Use of Electrical Conductivity Logging for Risk Evaluation at a Gasoline Spill Site

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U.S. EPA risk management paradigm is to destroy the hazard or prevent exposure. States implementing the UST program often don't use the flexibility in the U.S. EPA policy.

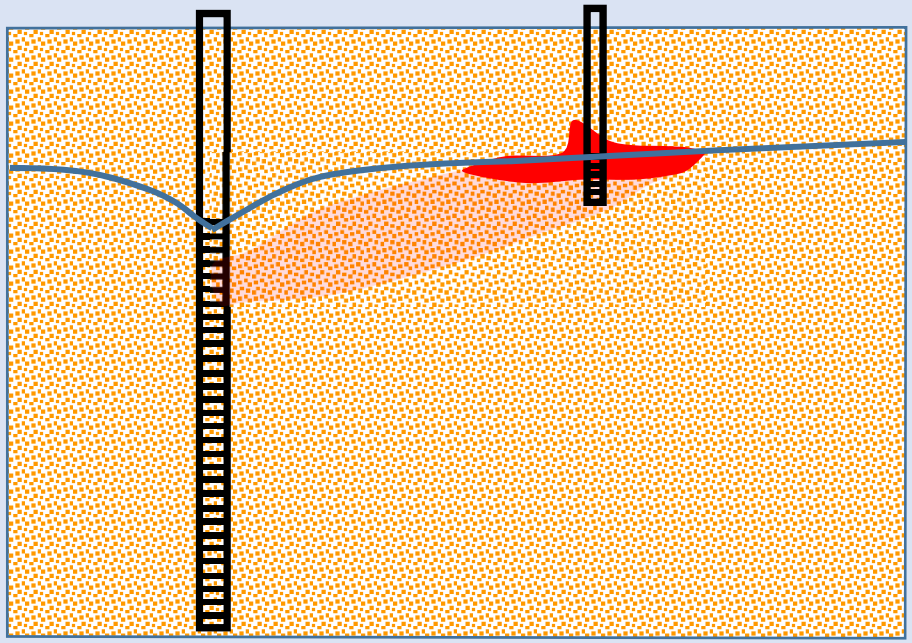
They put too much attention on destroying the hazard and do not think of ways to prevent exposure.

They try to manage the contaminants instead of managing the aquifer as a water supply.

Our ability to clean up contamination in ground water depends to a large extent on our ability to move fluids through the contaminated material.

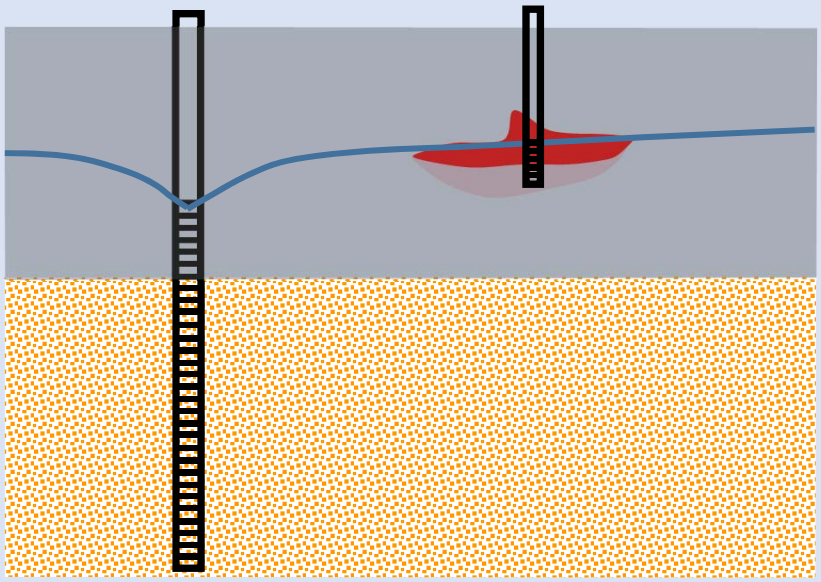
Groundwater flows rapidly through sand and carries a plume of contamination to the water supply well.

The exposure is high, the risk is high, but these sites are relatively easy to clean up.



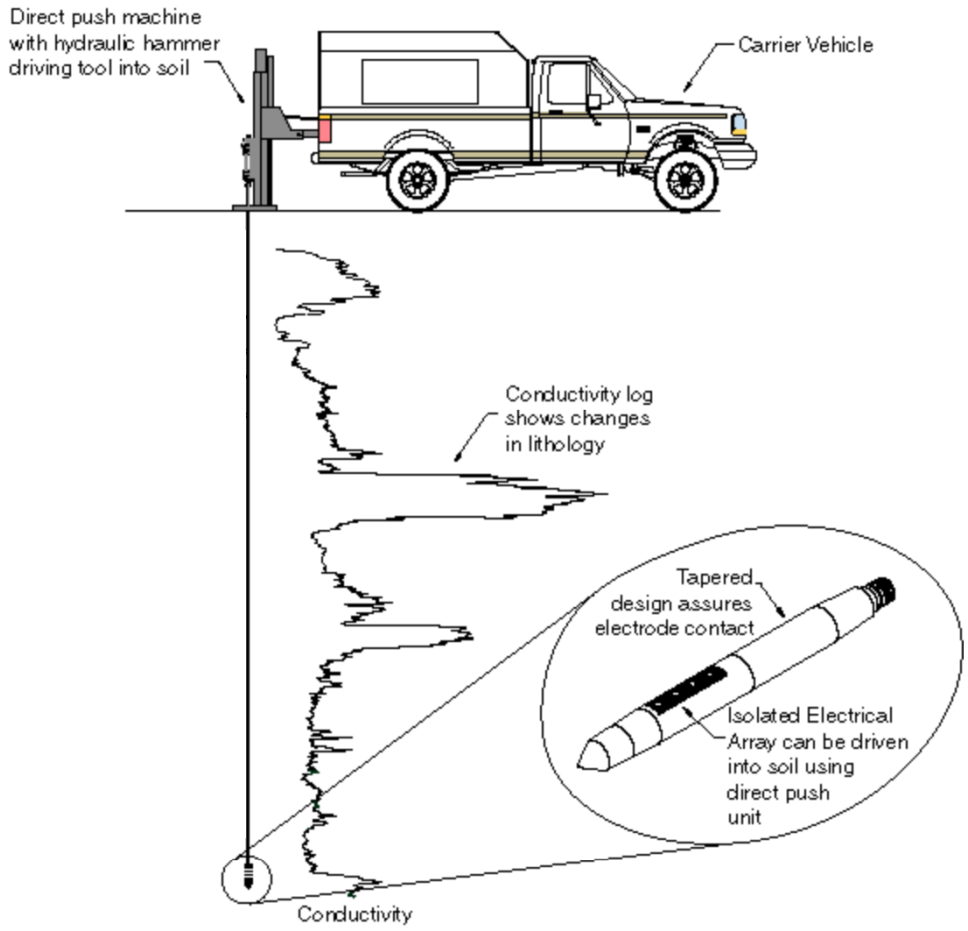
Groundwater flows very slowly through clay. Most often, the plume of contamination does not reach the water supply well.

