Use of Geophysics and Computer Modeling to Evaluate Structurally Controlled Plume Migration

2006 EPA Region III Technical Conference

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Christiansburg, Virginia
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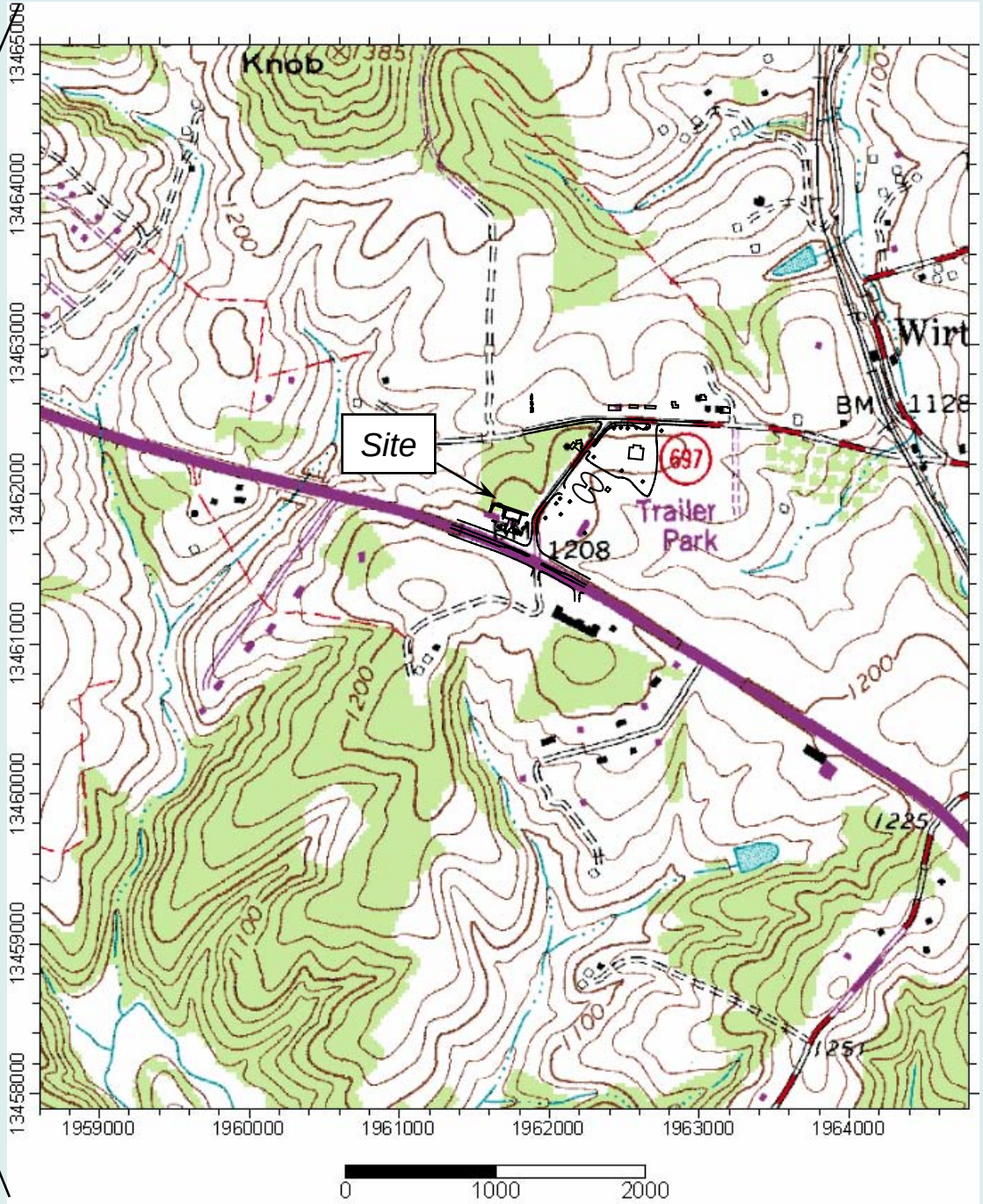
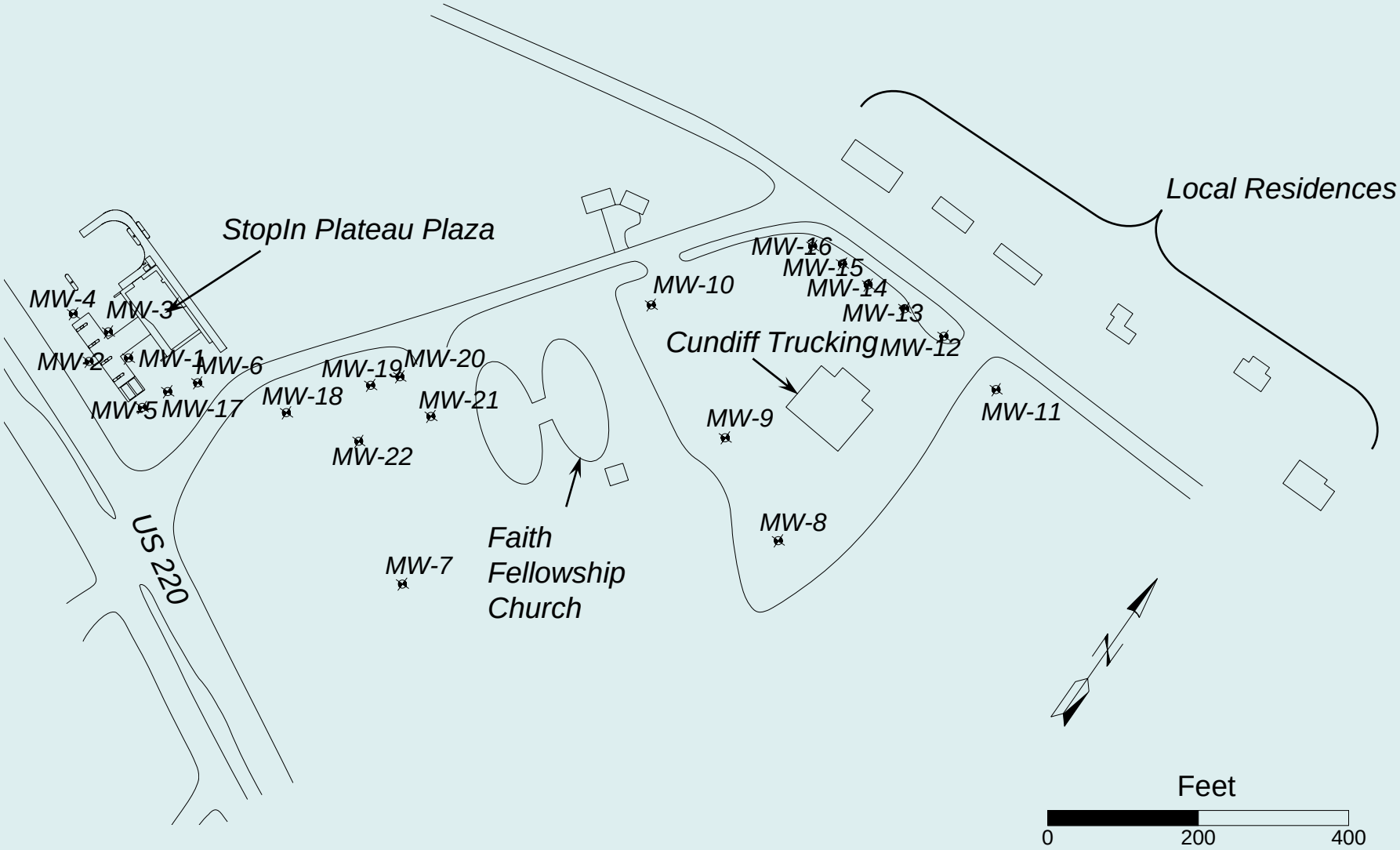
Site Location

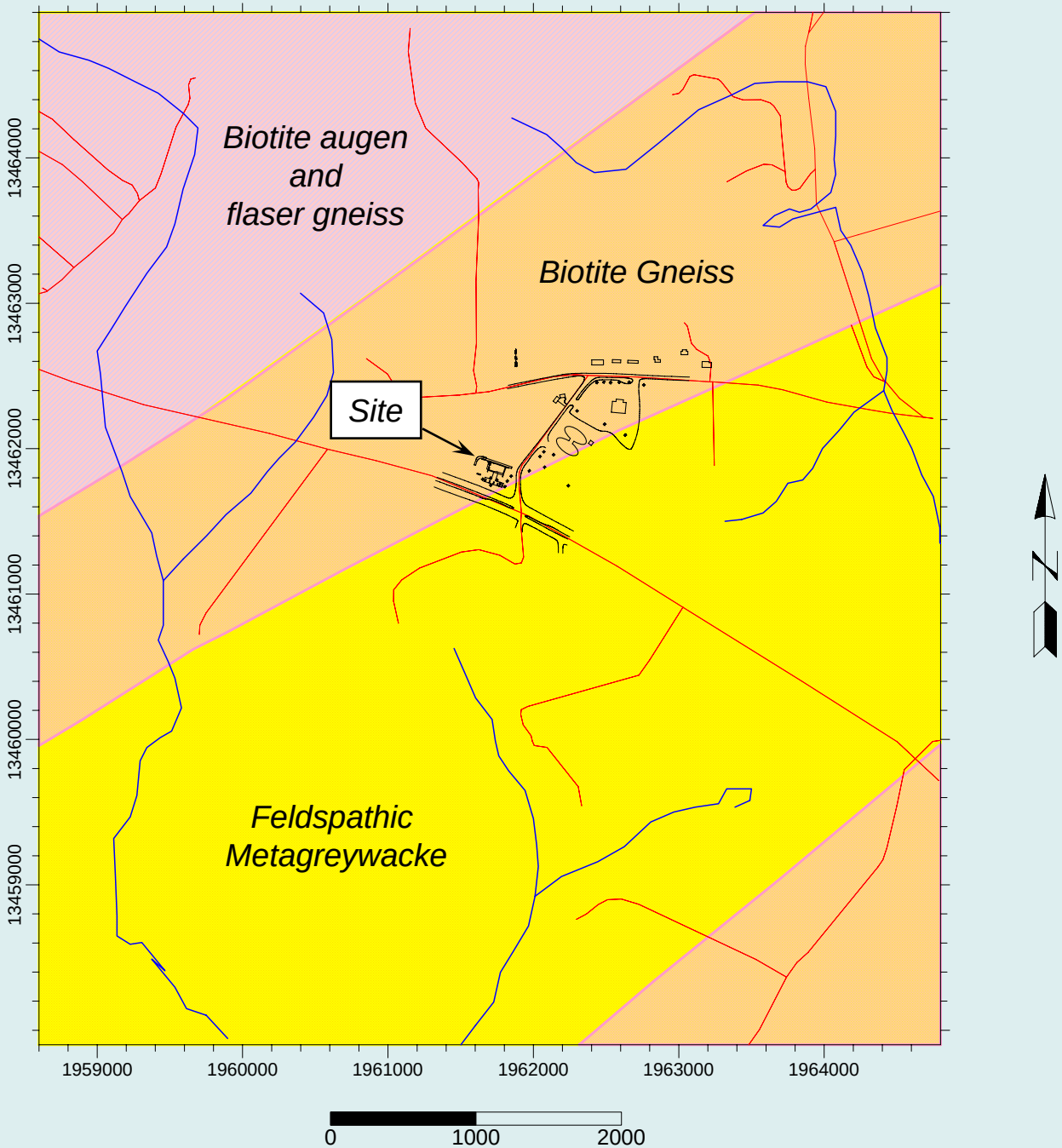


Site Detail

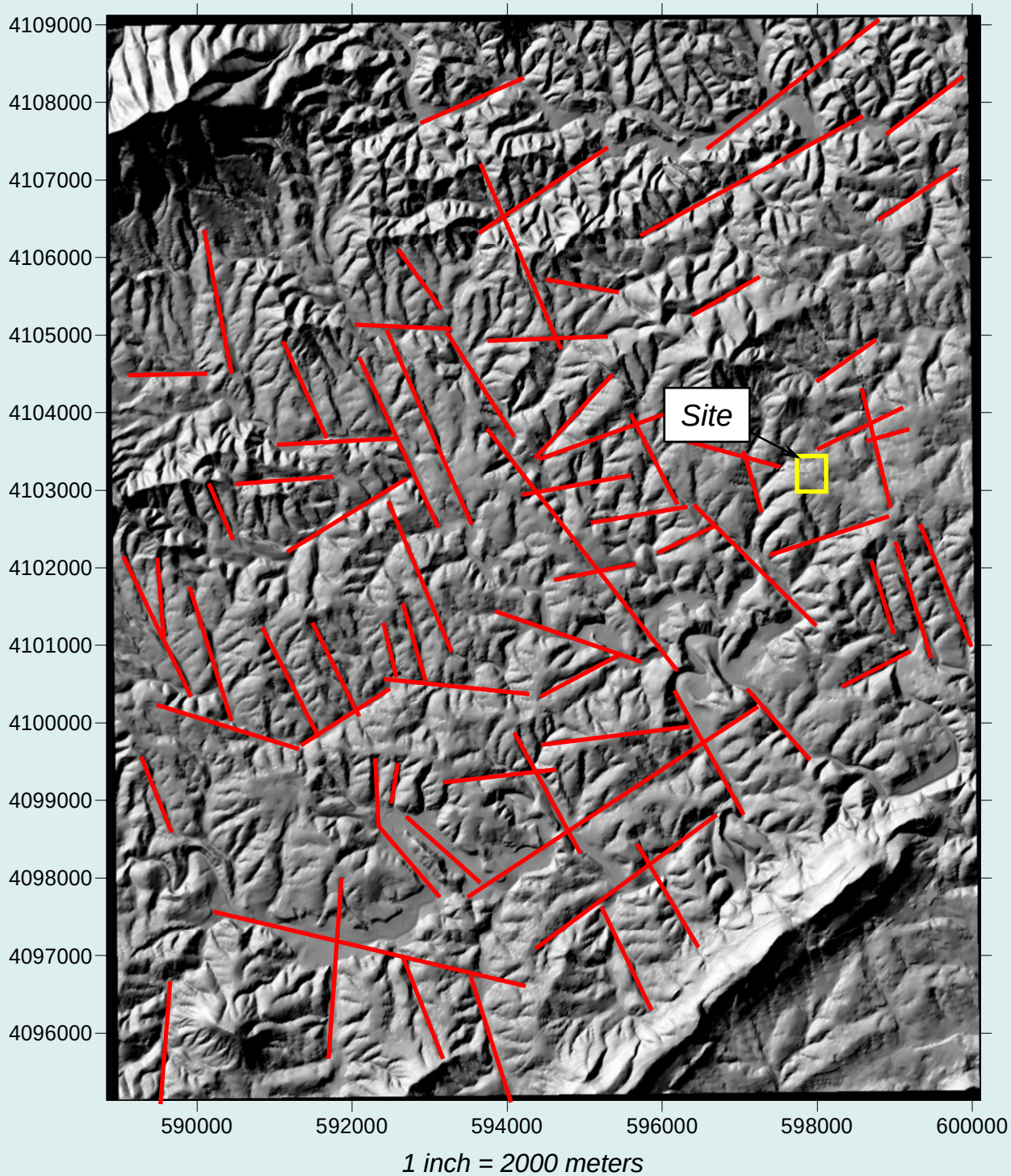

Local Residences
StopIn Plateau Plaza
MW-16
MW-15
MW-14
MW-13
MW-12
MW-10
MW-4
MW-3
MW-2
MW-1
MW-6
MW-19
MW-20
MW-18
MW-21
MW-5
MW-17
Cundiff Trucking
MW-9
MW-11
MW-22
MW-8
MW-7
Faith
Fellowship
Church
US 220
N
Feet
0
200
400

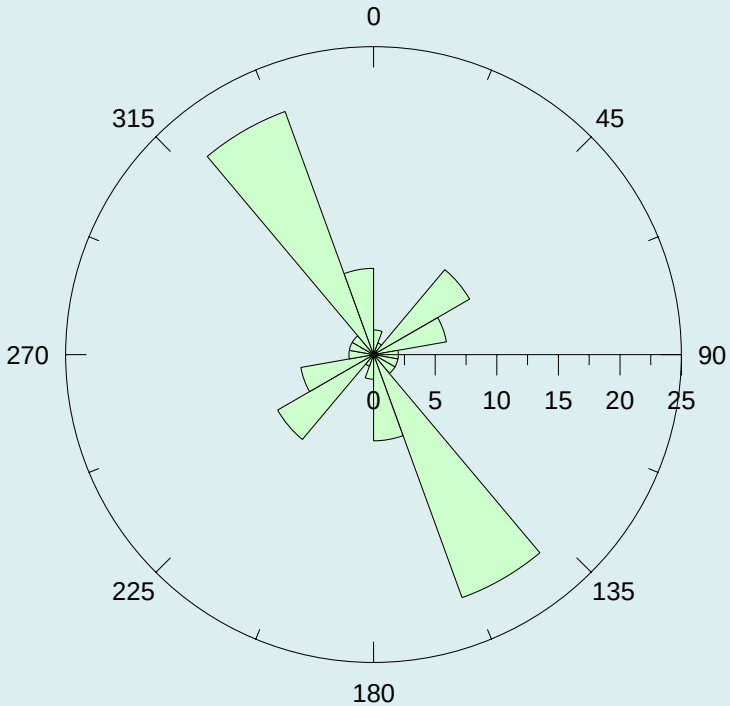
Portion of the Geologic Map of the Boones Mill 7.5 Minute Quadrangle

