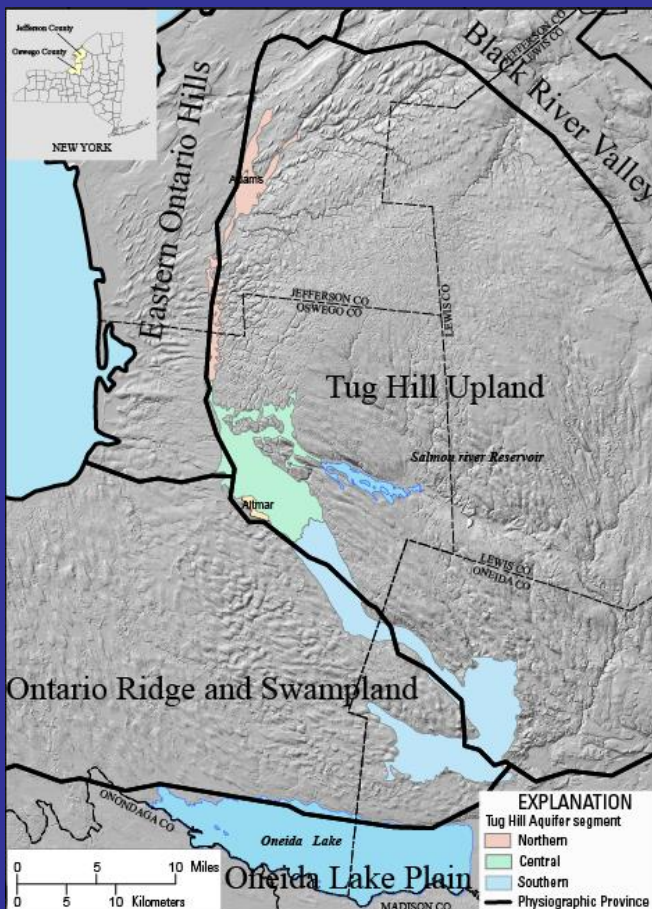
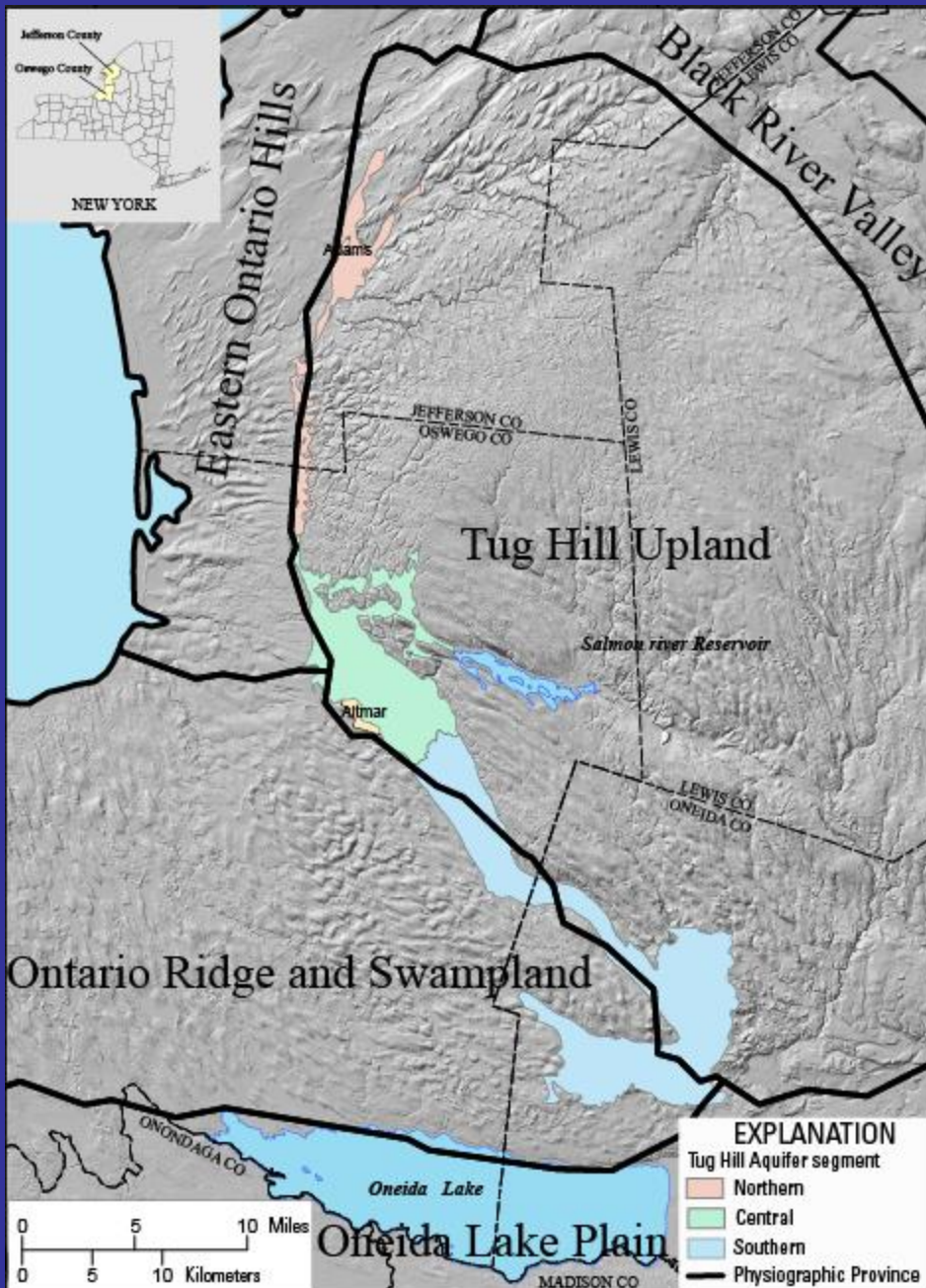


HYDROGEOLOGY AND WATER QUALITY OF THE TUG HILL AQUIFER SYSTEM



- Project discussions started in 2007
- Project officially starts in 2008 with funding from Tug Hill Commission and USGS
- Other funders during the years:
 - Jefferson & Oswego SWCDs
 - Tug Hill Land Trust
 - NY DEC



- 47-mile long, 103 mi² aquifer system
- Occupies portions of Jefferson, Oneida, and Oswego counties
- Large source of excellent quality water
- Supplies eleven municipalities, several businesses, a fish hatchery, farms, homeowners

NEW SOLE SOURCE AQUIFER DESIGNATED IN NEW YORK

- On November 2, 2006, the U.S. Environmental Protection Agency announced that it has designated the Northern Tug Hill Glacial Aquifer as a Sole Source Aquifer.
- The Sole Source Aquifer designation was initiated by a 2003 petition from the Village of Lacona. New York Rural Water Association worked with the Village of Lacona to prepare the document.

Original goal of project

- 2 phases

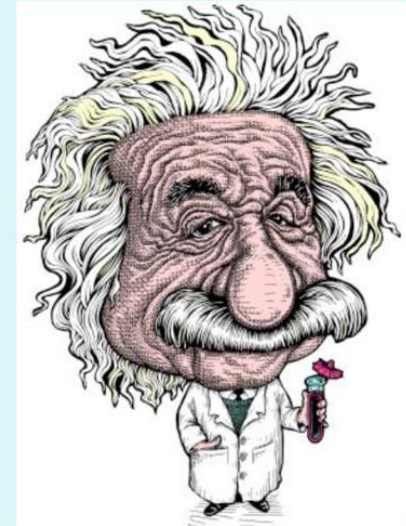
Collect hydrologic, geologic, and water quality data to describe the aquifer system

.....AND support:



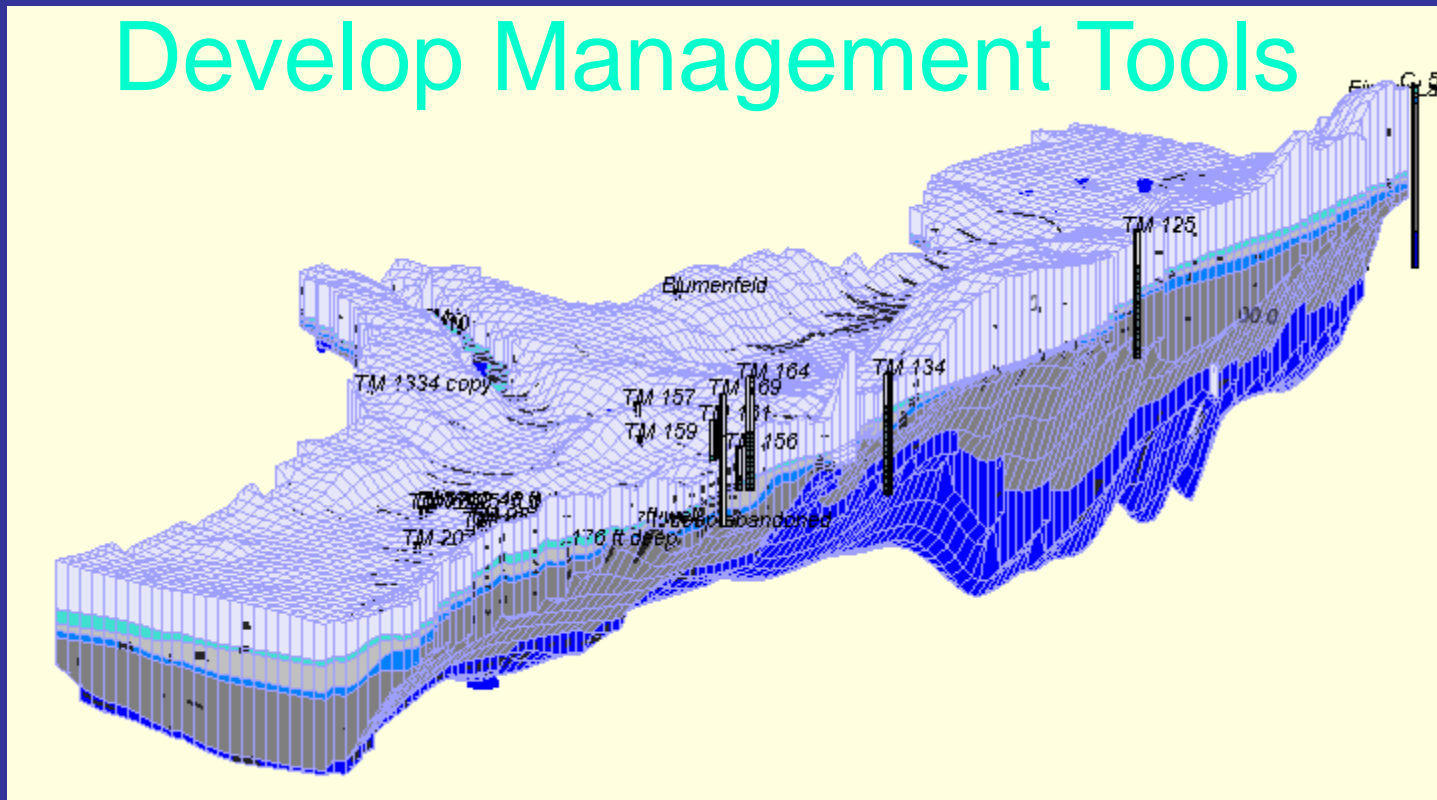
Collecting Data

Part of the Scientific Process of Inquiry

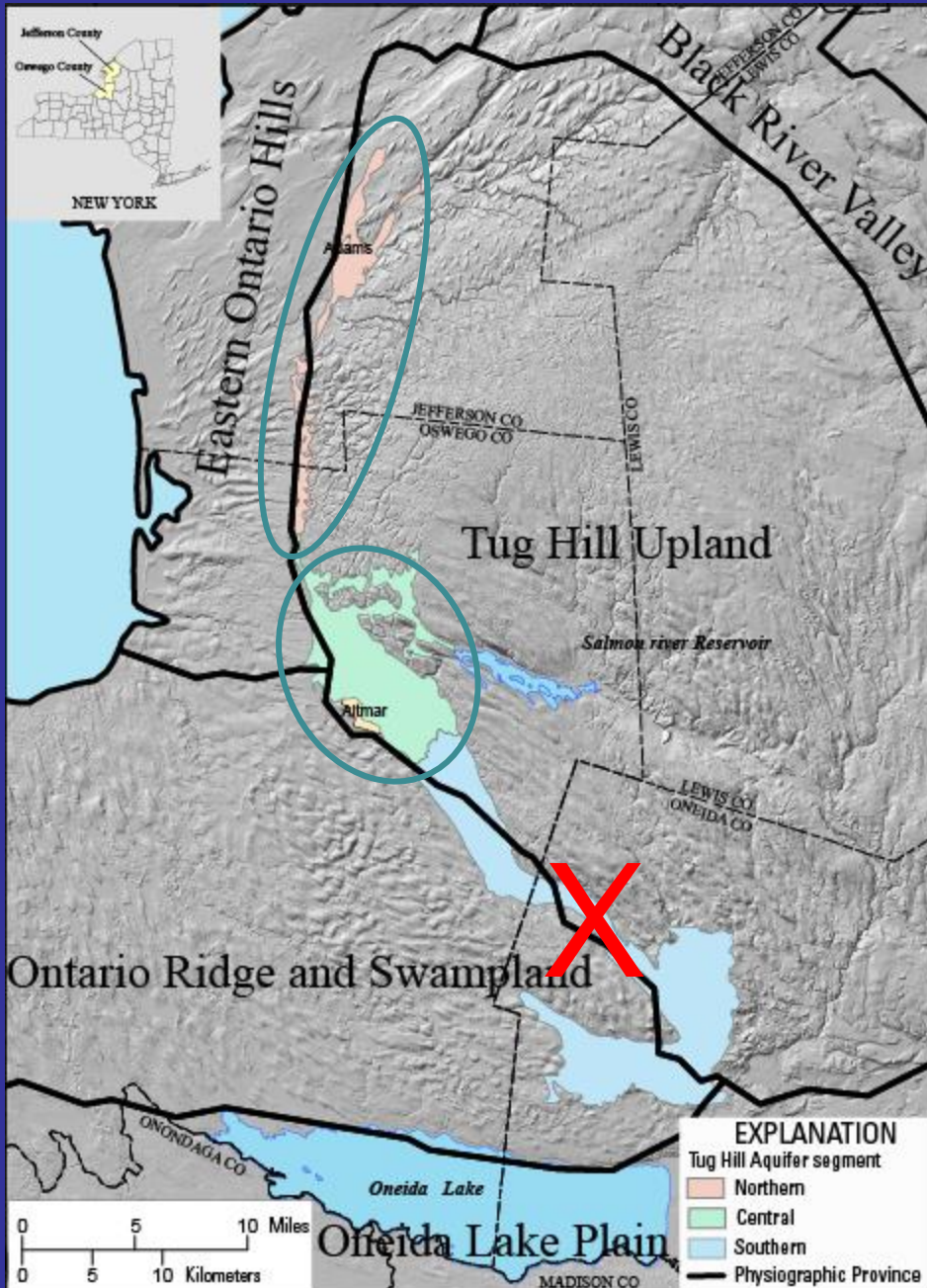


Predictive groundwater-flow models of each of the 3 aquifer sections

Develop Management Tools



MODFLOW- a numerical GW flow model that can simulate a wide variety of hydrologic features and processes such as rivers, streams, drains, springs, reservoirs, wells, evapotranspiration, and recharge from precipitation and irrigation



