Area B Groundwater Investigation Fort Detrick

Progress Report to the RAB

May 8, 2013

John Cherry

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Overview of Topics

- Work Completed Since February 2013 RAB Meeting and Project Status
- Groundwater Tracer Study Overview
- Vapor Intrusion Update (Phase 1)
- Upcoming Work
- Next Steps

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Work Completed Since the Last RAB

- Met with EPA and MDE to review the Draft Conceptual Site Model (CSM) report (February '13)
  - The CSM was discussed with the RAB during the last meeting.
- Received results for first round of Vapor Intrusion sampling
  - 4 off-post and 1 on-post buildings
- Initiated stream survey and background survey for groundwater tracer study.
- Continued to work on Right-of-Entry agreements for upcoming work.

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Status of Original RI Work Plan Activities

✓ Existing well assessment and repair	Feb 2011 to Apr 2011
✓ New well installation (onsite)	April 2011 to Mar 2012
✓ Direct Push Investigation	March 2012
✓ Spring and Seep Surveys	March 2012
✓ Groundwater/Surface Water Sampling	April 2012 /Sept 2012
► **Vapor Intrusion Sampling**	Jan 2013 (Round 1) **Summer 2013 (Round 2)**
► **Groundwater tracer study**	**Spring 2013 to Fall 2013**

Grey = completed

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Status of CERCLA Process

Current Phase →

- Remedial Investigation
  - Data collection and development of CSM
  - Future phase will include a full risk assessment as required by CERCLA

Interim Phase → Interim Remedial Action (connection of select residences to municipal water)

Future Phases

- Feasibility Study (Assessment of possible remedies)
- Proposed Plan (Public document to solicit input on preferred remedy)
- Record of Decision (Final legal document selecting remedy)
- Remedial Action (Implement Final Remedy)

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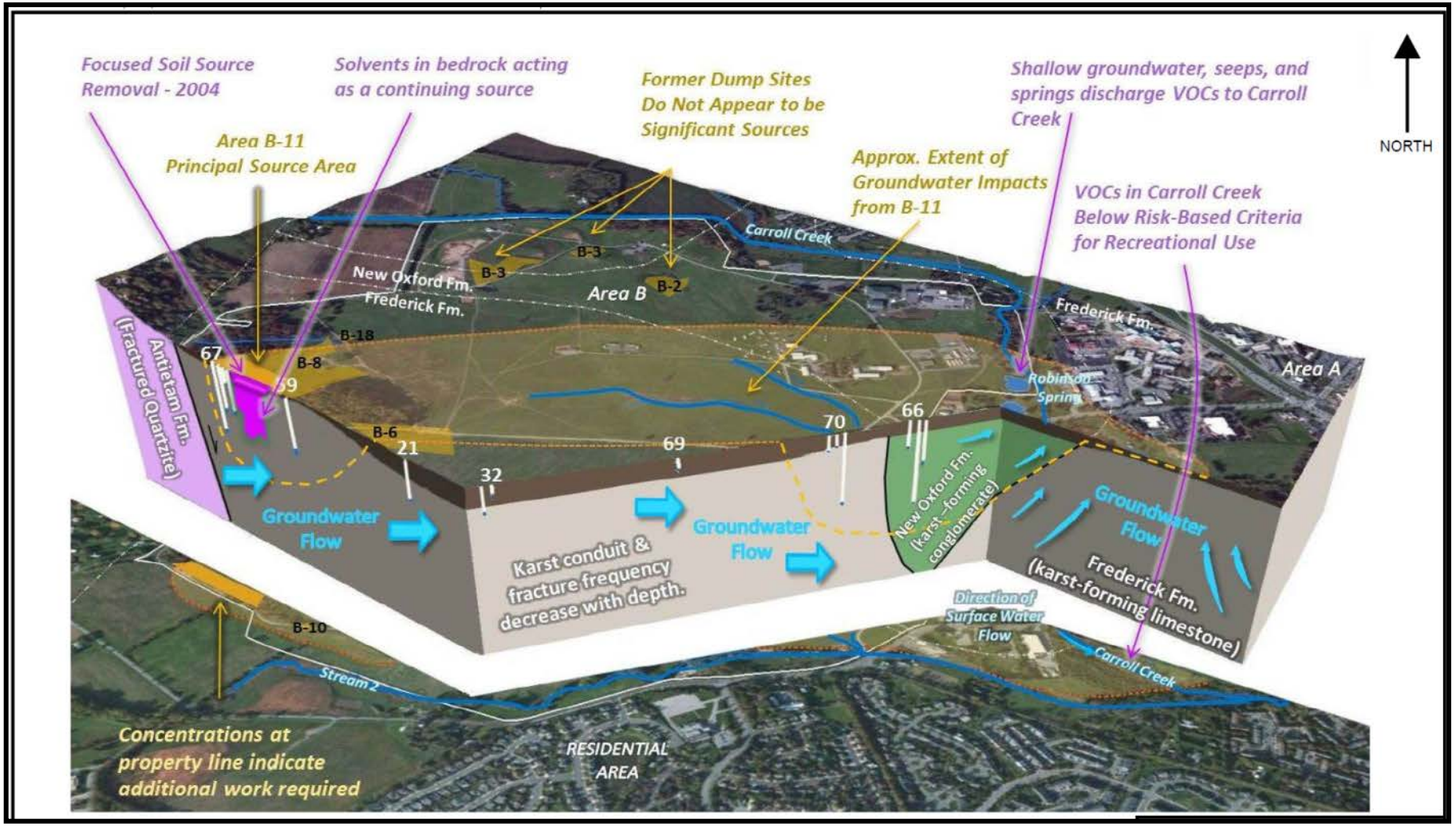
Area B Conceptual Site Model Review



Legend

- Streams
- Spring
- B-11 Boundary
- Trichloroethene in Groundwater
- Groundwater Flow Direction
- Geologic Contact

Aerial Source: ArcGIS Online Bing Imagery accessed 6/13/2012 via ArcGIS 10.

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Groundwater Tracer Study Overview

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Groundwater Tracer Study

- What is a groundwater tracer study?

- A tracer is introduced to the groundwater and monitored over time to see where and when the tracer appears at other monitoring points in the study area (e.g. wells, springs, surface water bodies).

- Useful for evaluating the groundwater flow velocity and direction of groundwater movement.

Groundwater Tracer Study

- Why is a groundwater tracer study planned at Area B?

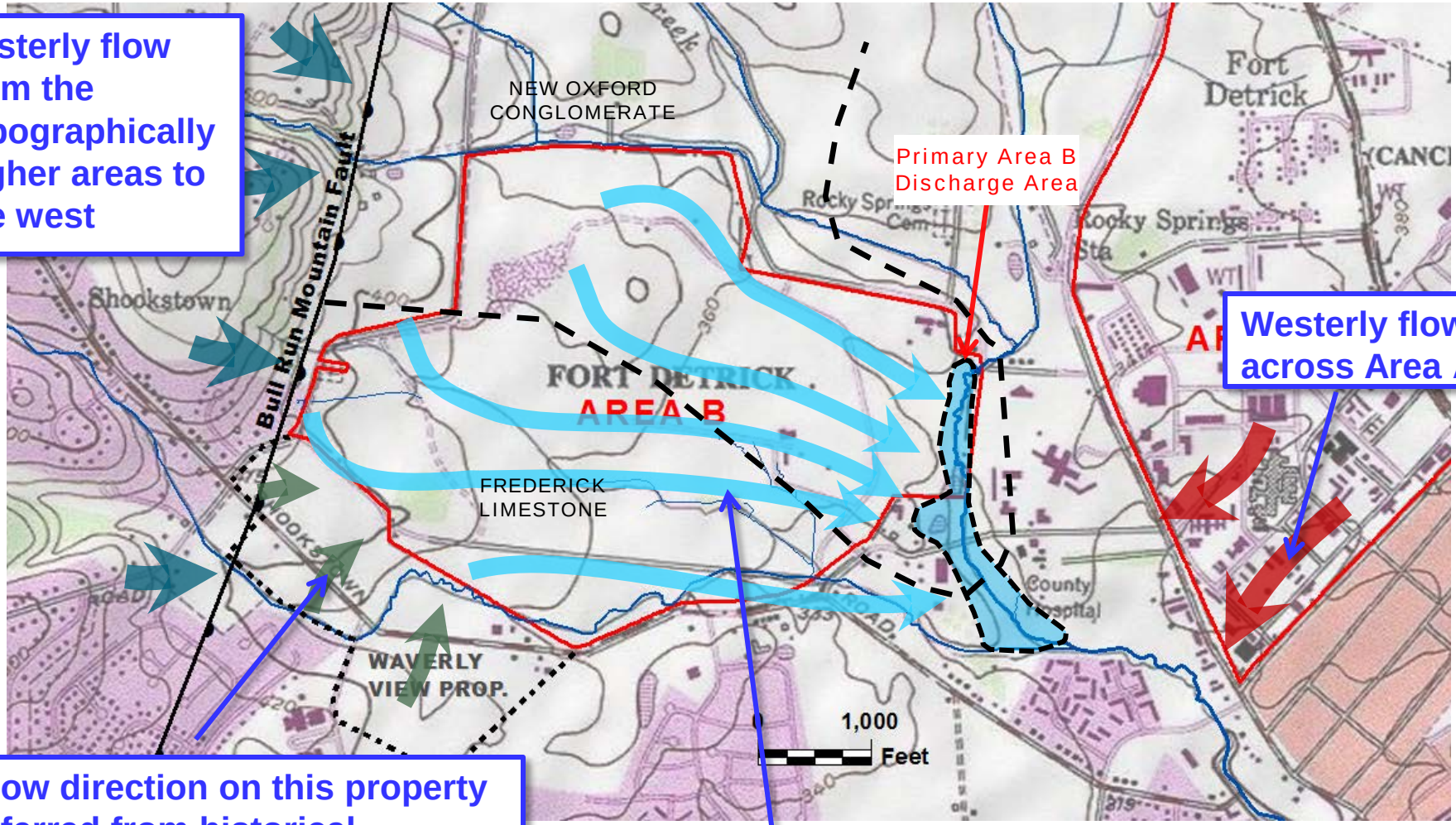
- To evaluate the movement of deep groundwater from the B-11 area and identify locations where groundwater discharges to springs and streams within the study area.
- The tracer study will confirm our understanding of groundwater flow within the study area and help identify any previously unknown points of discharge.
- Note a tracer study has been planned since the EPA-approved 2010 Remedial Investigation Work Plan and is now the next phase of work to be completed. This study will be an expansion of a prior tracer study completed in 1995.

Groundwater Tracer Study

- How does a tracer study work?

1. A background study is completed to choose an appropriate tracer and establish baseline conditions to account for possible interferences .
2. The chosen nontoxic tracer will be introduced to the groundwater via two deep Area B monitoring wells.
3. Frequent monitoring will be begin following a prescribed schedule:
   - Approximately 90 monitoring locations.
   - Weekly sampling at each monitoring location initially. Then reduced to biweekly or monthly as the study progresses.
   - Laboratory analysis of sampling devices and water samples each week will identify even low part-per-billion concentrations of the tracer.
4. Data evaluation will identify primary discharge locations for the tracer (and consequently groundwater) potentially including previously unidentified discharge locations. The results will factor into future investigation and/or remediation decisions.

Generalized Patterns of Groundwater Flow



Easterly flow from the topographically higher areas to the west

Westerly flow across Area A

Flow direction on this property inferred from historical measurements in existing monitoring wells

Easterly flow across Area B

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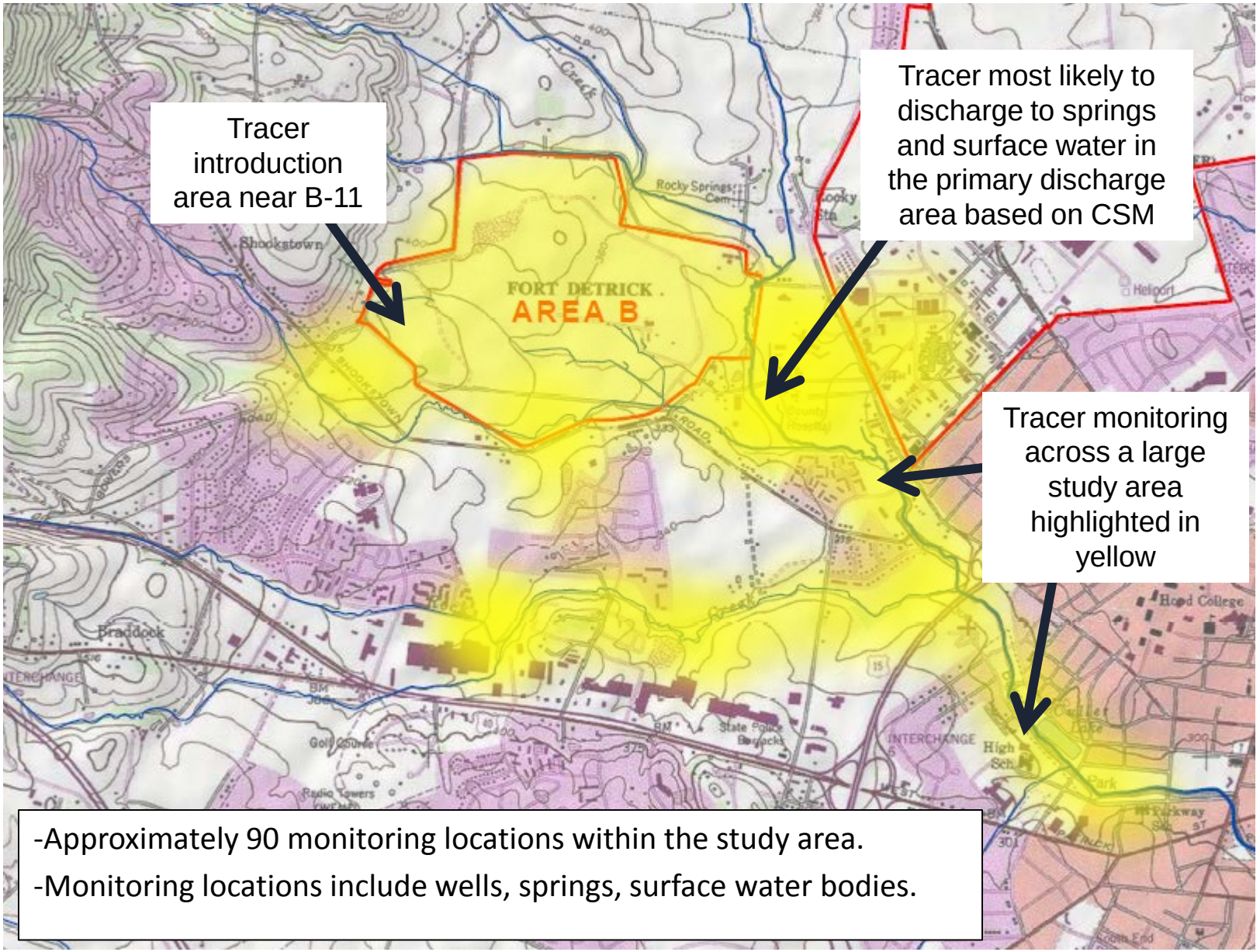
Tracer Study Area (approximate)



Groundwater Tracer Study

- What tracer will be used in the study?

- A tracer is a nontoxic substance that can be easily introduced to the groundwater, will readily flow with the groundwater, and can be confirmed through sampling and laboratory analysis at downgradient monitoring points.

- The tracer used for this study will be identified following completion of a background study to evaluate whether there are any background levels that could interfere with the study results.

- There are numerous options for tracers as these are commonly used for:
  - Municipal groundwater system evaluations (e.g., wellhead protection studies)
  - Utility conduit assessments
  - Groundwater investigations

- The tracer will be selected in coordination with EPA and MDE.

Groundwater Tracer Study

- Will the tracer be visible in wells, springs, or surface water?

- Depending on what tracer is selected, it is possible (though unlikely) that temporary discoloration may be visible in some wells or surface water monitoring points.
- Generally, laboratory analysis (rather than visual observation) is required to determine if the tracer is present at a monitoring location.
- Maximum detected tracer concentrations in water samples during the 1995 study were only 0.6 ppb, which are not visible to the naked eye.
- If discoloration was to be observed during the study:
    - Remember the tracer is nontoxic and poses no heath risk to public health or ecological organisms.

Groundwater Tracer Study Updates

- EPA and MDE currently reviewing a tracer study work plan. The tracer introduction will occur following regulatory concurrence with the plan.
- Background study currently underway.
- The tracer study will extend through Fall 2013.
- The Army and ARCADIS are planning technical discussions with EPA and MDE during the course of the study.
- The Army and ARCADIS will provide status updates during future community RAB meetings.
- A tracer study report will be prepared and submitted to EPA, MDE, and the RAB at the conclusion of the study.

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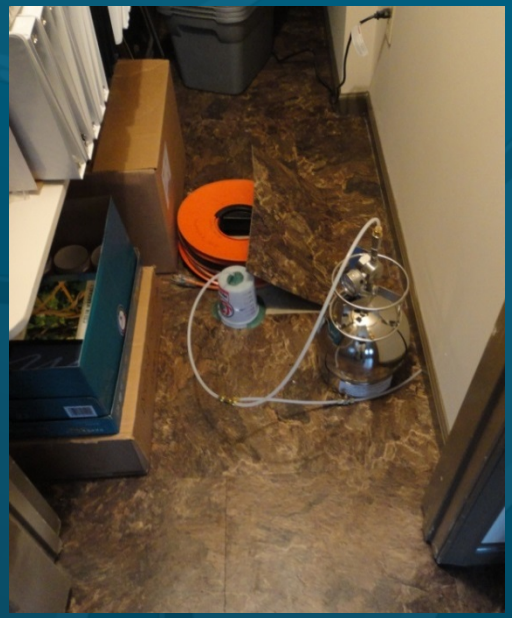
Vapor Intrusion Update



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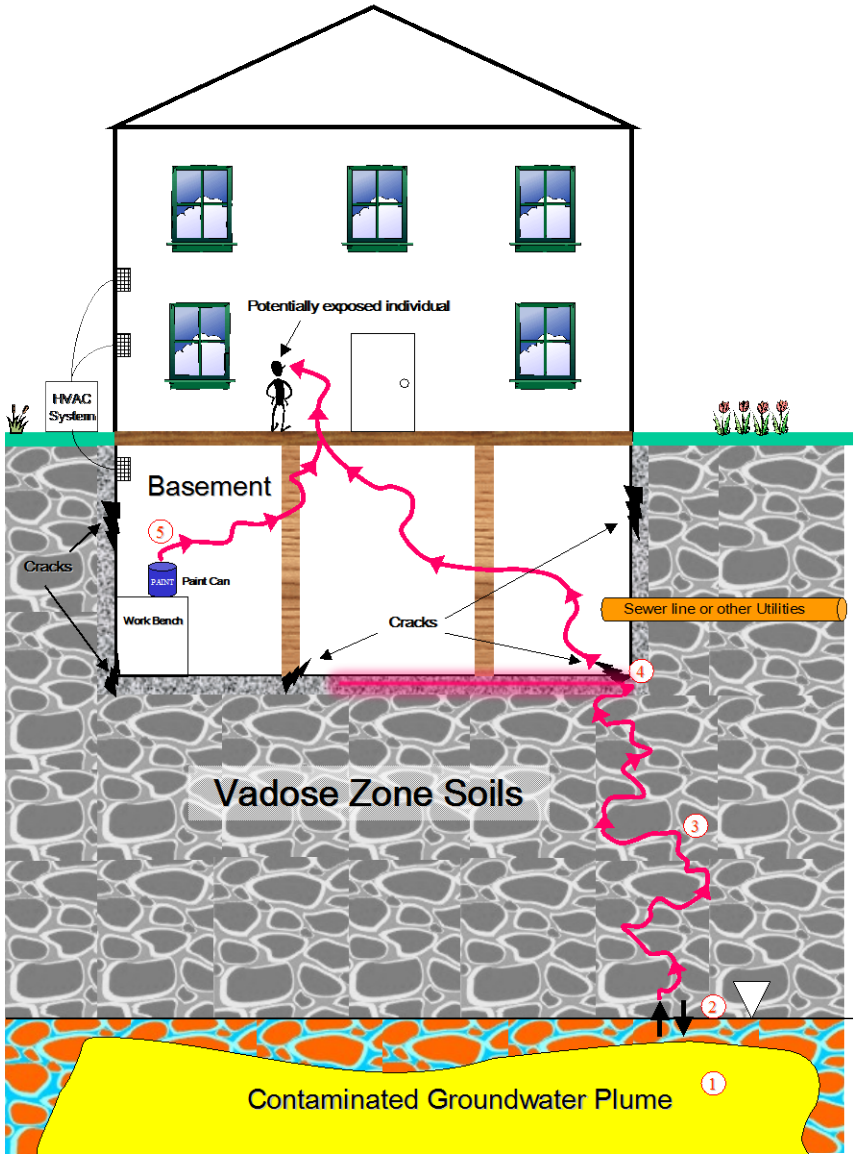
What is Vapor Intrusion?

