Why are cleanups at so many sites not preforming as expected?

Do we need a better definition of success for cleanups?

John T. Wilson, Scissortail Environmental Solutions, LLC.

NTC 2018, Wednesday September 12, 2018

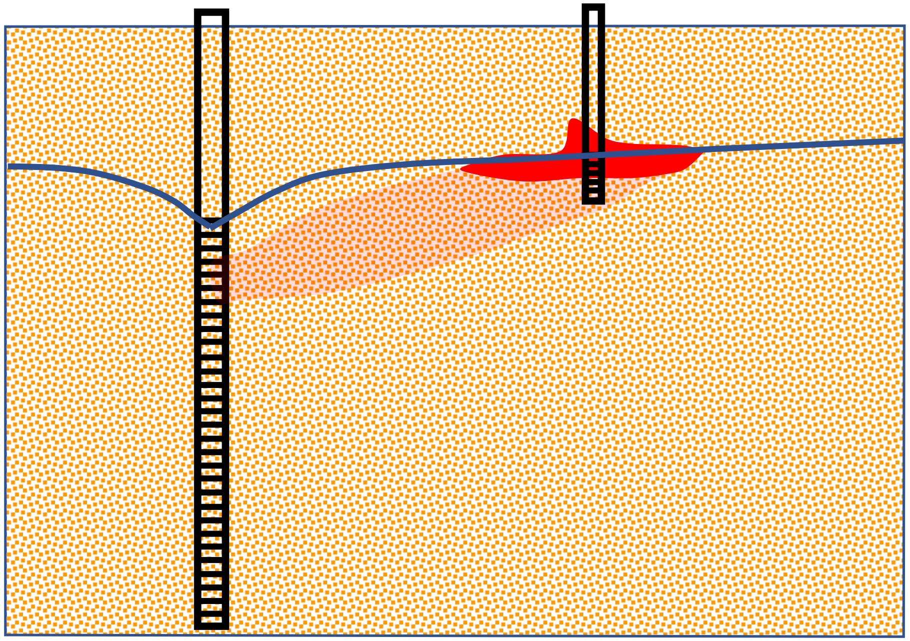
U.S. EPA risk management paradigm is to destroy the hazard or prevent exposure. States implementing the UST program often don’t use the flexibility in the U.S. EPA policy.

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

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

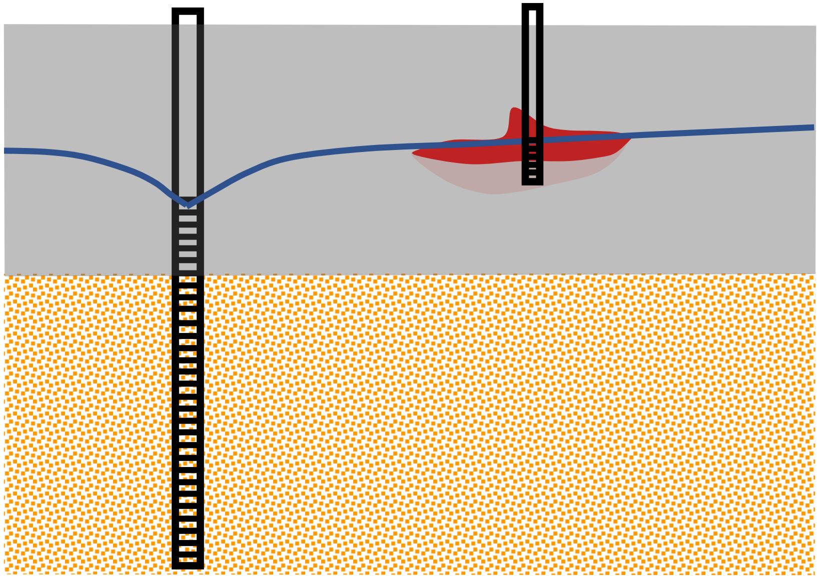
Groundwater flows rapidly through sand and can carry a plume of contamination to a water supply well.

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 and expensive to clean up.



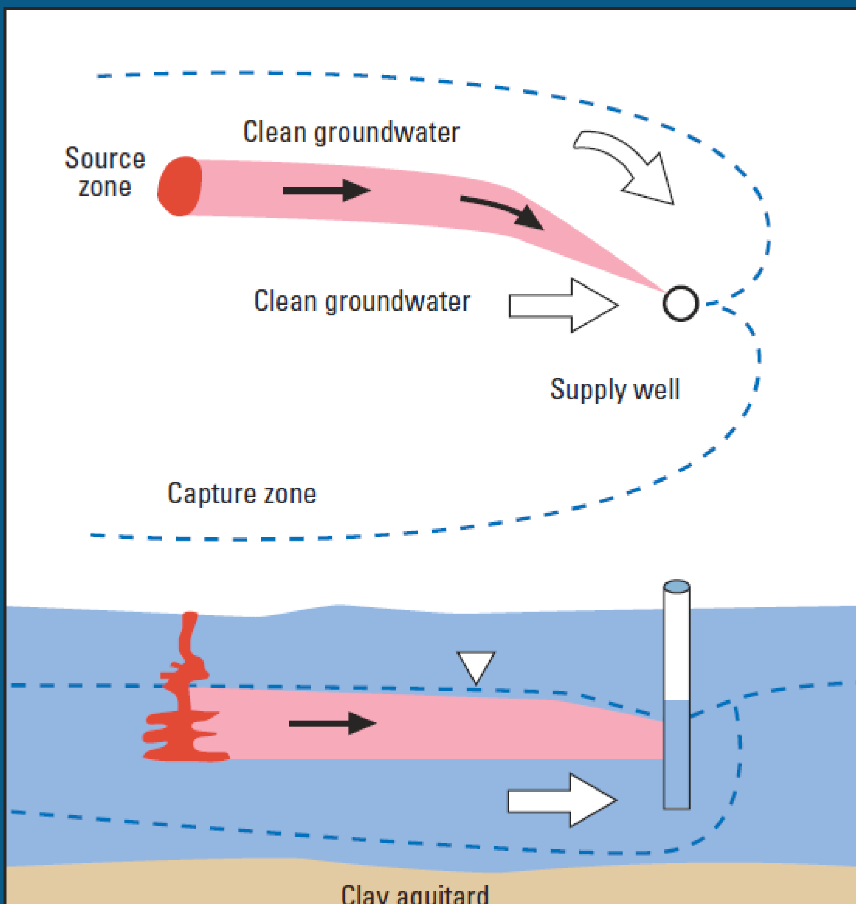
Clay overburden with low hydraulic conductivity is particularly common in flood plain landscapes.

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

FIGURE 1

Plume capture by a supply well

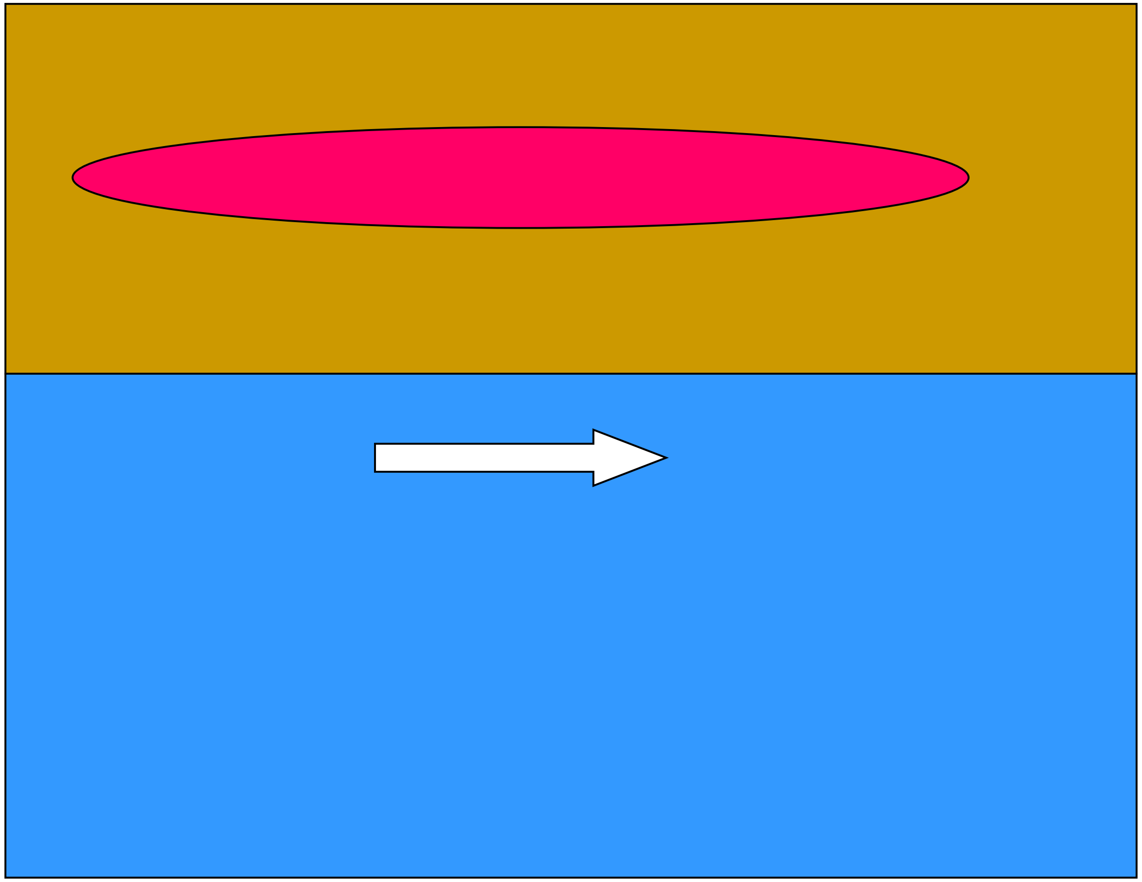
A dissolved plume of contaminants can be hydraulically captured by a downgradient supply well. The contaminant release shown is migrating within a uniform sand aquifer (no fill) overlying a clay aquitard. Clean water on all sides of the plume is also extracted, diluting the concentration of dissolved contaminants in the water pumped from the well.