(After Henika, 2004)

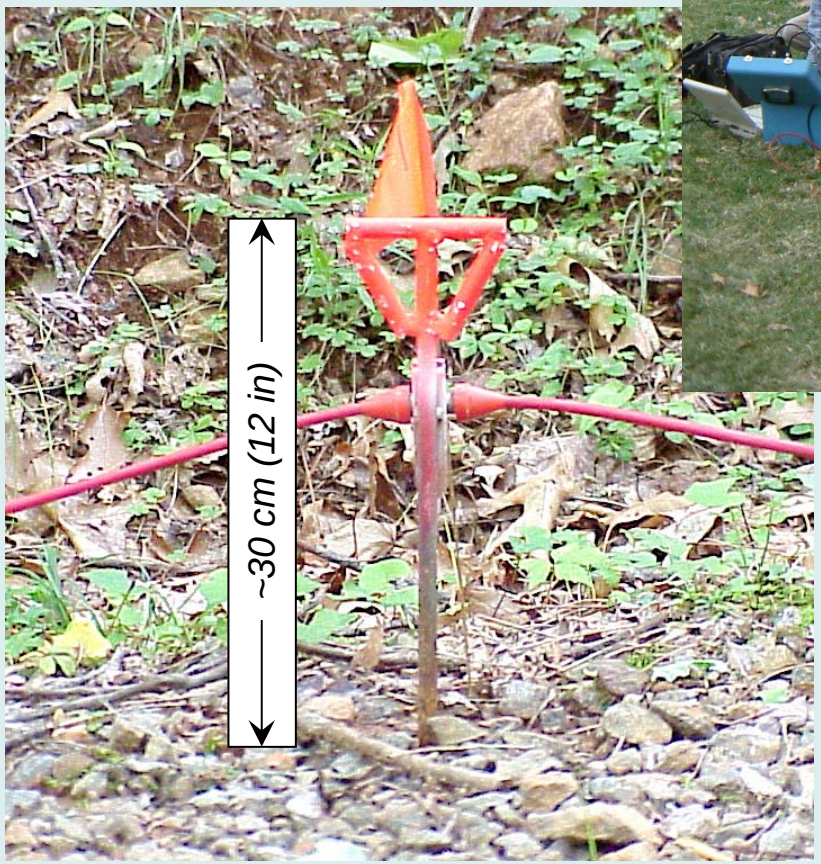


Regional Fracture Trace Patterns

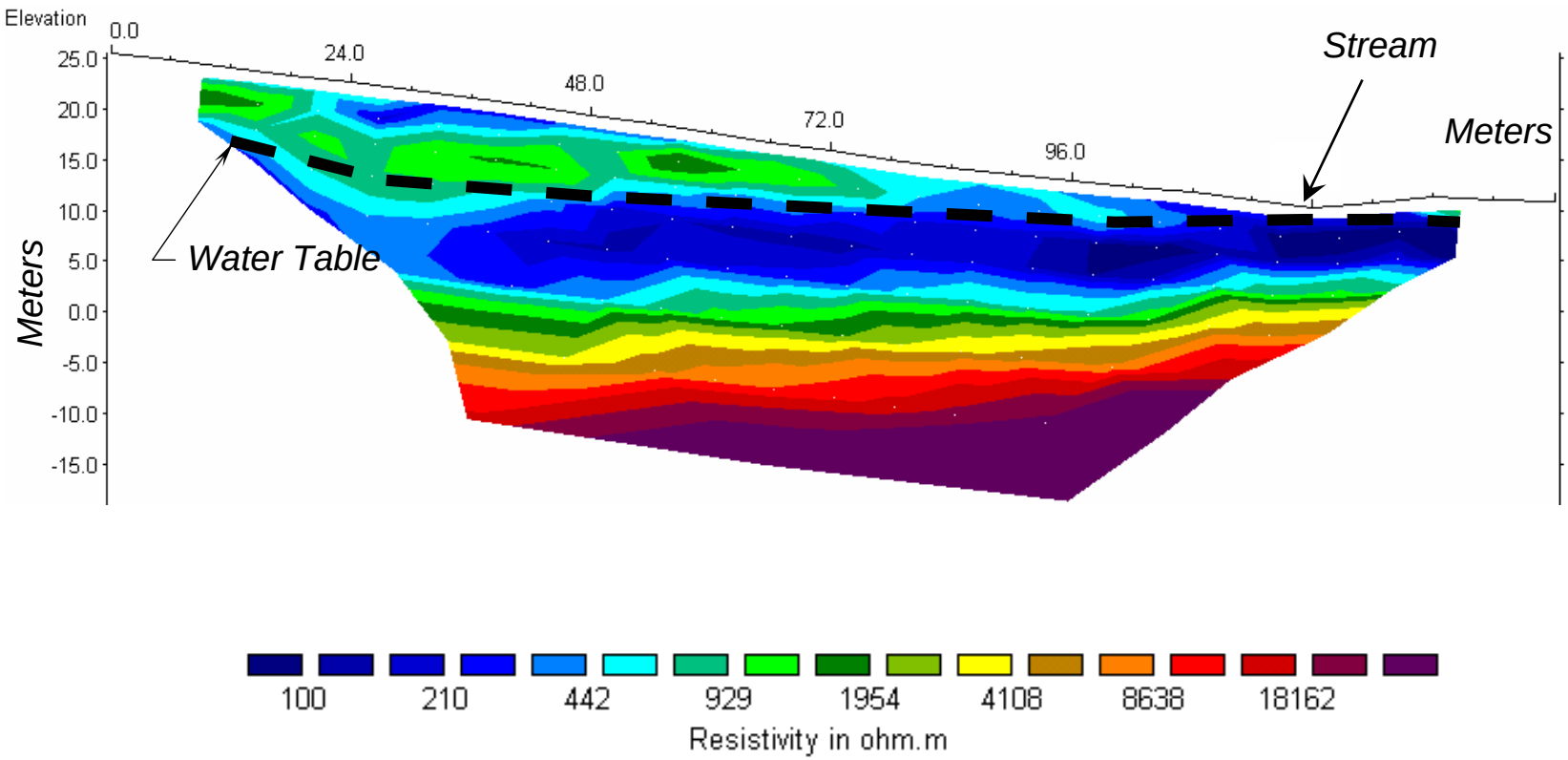




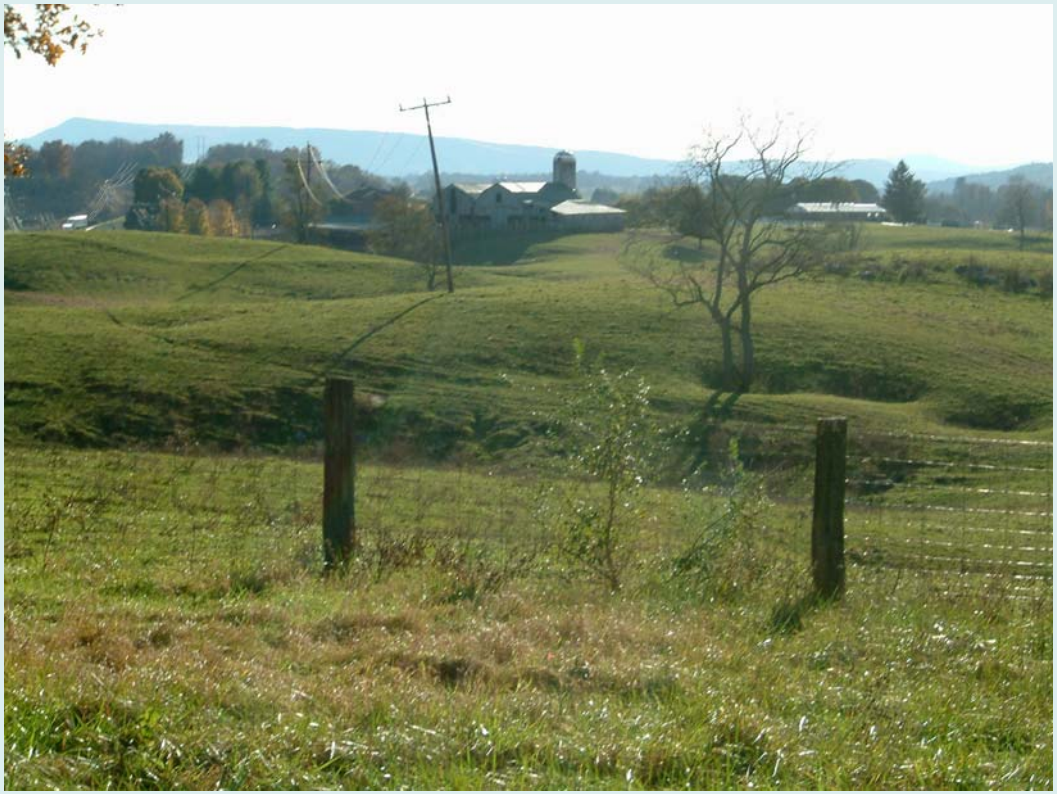
Resistivity Imaging

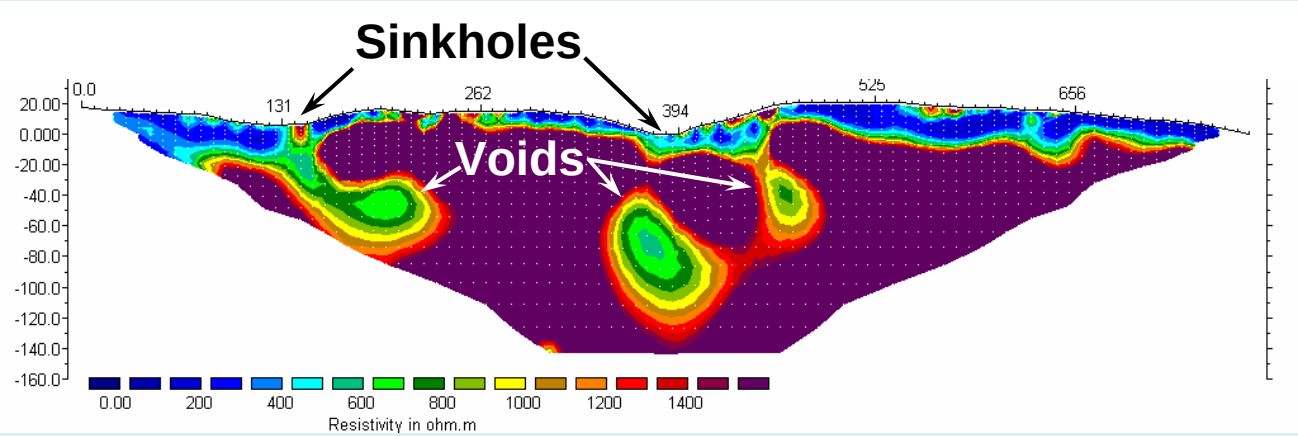


Examples:
Water Table



Karst Features

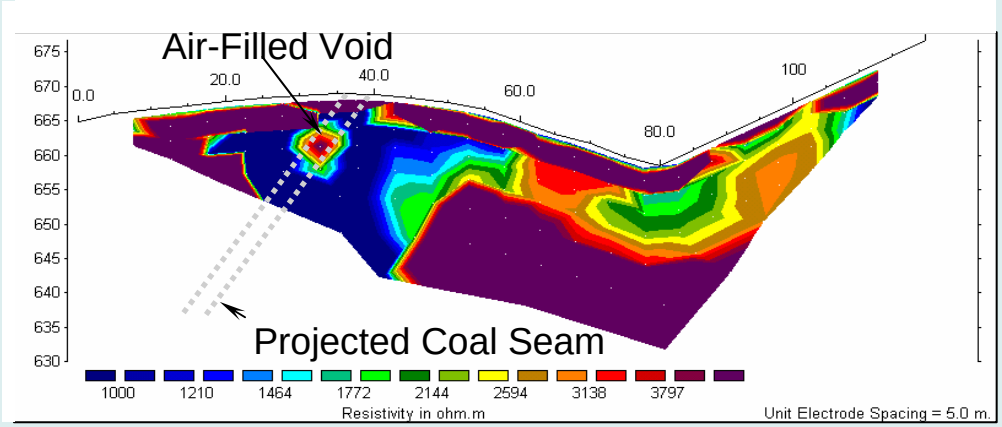




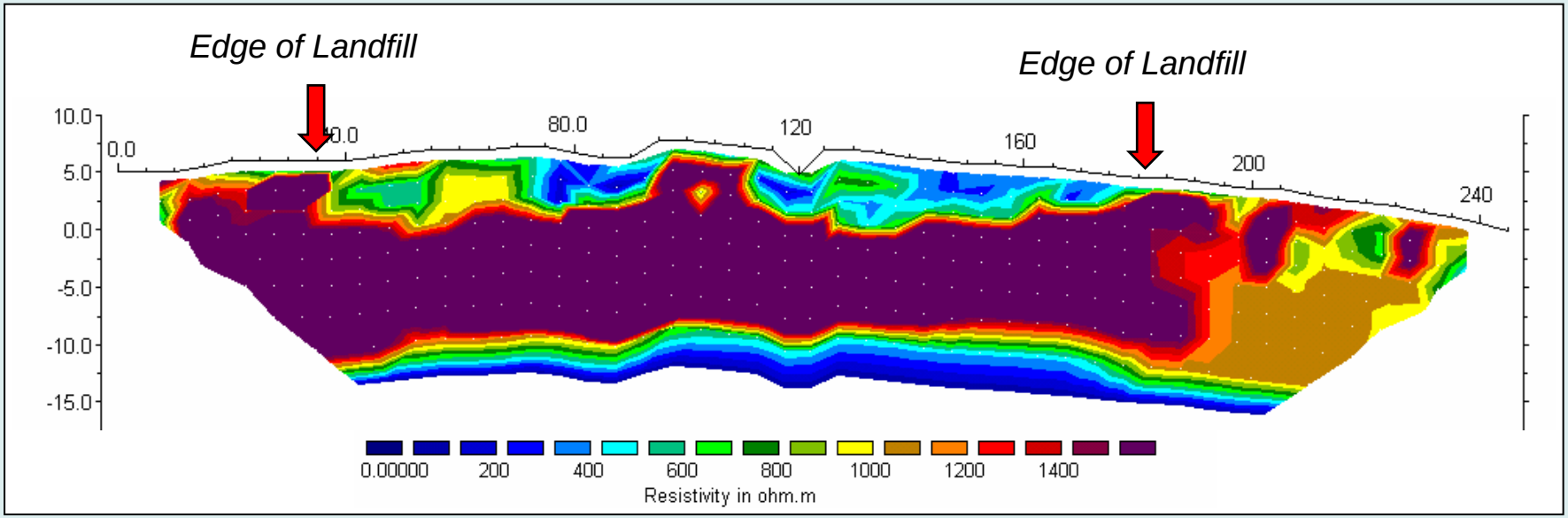
Mining

Mine opening
Air shaft

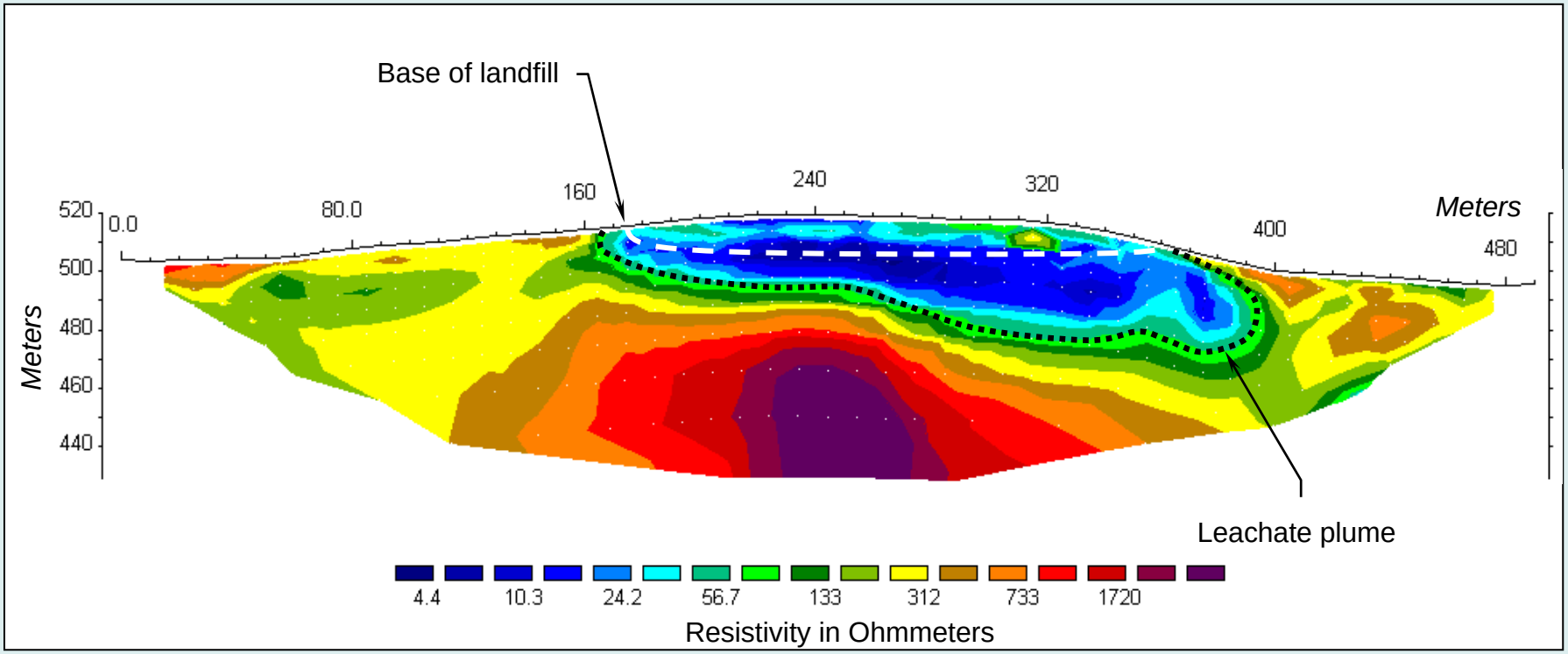
EL -89.3
R-BNG 257


Air-Filled Void
Projected Coal Seam
675
670
665
660
655
650
645
640
635
630
0.0
20.0
40.0
60.0
80.0
100
1000
1210
1464
1772
2144
2594
3138
3797
Resistivity in ohm.m
Unit Electrode Spacing = 5.0 m.