- Vapors from chemicals in groundwater that may rise up, accumulate beneath the building foundation, and infiltrate into the building via cracks or sumps in the slab.
- Movement is from groundwater through soil pore spaces (soil gas)
- Indoor background sources must be accounted for.
- Sub-slab gas sampling is conducted to test for potential vapor intrusion concerns, then indoor air sampling may be needed as a follow-up.



Vapor Intrusion Update

What is the process for the vapor intrusion study?

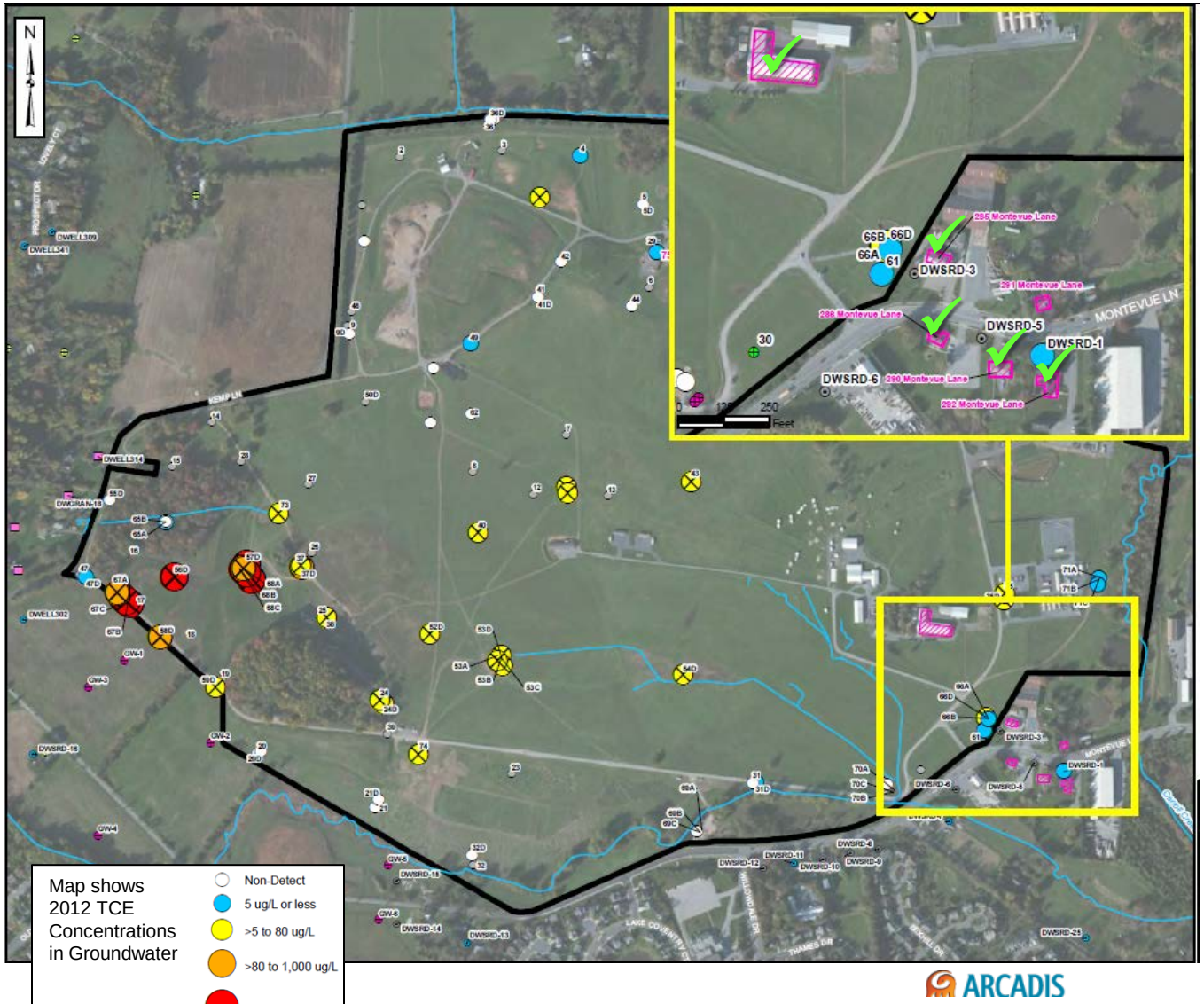
1. Once right of entry agreement is reached with the property owner, a building survey is completed to identify possible indoor sources for VOCs.

2. Sample locations are identified, utility avoidance is conducted, and sample ports are installed through the building slab.

3. Samples of sub-slab gas are collected and submitted for laboratory analysis.

Locations for Current Phase of Sub-Slab Gas Sampling

- Sub-slab sampling completed at five commercial buildings (3 locations each) in Jan. 2013.
- Sub-slab samples show no PCE or TCE detections above commercial/ industrial risk-based screening criteria.
- Second round of seasonal sub-slab gas sampling scheduled for Summer 2013 at the same locations.
- Follow-up indoor air sampling also planned.



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Upcoming Work

Upcoming Work

The following additional investigation activities are planned for 2013:

- Groundwater tracer study — Spring – Fall 2013
- On-going vapor intrusion sampling — Summer 2013
- Supplemental shallow direct push drilling (DPT) — Summer 2013
- Additional deep on-post and off-post drilling — Summer 2013

Note: Some pending work phases are still dependent on negotiating right of entry agreements with the property owners.

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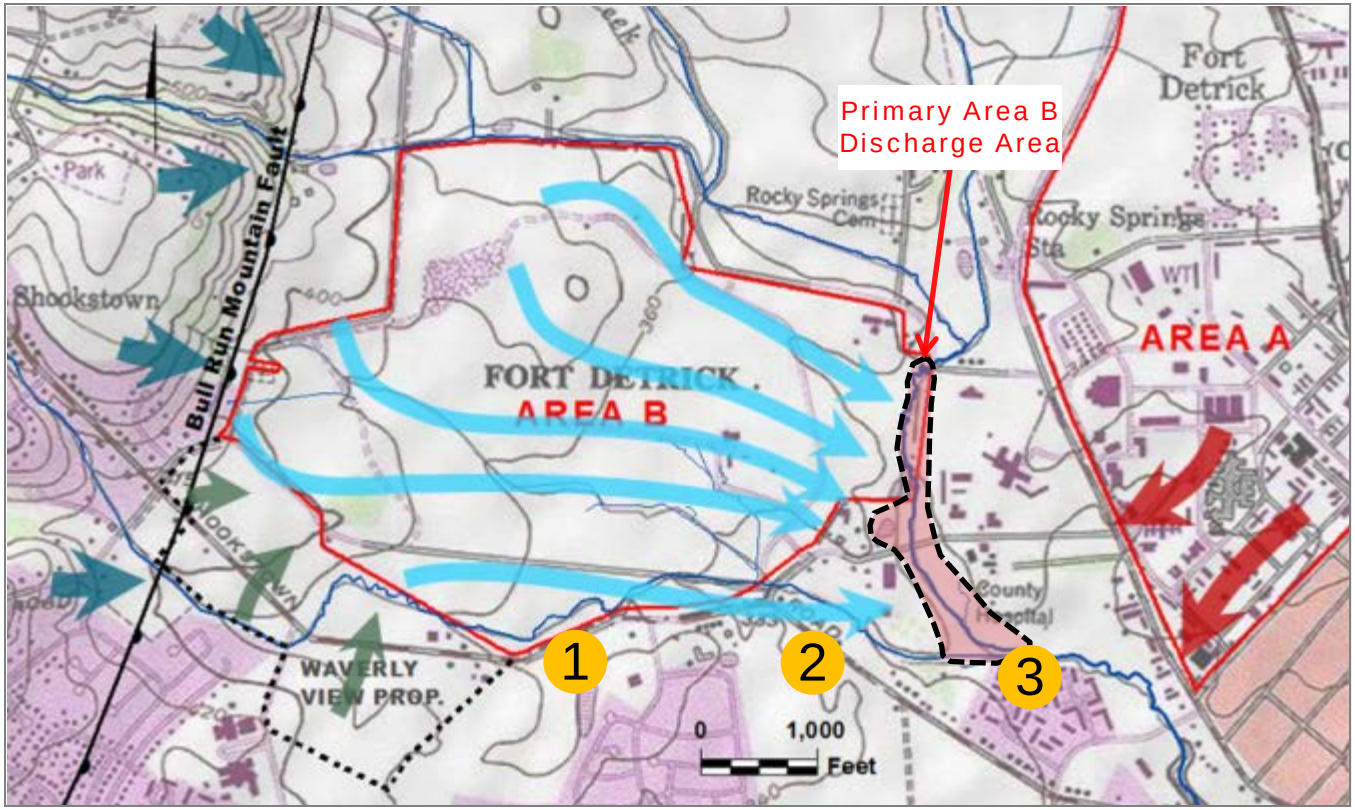
Supplemental Shallow DPT

- What is direct push drilling (DPT)?
  - A light weight drilling rig is used to hydraulically push sampling rods into the ground for collecting soil/groundwater samples and installing shallow small diameter wells.
  - Drilling depths in this area are limited to ~30-40 feet below ground surface due to shallow bedrock.
  - Approximately 50 DPT locations were completed in the study area in Spring 2012.

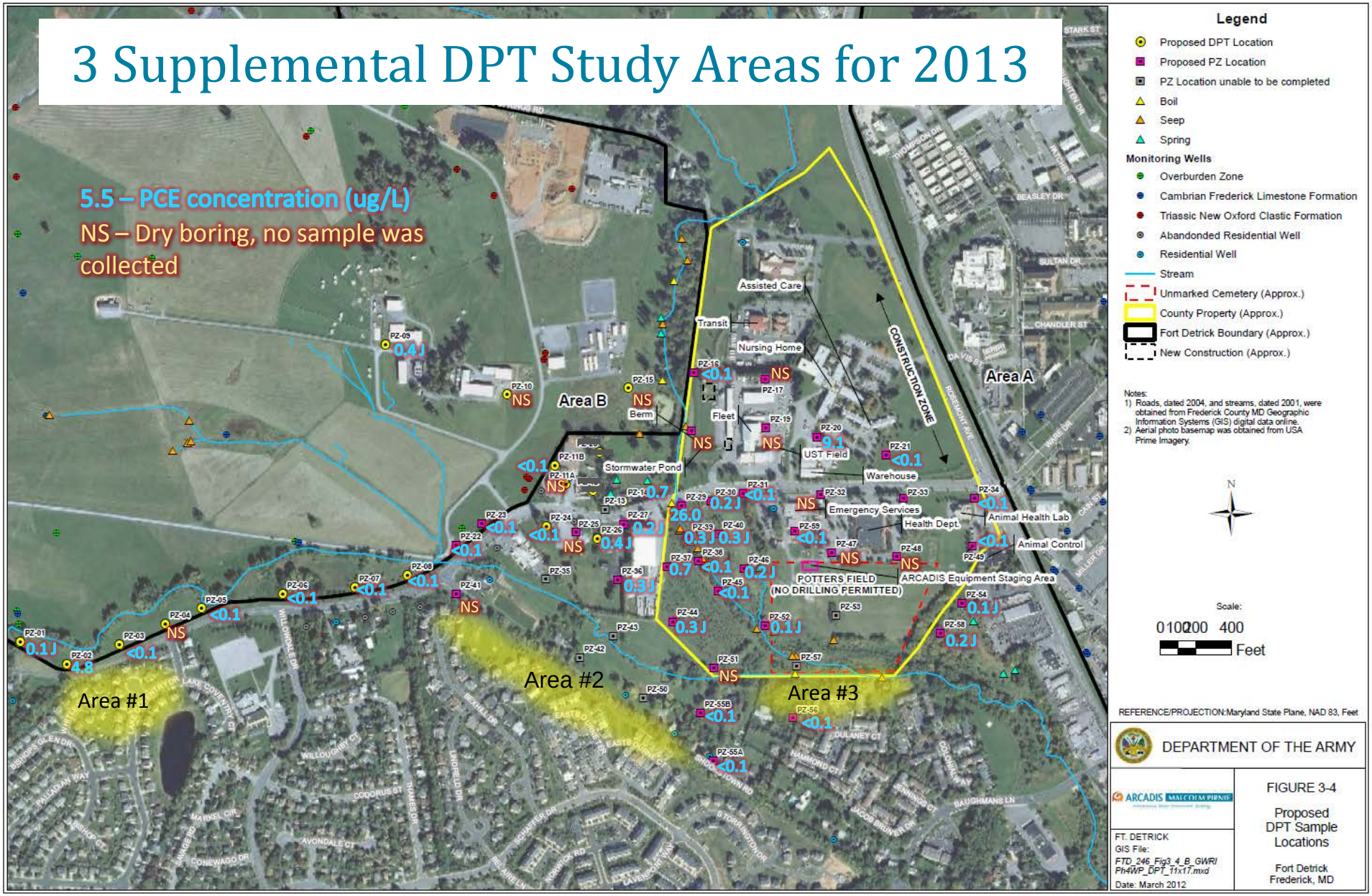
Supplemental Shallow DPT

1. 7 shallow DPT locations south of Area B and Shookstown Rd.
2. 3 shallow DPT locations south of Area B near Shookstown Rd.
3. 4 shallow DPT locations south of Carroll Creek

Generalized patterns of flow



3 Supplemental DPT Study Areas for 2013



Army seeking rights of entry for supplemental drilling in these three areas at locations approved by EPA and MDE.

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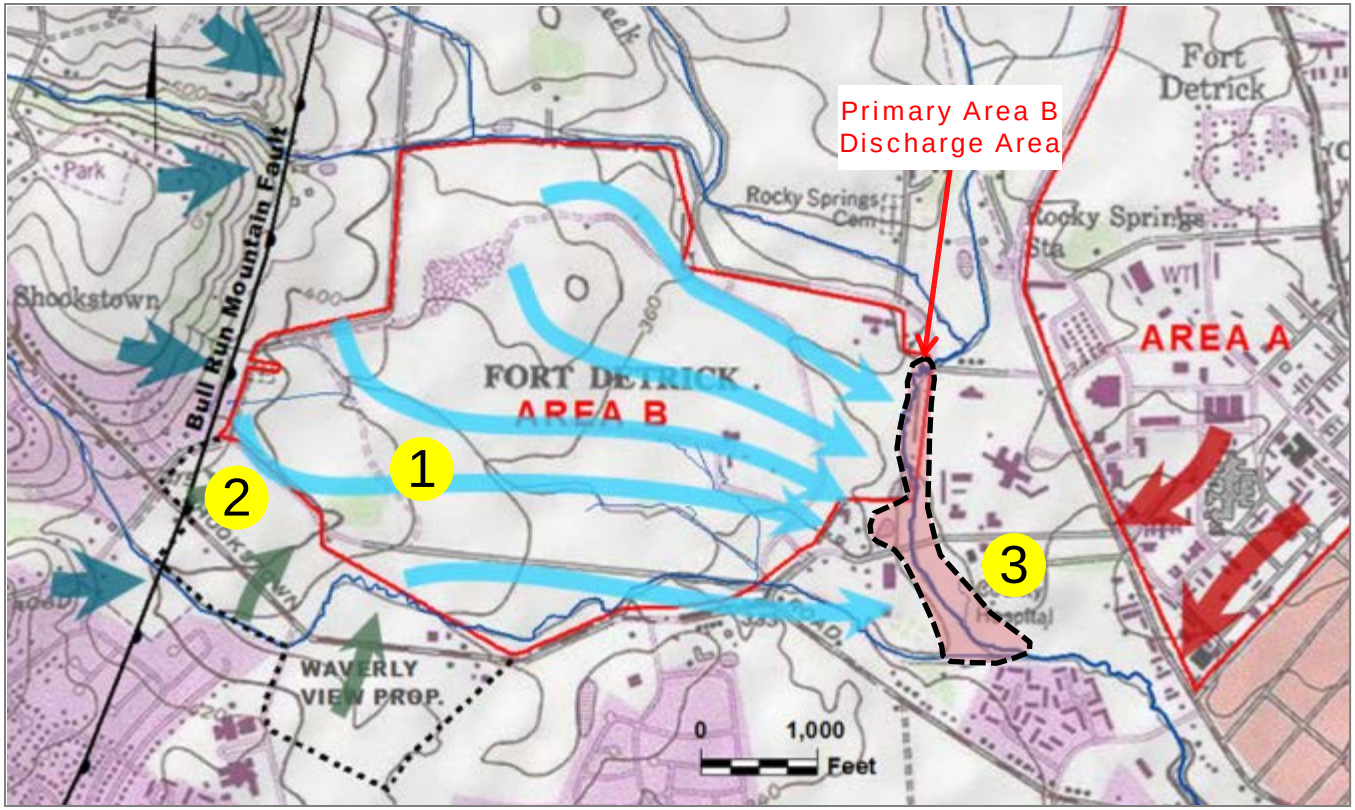
Additional Deep On-Post & Off-Post Drilling

- Right of entry agreements progressing for proposed off-post drilling locations.
- Drilling methodology will follow the same techniques employed during the 2011/2012 drilling program (including geophysical logging and packer testing).
- Maximum drilling depths anticipated to be ~400-500 feet below ground surface at some new locations.
- Multiple nested wells to be installed to aid in vertical contaminant delineation.
- Approximately 7 new borings with up to 11 nested wells installed.

Supplemental Deep Drilling Locations

1. Vertical delineation downgradient of B-11 to depths greater than 325 ft. (~ 2 nested wells)
2. Delineation south of B-11 area (Waverley Property) (~3 drilling areas w/ ~7 nested wells)
3. Horizontal delineation east of Carroll Creek (underflow) (~ 2 nested wells)

Generalized patterns of flow



Next Steps

Next Steps

- Conduct groundwater tracer study to assess deep groundwater flow (Spring-Fall 2013)
- Conduct round 2 vapor intrusion sampling (Summer 2013)
- Complete supplemental off-post DPT drilling (Summer 2013)
- Complete follow-on drilling activities and supplemental investigations based on identified data needs (Summer 2013)

Regular updates to be provided during community RAB meetings.

