



Hydrogeologic Appraisal of a Fractured-Rock Groundwater Contamination Site -- A Discrete-Zone Approach



Thanks to:

David A. Eckhardt, USGS

John H. Williams, USGS

Donald T. Bussey, U.S. EPA ERT



Background

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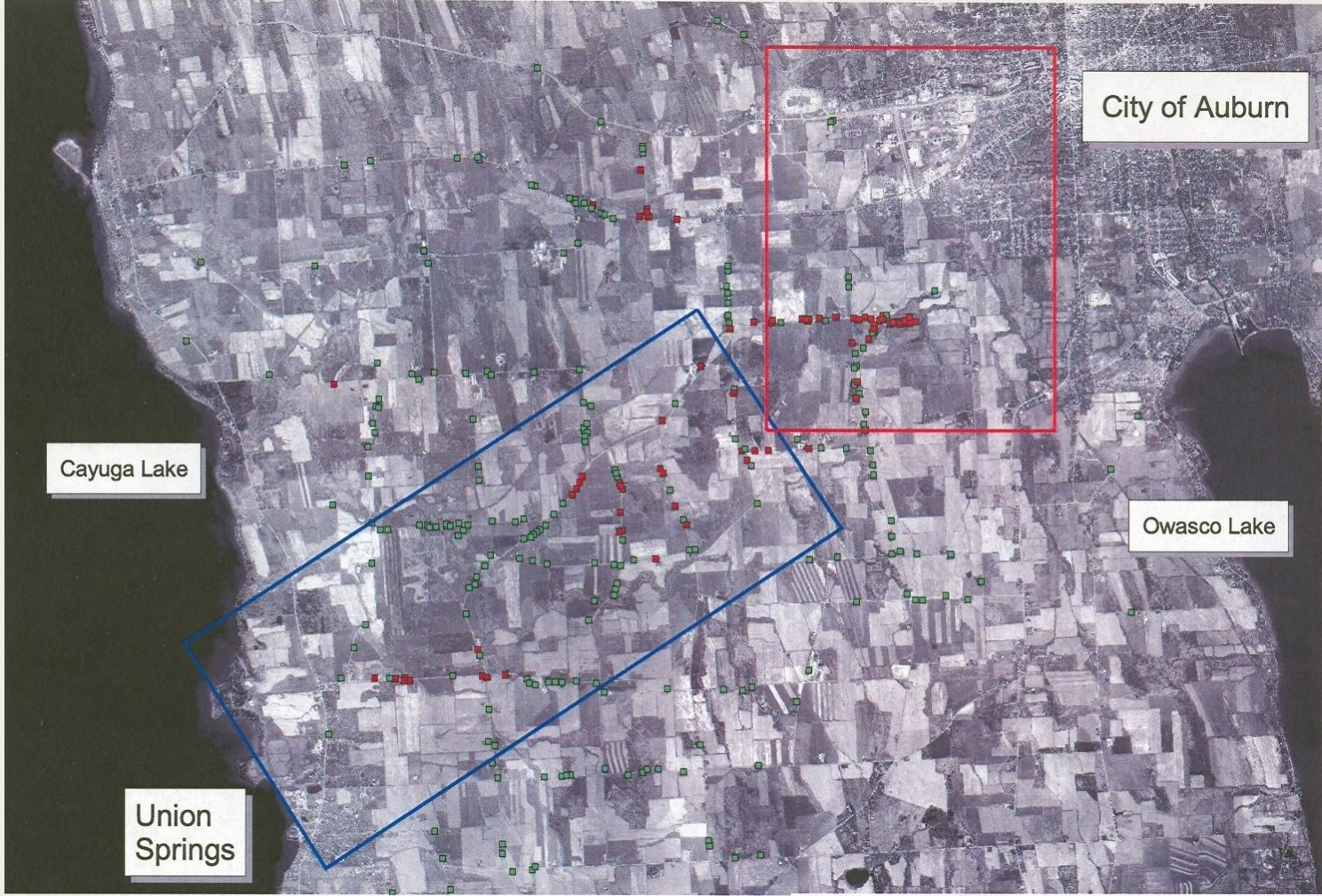


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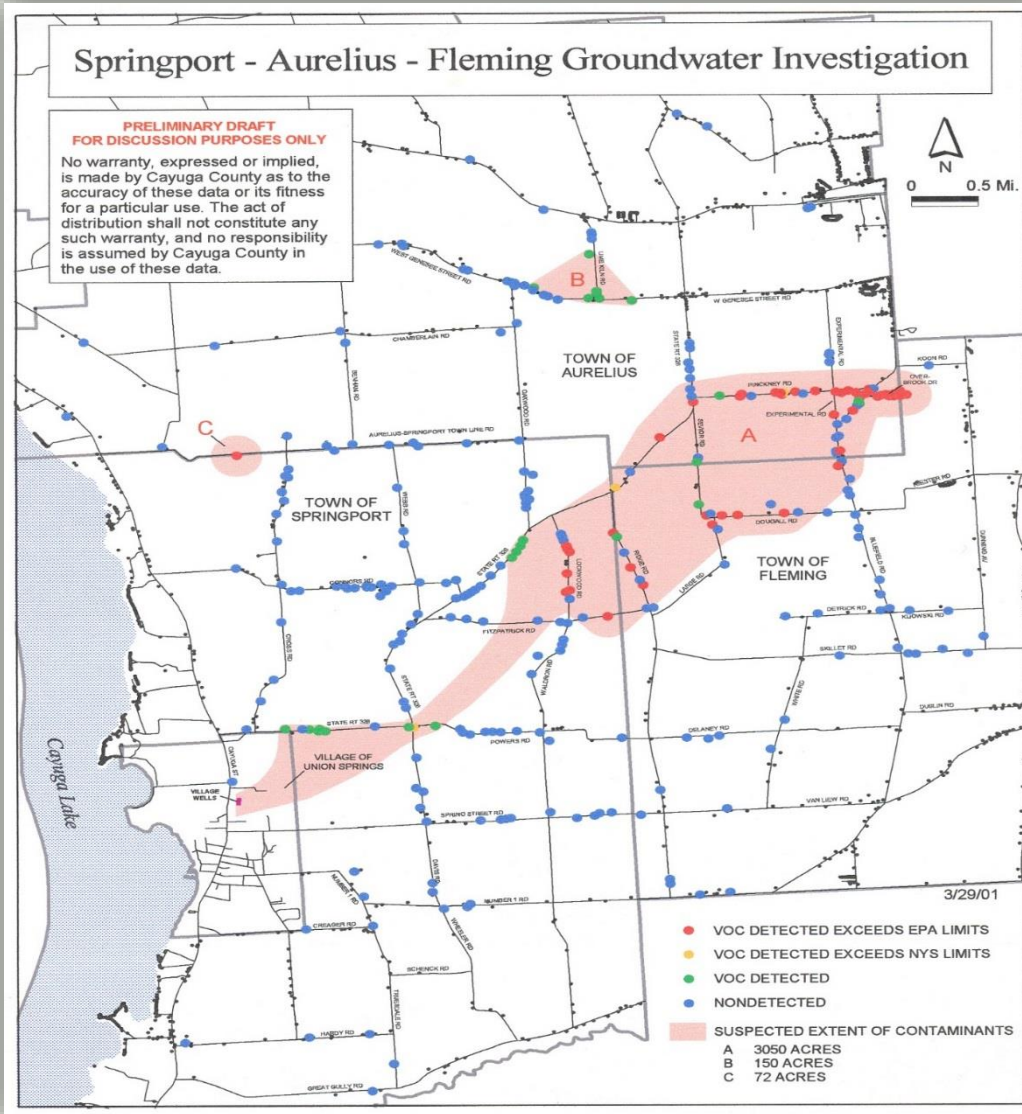
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- **An industrial facility located just to the north of where the VOC trail ends**
- **Groundwater at the industrial facility contains same VOCs as groundwater south of the facility**
- **Industrial facility's position is that their contaminated groundwater problem is limited to the overburden and shallow bedrock on- and north of the facility, and that deeper bedrock wells on it's southern property line are clean**