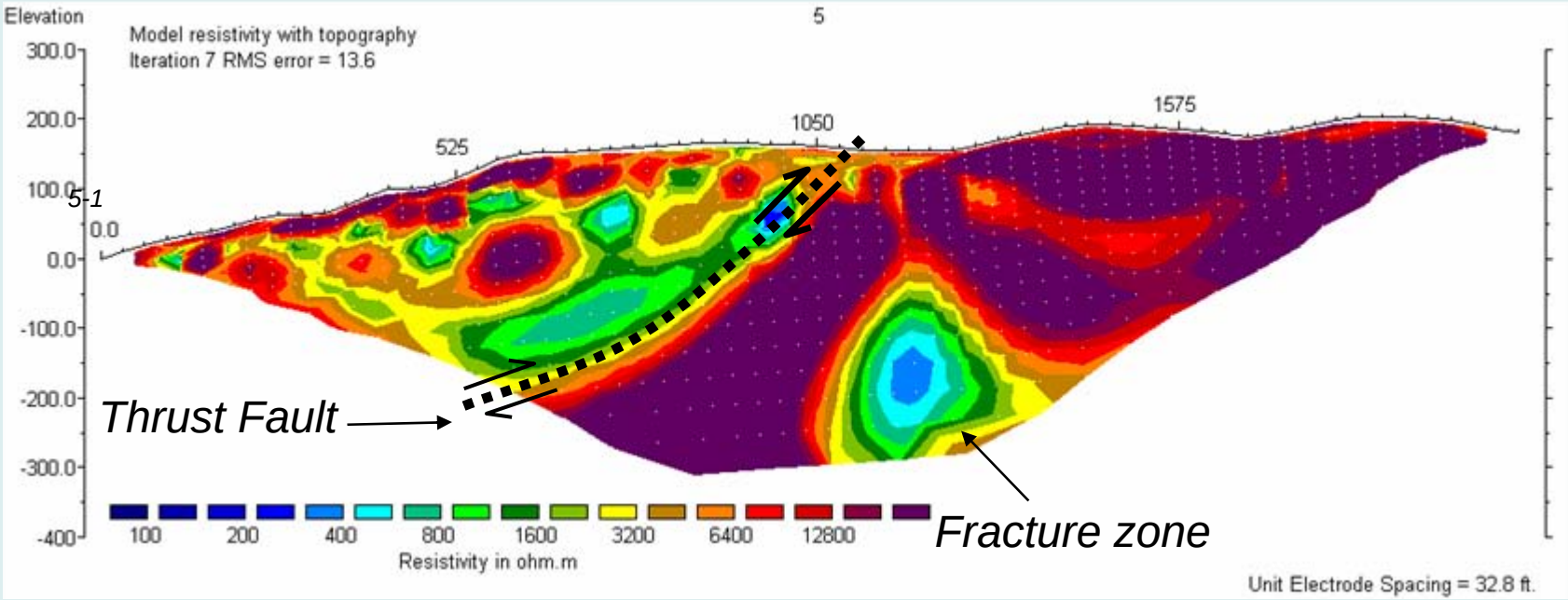
Landfill Extents



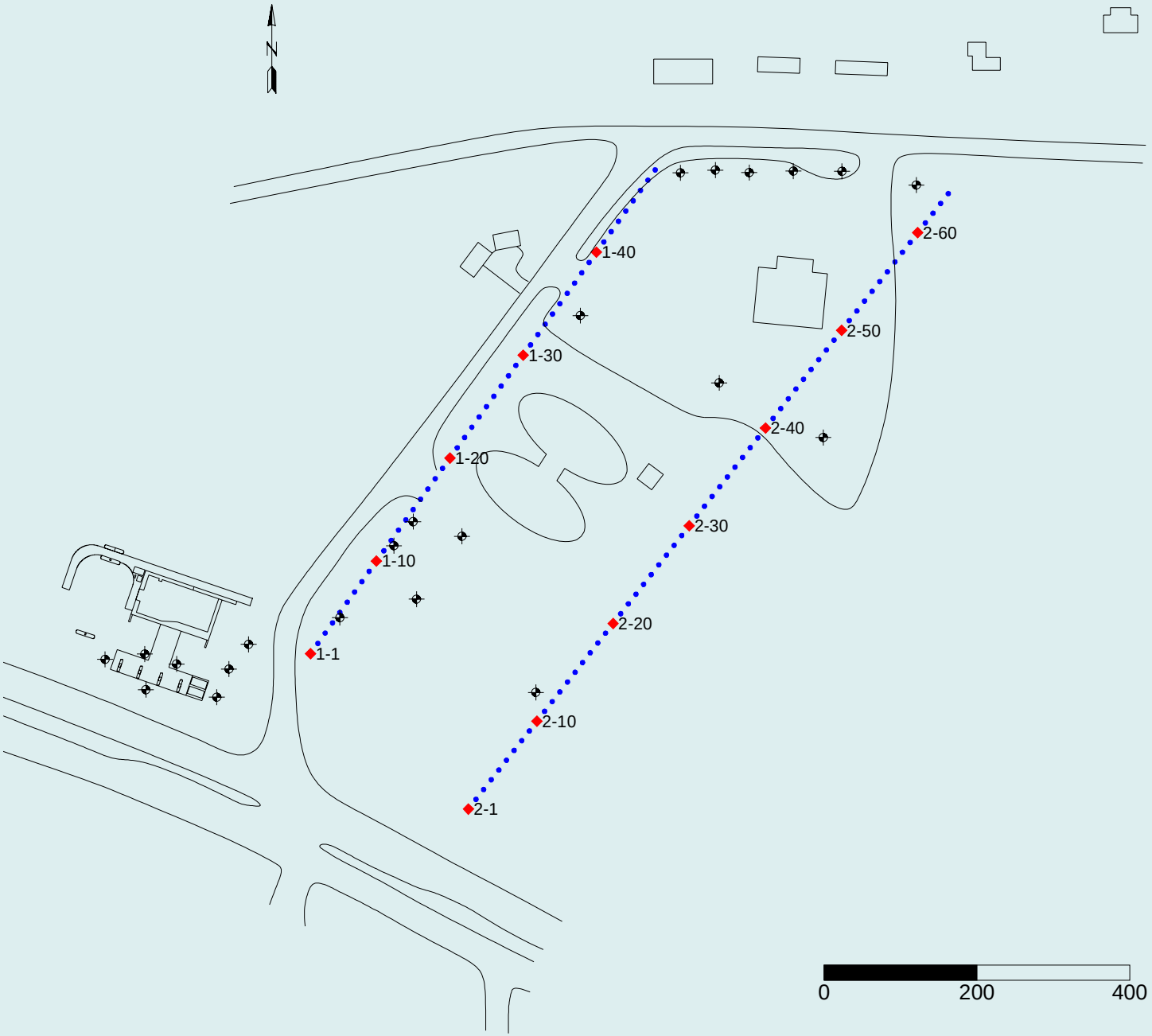
Contaminant Plumes



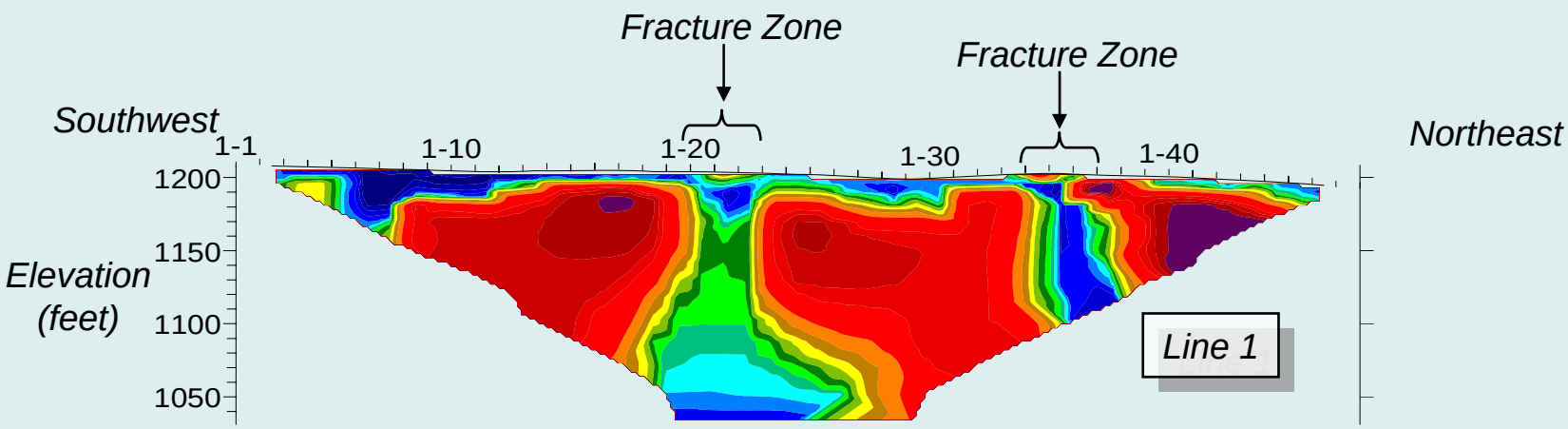
Faults and Fracture Zones

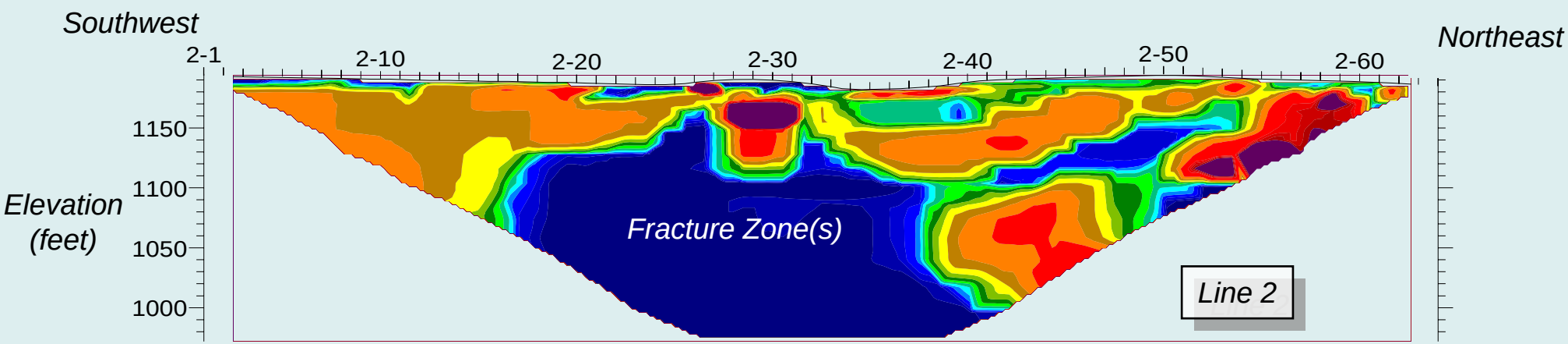


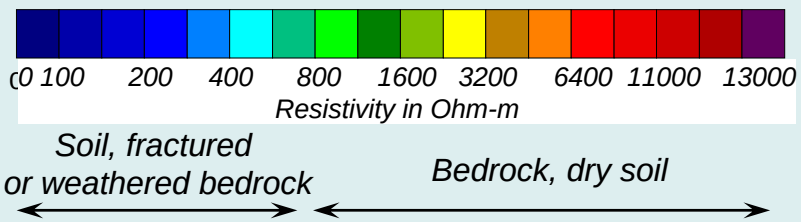
Two Resistivity Lines at Plateau Plaza



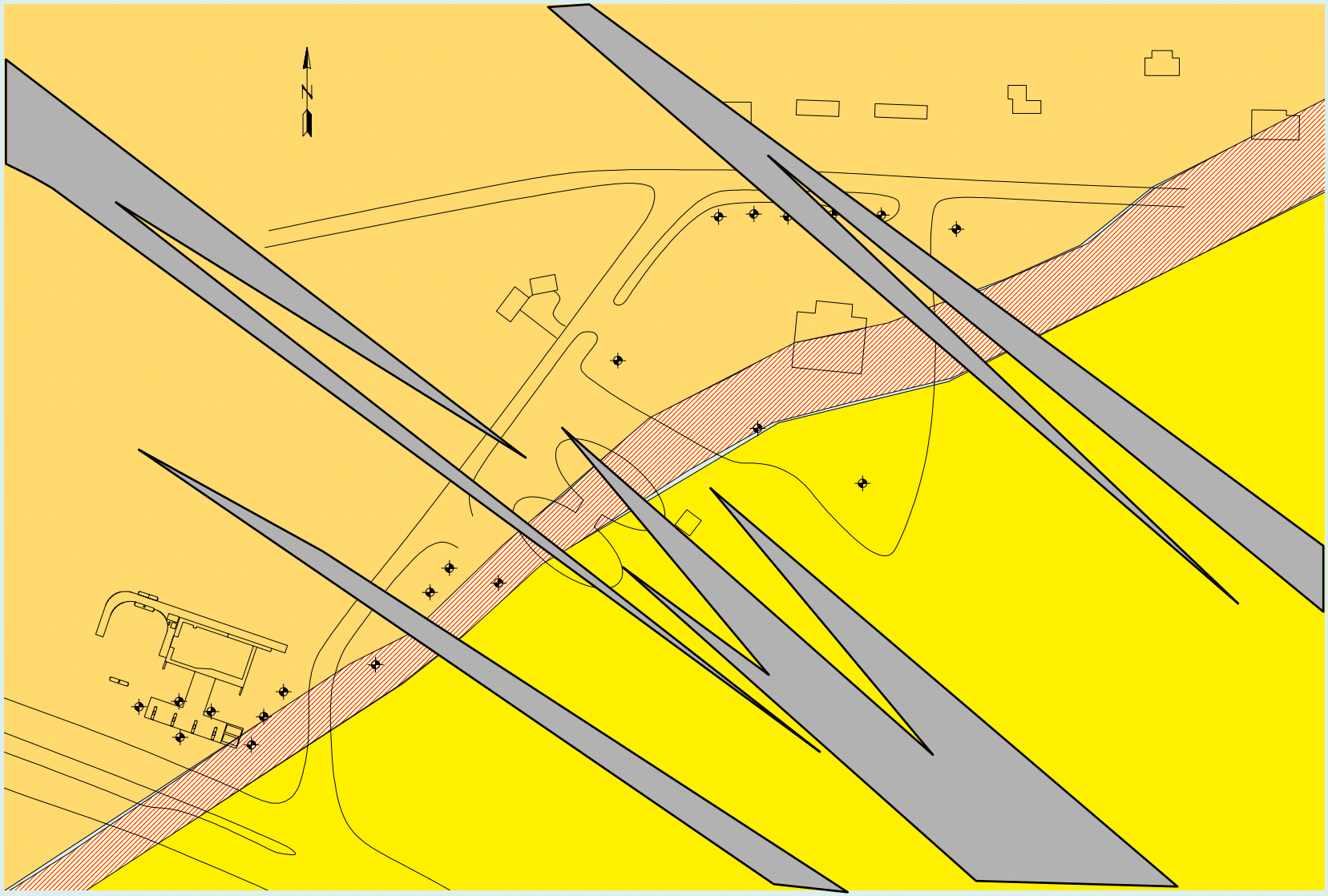
Results


Fracture Zone
Fracture Zone
Southwest
Northeast
1-1
1-10
1-20
1-30
1-40
1200
1150
1100
1050
Elevation (feet)
Line 1


