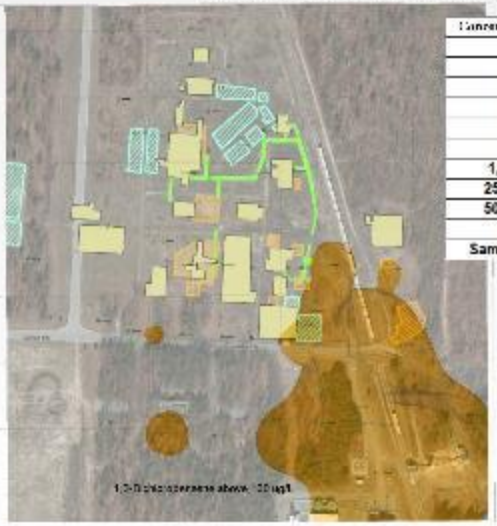
- Concentrations detected were well above groundwater restoration criteria
- Typically, very high dissolved-phase concentrations were detected
- Some chemicals were present in dissolved-phase samples at concentrations greater than 1% of their solubility (toluene, 1,2-dichlorobenzene, 1,1,1-TCA, PCE)

Waterloo Analytical Data

Chemical	Maximum Concentrations ug/L	Location	Depth, Feet	MCL ug/L	1% of Solubility (possible NAPL) ug/L
1,1-DCA	5,270	WL-10	88	7	50,400
1,1-DCA	9,040	WL-09	88	7	50,400
1,1,1-TCA	12,800	WL-09	88	200	12,900
1,1,1-TCA	16,400	WL-10	88	200	12,900
TCE	2,370	WL-08	55	5	12,800
PCE	4,340	WL-08	55	5	2,060
PCE	1,340	WL-45	18	5	2,060
1,2-DICLOROBENZENE	1,630	WL-14	25	N/A	1,560
1,2-DICLOROBENZENE	2,500	WL-34B	50	N/A	1,560
1,2-DICLOROBENZENE	2,530	WL-34	30.2	N/A	1,560
1,2-DICLOROBENZENE	3,150	WL-48	34.5	N/A	1,560
Trans-1,2-DCE	96	WL-32	77.5	100	54,200
VC	36,700	WL-03	124.4	2	88,000
1,1-DCE	1,160	WL-03	124.4	7	64,100
1,1-DCE	1,020	WL-10	88	7	64,100
TETRAHYDROFURAN	3,600	WL-41	130	N/A	10,000,000
CHLOROBENZENE	3,670	WL-33B	41.1	100	4,980
CHLOROBENZENE	4,030	WL-33C	45.1	100	4,980
BENZENE	1,130	WL-04	118.4	5	17,900
BENZENE	1,200	WL-23	154	5	17,900
BENZENE	1,280	WL-33B	46.7	5	17,900
BENZENE	1,530	WL-23	156.7	5	17,900
1,2-DCA	20,000	WL-23	154	5	86,000
1,2-DCA	24,100	WL-23	156.7	5	86,000
TOLUENE	57,400	WL-46	30.3	1,000	5,260
TOLUENE	58,400	WL-33C	40.1	1,000	5,260
TOLUENE	137,000	WL-33A	150.2	1,000	5,260

Nature and Extent of Contamination

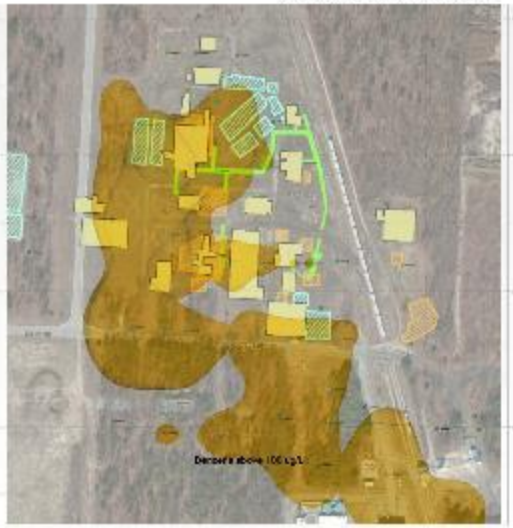
1,2-Dichlorobenzene Above 100 µg/L



Number of Detections

Concentration Range (ug/L)	1,2-Dichlorobenzene
0 - 13	228
13 - 49	168
50 - 99	66
100 - 249	29
250 - 599	33
600 - 999	10
1,000 - 24,999	10
25,000 - 49,999	0
50,000 - 99,999	0
>100,000	0
Sample population	1004