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- **Late 2000, U.S. EPA began installation and operation of 50-plus carbon treatment systems at residences and 3 air strippers at local farms**
- **Early Fall 2001, U.S. EPA began to conduct a VOC source area assessment for PRP identification and potential cost recovery**



Generalized Site Geology

- **Topography slopes downwards to the north**

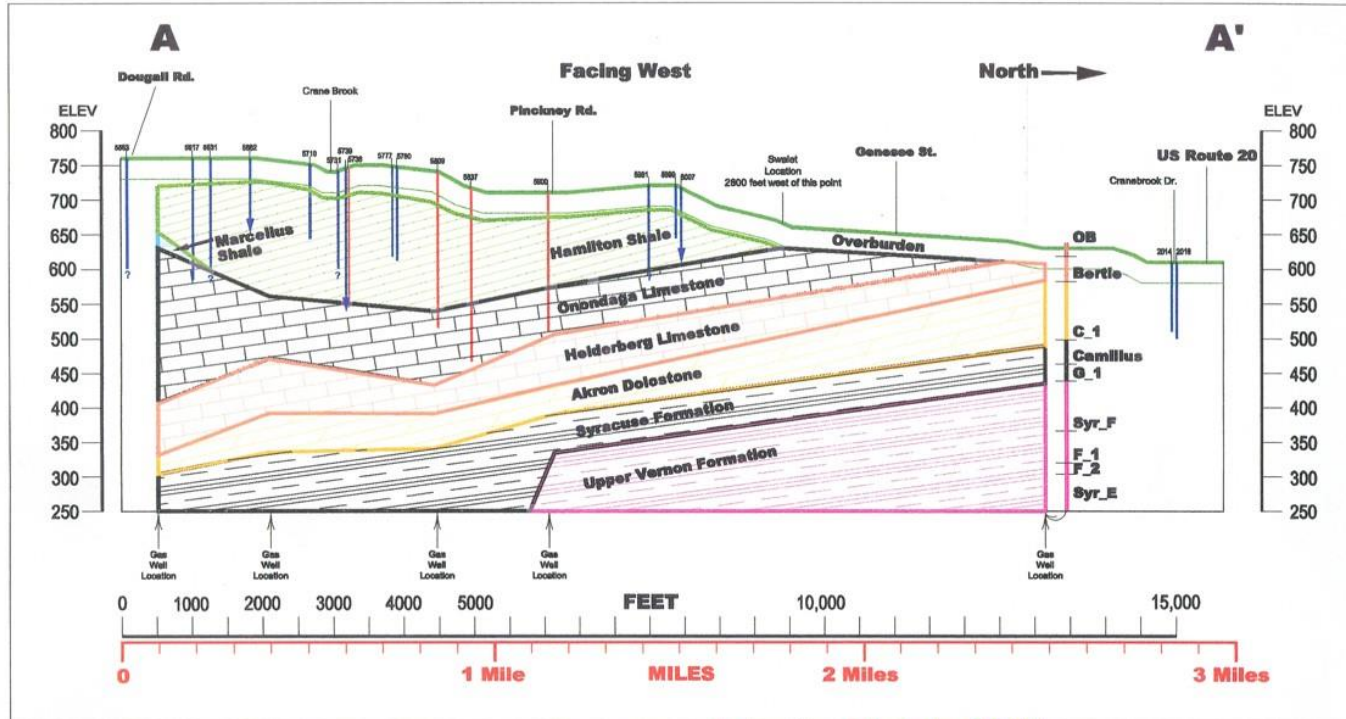


Generalized Site Geology

- **Topography slopes downwards to the north**
- **Layer-cake stratigraphy dips to the south**



Generalized Site Geology



Cross-Section Projected along Bluefield and Experimental Roads
Geology from gas wells on file in the Division of Mineral Resources

Vertical exaggeration = 10X.

670 Street Number Domestic waterwell, not showing chlorinated compounds, "ND"	670 Street Number Domestic waterwell, at least as deep as shown
688 Street Number Domestic waterwell showing contamination from chlorinated compounds	676 Street Number Domestic waterwell, depth not known



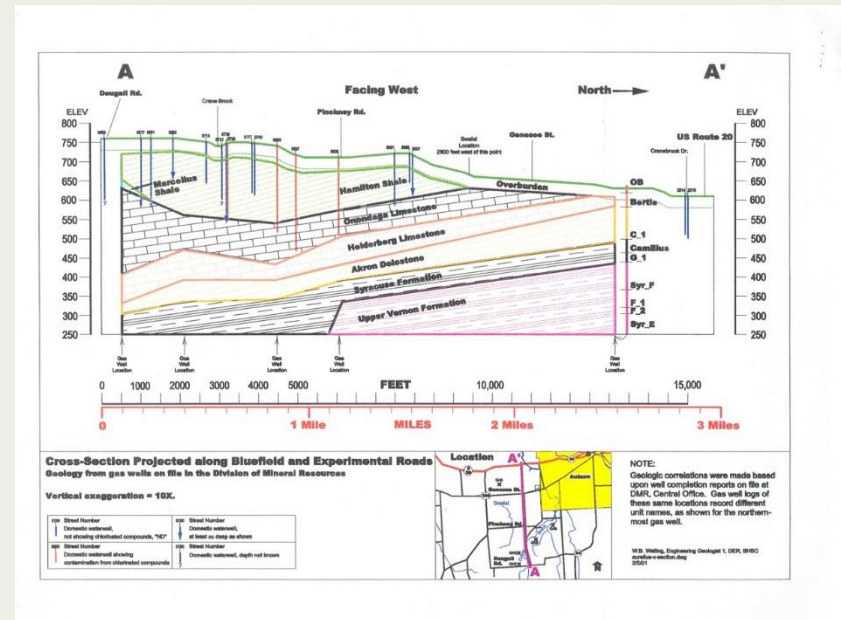
NOTE:

Geologic correlations were made based upon well completion reports on file at DMR, Central Office. Gas well logs of these same locations record different unit names, as shown for the northernmost gas well.

W.B. Willing, Engineering Geologist 1, DER, BHSC
 susdms-2-section.dwg
 2/5/01

Generalized Site Geology

- Topography slopes downwards to the north
- Layer-cake stratigraphy dips to the south
- Stratigraphic sequence includes Upper Silurian to Middle Devonian carbonates (limestone, dolostone, and evaporites) capped in the south by Middle Devonian limey shale, overlain by glacial till



AGE	UNIT	SUB-UNIT	THICKNESS- FEET
MIDDLE DEVONIAN	MARCELLUS FORMATION	CHITTENANGO SHALE	??
		CHERRY VALLEY LIMESTONE	3
		UNION SPRINGS SHALE	10
	ONONDAGA FORMATION	SENECA MEMBER	22
		MOOREHOUSE MEMBER	34
		NEDROW MEMBER	11
		EDGECLIFF MEMBER	8
LOWER DEVONIAN	MANLIUS FORMATION		36
	RONDOUT FORMATION		34
UPPER SILURIAN	COBLESKILL FORMATION		13
	BERTIE GROUP	OXBOW MEMBER	8
		FORGE HOLLOW MEMBER	??