The exposure is low, but these sites are difficult to clean up.

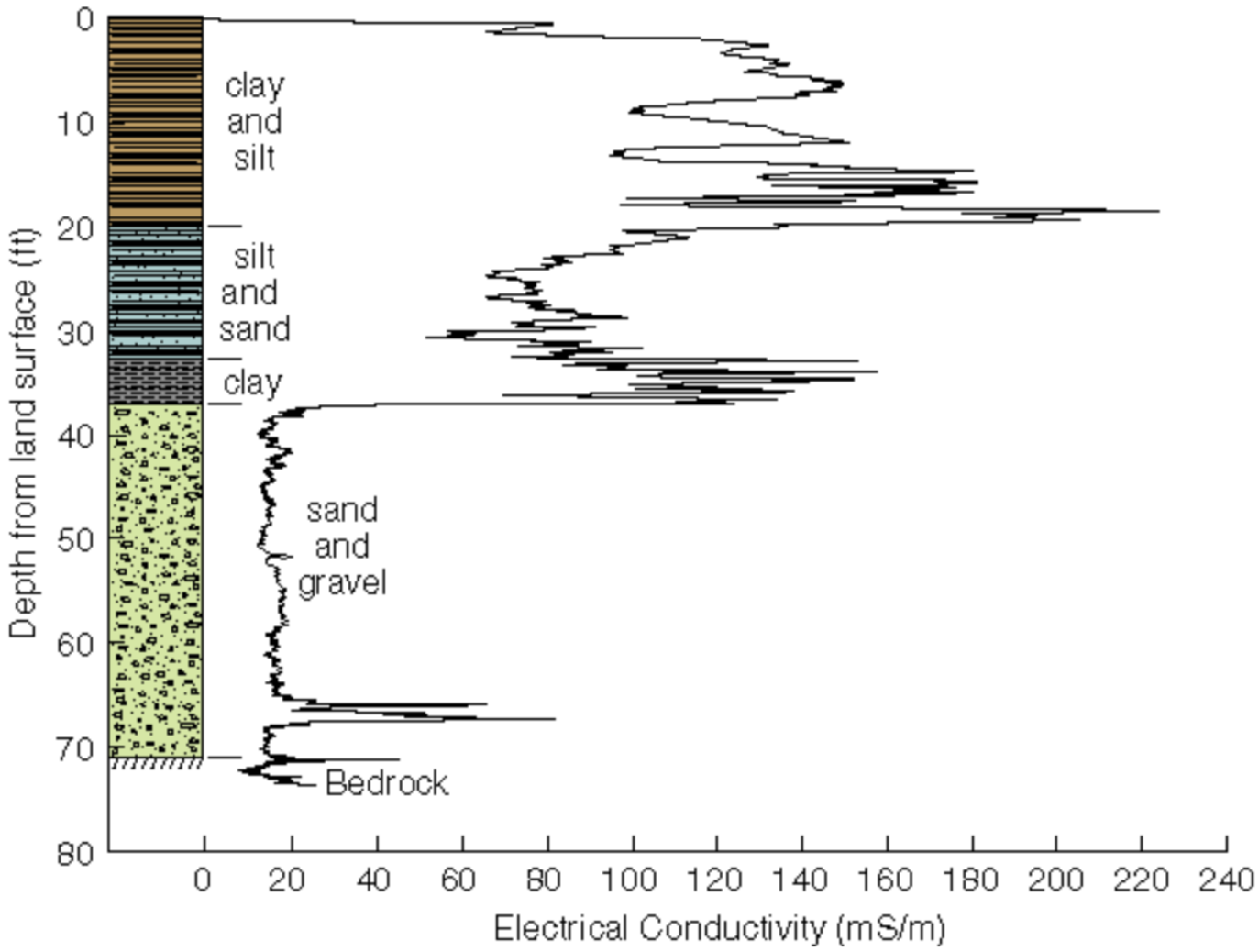


Clay overburden with low hydraulic conductivity is particularly common in flood plain landscapes.

How can we characterize these sites to determine whether the drinking water aquifer is exposed to contamination with petroleum hydrocarbons from a UST release?



Butler et al. 1999. Hydrostatic Characterization of Unconsolidated Alluvial Deposits with Direct-Push Sensor Technology. Kansas Geological Survey Open File Report 99-40.


clay
and
silt
silt
and
sand
clay
sand
and
gravel
Bedrock
Depth from land surface (ft)
0
10
20
30
40
50
60
70
80
0
20
40
60
80
100
120
140
160
180
200
220
240
Electrical Conductivity (mS/m)

Approach:

1) Conduct a survey of electrical conductivity.

2) Evaluate lithology from the logs, to produce a site conceptual model for vertical flow of ground water down to the drinking water aquifer.

3) Collect ground water samples from temporary wells.

