DCS
AMERICAS
Design and Consulting Services

FORMER TRW MICROWAVE SITE

Current Site Status and Path Forward

July 9, 2020

AECOM

AECOM Imagine it. Delivered.

Meeting Agenda and Objectives

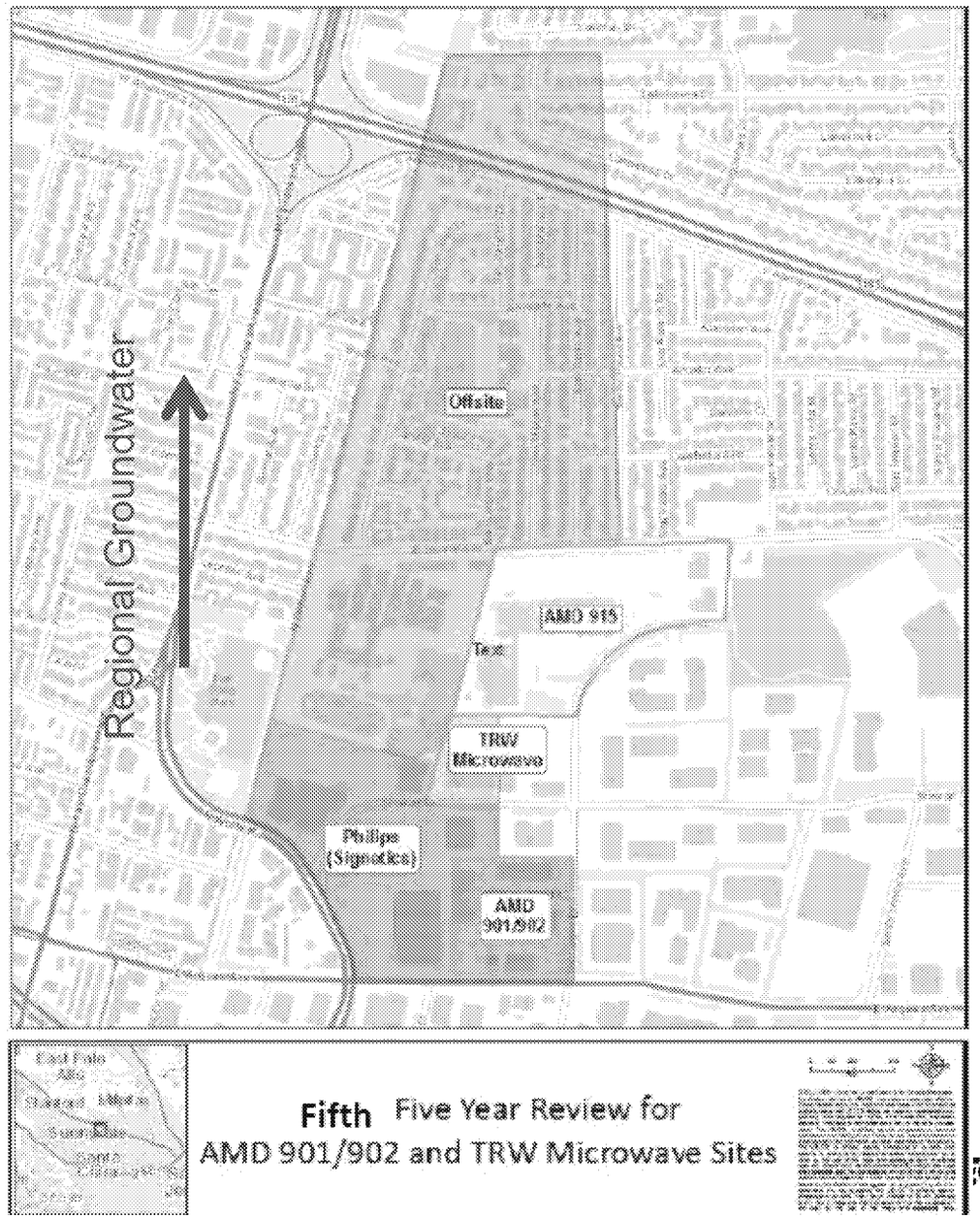
1. Brief review of site background and status
2. Remedial / Vapor Intrusion Activities
3. Site Strategy and Proposed Path Forward
4. ESS Overview and Key Findings

Image from Google

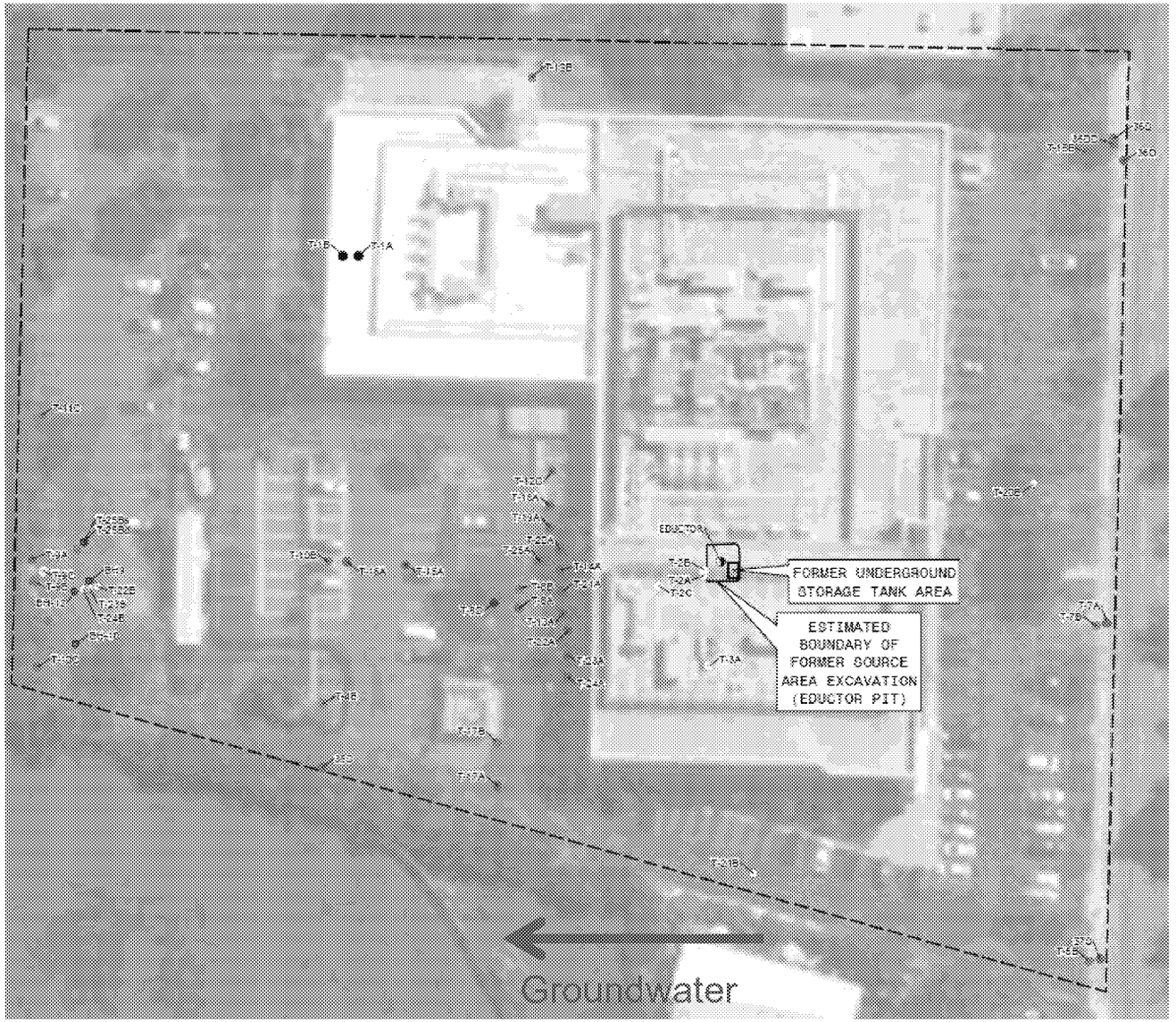
AECOM

Regional Setting and Nearby Releases

- Philips, AMD, and Northrop Grumman (the Triple Site) share responsibility for the management and remediation of the co-mingled groundwater plume, the Off-Site Operable Unit (OOU).
- VOC-Impacted sites within 1,000 feet of TRW Microwave site:
  - Advanced Micro Devices (AMD) Buildings 901/902
  - Philips Semiconductors (Philips; formerly Signetics) Buildings 811
  - Philips 815 and 440
  - AMD Building 915
- USEPA is the lead agency for the Triple Site, but Philips has historically been under a different regulatory program.



Site Layout



LEGEND

- A-ZONE MONITORING WELL
- B1-ZONE MONITORING WELL
- B2-ZONE MONITORING WELL
- B3-ZONE MONITORING WELL
- B4-ZONE MONITORING WELL
- EDUCTOR - DESTROYED 2014
- NEWLY INSTALLED MONITORING WELL
- MONITORING WELL - DESTROYED 2014
- MONITORING WELL - DESTROYED 2004
- MONITORING WELL - DESTROYED OCTOBER 2019
- PROPERTY BOUNDARY

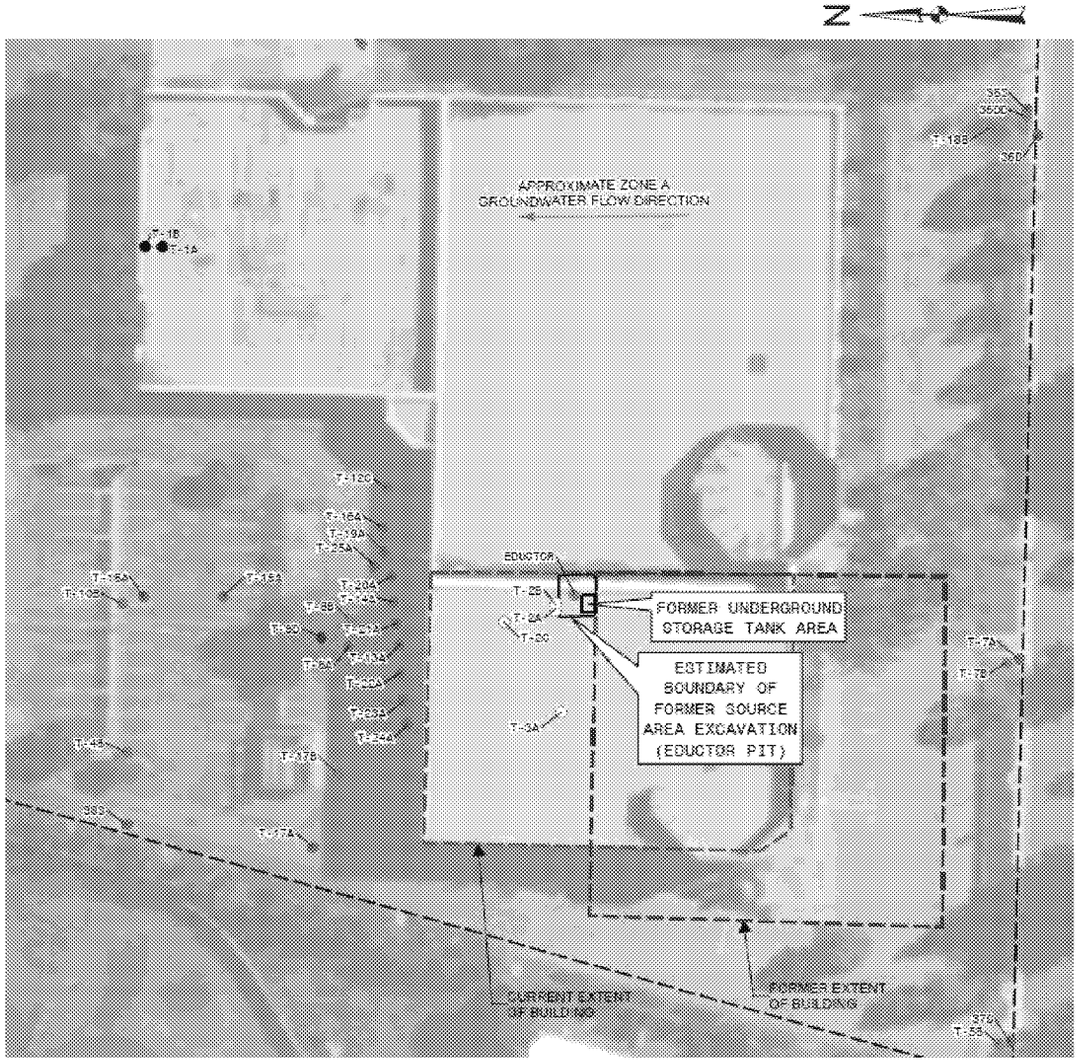
N

AECOM

Operational History

Ownership and Operations

- 1968 – 1974: Aertech Industries assembled and tested microwave and semiconductor components
- 1974: TRW Inc. acquired the site
- 1987: FEI Microwave purchased the site
- 1993: Microwave ends manufacturing activities
- 1995 – 2000: Site acquired by Stewart Associates and leased to Diablo Research corporation
- 2001 – 2003: Building remodeled, including construction over the former location of the underground storage tank
- 2001 – 2014: Site unoccupied
- 2014 – 2015: Building redeveloped
- 2015 – Present: Site leased by Apple

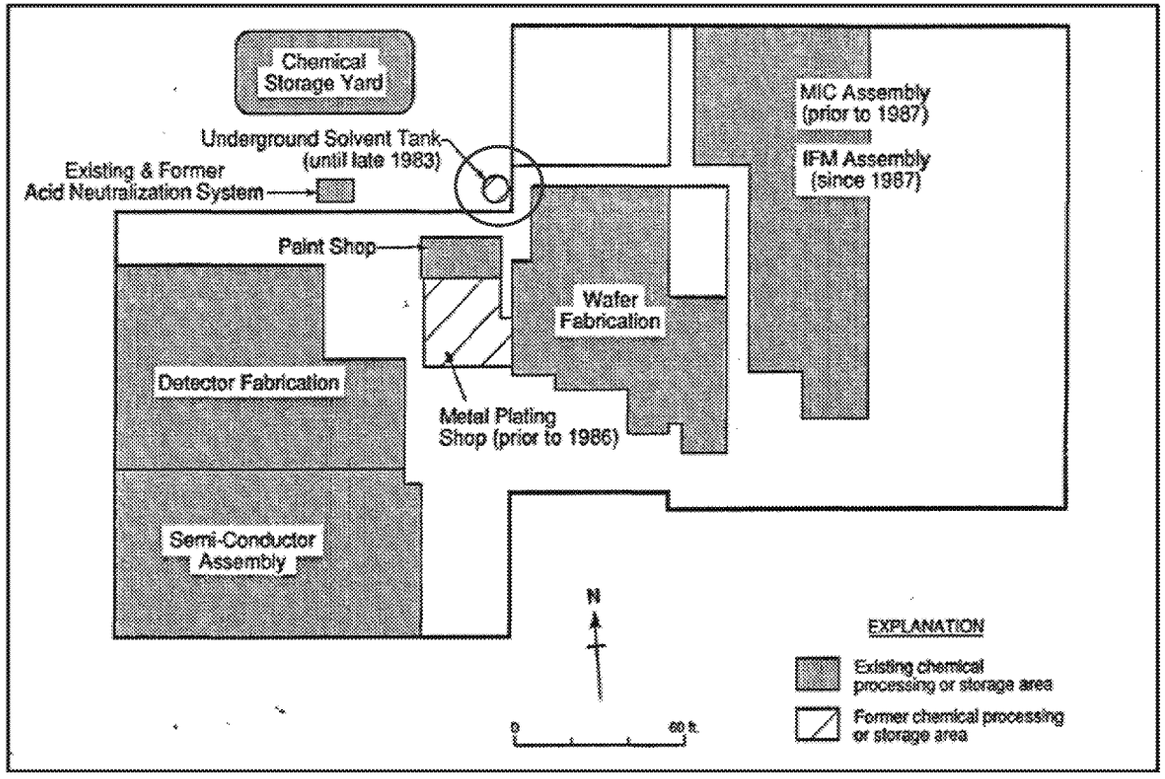


AECOM

Previous Chemical Usage

Chemical Use

- 1968 – 1993 TCE and other industrial solvents used
- 1970 – 1982 Waste solvent stored in UST (considered the source area)
- 1968 – 1984 Ammonia gas and acid neutralization system operated (not associated with contamination at the site)



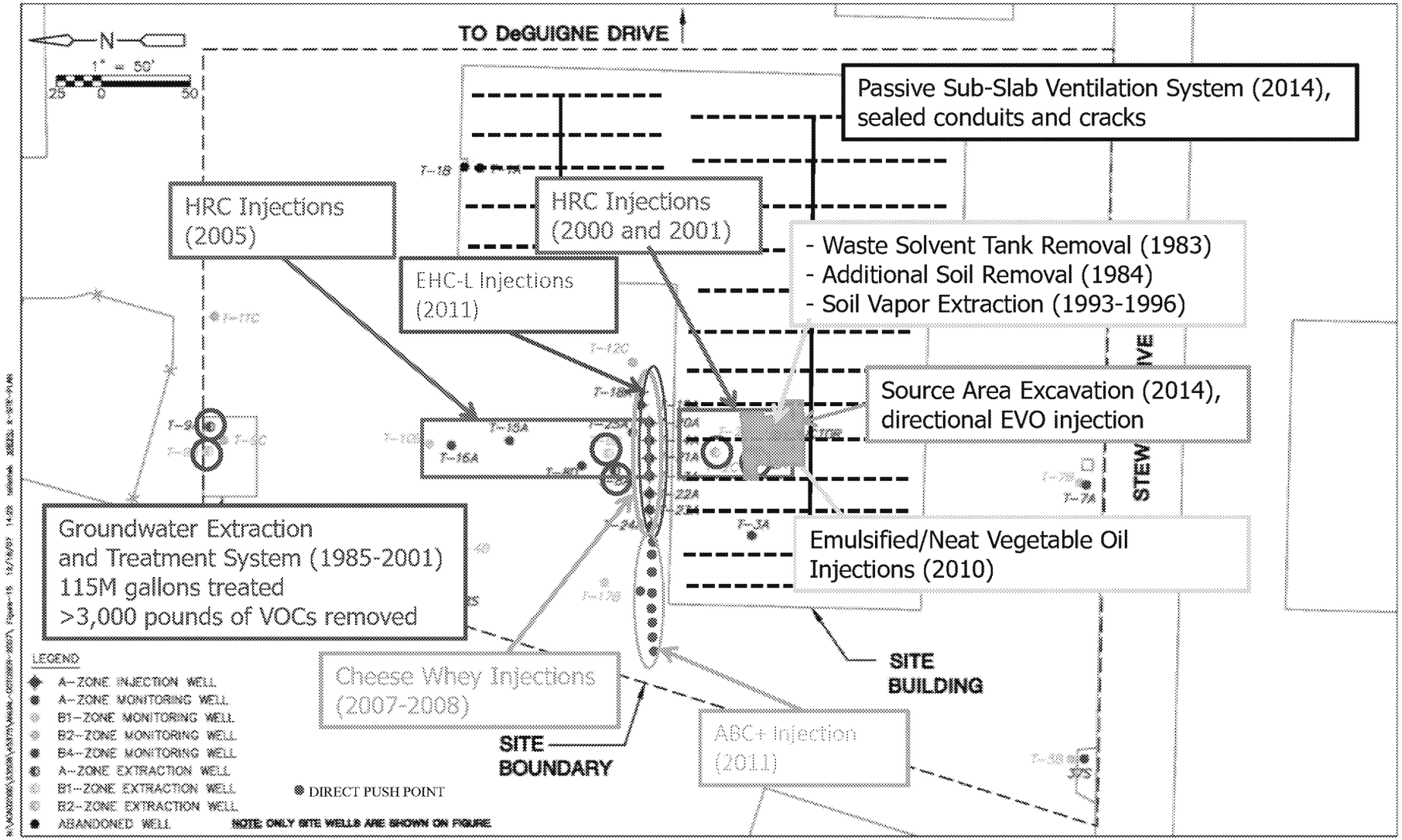
Adapted from the Record of Decision (USEPA 1991)

AECOM

Regulatory History

- Site is managed under the CERCLA process
- Regulatory oversight was previously delegated to the Water Board and a cleanup order (Order No. 91-103) was issued in 1984
- ROD was approved in 1991: ROD included TRW, AMD, Philips, and the OOU. Remedy for each site was pump and treat.
- P&T operated 1985 to 2001. Was turned off because pulling contamination on to the site. Cessation of P&T and transition to in situ remediation was supported by the Water Board.
- Focused Feasibility Study was submitted to the Water Board and USEPA in May 2011 but never finalized.
- USEPA took over the lead agency role August 7, 2014.
- Five Year Review prepared by USACE in September 2014; responses led to a need for an updated CSM and using ESS.
- Most recent Five Year Review prepared by USACE in September 2019.