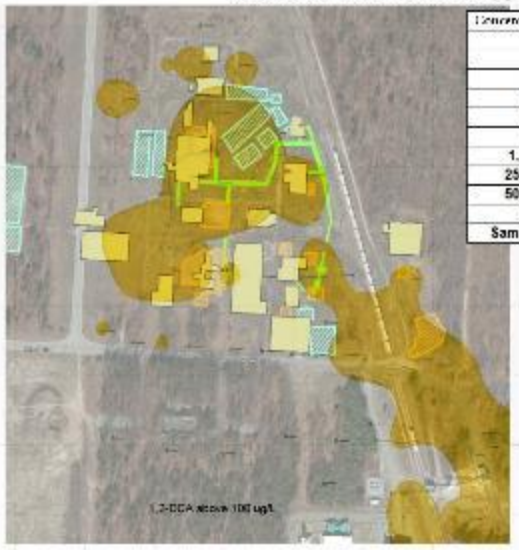
Benzene Above 100 µg/L



Number of Detections

Concentration Range (ug/L)	Benzene
0 - 5	275
5 - 49	168
50 - 99	53
100 - 249	56
250 - 499	25
500 - 999	12
1,000 - 24,999	5
25,000 - 49,999	0
50,000 - 99,999	0
>100,000	0
Sample population	1004

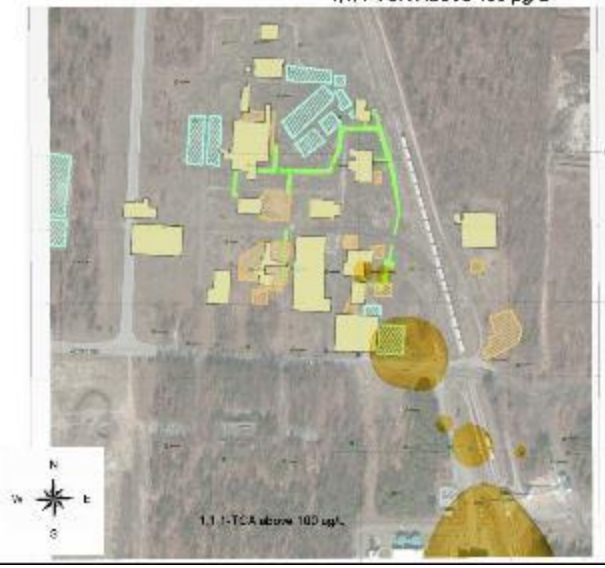
1,2-Dichloroethane Above 100 µg/L



Number of Detections

Concentration Range (ug/L)	1,2-Dichloroethane
0 - 5	173
5 - 49	138
50 - 99	34
100 - 249	23
250 - 749	19
750 - 999	4
1,000 - 24,999	17
25,000 - 49,999	0
50,000 - 99,999	0
>100,000	0
Sample population	1004