M. D. Einarson and D. Mackay.

Predicting Impacts of Ground Water Contamination.

Environmental Science & Technology, Vol. 35, No. 3, pages 66A – 73A, 2001.



How does contamination in NAPL in a layer of silt or clay interact with flowing groundwater in an aquifer below the silt or clay layer?

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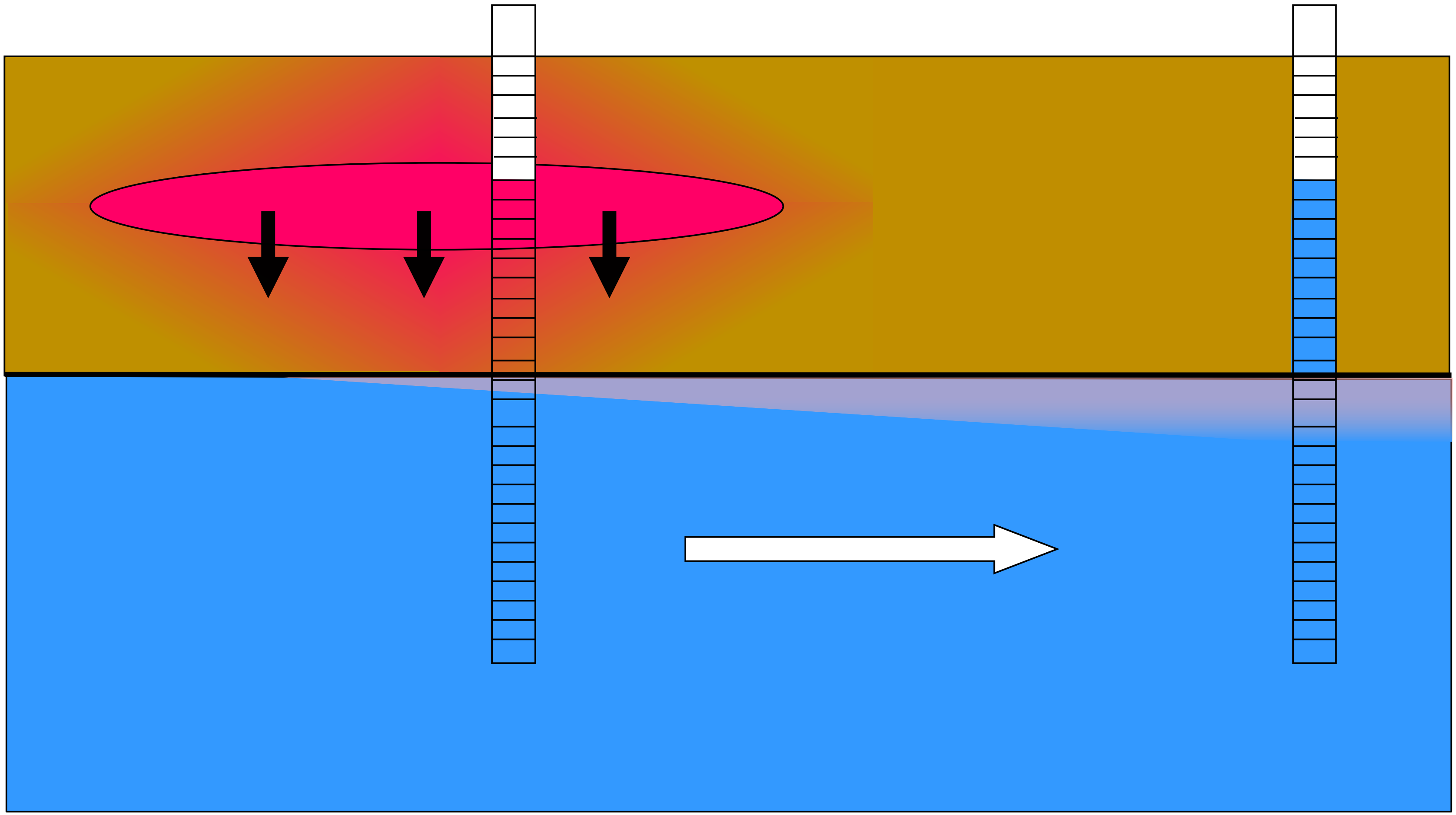

Most of the contamination sampled in a well that is screened across NAPL in clay and silt is not available to move with flowing groundwater.