Previous Remedial Activities



AECOM

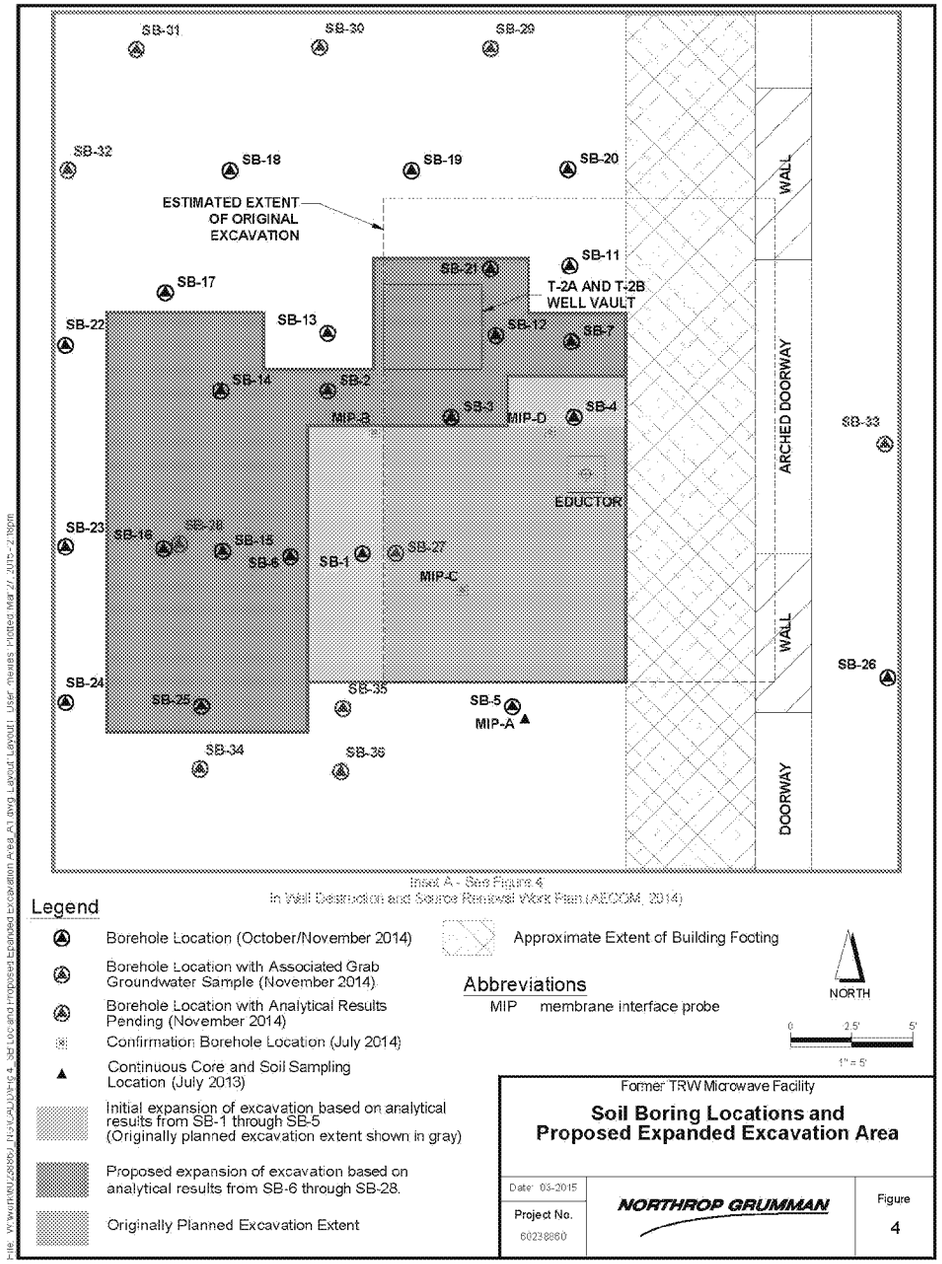
Enhanced Anaerobic Biodegradation (EAB) Program

- More than 10 years of active EAB programs:
  - October 2000 – Injected HRC into former source area Zone A and Zone B1
  - June 2001 – Additional HRC injections into Zone A and Zone B1
  - August 2005 – Additional HRC injections downgradient of the source area
  - 2007-2008 – Injection of cheese whey into Zone A wells downgradient of the source area
  - October 2010 – Injection of emulsified vegetable oil (EVO) into the source area
  - November 2010 – Injection of neat soybean oil into the source area
  - November 2011 – Injection of EHC-L into Zone A wells and ABC+ into Zone A and Zone B1
  - December 2014 – Injection of EVO under building footings in the vicinity of the source area
- Previous CSIA analysis at the site confirmed EAB successfully caused degradation of COCs
- Presence of daughter products (cDCE, VC, ethene) confirmed complete degradation and removal of contaminant mass

AECOM

Source Area Excavation Extent

- Excavation extent guided by soil boring results
- Hydropunch was used to correlate soil concentrations with groundwater concentrations
- Excavated soil correlated with:
  - TCE > 150 ug/L in groundwater
  - cDCE > 250 ug/L in groundwater
  - There are similar to concentrations coming onsite from upgradient
- 2014 excavation extent was significantly larger than the 1984 excavation
- Removed approximately 400 cubic yards of soil



AECOM

Source Area Excavation

Breaking up concrete for expanded excavation activities

Large diameter auger

Extent of the excavation area (fitted with rebar after excavation activities complete) looking north with vent risers for the passive sub-slab vapor collection system in the foreground

AECOM

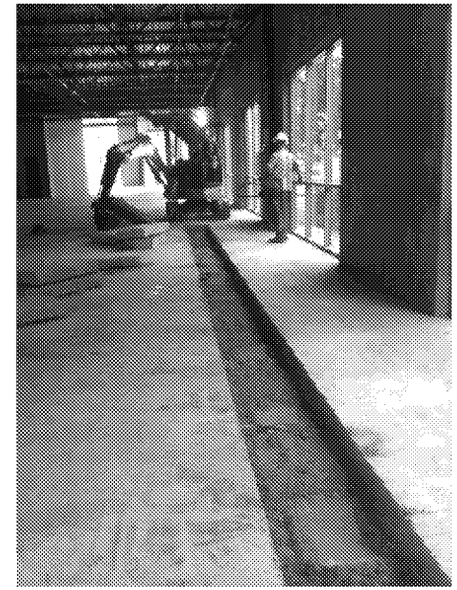
Vapor Intrusion

- December 2013 – VI evaluation showed that TCE was present inside the building between 6.8 µg/m^3 to 7.7 µg/m^3
- August/September 2014 – Proactively installed a passive sub-slab vapor collection system underneath the site building to mitigate any potential VI
- November 2014 – Destroyed wells inside building to eliminate pathway
- April 2015 – Sealed concrete slab cracks/penetrations, elevator shaft, and space between walls
- May 2015 - Performed VI sampling event to evaluate post-mitigation conditions and confirmed mitigation measures sufficiently effective

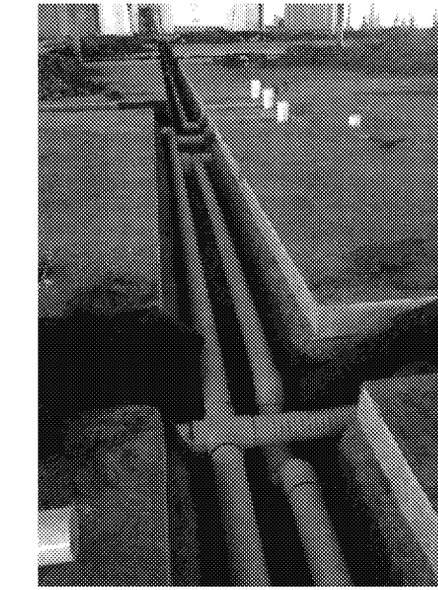
AECOM

Vapor Intrusion

Passive Sub-Slab Vapor Collection System Installation

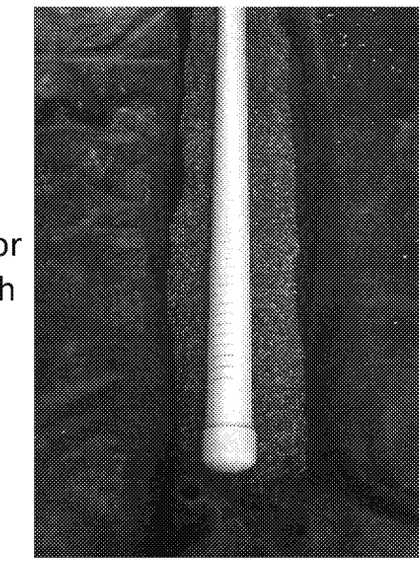


Vapor collection trench lined with geotextile fabric, backfilled with pea gravel, and installed slotted pipe

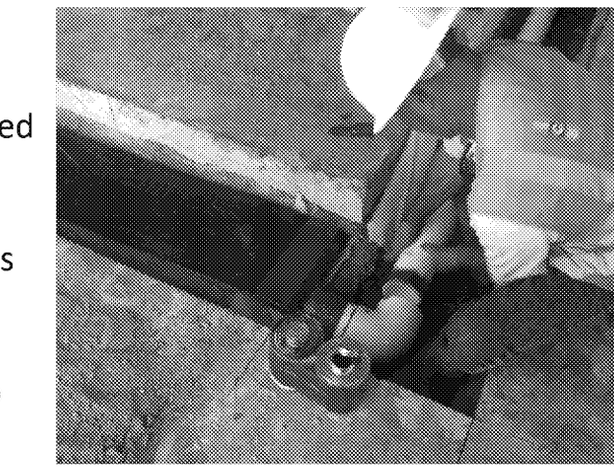


Slotted vapor collection piping connected to solid header pipes leading to vent risers

Capped end of slotted pipe installed in vapor collection trench



Geovent (installed in place of slotted pipes where not enough clearance was available for pipes) being connected to pipe header



AECOM

2017 Site Strategy Presented to USEPA

- Decades of active remediation have been performed, including removal of the onsite source area.
- A passive sub-slab depressurization system has already been installed under the entire onsite building to mitigate any potential future vapor intrusion risk.
- Maximum Contaminant Levels (MCLs) are not realistic cleanup goals for site groundwater due to impacts from upgradient, off-site sources.
- Plan to propose “background water quality” as alternate cleanup goals.
  - Background = contaminant concentrations migrating onto the site from upgradient, off-site sources
  - Map contaminant migration pathways using an ESS approach, including identifying contaminant migration from off-site sources
- Optimize groundwater monitoring network in light of updated CSM.
- At the request of USEPA, prepare a Focused Feasibility Study document to formalize alternate cleanup goals and present remedial alternatives.

AECOM

2019 FYR Summary – Supportive of Site Strategy

- Previous in-situ remedies and institutional controls at TRW and AMD sites are providing protectiveness.
- Existing1992 covenant and agreement for TRW site prohibits use of groundwater, using the site as a daycare, or excavation of soils without prior approval of the Regional Board until cleanup levels stated in the ROD are achieved.
- Points to extensive ESS work done at TRW site as beneficial to the CSM and understanding of contaminant migration.
- Passive sub-slab system at TRW site adequately mitigates potential indoor air issues based on 2015 sampling.
- Acknowledges that achieving cleanup goals with the presence of upgradient sources (specifically Philips) would be difficult.
- Identified recommendations from USACE:
  - Select a revised remedy which incorporates long-term stewardship measures for the current vapor intrusion mitigation measures in place, as well as addresses potential vapor intrusion in the event of future land use changes.
  - Revised soil and groundwater remedy should be selected, as the remedy selected in the ROD is no longer operating.

AECOM

2019 FYR – Identified TRW CSM as Model for Surrounding Sites

Northrup Grumman, the company responsible for the TRW Site, updated their Conceptual Site Model and detailed the depositional environment of alluvial deposits in the Triple Site area[2]. Numerous hydrostratigraphic units (HSU) were identified within A, B1, and B2 Zones. These hydrostratigraphic units have not been projected or identified to any significant extent beyond the TRW Site. Permeable channel deposits representing hydrostratigraphic unit preferred pathways have been identified in the A and B1 Zones at the Signetics Site.

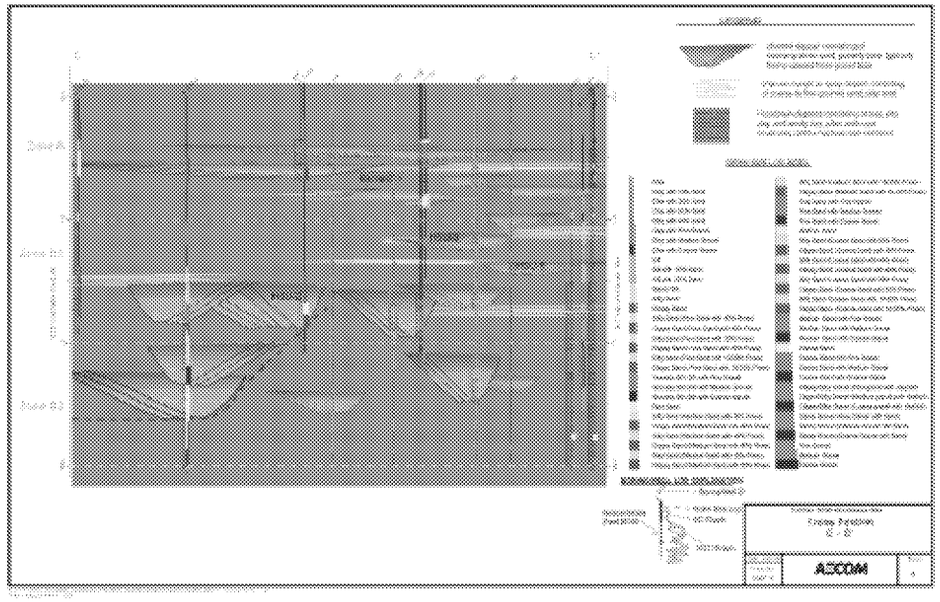


Figure 4. Cross-Section Showing hydrostratigraphic units in the A, B1, and B2, Zones Beneath the TRW Site

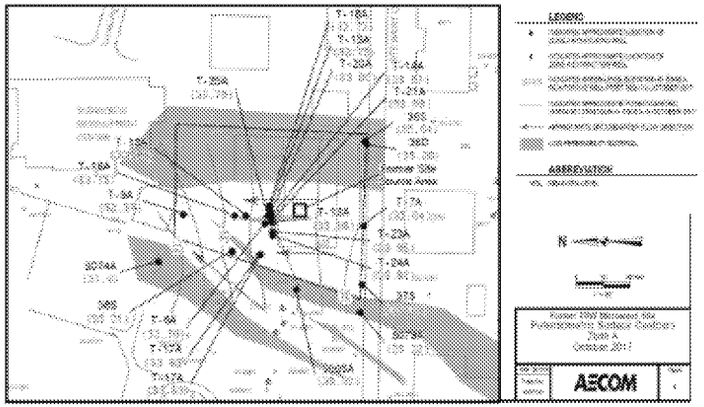


Figure B-13. TRW A Aquifer Zone hydrostratigraphic units Showing Channelized Flow Patterns and Groundwater Contours (note figure orientation)

Furthermore, there is a wide gap in in the level of detail and accuracy of the Conceptual Site Model for the Offsite OU and the TRW Site, which should be narrowed to be able to achieve greater success in mass removal, leading to aquifer restoration and mitigation of risks to human health and the environment. The Conceptual Site Model needs to be updated to account for the preferred transport pathways of the fluvial depositional environment known to exist in the region. The Conceptual Site Model update should include the following activities: regional pre-remediation hydraulic gradients should be estimated; a detailed review of lithologic changes from boring logs should be conducted; permeability zones should be identified and identified thicknesses; detailed cross-sections that map out high permeability zones should be constructed; and new subsurface chemical and stratigraphic data should be assimilated where appropriate.