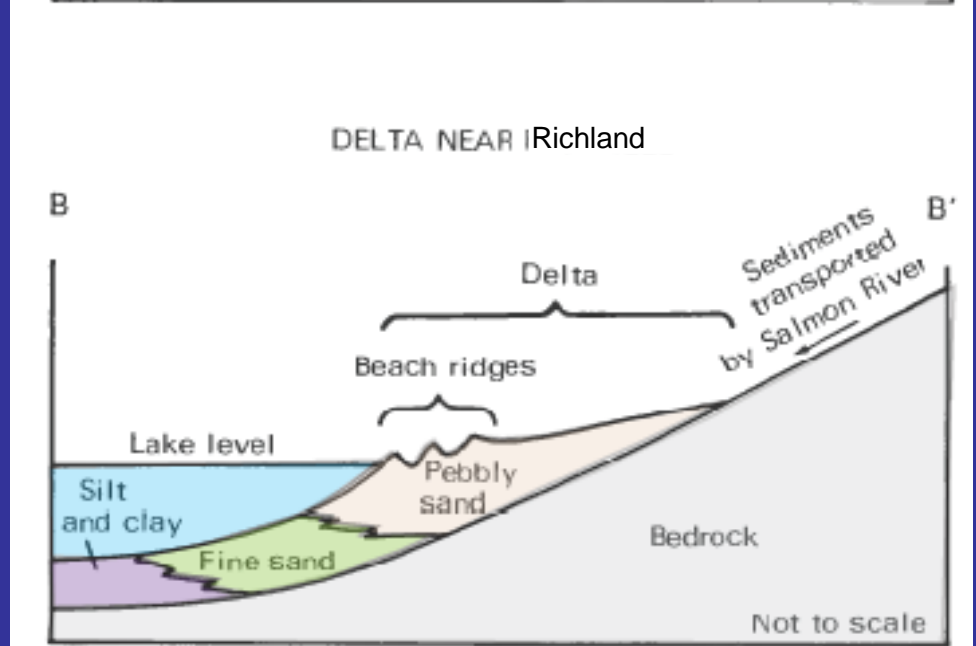
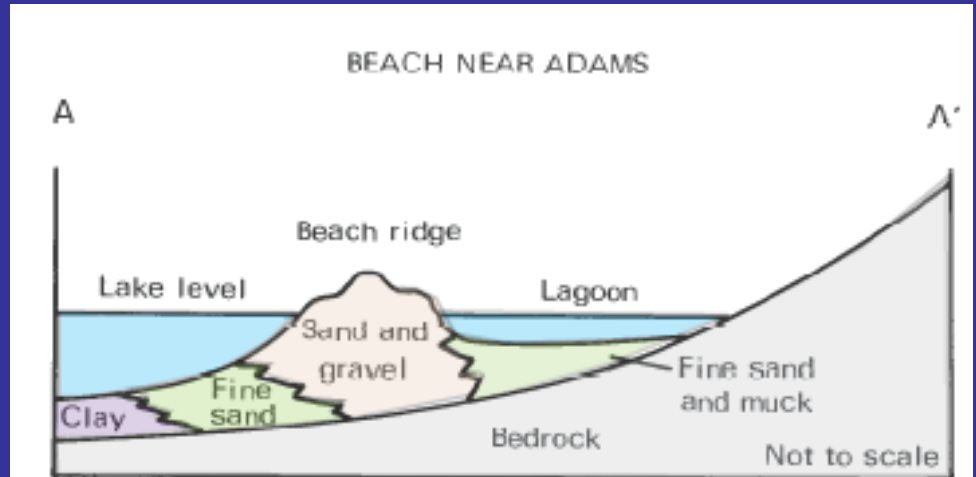
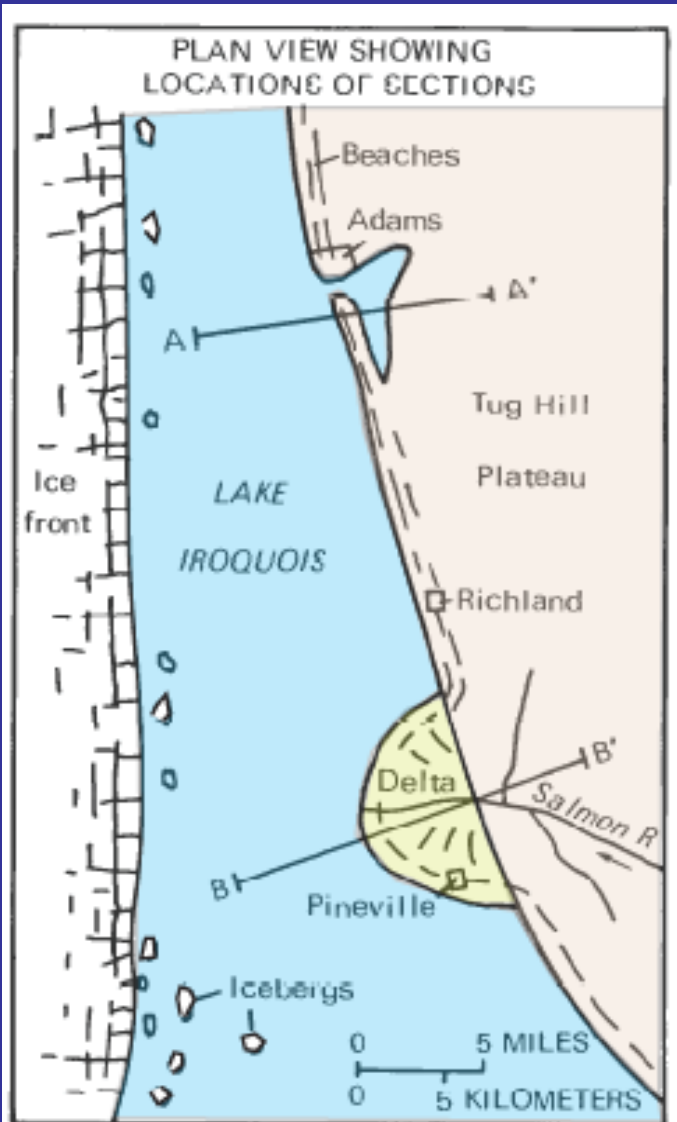
- Scope changed in 2011 to include just the northern and central sections of the aquifer.
- Decrease in funding
- Concentration of population
- Habitat and water quantity issues

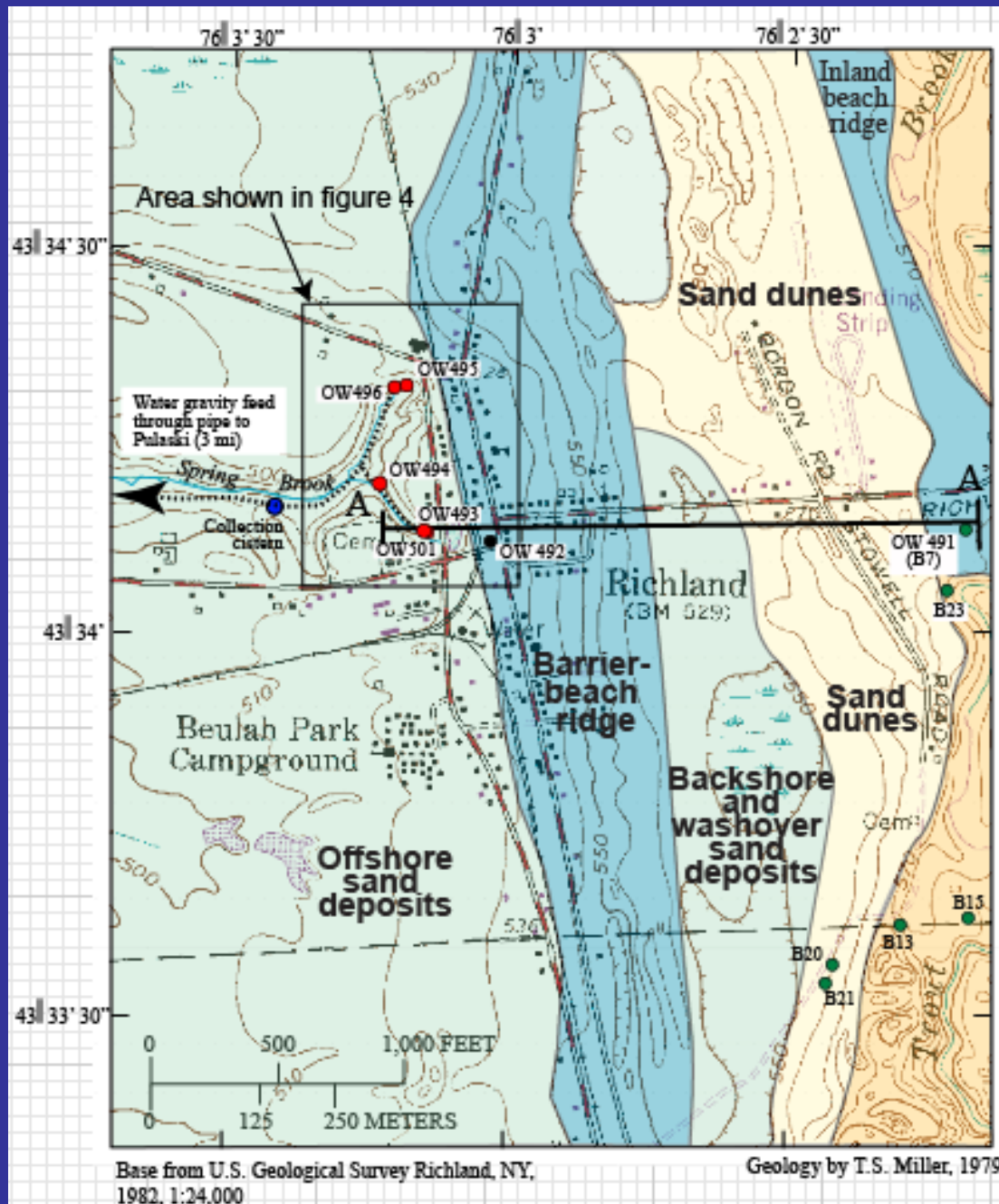
Aquifer Setting



How did it get here?

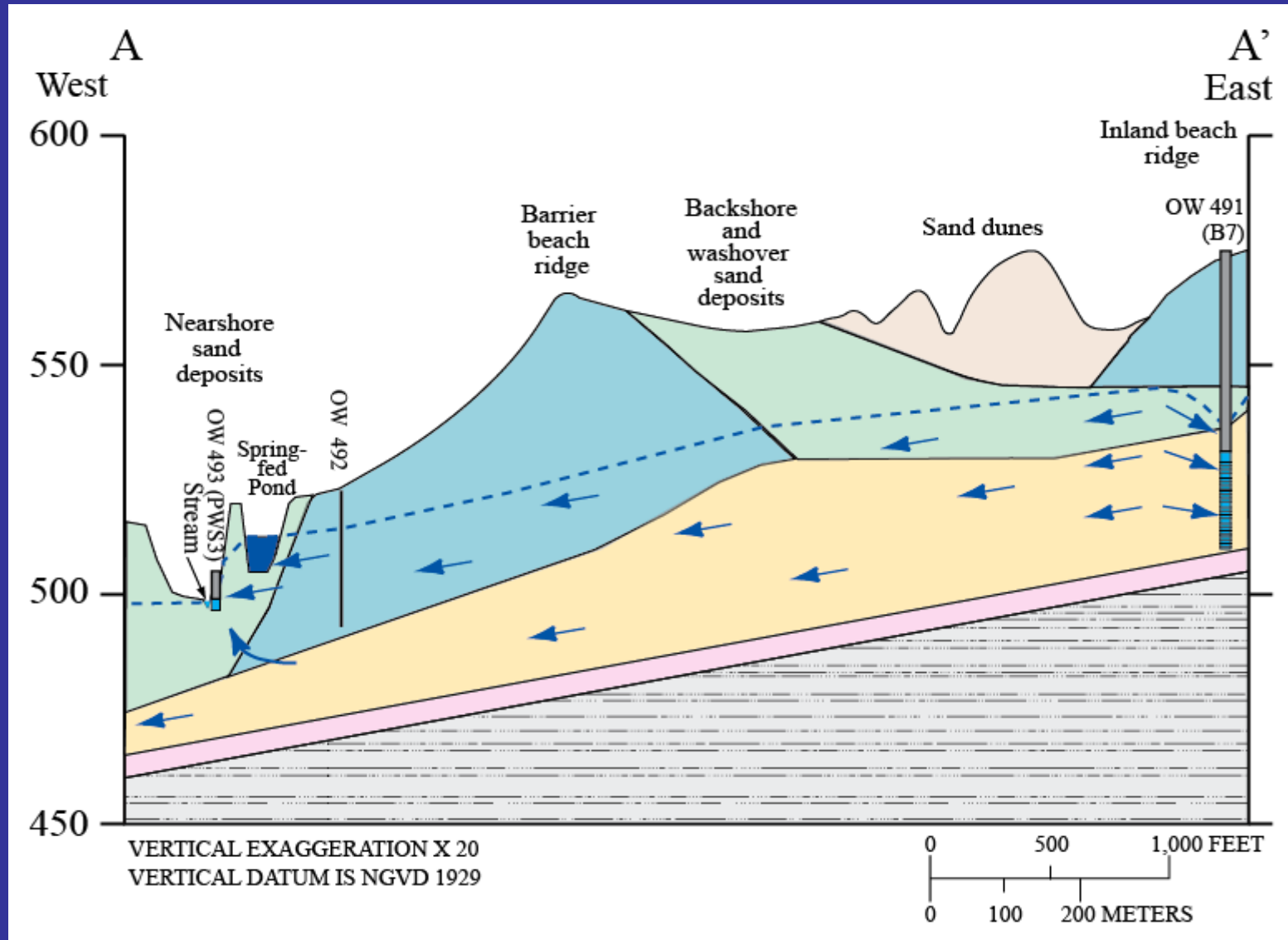
TYPICAL GLACIOLACUSTRINE DEPOSITS IN THE NORTH AND CENTRAL PARTS OF THE TUG HILL AQUIFER