FIGURE 2
GENERALIZED SITE STRATIGRAPHIC COLUMN
CAYUGA COUNTY GROUNDWATER
CONTAMINATION SITE
CAYUGA COUNTY, NEW YORK

U.S. EPA ENVIRONMENTAL RESPONSE TEAM CENTER
RESPONSE ENGINEERING AND ANALYTICAL CONTRACT
88-C98-223
W.O.# R1499 212

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Bedrock Borehole Installation

- **Monitor well location selection and target depth determination**



Bedrock Borehole Installation

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- **Well depths between 180 and 240 feet based on 'hot' residential well depths**



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- Monitor well location selection and target depth determination
- Well depths between 180 and 240 feet
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- Bedrock cores logged by USGS



Borehole Video and Geophysical Logging

- **Borehole video logging conducted by U.S. EPA Environmental Response Team**



Borehole Video and Geophysical Logging

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- Cascading groundwater observed entering boreholes above static well water levels



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- **Borehole video logging conducted by U.S. EPA Environmental Response Team**
- **Cascading groundwater observed entering boreholes above static well water levels**
- **Cored borehole**



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- Cascading groundwater observed entering boreholes above static well water levels
- Air hammer drilled borehole



Borehole Video and Geophysical Logging

- Borehole video logging conducted by U.S. EPA Environmental Response Team
- Cascading groundwater observed entering boreholes above static well water levels
- Solution void zone observed within the Forge Hollow Member of the Bertie Formation



Borehole Video and Geophysical Logging

- **Solution void zone in the Forge Hollow Member of the Bertie Formation**



Borehole Video and Geophysical Logging

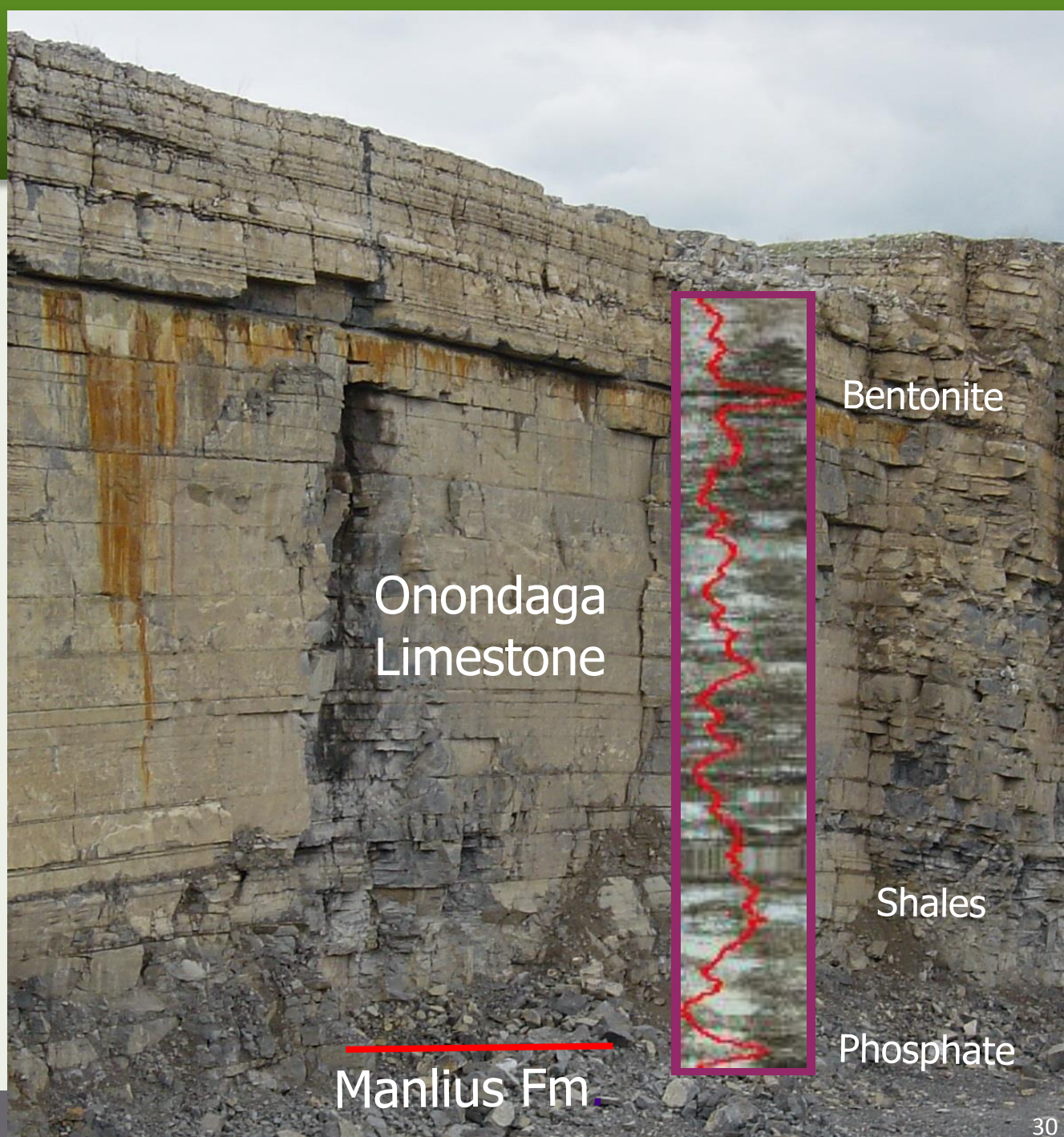
- **Borehole video logging conducted by U.S. EPA Environmental Response Team**
- **Gamma, caliper, and temperature geophysical logging conducted by U.S. EPA Environmental Response Team**



Borehole Video and Geophysical Logging



Use of typical stratigraphic marker beds that are easily identified in gamma logs