Case Study of a motor gasoline spill at Port Hueneme, California

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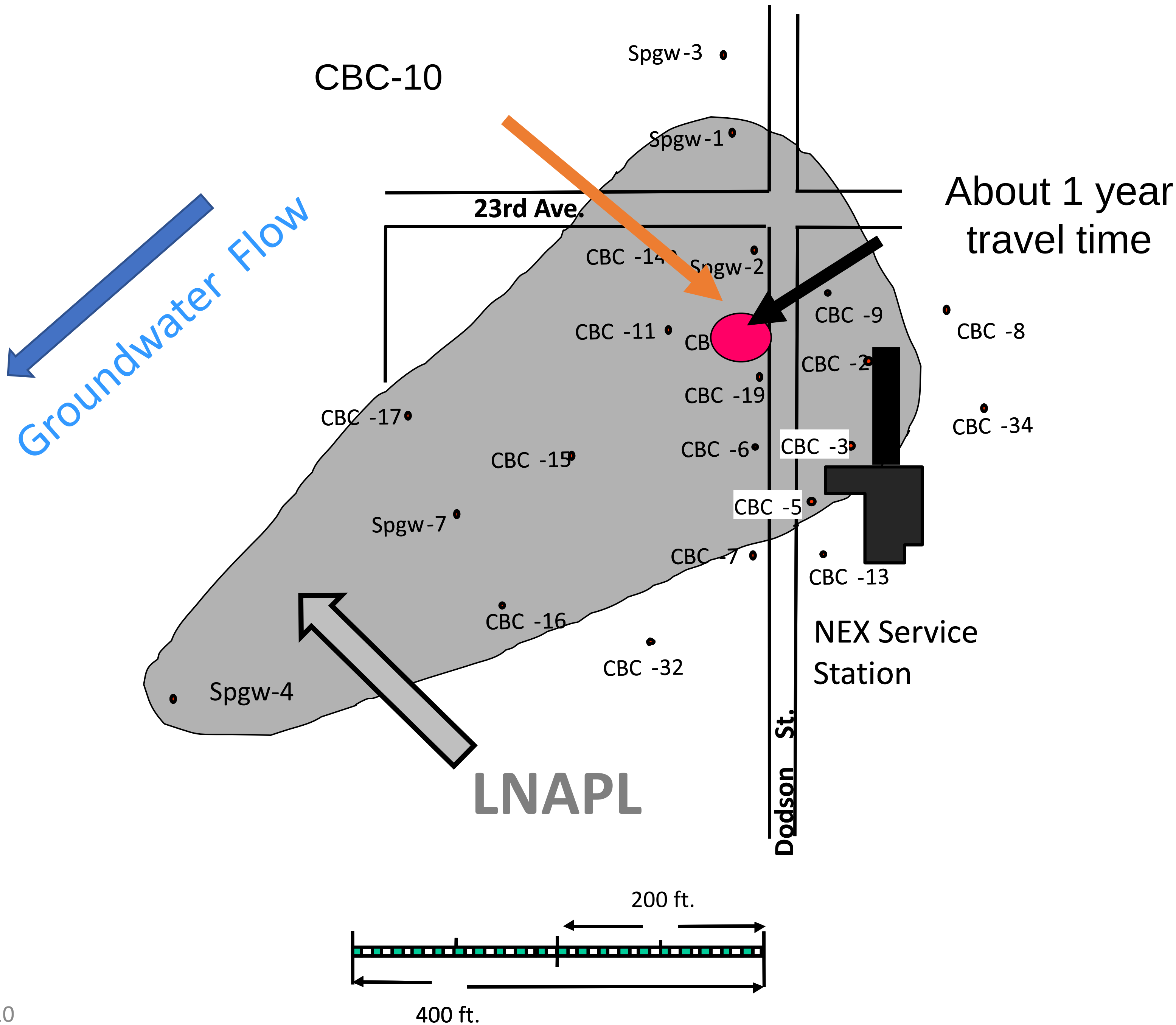
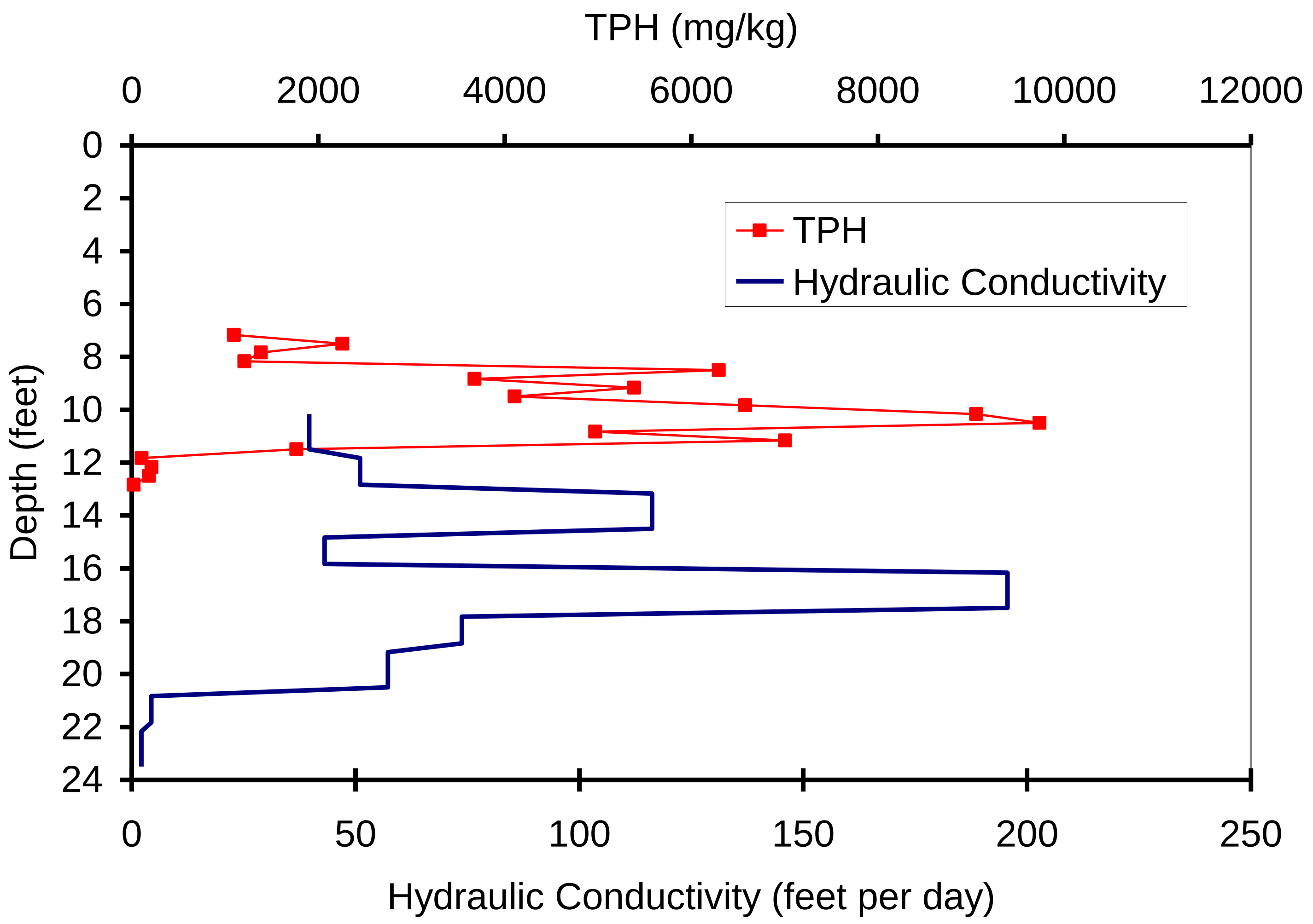
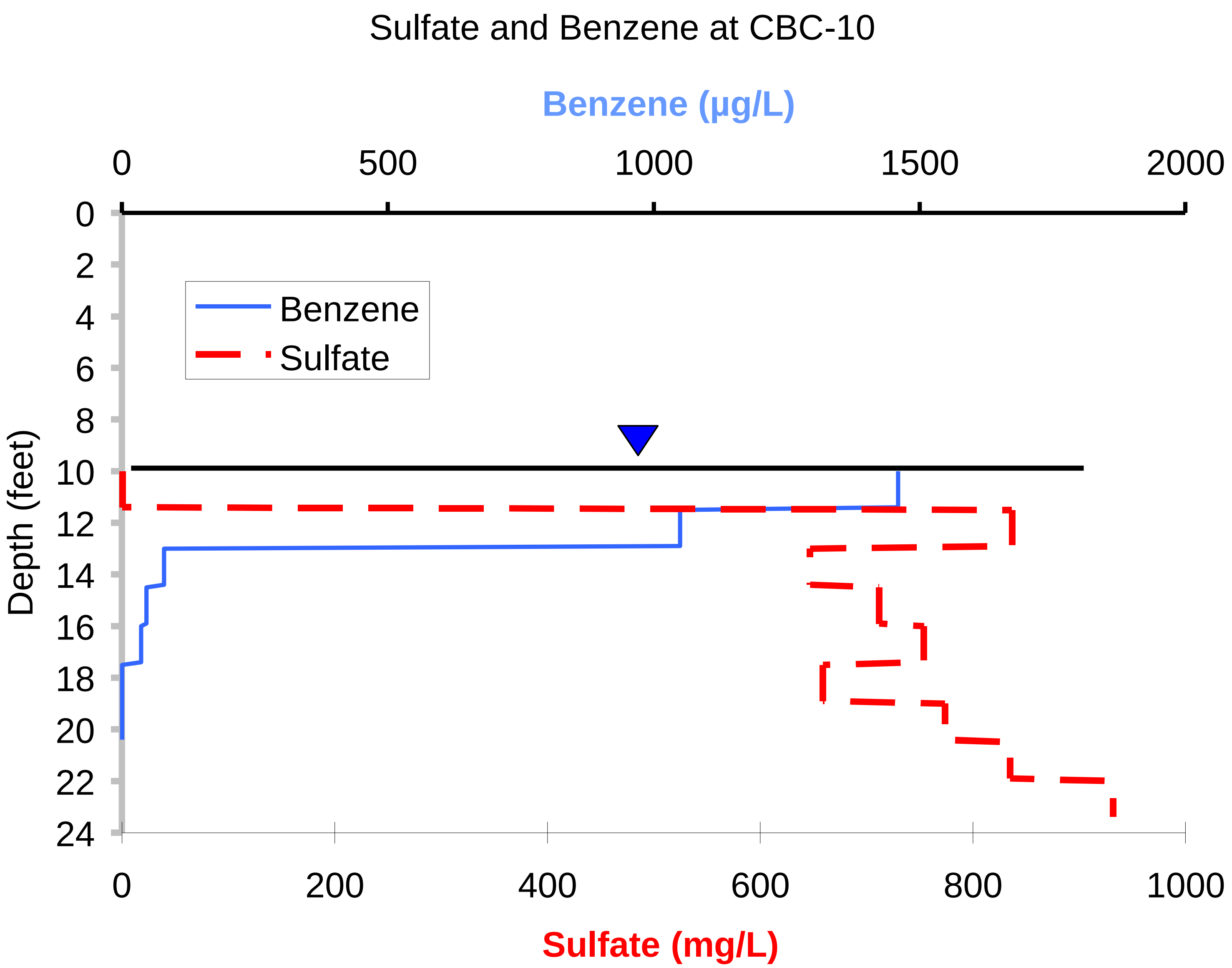

CBC-10
About 1 year travel time
Groundwater Flow
Spgw-3
Spgw-1
23rd Ave.
CBC -14
Spgw-2
CBC -9
CBC -8
CBC -11
CB
CBC -2
CBC -19
CBC -34
CBC -17
CBC -15
CBC -6
CBC -3
CBC -5
Spgw-7
CBC -7
CBC -13
CBC -16
NEX Service Station
CBC -32
Spgw-4
LNAPL
Dodson St.
200 ft.
400 ft.

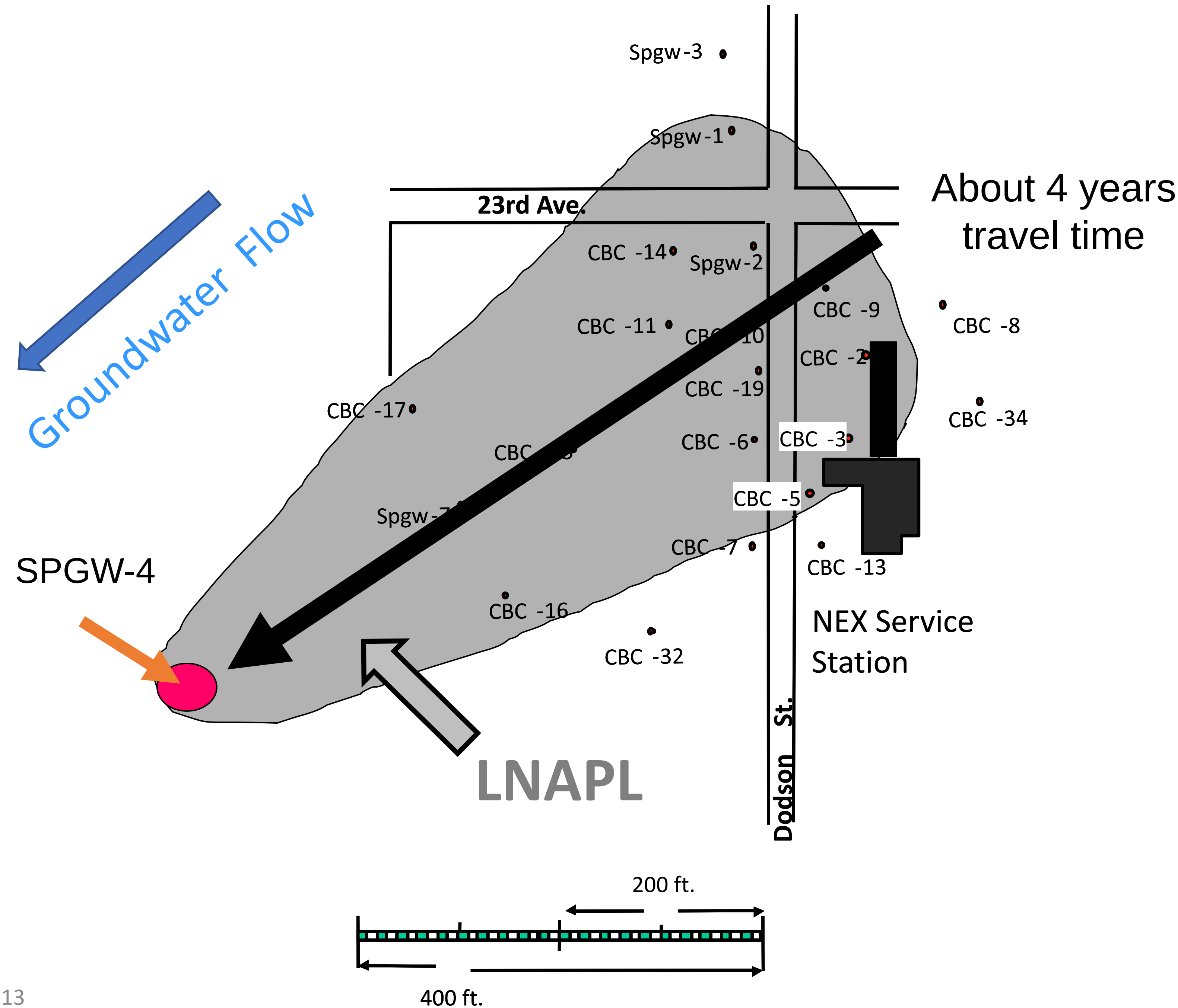
CBC-10



TPH (mg/kg)
0
2000
4000
6000
8000
10000
12000
TPH
Hydraulic Conductivity
Depth (feet)
0
2
4
6
8
10
12
14
16
18
20
22
24
0
50
100
150
200
250
Hydraulic Conductivity (feet per day)