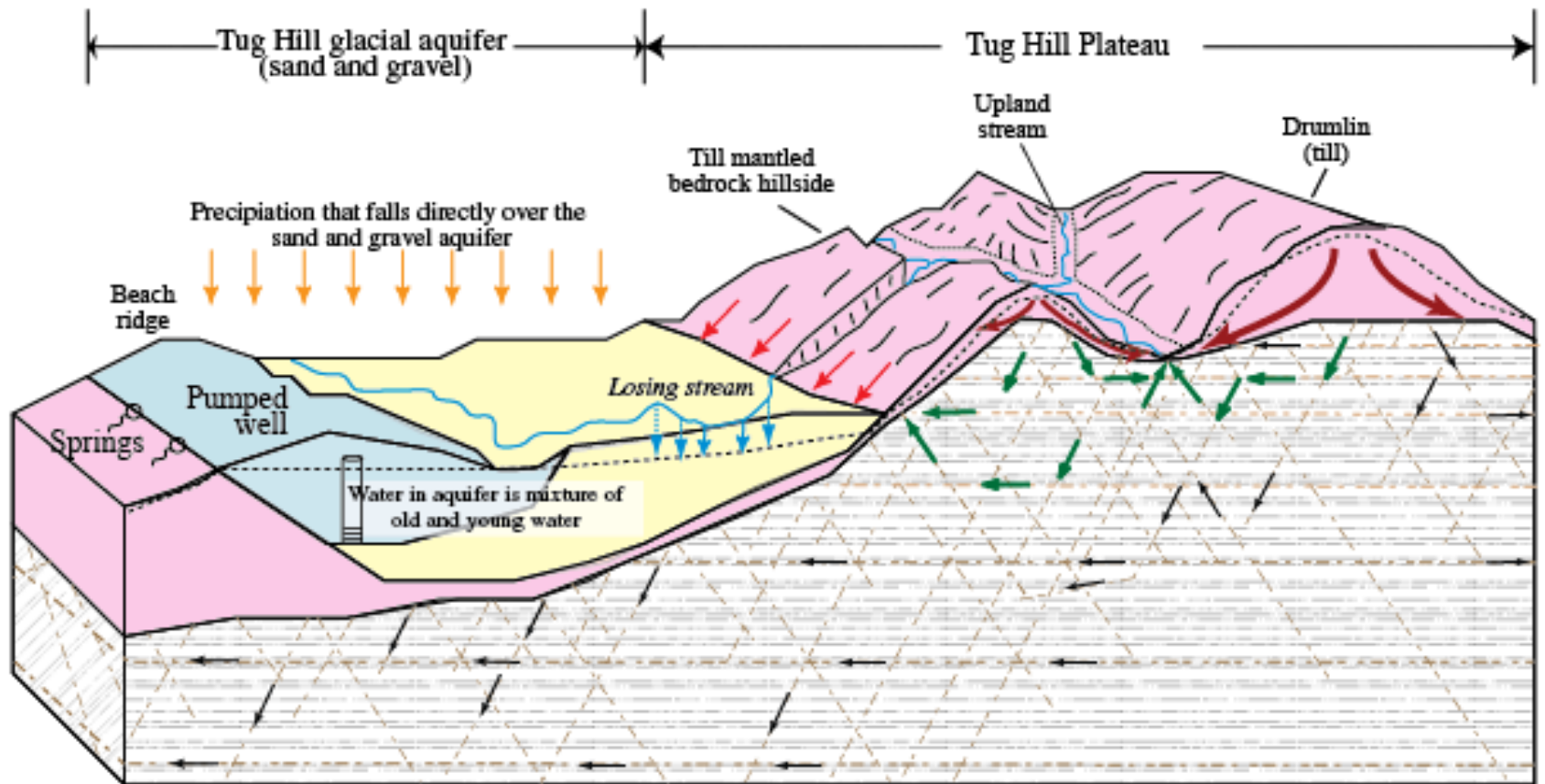


Geohydrologic setting of the Pulaski well field at Richland

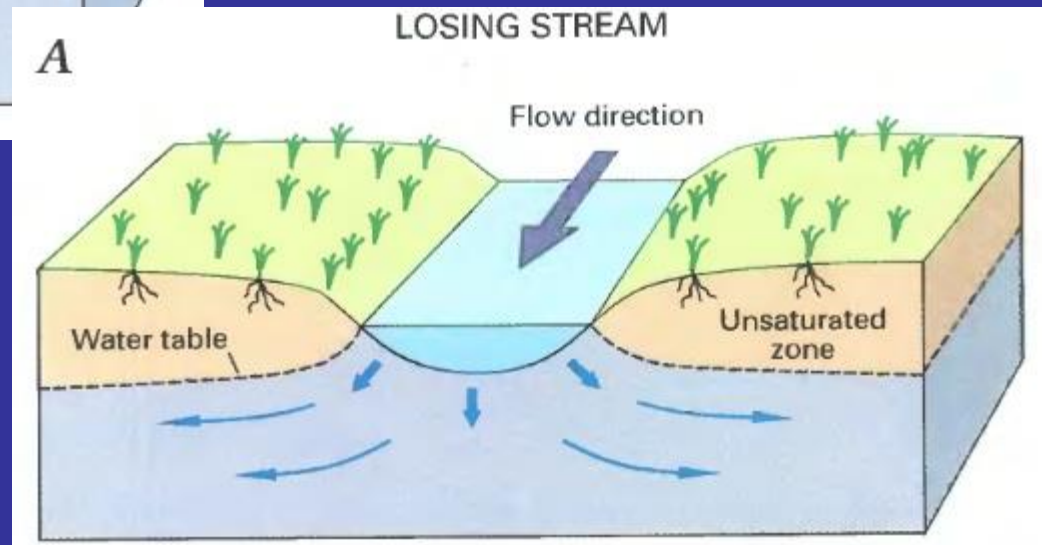
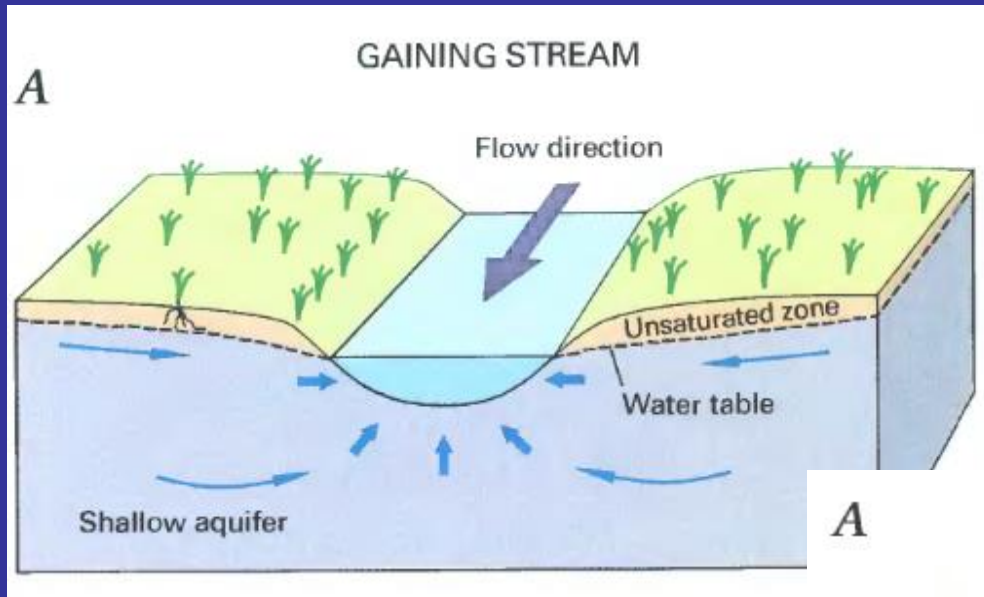
GEOLOGIC SECTION RICHLAND



Sources of recharge to the Tug Hill sand and gravel aquifer



SURFACE WATER/GROUND WATER INTERACTION IS AN IMPORTANT CHARACTERISTIC IN UNCONFINED AQUIFERS SUCH AS THE TUG HILL AQUIFER



What types of data were collected

- Compiled GIS basemaps
- Inventory of post-2000 wells (field verify locations) and wells from published reports
- Installed real-time stream gage on Trout Brook (operated for 3 years)
- Deployed 4 stream temperature loggers
- Collected WQ samples in streams (north & central)
- Seepage measurements in streams (north & central)

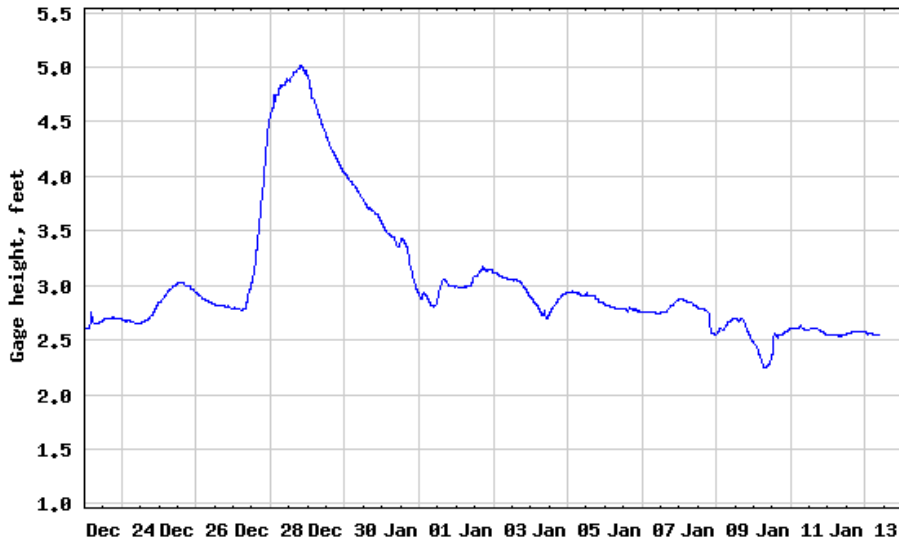
What types of data were collected

- Deployed four WL data loggers (Richland well field and north of Adams)
- Collected over 20 GW samples / over 18 SW samples for water quality
- Revisions to Aquifer Boundary and Geology maps based on new information: especially near Adams (extends sole source aquifer)
- Passive seismic (north and central) for aquifer thickness
- Conducted Drilling north of Adams

Trout Brook gage site



USGS 0425040001 TROUT BROOK UPSTREAM OF CR-48 AT CENTERVILLE NY



----- Provisional Data Subject to Revision -----

[Create presentation-quality graph](#)

Parameter 00065

REAL-TIME STREAM GAGE TROUT BROOK, NEAR CENTERVILLE 2009-2010

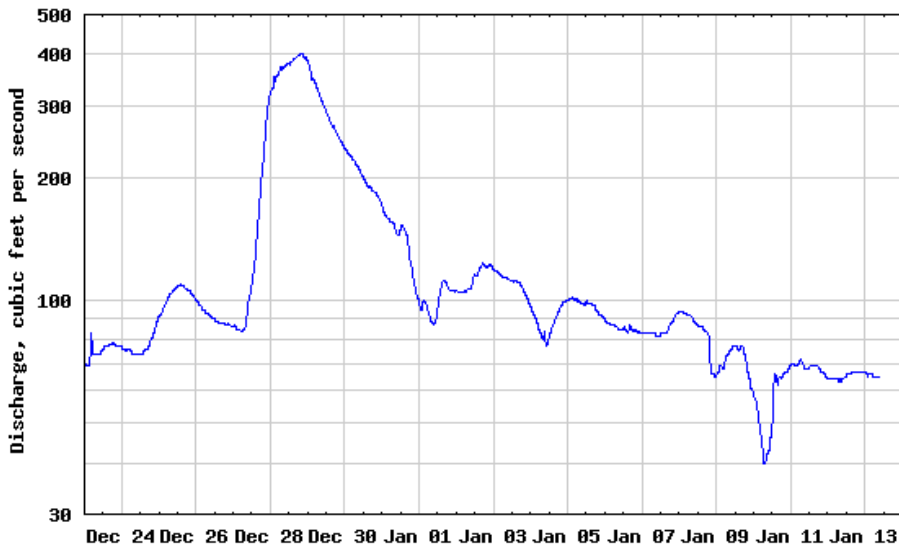
data used to determine
seasonal flow
characteristics

calibration data for
groundwater model

Discharge, cubic feet per second

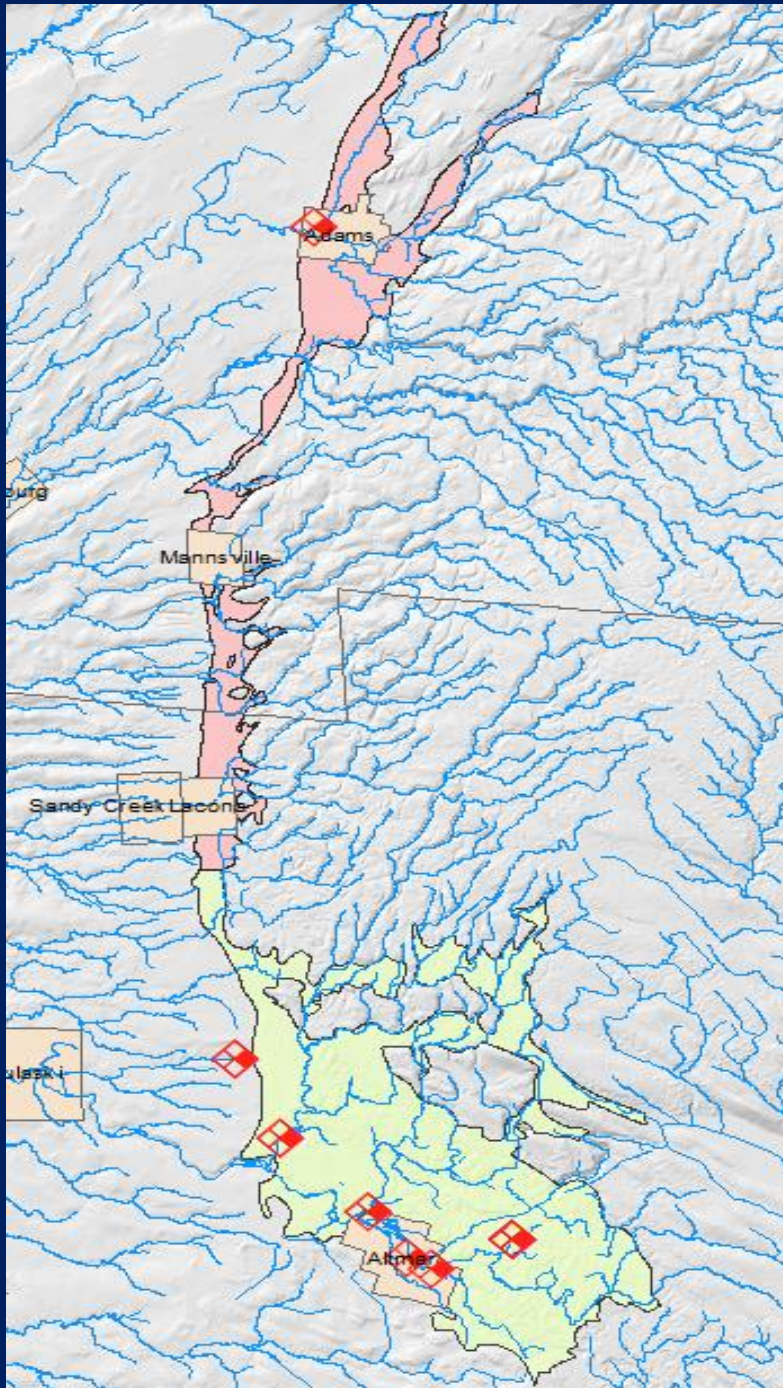
Most recent instantaneous value: 65 01-13-2009 09:15