Southwest
Northeast
2-1
2-10
2-20
2-30
2-40
2-50
2-60
1150
1100
1050
1000
Elevation (feet)
Fracture Zone(s)
Line 2


0 100 200 400 800 1600 3200 6400 11000 13000
Resistivity in Ohm-m
Soil, fractured or weathered bedrock
Bedrock, dry soil

Conceptual Model



Biotite Gneiss

Feldspathic Metagreywacke

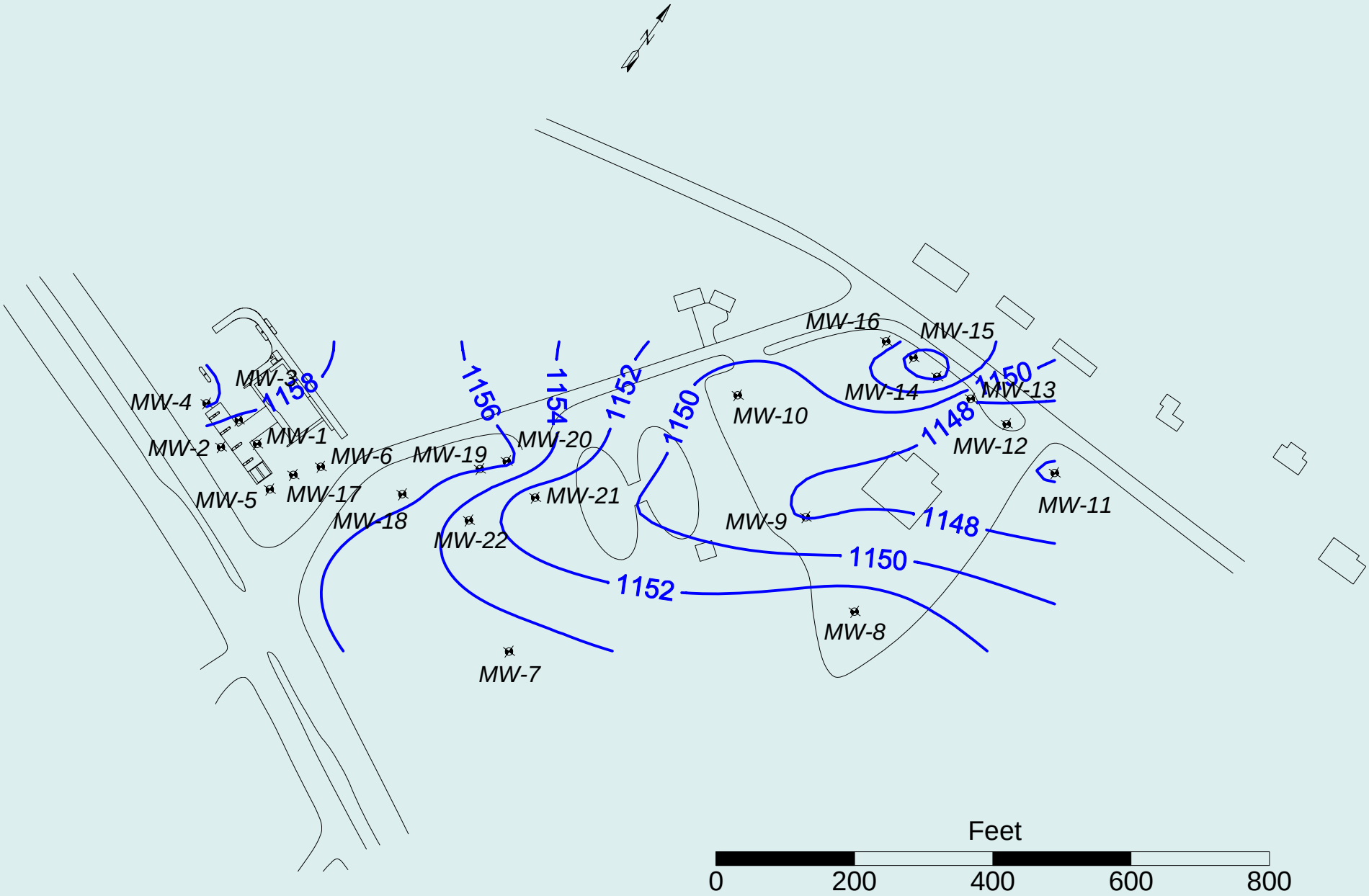
Fracture

Fault Zone / Formation Contact

Feet

0 200 400

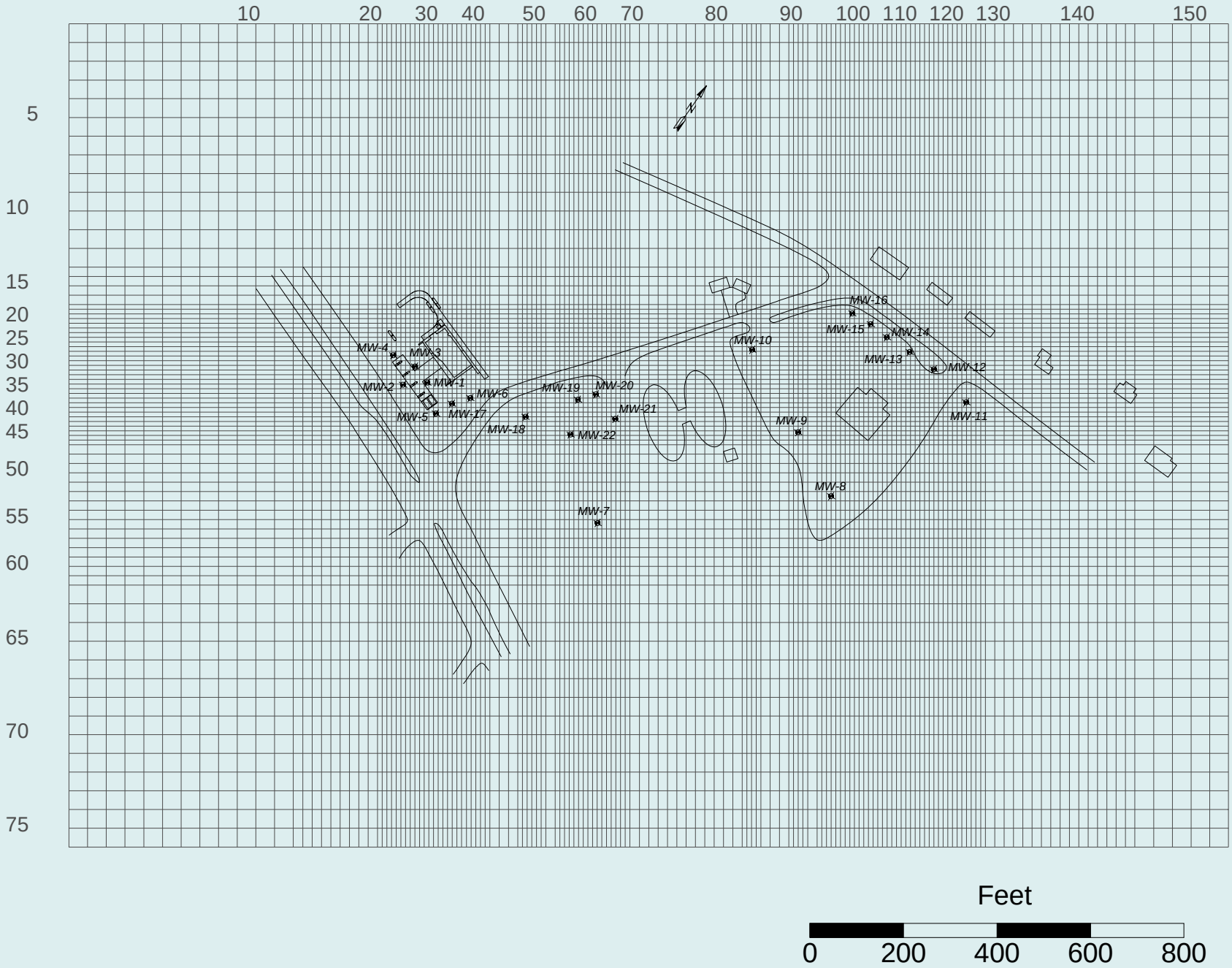
Contours of Average Water Levels



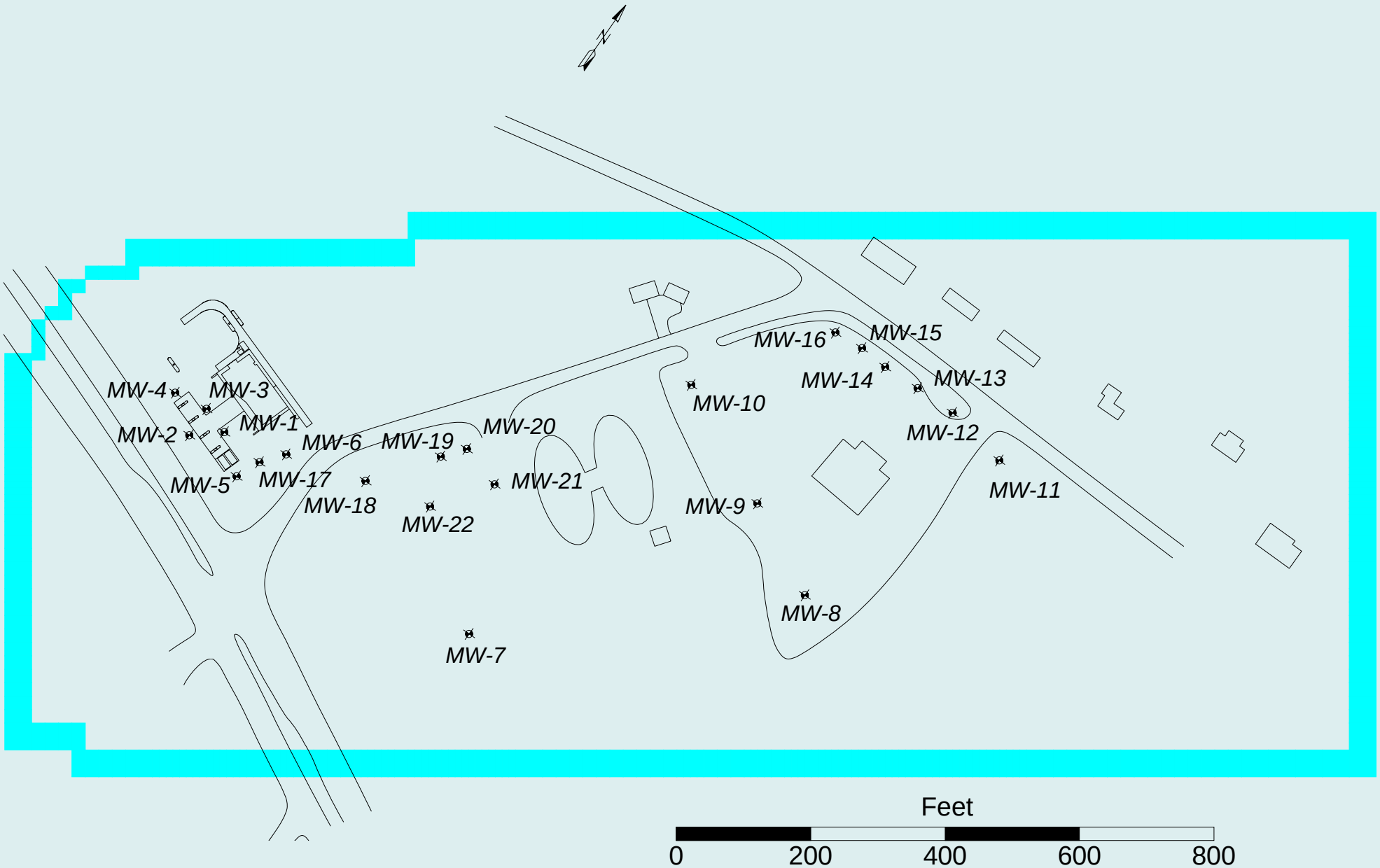
Flow model Calibration Criteria

- *Absolute Residual Mean < 10% of Head Range: 1.47 ft*
- *Max and Min Residual < 10% of Head Range: ±1.47 ft*
- *Modeled Groundwater Flow Direction and Gradient Consistent With Observed*

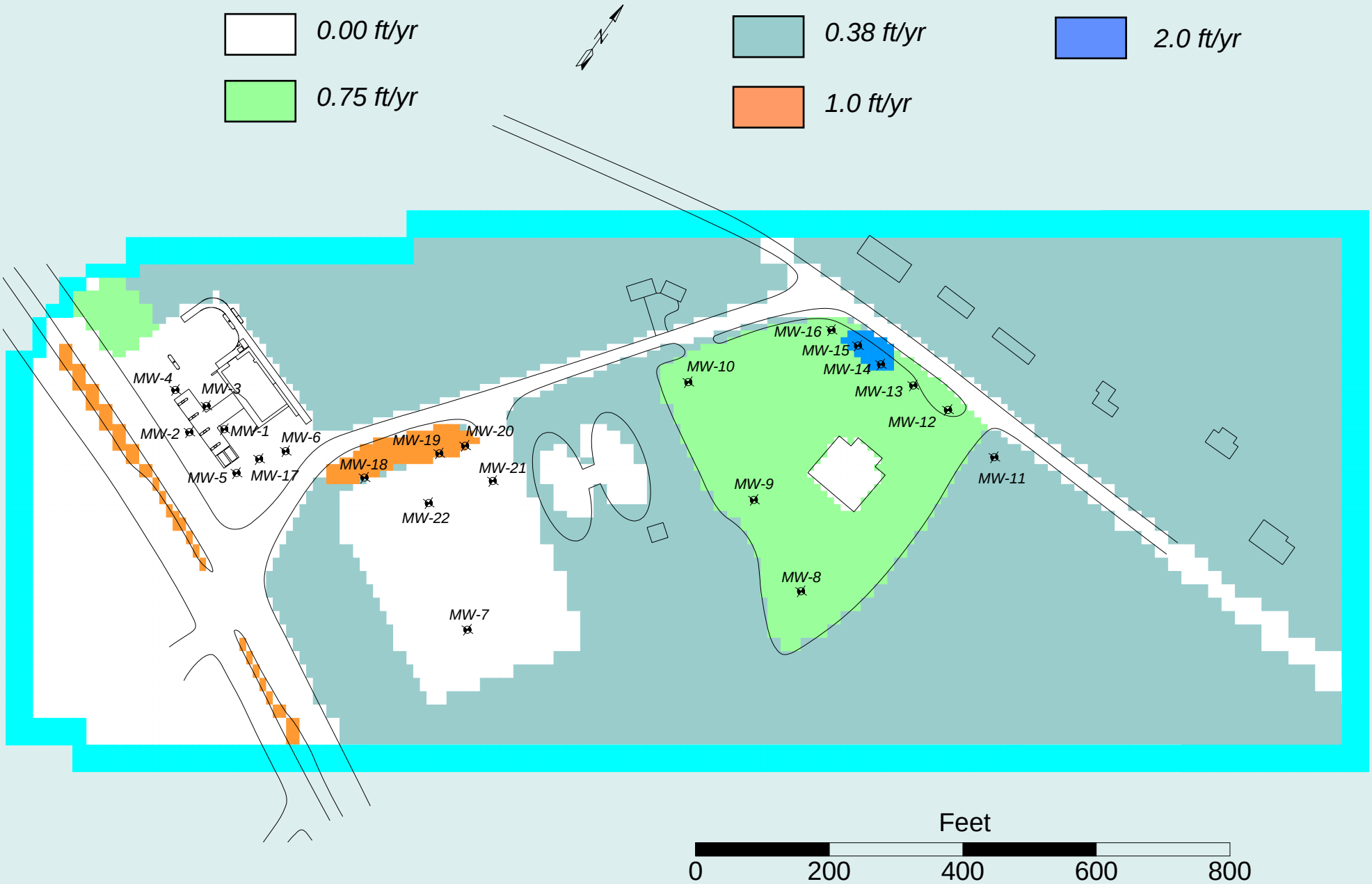
Model Grid


10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
N
MW-1
MW-2
MW-3
MW-4
MW-5
MW-6
MW-7
MW-8
MW-9
MW-10
MW-11
MW-12
MW-13
MW-14
MW-15
MW-16
MW-17
MW-18
MW-19
MW-20
MW-21
MW-22
Feet
0
200
400
600
800