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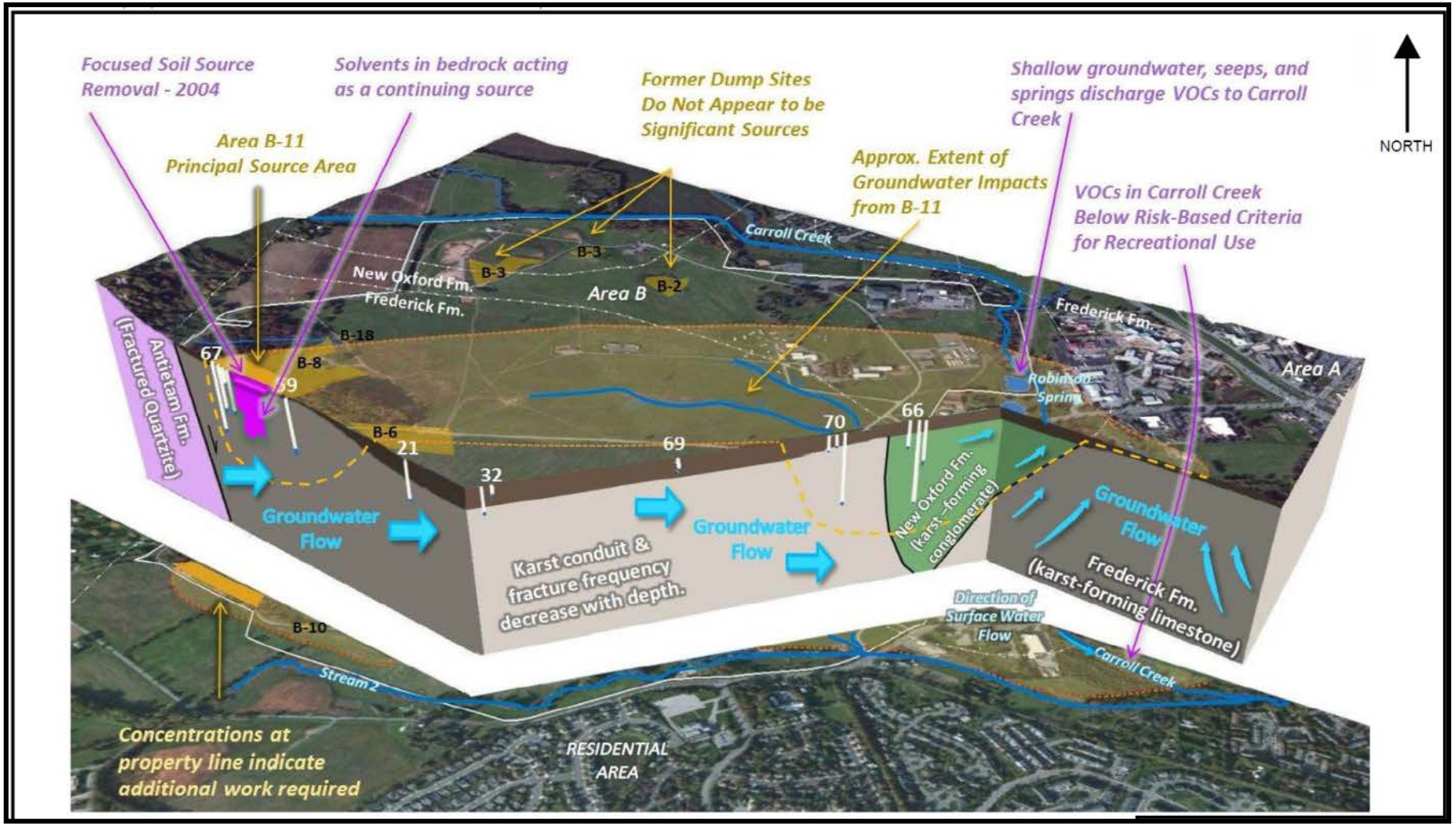
Questions and Discussion

EXTRA SLIDES

Area B Conceptual Site Model Review



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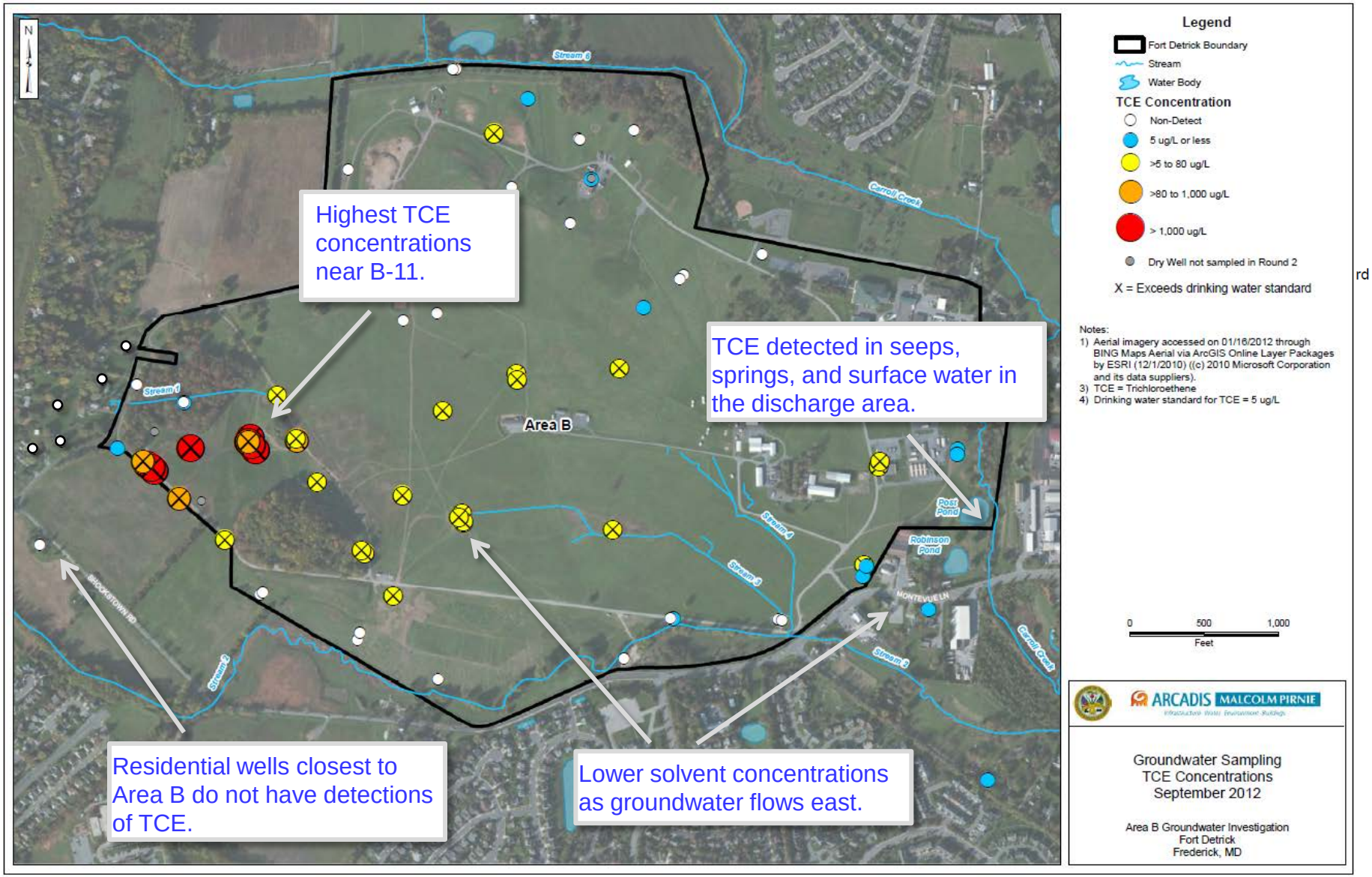
TCE in Groundwater Sept 2012



TCE in Groundwater April 2012

Legend

- Fort Detrick Boundary
- Stream
- Non-Detect
- 5 ug/L or less
- >5 to 80 ug/L
- >80 to 1,000 ug/L
- >1,000 ug/L

X = Exceeds drinking water standard

Notes:
1) Aerial imagery accessed through BING Maps Aerial via ArcGIS Online Layer Packages by ESRI (12/1/2010) (c) 2010 Microsoft Corporation and its data suppliers accessed on 05/29/2012 through ArcGIS 9.3.1.
2) ug/L = micrograms per liter
3) TCE = Trichloroethene
4) Drinking water standard for TCE = 5 ug/L

0 500 1,000
Feet

REFERENCE/PROJECTION: Maryland State Plane, NAD 83, Feet

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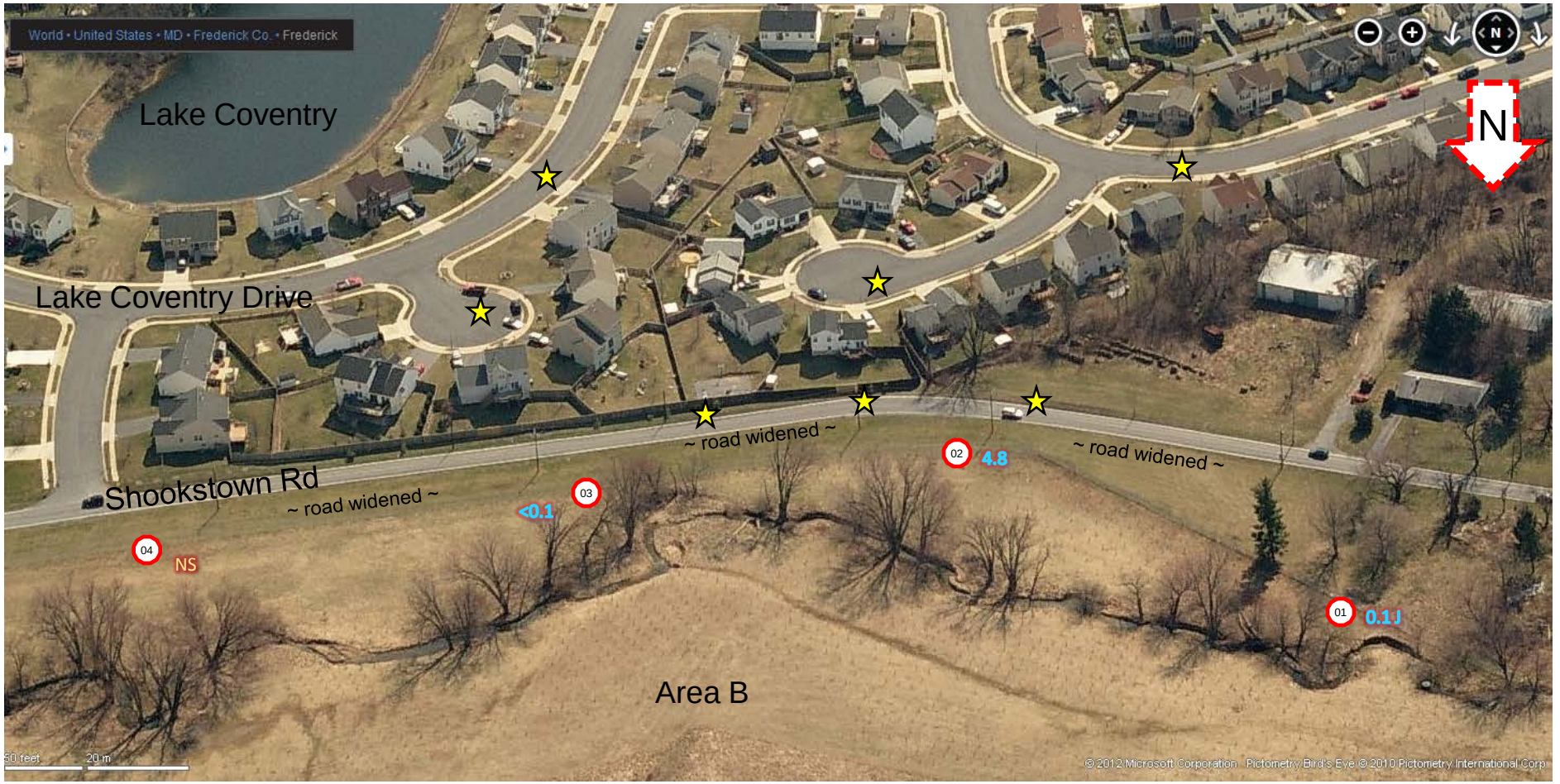
Groundwater Sampling
TCE Concentrations
March/April 2012

Fort Detrick
Frederick, MD

List of the 216 Chemicals Tested

1,1,1-Trichloroethane
1,1,2,2-Tetrachloroethane
1,1,2-trichloro-1,2,2-trifluoroethane
1,1,2-Trichloroethane
1,1'-Biphenyl
1,1-Dichloroethane
1,1-Dichloroethene
1,2,3,4,6,7,8-HpCDD
1,2,3,4,6,7,8-HpCDF
1,2,3,4,7,8,9-HpCDF
1,2,3,4,7,8-HxCDD
1,2,3,4,7,8-HxCDF
1,2,3,6,7,8-HxCDD
1,2,3,6,7,8-HxCDF
1,2,3,7,8,9-HxCDD
1,2,3,7,8,9-HxCDF
1,2,3,7,8-PeCDD
1,2,3,7,8-PeCDF
1,2,3-Trichlorobenzene
1,2,3-Trichloropropane
1,2,4-Trichlorobenzene
1,2,4-Trimethylbenzene
1,2-Dibromo-3-chloropropane
1,2-Dibromoethane
1,2-Dichlorobenzene
1,2-Dichloroethane
1,2-Dichloropropane
1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,4-Dioxane
1,4-Naphthoquinone
2,2-Dichloropropionic Acid
2,2'-Oxybis(1-Chloropropane)
2,3,4,6,7,8-HxCDF
2,3,4,7,8-PeCDF
2,3,7,8-TCDD
2,3,7,8-TCDF
2,4,5-T
2,4,5-TP
2,4,5-Trichlorophenol
2,4,6-Trichlorophenol
2,4-D
2,4-DB
2,4-Dichlorophenol
2,4-Dimethylphenol
2,4-Dinitrophenol
2,4-Dinitrotoluene
2,6-Dinitrotoluene
2-Butanone
2-Chloronaphthalene
2-Chlorophenol
2-Hexanone
2-Methyl-4-Chlorophenoxyacetic Acid
2-Methylnaphthalene
2-Methylphenol
2-Nitroaniline
2-Nitrophenol
3,3'-Dichlorobenzidine
3-Nitroaniline
4,4'-DDD
4,4'-DDE
4,4'-DDT
4,6-Dinitro-2-methylphenol
4-Amino-3,5,6-Trichloropicolinic Acid
4-Bromophenyl-phenylether
4-Chloro-3-Methylphenol
4-Chloroaniline
4-Chlorophenyl-phenylether
4-Methyl-2-pentanone
4-Methylphenol
4-Nitroaniline
4-Nitrophenol
Acenaphthene
Acenaphthylene
Acetone
Acetophenone
Aldrin
Alpha-BHC
Alpha-Chlordane
Aluminum
Anthracene
Antimony
Aroclor-1016
Aroclor-1221
Aroclor-1232
Aroclor-1242
Aroclor-1248
Aroclor-1254
Aroclor-1260
Arsenic
Atrazine
Barium
Benzaldehyde
Benzene
Benzo(a)anthracene
Benzo(a)pyrene
Benzo(b)fluoranthene
Benzo(g,h,i)perylene
Benzo(k)fluoranthene
Benzoic Acid
Benzyl Alcohol
Beryllium
Beta-BHC
bis(2-Chloroethoxy)methane
bis(2-Chloroethyl)ether
bis(2-Chloroisopropyl)ether
bis(2-Ethylhexyl)phthalate
Boron
Bromide
Bromodichloromethane
Bromoform
Bromomethane
Butylbenzylphthalate
Cadmium
Calcium
Caprolactam
Carbazole
Carbon Disulfide
Carbon Tetrachloride
Chloride
Chlorobenzene
Chloroethane
Chloroform
Chloromethane
Chromium
Chrysene
cis-1,2-Dichloroethene
cis-1,3-Dichloropropene
Cobalt
Copper
Cyanide
Cyclohexane
Delta-BHC
Dibenzo(a,h)anthracene
Dibenzofuran
Dibromochloromethane
Dicamba
Dichlorodifluoromethane
Dichlorprop
Dieldrin
Diethylphthalate
Dimethylphthalate
Di-n-Butylphthalate
Di-n-Octylphthalate
Dinoseb
Diuron
Endosulfan I
Endosulfan II
Endosulfan Sulfate
Endothall
Endrin
Endrin Aldehyde
Endrin Ketone
Ethylbenzene
Fenuron
Fluoranthene
Fluorene
Gamma-BHC (Lindane)
Gamma-Chlordane
Gross Alpha
Gross Beta
Heptachlor
Heptachlor Epoxide
Hexachlorobenzene
Hexachlorobutadiene
Hexachlorocyclopentadiene
Hexachloroethane
Indeno(1,2,3-cd)pyrene
Iron
Isophorone
Isopropylbenzene
Lead
m&p-Xylene
Magnesium
Manganese
MCPP
Mercury
Methoxychlor
Methyl acetate
Methyl tert-butyl ether
Methylcyclohexane
Methylene Chloride
Monuron
Naphthalene
Nickel
Nitrate-N
Nitrobenzene
N-Nitroso-di-n-propylamine
N-Nitrosodiphenylamine
Octachlorodibenzofuran
Octachlorodibenzo-p-Dioxin
o-Xylene
Pentachlorophenol
Percent Moisture
Phenanthrene
Phenol
Potassium
Pyrene
Selenium
Silver
Simazine
Sodium
Styrene
Sulfate
Tetrachloroethene
Thallium
Toluene
Total Dissolved Solids
Toxaphene
trans-1,2-Dichloroethene
trans-1,3-Dichloropropene
Trichloroethene
Trichlorofluoromethane
Vanadium
Vinyl Chloride
Zinc

Potential Supplemental DPT Borings SE of PZ-02



- Locations are approximate; pending access agreements & utility avoidance.
- Approximate RIWP DPT location = 02 (not surveyed yet)
- Note that Shookstown Rd has been widened since the date of the aerial image.
- Proposed new DPT location = ☆ PCE concentration (ug/L)= 0.1J