USGS 0425040001 TROUT BROOK UPSTREAM OF CR-48 AT CENTERVILLE NY

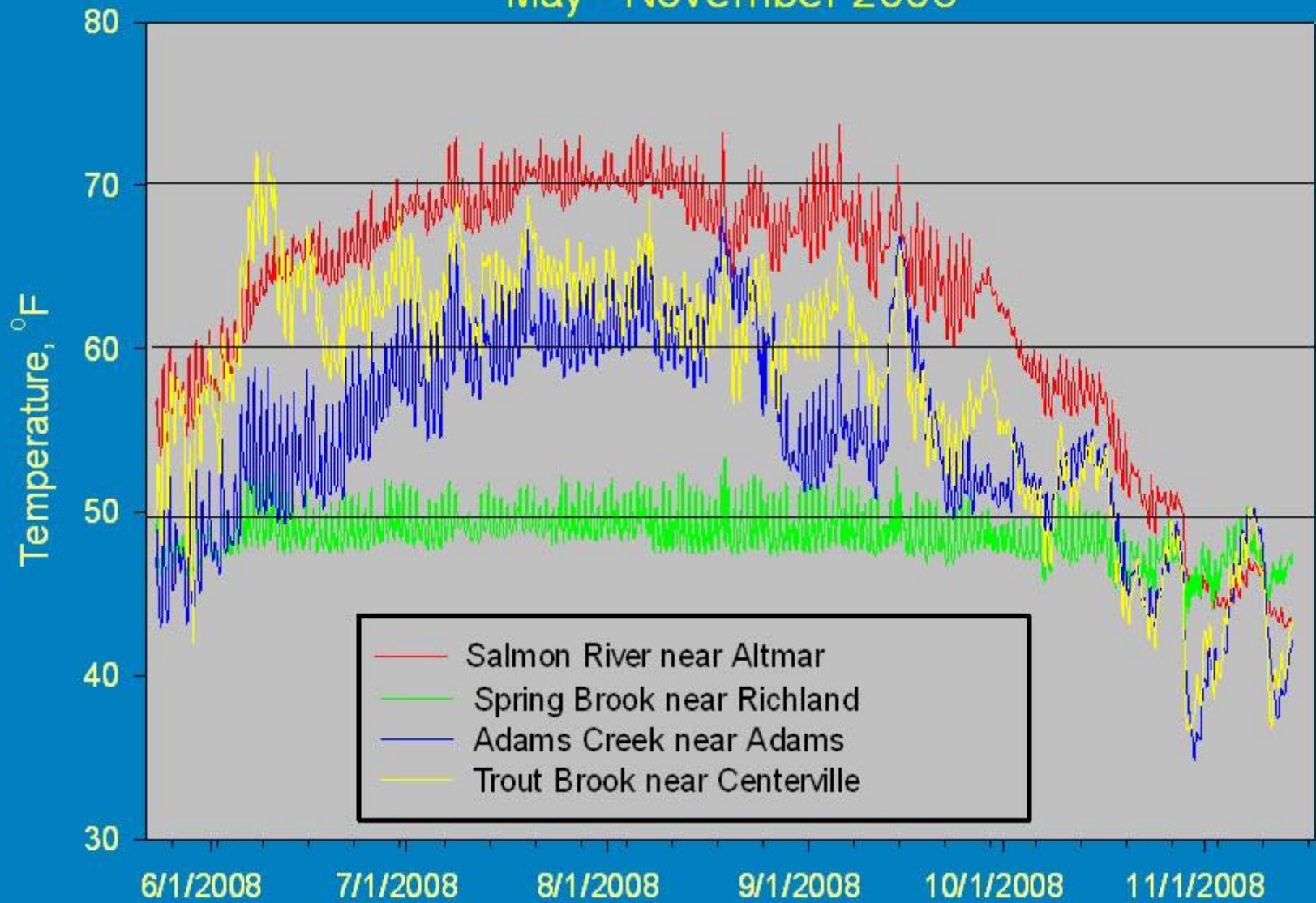


----- Provisional Data Subject to Revision -----

Stream Temperature collected at 8 sites



Water Temperature in Four Tug Hill Streams May - November 2008

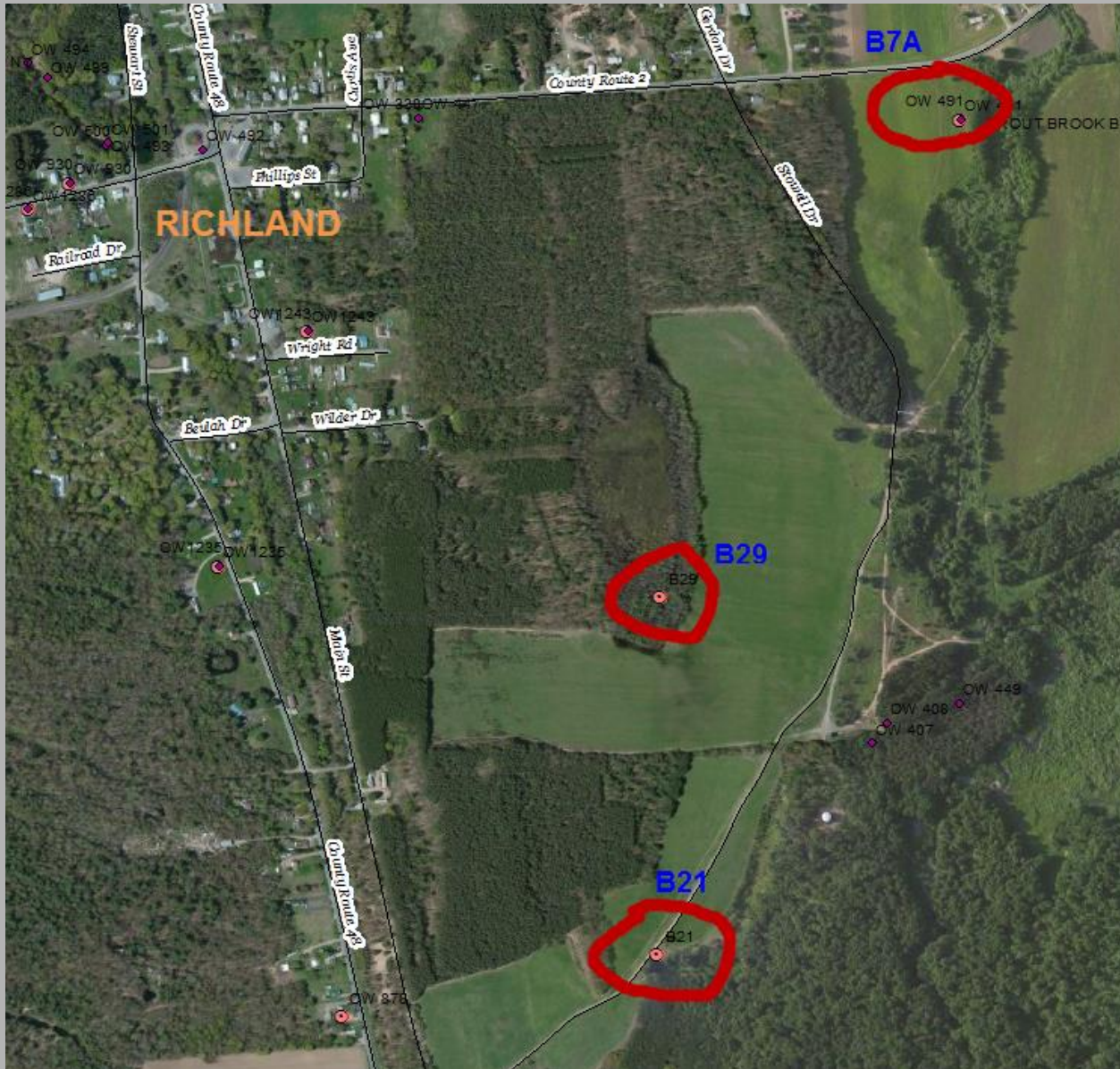




Continuous water–level and temperature data at 4 sites

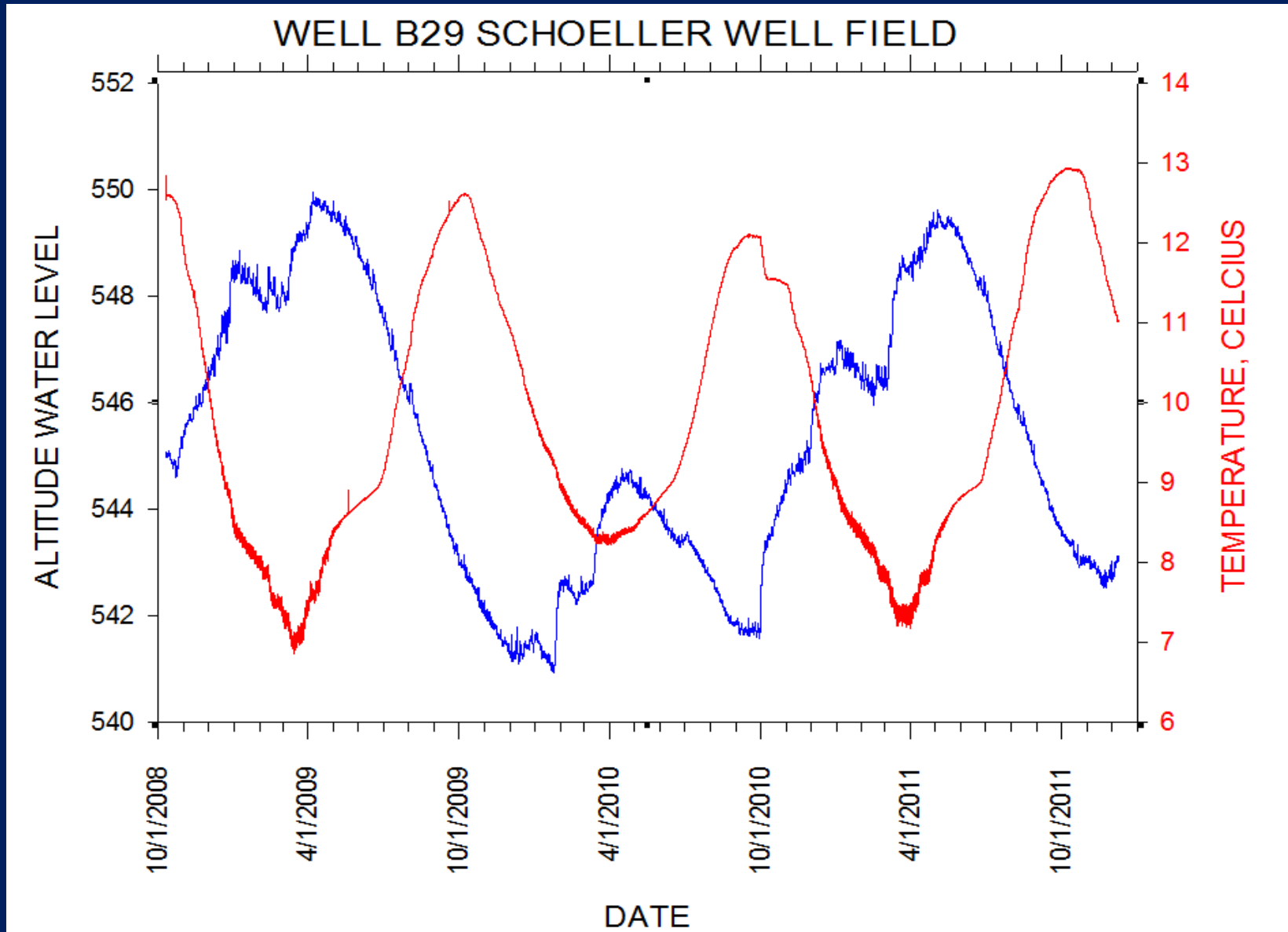
Continuous recorder records every hour water level in well

Richland well field
(well B29)



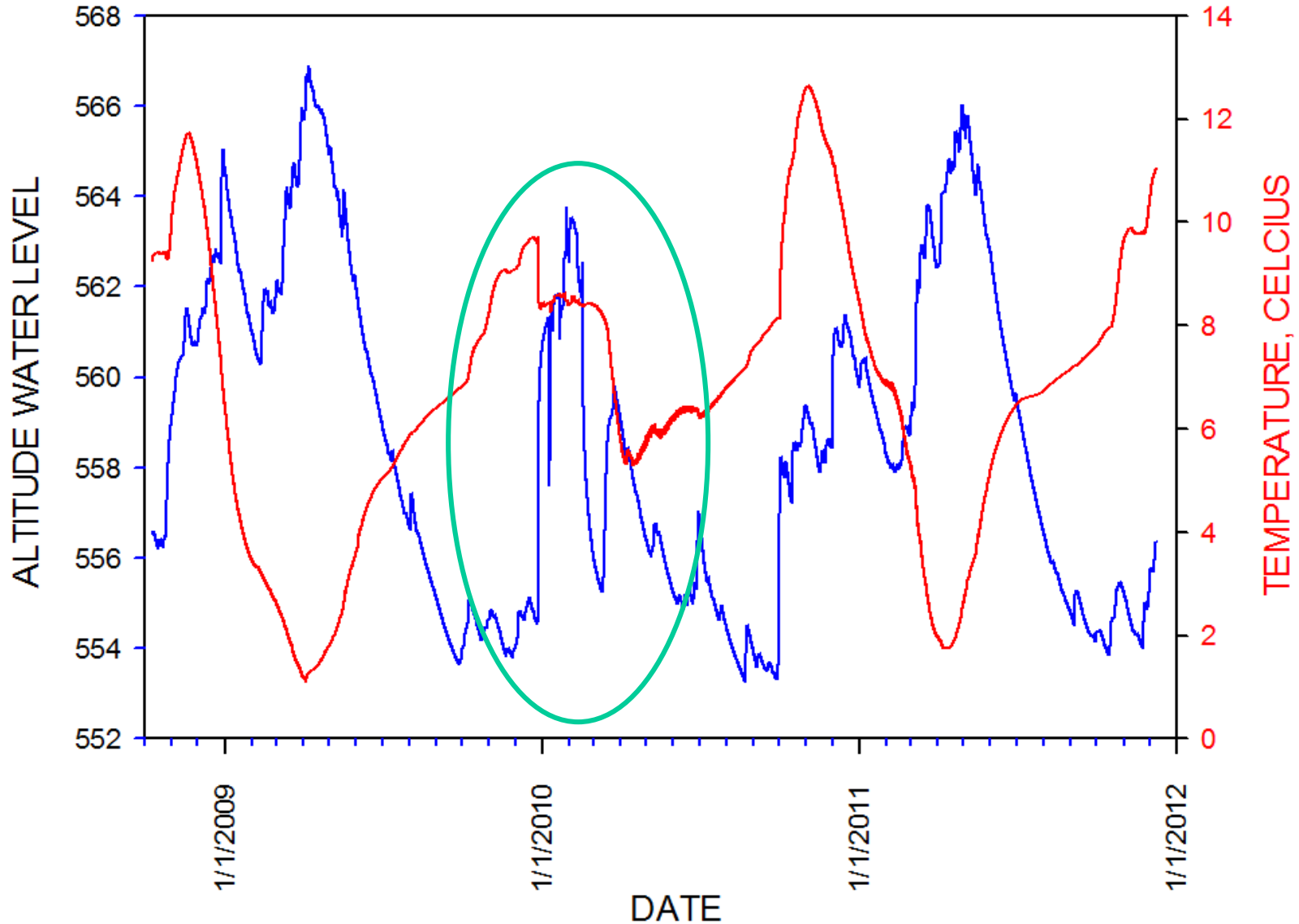
Continuous groundwater level monitoring in three wells at Richland well field

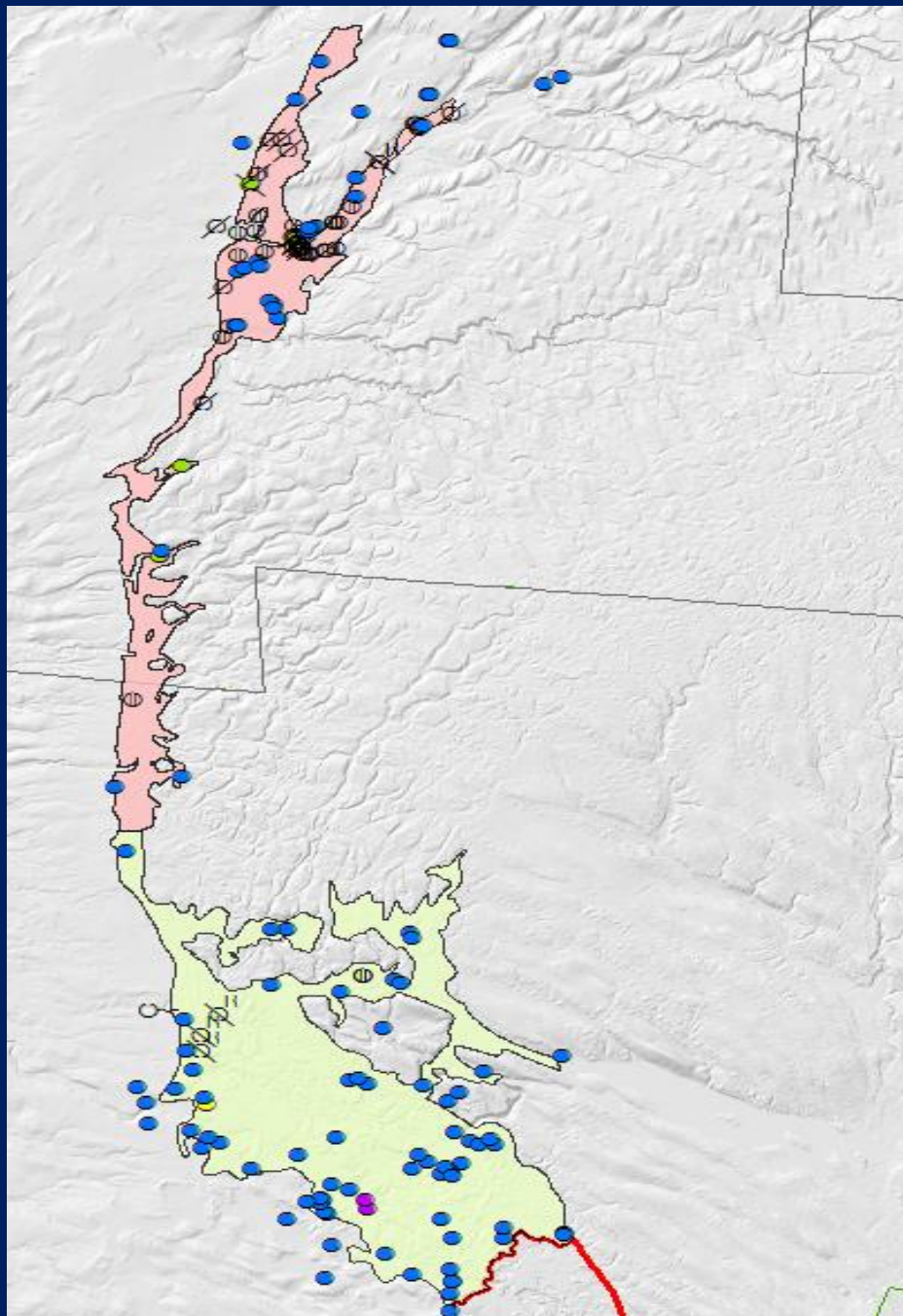
Well B29 (distal from stream)