[2] A Conceptual Site Model is comprehensive graphical and written summary of what is known or hypothesized about environmental contamination at a site. It provides a platform for evaluating the data gaps and related uncertainty associated with site history and operations; geology, hydrogeology and hydrology; contaminant sources, release mechanisms and fate and transport; potential receptors and exposure pathways.

AECOM

Proposed Path Forward Discussion

- Upcoming field work and documents
  - Submit updated CSM - July 2020
  - Submit long-term groundwater monitoring plan – August 2020
  - Continue annual groundwater monitoring – October 2020
  - Submit Focused Feasibility Study – November 2020
- ROD Amendment – USEPA to provide update

AECOM

ESS DISCUSSION

Evolution of sequence stratigraphic framework at TRW

- Historic depth zonation A, B1, B2
- 2014 Five-Year Report flagged increasing downgradient concentrations at TRW, suggested additional source characterization / remediation on-site

Issue	Recommendation
Increasing contaminant of concern concentrations in downgradient wells indicates that the remedy is not containing off-site migration.	Investigate and implement optimization options for the in situ bioremediation to decrease downgradient groundwater contamination.
On site trends were evaluated without consideration of impacts from off-site sources	2014 source area excavation resulted in decreases in d/g groundwater contamination

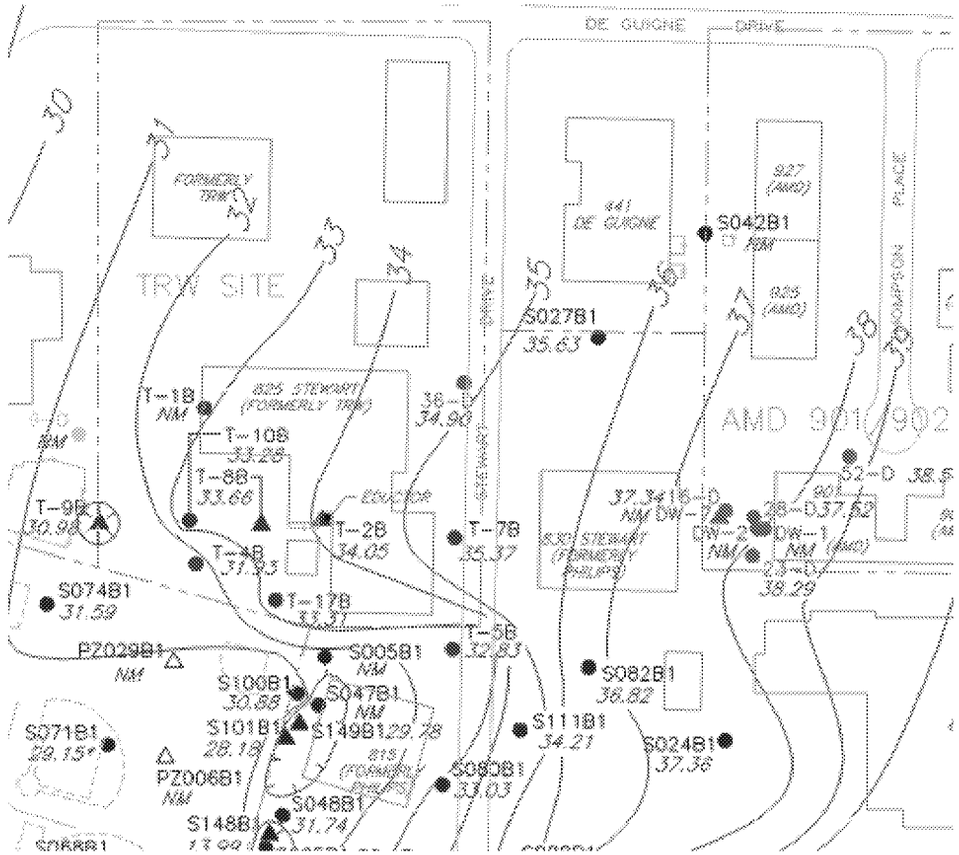
- Identified a need to better understand contaminant transport pathways through the use of Environmental Sequence Stratigraphy

AECOM

Evolution of sequence stratigraphic framework at TRW

- ESS Process: brief overview
  - Identified sequences typical of fluvial channel deposits
  - T-9B (downgradient Zone B1 well) identified as being screened across multiple sand channels within Zone B1
  - Preliminary facies mapping identified HSU-1 (onsite source channel) and HSU-2 (offsite source channel), verified with analyte signatures
  - Showed T-9B not representative of TRW contamination
  - Identified data gaps with respect to onsite migration of contamination
- 2017, 2018 MIP / HPT program
  - Confirmed HSU hypothesis
  - Enabled refined HSU mapping and field work planning for confirmation and monitoring well installation
- 2018 Boring and well installation program
  - Further refined HSU maps and csm
  - Installed monitoring wells to monitor individual HSUs

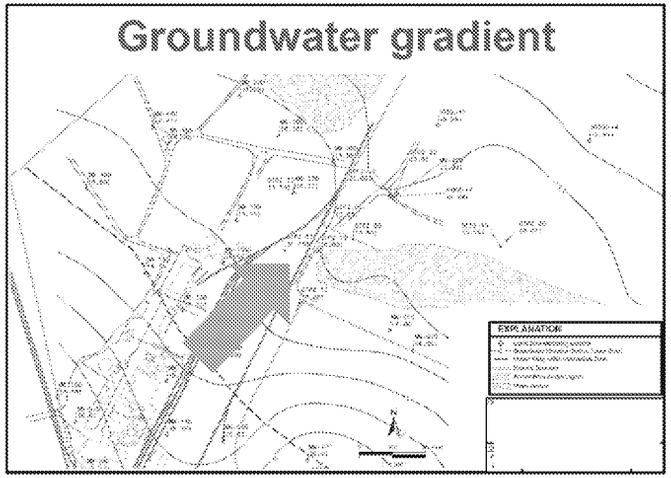
"B1" water levels, Locus, 2011

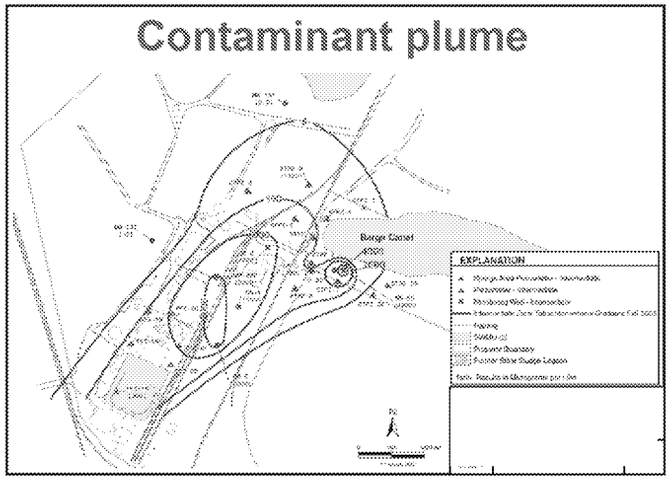


AECOM

Subsurface Heterogeneity and Groundwater Remediation

- Historically, simplifying assumptions of aquifer **homogeneity and isotropy** applied to designing and implementing groundwater remediation programs – the "water supply legacy"
- While heterogeneity was recognized, it was thought that we could **"engineer around geology"**





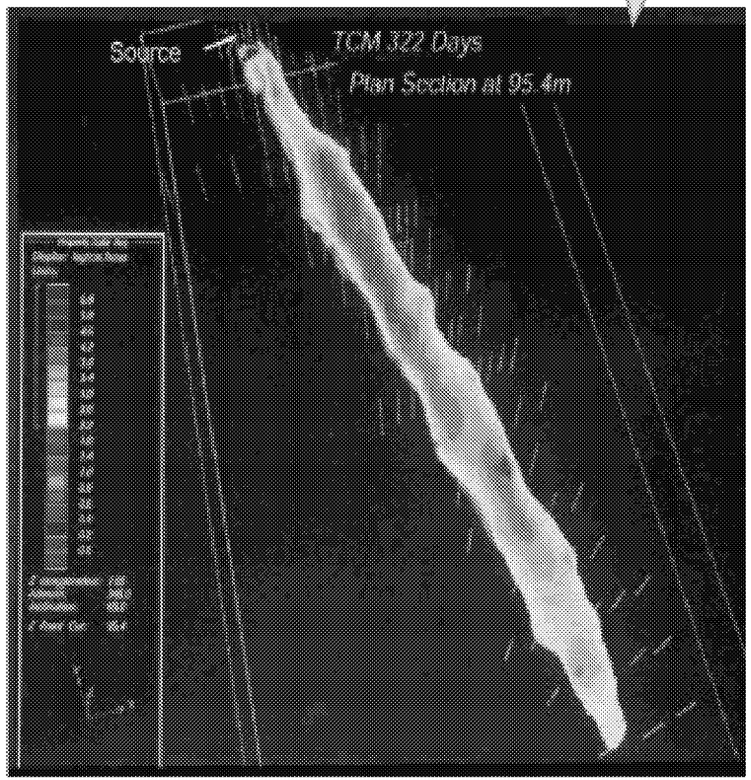
AECOM

Plume Morphology

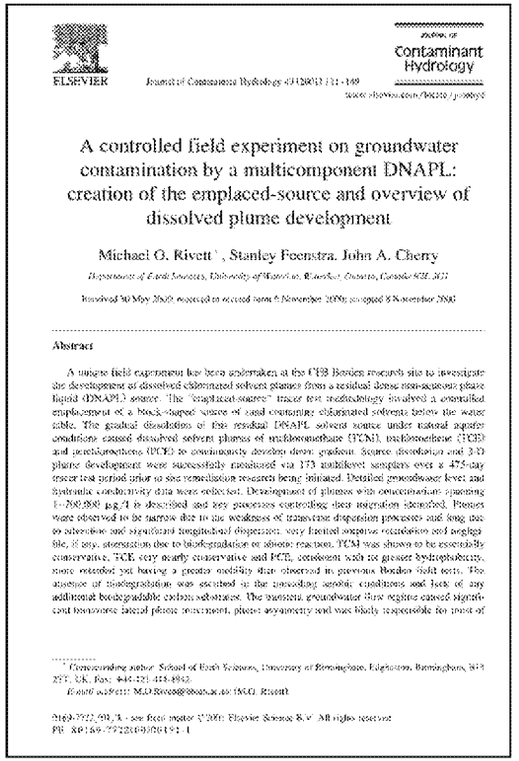
In the absence of geologic heterogeneity, plumes exhibit very linear migration patterns

- Field studies (e.g., Rivett, Feenstra, and Cherry, 2001) demonstrate transverse dispersivity of dissolved plumes is near-zero, and observed transverse dispersion is a result of fluctuating groundwater gradients and very limited geologic heterogeneity at the site
- Large-scale plume "spreading" requires geologic control or major flow gradient modification by pumping, etc.

TCM plume extending from DNAPL source emplaced into natural aquifer



6. View of the Borden emplaced-source taken toward the end of the tracer test facing approximately north. The source zone was emplaced 4–5 m below ground at the location of the "box" (metal form used to emplace the source zone) in the foreground.



ELSEVIER

Journal of Contaminant Hydrology 43 (2000) 131–169

Contaminant Hydrology

A controlled field experiment on groundwater contamination by a multicomponent DNAPL: creation of the emplaced-source and overview of dissolved plume development

Michael O. Rivett *, Stanley Feenstra, John A. Cherry

Department of Earth Sciences, University of Waterloo, Waterloo, Ontario, Canada N2L 3G1

Received 30 May 2000; accepted in revised form 6 November 2000; accepted 8 November 2000

Abstract

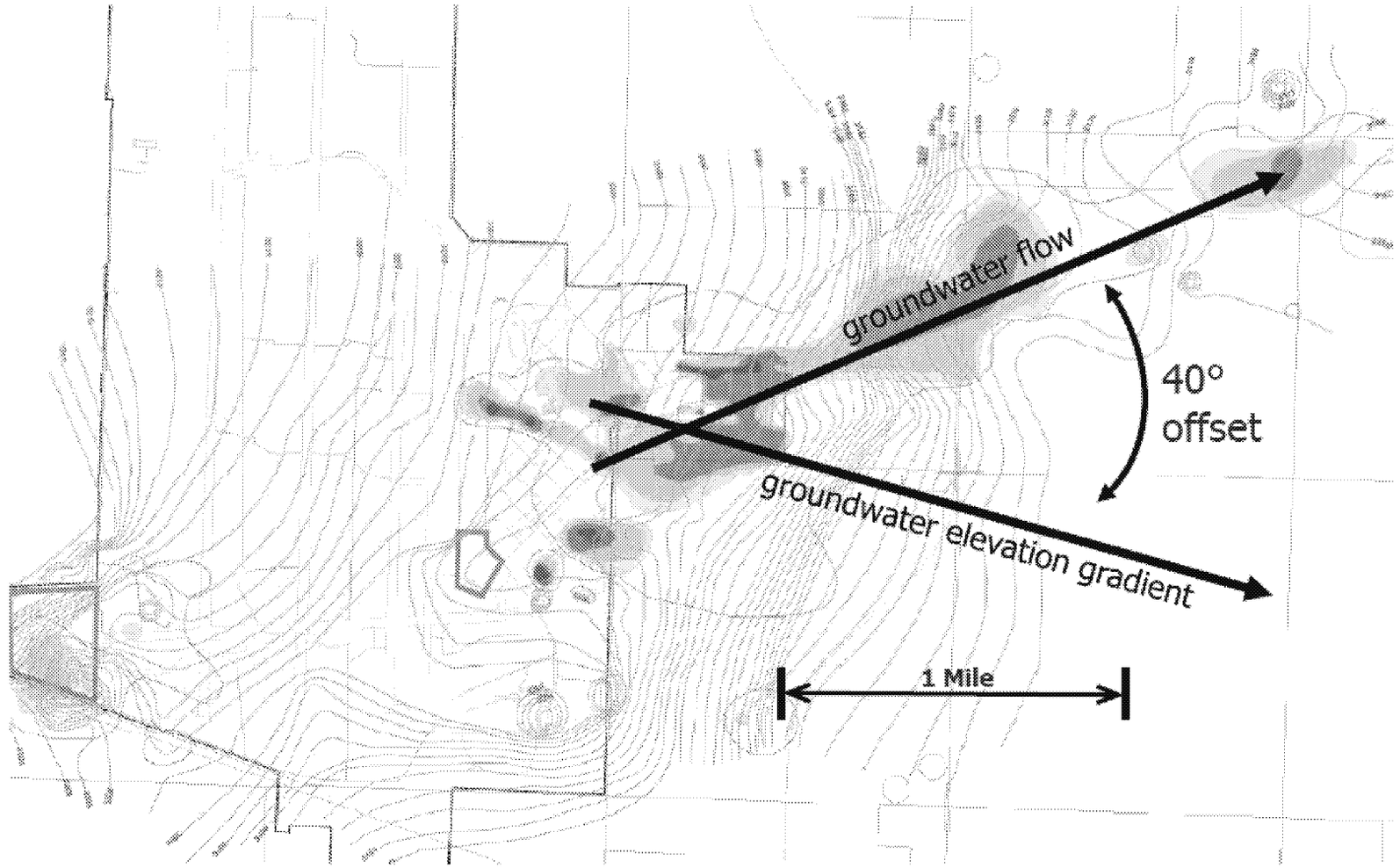
A unique field experiment has been undertaken at the CFB Borden research site to investigate the development of dissolved chlorinated solvent plumes from a residual dense non-aqueous phase liquid (DNAPL) source. The "emplaced-source" tracer test methodology involved a controlled emplacement of a block-shaped source of sand containing chlorinated solvents below the water table. The gradual dissolution of the residual DNAPL solvent source under natural aquifer conditions caused dissolved solvent plumes of trichloromethane (TCM), trichloroethene (TCE) and tetrachloroethene (PCE) to continuously develop down gradient. Source dissolution and 3-D plume development were successfully monitored via 173 multilevel samplers over a 475-day tracer test period prior to site remediation research being initiated. Detailed groundwater level and hydraulic conductivity data were collected. Development of plumes with concentrations spanning 1–700,000 μg/l is described and key processes controlling their migration identified. Plumes were observed to be narrow due to the weakness of transverse dispersion processes and long due to extensive and significant longitudinal dispersion; very limited sorption retardation and negligible, if any, attenuation due to biodegradation or abiotic reactions. TCM was shown to be essentially conservative, TCE very nearly conservative and PCE, consistent with its greater hydrophobicity, more retarded yet having a greater mobility than observed in previous Borden field tests. The absence of biodegradation was ascribed to the prevailing anaerobic conditions and lack of any additional biodegradable carbon substrate. The transient groundwater flow regime caused significant transverse lateral plume movement, plume asymmetry and was likely responsible for most of

* Corresponding author. School of Earth Sciences, University of Birmingham, Edgbaston, Birmingham, B15 2TT, UK. Fax: +44-121-414-4942.
E-mail address: M.O.Rivett@bham.ac.uk (M.O. Rivett).