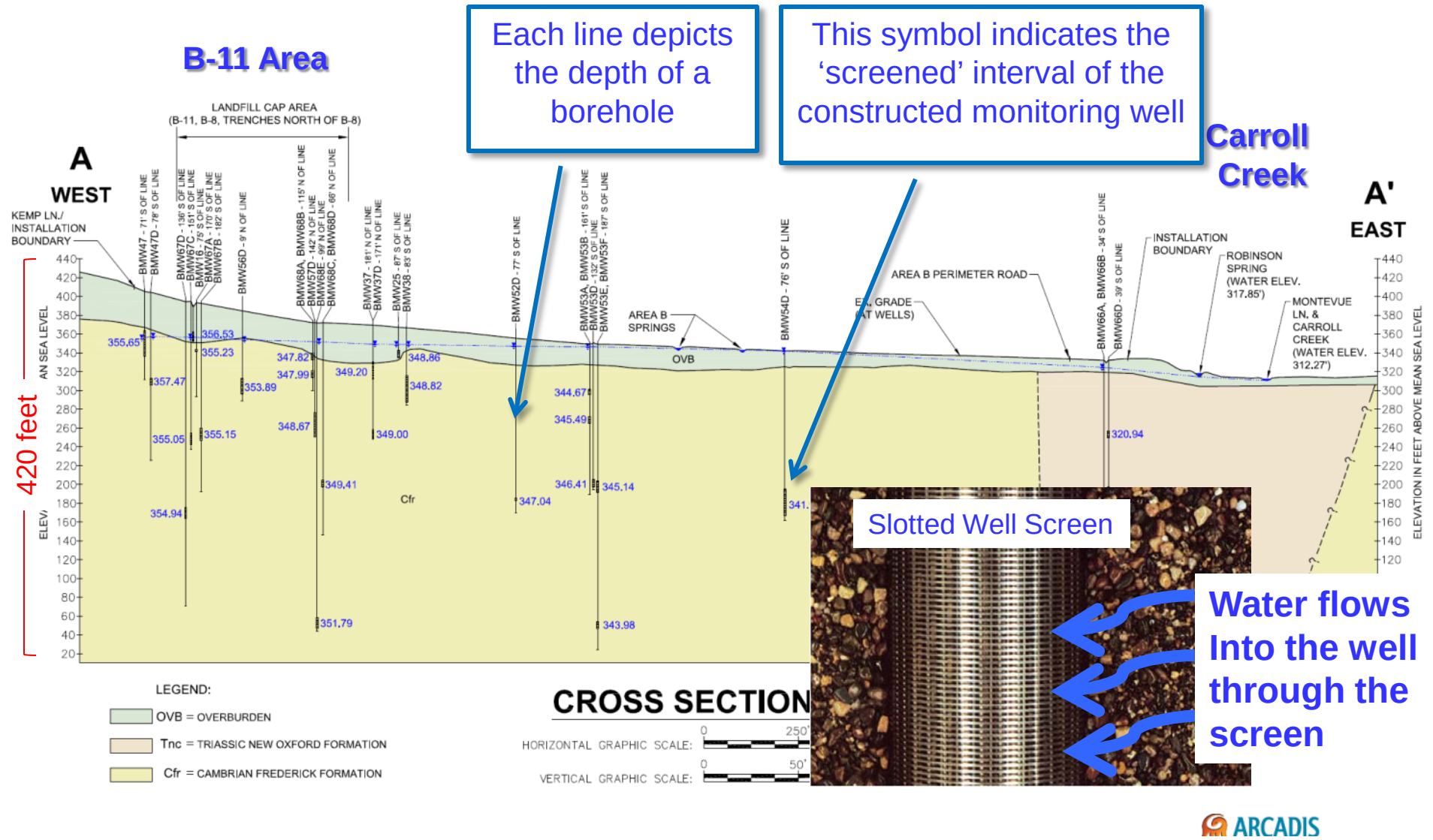
Potential Supplemental DPT Borings E of PZ-44

- Locations are approximate; pending access agreements & utility avoidance.
- Approximate RIWP DPT location = 55a (not surveyed yet)
- Proposed DPT location = ☆ (these would be piezometers, rather than DPT grab samples)
- TCE concentration (ug/L) = 5.0

Potential Supplemental DPT Borings SW of PZ-44

- Locations are approximate; pending access agreements & utility avoidance.
- Approximate RIWP DPT location = (44) (not surveyed yet)
- Proposed DPT location = ☆ (these would be piezometers, rather than DPT grab samples)

Cross-Section Showing Vertical Distribution of Select Wells Across Area B from West to East



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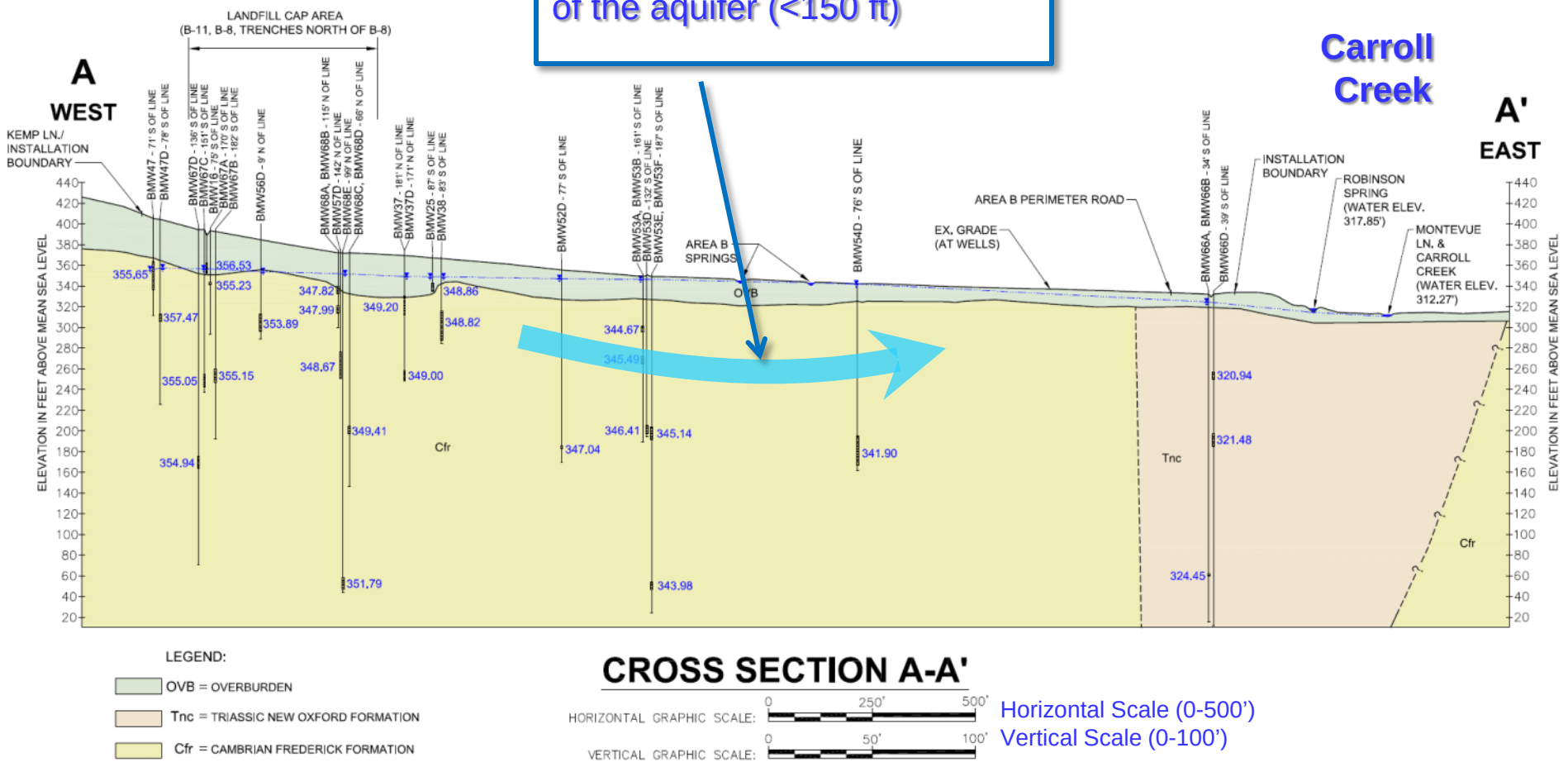
General Drilling Observations

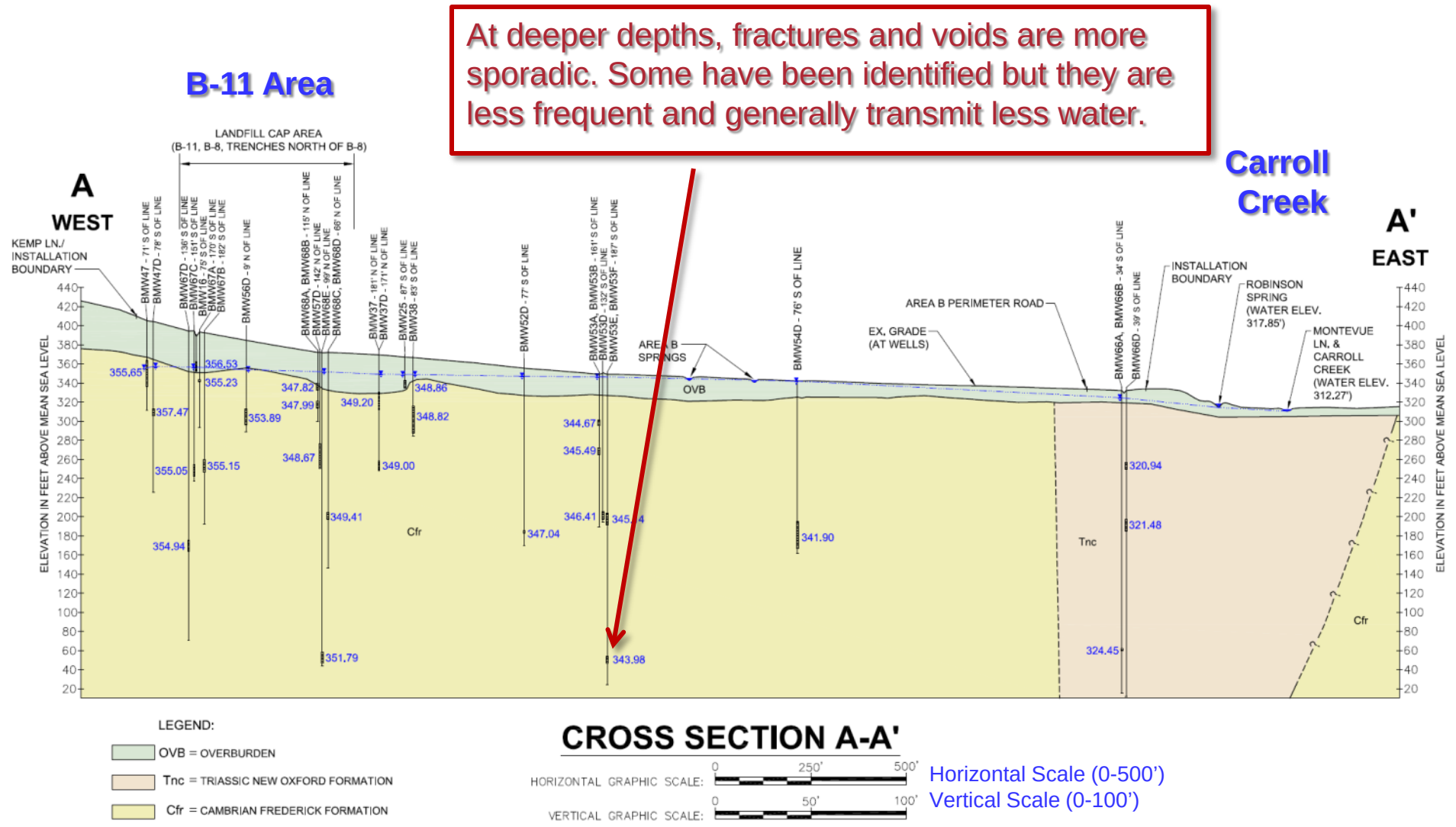
The bulk of the groundwater flows in the shallower portions of the aquifer (<150 ft)



Horizontal Scale (0-500')
Vertical Scale (0-100')

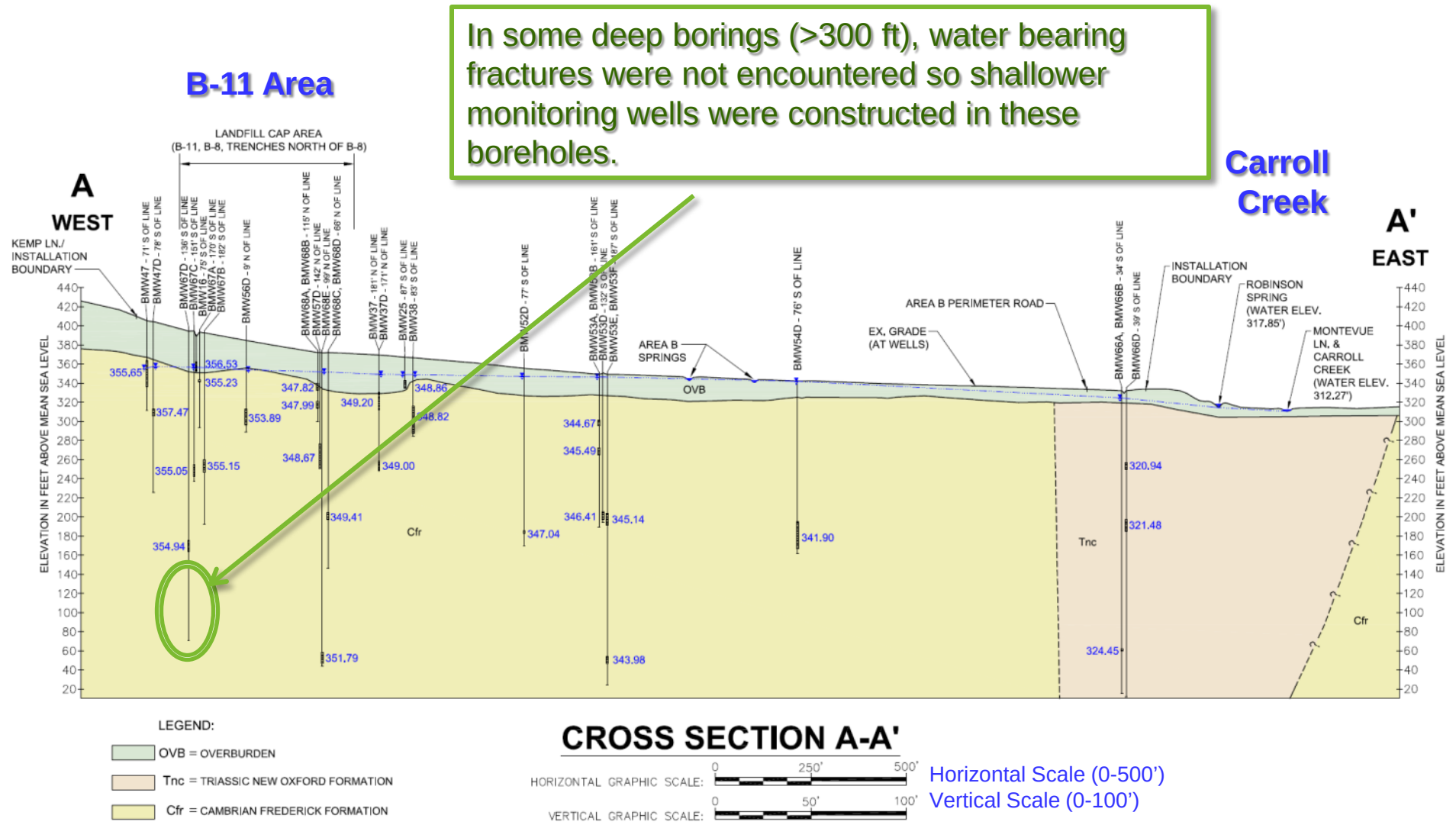
General Drilling Observations

At deeper depths, fractures and voids are more sporadic. Some have been identified but they are less frequent and generally transmit less water.



General Drilling Observations

In some deep borings (>300 ft), water bearing fractures were not encountered so shallower monitoring wells were constructed in these boreholes.



Deep Borings (>300 ft)

Boring ID	Total Boring Depth	Well Construction Depth(s)
53E/F	325’	145-160’ 295-305’ ★
65A/B	327’	112-127’ 298-313’ ★
66A/B	320’	75-85’ 135-150’
67D	325’	220-235’’
68E	328’	313-328’ ★
69B/C	325’	-none-
70C	325’	221-231’
71B/C	325’	170-180’ 222-232’
78B	325’	140-150’

★= Wells > 300 ft deep

- 9 borings have been drilled to 320 ft or deeper.
- At most deep borings, no deep water bearing fractures were observed.
- EPA, MDE, Army, and ARCADIS technical staff reviewed the drilling information and concurred on the well construction plans.
- 3 deep wells have been constructed to date >300 ft. Deep wells were not warranted in the other 5 deep borings based on drilling observations.