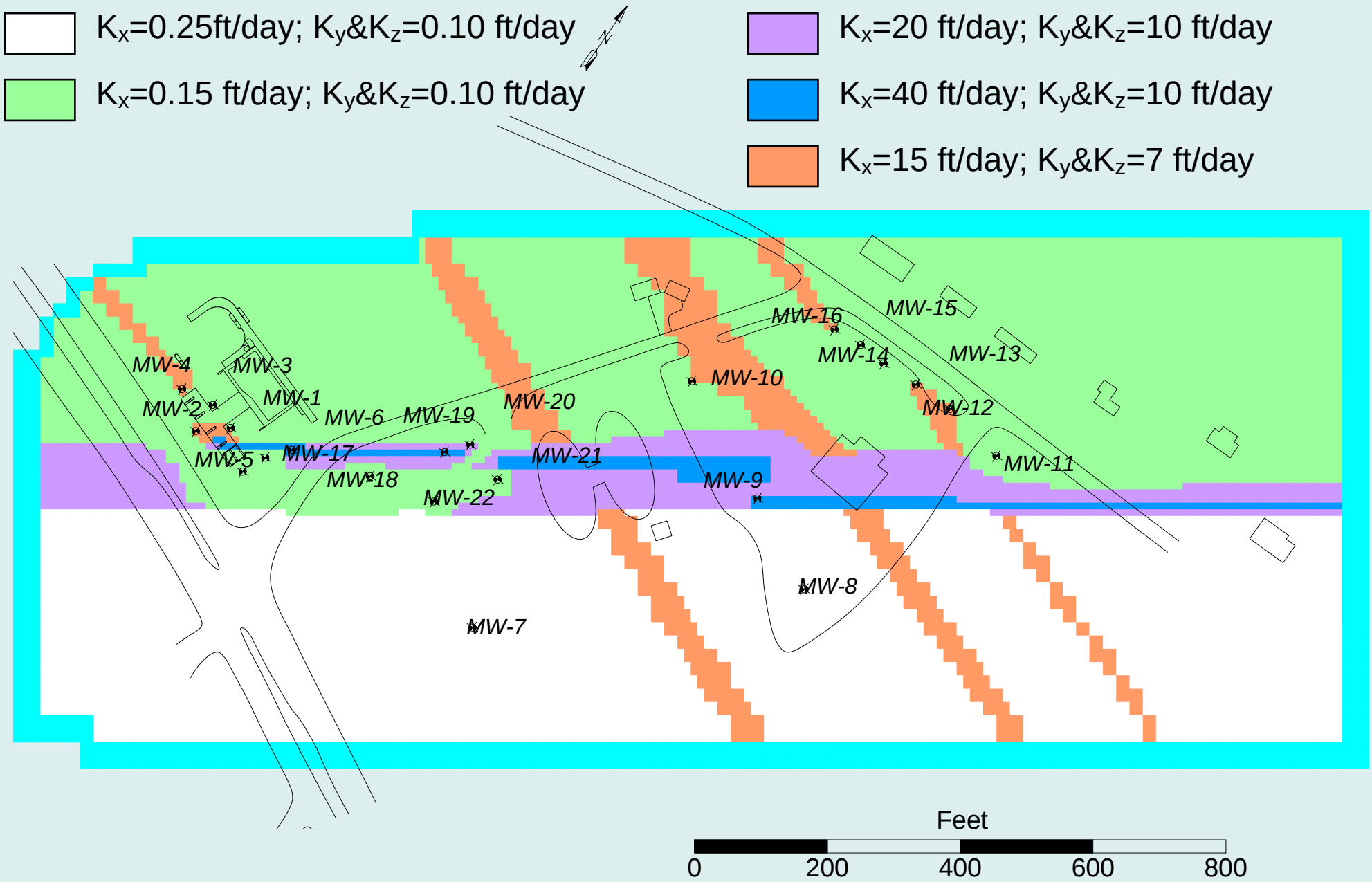
General Head Boundary Cells



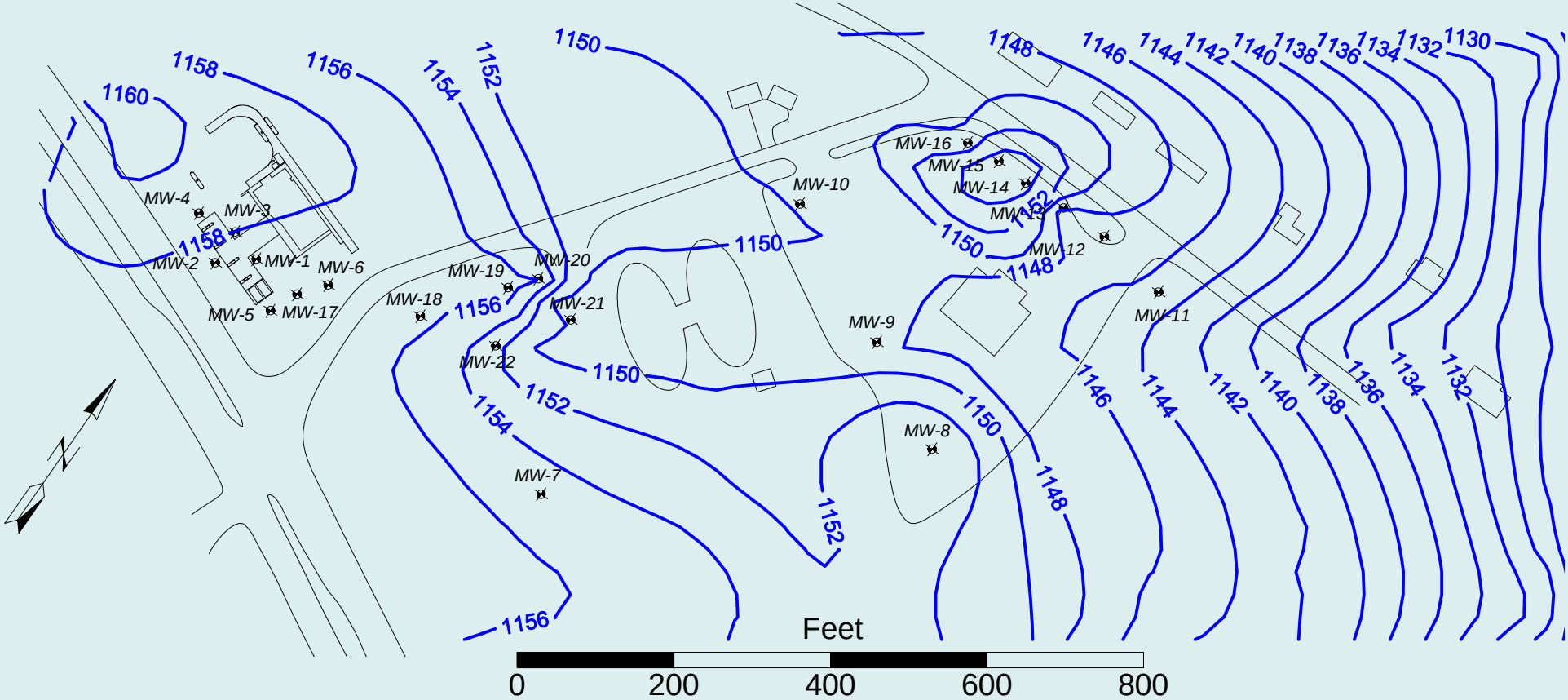
Recharge Zones



Hydraulic Conductivity Zones

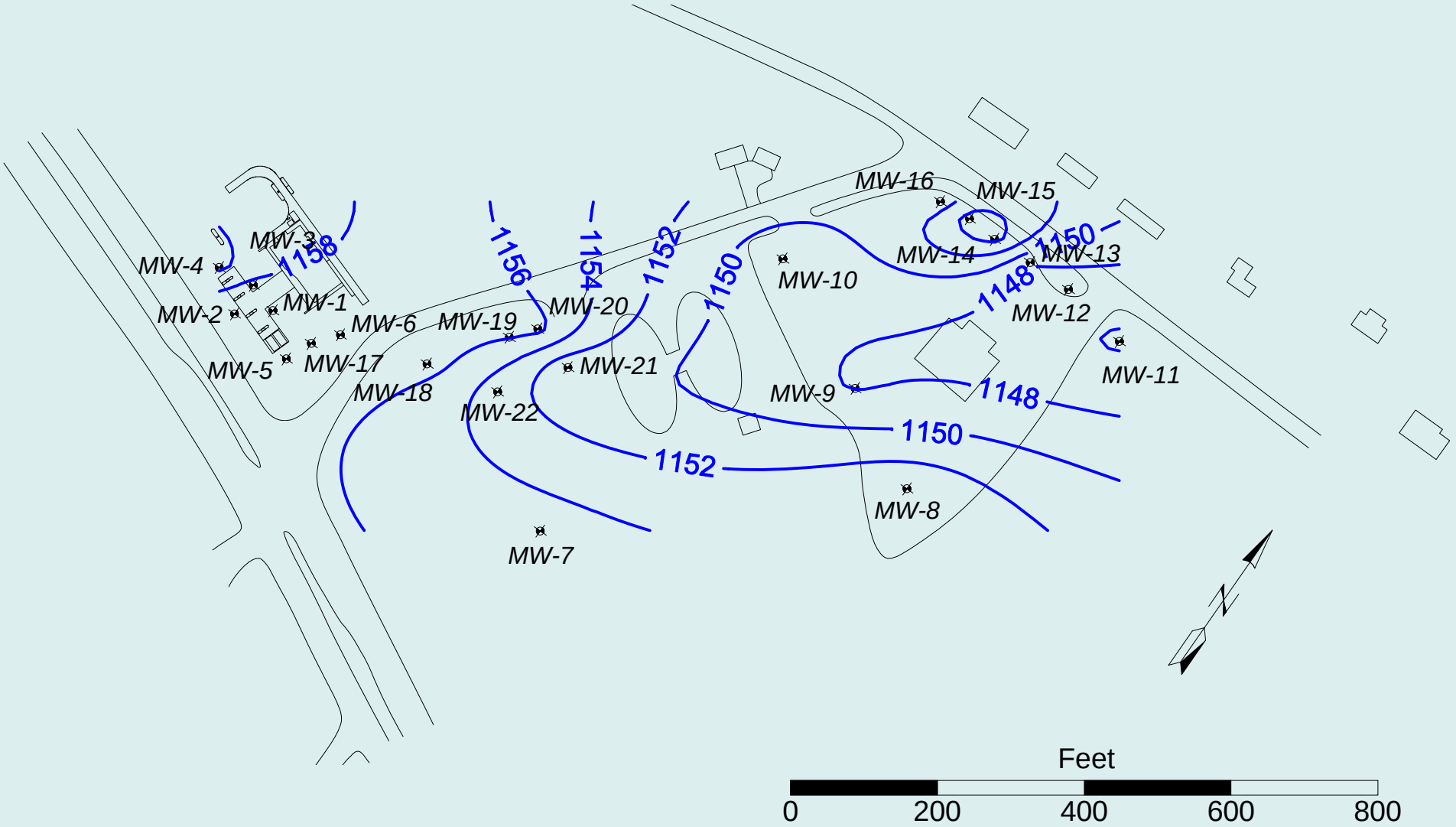


Contours of Modeled Water Levels

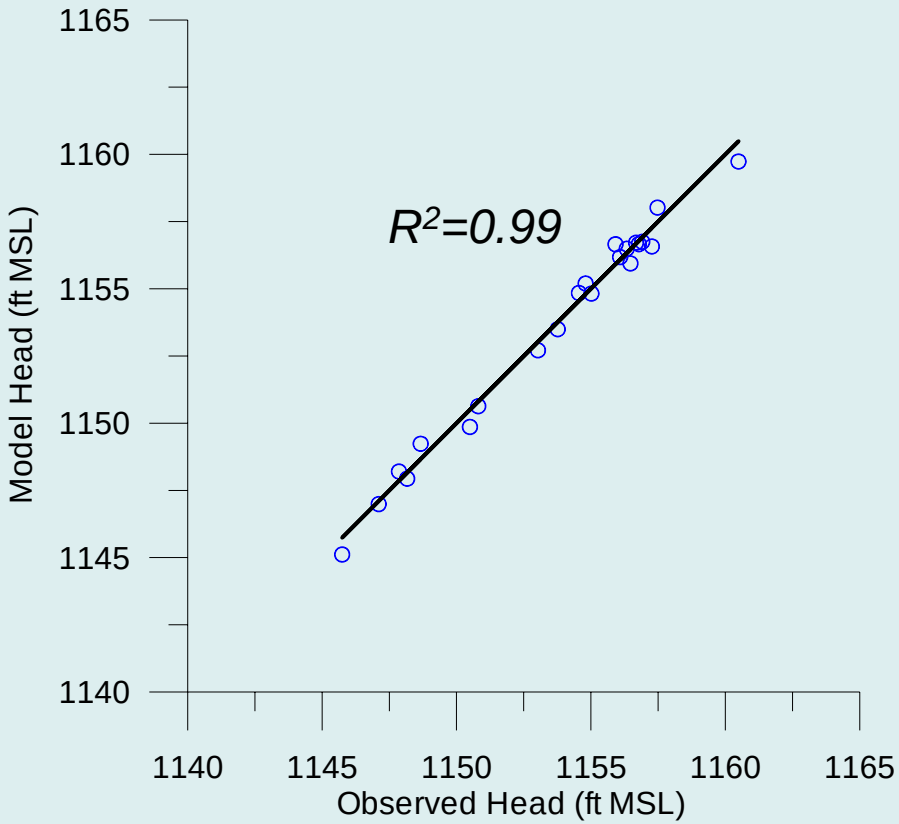


Criterion	Result
Absolute Residual Mean < 1.47 ft	**Absolute Residual Mean = 0.36 ft**
Max and Min Residual < 1.47 ft	**Max = 0.76 ft** **Min = -0.75 ft**
Modeled Groundwater Flow Direction and Gradient Consistent With Observed	**Yes**

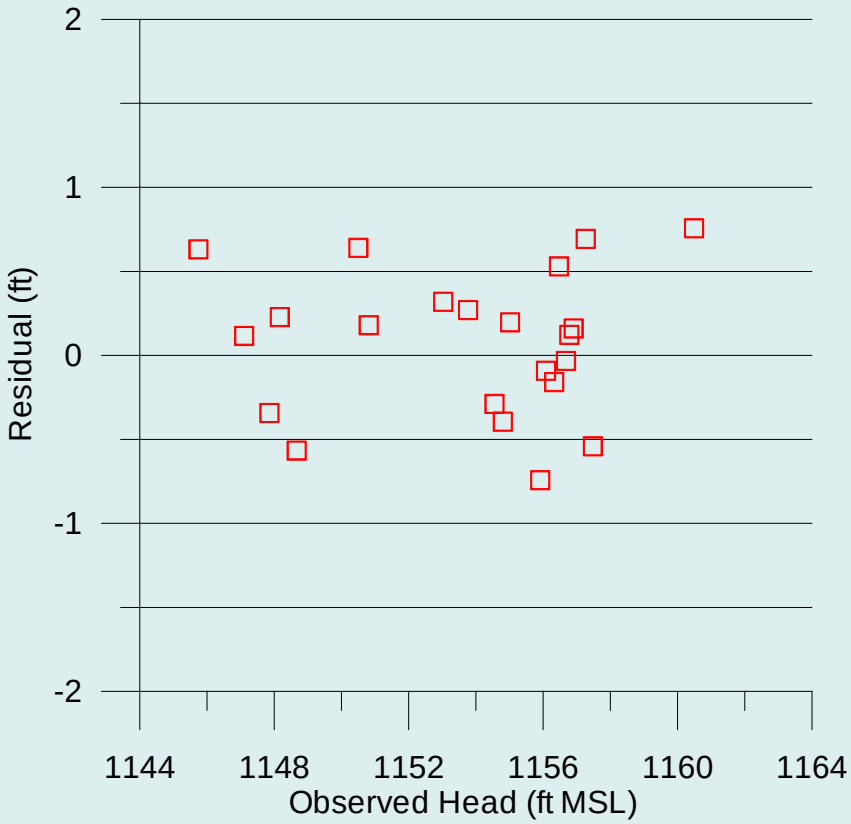
Contours of Observed Average Water Levels