0169-7722/00/$ – see front matter © 2000 Elsevier Science B.V. All rights reserved.
PII: S0169-7722(00)00191-1

AECOM

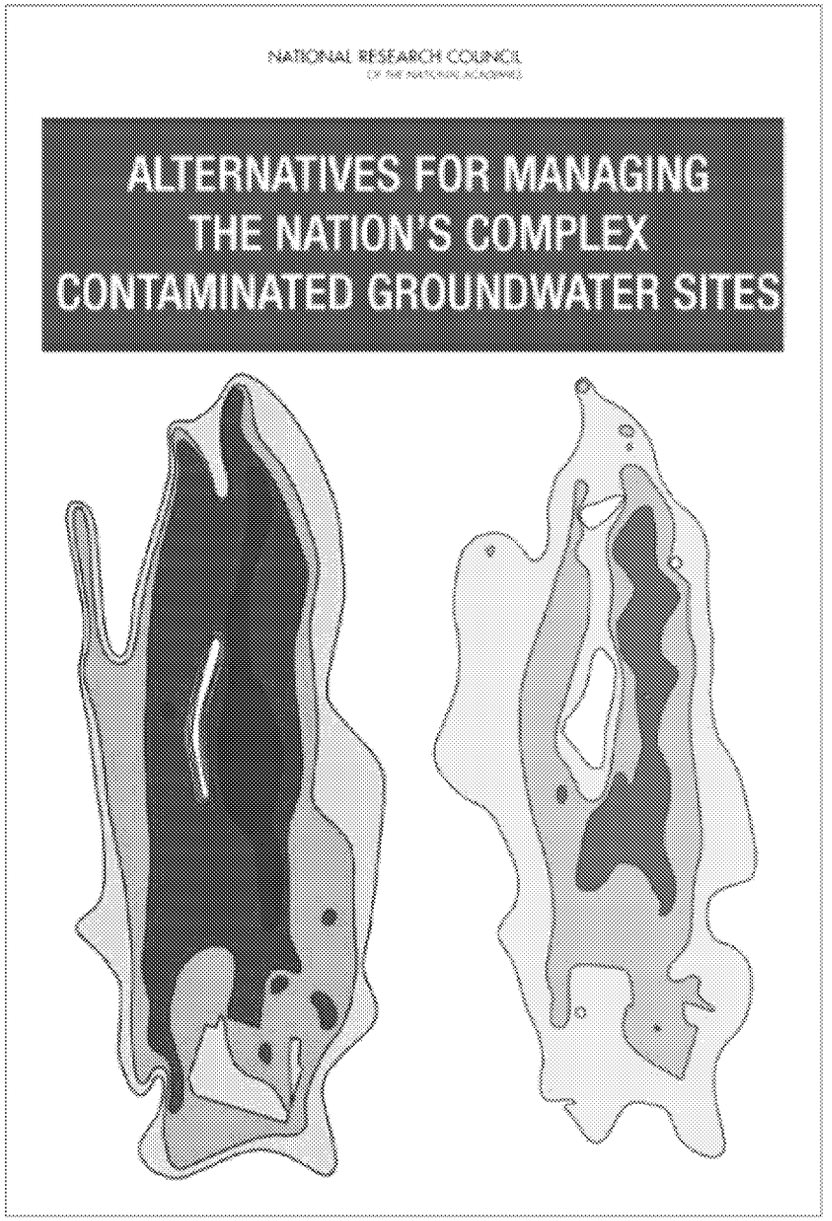
Potentiometric Surface Map vs. COC Migration



AECOM

THE CHALLENGE OF COMPLEX GROUNDWATER SITE MANAGEMENT

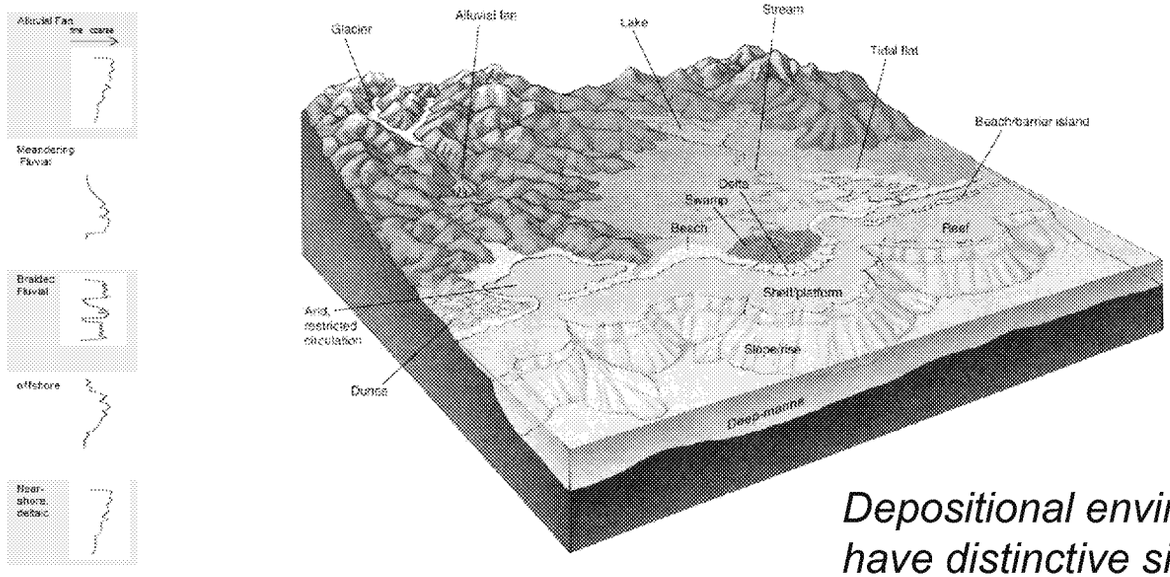
- More than **126,000** sites across the U.S. require remediation
- More than **12,000** of these sites are considered "complex"
- "…due to **inherent geologic complexities**, restoration within the next 50-100 years is likely not achievable."



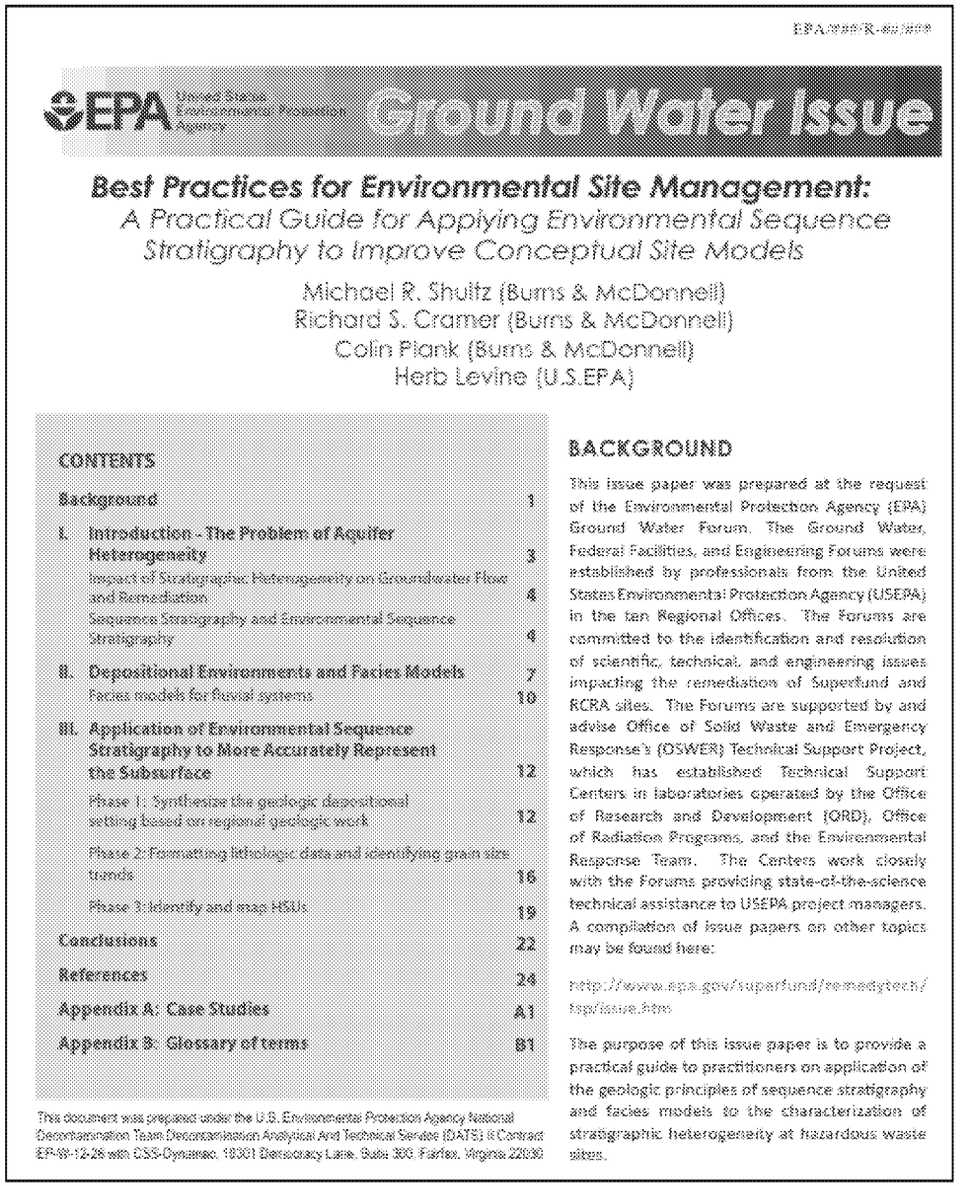
AECOM

Environmental Sequence Stratigraphy (ESS)

- Sequence Stratigraphy was developed in the petroleum industry to map out and predict geologic conditions that influence petroleum occurrence and migration.
- Reformat lithology data based on graphic grainsize logs and expert knowledge of depositional environments.
- Apply Sequence Stratigraphic principles, “rules of thumb”, facies models to develop CSMs for complex groundwater sites



Depositional environments have distinctive signatures and predictable patterns



EPA/[illegible]/R-[illegible]

EPA United States Environmental Protection Agency **Ground Water Issue**

Best Practices for Environmental Site Management:
A Practical Guide for Applying Environmental Sequence Stratigraphy to Improve Conceptual Site Models

Michael R. Shultz (Burns & McDonnell)
Richard S. Cramer (Burns & McDonnell)
Colin Plank (Burns & McDonnell)
Herb Levine (U.S.EPA)

CONTENTS

Background 1
I. Introduction - The Problem of Aquifer Heterogeneity 3
Impact of Stratigraphic Heterogeneity on Groundwater Flow and Remediation 4
Sequence Stratigraphy and Environmental Sequence Stratigraphy 4
II. Depositional Environments and Facies Models 7
Facies models for fluvial systems 10
III. Application of Environmental Sequence Stratigraphy to More Accurately Represent the Subsurface 12
Phase 1: Synthesize the geologic depositional setting based on regional geologic work 12
Phase 2: Formatting lithologic data and identifying grain size trends 16
Phase 3: Identify and map HSUs 19
Conclusions 22
References 24
Appendix A: Case Studies A1
Appendix B: Glossary of terms B1

This document was prepared under the U.S. Environmental Protection Agency National Decontamination Team Decontamination Analytical And Technical Service (DATS) II Contract EP-W-12-26 with CSS-Dynamac, 18301 Democracy Lane, Suite 300, Fairfax, Virginia 22030

BACKGROUND

This issue paper was prepared at the request of the Environmental Protection Agency (EPA) Ground Water Forum. The Ground Water, Federal Facilities, and Engineering Forums were established by professionals from the United States Environmental Protection Agency (USEPA) in the ten Regional Offices. The Forums are committed to the identification and resolution of scientific, technical, and engineering issues impacting the remediation of Superfund and RCRA sites. The Forums are supported by and advise Office of Solid Waste and Emergency Response's (OSWER) Technical Support Project, which has established Technical Support Centers in laboratories operated by the Office of Research and Development (ORD), Office of Radiation Programs, and the Environmental Response Team. The Centers work closely with the Forums providing state-of-the-science technical assistance to USEPA project managers. A compilation of issue papers on other topics may be found here:

http://www.epa.gov/superfund/remedytech/tsp/issue.htm

The purpose of this issue paper is to provide a practical guide to practitioners on application of the geologic principles of sequence stratigraphy and facies models to the characterization of stratigraphic heterogeneity at hazardous waste sites.

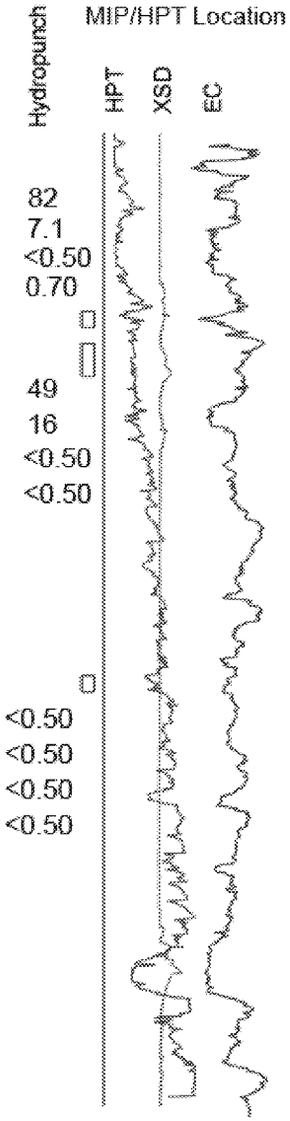
25

AECOM

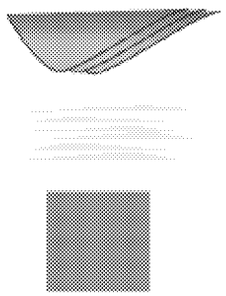
Legend for following slides and cross sections

Monitoring well or hydropunch screen and groundwater analytical data (Q4 2019 for MWs, date of install for MIP/HPT Hydropunch Samples

TCE	57
cis-1,2,DCE	1.3
VC	<0.50
Freon-113	1.2



LEGEND

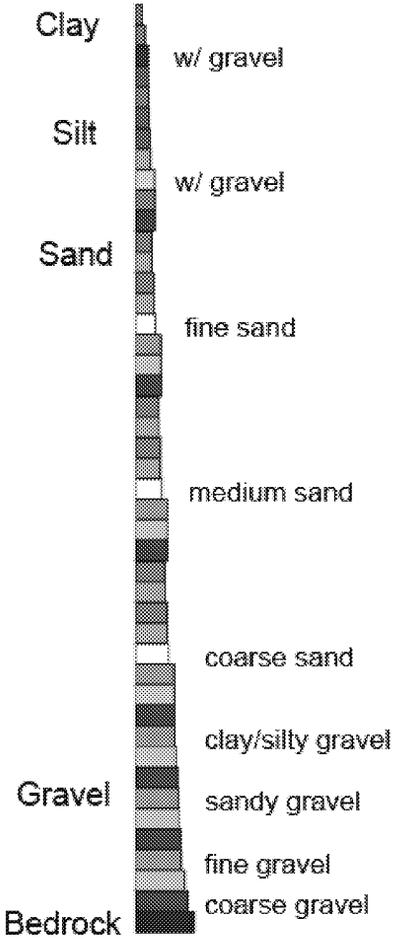


channel deposit consisting of coarse-grained sand, gravelly sand typically fining-upward from gravel base

channel margin or splay deposit consisting of coarse-to fine-grained sand, silty sand

Floodplain deposits consisting of clay, silty clay, and sandy clay, often with root structures, caliche nodules (soil horizons)

Graphic Grain Size Legend



Width of log column denotes predominant grain size as described for that interval in boring log.

Color in log column indicates following:

red = gravelly (coarse)
orange = gravelly (fine-medium)
yellow = "clean" sand
green = silty
blue = clayey

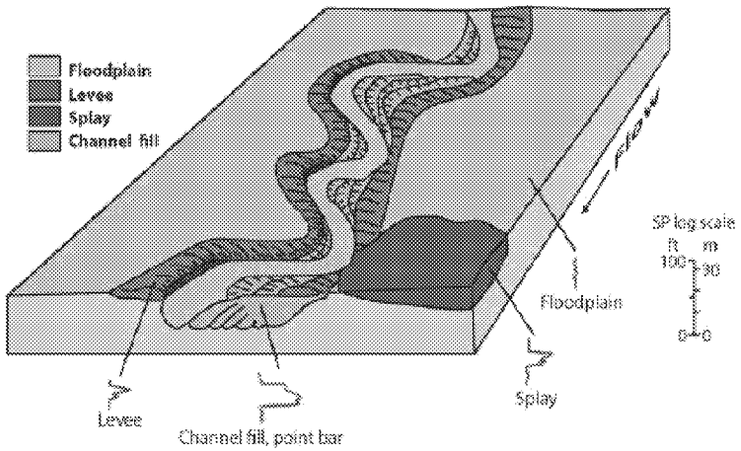
Brown colors represent mixtures of sand, silt, and gravel in clayey matrix (i.e., diamicton in glacial till).

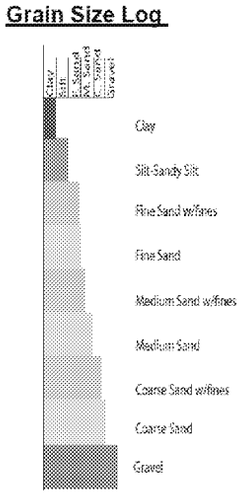
Blank intervals indicate no sample recovered.