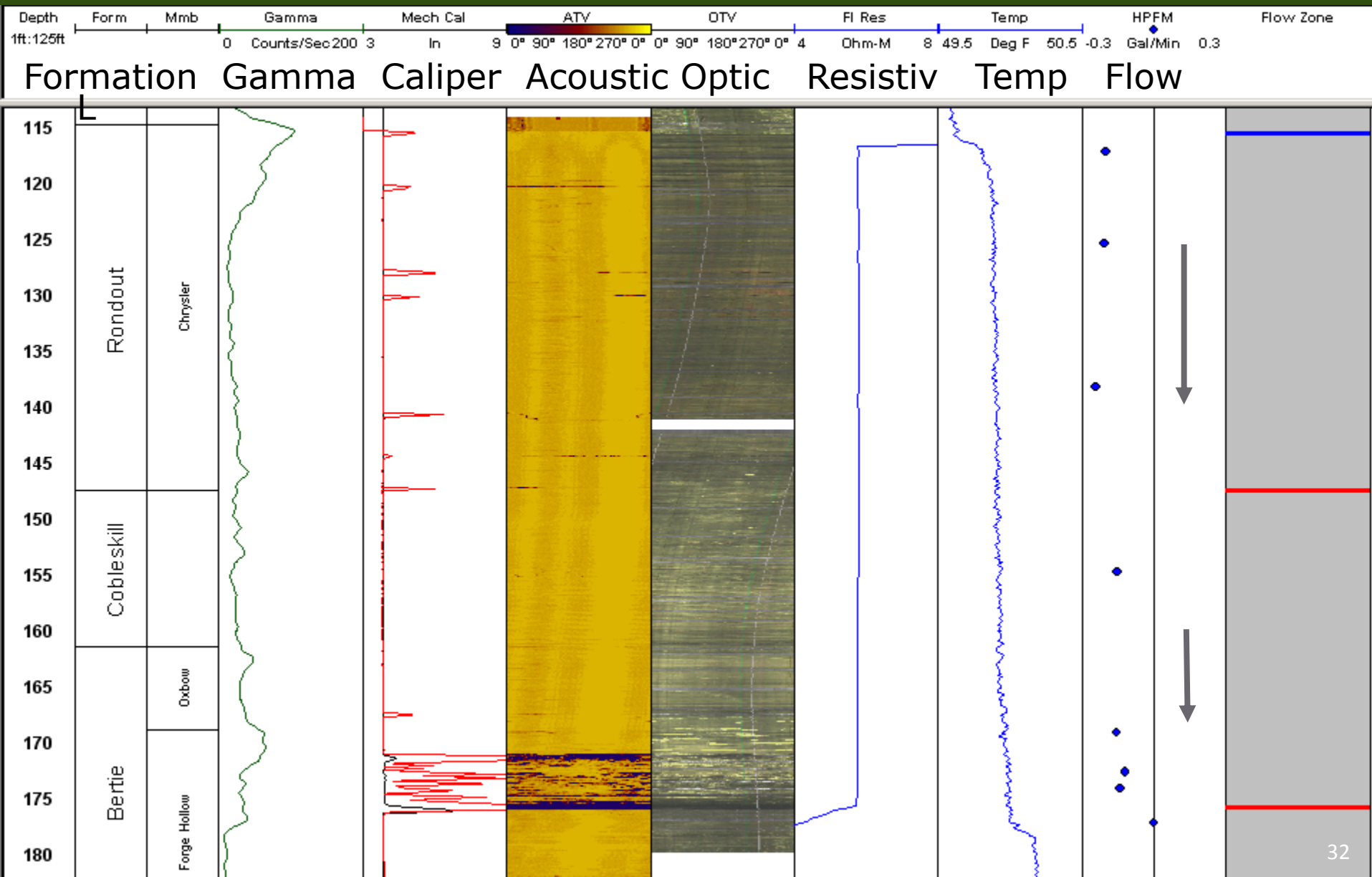


Borehole Video and Geophysical Logging

- **Borehole video logging conducted by U.S. EPA Environmental Response Team**
- **Gamma, caliper, and temperature geophysical logging conducted by U.S. EPA Environmental Response Team**
- **Heat-pulse flowmeter, and optical and acoustic televiewer geophysical logging conducted by U.S. Geological Survey**

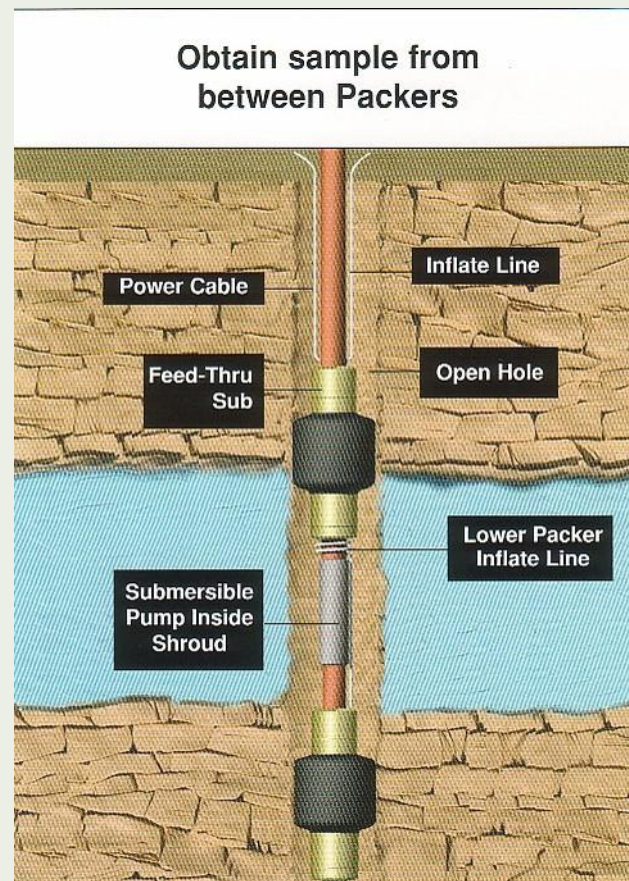


Geophysical, Stratigraphic, and Flow-Zone Logs EPA-1



Straddle Packer Groundwater Sampling

- Subsequent to drilling and concurrent with borehole video and geophysical logging, each boring was sampled using straddle packer assemblies



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- Intervals sampled were selected based on bedrock core examined, notes made during drilling, and borehole video and geophysical data



Straddle Packer Groundwater Sampling

- Subsequent to drilling and concurrent with borehole video and geophysical logging, each boring was sampled using straddle packer assemblies
- Intervals sampled were selected based on bedrock core examined, notes made during drilling, and borehole video and geophysical data
- Sampled zones had multiple samples collected over time to evaluate possible effects of vertical borehole flow contaminating or diluting recovered samples



Straddle Packer Testing Results

- Boreholes (within the plume) were found to have VOCs in the transmissive zone of the Forge Hollow Member of the Bertie Formation**

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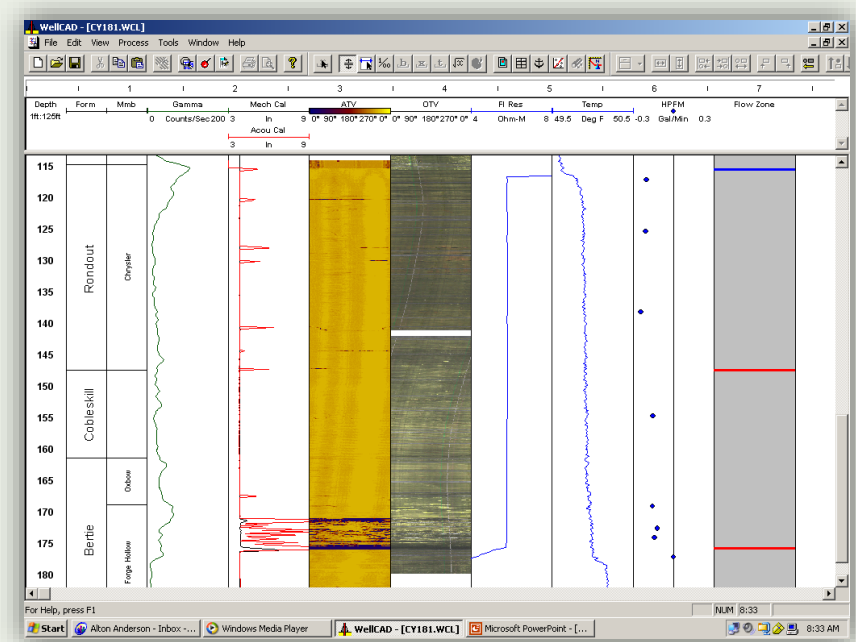
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 RESPONSE ENGINEERING AND ANALYTICAL CONTRACT
 88-06-023
 W.O.# REVISE 312

FIGURE 2
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 CAYUGA COUNTY GROUNDWATER
 CONTAMINATION SITE
 CAYUGA COUNTY, NEW YORK

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Straddle Packer Testing Results

- Boreholes (within the plume) were found to have VOCs in the transmissive zone of the Forge Hollow Member of the Bertie Formation
- Contaminated zone was discovered to be diluted by clean water flowing vertically downwards from clean upper zones