CONTINUOUS GROUNDWATER-LEVEL MONITORING (near stream)

WELL B7A SCHOELLER





**Well database
created
including over
150 wells**

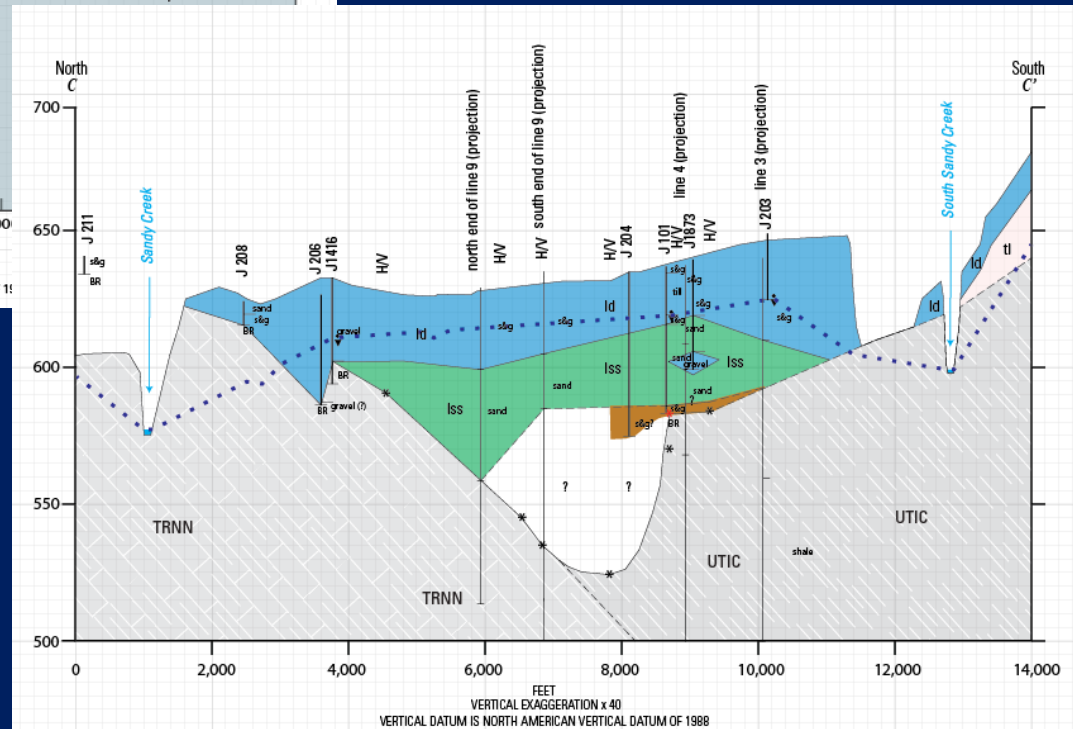
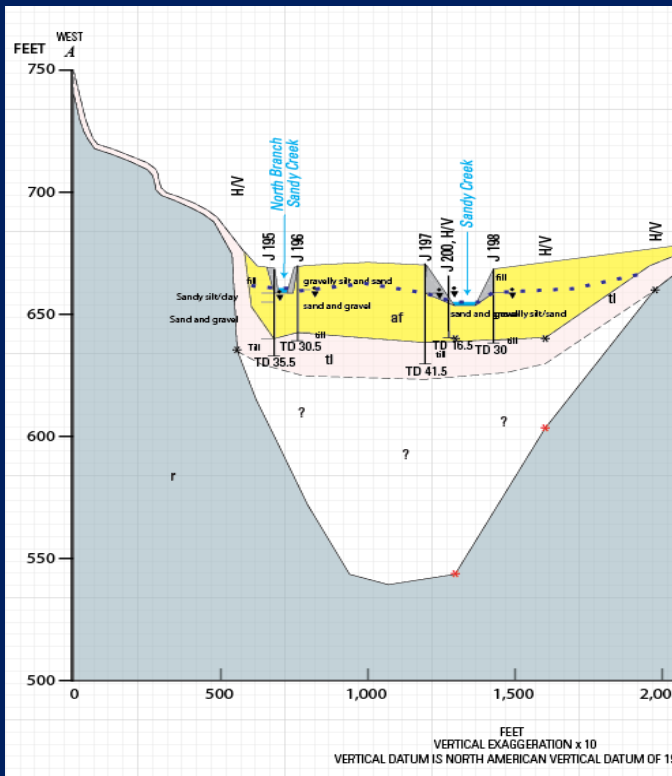
**76 wells – Jefferson
Co.
82 wells Oswego Co.**

All wells in USGS NWIS database accessible online at: | http://waterdata.usgs.gov/ny/nwis/county_cd

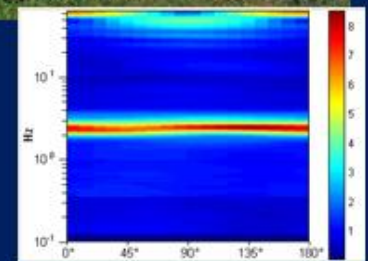
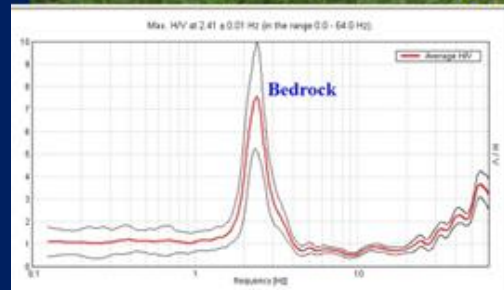
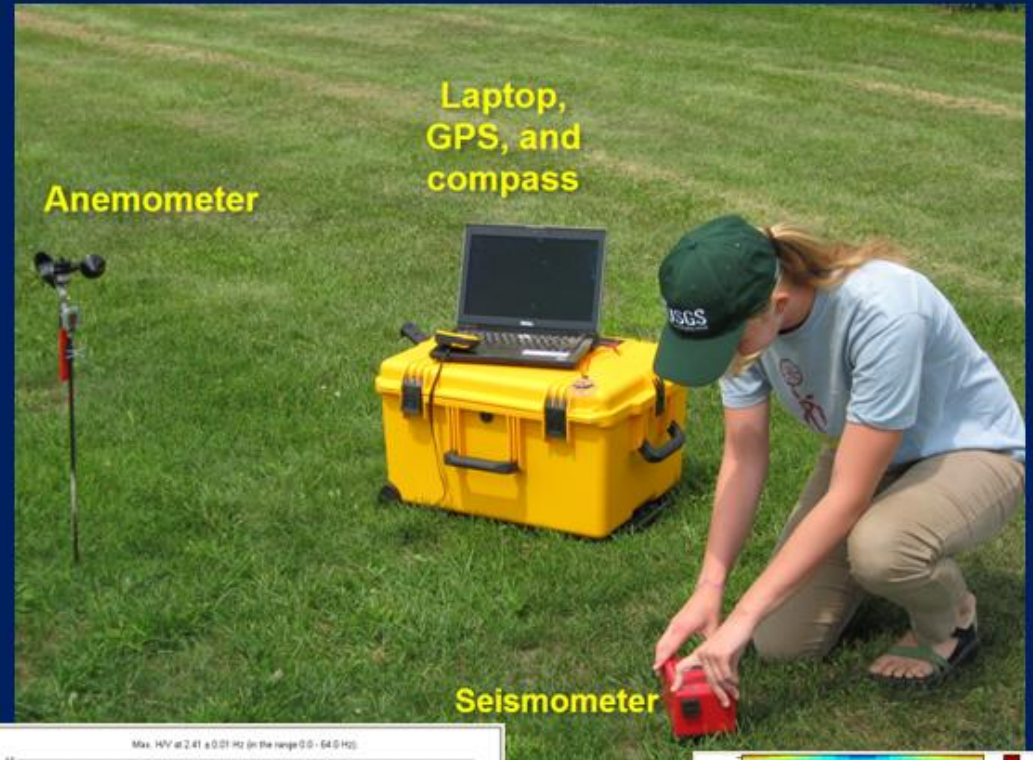
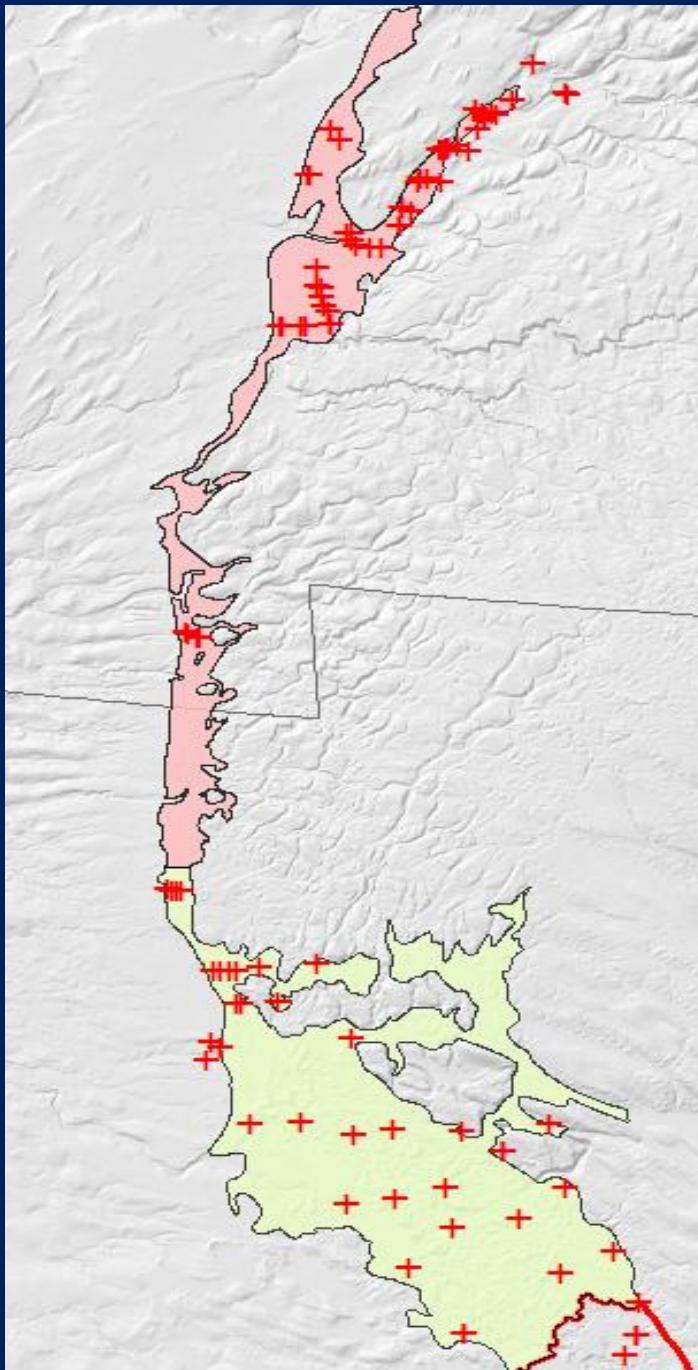
Appendix 1. Records of selected wells in the Northern and Central sections of the Tug Hill aquifer system in Jefferson and Oswego counties, New York. [S&G, sand and gravel; --, no data; ft., feet; dia. (in), diameter in inches; gal/min; NGVD 29, National Geodetic Vertical Datum of 1929; >, greater than]

Well site name	Date drilled	Well depth (ft.)	Depth of casing (ft.)	Casing diameter (in)	Altitude land surface (NGVD 29, in ft.)	Aquifer type (aquifer layer)	Water level below land surface (ft.)	Altitude water level (ft.)	Date water level measured	Depth to bedrock (ft.)	Altitude top of bedrock (NGVD 29, in ft.)	Reported yield (gal/min)	Remarks
J 101	5/14/1985	25	23	2	642	Sand	18	624	5/16/1985	54	588	--	0-3 S&G, 3-18 till, 18-21 S&G, 21-50 f-c sand, 50-54 S&G, 54 ft. bedrock.
J 102		25	--	--	633	Sand and gravel	--	--		--	--	--	Driven well. WQ sample 8/28/1985.
J 103	5/15/1985	--	--	--	605	Sand	34	571	5/15/1985	--	--	--	Test boring. No well. 0-30 f-m sand, 30-66 ft. f-vf sand, heaves up augers.
J 104	6/15/1975	45	--	6	634	Sand and gravel	9.8	624.2	9/8/1983	--	--	--	0-45 ft. sand and gravel
J 105	1/0/1900	40	--	2	629	Sand and gravel	22	607	4/16/1985	48	581	--	Test well. 0-40 pebbly sand, 40-46 silty sand, 46-48 till. 48 ft. bedrock
J 106	4/17/1985	37	37	2	642	Sand and gravel	12	630	4/17/1985	43	599	--	0-40 S&G, 40-43 till, 43 ft. bedrock.
J 107	1/0/1900	21	21	2	625	Sand	7.3	617.7	4/16/1985	36	589	--	0-18 S&G, 18-22 sand. 22-32 silt, 32-36 till, 36 ft. bedrock.