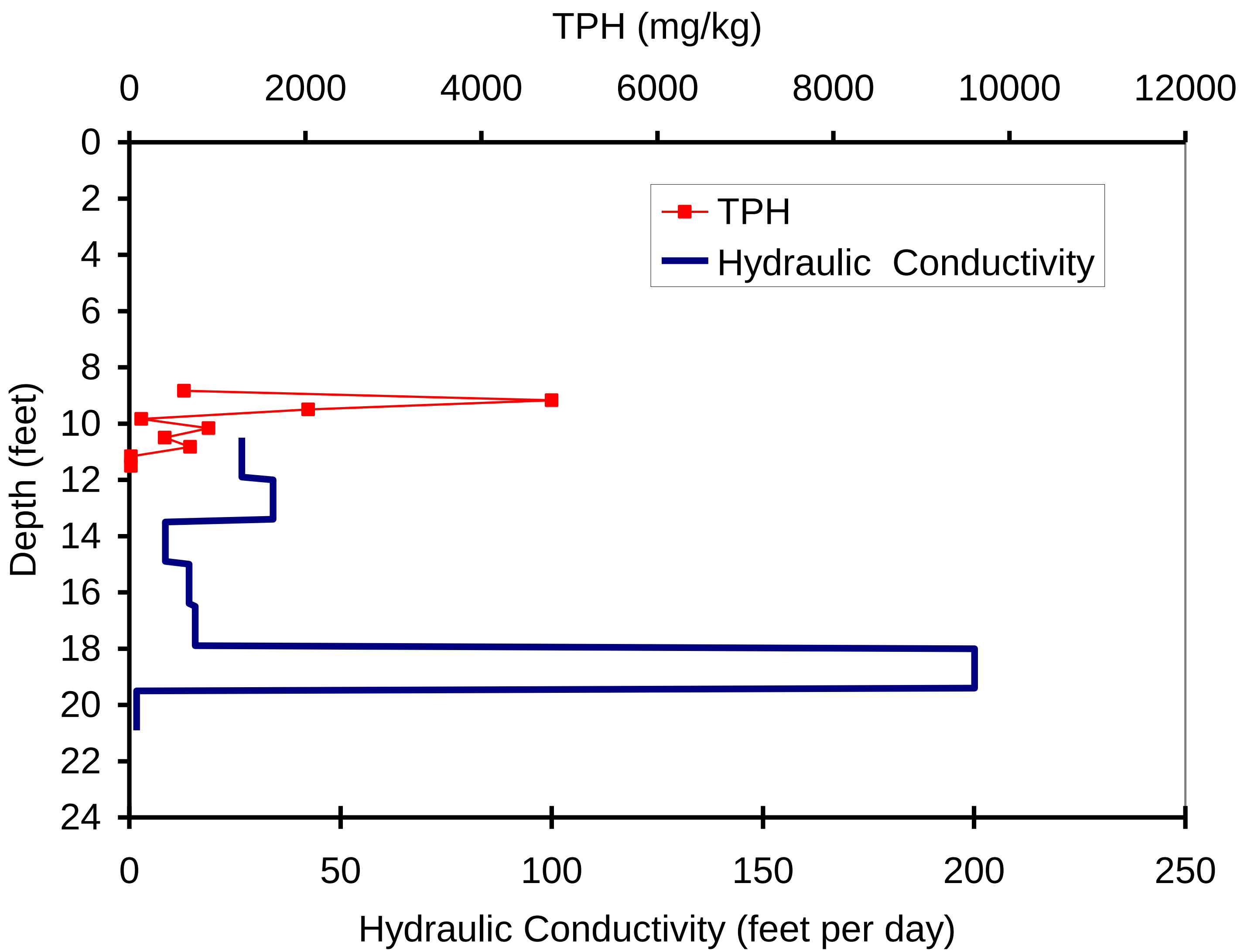

Sulfate and Benzene at CBC-10
Benzene (µg/L)
0
500
1000
1500
2000
0
2
4
6
8
10
12
14
16
18
20
22
24
Depth (feet)
Benzene
Sulfate
0
200
400
600
800
1000
Sulfate (mg/L)

12

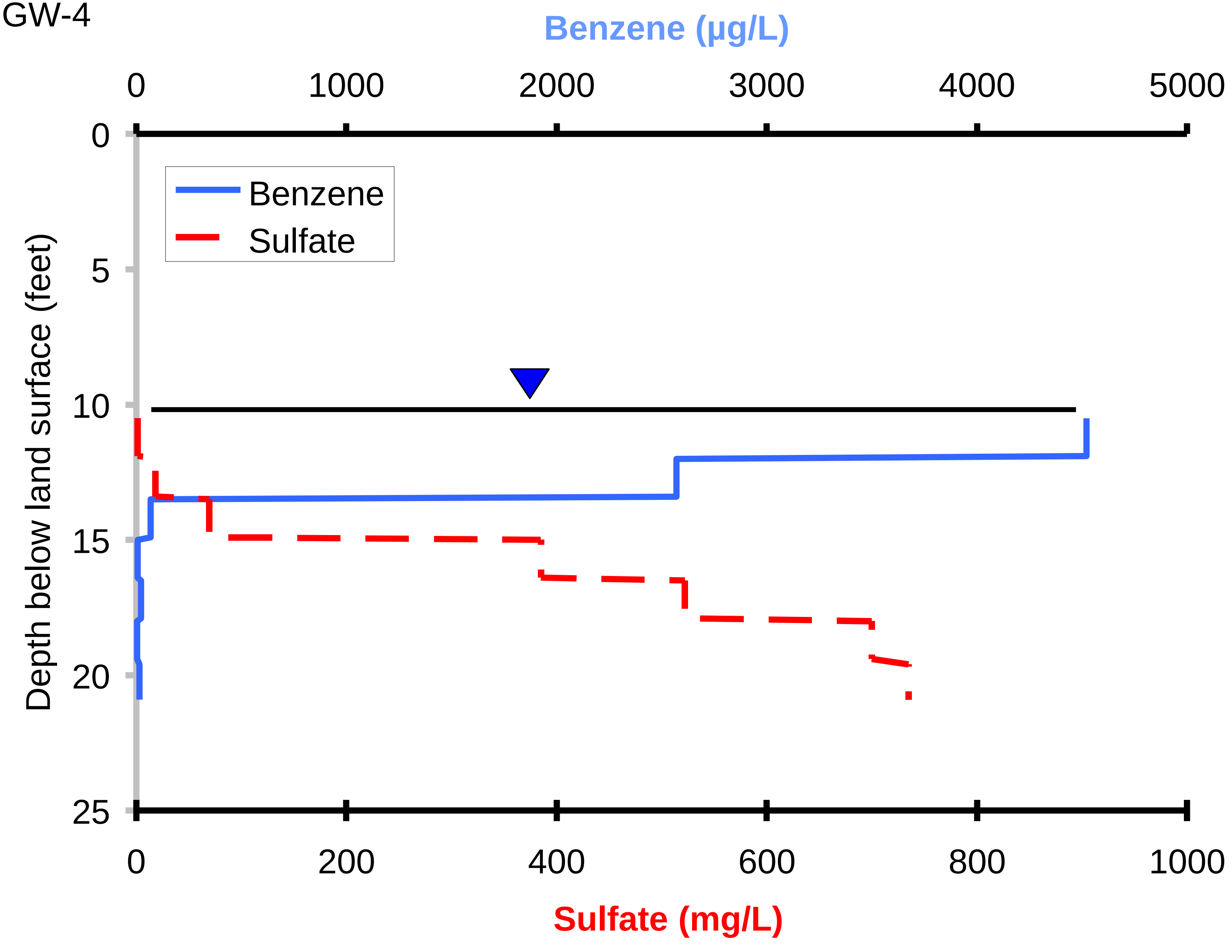


Spgw-3
Spgw-1
23rd Ave.
About 4 years travel time
Groundwater Flow
CBC -14
Spgw-2
CBC -9
CBC -8
CBC -11
CBC -19
CBC -34
CBC -17
CBC -6
CBC -5
CBC -13
SPGW-4
CBC -16
CBC -32
NEX Service Station
LNAPL
Dodson St.
200 ft.
400 ft.