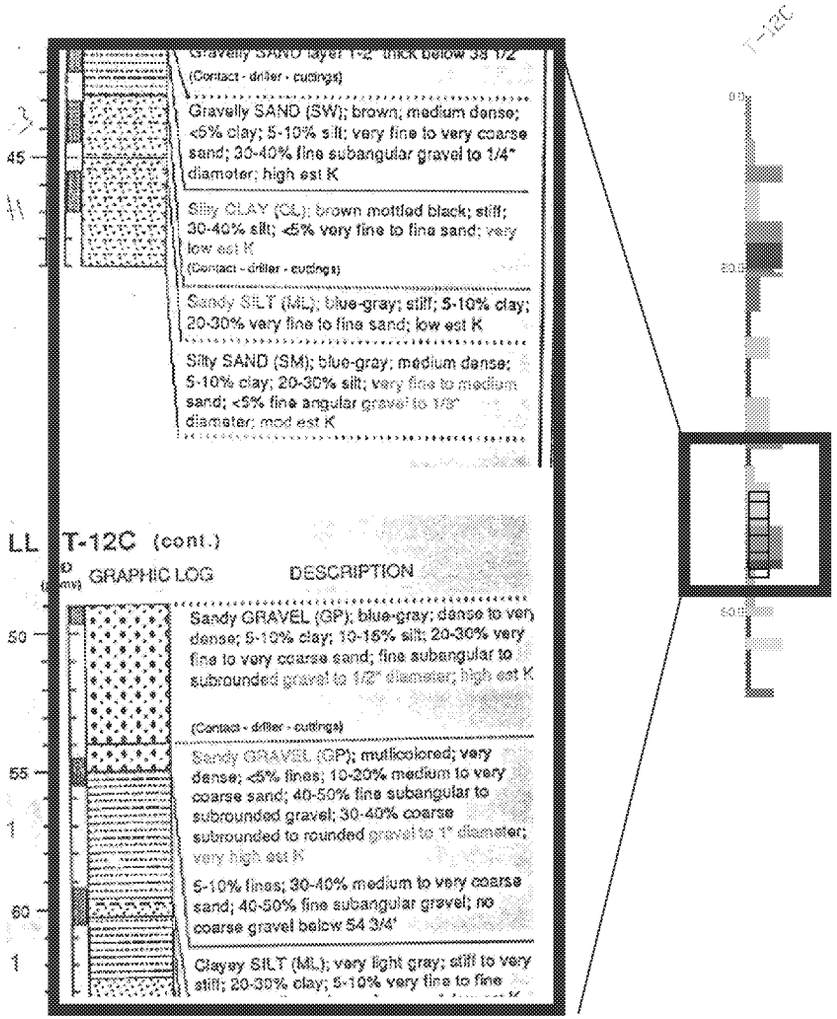
AECOM

Workflow: Creating Graphic Grain Size Logs

- Normalize different vintages of data collection, etc.
- Identify trends in maximum grain size (indicator of energy level in depositional processes)
- Provides “pseudo-elog”
- Example of fining upward channel deposit



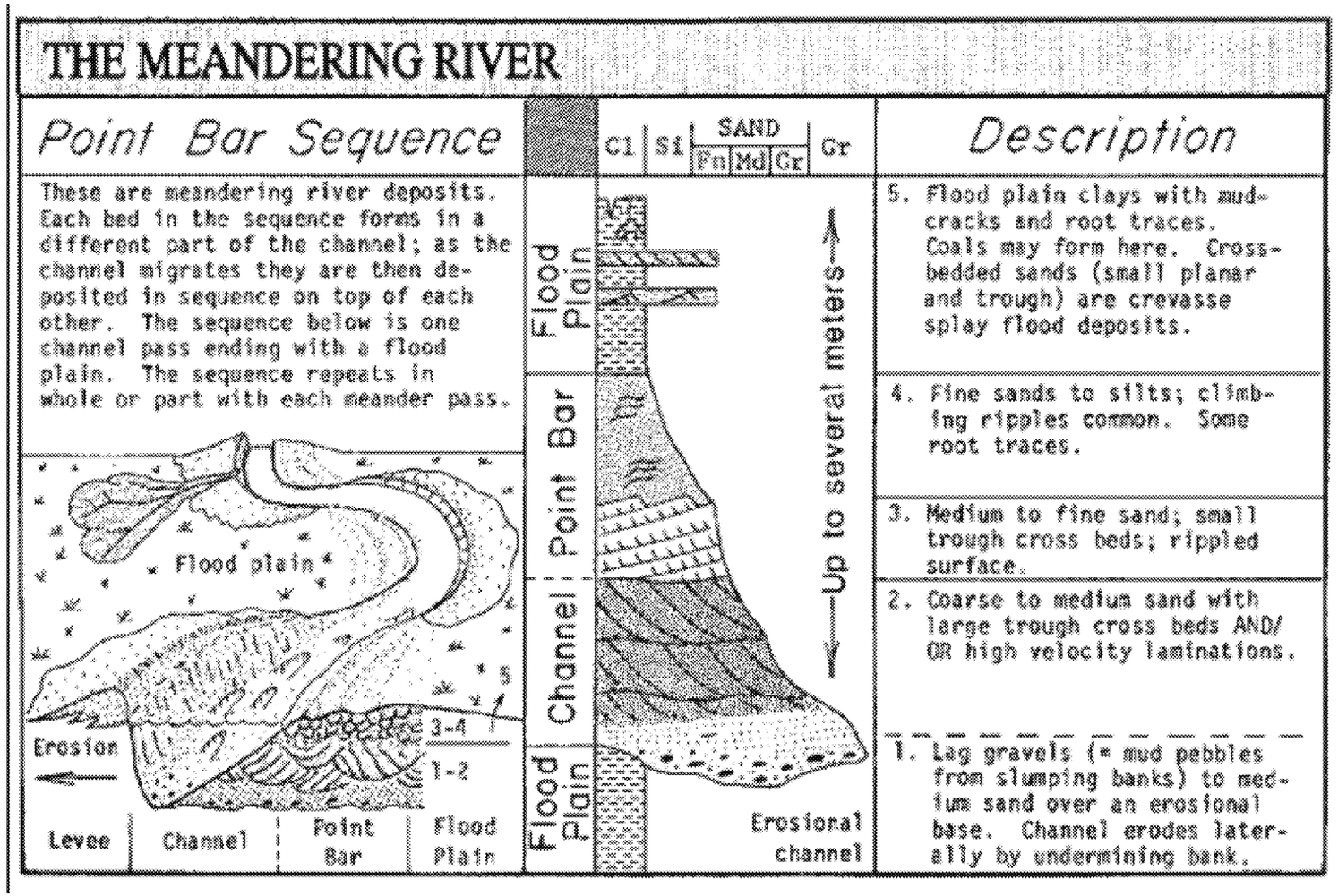




AECOM

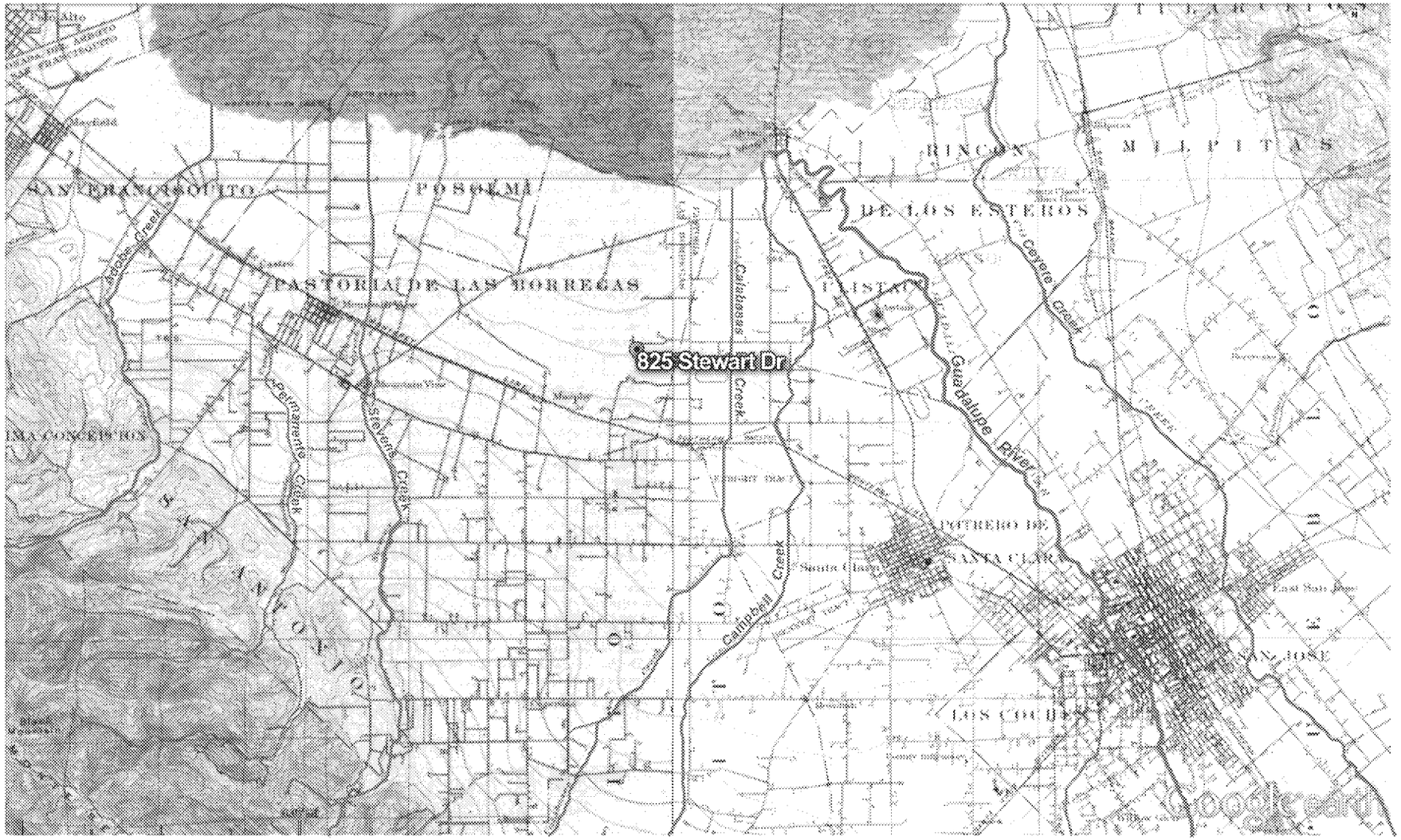
ESS Background – Depositional Environment

- TRW underlain by river deposits, channel and point bar deposits, splays, floodplain deposits
- Highest perm in “lag” deposits at bases of channel sequences
- Minor lateral migration, channels “confined” by floodplain deposits



AECOM

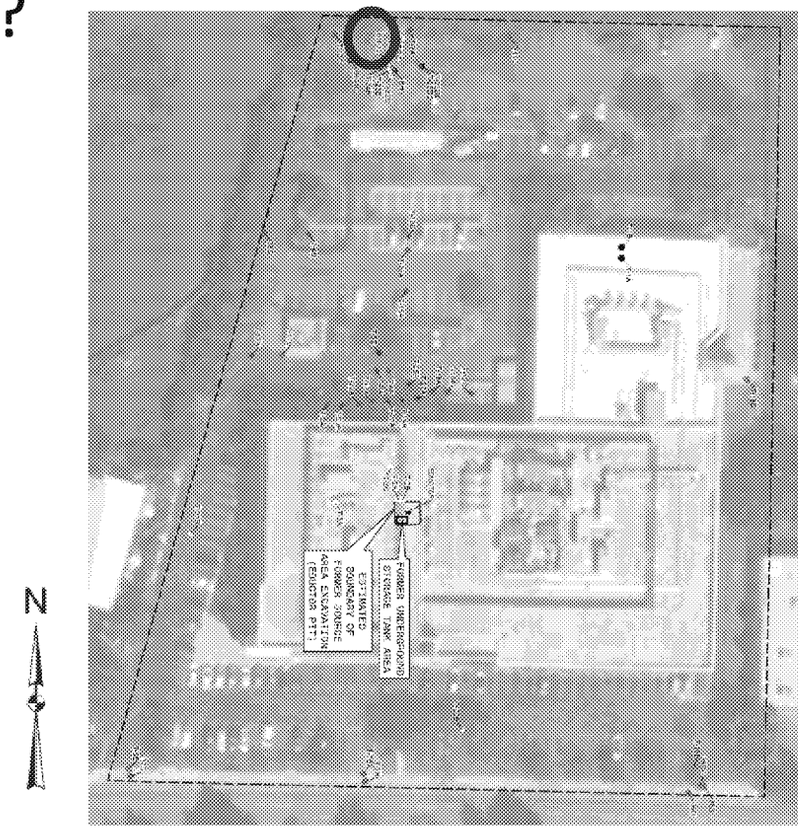
Historic Stream Courses approximately N-S

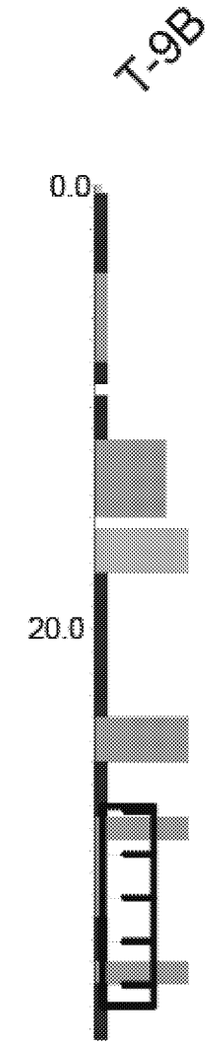


AECOM

Well T-9B Grain Size Log

- Two channel deposits within screened interval
- What are the implications?



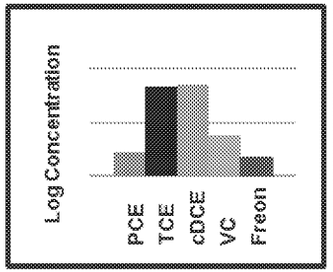


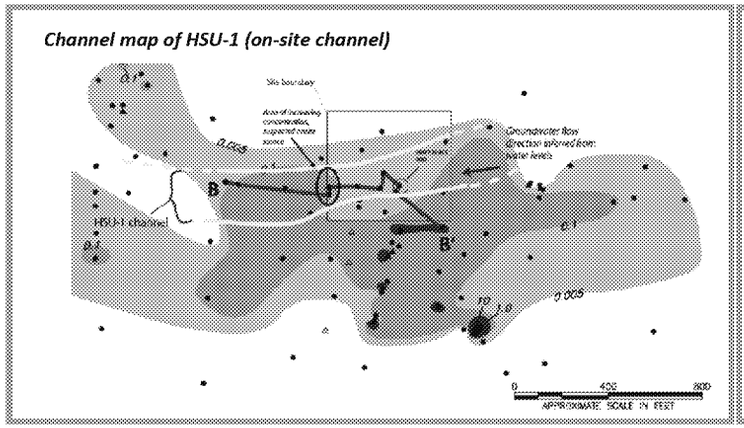
AECOM

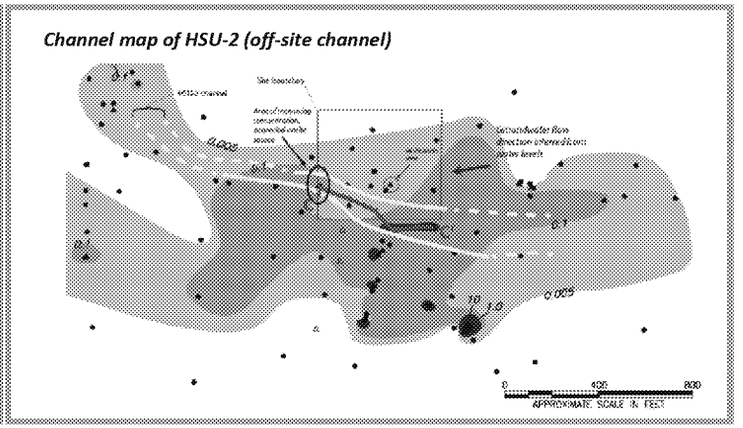
Down-channel cross sections and contaminant fingerprinting

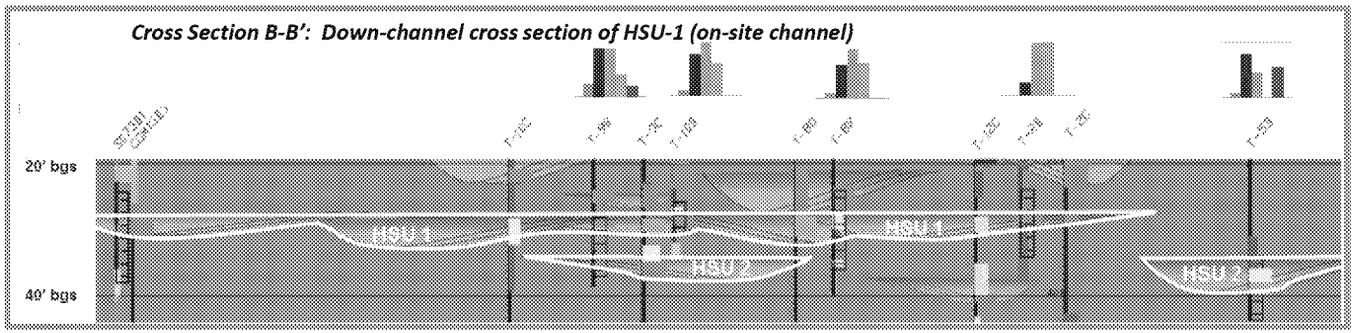
- Mapping of T-9B channels indicate onsite- and offsite sources with Freon 113 offsite marker
- Contaminant fingerprinting provides independent confirmation
- paleochannels represent HSUs, controlling contaminant F&T
- VC onsite marker
- Historic freon in T-4B
- T-9B screen samples two distinct channels
- Initiated HRSC (MIP/HPT/hydropunch) work plan to identify other offsite sources
- Facies mapping undertaken across TRW site

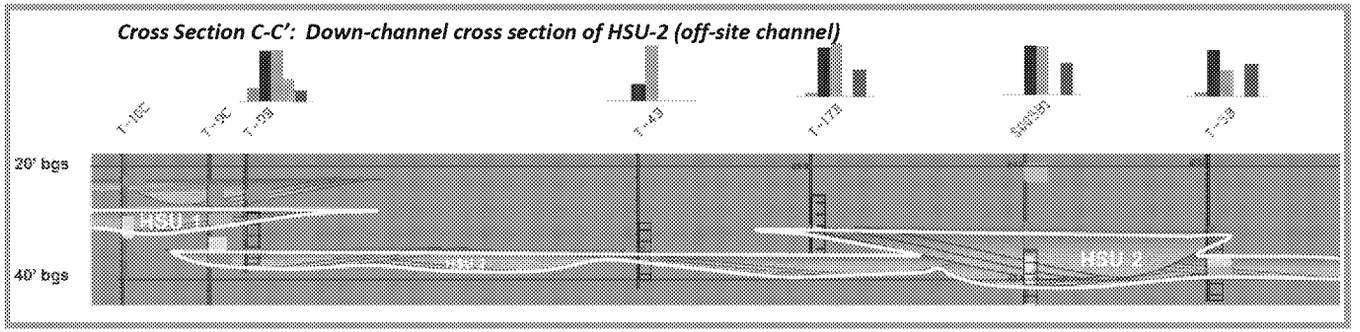
5 yr avg.