Observed vs. Model Heads



Observed Head vs. Residual



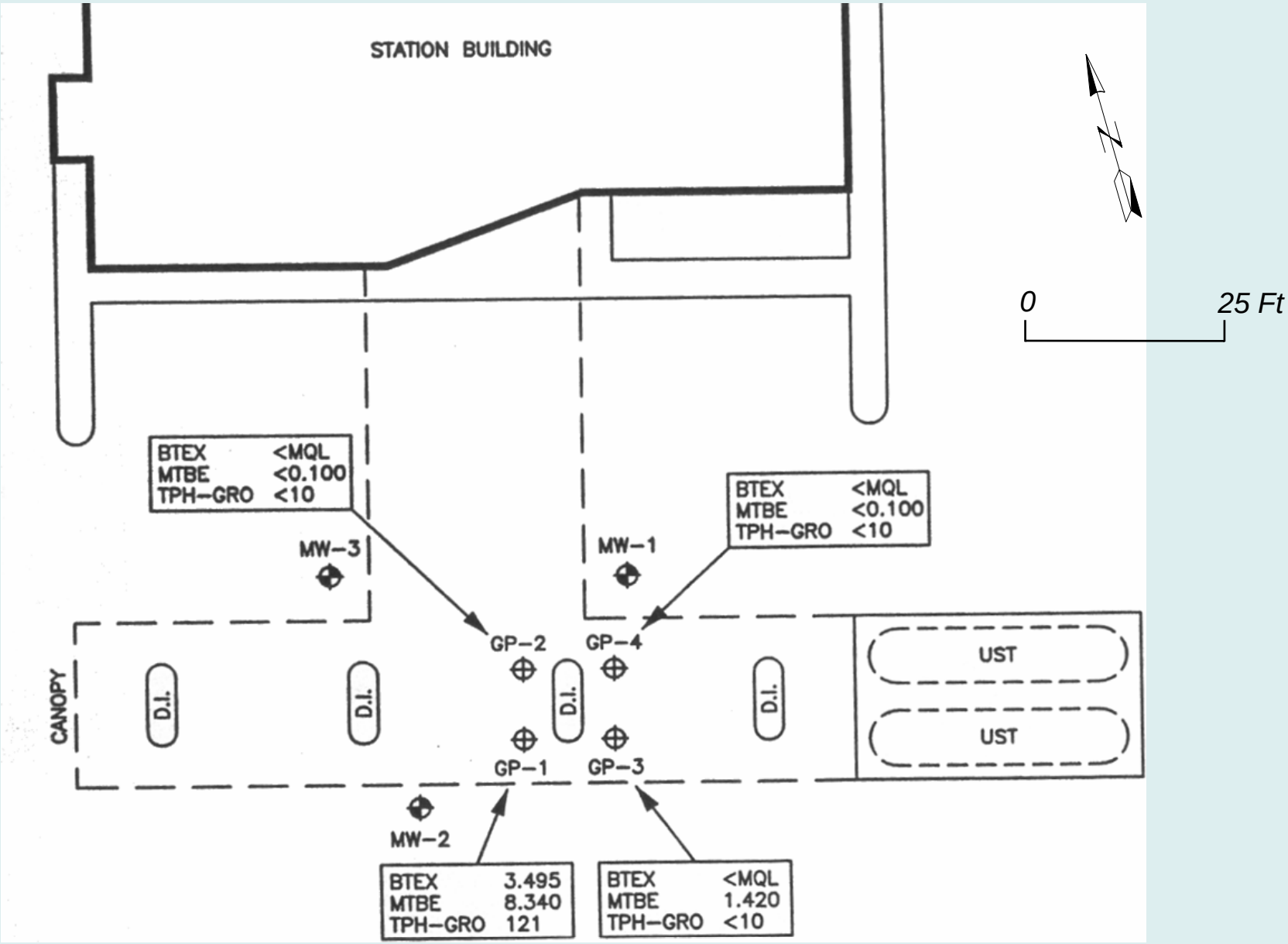
Calibration Statistics

Min Residual: -0.74 ft
Max Residual: 0.75 ft
Abs Residual Mean: 0.36 ft

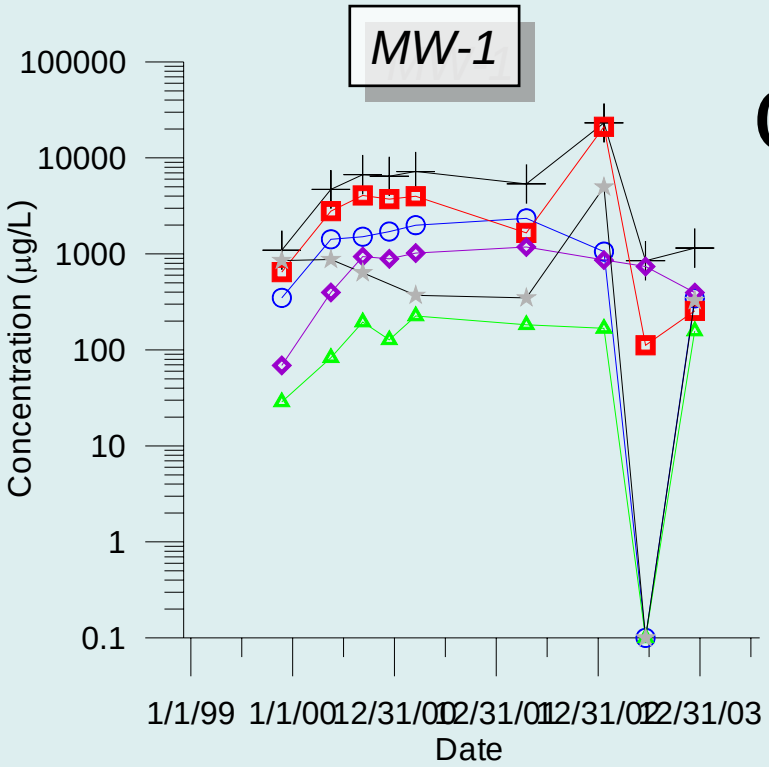
Transport Modeling

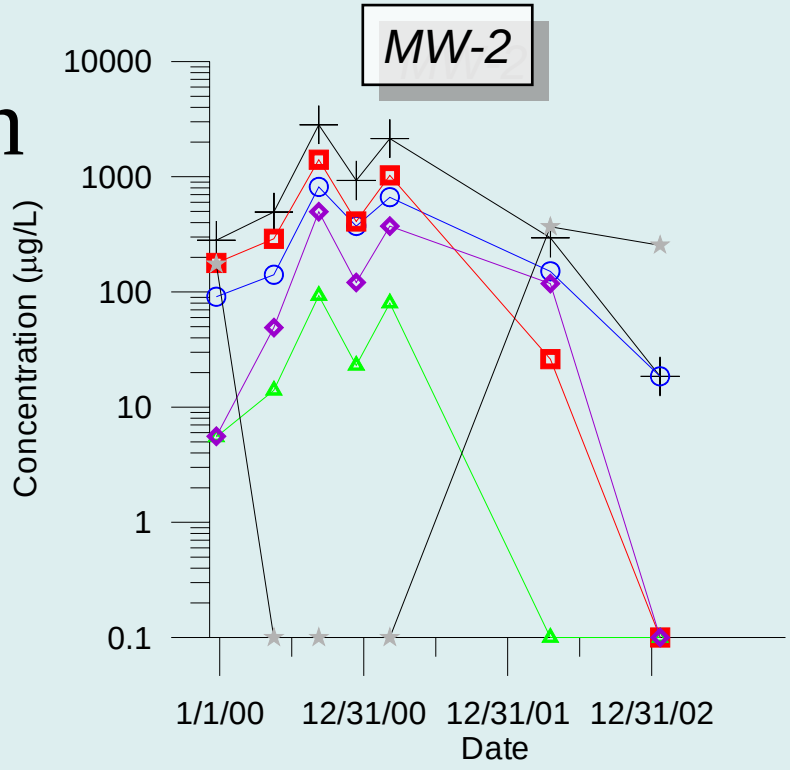
- Use the calibrated flow model
- Source Area?
- Continuous vs Pulse?
- Calibration