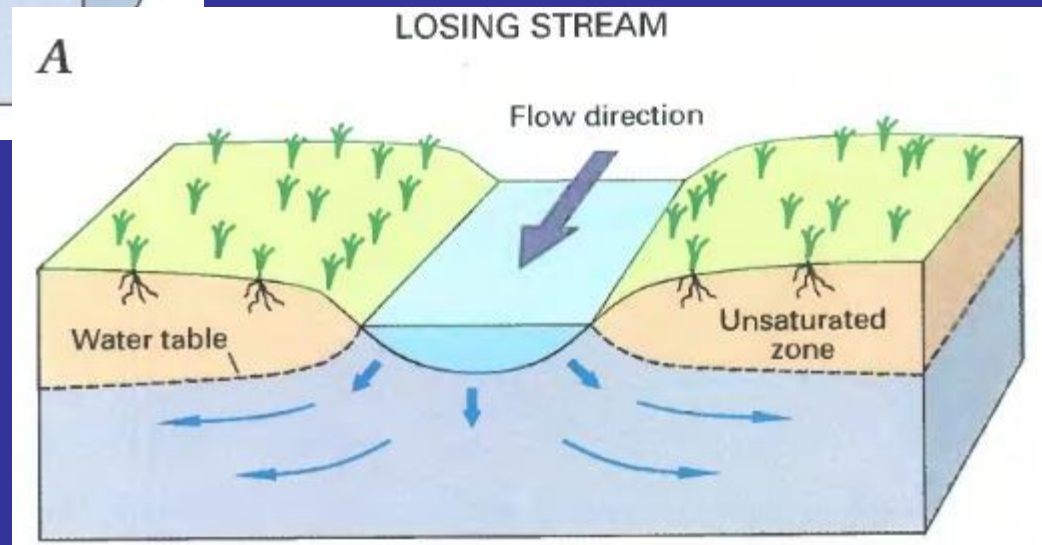
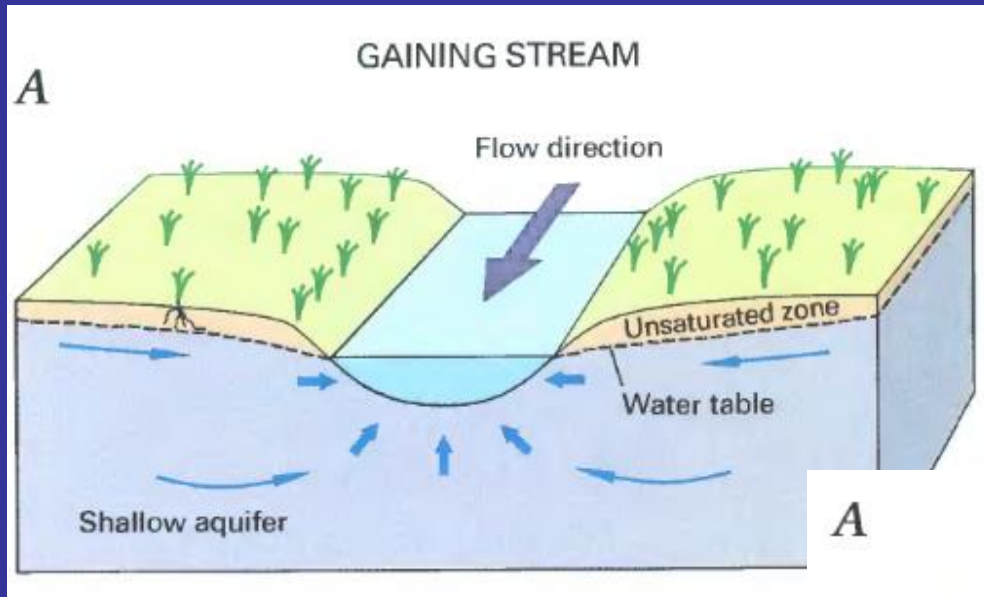
Allows the construction of hydro-geologic cross sections

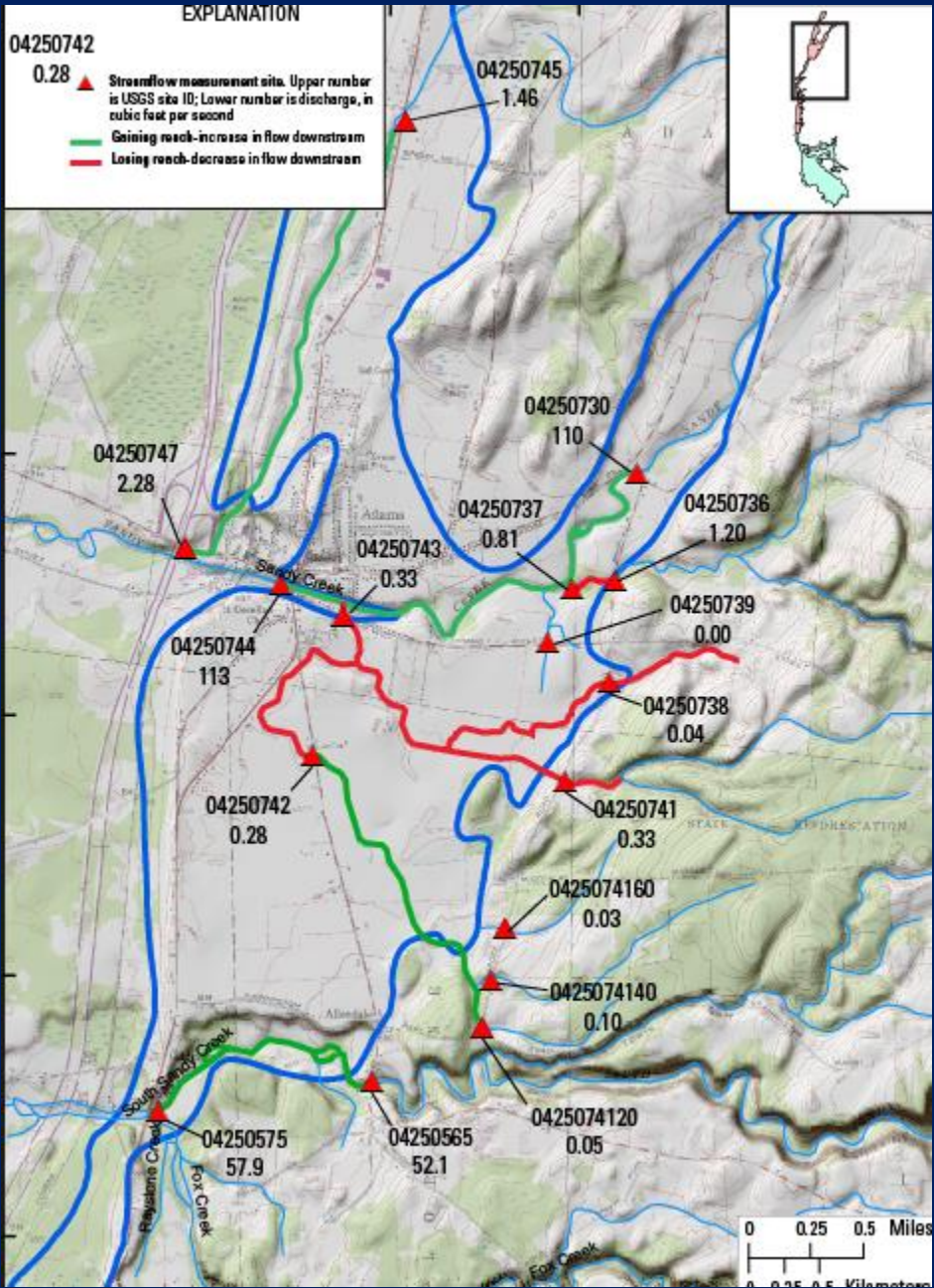


Seismic surveys conducted at over 200 sites



SURFACE WATER/GROUND WATER INTERACTION IS AN IMPORTANT CHARACTERISTIC IN UNCONFINED AQUIFERS SUCH AS THE TUG HILL AQUIFER



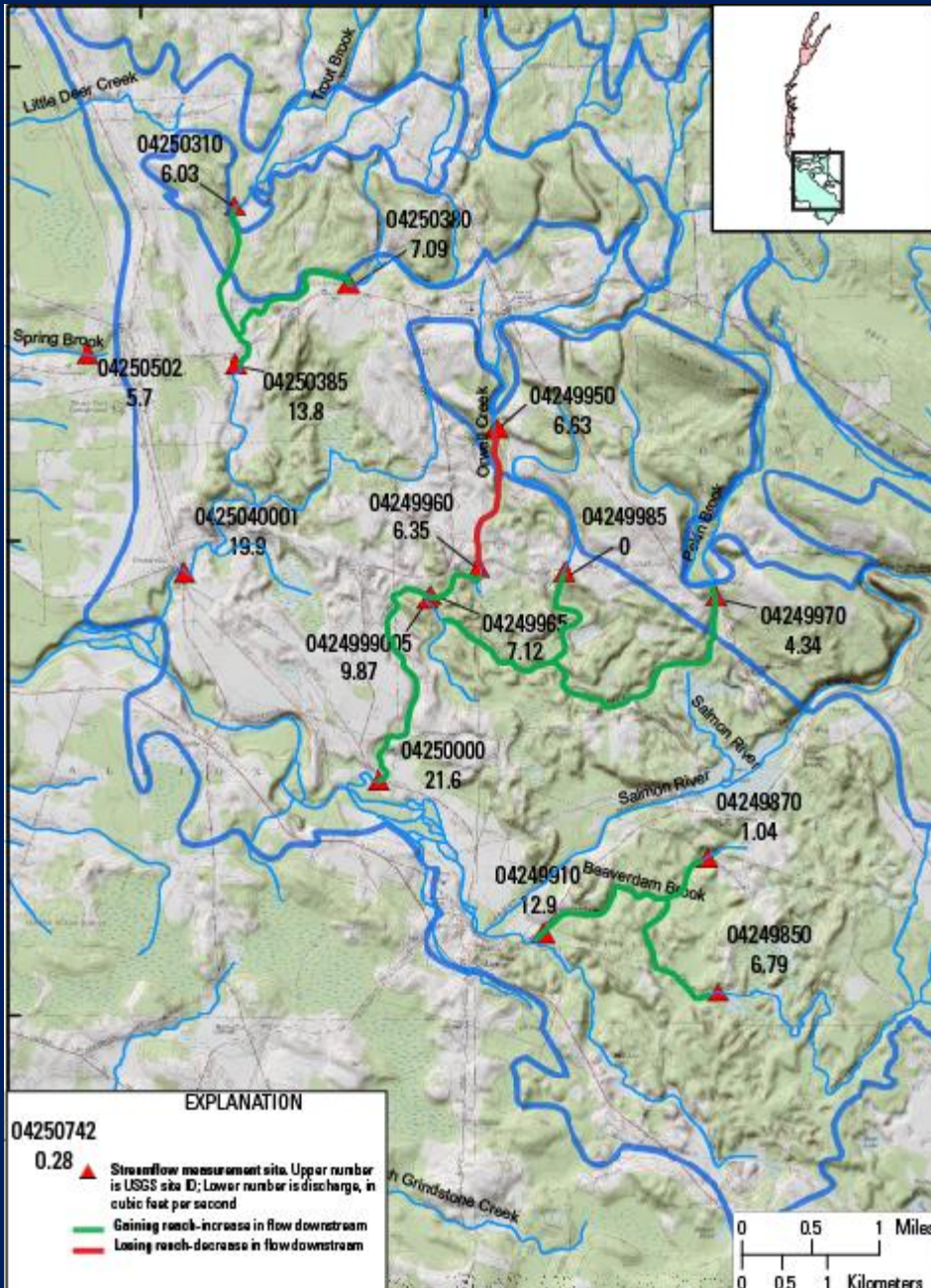


Stream Gain-Loss measurements

Northern Section near Adams

Stream Gain-Loss measurements

Southern Section near Altmar



Station ID Number

Physical properties

Dissolved oxygen (field)
pH (field)
Specific conductance (field)
Water Temperature

Common ions

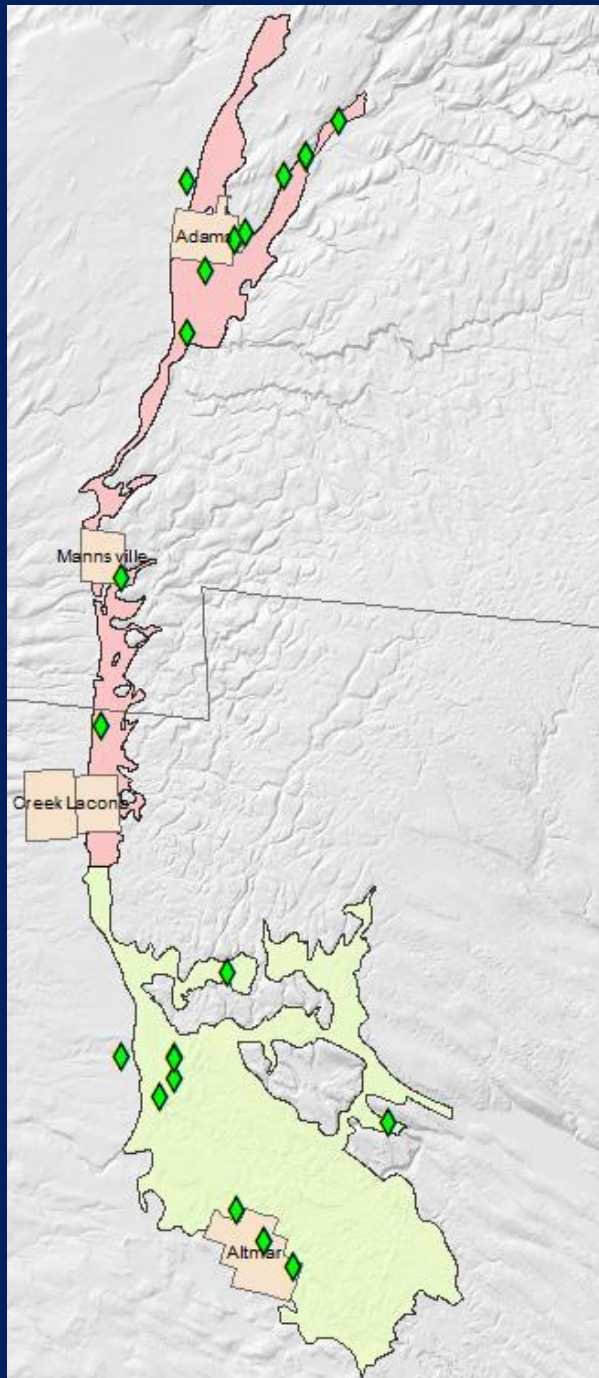
Hardness, filtered
Calcium, filtered
Magnesium, filtered
Potassium, filtered
Sodium, filtered
Alkalinity, filtered CaCO₃
Chlorides, filtered
Silica, filtered
Sulfate, filtered
Iron, filtered
Manganese, filtered

Nutrients

Ammonia, as N, filtered
Nitrate, as N, NO₂+NO₃, filtered
Nitrite, as N, filtered
Phosphorous, unfiltered, as P
Orthophosphate, as P, filtered

Water Quality samples
collected at Streams
and wells throughout
both aquifer sections

Data downloadable at:
http://waterdata.usgs.gov/ny/nwisunty_cd



24 Groundwater Quality samples collected at 19 wells

- 10 wells in the northern section
- 9 wells in the central section

http://waterdata.usgs.gov/ny/nwisunty_cd

Chemical Constituents

Inorganics

Description: Hydro Fracking inorganics

Price: \$360.11

Owner: BDT, NWQL

Analyte▲	Lab Code	Parameter Code
Alkalinity, laboratory	2109	29801
Aluminum	1784	01106
Antimony	1785	01095
Arsenic	3122	01000
Barium	1786	01005
Beryllium	1787	01010
Boron	2504	01020
Bromide	3166	71870
Cadmium	1788	01025
Calcium	659	00915
Chloride	1571	00940
Chromium	3126	01030
Cobalt	3124	01035
Copper	3128	01040
Fluoride	31	00950
ICP Mass Spectrometry (ICPMS) setup	2181	L2181
Inductively coupled plasma (ICP) setup	2002	L2002
Iron	645	01046
Lead	1792	01049

Lithium	664	01130
Magnesium	663	00925
Manganese	1793	01056
Molybdenum	1794	01060
Nickel	3130	01065
pH, laboratory	68	00403
Potassium	2773	00935
Residue, 180 degrees Celsius (TDS)	27	70300
Selenium	3132	01145
Silica	667	00955
Silver	1796	01075
Sodium	675	00930
specific conductance, laboratory	69	90095
Strontium	2507	01080
Sulfate	1572	00945
Uranium, natural	1797	22703
Zinc	3138	01090

Nutrients

Description: NAWQA, Ground Water, Nutrients

Price: \$54.49

Owner: NAWQA

Analyte▲	Lab Code	Parameter Code	M	CAS Number	RL	Unit	RL Type	C A	Container ID
Nitrogen, ammonia as N	3116	00608	00048	7664-41-7	0.010	mg/L	ltmdl	C	54 (FCC)
nitrogen, nitrite	3117	00613	00049	14797-65-0	0.0010	mg/L	mdl	C	54 (FCC)
nitrogen, nitrite + nitrate	3156	00631	RED01		0.04	mg/L	mdl		54 (FCC)
Total nitrogen (NH3+NO2+NO3+Organic), filtered	2754	62854	CL063	17778-88-0	0.05	mg/L	ltmdl		54 (FCC)
phosphorus, phosphate, ortho	3118	00671	00048	14265-44-2	0.004	mg/L	ltmdl	C	54 (FCC)

Groundwater Dating

**Chlorofluorocarbons (CFCs)-
young groundwater
(50 year time scale)**

Tritium/Helium $^3\text{H}/^3\text{He}$ Dating

Tritium (gross date-before or after 1952)