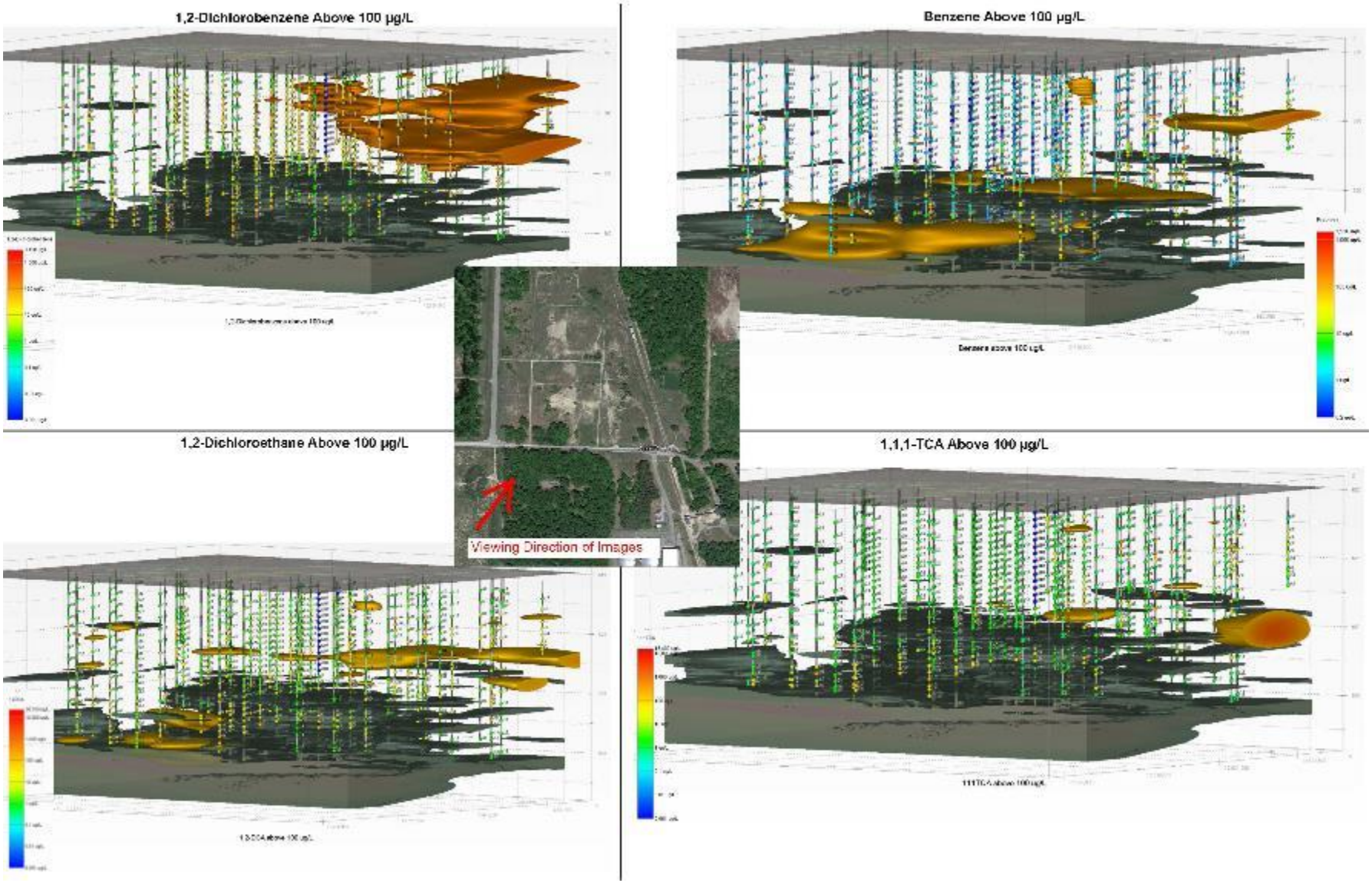
1,1,1-TCA Above 100 µg/L



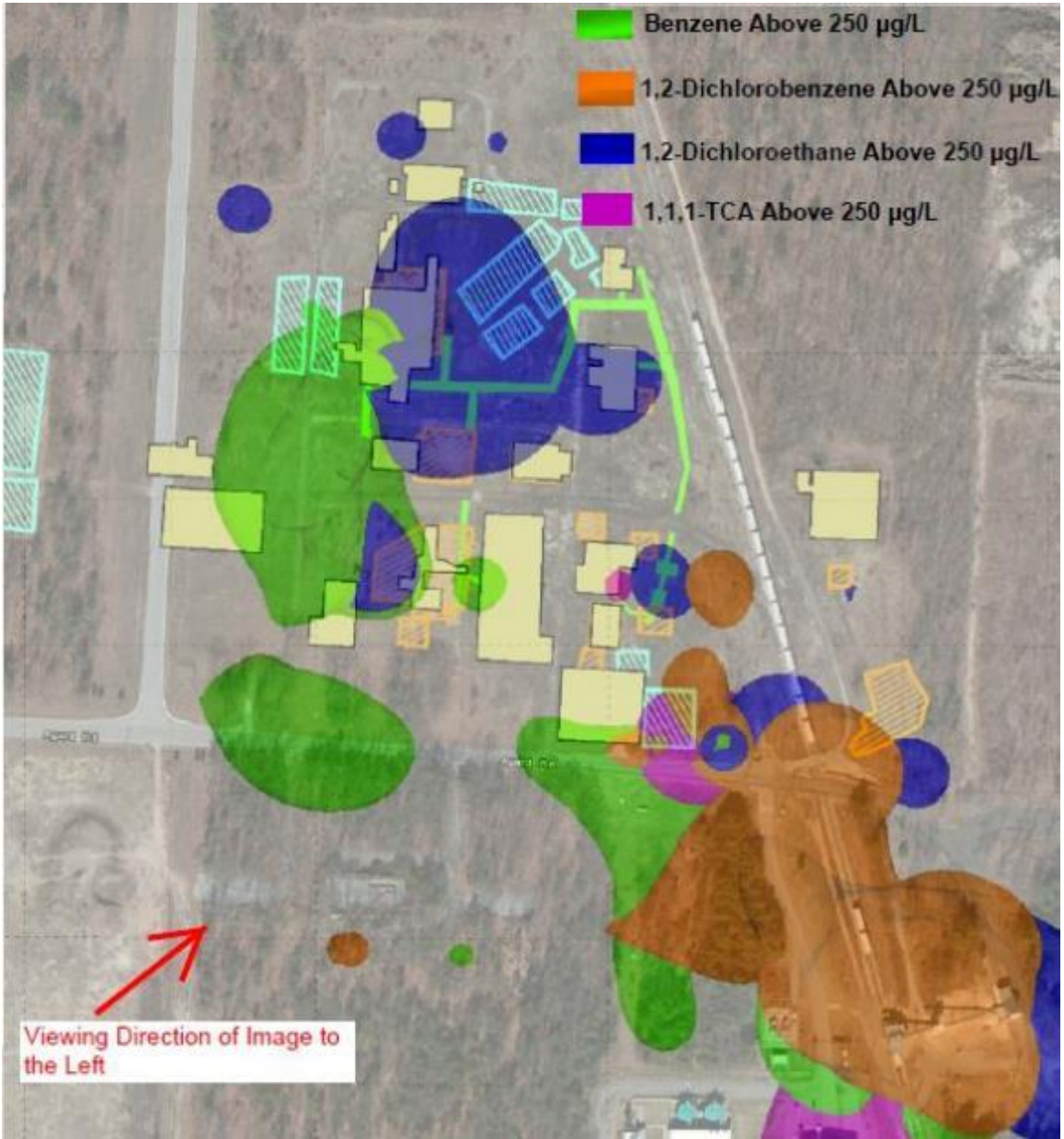
Number of Detections

Concentration Range (ug/L)	1,1,1-Trichloroethane
0 - 5	42
5 - 49	20
50 - 99	3
100 - 250	4
250 - 749	4
750 - 999	1
1,000 - 24,999	9
25,000 - 49,999	0
50,000 - 99,999	0
>100,000	0
Sample population	1004