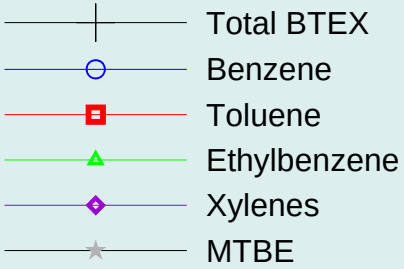
Observed Residual Phase

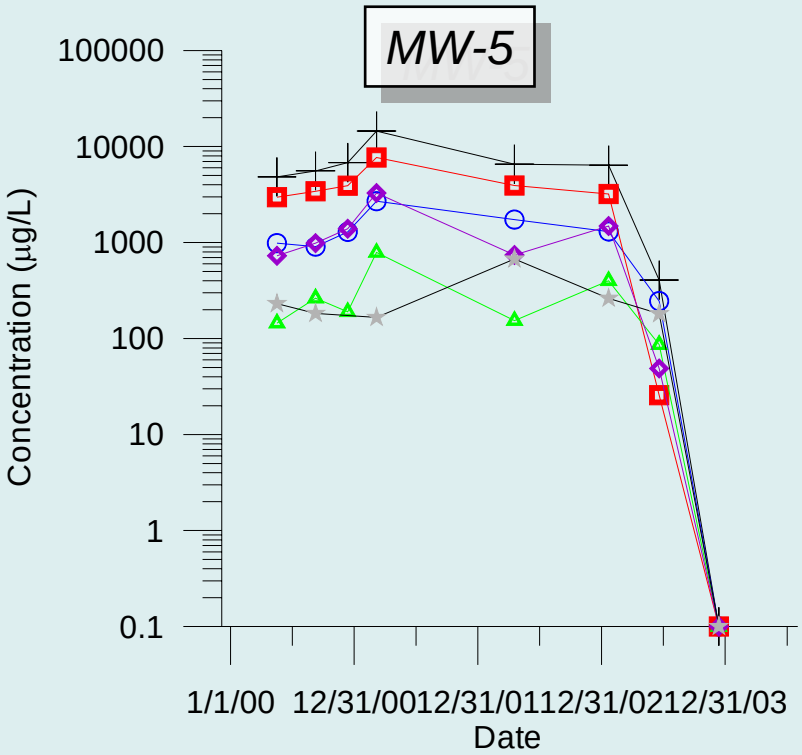


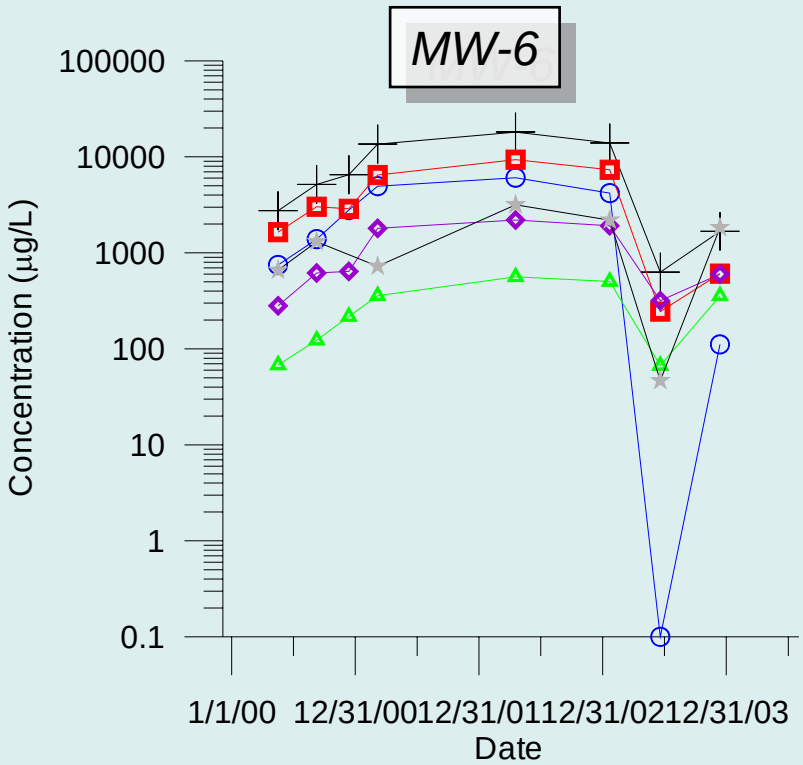
Observed Concentration Trends



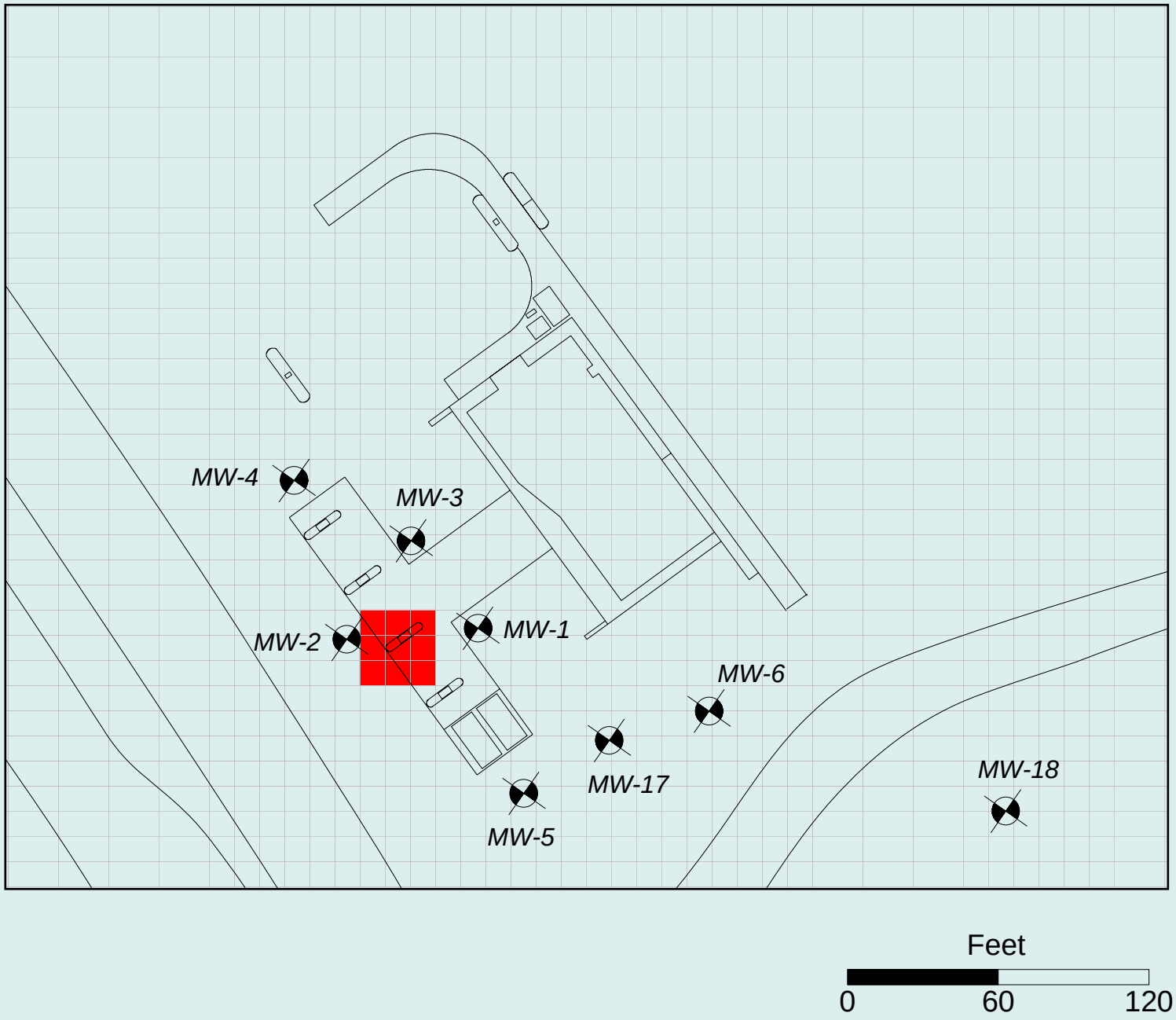








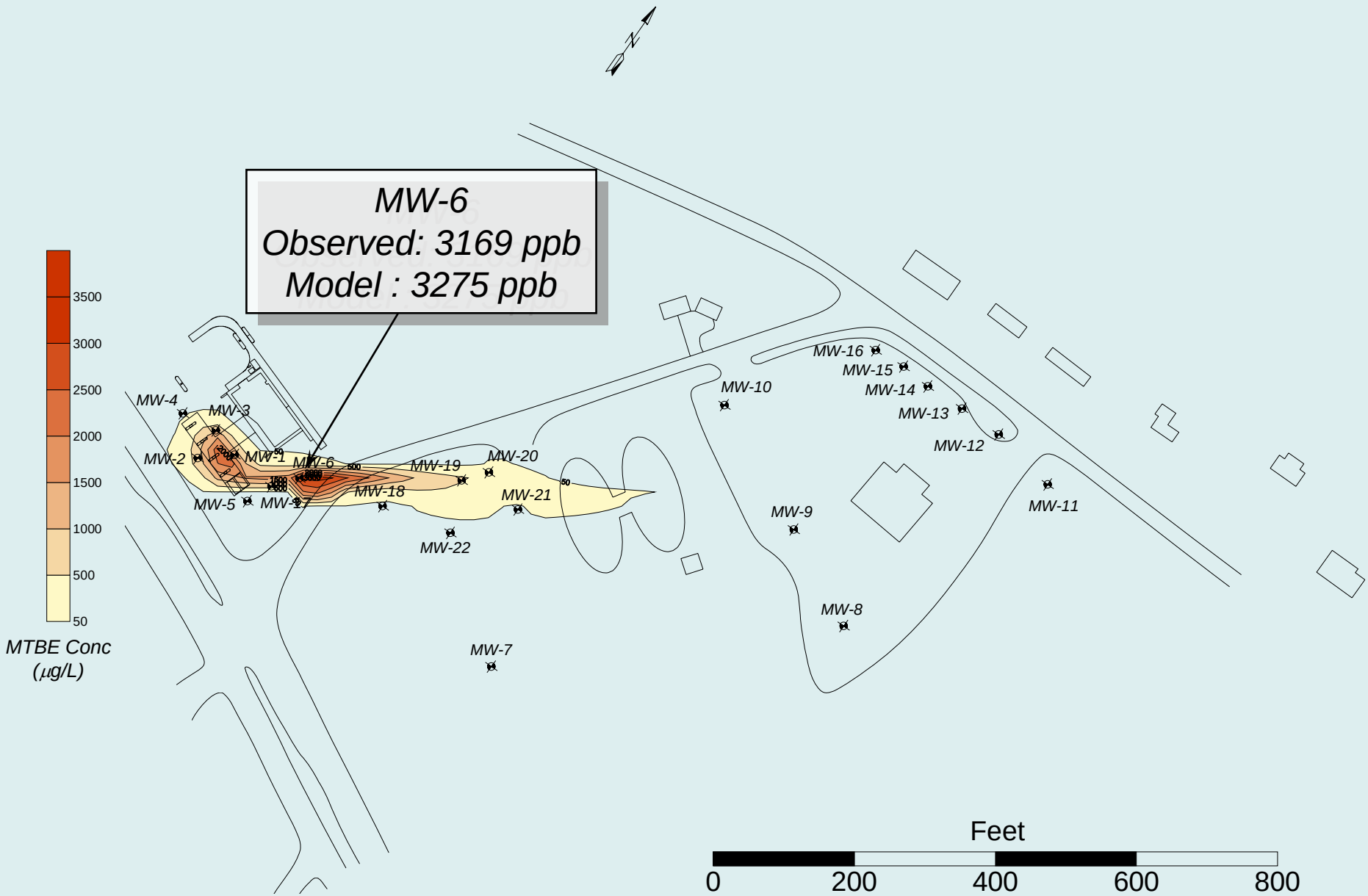
Modeled Source Area



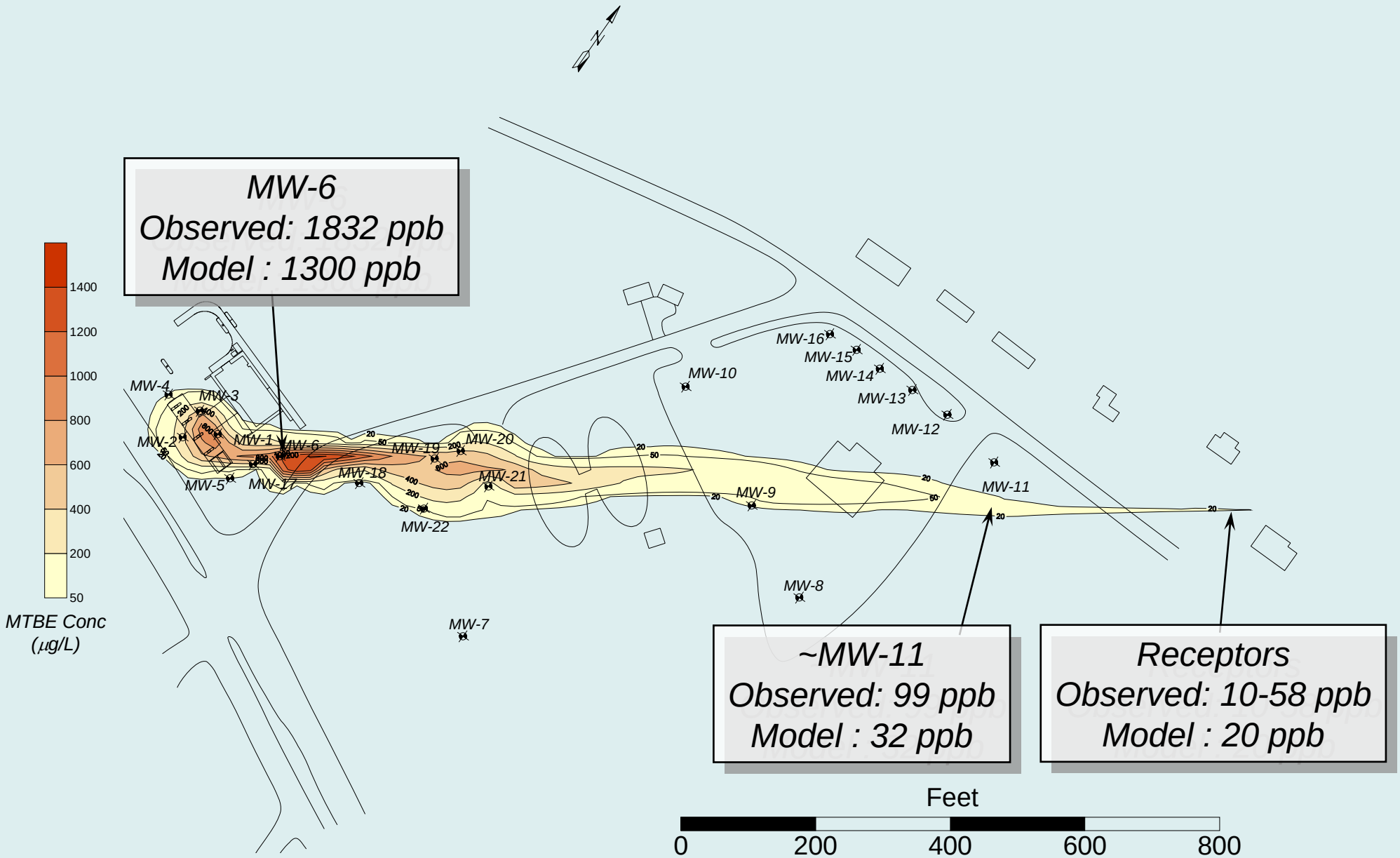
Transport Model Calibration

- *Semi-Quantitative Approach*
- *MW-6 at 2 ½ years*
- *MW-6, MW-11 and Domestic Well Receptors at 4 years*
- *MW-11 and MW-20 at 5 years*