SPGW-4


TPH (mg/kg)
0
2000
4000
6000
8000
10000
12000
TPH
Hydraulic Conductivity
Depth (feet)
0
2
4
6
8
10
12
14
16
18
20
22
24
0
50
100
150
200
250
Hydraulic Conductivity (feet per day)

SPGW-4



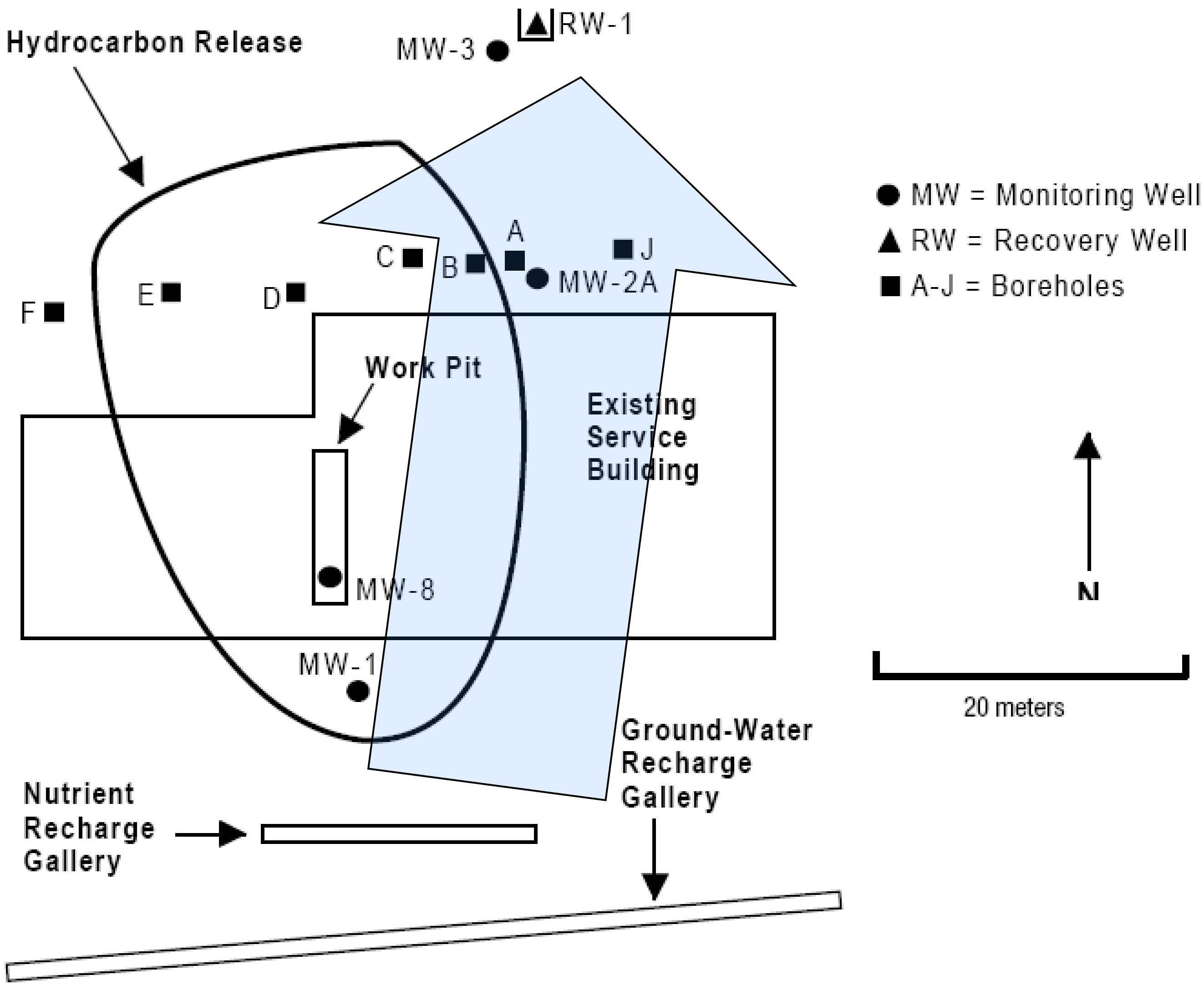
Benzene (µg/L)
0
1000
2000
3000
4000
5000
0
5
10
15
20
25
Depth below land surface (feet)
Benzene
Sulfate
0
200
400
600
800
1000
Sulfate (mg/L)

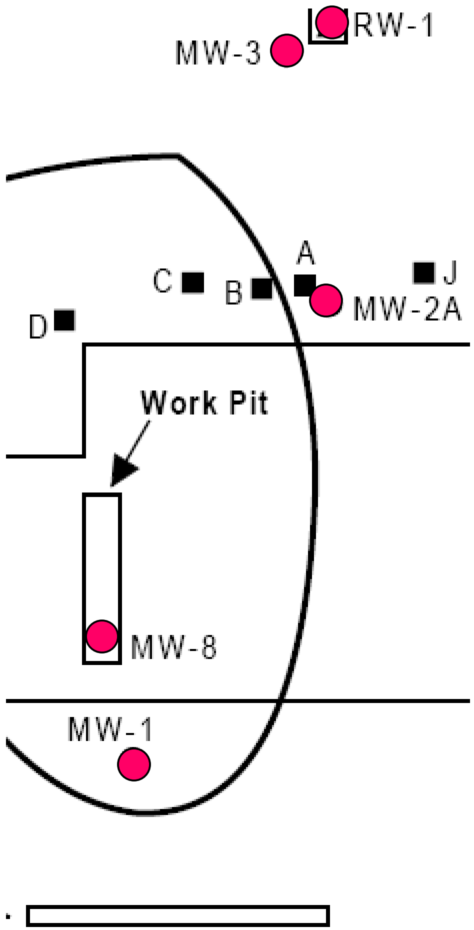
Case study from the Public Services Site, a RCRA site in Denver, Colorado.

The site was a garage used to service trucks.

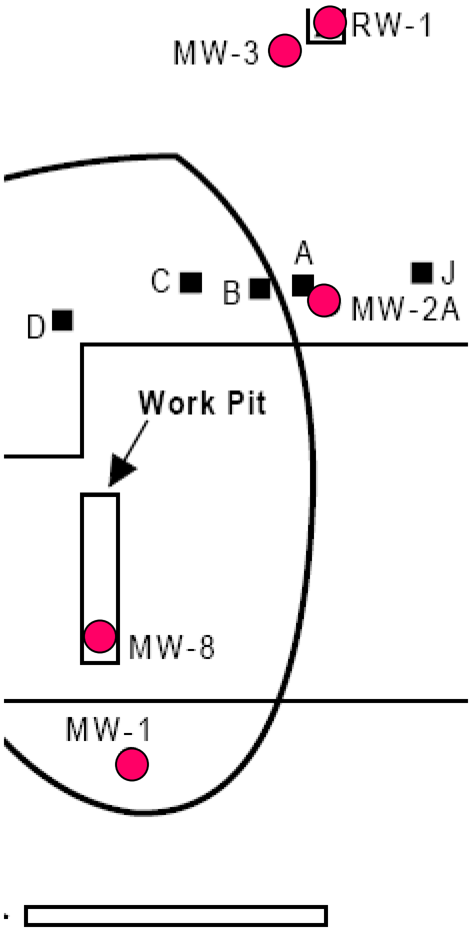
Gasoline, motor oil, and transmission fluid was disposed to dry well under the floor of the garage.

Ground water was cleaned up using aerobic in situ bioremediation.