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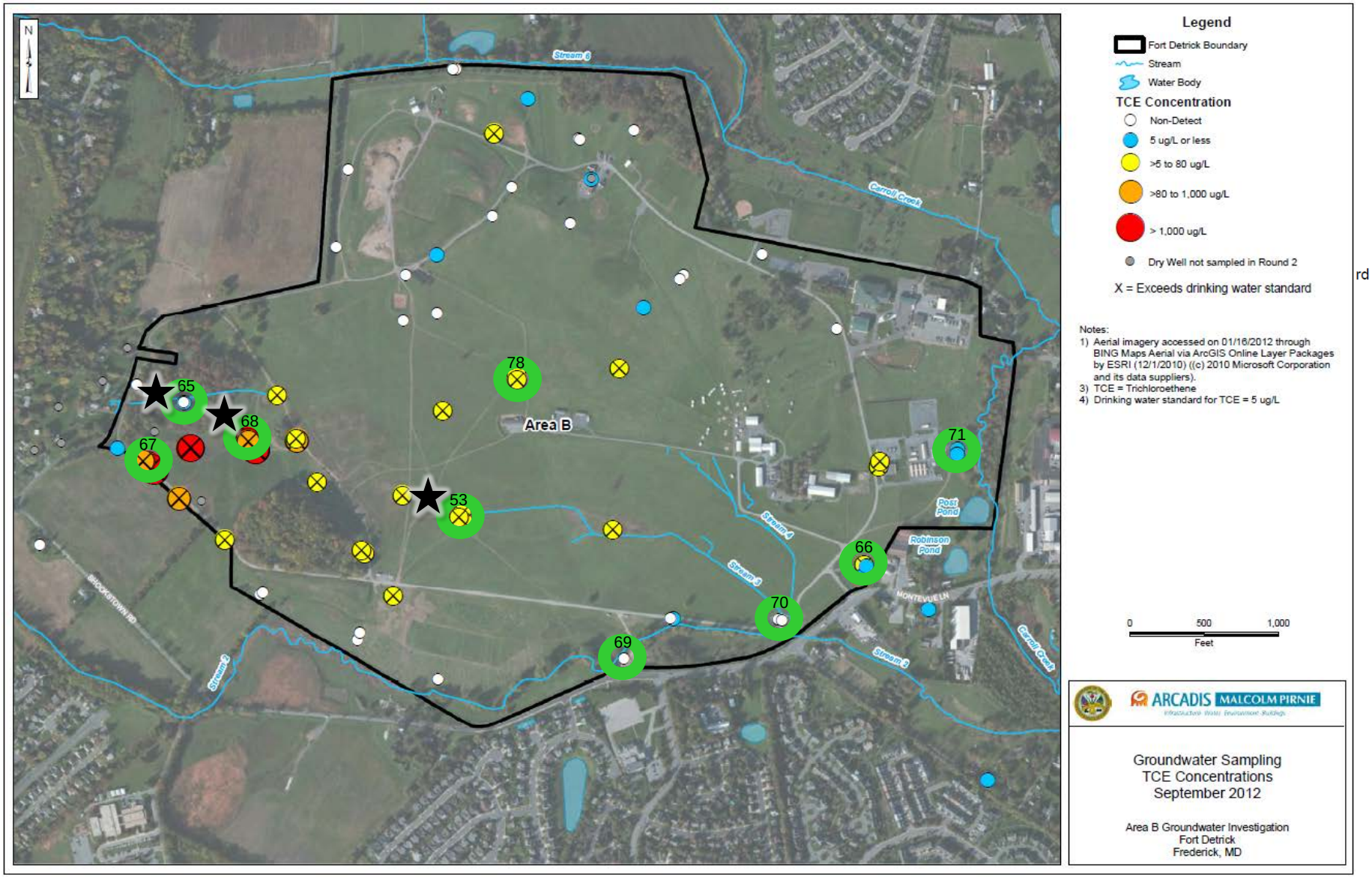
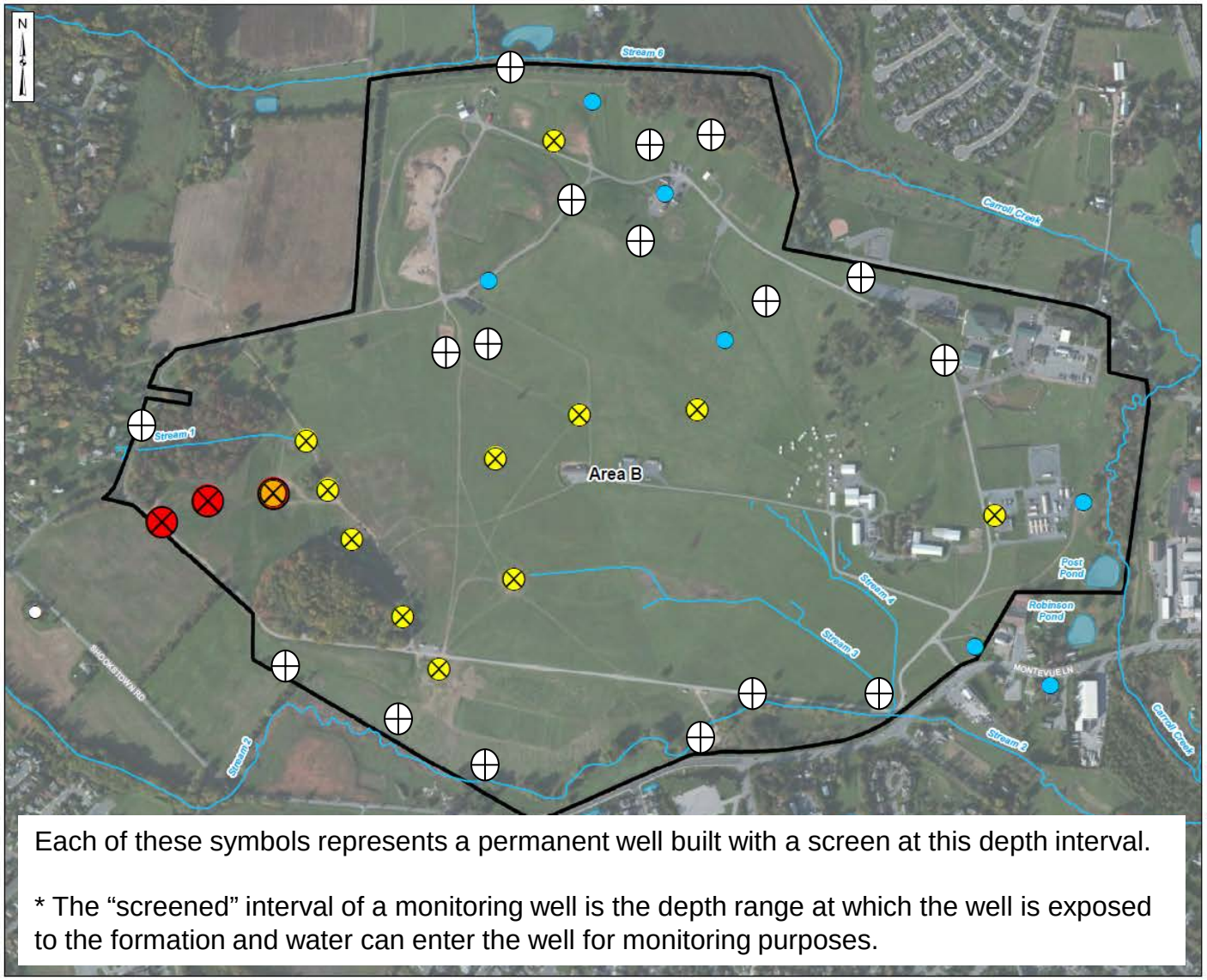
Deep Borings (>320 ft)

= deep boring >320 ft deep ★ = Well constructed > 300 ft deep



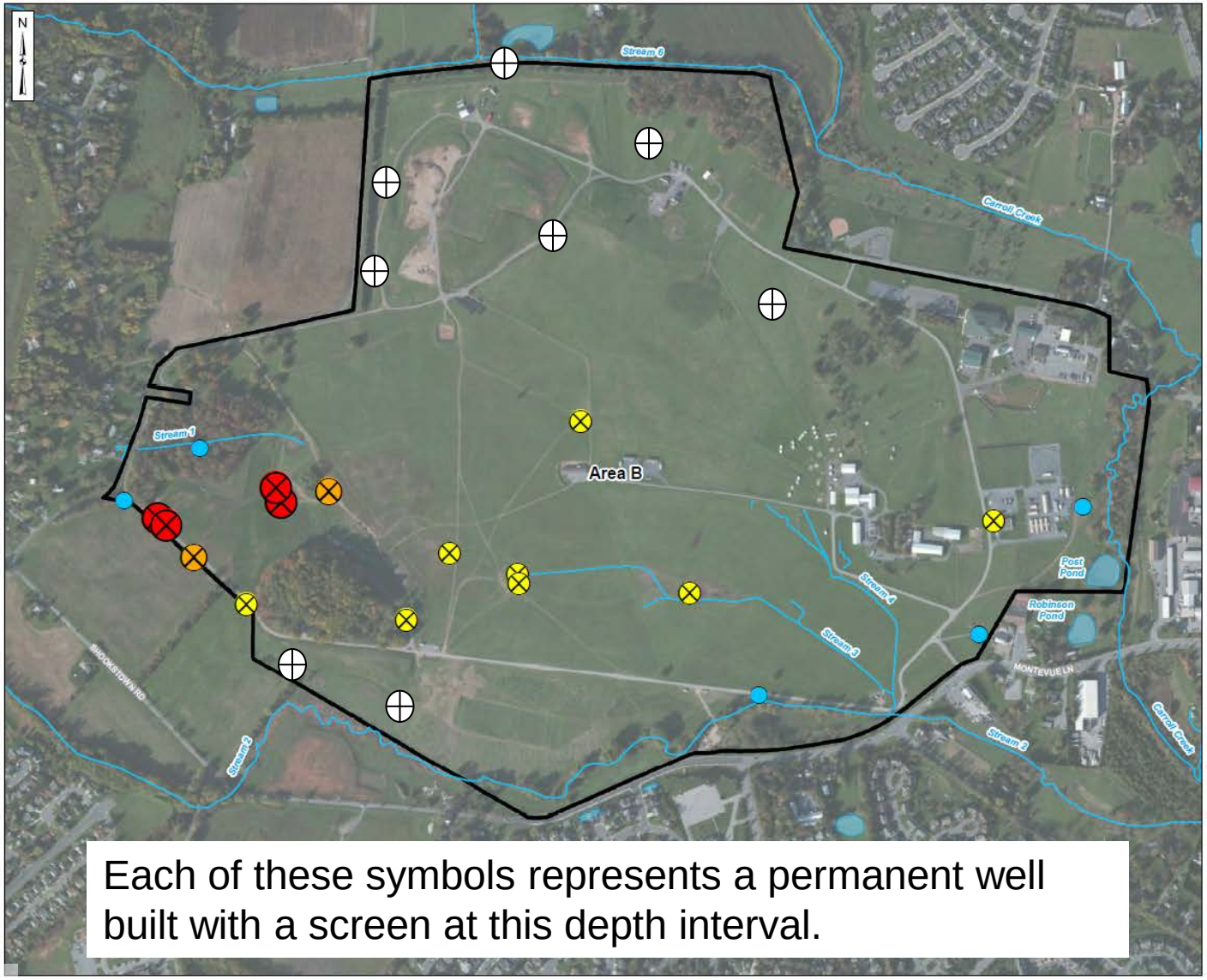
Monitoring Wells Screened* from 7-100 ft Deep



Each of these symbols represents a permanent well built with a screen at this depth interval.

* The “screened” interval of a monitoring well is the depth range at which the well is exposed to the formation and water can enter the well for monitoring purposes.

Monitoring Wells Screened from 100-200 ft Deep



Legend

- Fort Detrick Boundary
- Stream
- Water Body

TCE Concentration

- Non-Detect
- 5 ug/L or less
- >5 to 80 ug/L
- >80 to 1,000 ug/L
- > 1,000 ug/L

X = Exceeds drinking water standard

Notes:
1) Aerial imagery accessed on 01/16/2012 through BING Maps Aerial via ArcGIS Online Layer Packages by ESRI (12/1/2010) ((c) 2010 Microsoft Corporation and its data suppliers).
3) TCE = Trichloroethene
4) Drinking water standard for TCE = 5 ug/L

0 500 1,000
Feet

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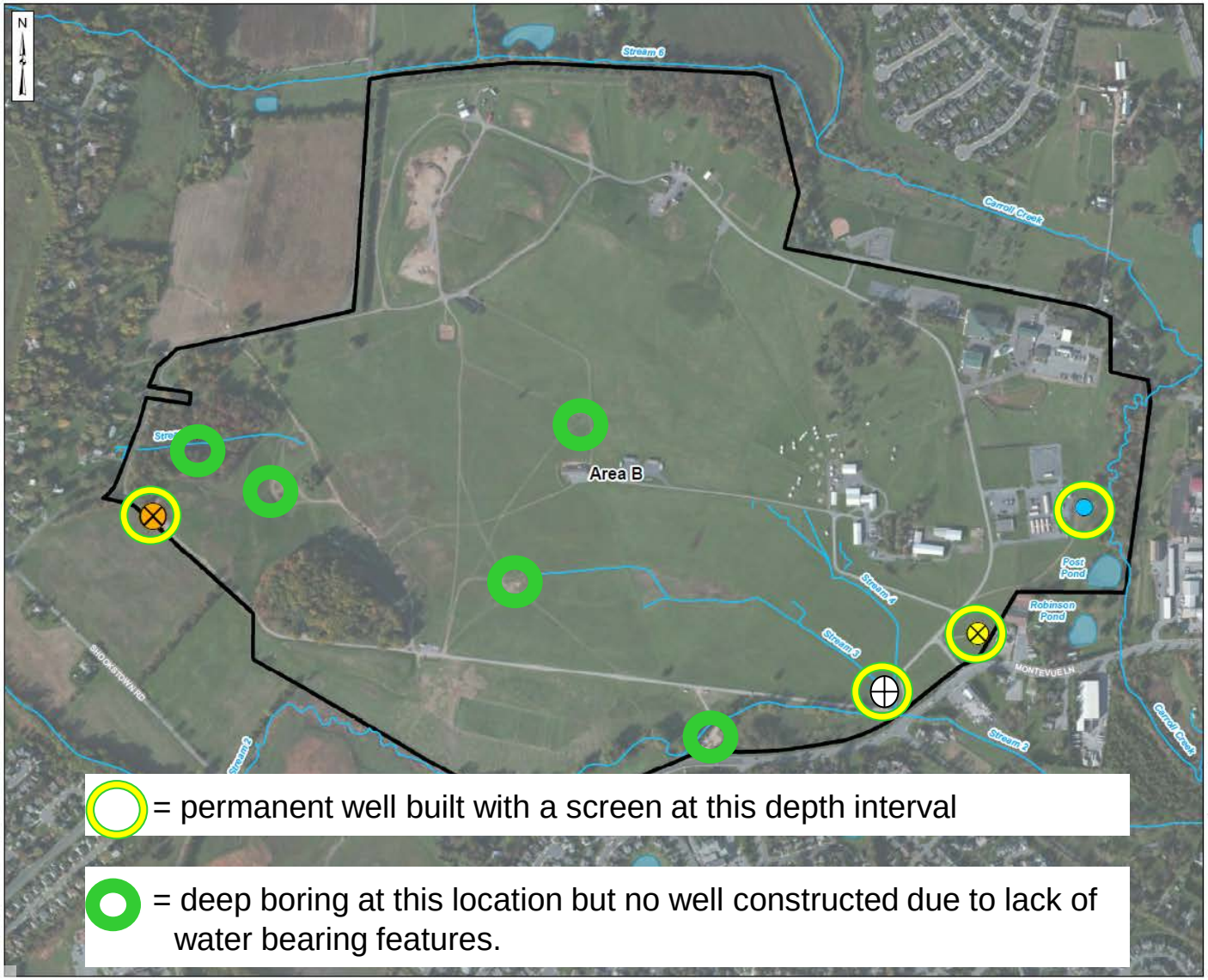
Groundwater Sampling
TCE Concentrations
Maximum Well Depth 100-200 ft
September 2012

Area B Groundwater Investigation
Fort Detrick
Frederick, MD

Monitoring Wells Screened from 200-300 ft Deep



= permanent well built with a screen at this depth interval

= deep boring at this location but no well constructed due to lack of water bearing features.

Legend

- Fort Detrick Boundary
- Stream
- Water Body

TCE Concentration

- Non-Detect
- 5 ug/L or less
- >5 to 80 ug/L
- >80 to 1,000 ug/L
- > 1,000 ug/L

X = Exceeds drinking water standard

Notes:
1) Aerial imagery accessed on 01/16/2012 through BING Maps Aerial via ArcGIS Online Layer Packages by ESRI (12/1/2010) ((c) 2010 Microsoft Corporation and its data suppliers).
3) TCE = Trichloroethene
4) Drinking water standard for TCE = 5 ug/L

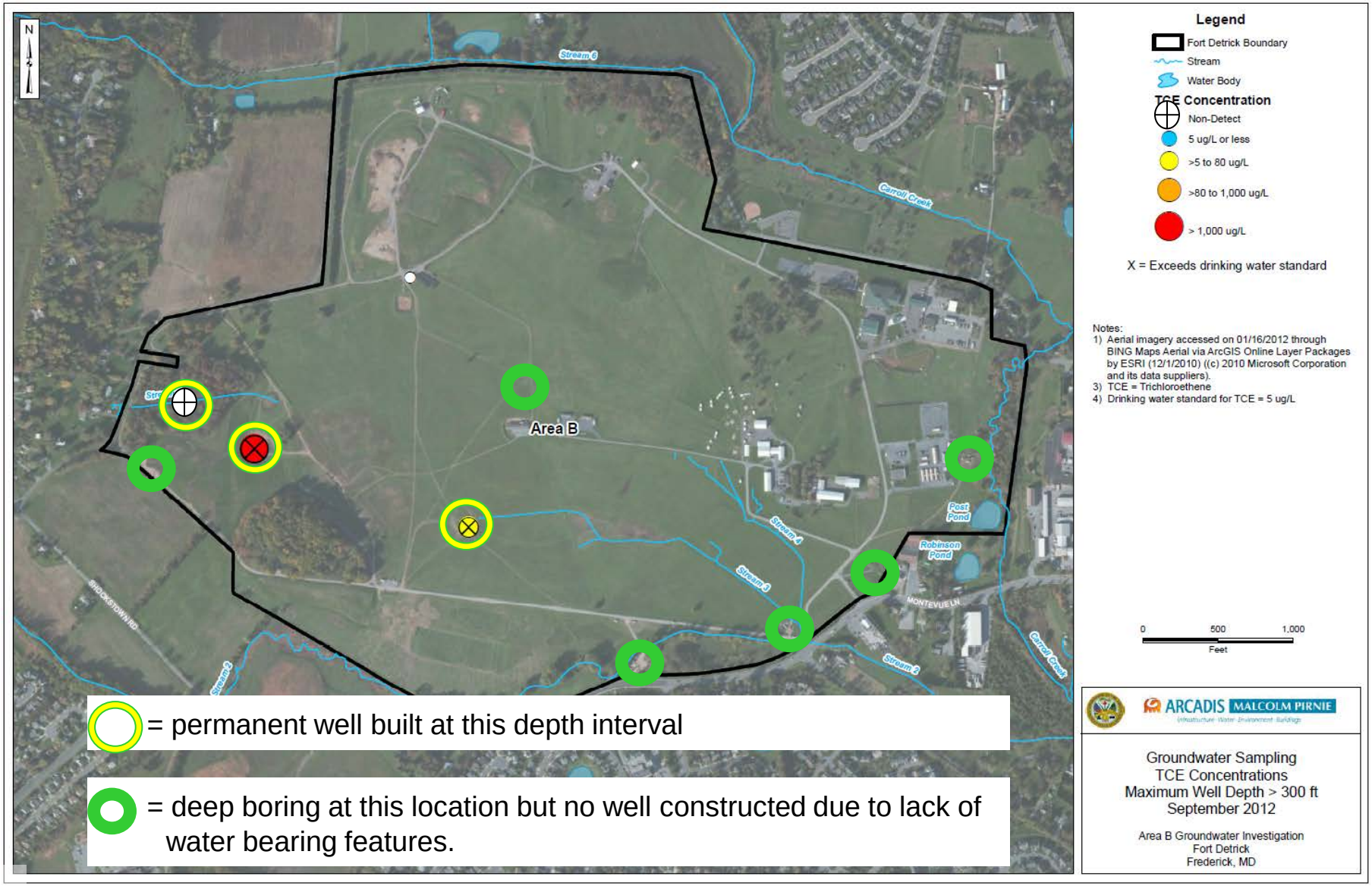
0 500 1,000
Feet

ARCADIS MALCOLM PIRNIE

Groundwater Sampling
TCE Concentrations
Maximum Well Depth 200-300 ft
September 2012

Area B Groundwater Investigation
Fort Detrick
Frederick, MD

Monitoring Wells Screened >300 ft Deep



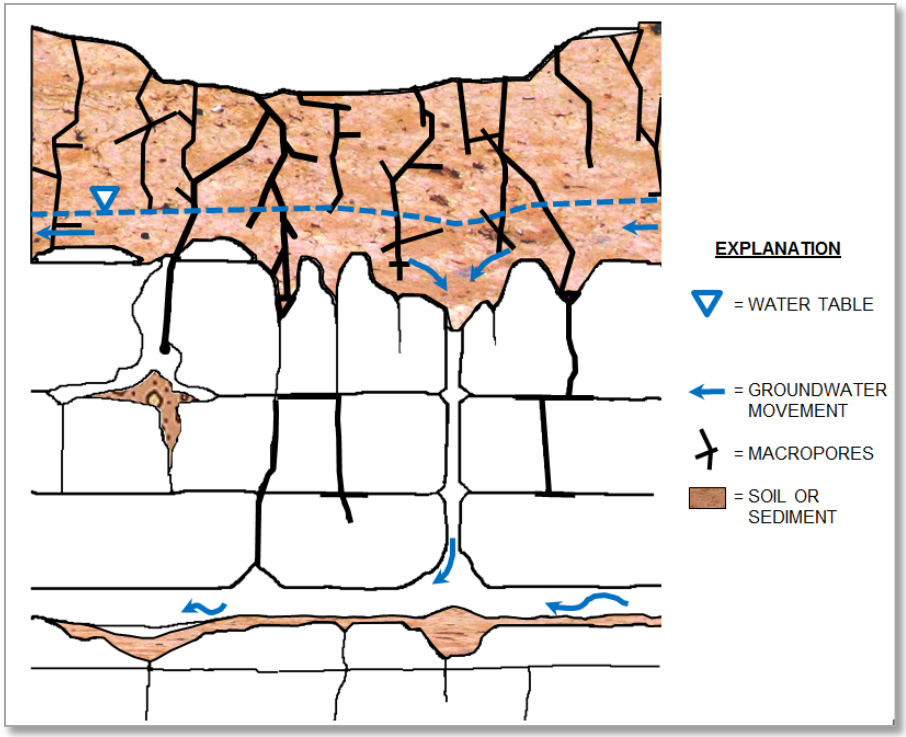
Review of Karst and DNAPL Behavior in Karst

- The next slides use a hypothetical sketch to review key concepts in karst geology, DNAPL contamination in karst geology, and drilling/investigation considerations in karst environments.