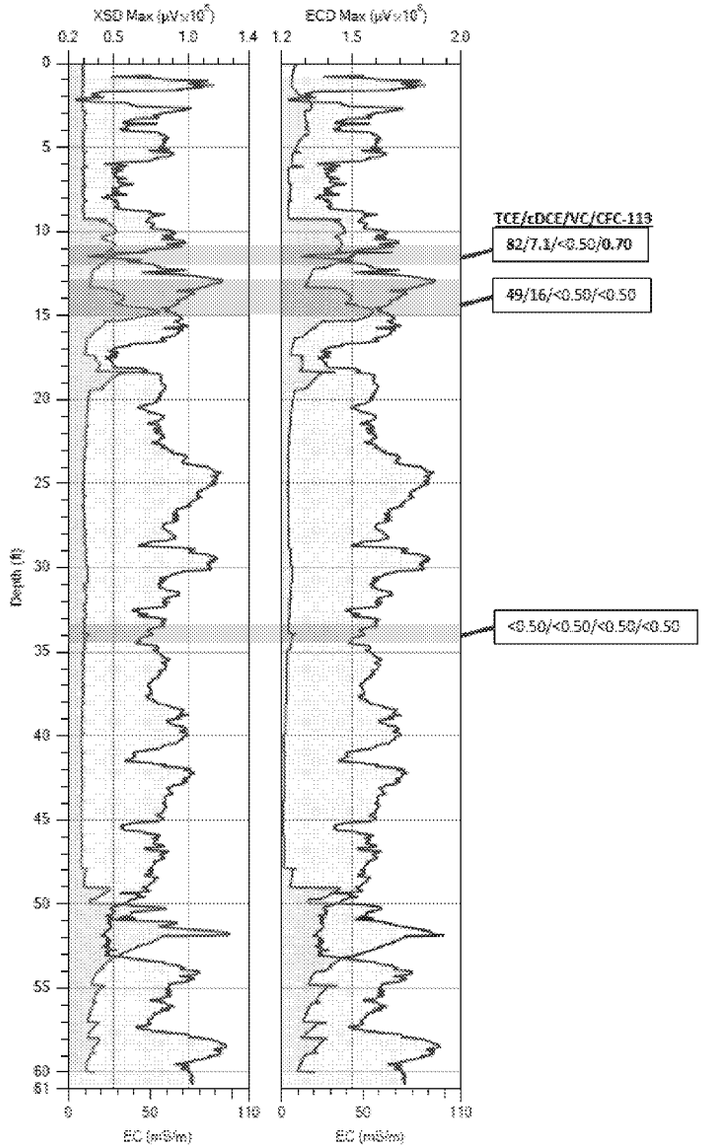




AECOM

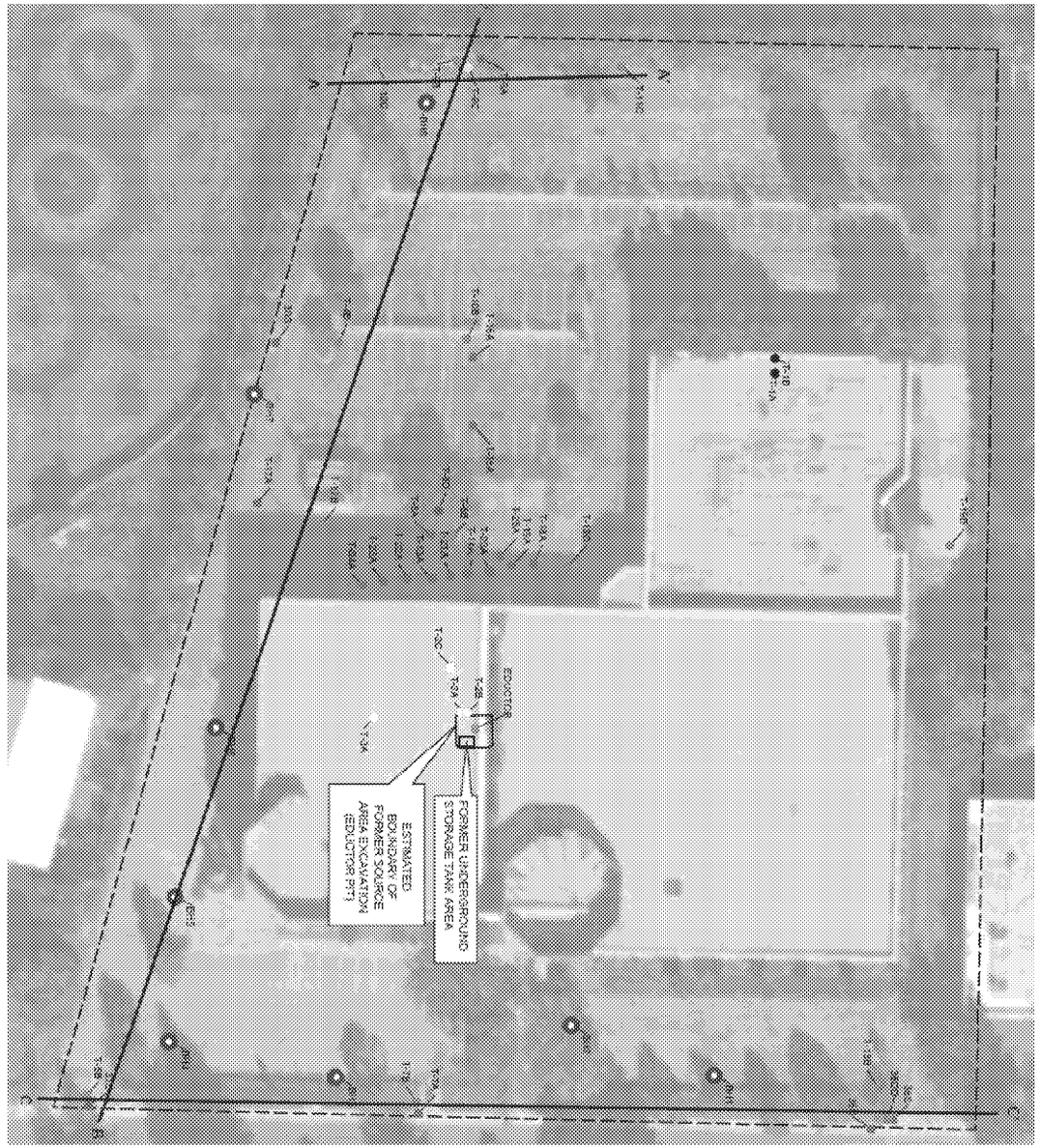
High Resolution Site Characterization (HRSC) Data

- Fluvial (river) channel deposits (sand and gravel) of limited lateral extent encased in floodplain silts and clays provide permeable pathways for groundwater and contaminant transport. Connectivity between channels is limited.
- On-site migration of contaminants is occurring via channel pathways.
- Three HSUs mapped in “B1 Zone”, one mapped in “A Zone”.
- Shallower in the section, the contaminant mass is in the lower permeability material, whereas, the deeper channel shows more mass in the permeable material.



AECOM

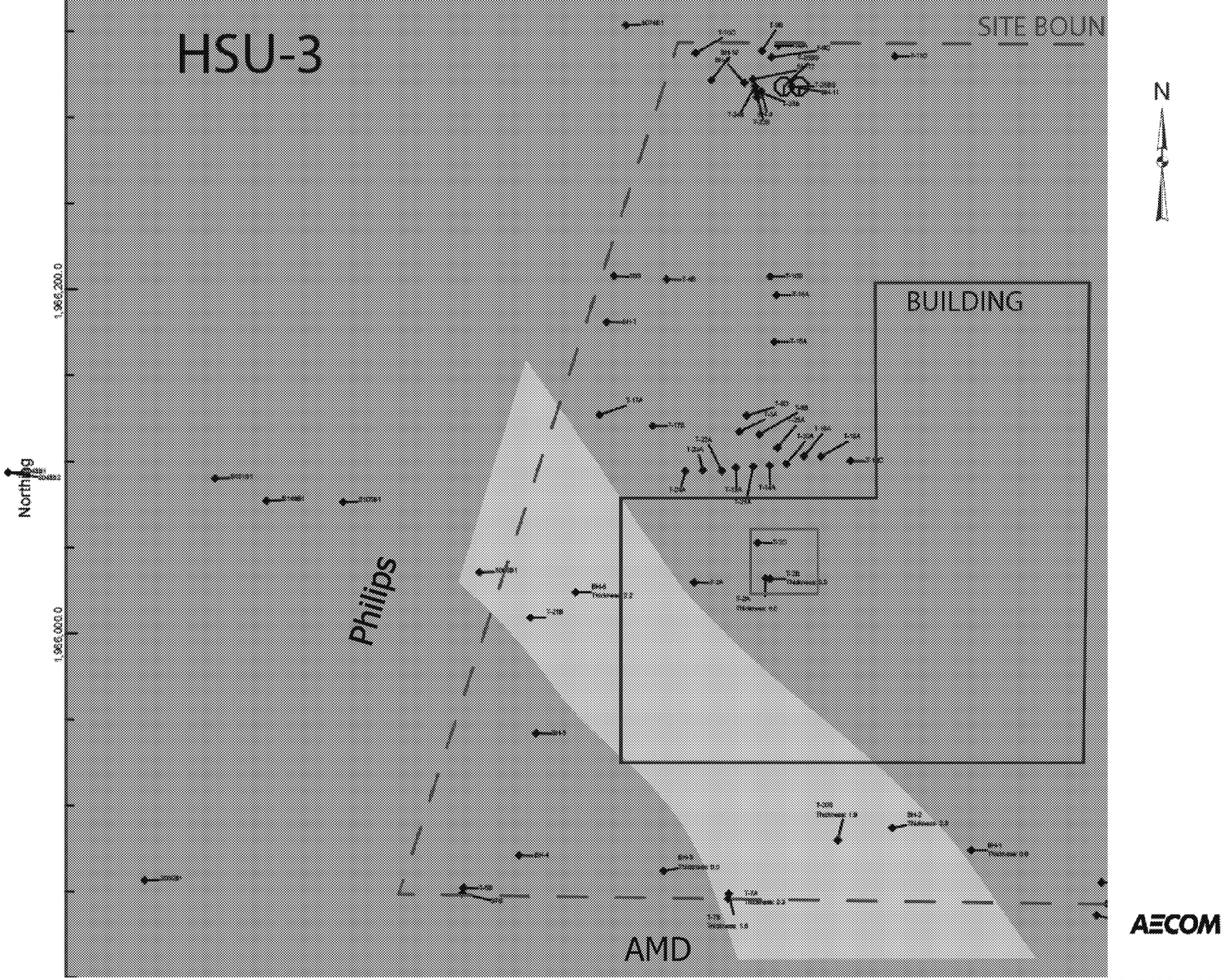
HRSC Location Map



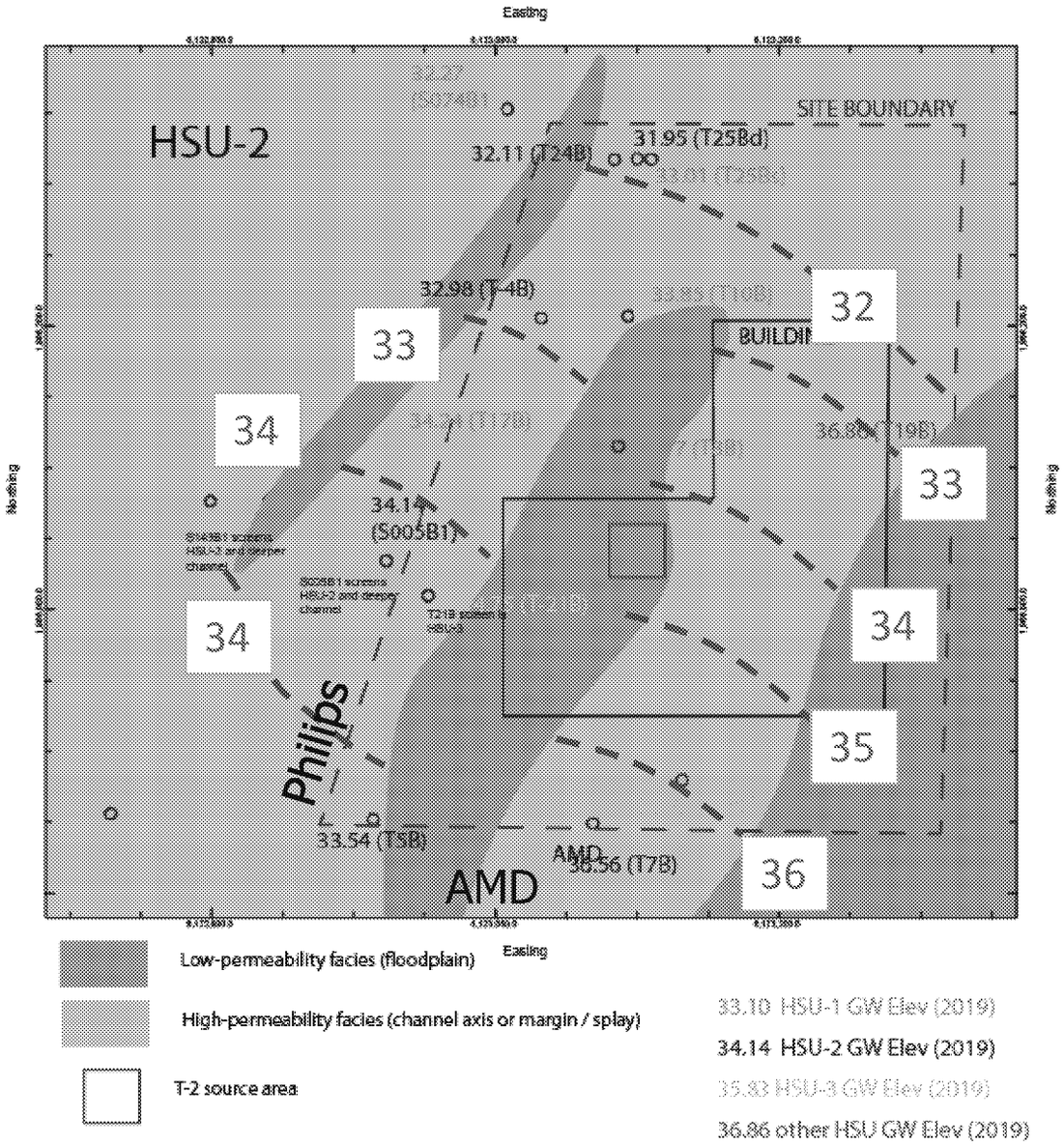
AECOM

Facies Mapping

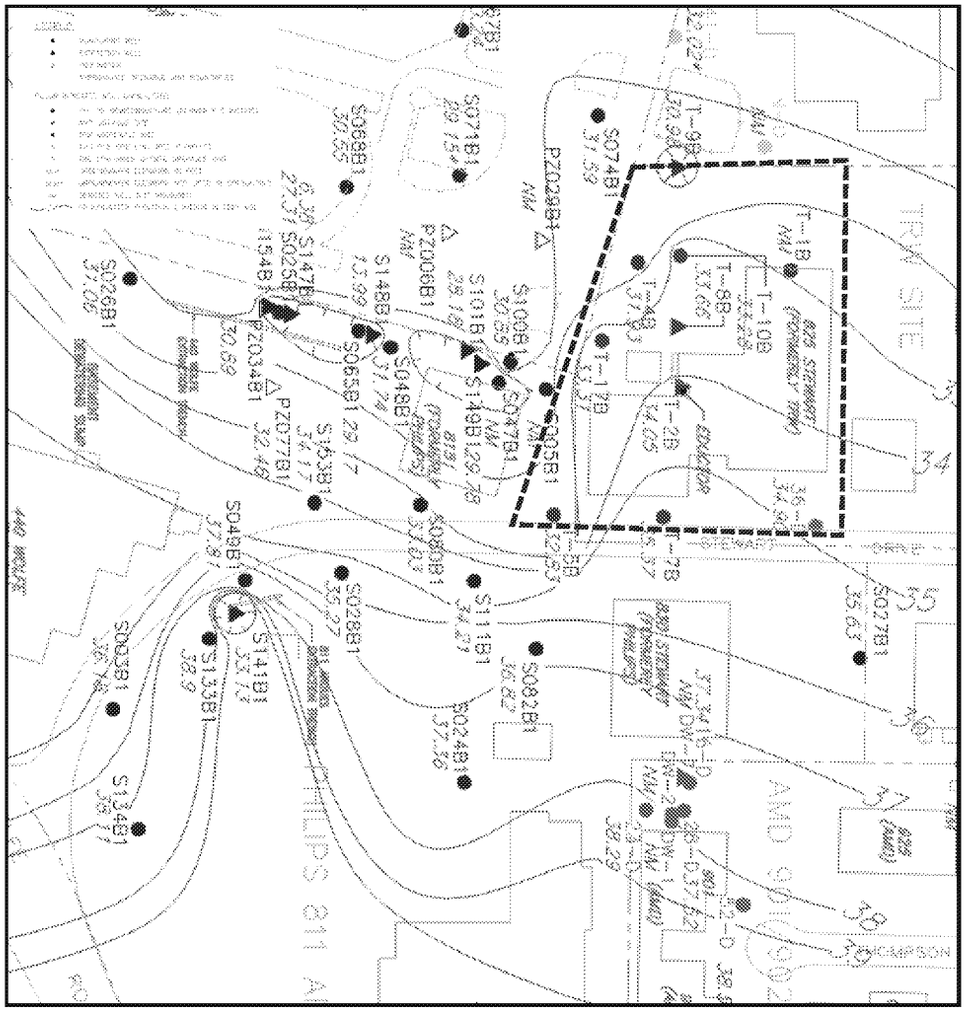
- Stratigraphic contacts picked in all wells (Rockworks)
- Thickness posted and facies maps drawn
- Shows channel boundaries at a specific depth interval



AECOM



Potentiometric surface maps must be used with caution to define groundwater flow directions or capture zones in channelized environments