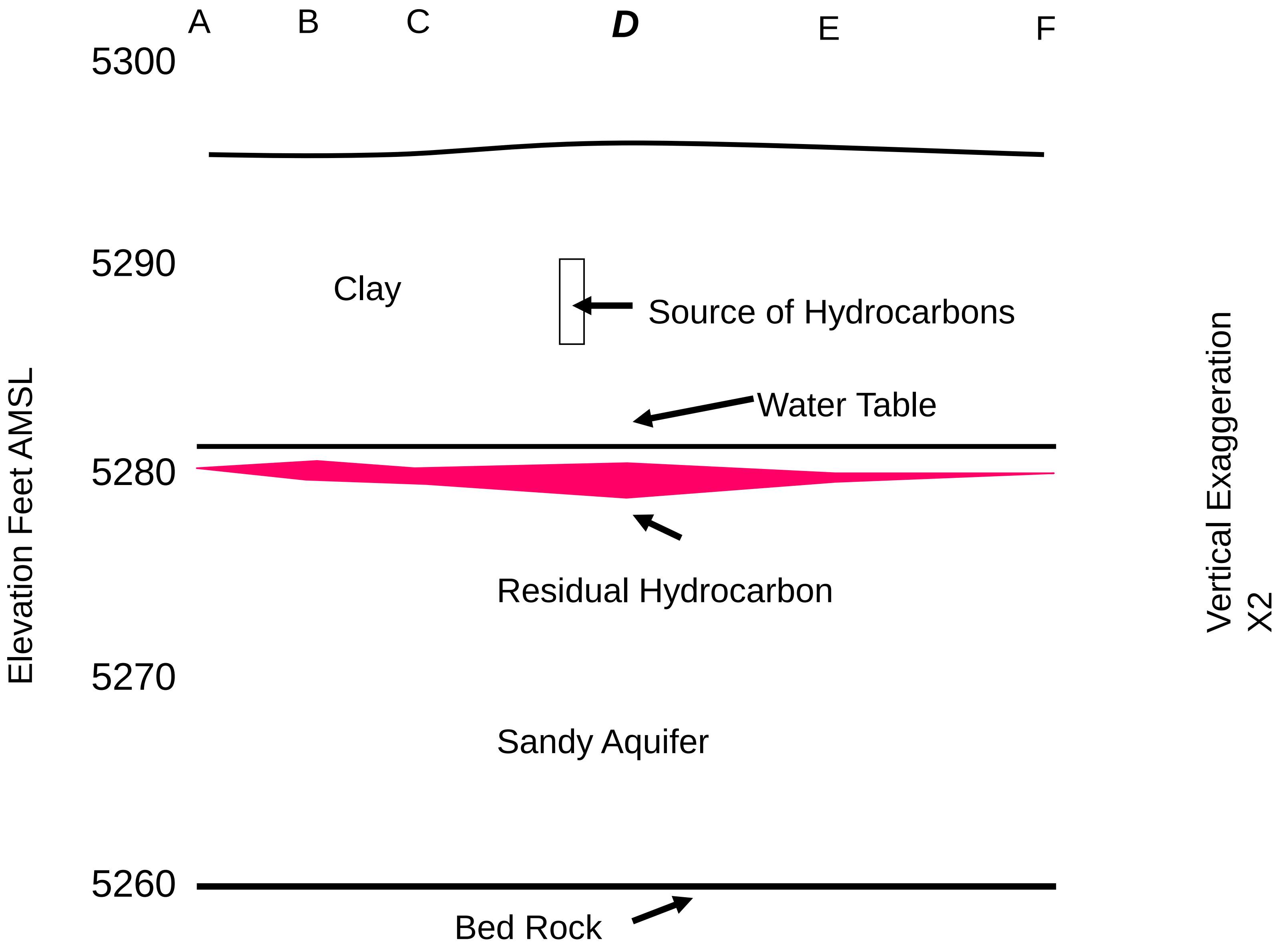

Hydrocarbon Release
MW-3
RW-1
A
C
B
J
MW-2A
E
D
F
Work Pit
Existing
Service
Building
MW-8
MW-1
Ground-Water
Recharge
Gallery
Nutrient
Recharge
Gallery
MW = Monitoring Wells
RW = Recovery Well
A-J = Boreholes
N
20 meters



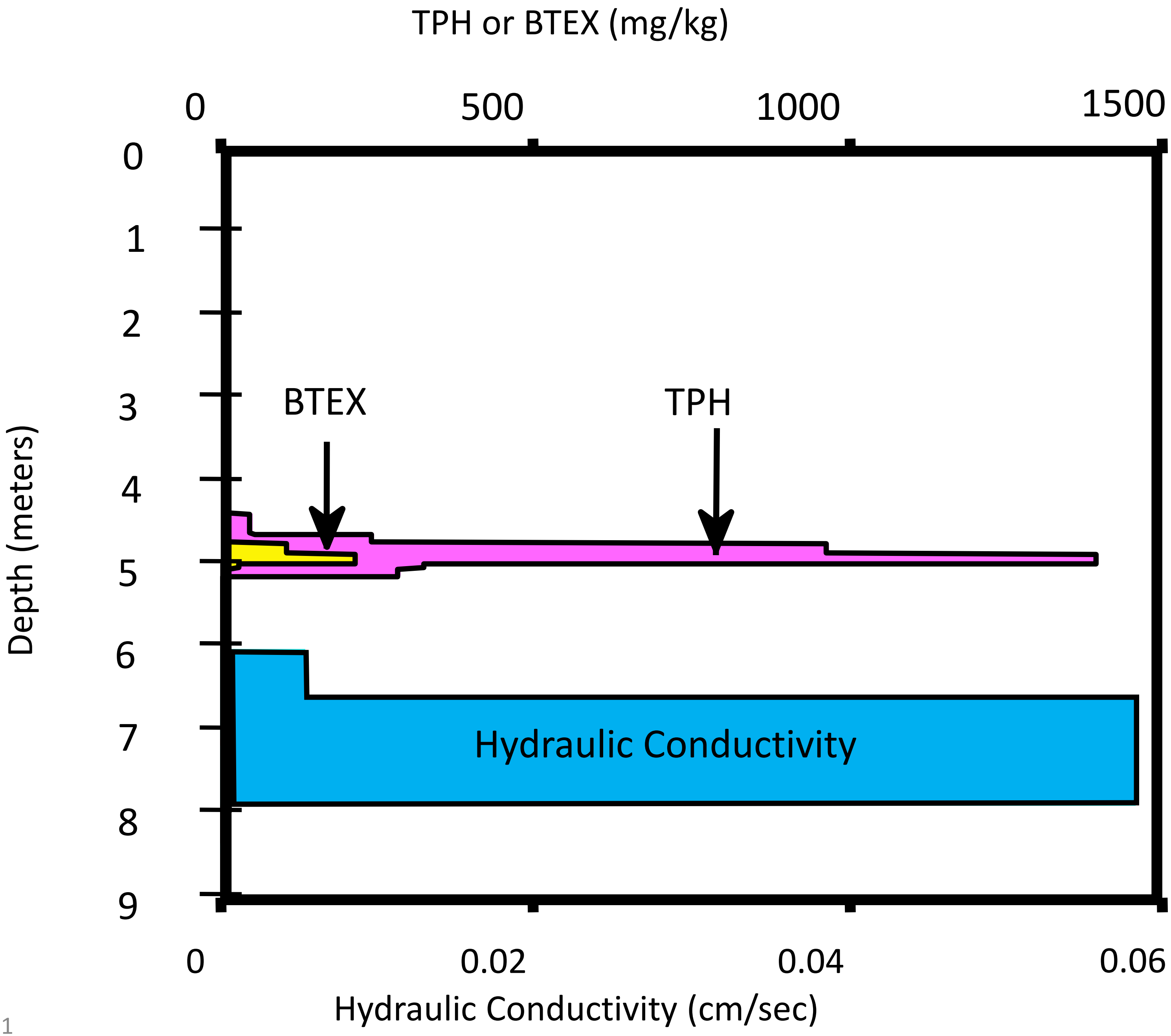
Reduction in BTEX During Bioremediation			
Well	Before	During	After
	µg/L		
MW-1	2,030	164	<6
MW-8	1,800	331	34
MW-2A	?	1,200	13
MW-3	1,200	820	46
RW-1	<1	2	<1



Reduction in Benzene During Bioremediation			
Well	Before	During	After
	µg/L		
MW-1	220	<1	<1
MW-8	180	130	16
MW-2A	?	11	0.8
MW-3	11	5	2
RW-1	<1	2	<1



A
B
C
D
E
F
5300
5290
5280
5270
5260
Clay
Source of Hydrocarbons
Water Table
Residual Hydrocarbon
Sandy Aquifer
Bed Rock
Elevation Feet AMSL
Vertical Exaggeration
X2



TPH or BTEX (mg/kg)
0
500
1000
1500
Depth (meters)
0
1
2
3
4
5
6
7
8
9
BTEX
TPH
Hydraulic Conductivity
0
0.02
0.04
0.06
Hydraulic Conductivity (cm/sec)

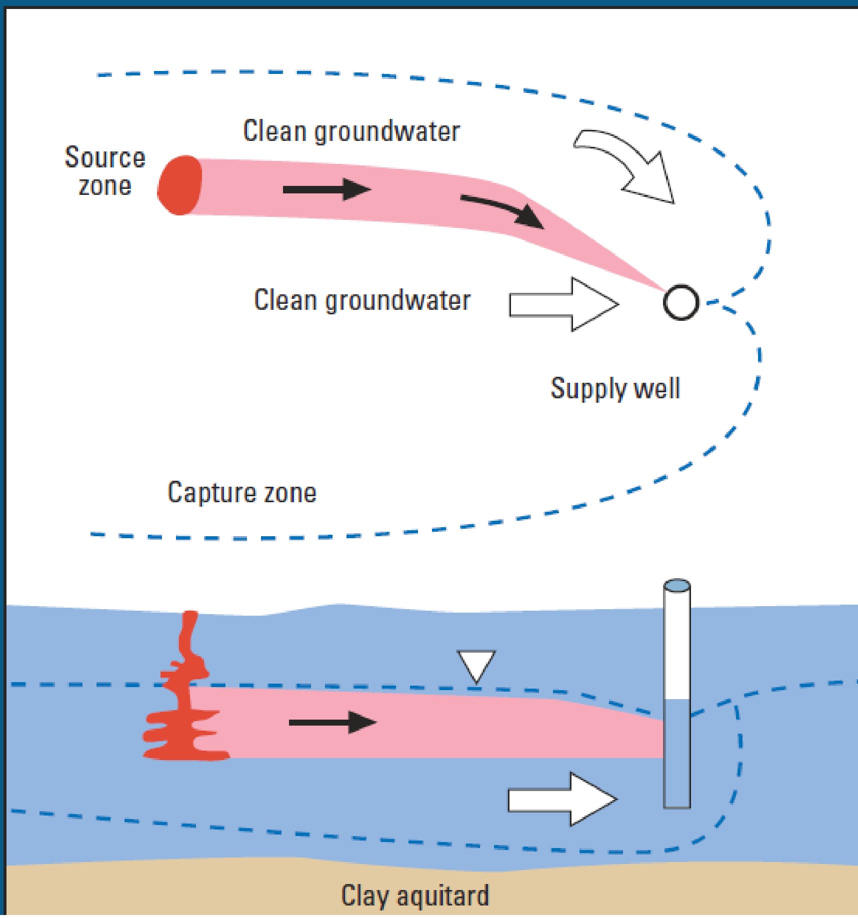
Electron Acceptor Supply at the Public Services Site				
Depth	Hydraulic Conductivity	Dissolved Oxygen	Nitrate Nitrogen	Sulfate
Meters below grade	cm/sec	mg/L		
5.48 to 6.10	0.00012	Could not measure	Could not measure	Could not measure
6.10 to 6.71	0.0049	0.6	8.9	226
6.71 to 7.21	0.058	0.3	7.1	232
7.21 to 7.92	0.058	0.5	4.9	239
9.92 to 8.53	0.000204	1.4	4.8	215
8.53 to 9.14	<0.000001	Could not measure	Could not measure	Could not measure

Fuel Derived Organic Compounds at the Public Services Site				
Depth	Hydraulic Conductivity	MTBE	Benzene	BTEXTMB
Meters below grade	cm/sec	µg/L		
5.48 to 6.10	0.00012	10.6	11.3	636
6.10 to 6.71	0.0049	<1	2.8	64
6.71 to 7.21	0.058	<1	1.0	25
7.21 to 7.92	0.058	<1	<1	23
9.92 to 8.53	0.000204	<1	<1	24
8.53 to 9.14	<0.000001	<1	<1	92

FIGURE 1

Plume capture by a supply well

A dissolved plume of contaminants can be hydraulically captured by a downgradient supply well. The contaminant release shown is migrating within a uniform sand aquifer (no fill) overlying a clay aquitard. Clean water on all sides of the plume is also extracted, diluting the concentration of dissolved contaminants in the water pumped from the well.