Dissolved Gases

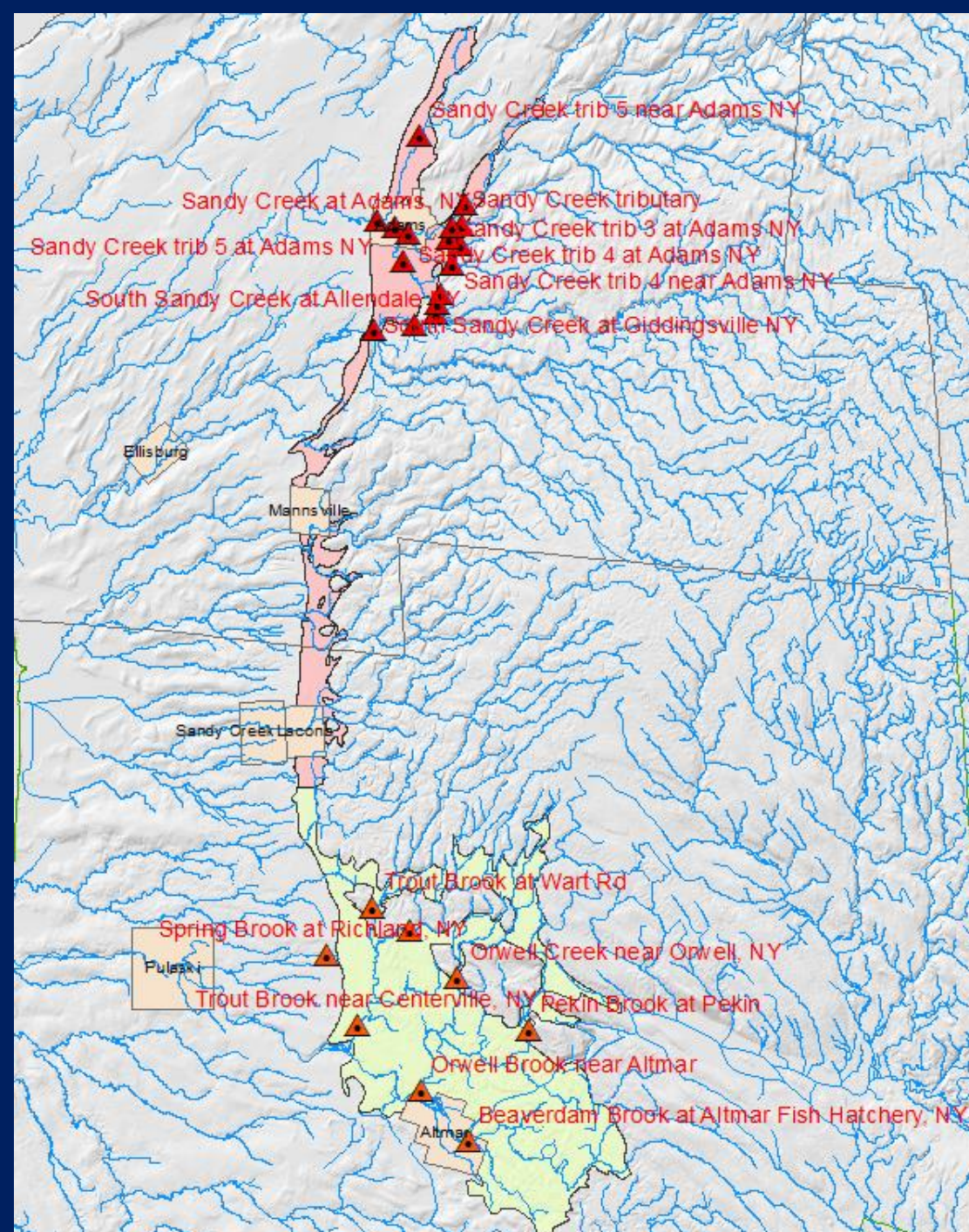
O_2 , CH_4 , CO_2 , H_2S , N_2O , N_2

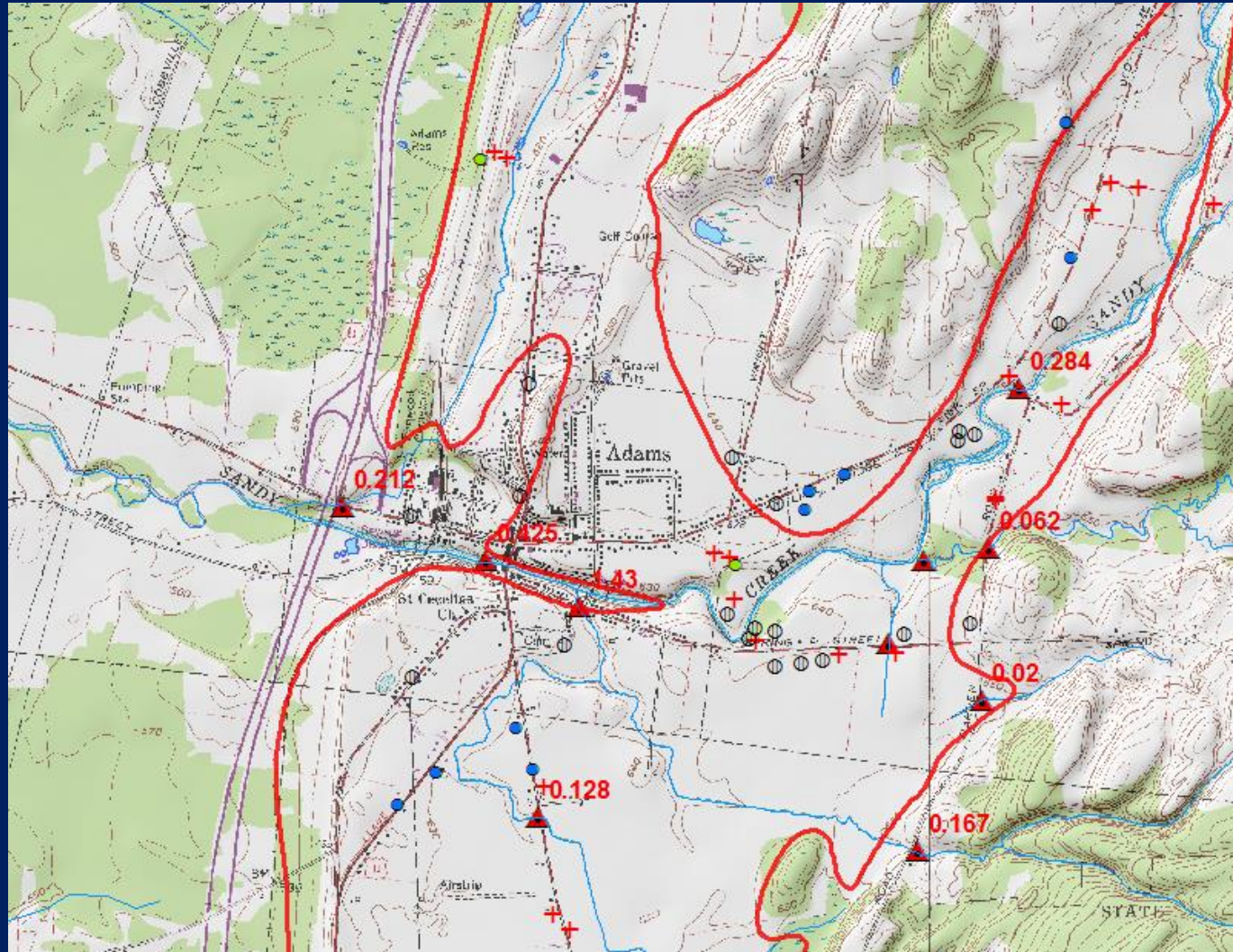
- Used to interpret CFC dates
- Indicators of oxidizing/reducing environments
- Estimate recharge temperature

Stream Water Quality
collected at 24 sites

16 in northern section
8 in central section

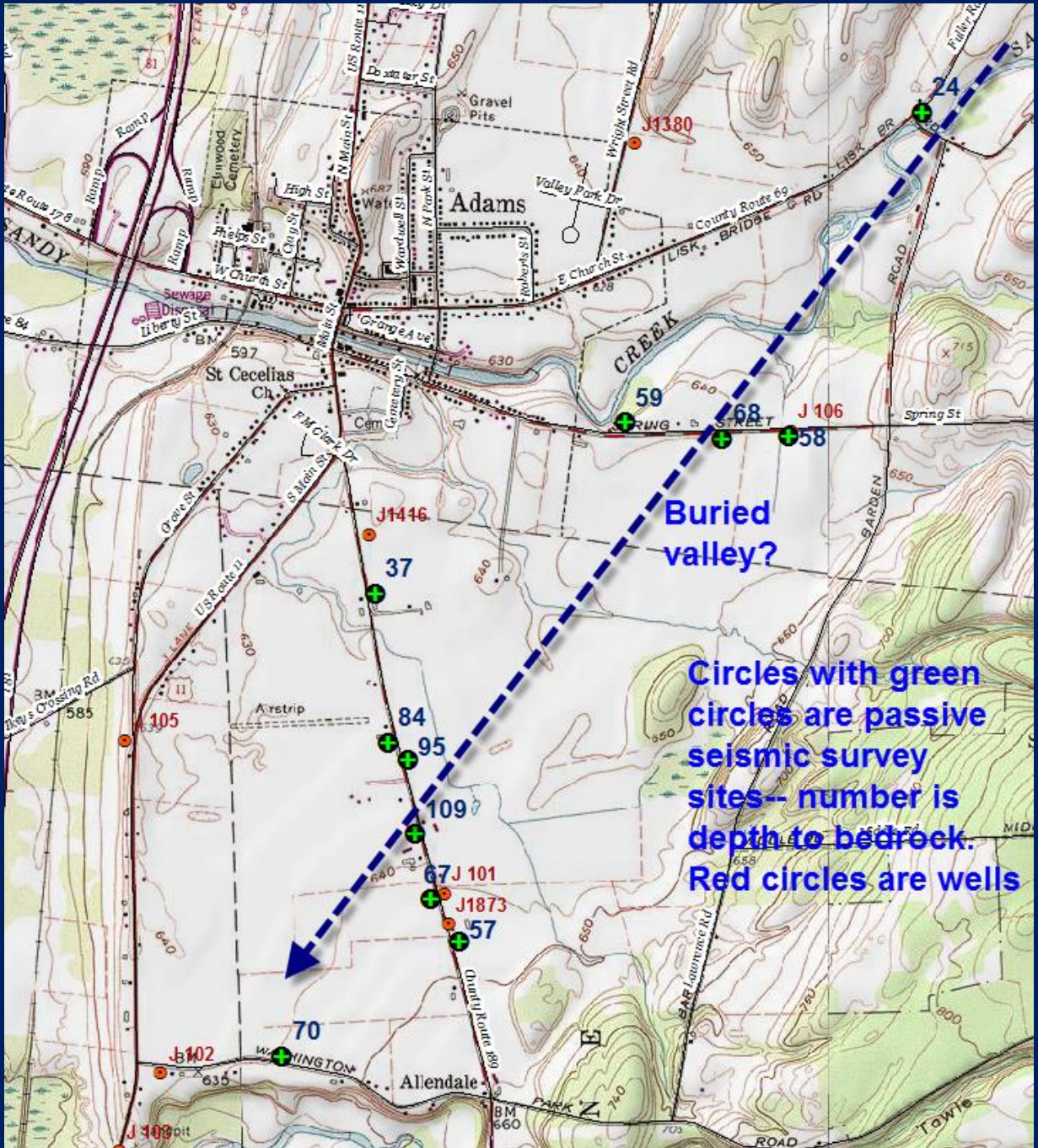
http://waterdata.usgs.gov/ny/nwisunty_cd