4) Compare the vertical distribution of benzene in ground water to the capacity to move ground water and produce a plume.

Approach:

1) Collect core samples at various depths.

2) Extract the cores and determine concentrations of TPH and Benzene in the sediment (mg/kg).

3) Calculate concentration of Benzene in pore water.

4) Confirm the well samples by comparing the calculated distribution of Benzene in water to the site conceptual model for flow of ground water.

The "expected" Benzene concentration in soil pore water (C_w) is calculated as:

$$C_w = \frac{C_{o,NAPL}}{K_{NAPL} + \frac{\theta_w}{\theta_{NAPL}}}$$

Where:

C_w is the concentration in the ground water

$C_{o,\ NAPL}$ is the concentration in the gasoline that was spilled

θ_{NAPL} is the porosity filled with gasoline

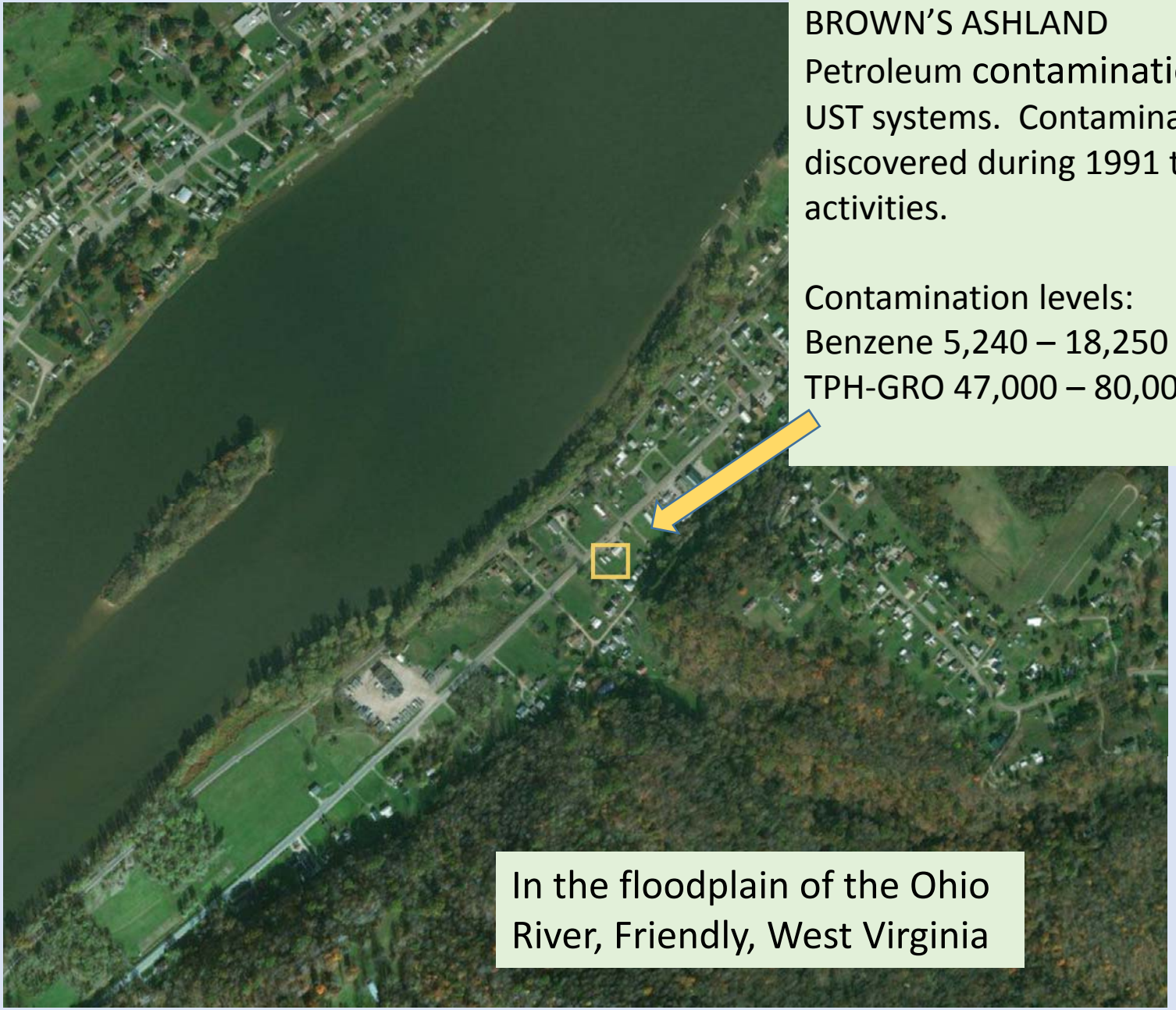
θ_w is the water-filled porosity

K_{NAPL} is the distribution coefficient between gasoline and water

Rixey, W. G. and S. Joshi. Dissolution of MTBE from a residually trapped gasoline source, API Soil and Groundwater Research Bulletin No. 13, American Petroleum Institute, 2000.

$C_{o,\ NAPL}$ (the concentration of Benzene in the gasoline that was spilled) is estimated from the concentrations of Benzene and TPH in the core extracts:

$C_{o,\ NAPL}$ = benzene (mg/kg)/ TPH (mg/kg)