Straddle Packer Testing Results

- **Monitor wells (within the plume) were found to have VOCs in the transmissive zone of the Forge Hollow Member of the Bertie Formation**
- **Contaminated zone was discovered to be diluted by clean water flowing vertically downwards from clean upper zones**
- **Ironically, the industrial facility's owner's initial concern was the possibility of contaminated shallow water moving into clean lower zones**



Installation of Discrete-zone Multi-level Assemblies

- In 2003 the site was listed on the National Priorities List (NPL) and became a Superfund Site
- U.S. EPA initiated the Remedial Investigation process
- To evaluate the complex hydrogeology, it was decided to equip the boreholes and several abandoned homeowner wells with permanently installed discrete-zone assemblies



Installation of Discrete-zone Multi-level Assemblies

◆ Westbay System

- » Isolates and seals differential-head zones in boreholes
- » Prevents short-circuit flows in boreholes
- » Provides multiple-level flow-field maps
- » Allows sample collection from discrete zones (small purge volume)

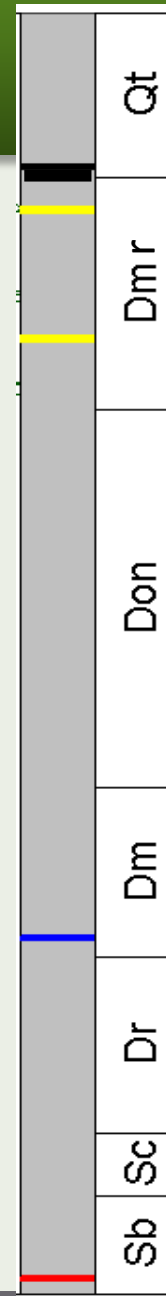
Regional stratigraphic sequence and borehole flow in recharge areas

Base of casing

Flow zones with hydraulic head above composite head

Composite Hydraulic head

Flow zone with hydraulic head below composite head



Till

Marcellus Shale
S1

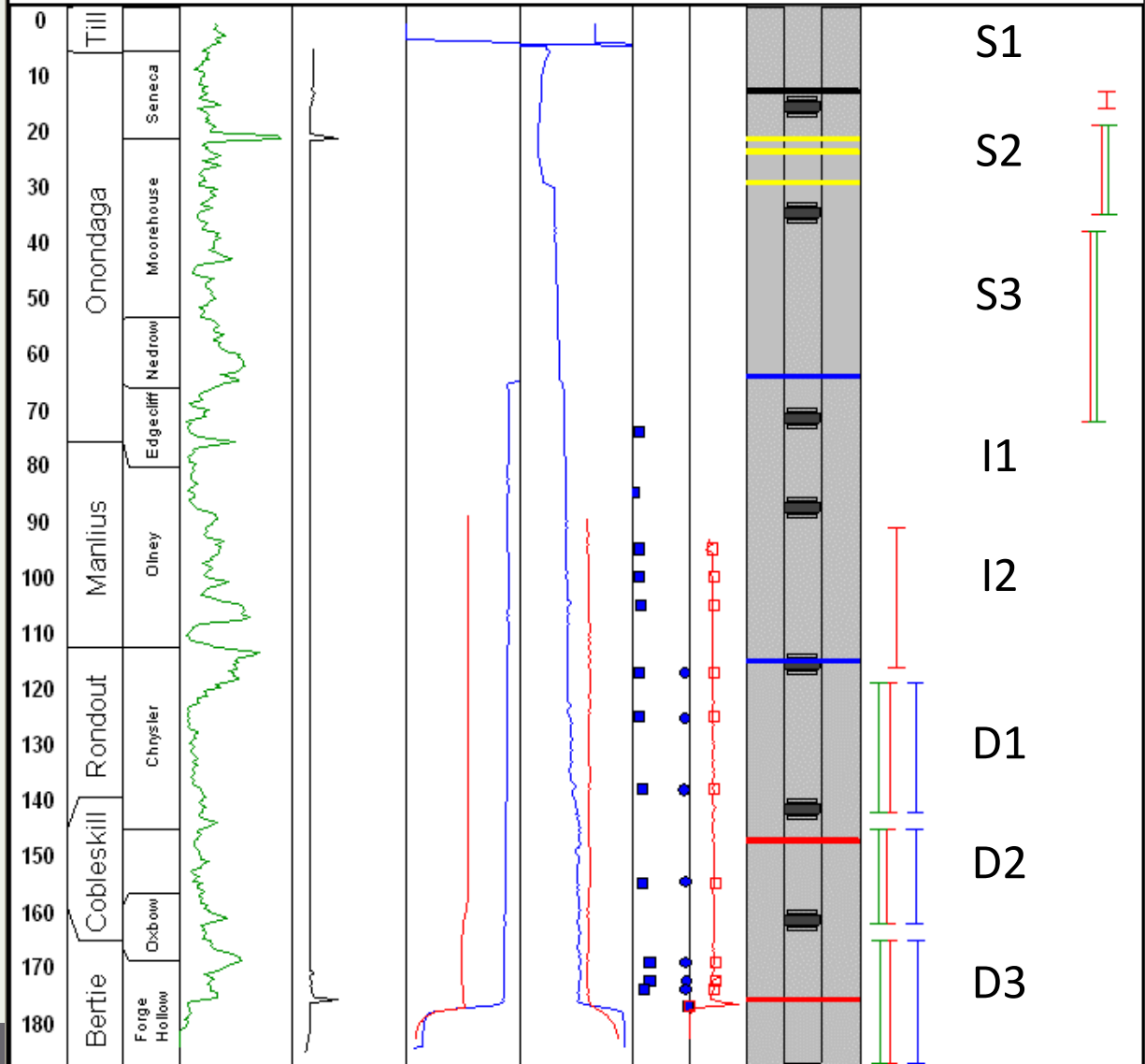
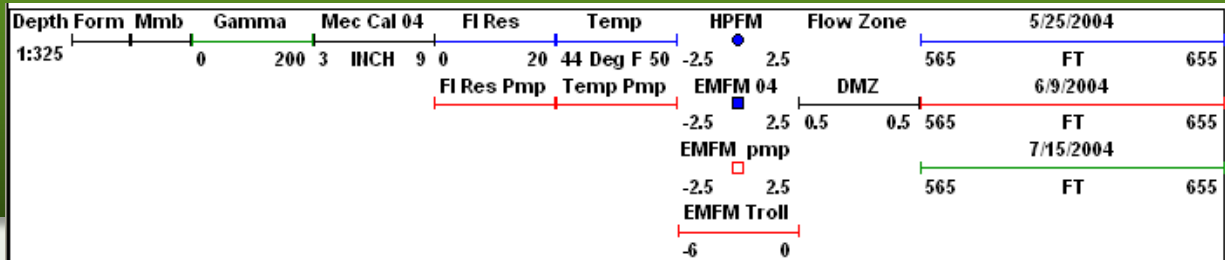
Onondaga Limestone
S2 – S3