Definitions:

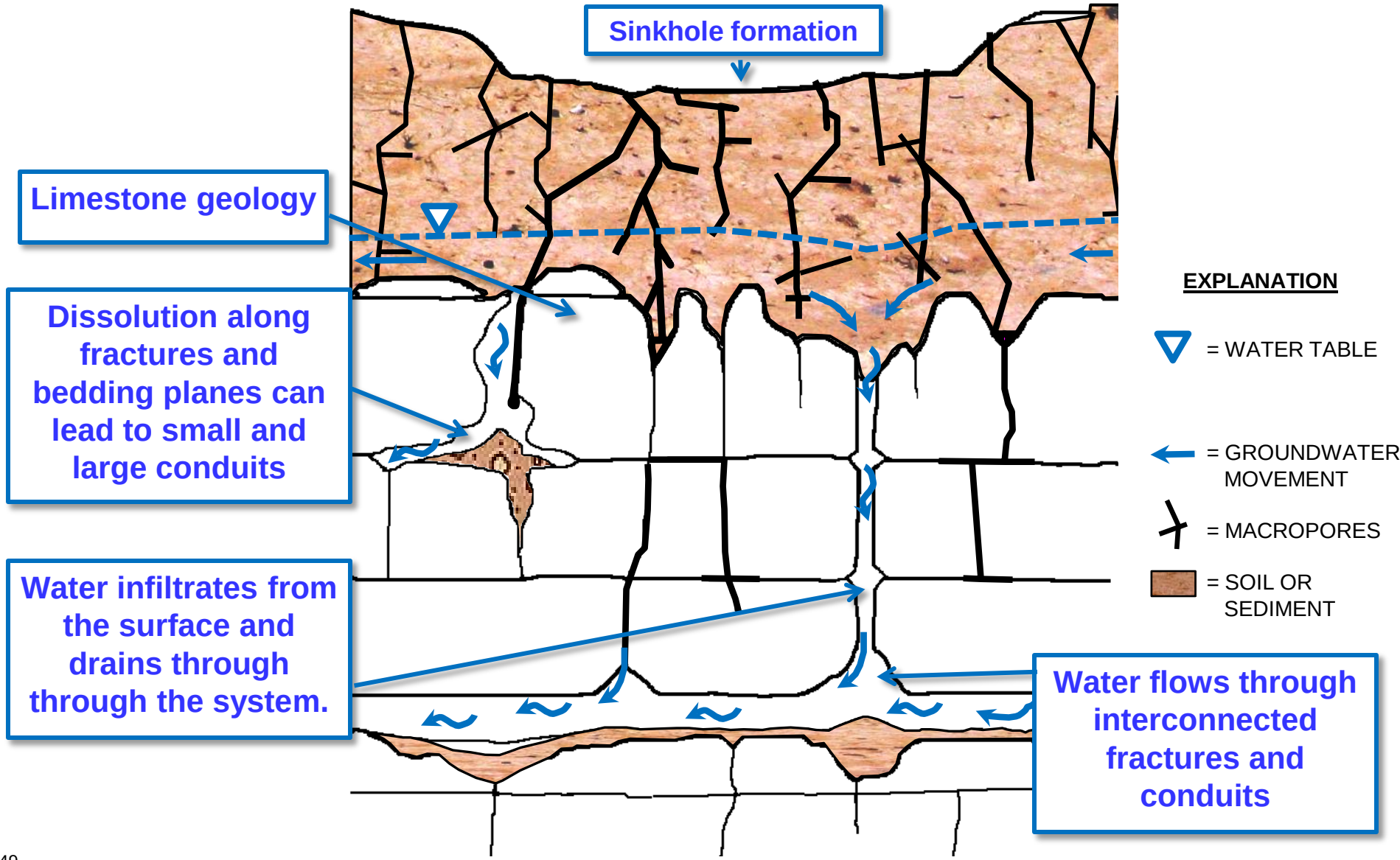
Karst: geologic formation shaped by dissolution of soluble rock resulting in surficial features such as sink holes and subterranean drainage networks of solution-widened fractures.

DNAPL: (Dense Non-Aqueous Phase Liquid) A liquid that is denser than water, does not readily dissolve in water, and tends to sink below the water table. TCE and PCE are both DNAPLs.



Understanding Karst Geology

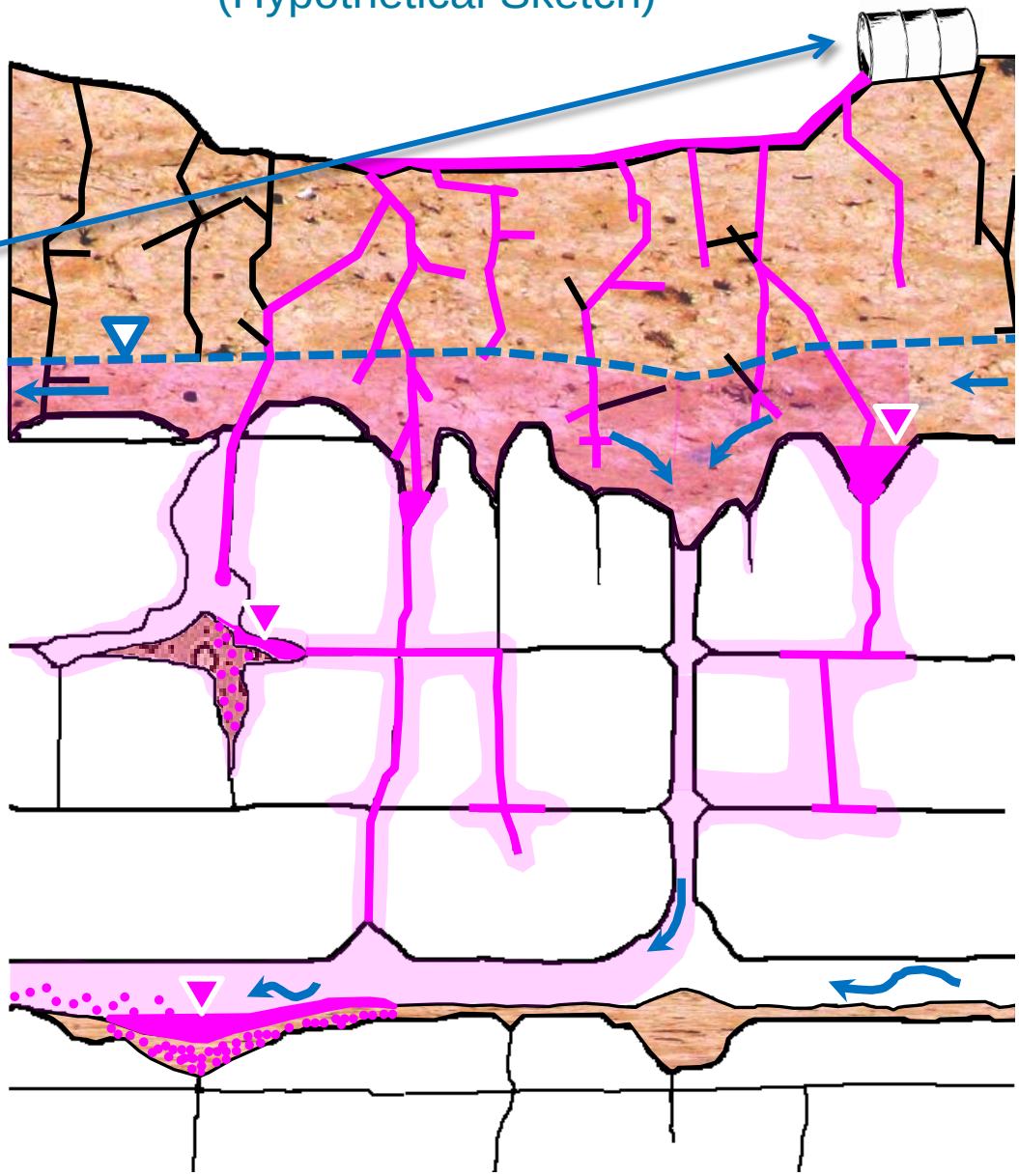
(Hypothetical Sketch)



Understanding Karst and DNAPL Behavior in Karst

(Hypothetical Sketch)

Assume a hypothetical DNAPL release



EXPLANATION

= WATER TABLE

= DNAPL POOL

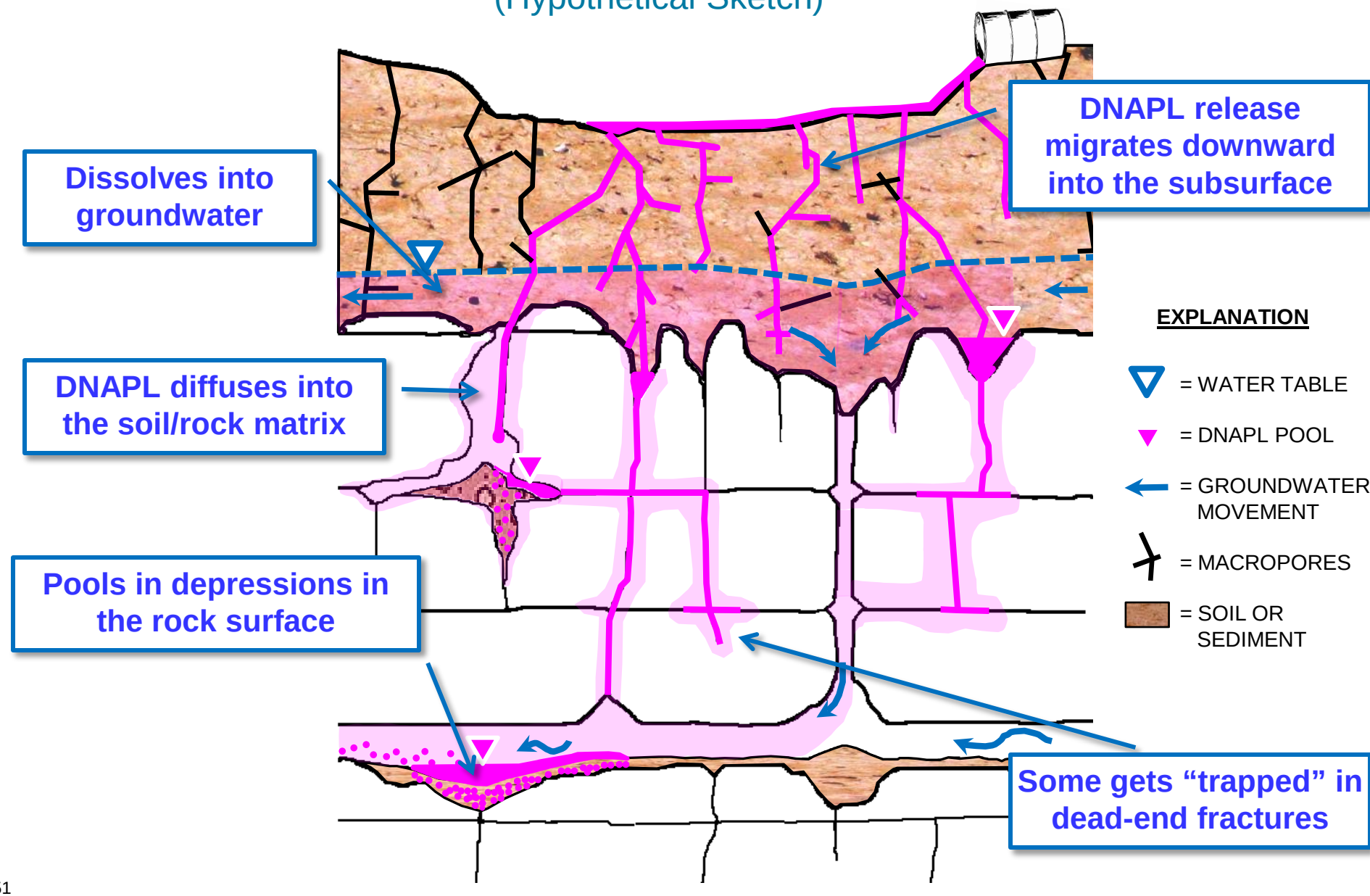
= GROUNDWATER MOVEMENT

= MACROPORES

= SOIL OR SEDIMENT

Understanding How DNAPL Behaves in Karst

(Hypothetical Sketch)



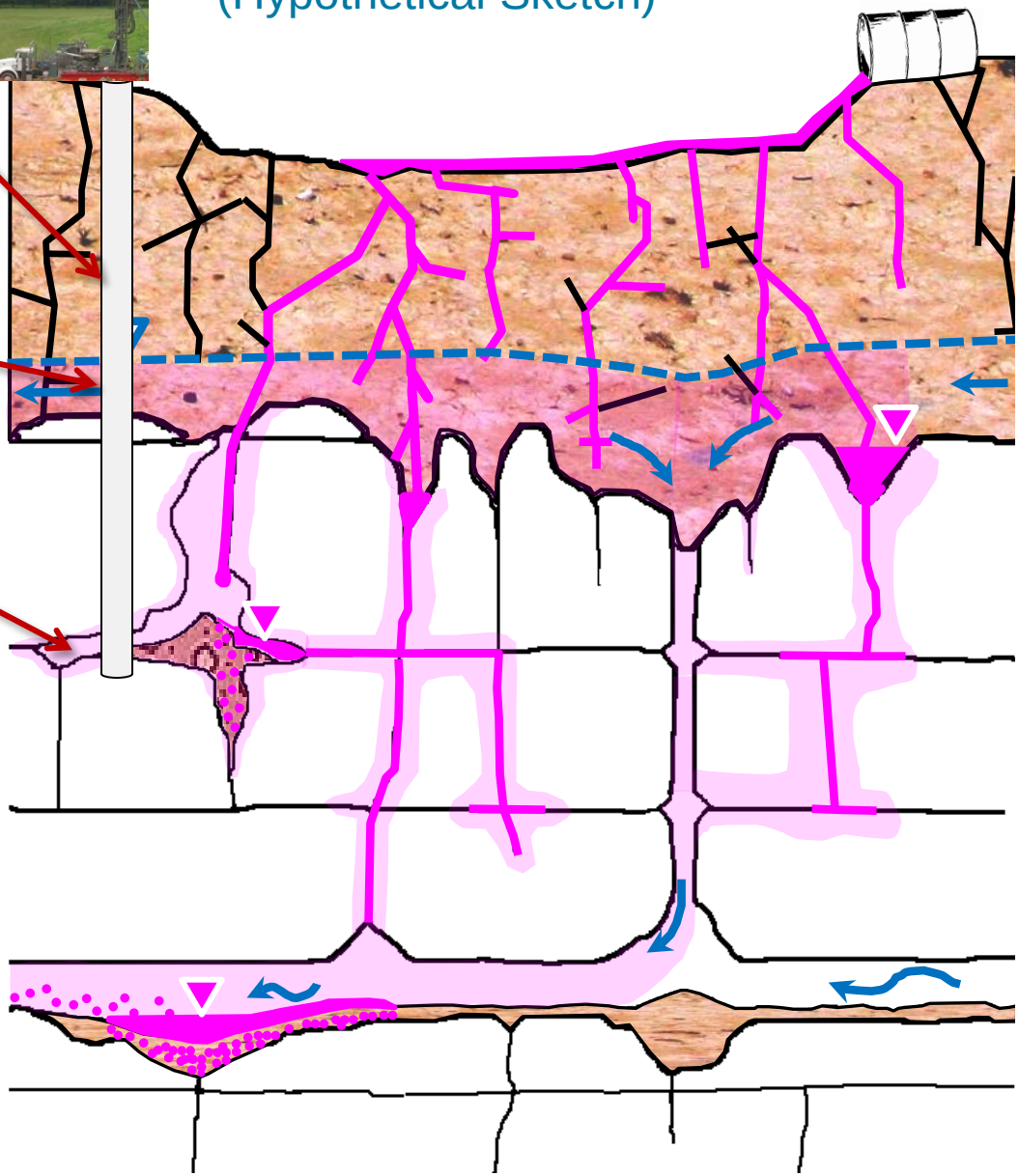
Hypothetical Observations During Drilling

(Hypothetical Sketch)