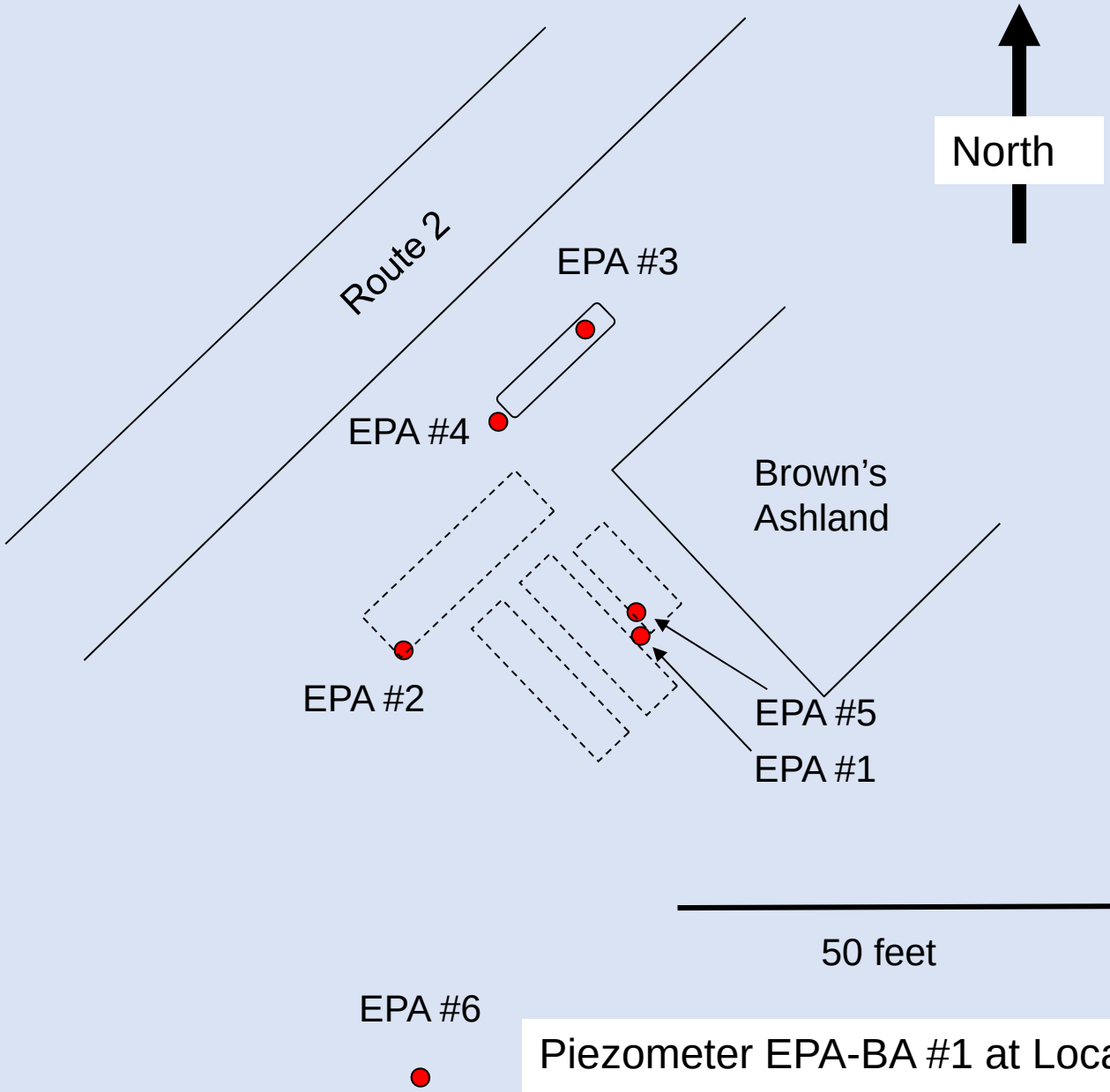


BROWN'S ASHLAND

Petroleum contamination was from UST systems. Contamination was discovered during 1991 tank removal activities.

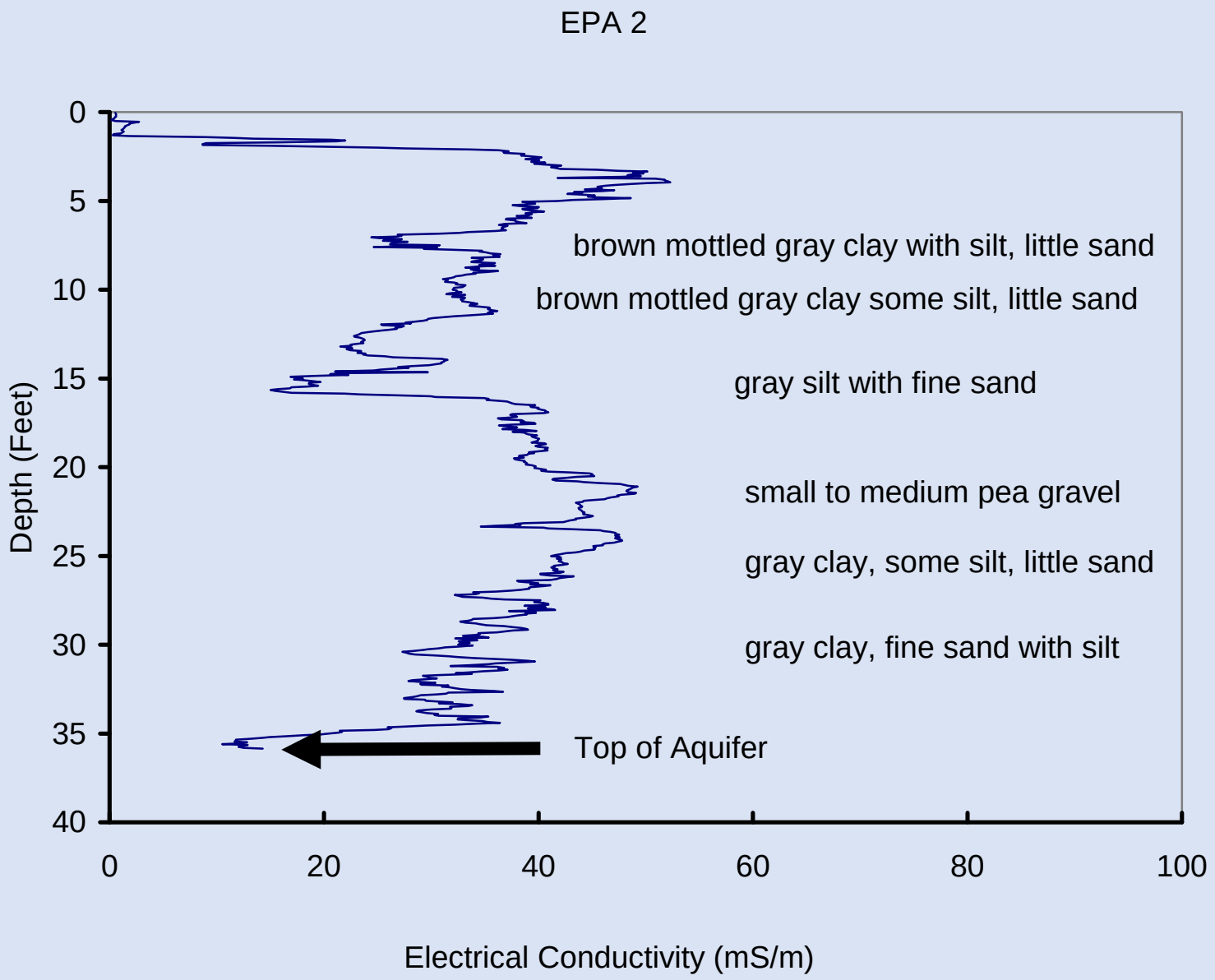
Contamination levels:
Benzene 5,240 – 18,250 ppb
TPH-GRO 47,000 – 80,000 ppb.