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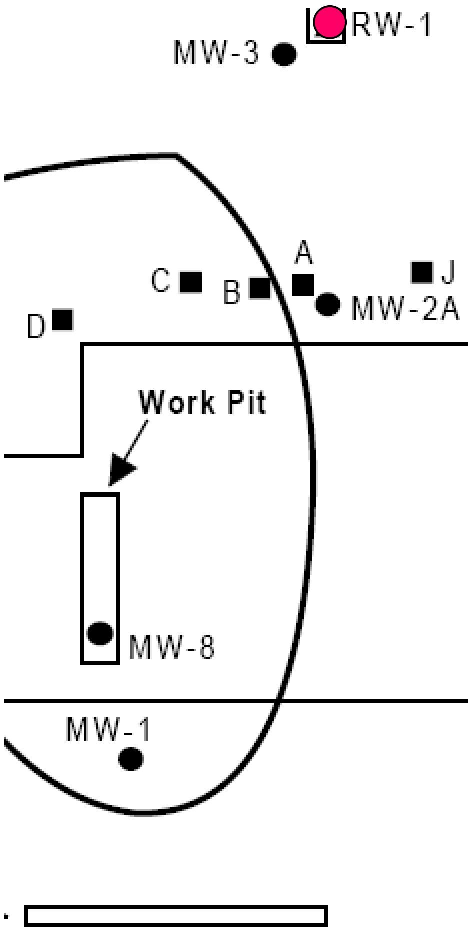

Reduction in BTEX During Bioremediation			
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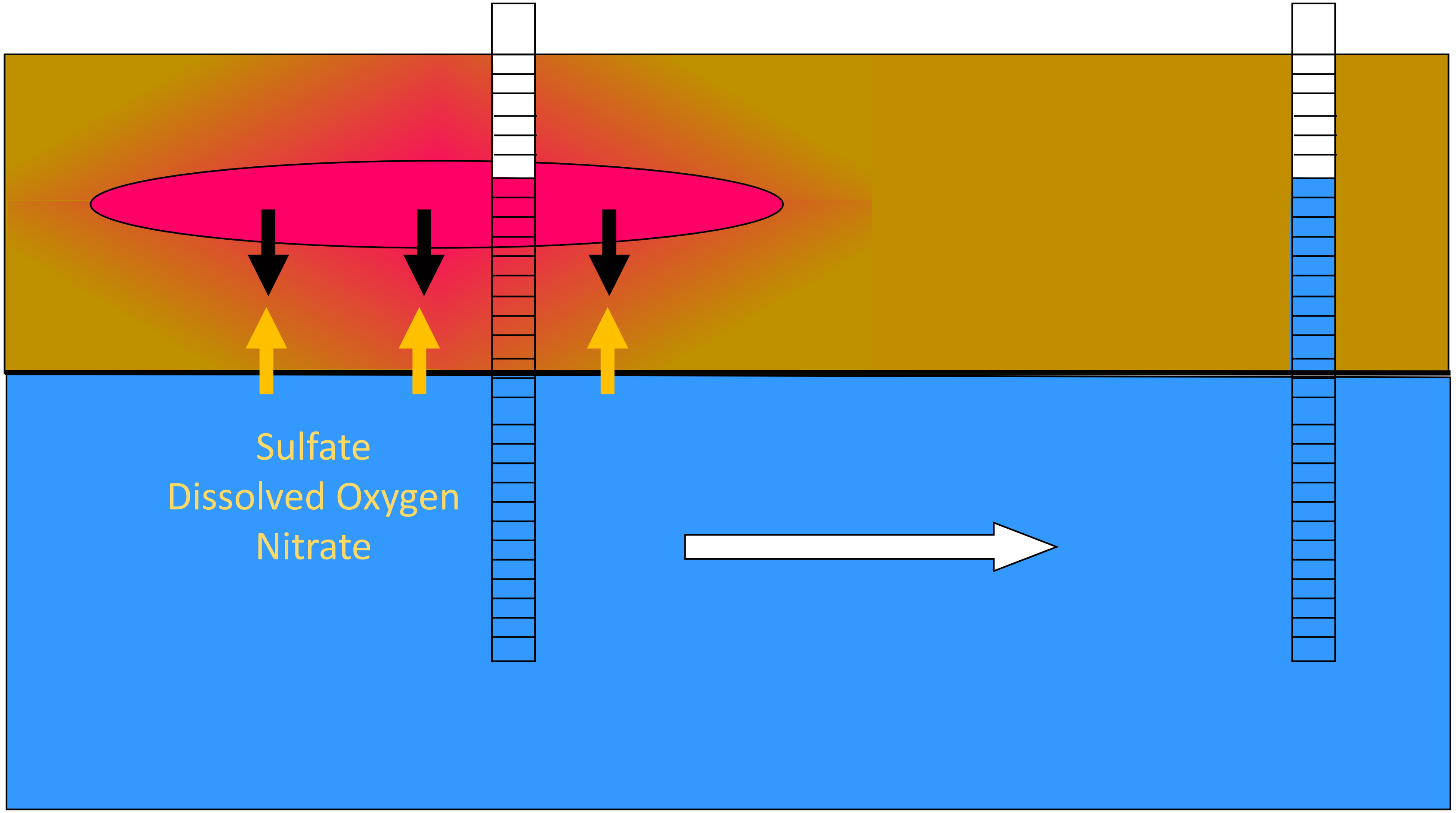
MW-2A	?	1,200	13
MW-3	1,200	820	46
RW-1	<1	2	<1

The pumped recovery well was never contaminated.



Soluble electron acceptors can diffuse into the clay and allow the bacteria to biodegrade the contaminants before they ever got to the aquifer.

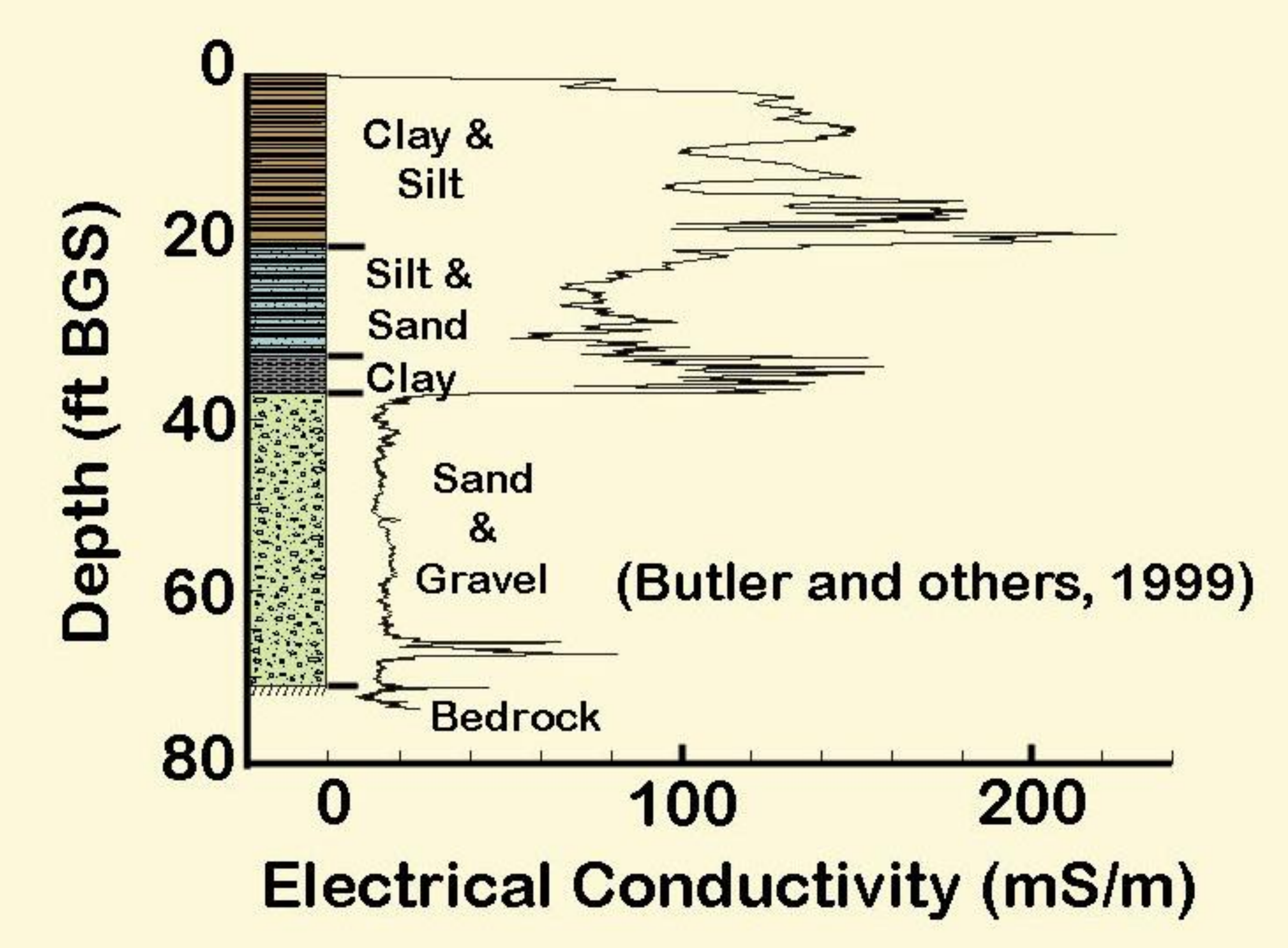
If the natural attenuation processes in the aquifer consume the contamination in the high flow zones as fast as the contamination leaves the low flow zones, the contamination cannot move away from the spill and the receptor is protected.