Dry above the water table

Groundwater encountered in the overburden

Void encountered



EXPLANATION

= WATER TABLE

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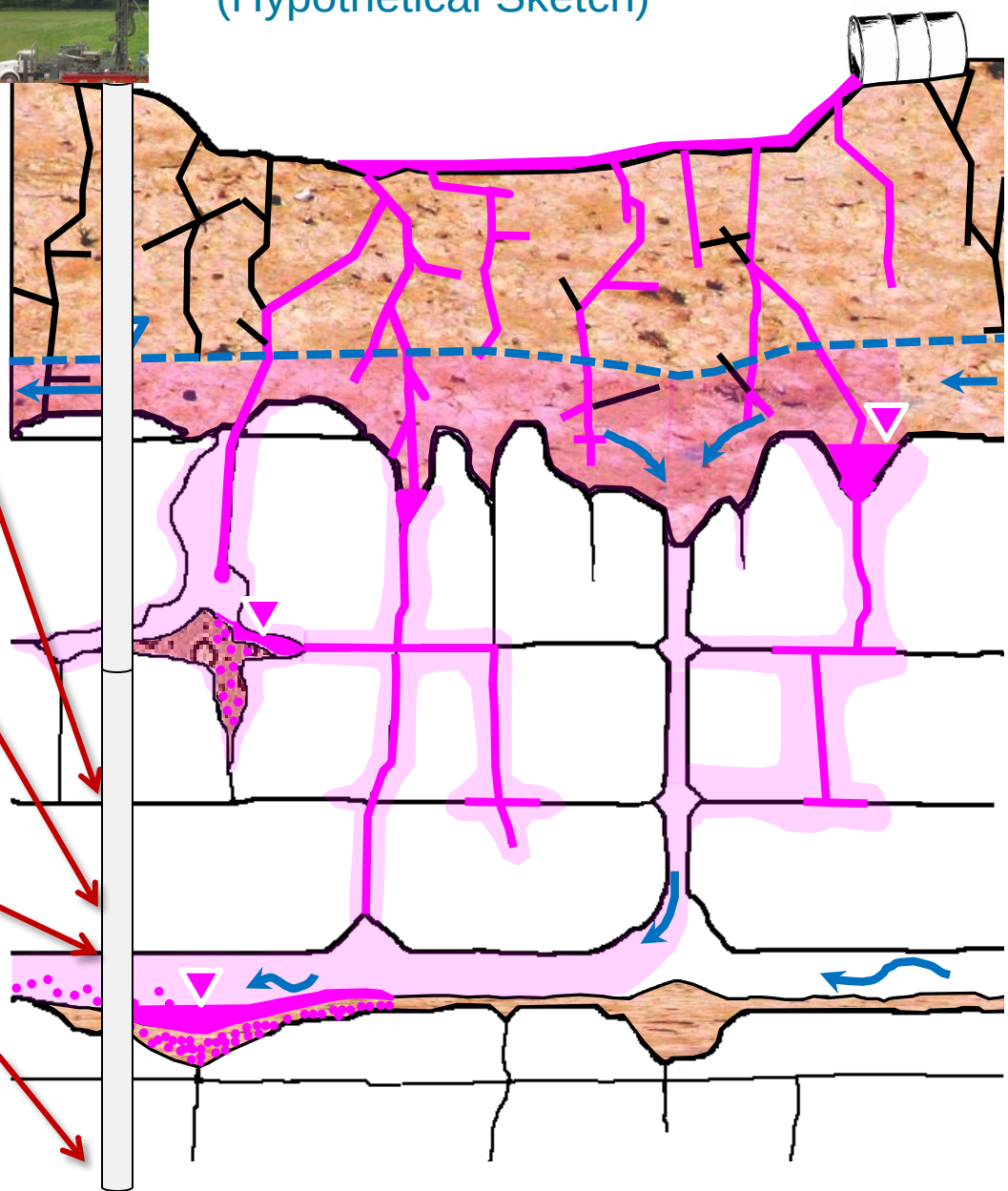
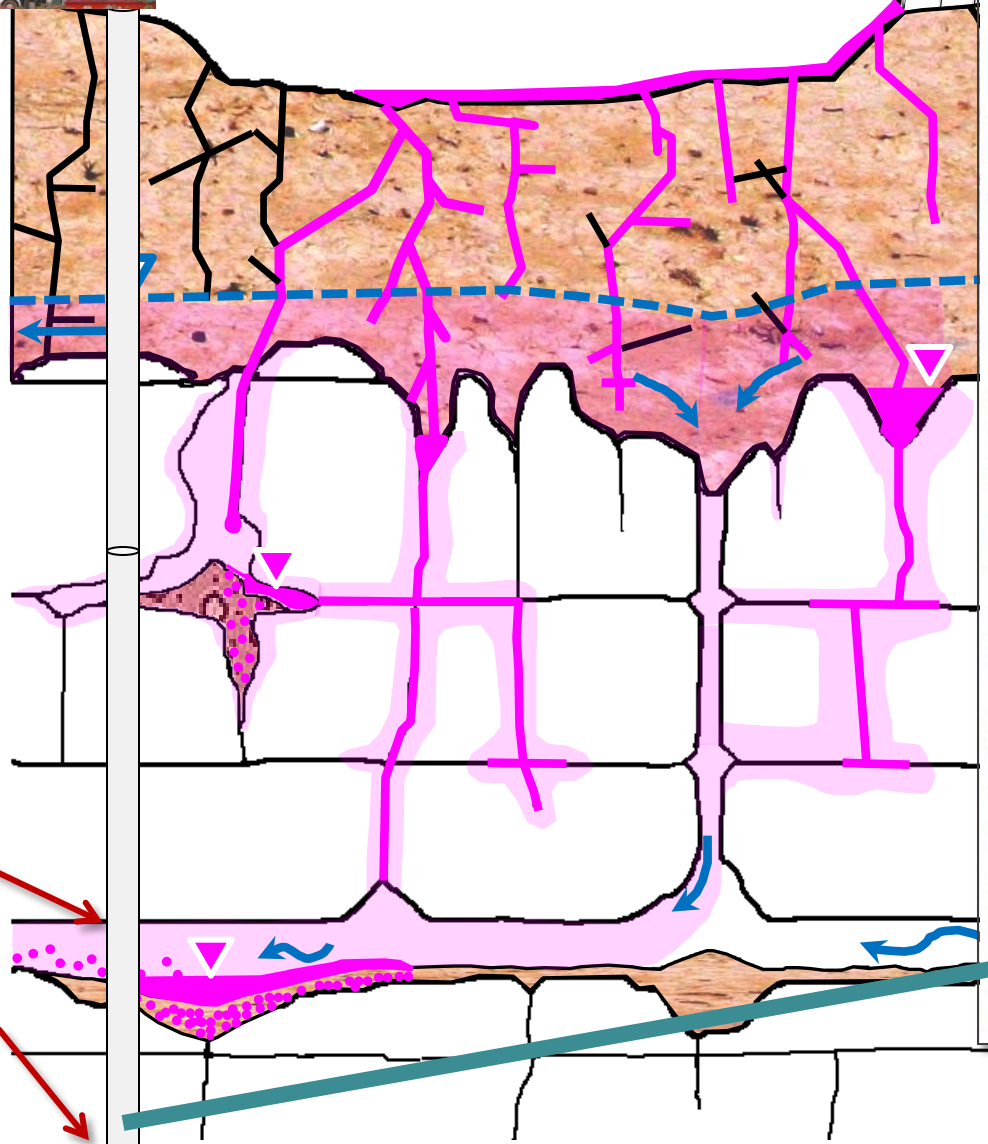
Hypothetical Observations During Drilling

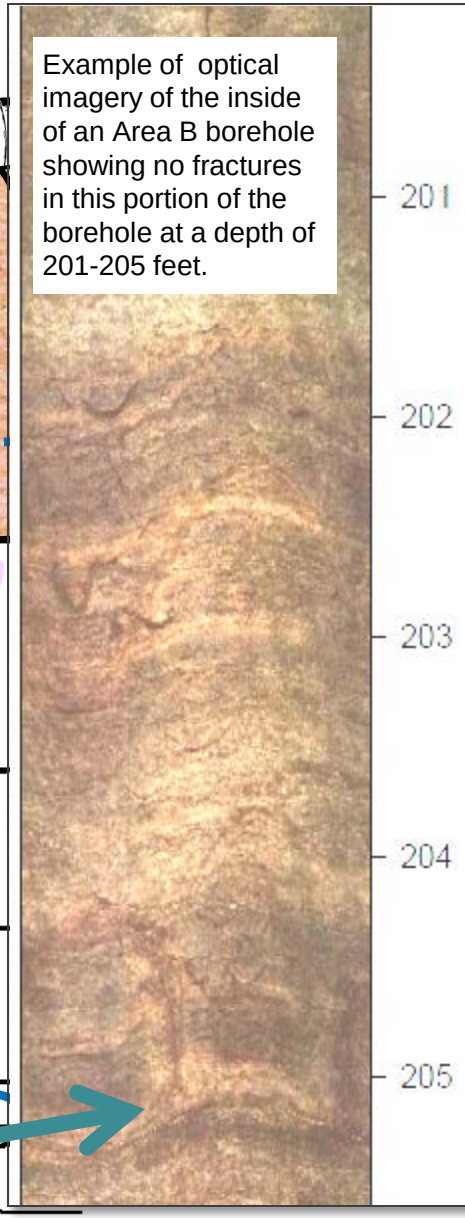
(Hypothetical Sketch)



Hypothetical Observations During Drilling

(Hypothetical Sketch)



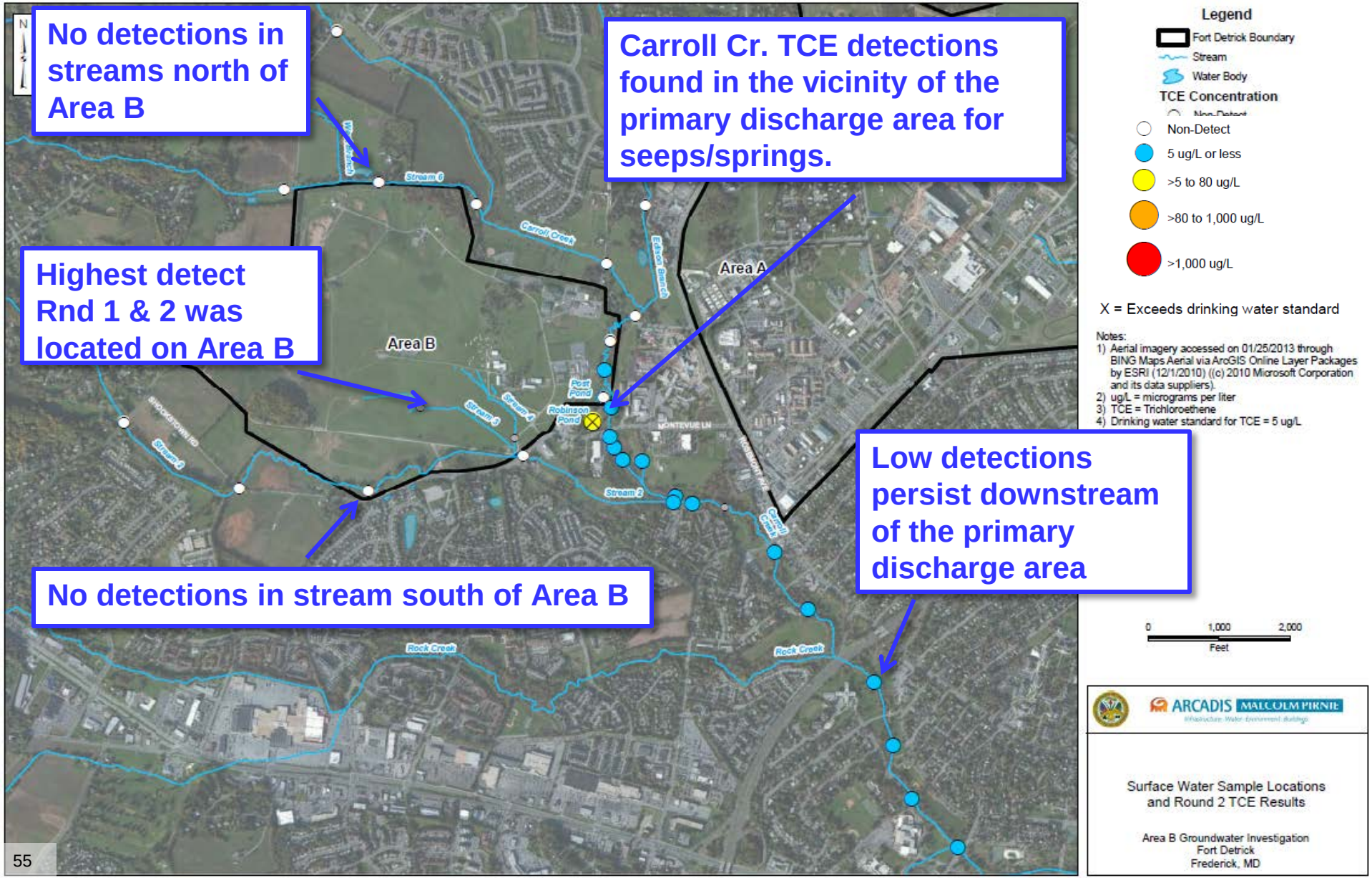


Example of optical imagery of the inside of an Area B borehole showing no fractures in this portion of the borehole at a depth of 201-205 feet.

Significant void and water bearing zone.

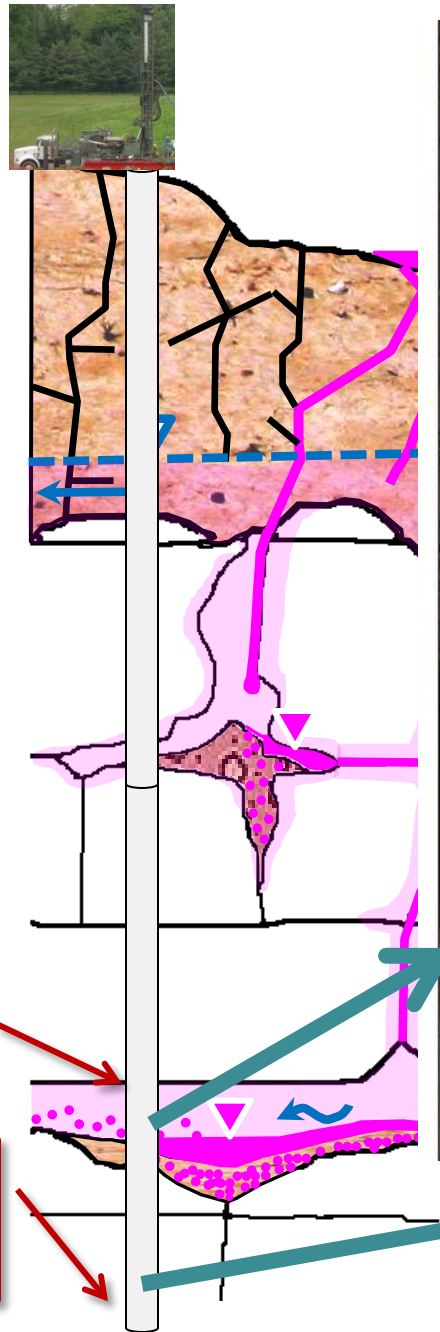
No fractures or fractures with little water.

TCE in Surface Water Sept 2012



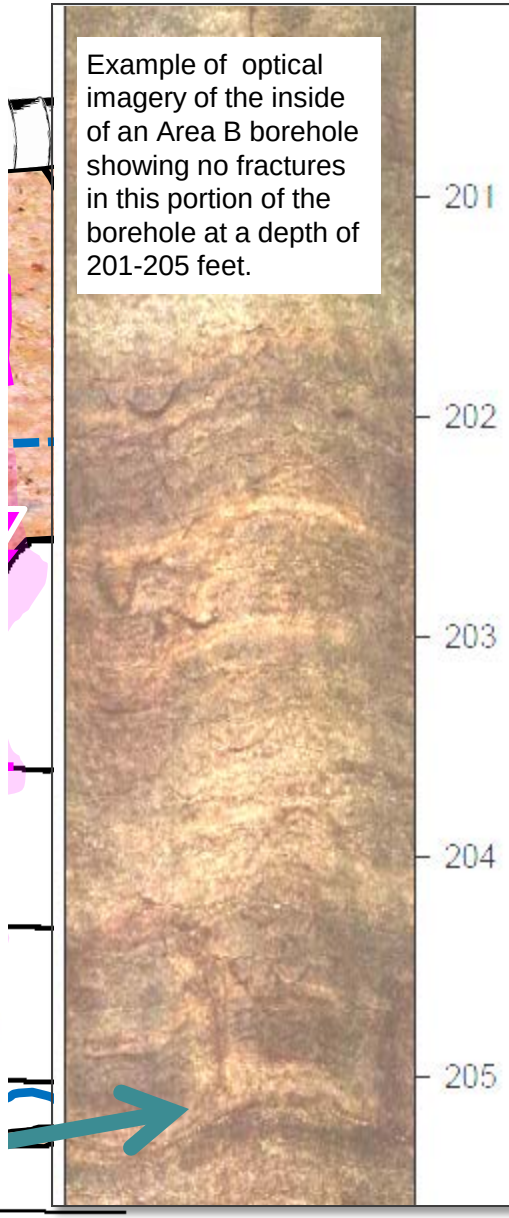
Hypothetical Observations During Drilling

Note: Optical and acoustical televiewer imagery were included in the suite of technologies used during the recent Area B drilling activities to aid in identifying appropriate zones for screening newly constructed monitoring wells. Examples are provided here to show how this imagery can help visually identify potentially water-bearing fractures and voids across the entire depth of the borehole.



Example of optical imagery of the inside of an Area B borehole showing a large void about 1 ft wide at a depth of about 43 feet.

Example of optical imagery of the inside of an Area B borehole showing no fractures in this portion of the borehole at a depth of 201-205 feet.

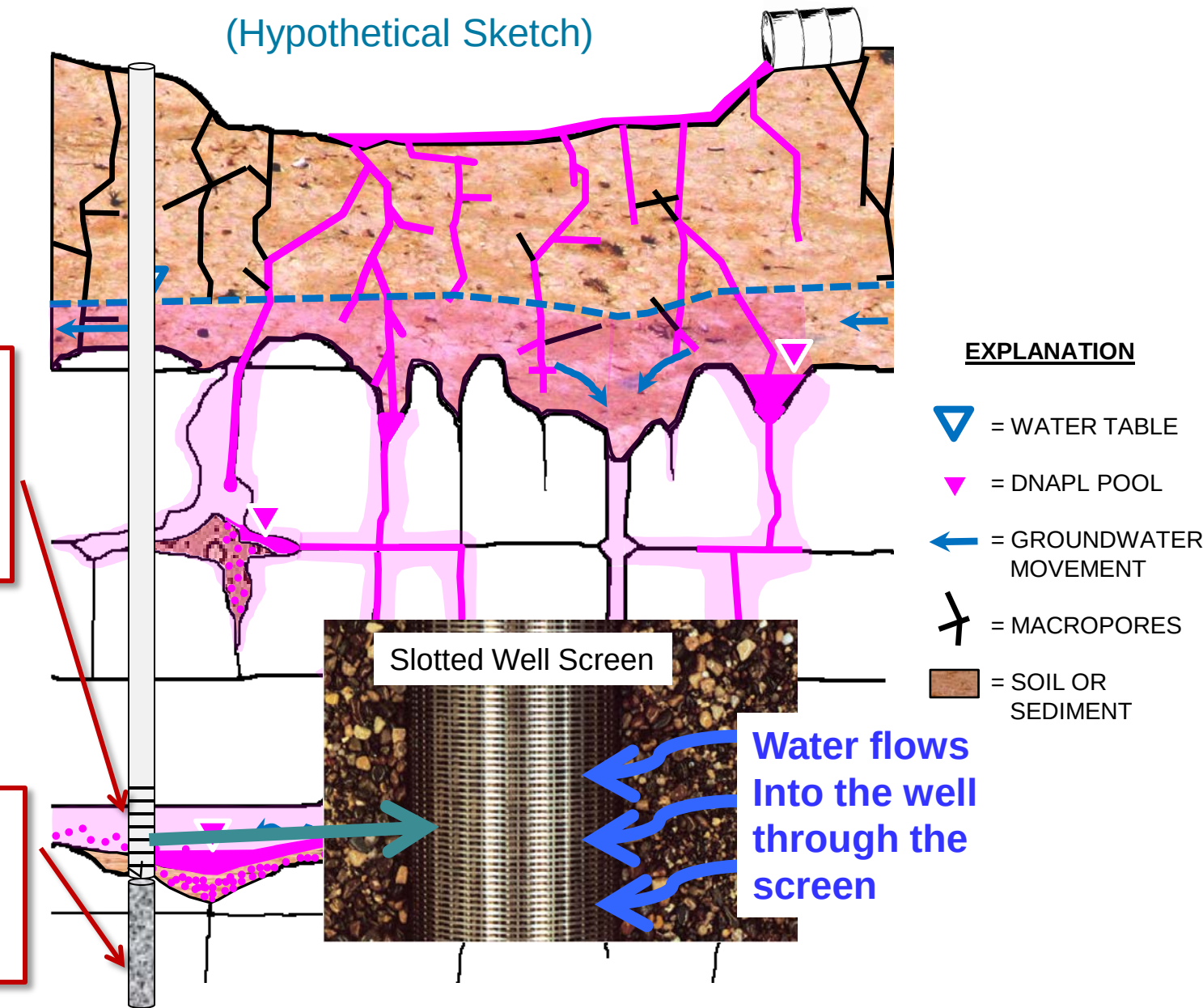


Significant void and water bearing zone.

No fractures or fractures with little water.