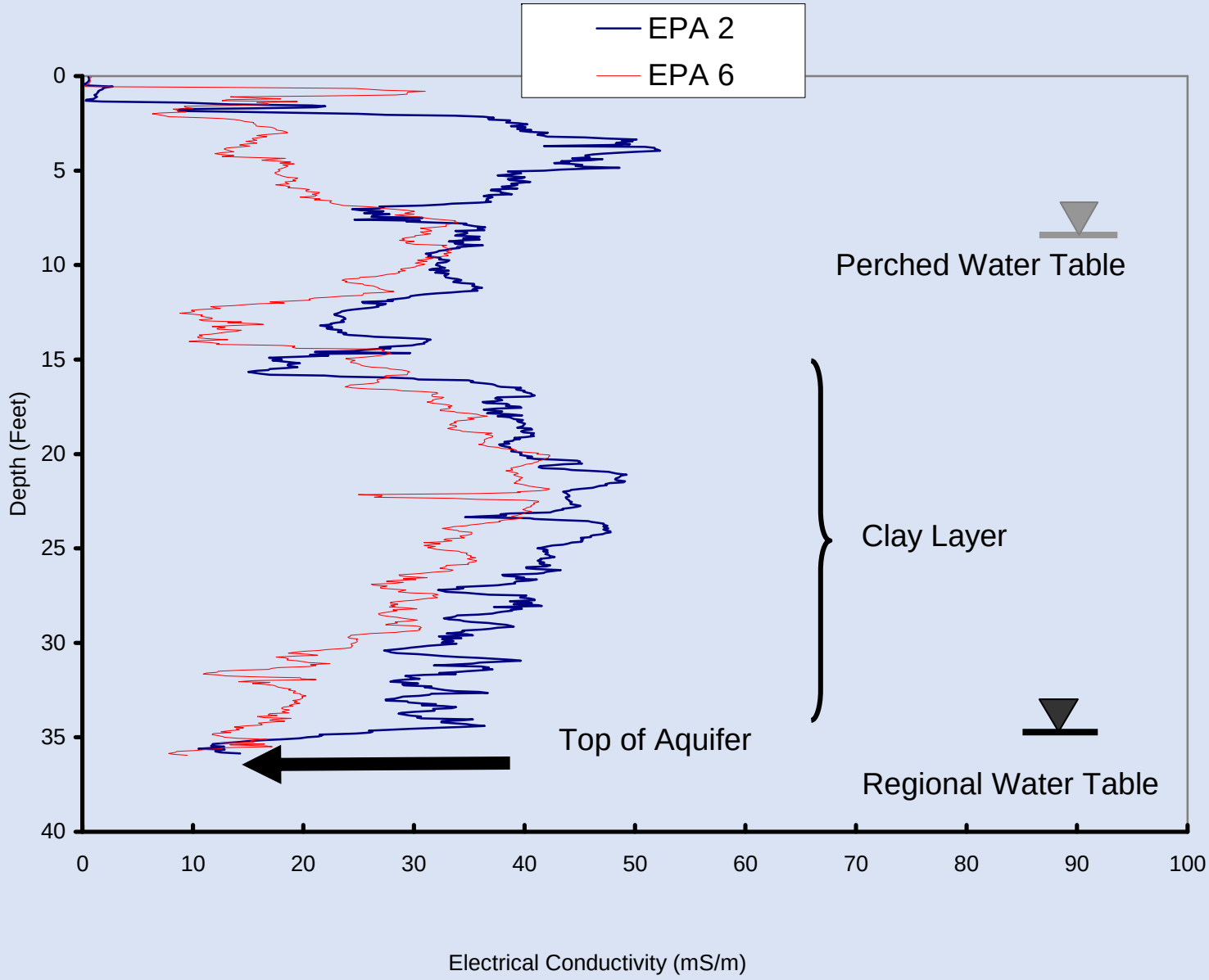
In the floodplain of the Ohio River, Friendly, West Virginia