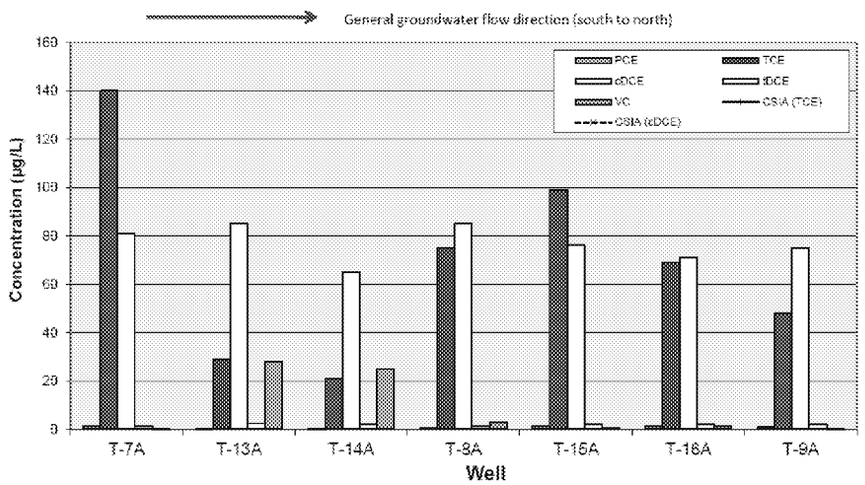


October 2011 pot map from OOU

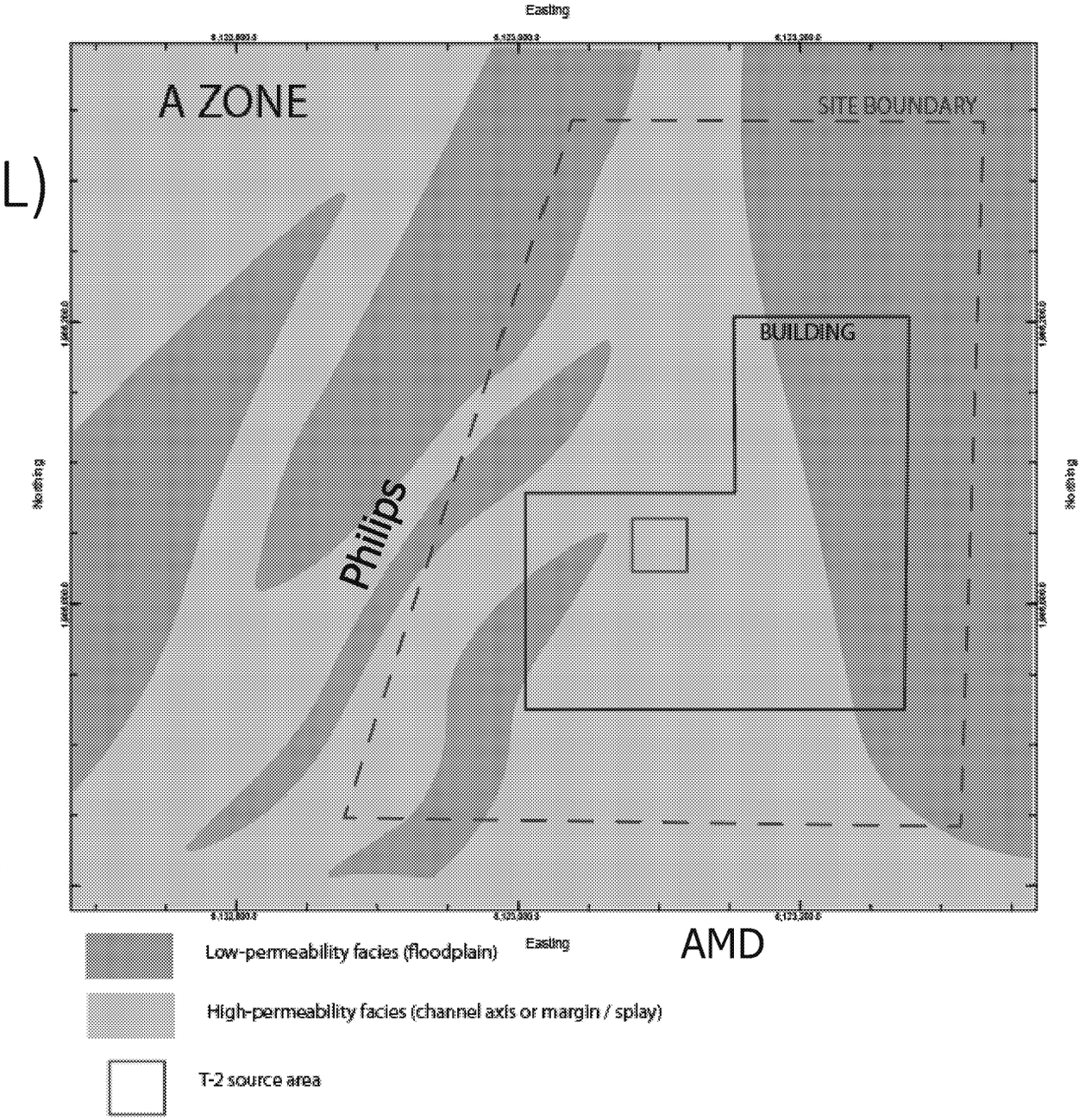
AECOM

Zone A
(water surface to 15 ft aMSL)

- Fairly continuous sand channels across the site
- Concentrations decrease across the site



Note: Groundwater flow direction is generally along the wells listed above, from south to north, from onsite well T-7A to well T-9A.

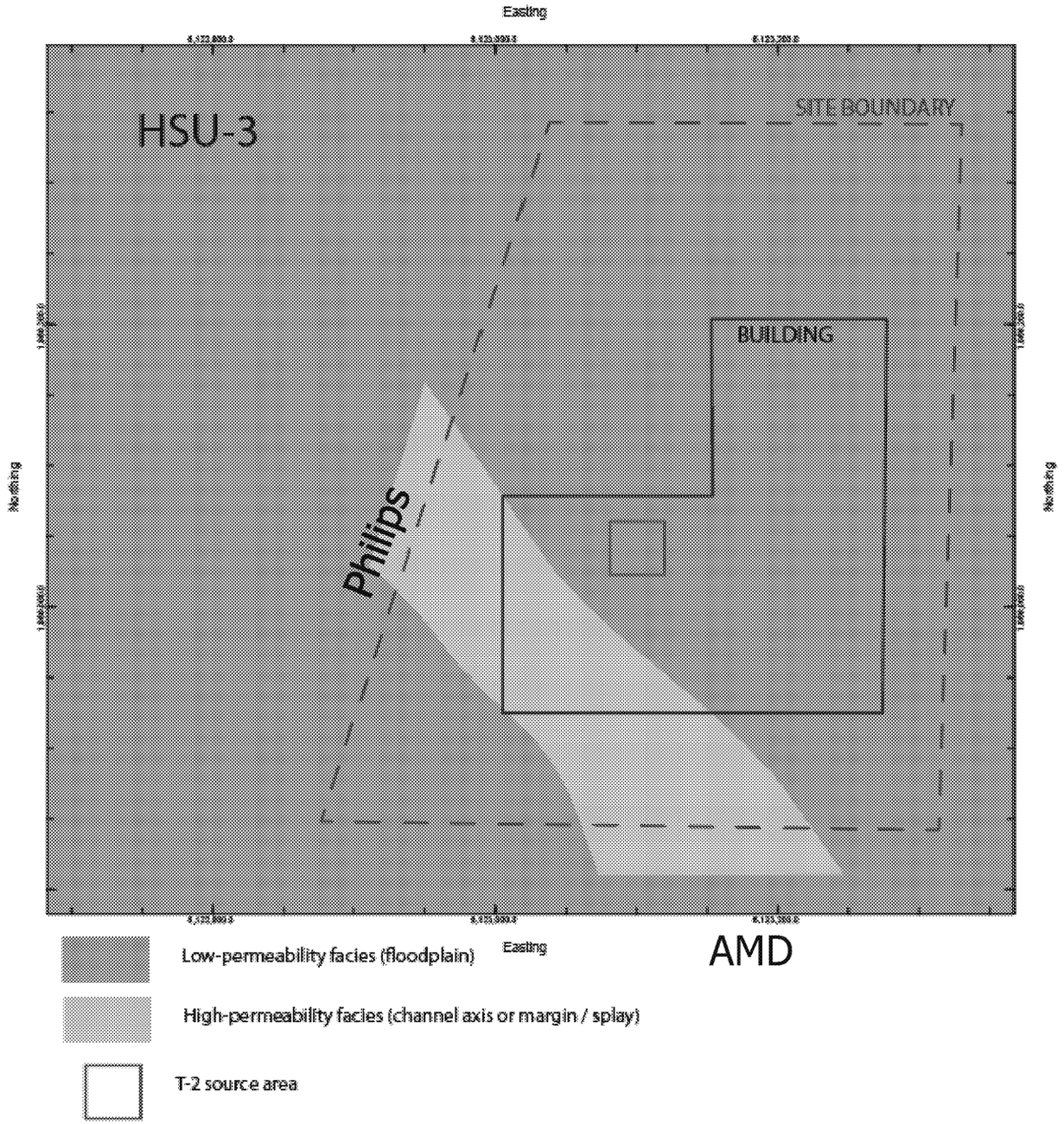


AECOM

Zone B1; HSU-3

(shallowest HSU;
15-10 ft aMSL)

- Discovered during HRSC activities
- Channel contained higher concentrations entering the site than were previously monitored in well T-7B

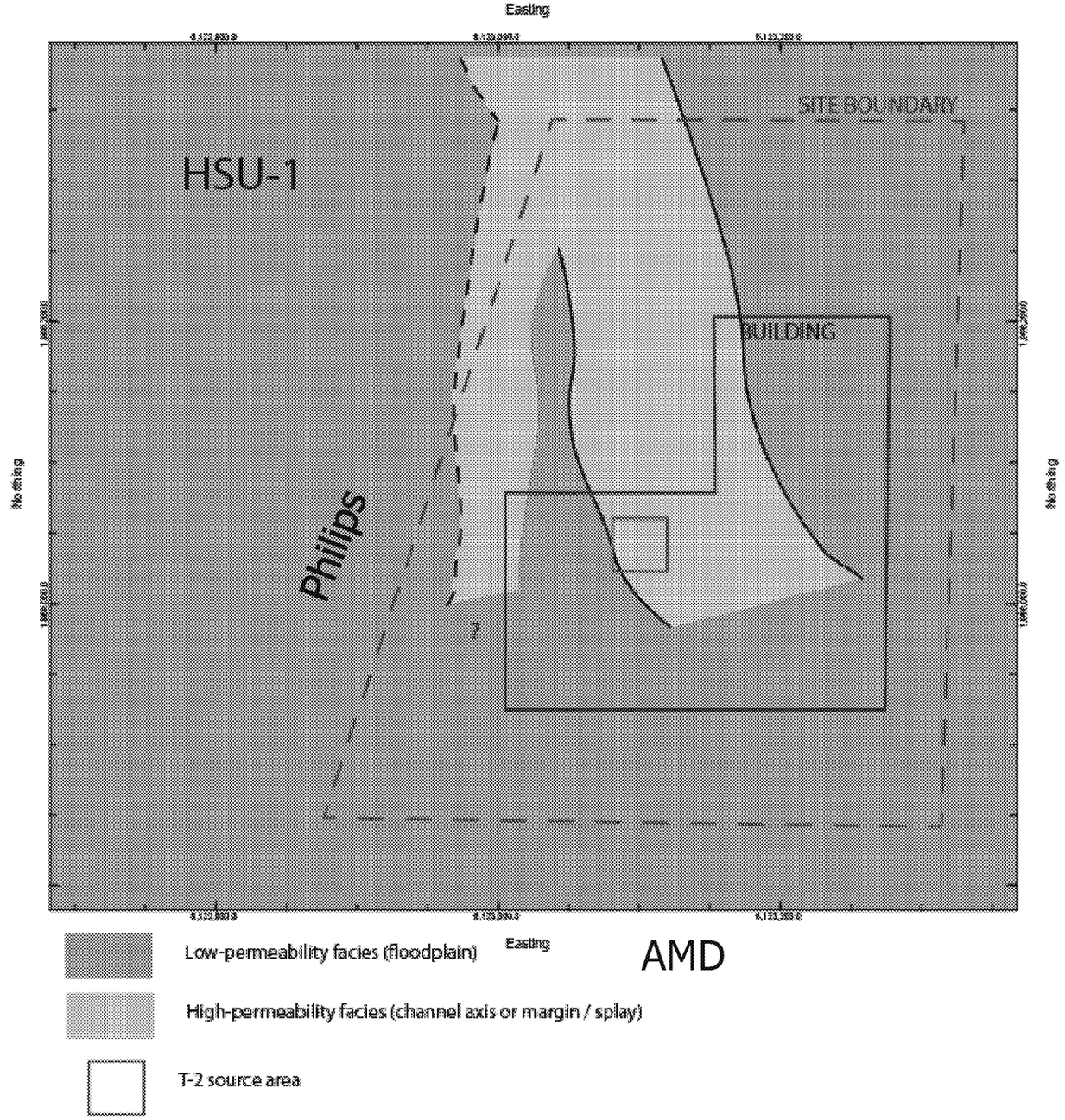


N

AECOM

Zone B1; HSU-1
(middle HSU; 10-15 ft aMSL)

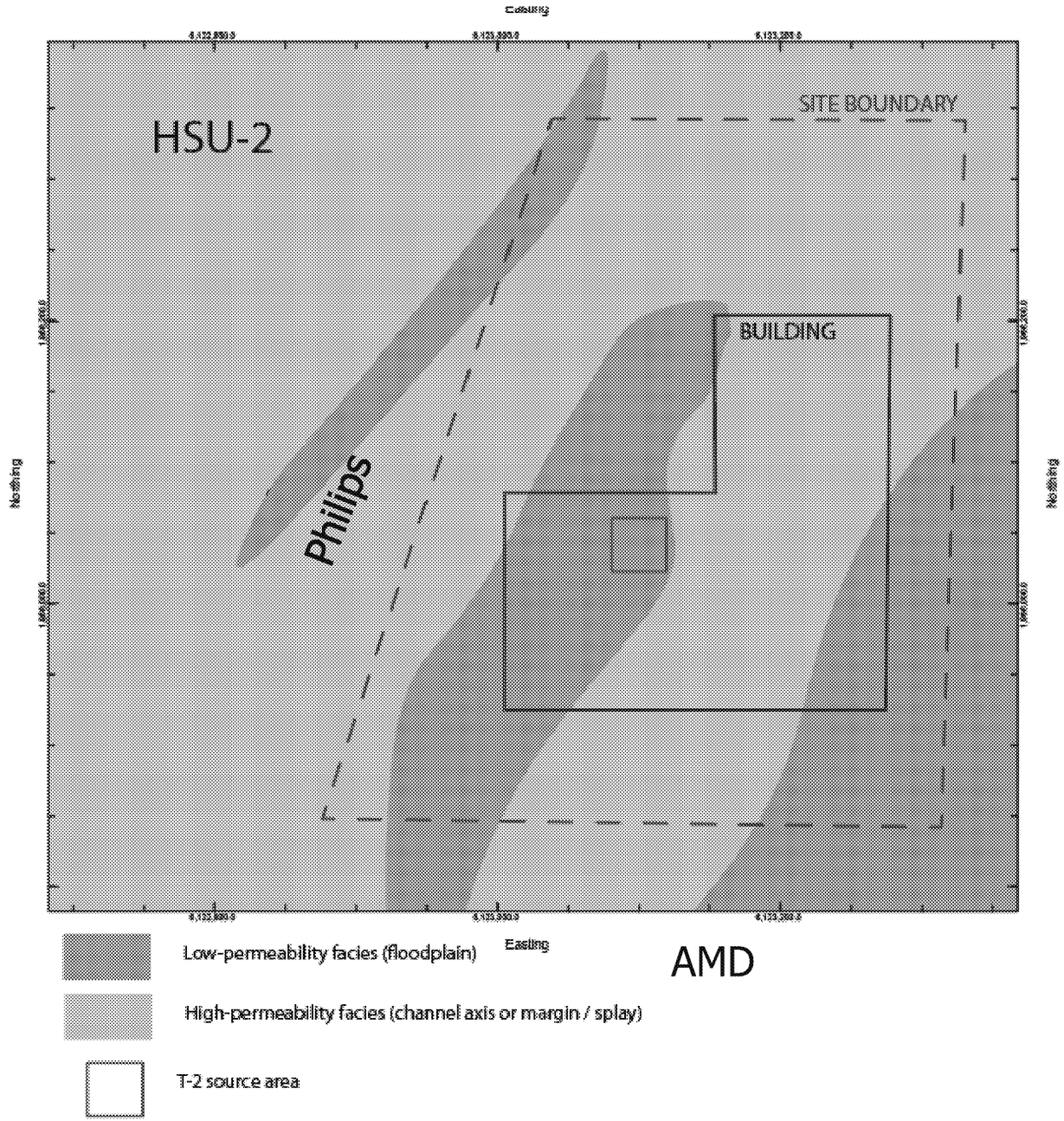
- Main pathway from former source area
- Joins with T-17B sand (to the west), which is influenced by offsite, at downgradient site boundary



AECOM

Zone B1; HSU-2
(deepest HSU;
0-10 ft aMSL)

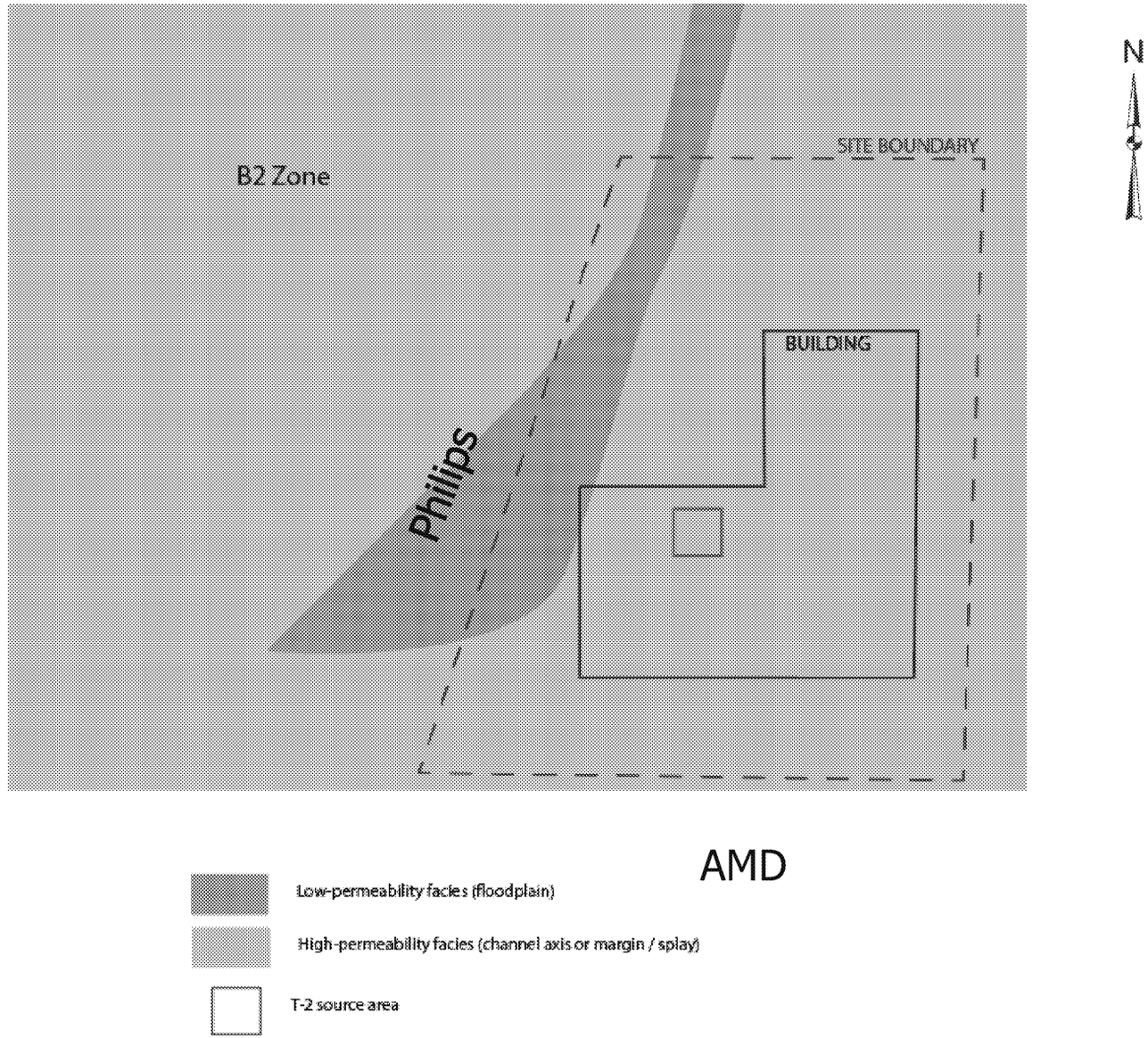
- Western channel transport from offsite (Philips)
- Merges with onsite channel in the vicinity of the downgradient site boundary.
- Not present at former source area