Constructing a Monitoring Well Based on Drilling Observations

(Hypothetical Sketch)

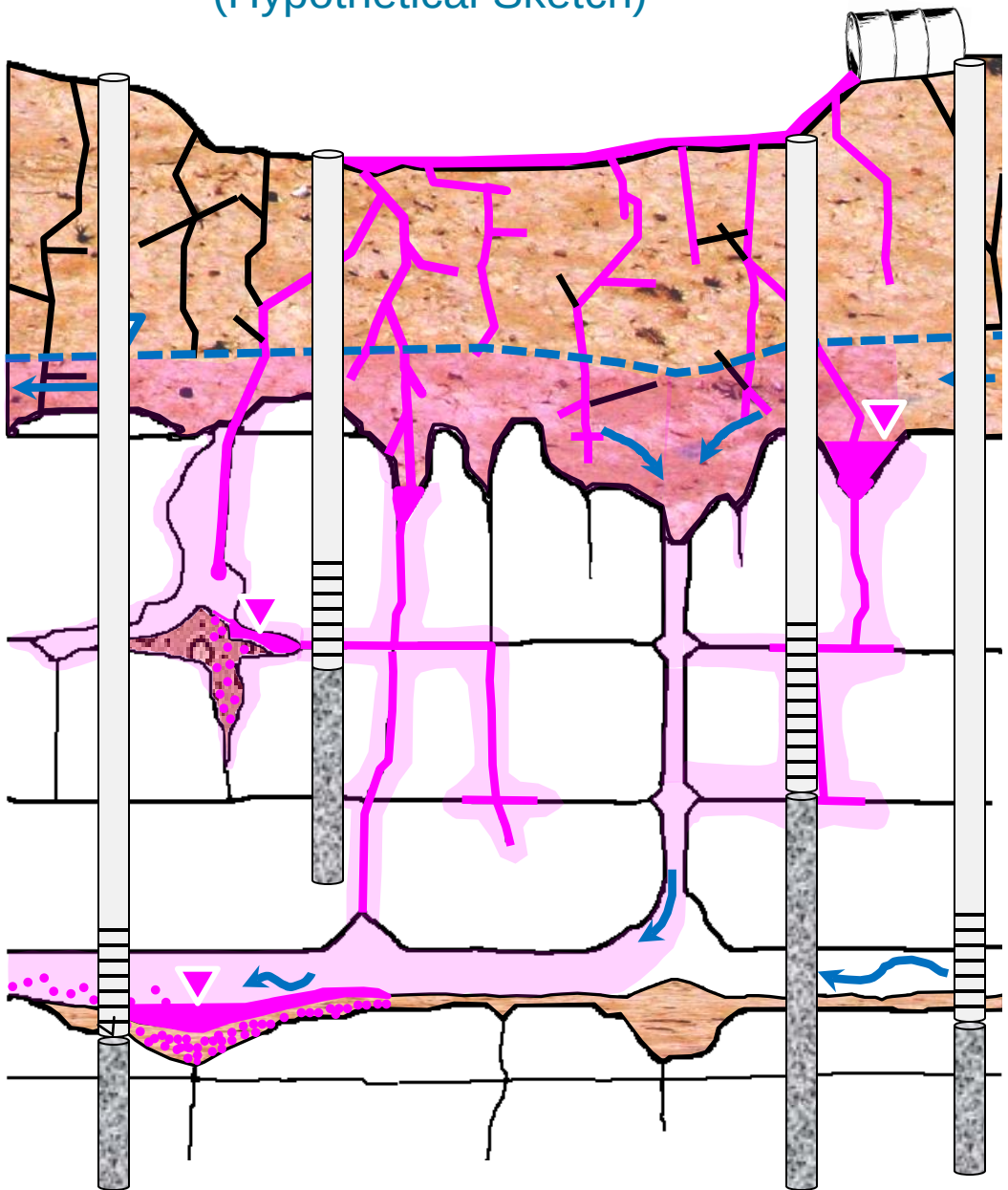


Drilling Considerations

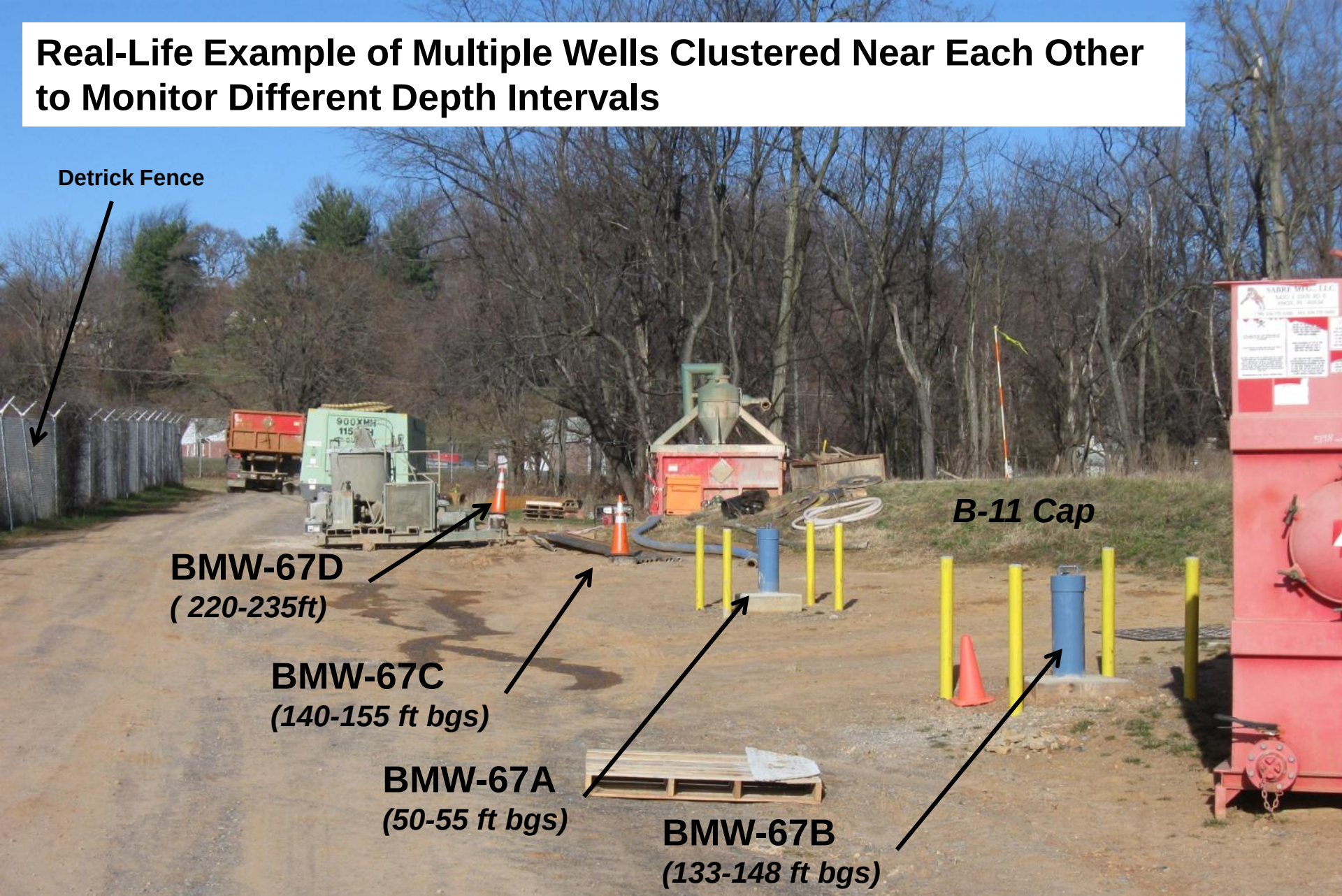
(Hypothetical Sketch)

Example of multiple wells constructed in a source area to target different depths.

Drilling observations, geophysical logging, and sampling used to target specific zones for long-term monitoring wells.

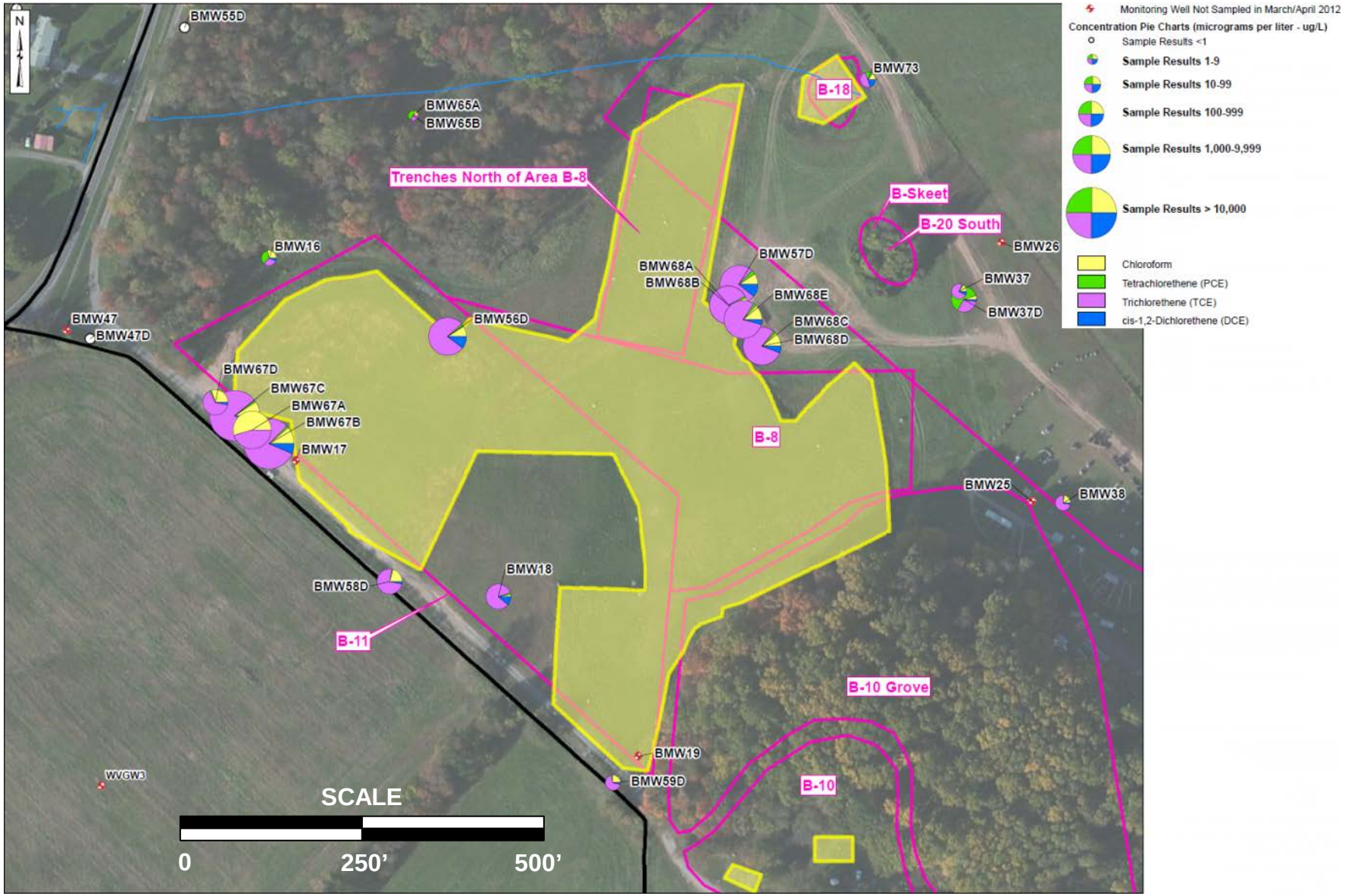


Real-Life Example of Multiple Wells Clustered Near Each Other to Monitor Different Depth Intervals



Area B - Western Corner near B-11 Landfill (facing north west)

Vertical Distribution of VOCs



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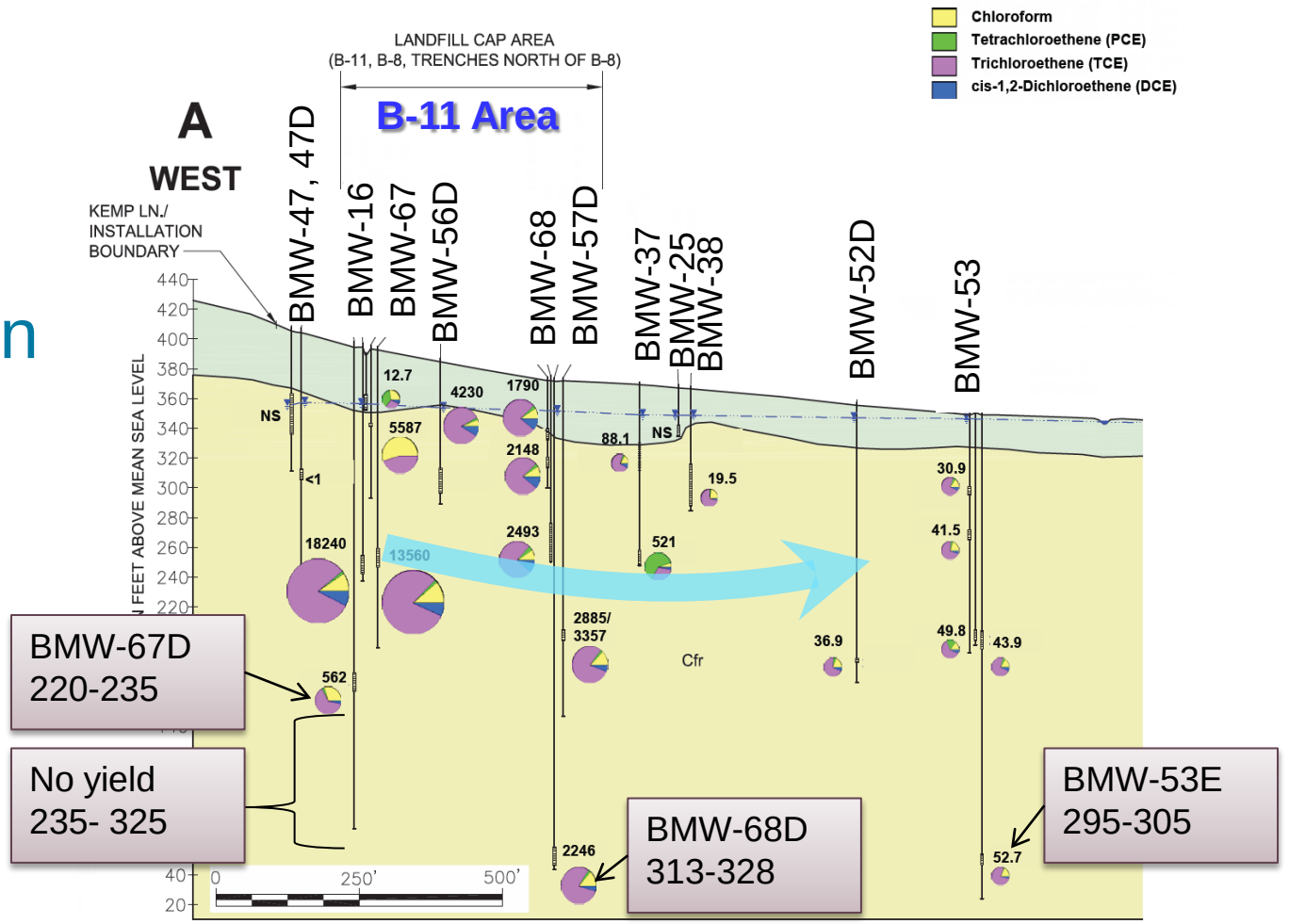
Vertical Distribution of VOCs

Currently known vertical distribution of major VOCs



= groundwater flow direction

Pie charts sizes reflect relative concentration of VOCs. Larger pie charts have higher concentrations than smaller pie charts.

Carroll Creek VOC Data

As reported during the July 2012 RAB, site related contaminants have been detected at low concentrations in Carroll Creek.

For the Round 2 sampling (Sept 2012), TCE concentrations in Carroll Creek are:

- Below drinking water standards (MCLs)
- Below human health screening criteria for recreational use of the creek (for child or adult)
- Below human health screening criteria for ingestion of fish from the creek

-No risks for these activities

-Carroll Creek is not used as a drinking water source

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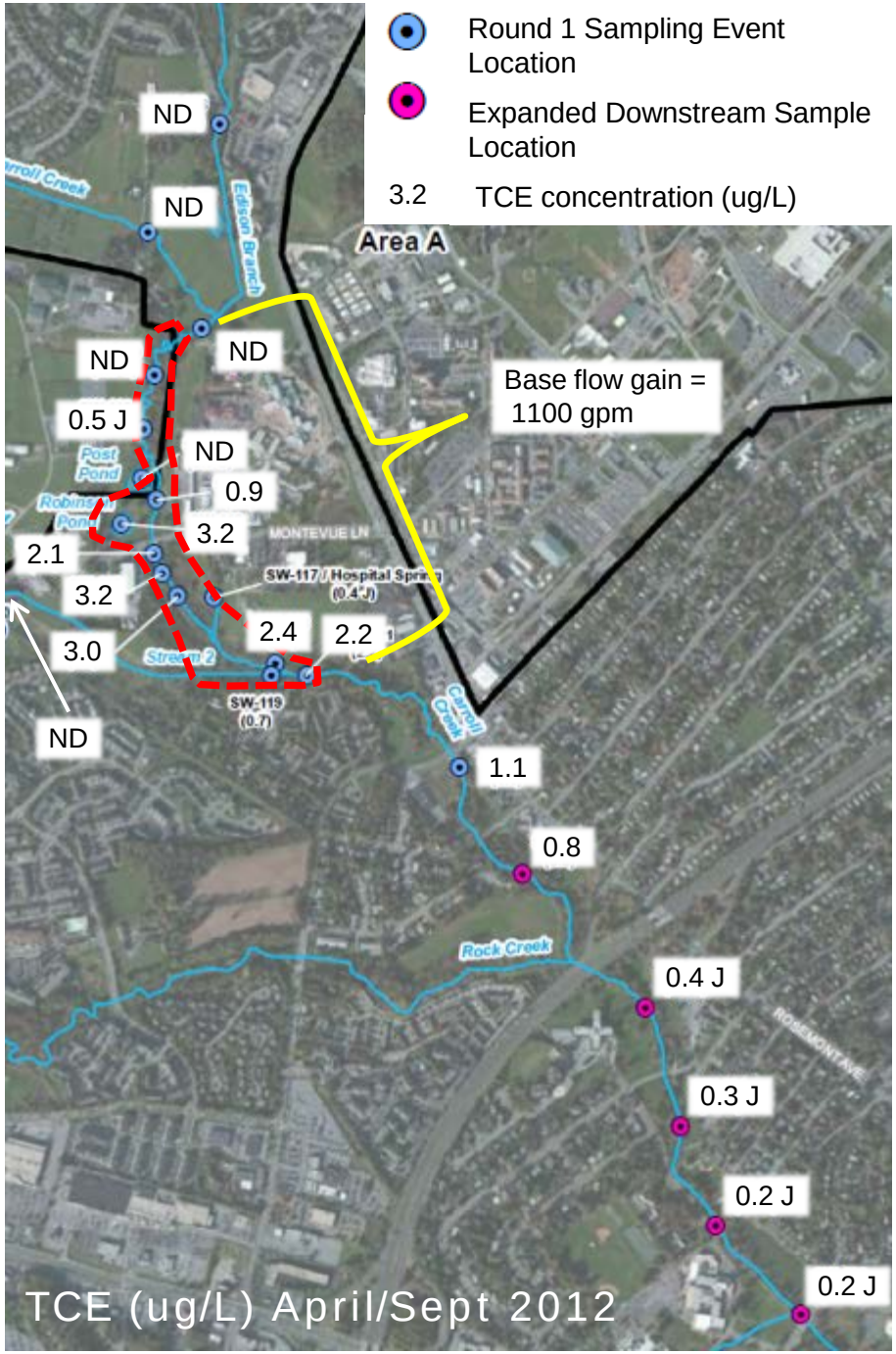
Surface Water



- Preliminary analysis suggests concentrations consistent with loading from springs in primary discharge area (red outline).
- Potential alternate sources may have minor effect.
- Downstream transport suggests attenuation due to dilution and volatilization.

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