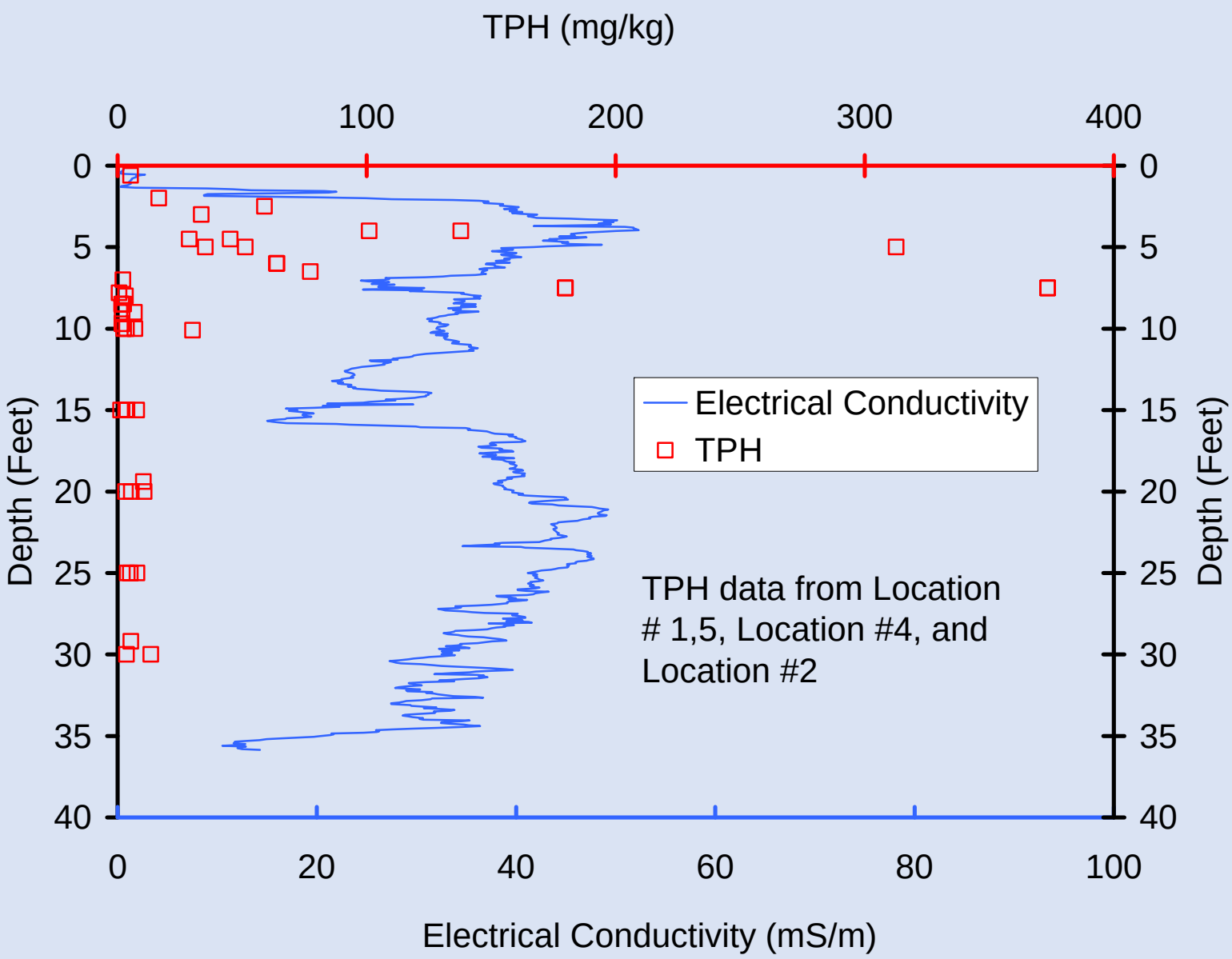


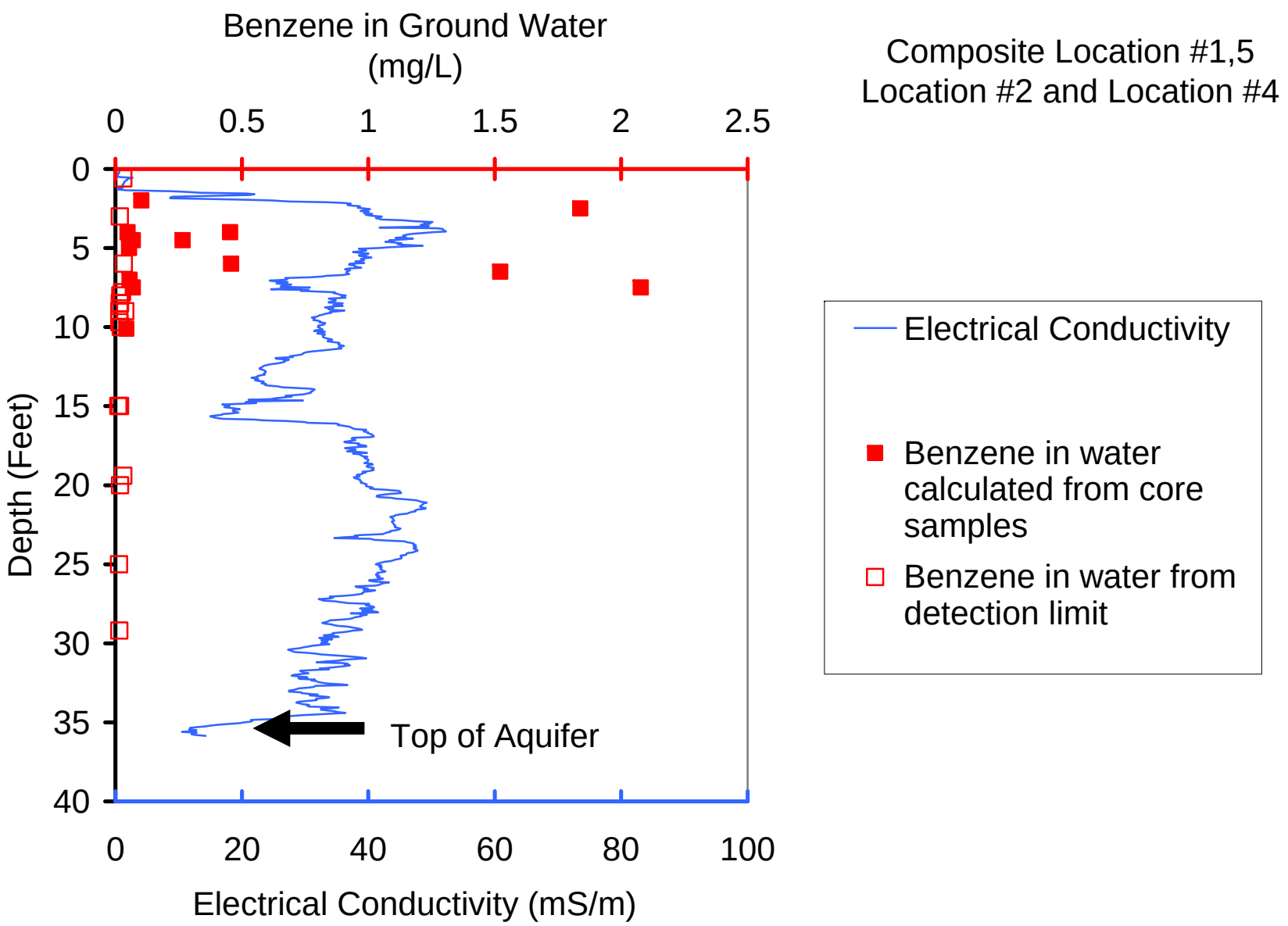
Piezometer EPA-BA #1 at Location #1

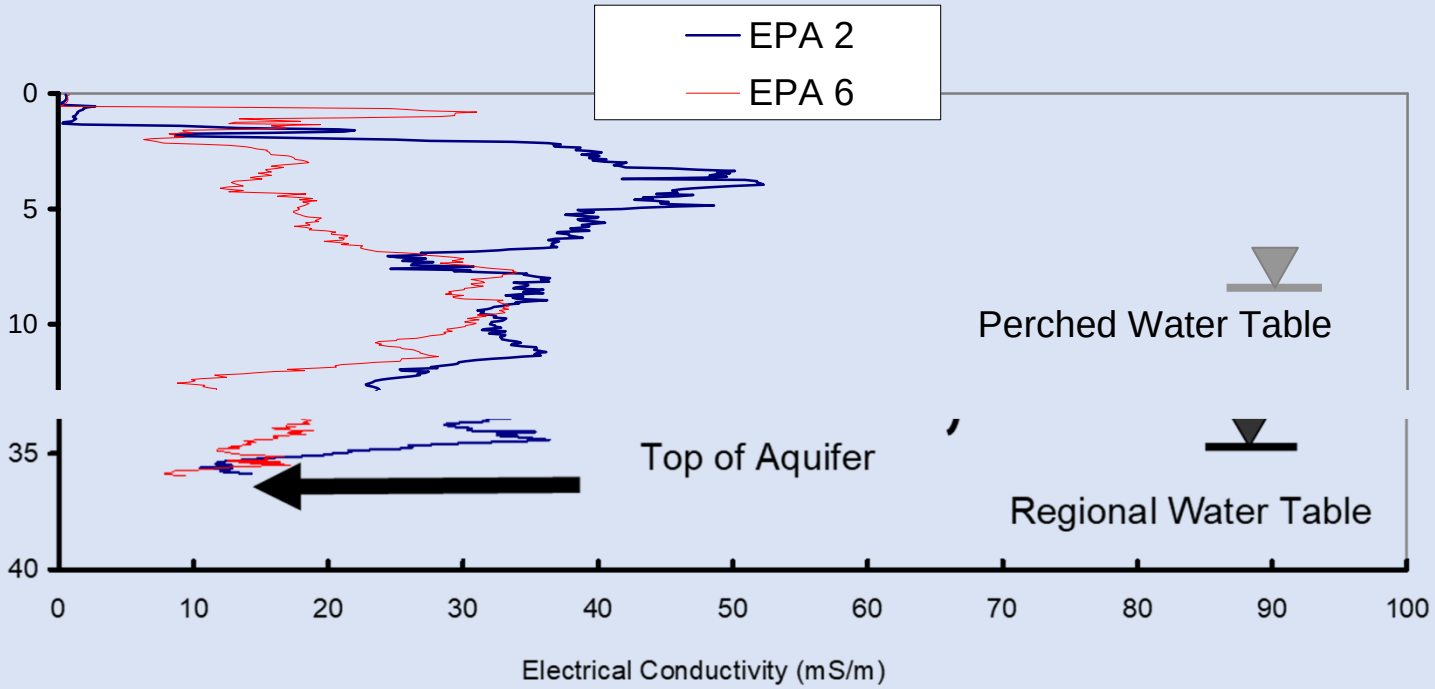
screened 30' to 35' bgs,, river cobble at 35

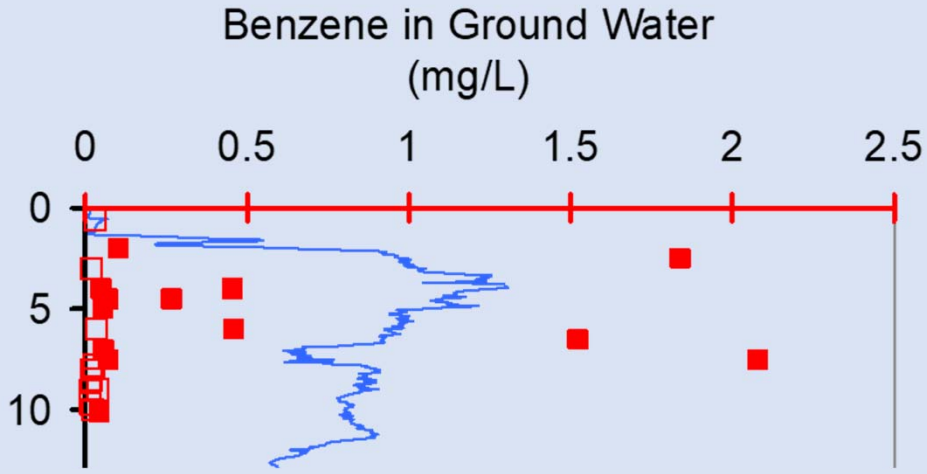

EPA 2
Depth (Feet)
0
5
10
15
20
25
30
35
40
0
20
40
60
80
100
Electrical Conductivity (mS/m)
brown mottled gray clay with silt, little sand
brown mottled gray clay some silt, little sand
gray silt with fine sand
small to medium pea gravel
gray clay, some silt, little sand
gray clay, fine sand with silt
Top of Aquifer