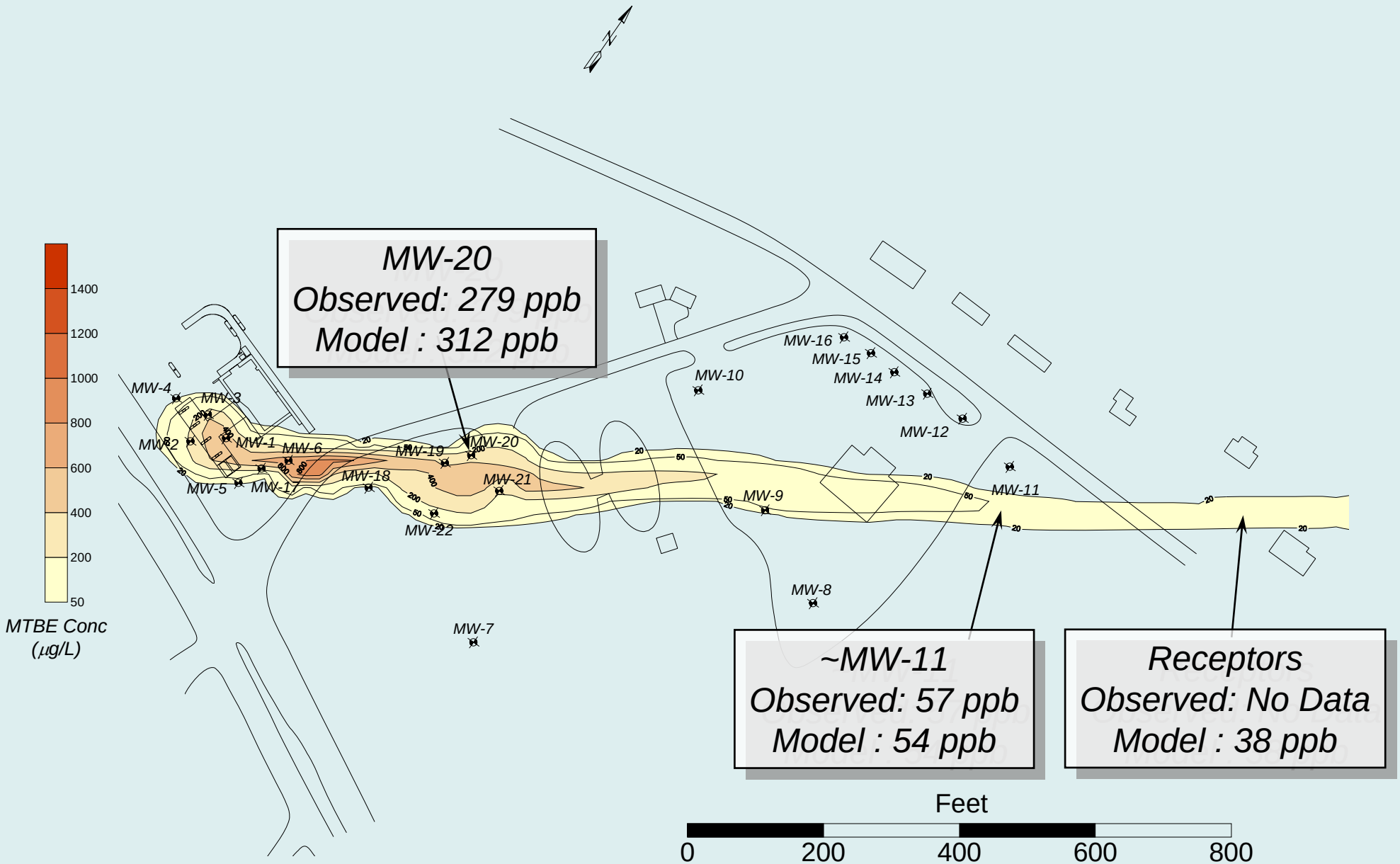
Simulated MTBE Plume at 2½ Years



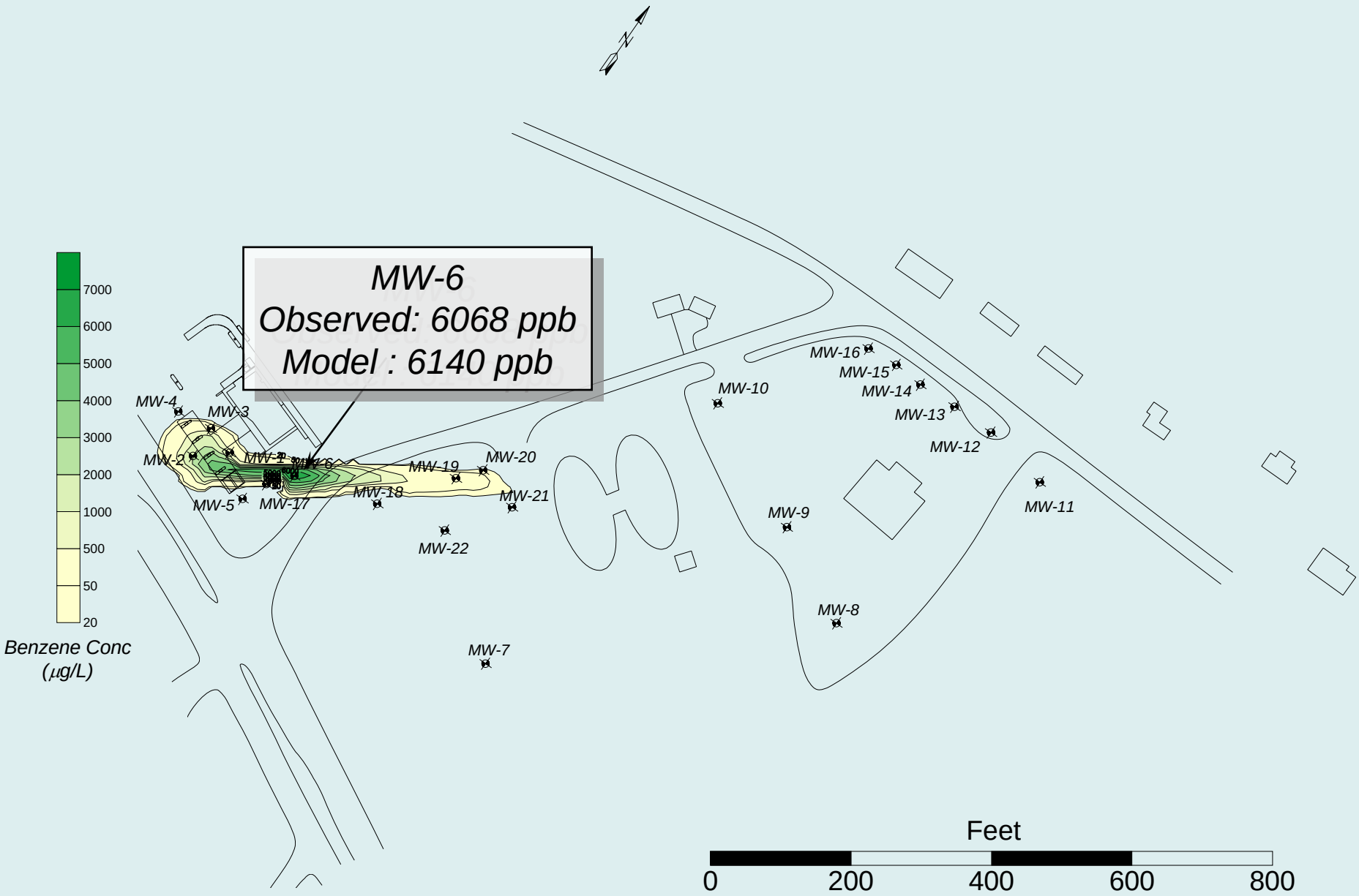
Simulated MTBE Plume at 4 Years



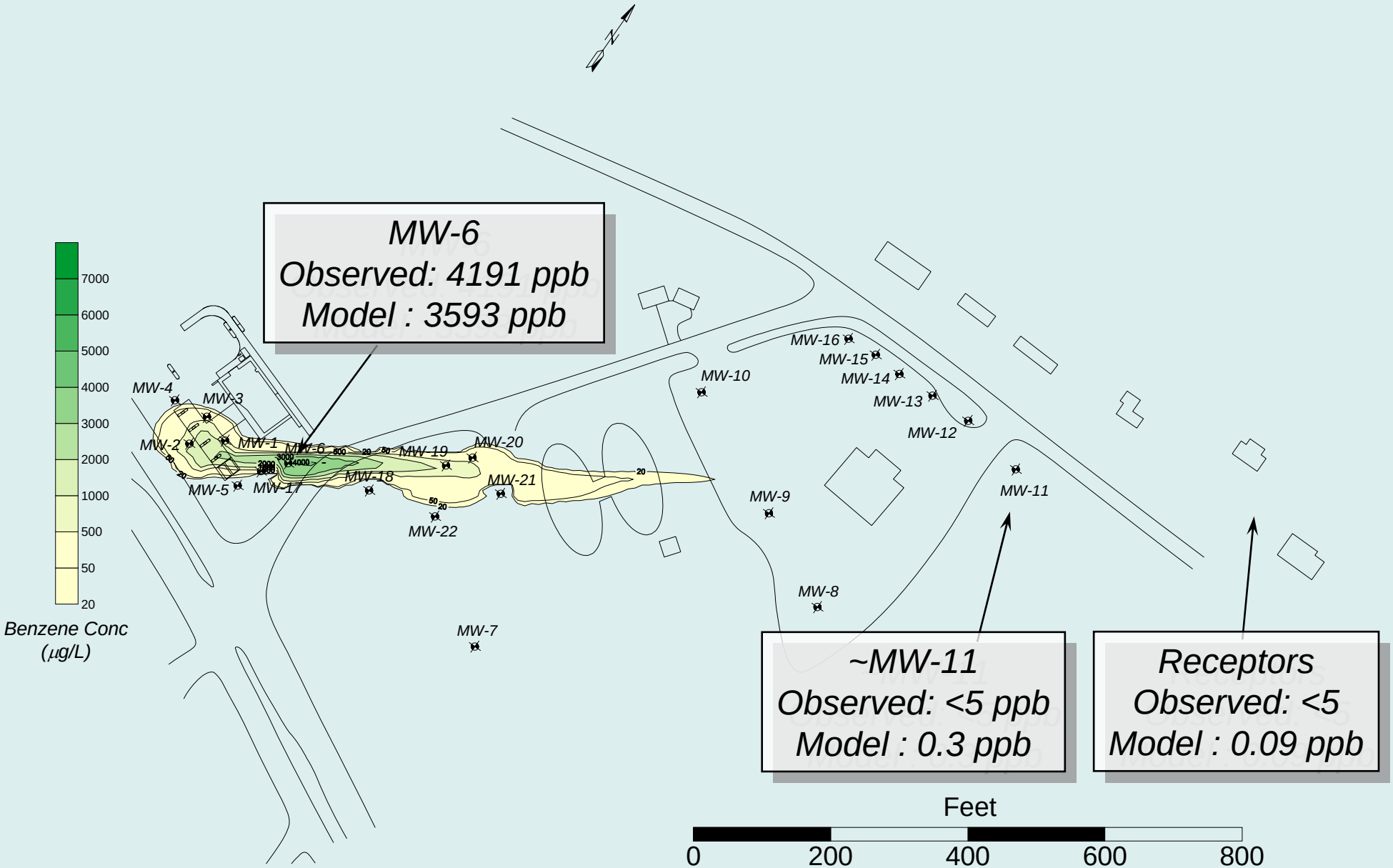
Simulated MTBE Plume at 5 Years



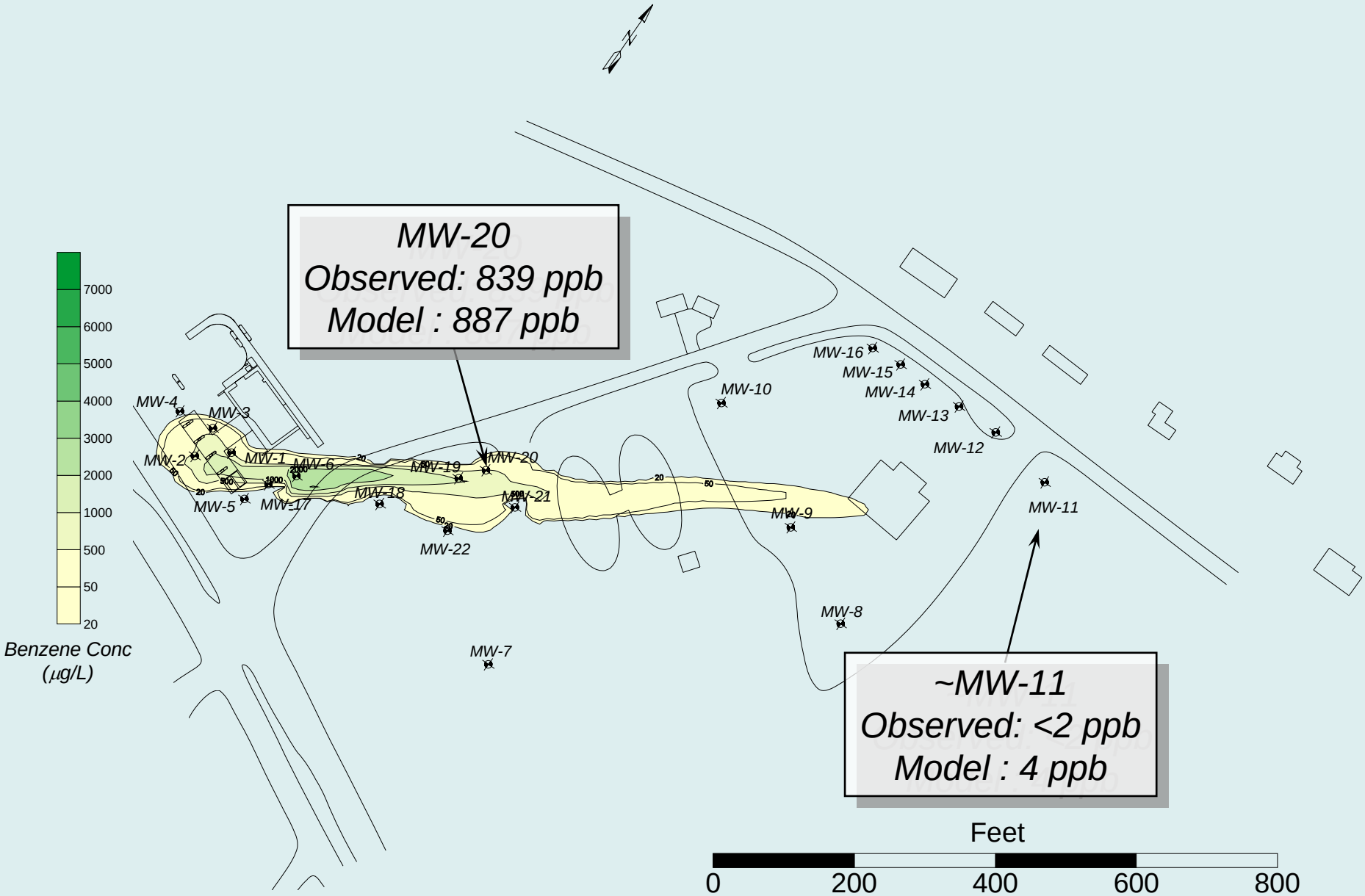
Simulated Benzene Plume at 2½ Years



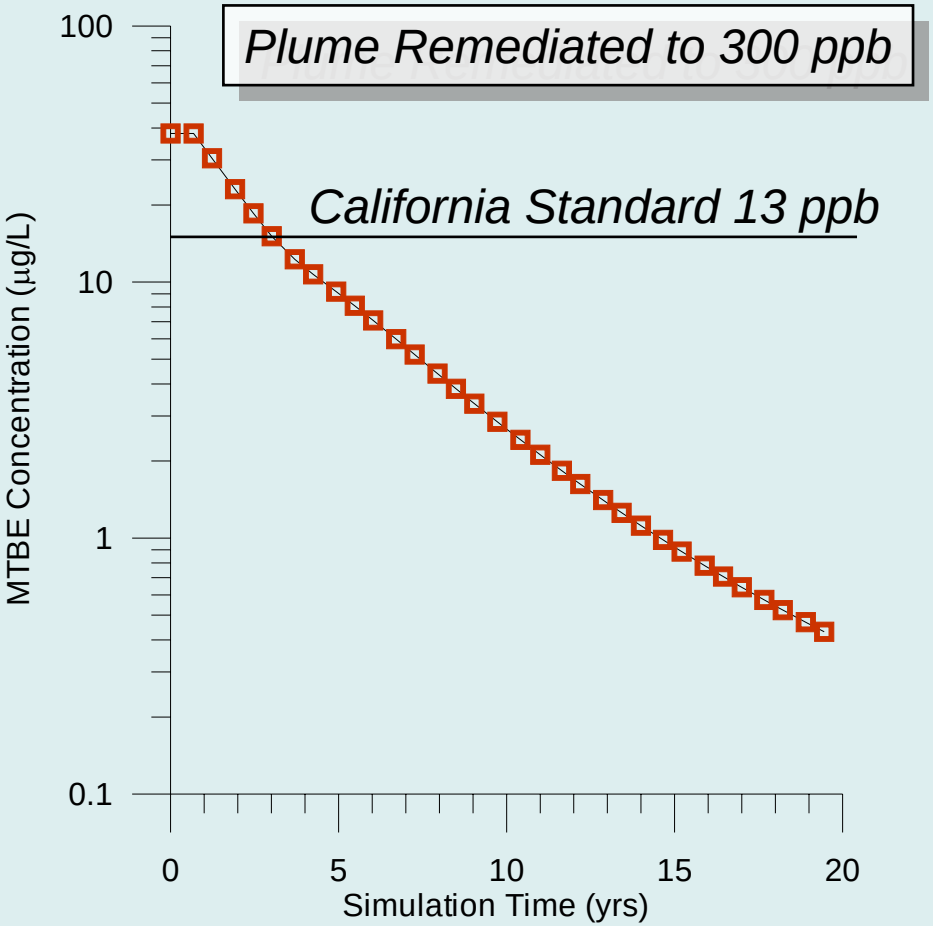
Simulated Benzene Plume at 4 Years

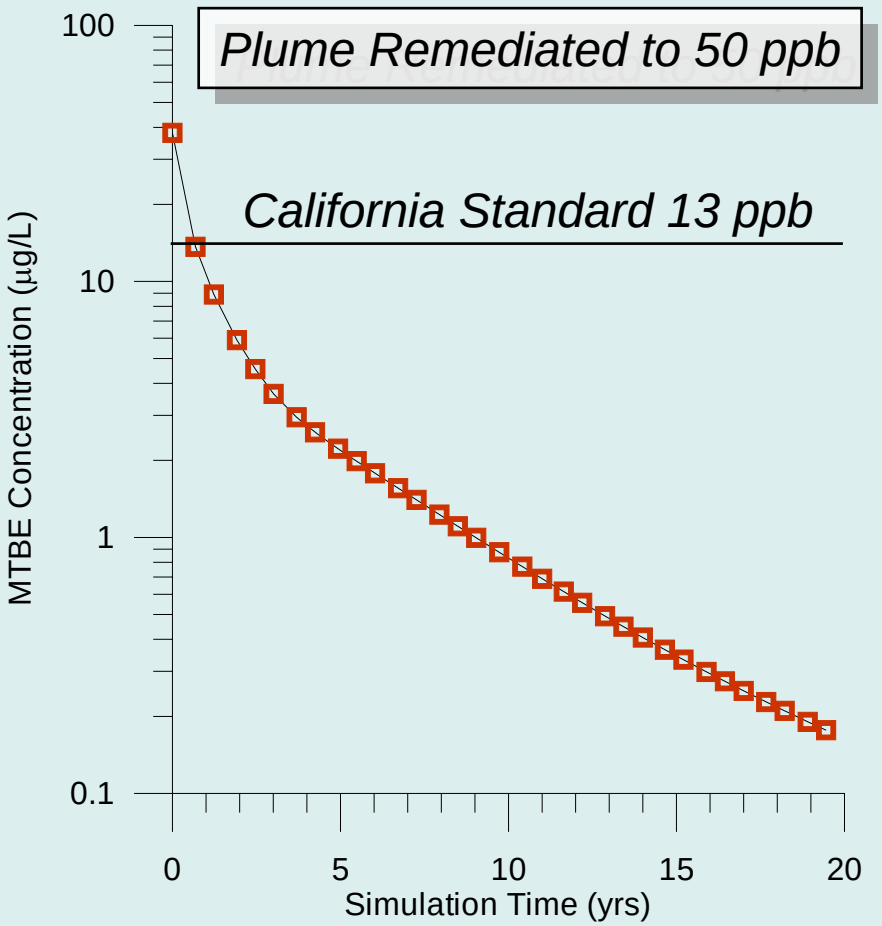


Simulated Benzene Plume at 5 Years

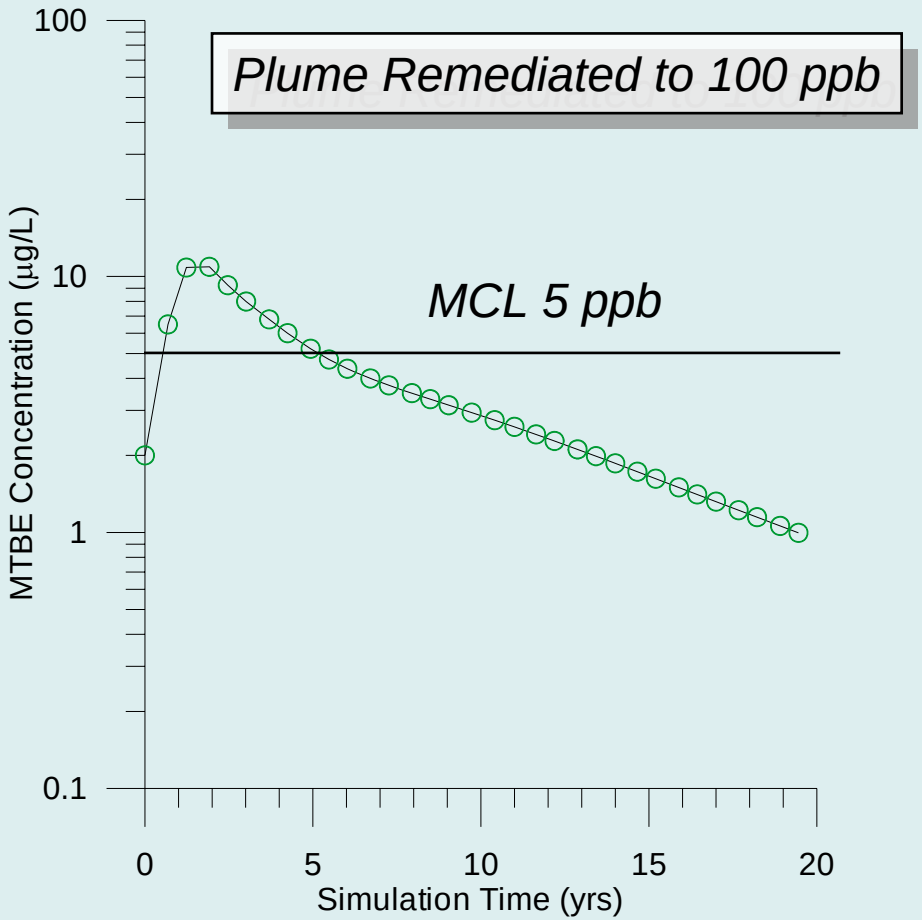


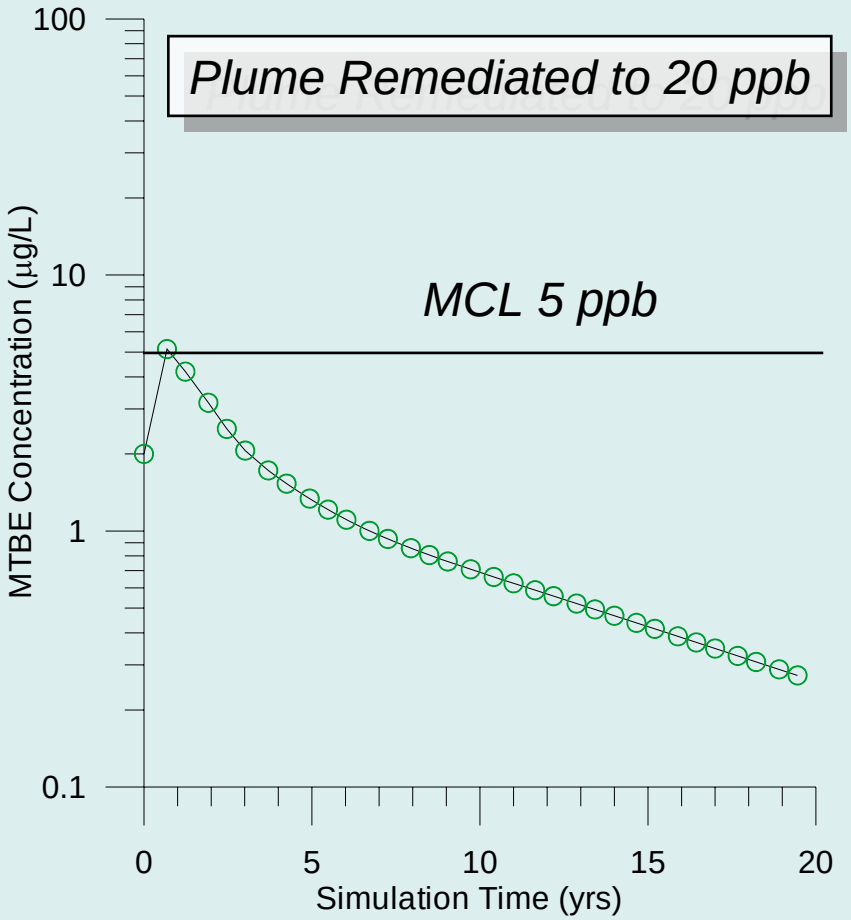
Simulated MTBE Concentration vs. Time at Receptors





Simulated Benzene Concentration vs. Time at Receptors





Model Provides a Basis for Remedial Decision Making

- *Endpoints Analysis*
- *No Remedial Action and find an alternative water supply*
- *Optimization of recovery wells*

Conclusions

- Modeling provides one of the best predictive tools for remedial decision-making
- A good model must consider the geology
- Resistivity imaging can provide valuable characterization data for model parameterization