If groundwater that leaves the spill site meets drinking water standards, then natural processes are protecting the aquifer as a source of drinking water.

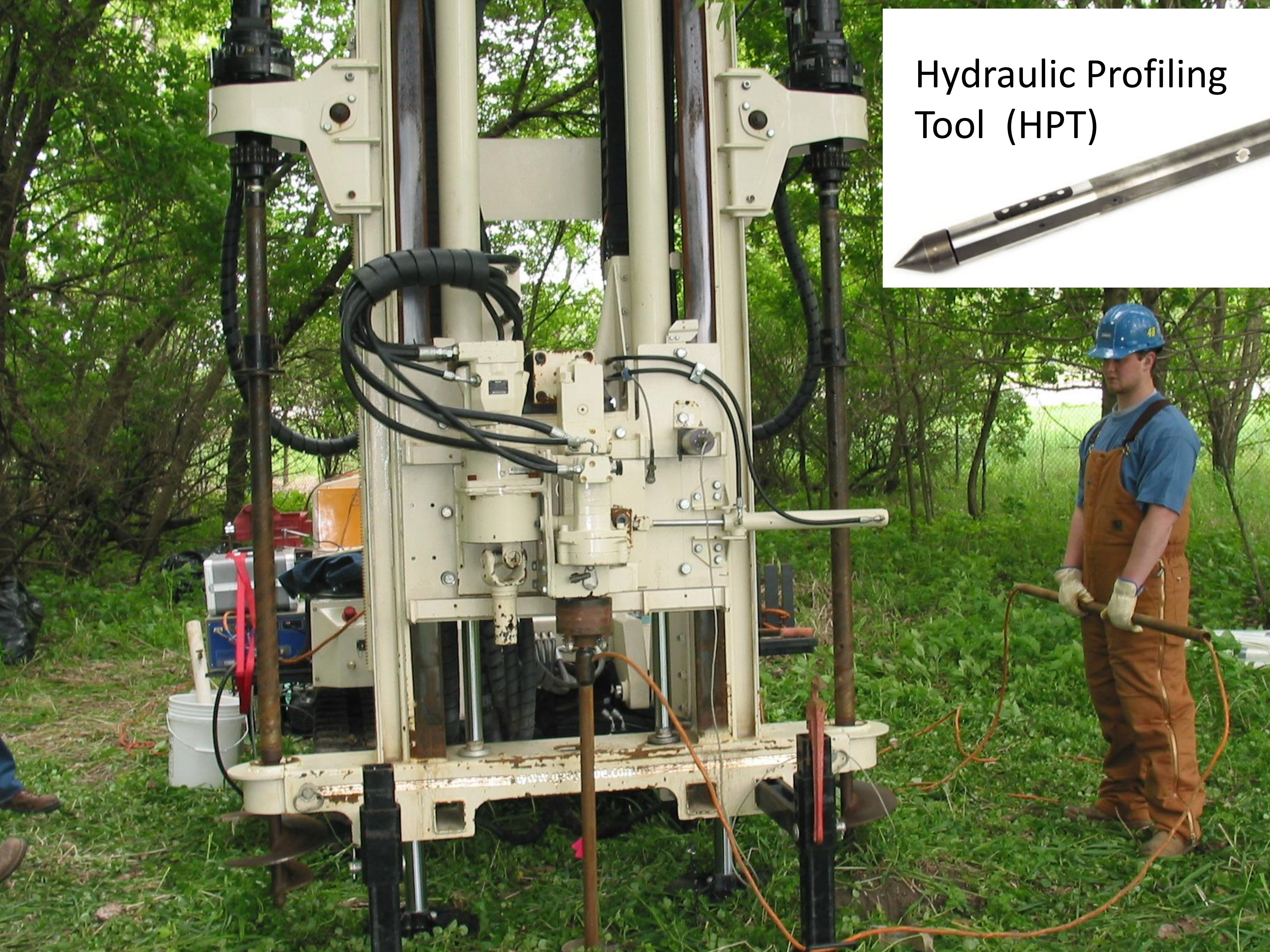
It may not be necessary to clean the water in all of the monitoring wells to drinking water standards to be protective of the aquifer as a source of drinking water.

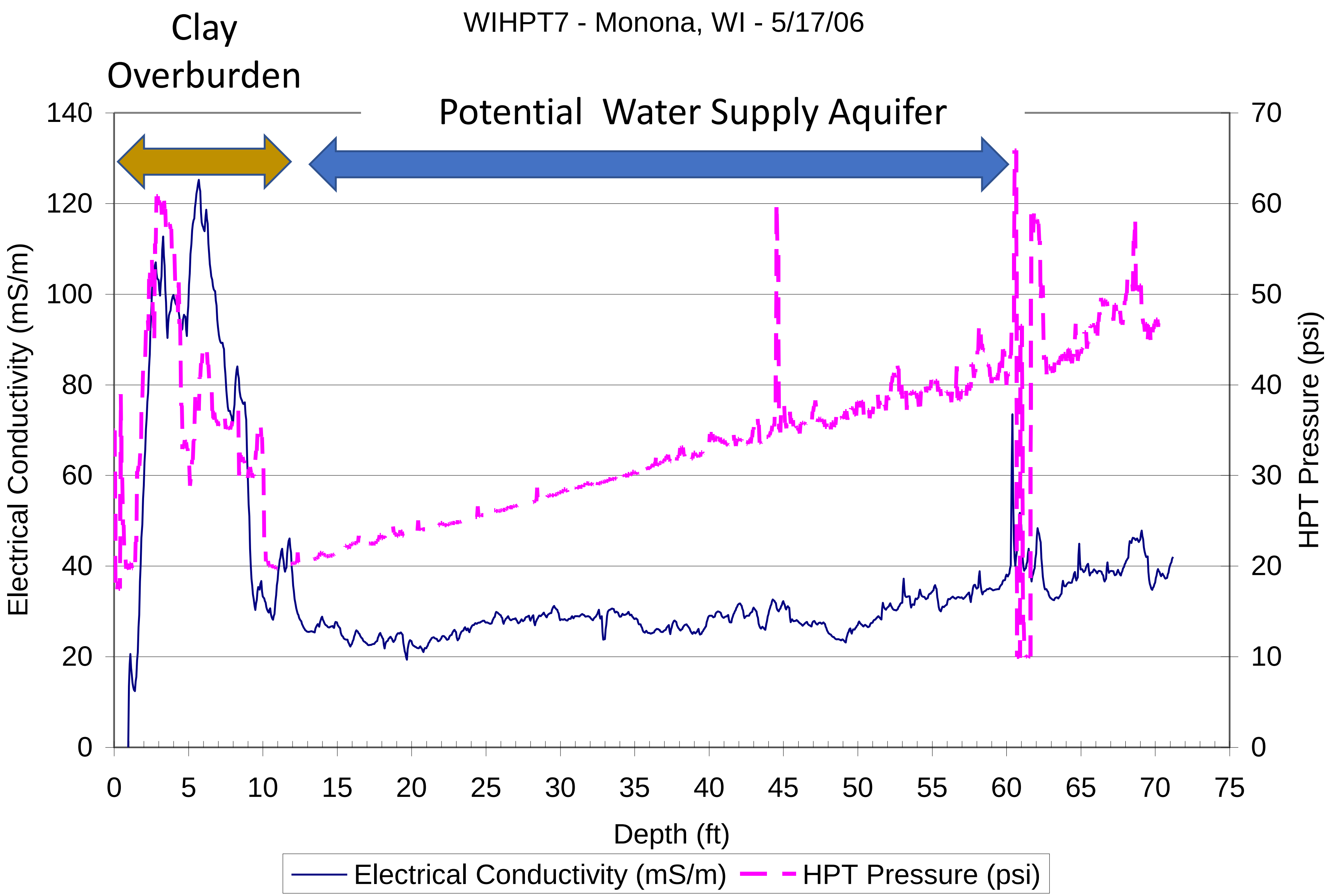
It is only necessary to clean the spill to the point where groundwater that leaves the spill site meets drinking water standards.


Electrical Conductivity Probe



Depth (ft BGS)
0
20
40
60
80
Clay &
Silt
Silt &
Sand
Clay
Sand
&
Gravel
Bedrock
(Butler and others, 1999)
0
100
200
Electrical Conductivity (mS/m)


Hydraulic Profiling
Tool (HPT)



Clay
Overburden
WIHPT7 - Monona, WI - 5/17/06
Potential Water Supply Aquifer
140
120
100
80
60
40
20
0
Electrical Conductivity (mS/m)
70
60
50
40
30
20
10
0
HPT Pressure (psi)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
Depth (ft)
Electrical Conductivity (mS/m)
HPT Pressure (psi)

Use the geophysical and site characterization tools to install monitoring wells that sample the aquifer in the same way a water production well would sample the aquifer. (Screen across the aquifer. Do something better than a five foot screen set across the water table).

Install monitoring wells down-gradient of the LNAPL. (check the OVM data in the well construction logs)

Interpret the need for further cleanup based on concentrations of contaminants in the down-gradient wells that are not influenced by LNAPL.