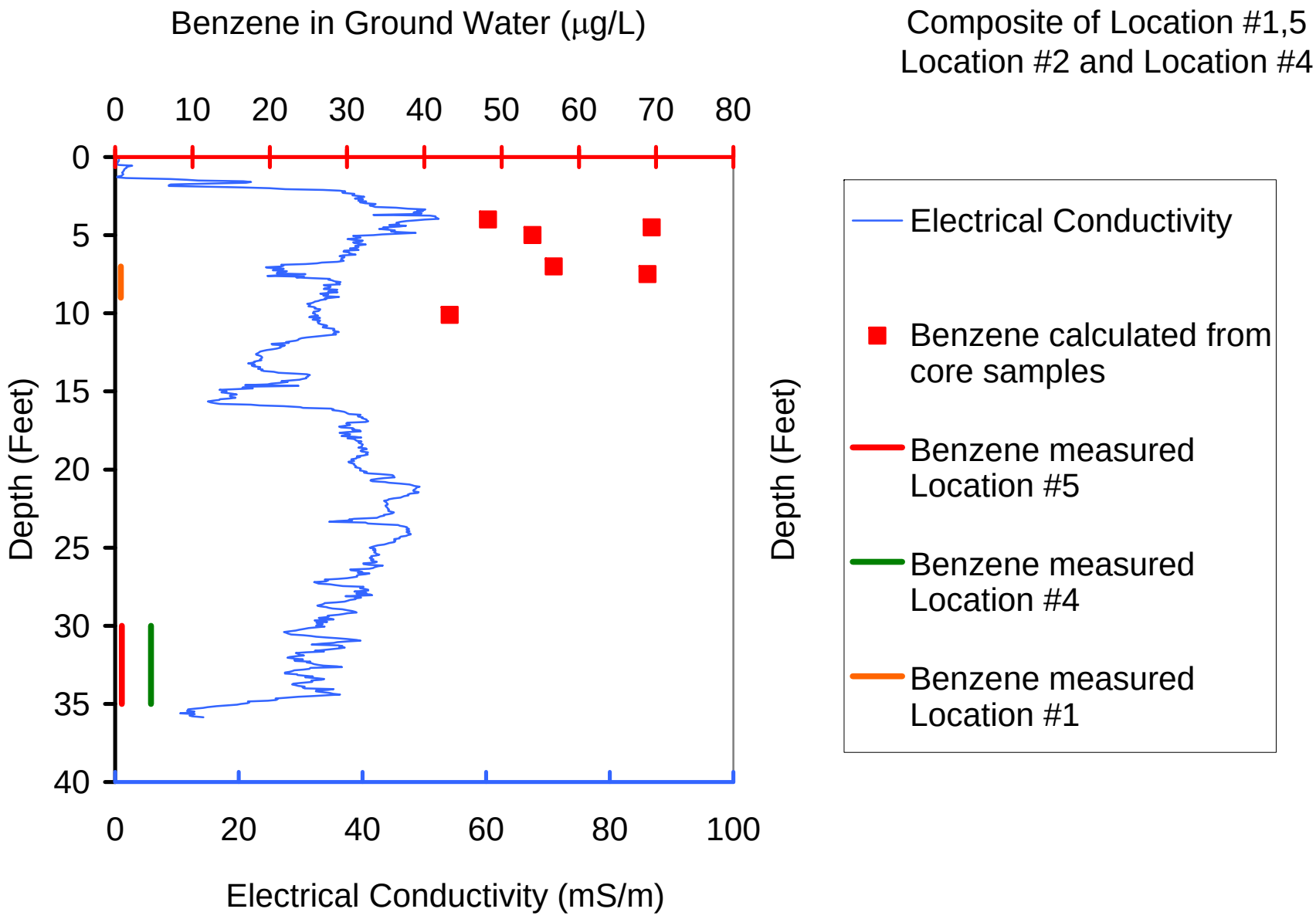

EPA 2
EPA 6
Depth (Feet)
0
5
10
15
20
25
30
35
40
Perched Water Table
Clay Layer
Top of Aquifer
Regional Water Table
0
10
20
30
40
50
60
70
80
90
100
Electrical Conductivity (mS/m)


TPH (mg/kg)
0
100
200
300
400
0
5
10
15
20
25
30
35
40
Depth (Feet)
Electrical Conductivity
TPH
TPH data from Location # 1,5, Location #4, and Location #2
0
20
40
60
80
100
Electrical Conductivity (mS/m)


Benzene in Ground Water
(mg/L)
0
0.5
1
1.5
2
2.5
Depth (Feet)
0
5
10
15
20
25
30
35
40
Top of Aquifer
0
20
40
60
80
100
Electrical Conductivity (mS/m)
Composite Location #1,5
Location #2 and Location #4
Electrical Conductivity
Benzene in water calculated from core samples
Benzene in water from detection limit


EPA 2
EPA 6
0
5
10
35
40
Perched Water Table
Top of Aquifer
Regional Water Table
0
10
20
30
40
50
60
70
80
90
100
Electrical Conductivity (mS/m)


Benzene in Ground Water
(mg/L)
0
0.5
1
1.5
2
2.5
0
5
10


Benzene in Ground Water (µg/L)
Composite of Location #1,5
Location #2 and Location #4
0
10
20
30
40
50
60
70
80
0
5
10
15
20
25
30
35
40
Depth (Feet)
Depth (Feet)
0
20
40
60
80
100
Electrical Conductivity (mS/m)
Electrical Conductivity
Benzene calculated from core samples
Benzene measured Location #5
Benzene measured Location #4
Benzene measured Location #1

Based on the distribution of TPH and the lithology, there is little chance that fuel contamination can enter the deep aquifer at this site.

This conclusion is supported by the concentrations of contaminants in temporary wells at the bottom of the clay layer. Measured concentration are below the MCLs.