Manlius Fm I1 – I2

Rondout Fm D1

Cobleskill Fm D2

Bertie Fm D3



EPA-1

8 discrete zones

Installation of Discrete-zone Multi-level Assemblies



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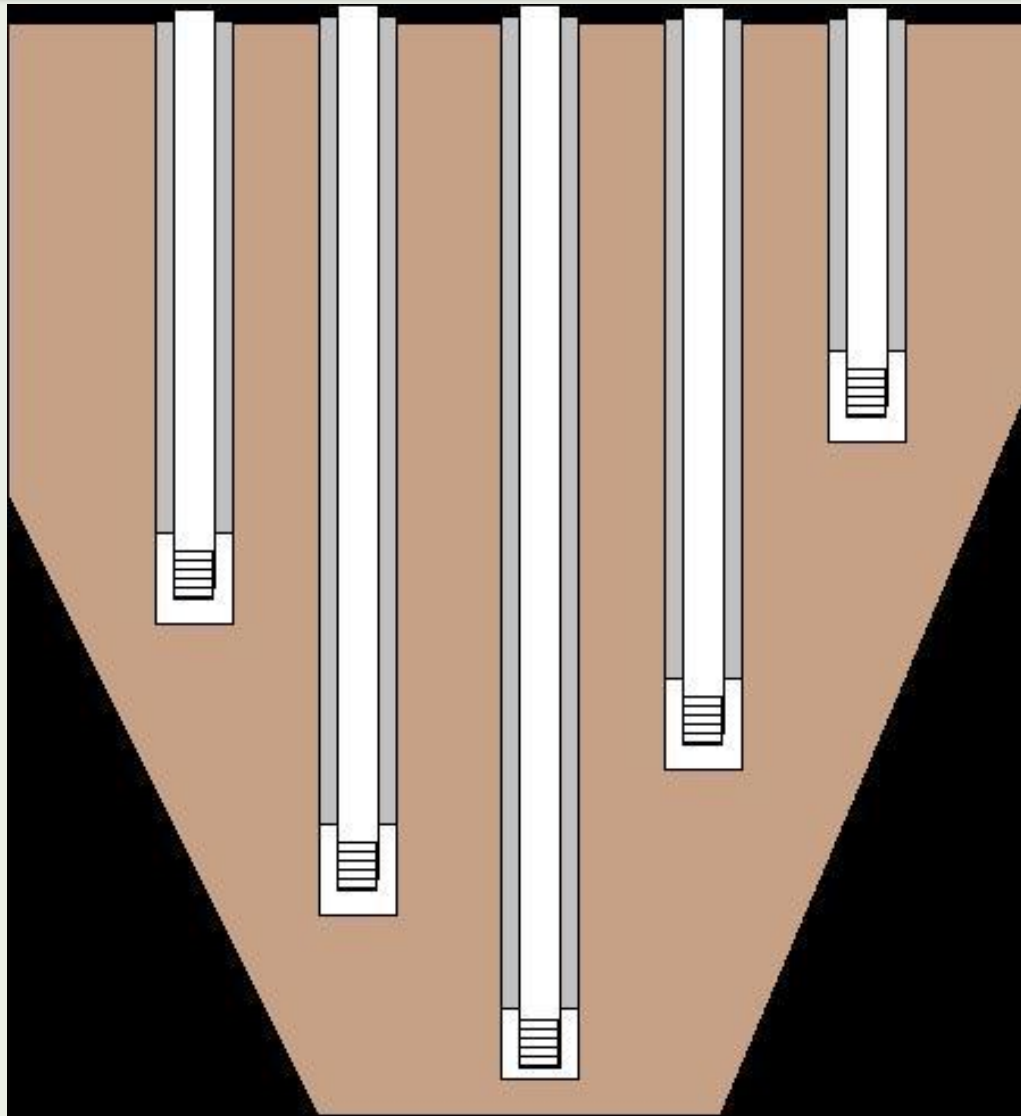
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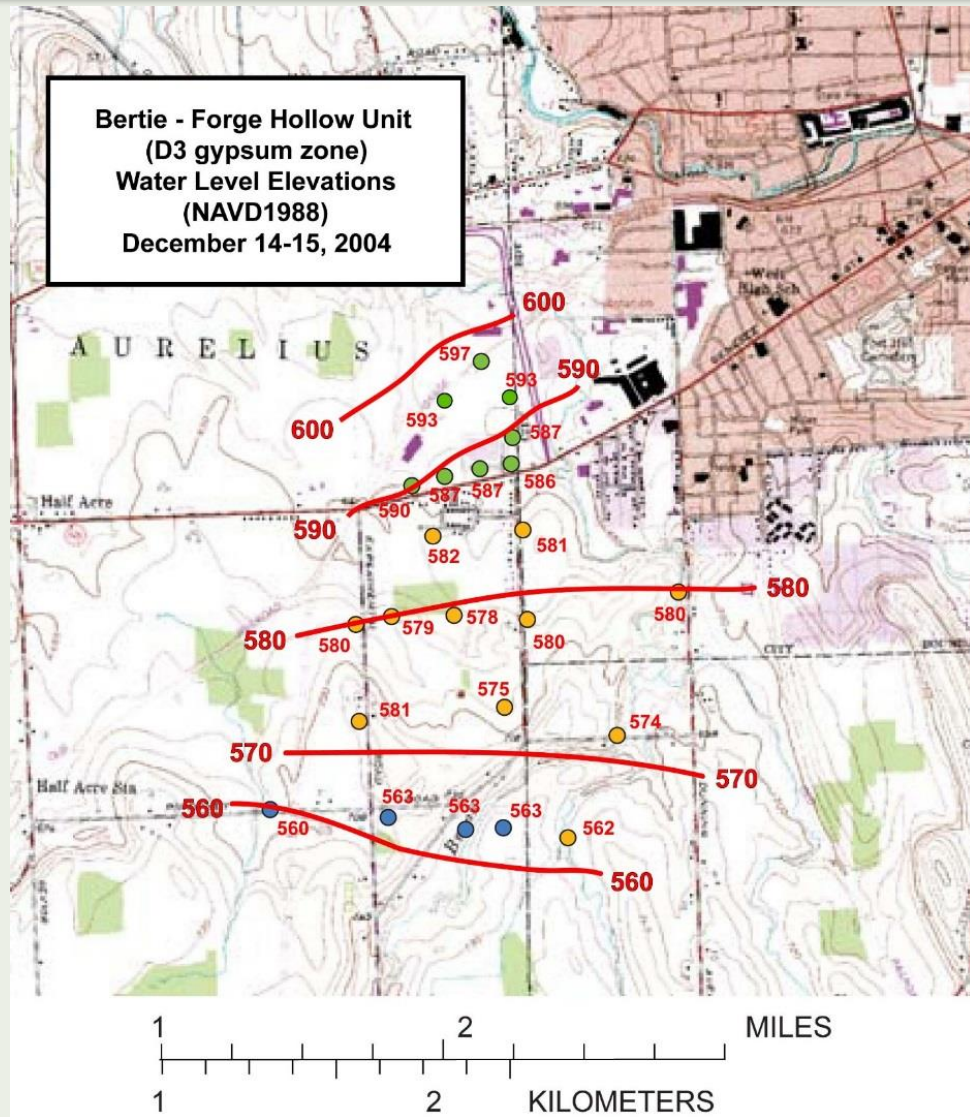
Multiple wells installed by Industrial Facility