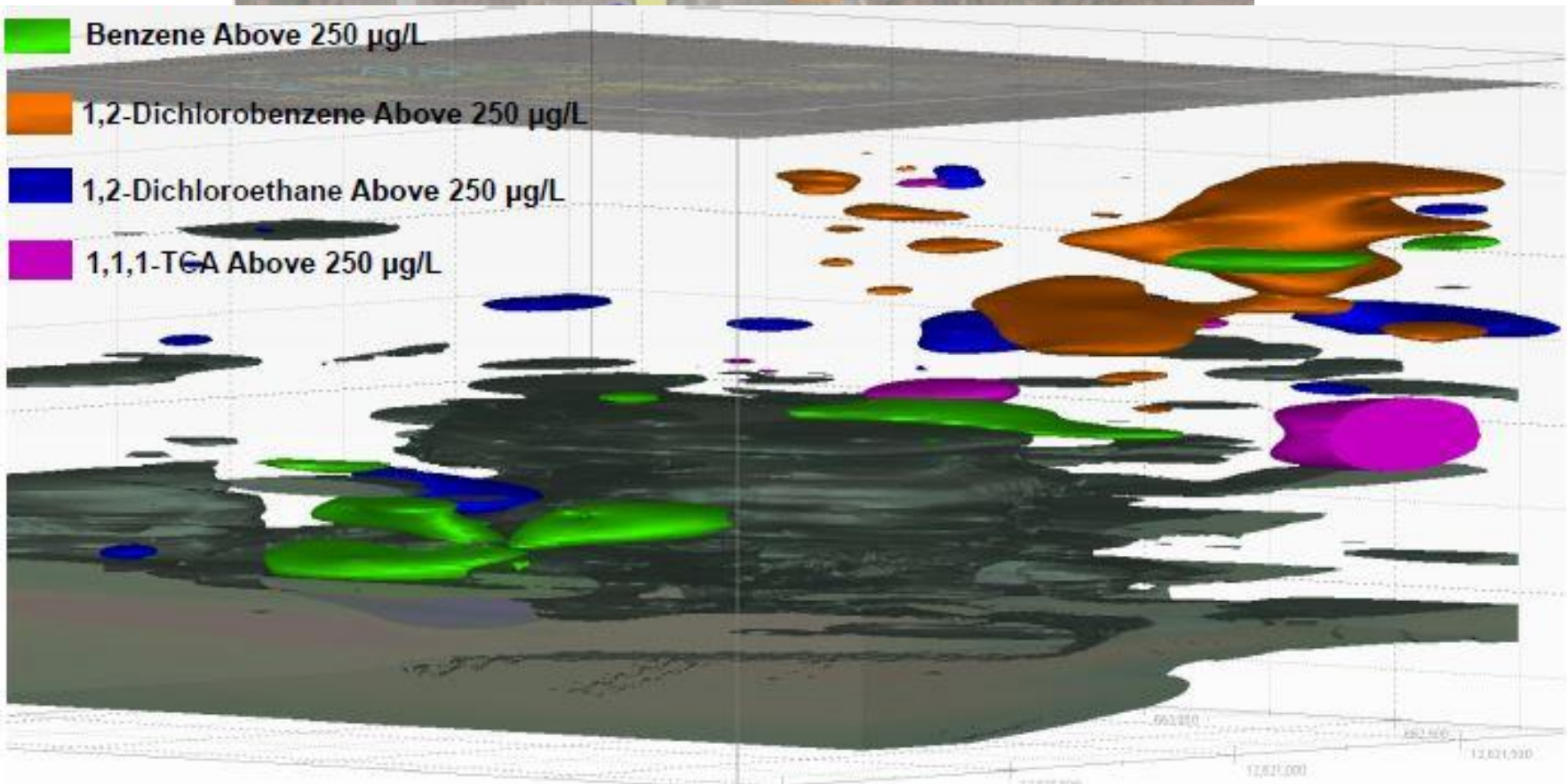
Nature and Extent of Contamination Continued



Nature and Extent of Contamination Continued



Nature and Extent of Contamination Continued



Summary of Findings

Dissolved-Phase Groundwater:

- Multiple contaminants are present
- Lateral and vertical extent varies by compound
- Contaminant pattern is indicative of multiple releases in many areas
- Higher dissolved-phase groundwater concentrations were generally detected just above low hydraulic conductivity (clay) zones
- Contamination does not appear to extend vertically below the lower clay

Summary of Findings Continued

NAPL Assessment:

- Direct evidence of NAPL was not observed
- Indirect evidence shows potential for NAPL to exist (dissolved-phase greater than 1% solubility for some compounds)
- Back-diffusion from low hydraulic conductivity zones appears to be the predominant process “feeding” the dissolved-phase plume
- Results are indicative of a late-stage release where back-diffusion is greater than NAPL dissolution
- Given size of source area and depth of contamination, the potential exists for small pockets or localized areas of NAPL to be present.

Planned Activities for 2017

OU3 Source Area:

- Perform mass distribution analysis

Downgradient Plume:

- Conduct additional VAS using HRSC methods
- Potentially supplement HRSC with sonic methods, if necessary

Site-Wide:

- Input downgradient sample results and Relative IK data into Earth Volumetric Studio (EVS)
- Expand 3D Visualization and Analysis (3DVA) to incorporate source area and downgradient results

Follow-up Activities

- Optimize extraction wells and monitoring network
- Identify potential remedial technologies for the site
- Assess effectiveness of potential technologies given site conditions

Questions?

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