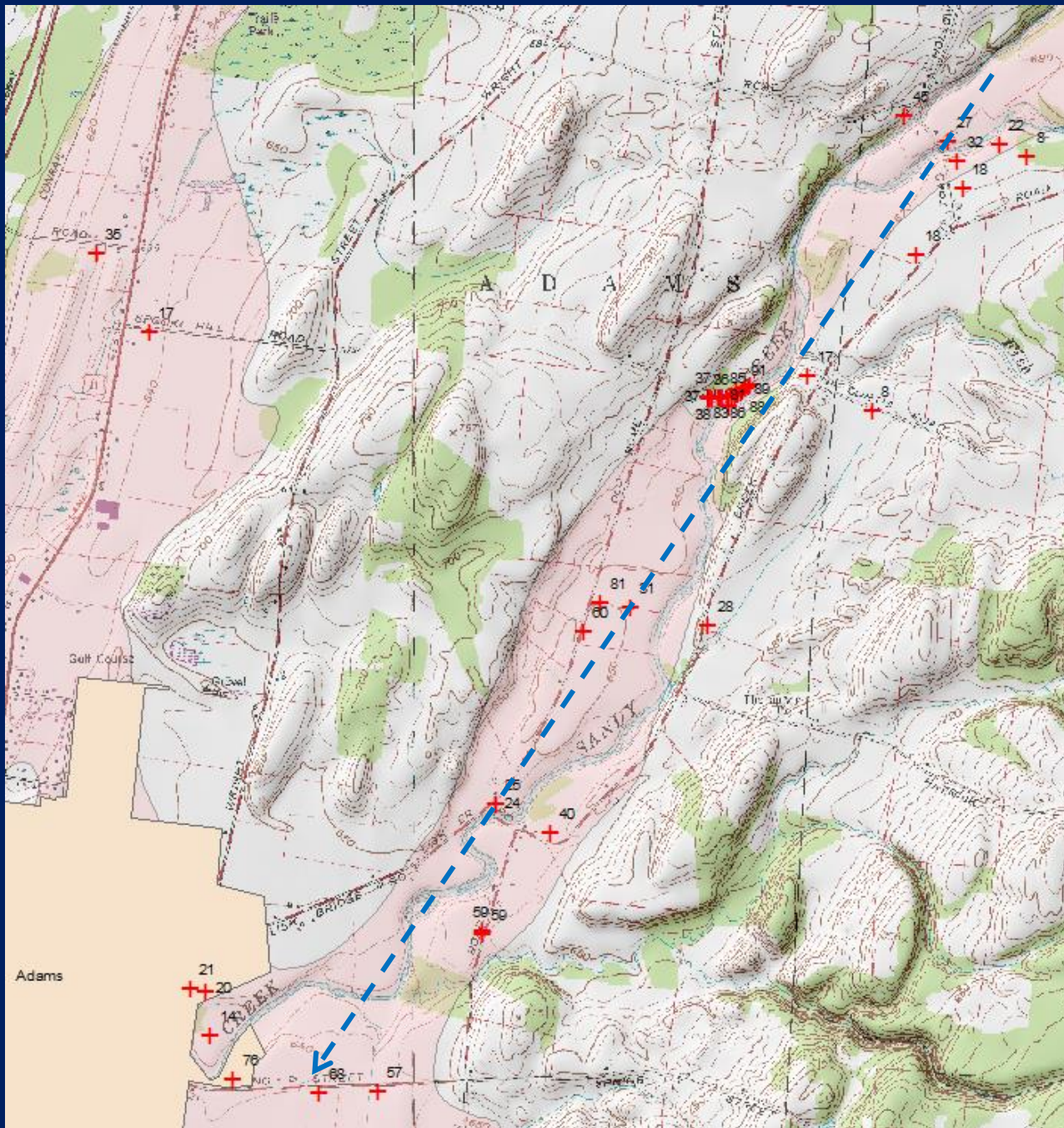




Detailed
work in
the
Adams
area

Results
of
passive
seismic
surveys
indicate
that there
is a
buried
valley



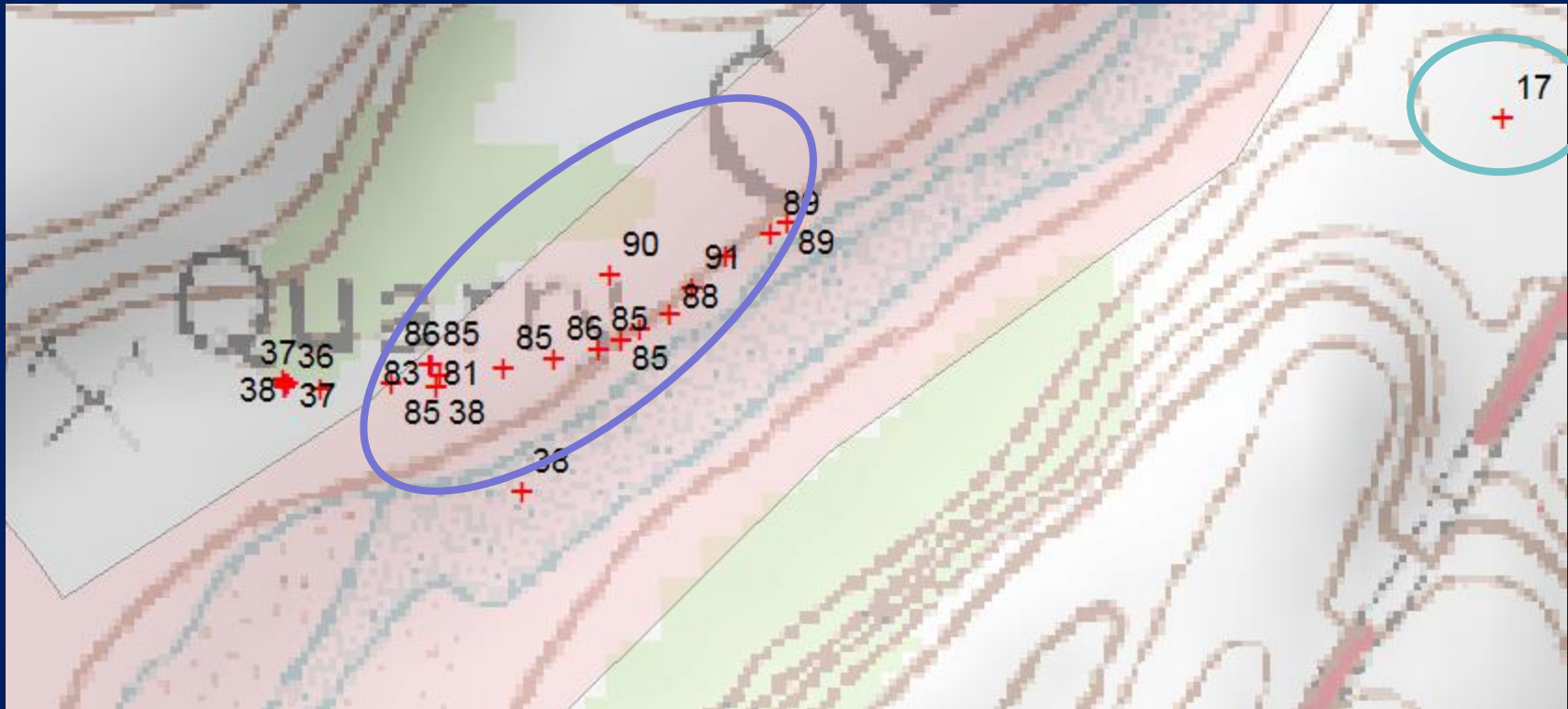


2 goals:

- Determine if bedrock recharges overlying unconsolidated aquifer
- Determine if northern and southern part of valley is hydraulically “connected”

2 goals:

- Determine if bedrock recharges overlying unconsolidated aquifer
- Determine if northern and southern part of valley is hydraulically “connected”

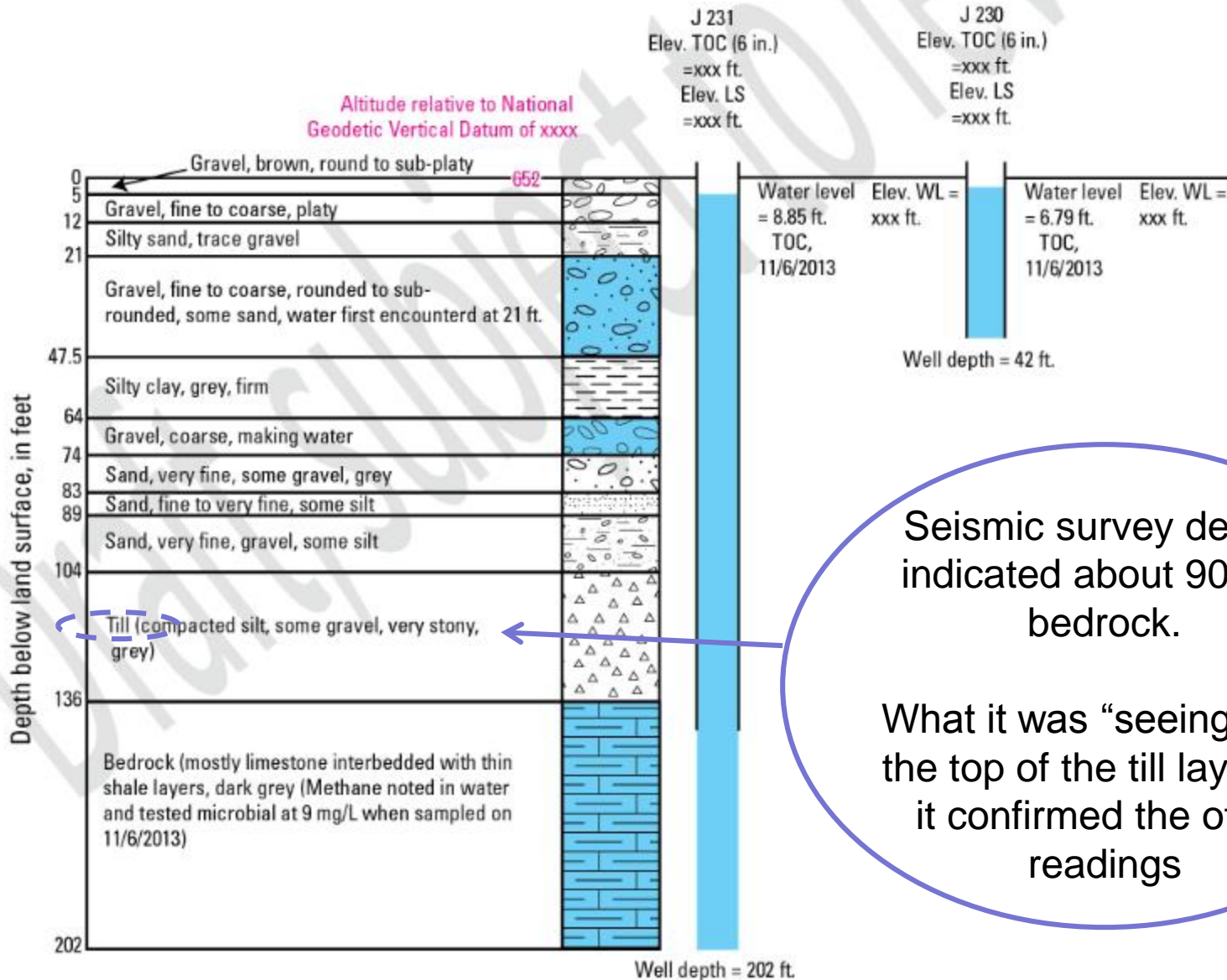




Drilling North of Adams November 2013

- 2 goals:
- Determine if bedrock recharges overlying unconsolidated aquifer
 - Determine if northern and southern part of valley is hydraulically “connected”

Logs of wells drilled North of Adams



Where are we in the program???



We found significant things!!!



Original proposal budget

Data collection and modeling phases

PROJECT: TUG HILL AQUIFER STUDY (NY07K) FY-2008-2013 BUDGET

	FY-2008	FY-2009	FY-2010	FY-2011	FY-2012	FY-2013	Totals	Percent
USGS	\$88,400	\$106,704	\$81,212	\$50,996	\$122,365	\$52,166	\$501,844	30%
COOPERATOR(S)	\$206,267	\$248,977	\$189,494	\$118,991	\$285,519	\$121,721	\$1,170,969	70%
TOTAL	\$294,667	\$355,681	\$270,706	\$169,988	\$407,884	\$173,887	\$1,672,813	100%

Original proposal budget

BUDGET BY PHASE AND FISCAL YEAR						
	FY-2008	FY-2009	FY-2010	FY-2011	FY-2012	FY-2013
PHASE-I	total					
Entire Tug Hill aquifer data collection	\$812,905					
USGS	\$111,606	\$126,937	\$5,328			
COOPERATOR(S)	\$260,414	\$296,187	\$12,432			
TOTAL	\$372,020	\$423,124	\$17,761			
PHASE-II	total					
	\$1,079,060					
	total					
Northern aquifer segment	\$359,687					
USGS			\$25,850	\$26,054	\$56,002	
COOPERATOR(S)			\$60,318	\$60,792	\$130,671	
TOTAL			\$86,168	\$86,845	\$186,673	
	total					
Central aquifer segment	\$359,687					
USGS			\$25,850	\$26,054	\$56,002	
COOPERATOR(S)			\$60,318	\$60,792	\$130,671	
TOTAL			\$86,168	\$86,845	\$186,673	
	total					
Southern aquifer segment	\$359,687					
USGS				\$12,363	\$40,207	\$46,114
COOPERATOR(S)				\$28,846	\$93,815	\$138,342
TOTAL				\$41,209	\$134,022	\$184,456
PROGRAM TOTAL	\$1,891,965					

Current expended budget

Data collection phase

	FY-2008	FY-2009		FY-2010	FY-2011	FY-2012	FY-2013	FY-2014					
USGS THC total	\$47,117 \$72,667 \$119,784												establish Trout brook gage; compile basemaps; well inventory; stream gain-loss at selected streams; four seasonal water-quality samples on selected streams;
USGS JC_SWCD total		\$9,000 \$9,000 \$18,000											measure discharge and sample 7 strams as they cross the northern aquife segment in Jefferson Co.; continue other well-data collection
USGS OC-SWCD total		\$4,671 \$10,000 \$14,671	\$10,000 \$10,000 \$20,000										continue gage @ Trout Brook for FY-10 and FY-11; continue basic data collection at selected wells and update well database
USGS THLT total			\$18,500 \$18,500 \$37,000										conduct H/V seismic sureveys; continue basic well dta collection
USGS JC_SWCD total						\$20,000 \$20,000 \$40,000							continue hydrogeologic mapping and well data collection in Jefferson Co. and near Adams; additional H/V seismic surveys; install water-level monitors in selected wells
USGS NYS DEC total							\$95,768 \$116,518 \$212,286						finalize data collection efforts in northern and central sections of the aquifer
YEARLY TOTALS	\$119,784	\$32,671	\$57,000	\$0		\$40,000	\$212,286		\$461,741	TOTAL to End FY-2014			
total USGS	\$47,117	\$13,671	\$28,500			\$20,000	\$95,768		\$205,056	84%	←		
all cooperators	\$72,667	\$19,000	\$28,500			\$20,000	\$116,518		\$256,685	45%	←		
TOTALS	\$119,784	\$32,671	\$57,000	\$0		\$40,000	\$212,286		\$461,741	57%	percentage of original budget		\$813,000

Current expended budget

Data collection phase

	FY-2008	FY-2009		FY-2010	FY-2011	FY-2012	FY-2013	FY-2014						
USGS THC	\$47,117 \$72,667													establish Trout brook gage; compile basemaps; well inventory; stream gain-loss at selected streams; four seasonal water-quality samples on selected streams;
total	\$119,784													
USGS JC_SWCD		\$9,000 \$9,000												measure discharge and sample 7 strams as they cross the northern aquife segment in Jefferson Co.; continue other well-data collection
total		\$18,000												
USGS OC-SWCD		\$4,671 \$10,000	\$10,000 \$10,000											continue gage @ Trout Brook for FY-10 and FY-11; continue basic data collection at selected wells and update well database
total		\$14,671	\$20,000											
USGS THLT			\$18,500 \$18,500											conduct HV seismic sureveys; continue basic well dta collection
total			\$37,000											
USGS JC_SWCD						\$20,000 \$20,000								continue hydrogeologic mapping and well data collection in Jefferson Co. and near Adams; additional HV seismic surveys; install water-level monitors in selected wells
total						\$40,000								
USGS NYS DEC							\$95,768 \$116,518							finalize data collection efforts in northern and central sections of the aquifer
total							\$212,286							
YEARLY TOTALS	\$119,784	\$32,671	\$57,000	\$0	\$0	\$40,000	\$212,286							\$461,741 TOTAL to End FY-2014
total USGS	\$47,117	\$13,671	\$28,500			\$20,000	\$95,768							\$205,056 44% ←
all cooperators	\$72,667	\$19,000	\$28,500			\$20,000	\$116,518							\$256,685 56% ← Original Budget
TOTALS	\$119,784	\$32,671	\$57,000	\$0	\$0	\$40,000	\$212,286							\$461,741 57% percentage of original budget \$813,000

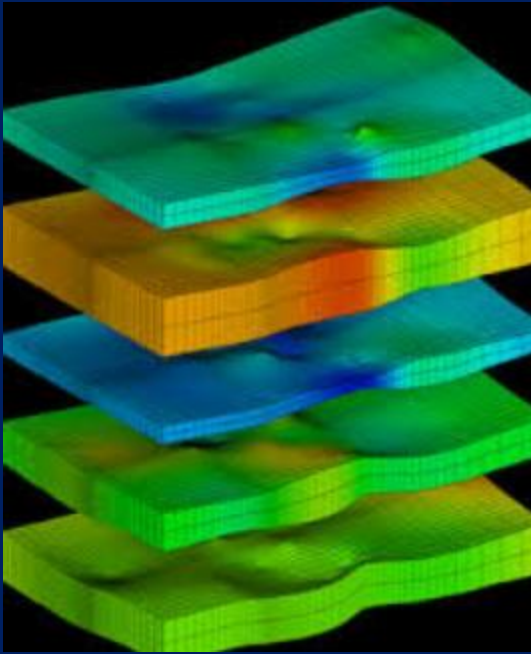
I MAY NOT BE THERE YET,
BUT I'M CLOSER
THAN I WAS YESTERDAY



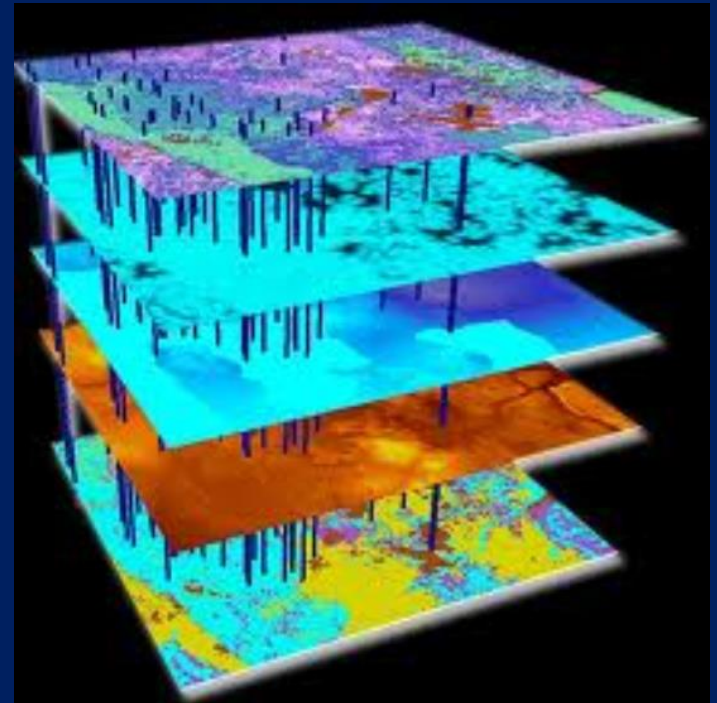
WHAT WASN'T ACCOMPLISHED

- **DRILLING** in areas lacking well or seismic data.
- **ADDITIONAL WATER QUALITY** especially in sensitive areas.
- **STREAMFLOW DATA IN ADDITIONAL 3-4 STREAMS** for model calibration.

WHAT'S NEXT???



- PREDICTIVE
GROUNDWATER
MODEL



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