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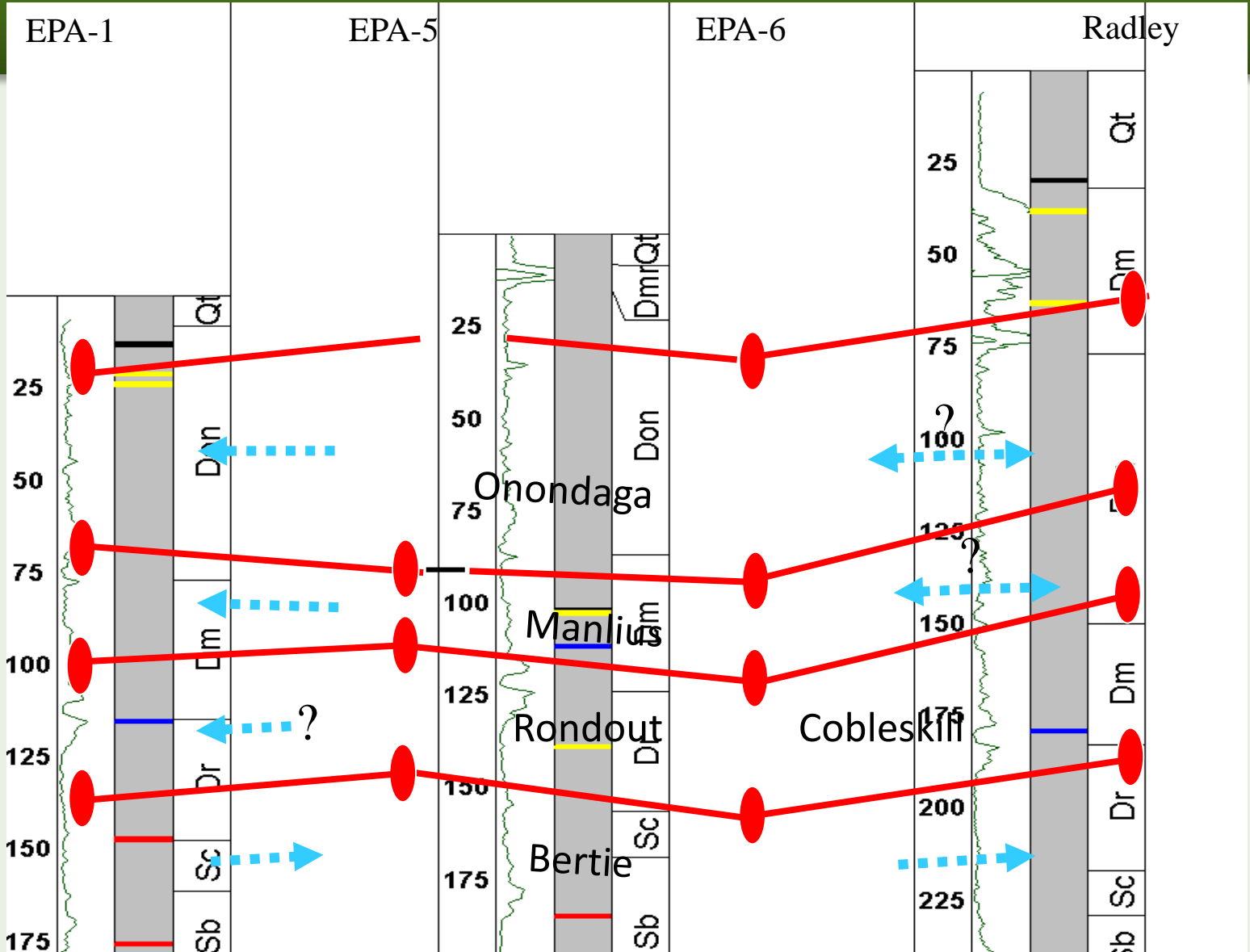
Water Level Elevations



750

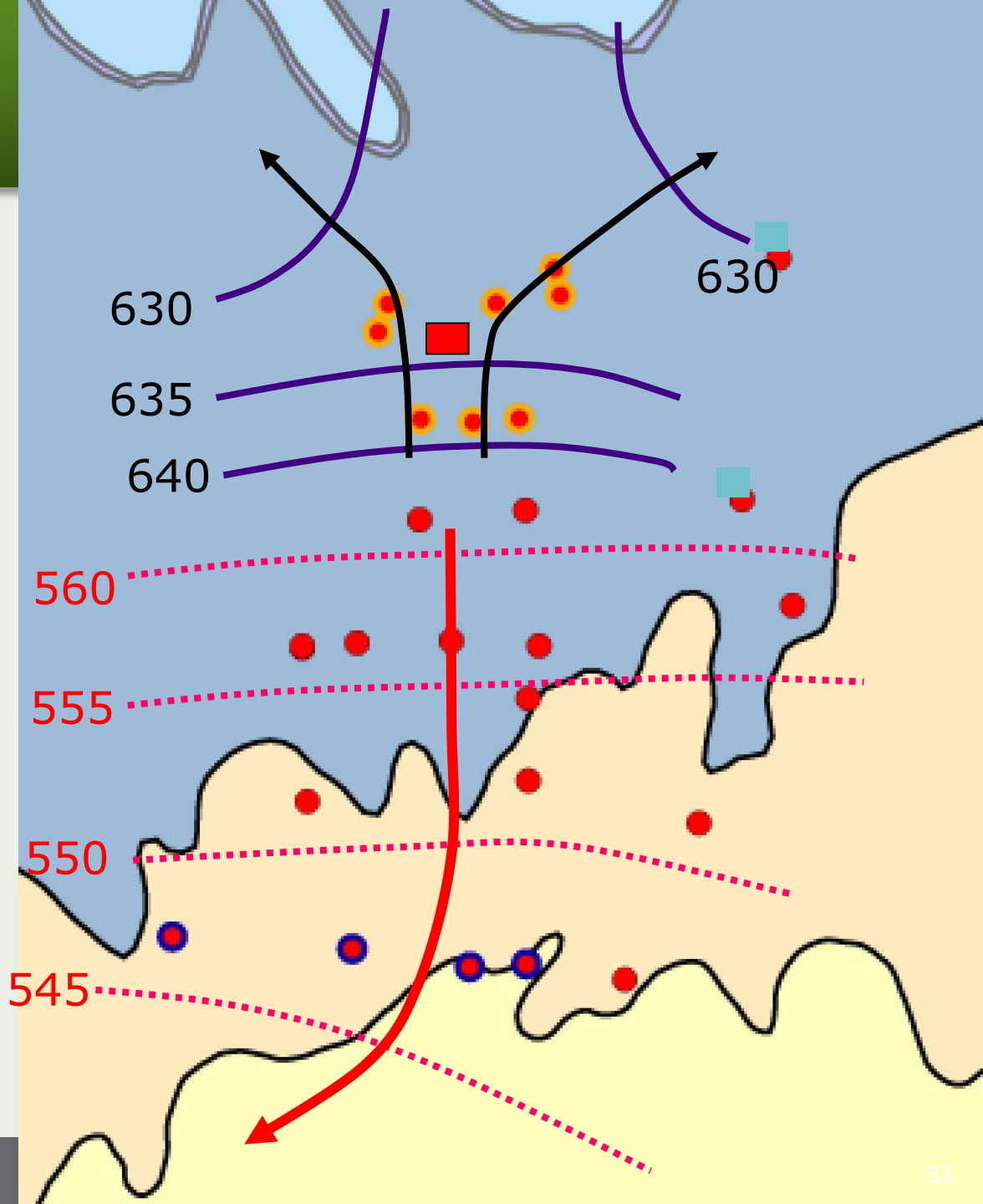
ELEVATION, IN FEET

450



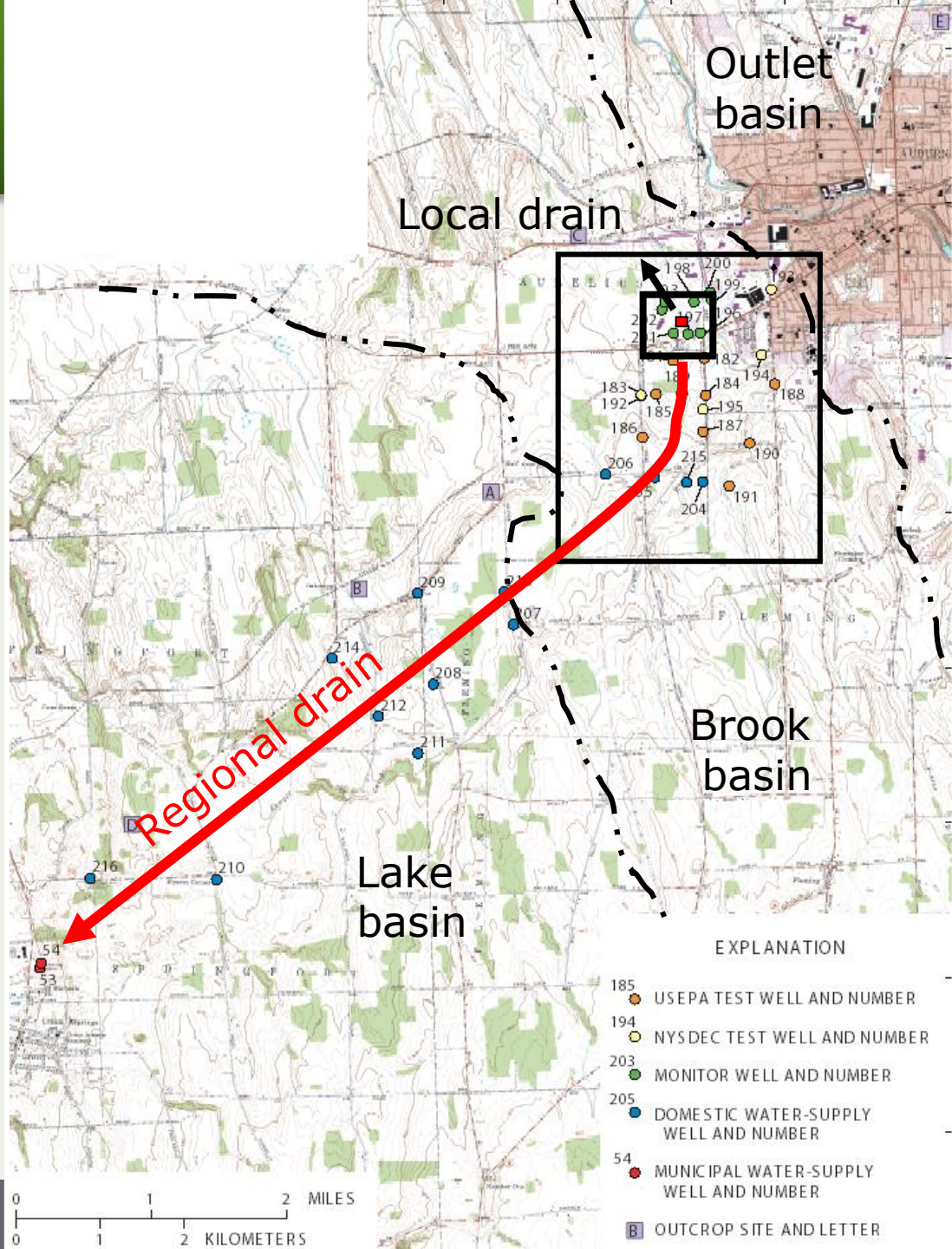
Groundwater at the wells in the Onondaga Limestone flows NW and NE

Groundwater at the EPA test wells in the Bertie Fm. flows South then SW



Local and Regional Flow Paths

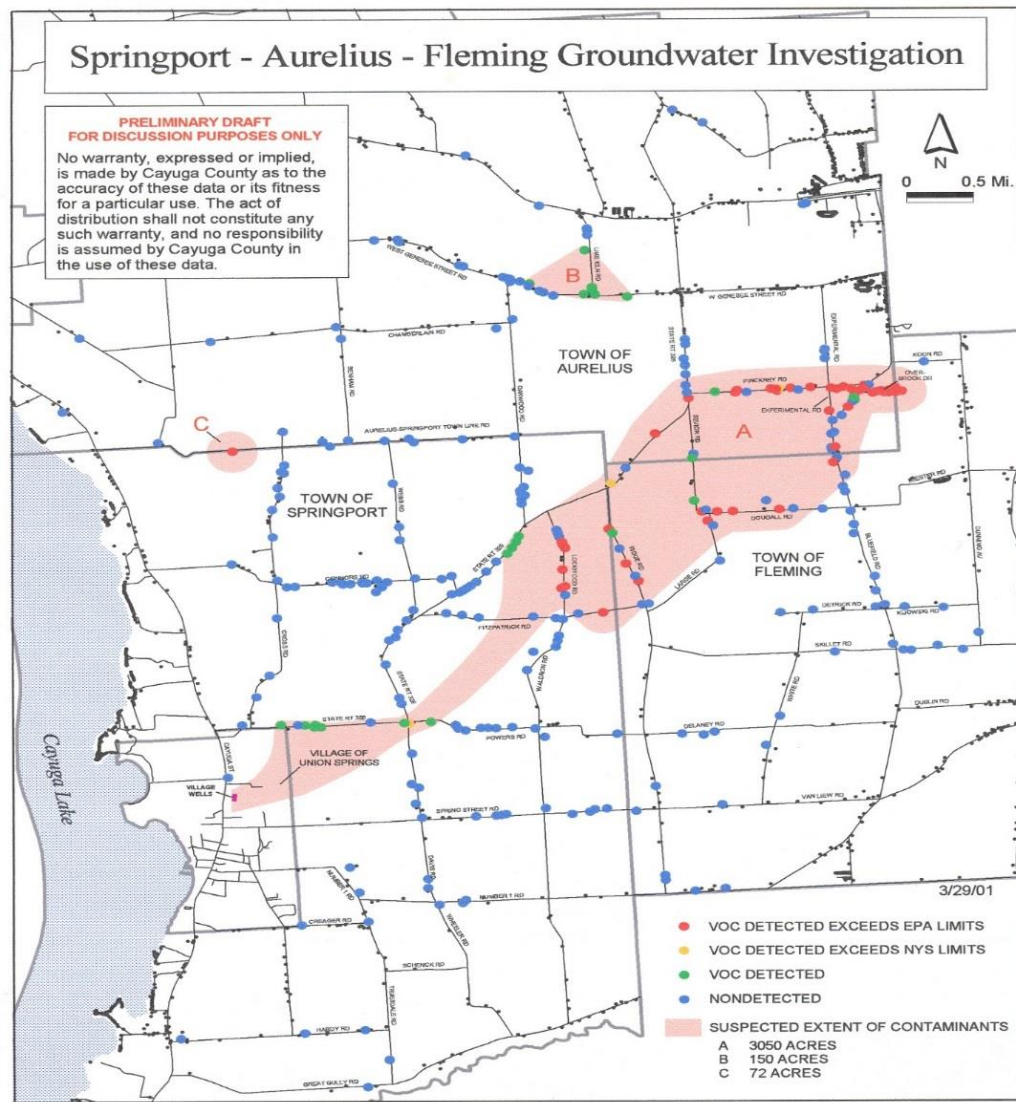
High likelihood that the Bertie Formation is a regional groundwater drain that allows movement of contaminated water toward southwest discharge points



Regional Discharge



Regional Discharge



Regional Discharge

- U.S. EPA Dive Team located a groundwater discharge into a small bay in Cayuga Lake near Union Springs where the Forge Hollow Member of the Bertie Formation outcrops
- The location was an old gypsum mine site



Questions?



Disclaimer

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