AECOM

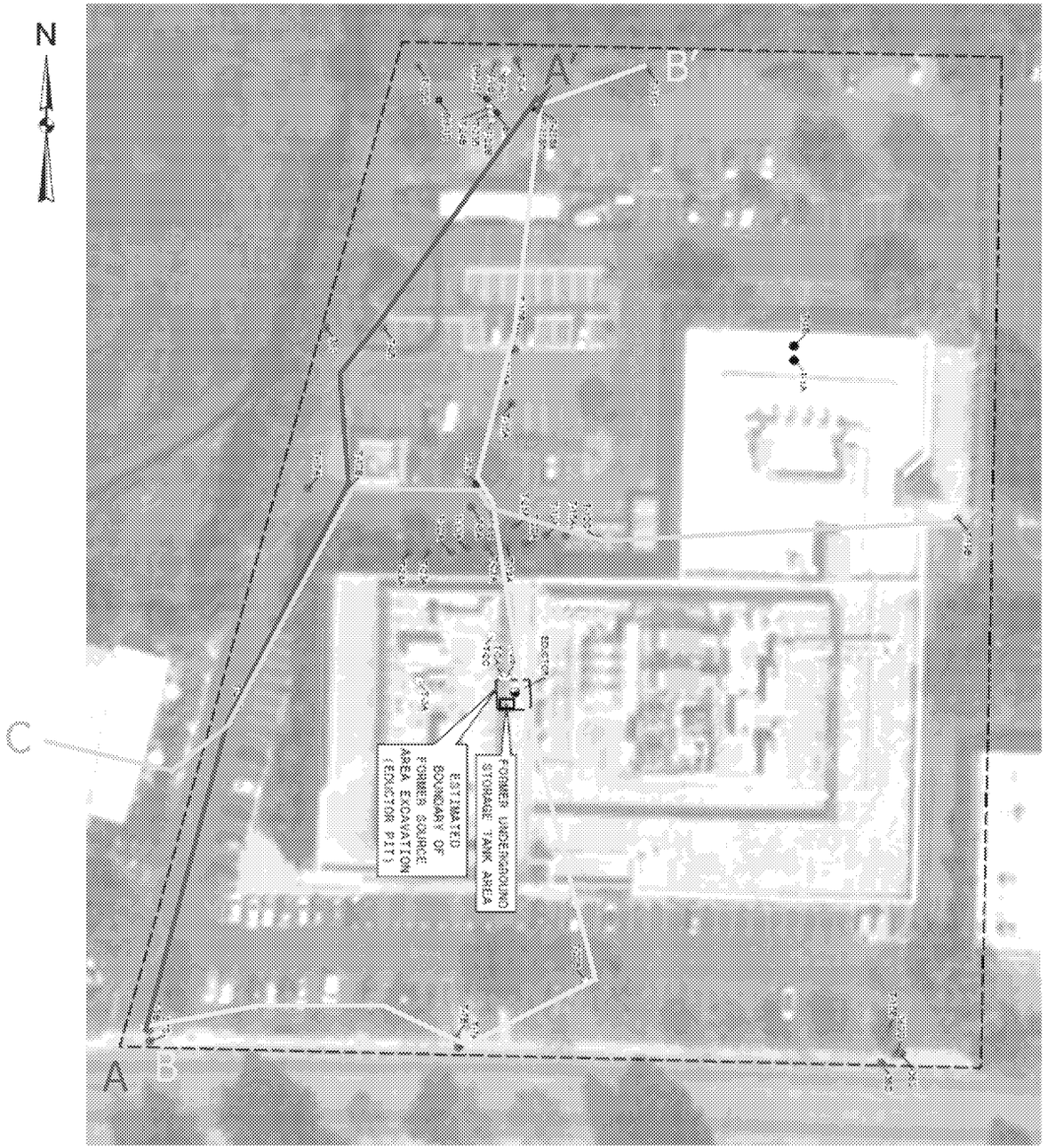
Zone B2

- Contamination considered to be from offsite sources due to the presence of Freon 113

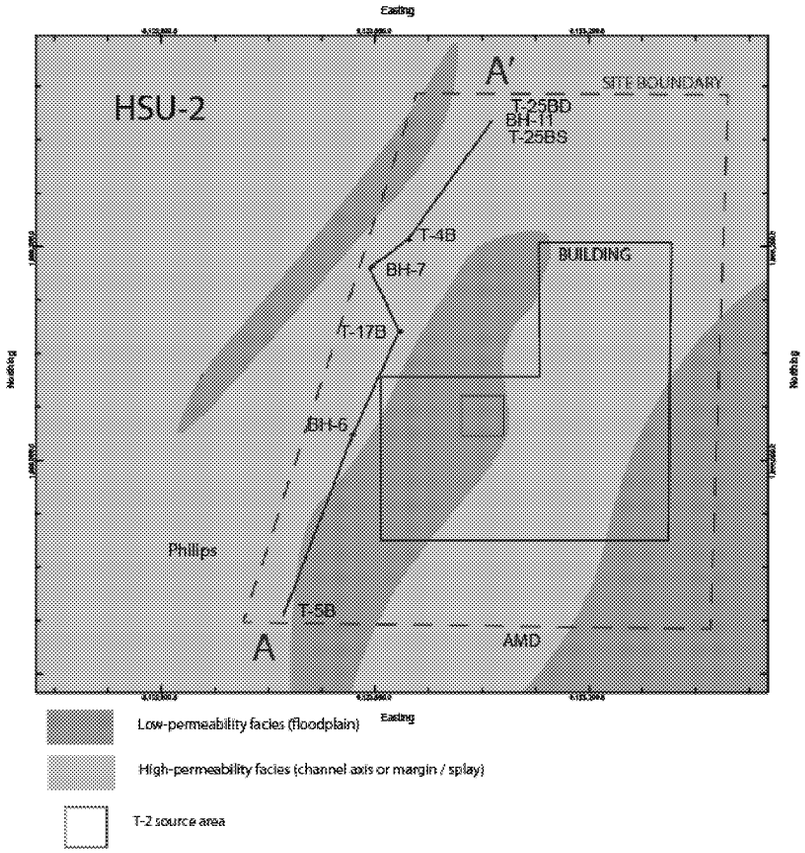


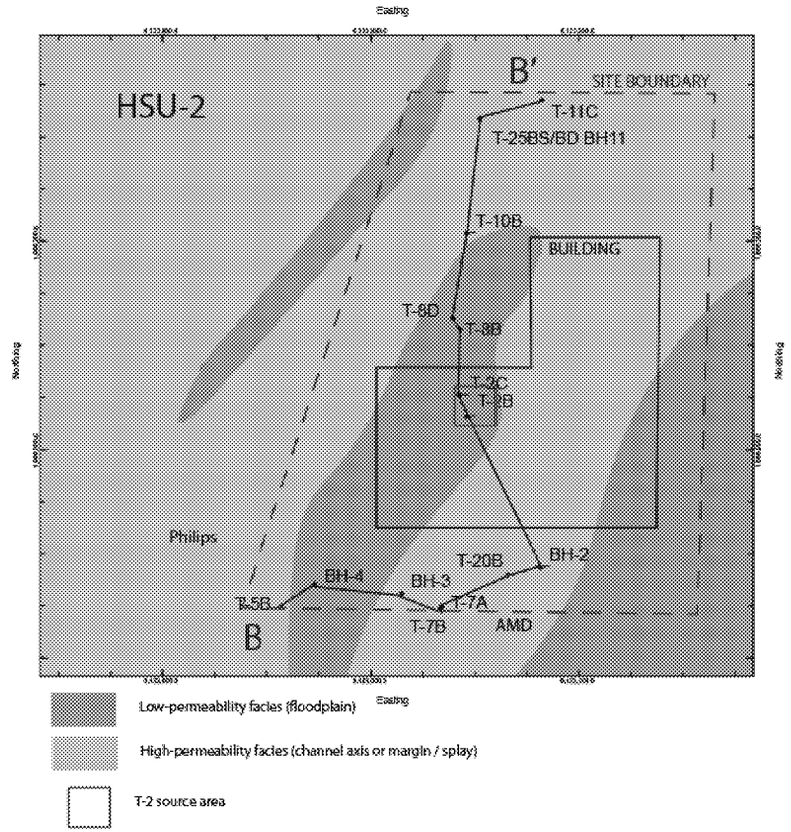
AECOM

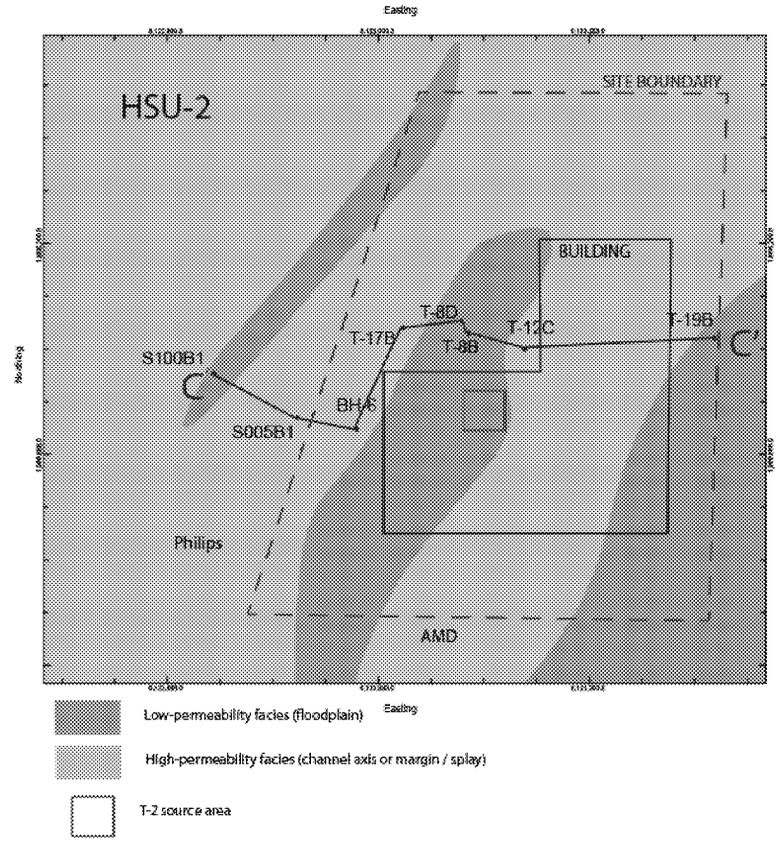
Cross Section Lines



AECOM


Easting
HSU-2
A'
SITE BOUNDARY
T-25BD
BH-11
T-25BS
T-4B
BH-7
BUILDING
T-17B
BH-6
Phillips
T-5B
A
AMD
Low-permeability facies (floodplain)
High-permeability facies (channel axis or margin / splay)
T-2 source area


Easting
HSU-2
B'
SITE BOUNDARY
T-11C
T-25BS/BD BH11
T-10B
BUILDING
T-8D
T-8B
T-2C
T-1B
Phillips
T-20B
BH-2
BH-4
BH-3
T-5B
T-7A
T-7B
AMD
B
Low-permeability facies (floodplain)
High-permeability facies (channel axis or margin / splay)
T-2 source area

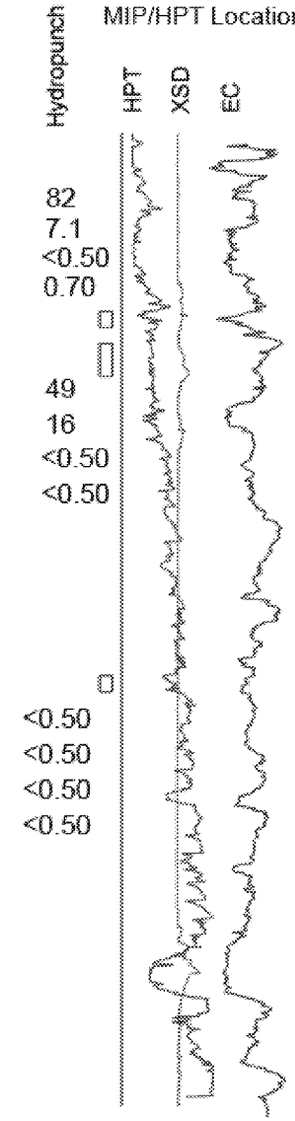

Easting
HSU-2
SITE BOUNDARY
BUILDING
T-8D
T-12C
T-19B
T-17B
T-8B
S100B1
C
C'
BH-6
S005B1
Phillips
AMD
Low-permeability facies (floodplain)
High-permeability facies (channel axis or margin / splay)
T-2 source area

AECOM

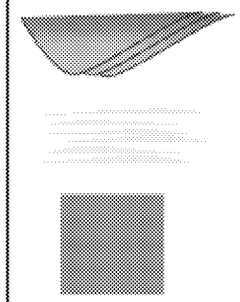
Cross Section Legend

Monitoring well or hydropunch screen and groundwater analytical data (Q4 2019 for MWs, date of install for MIP/HPT Hydropunch Samples

TCE	57
cis-1,2,DCE	1.3
VC	<0.50
Freon-113	1.2



LEGEND

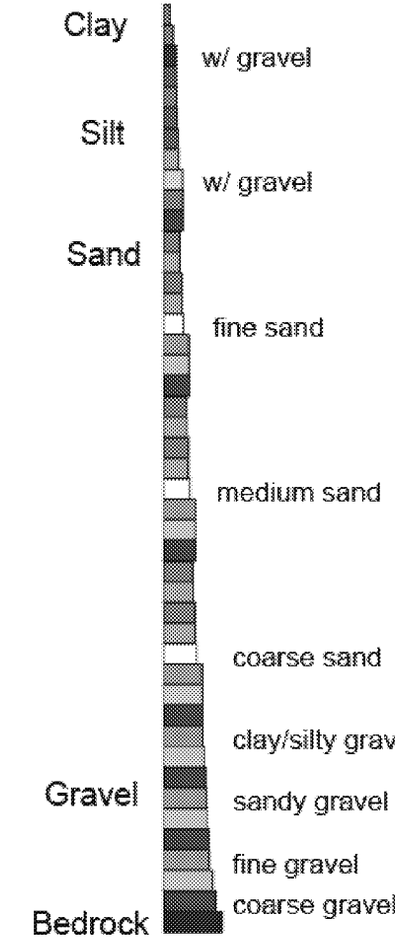


channel deposit consisting of coarse-grained sand, gravelly sand typically fining-upward from gravel base

channel margin or splay deposit consisting of coarse-to fine-grained sand, silty sand

Floodplain deposits consisting of clay, silty clay, and sandy clay, often with root structures, caliche nodules (soil horizons)

Graphic Grain Size Legend



Width of log column denotes predominant grain size as described for that interval in boring log.

Color in log column indicates following:

red = gravelly (coarse)
orange = gravelly (fine-medium)
yellow = "clean" sand
green = silty
blue = clayey

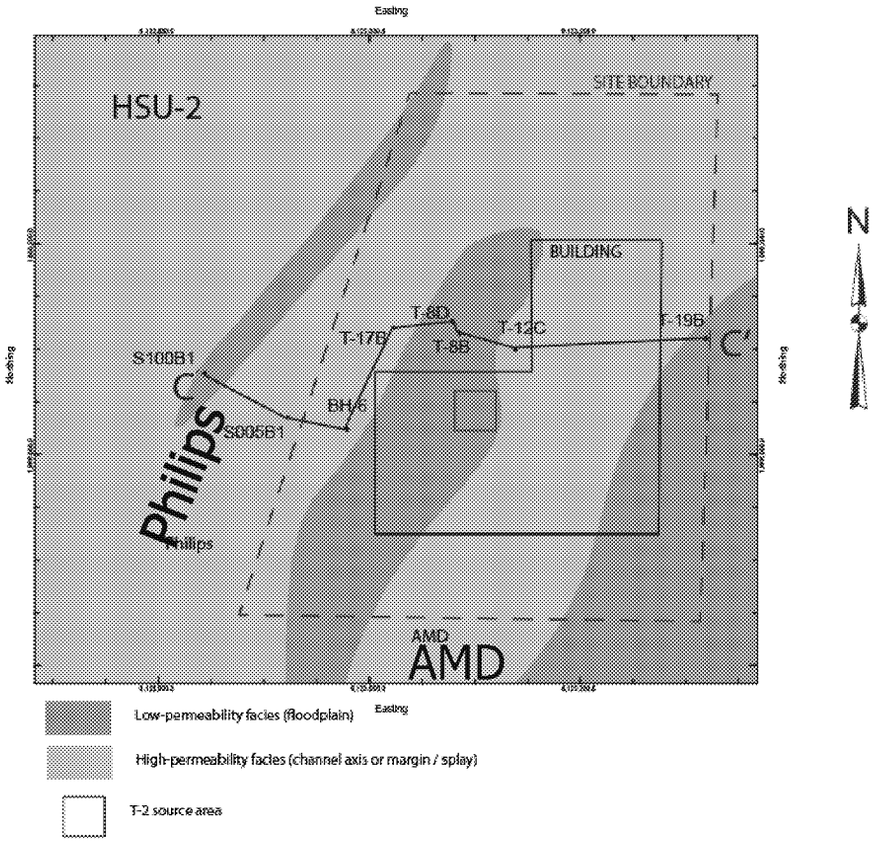
Brown colors represent mixtures of sand, silt, and gravel in clayey matrix (i.e., diamicton in glacial till).

Blank intervals indicate no sample recovered.

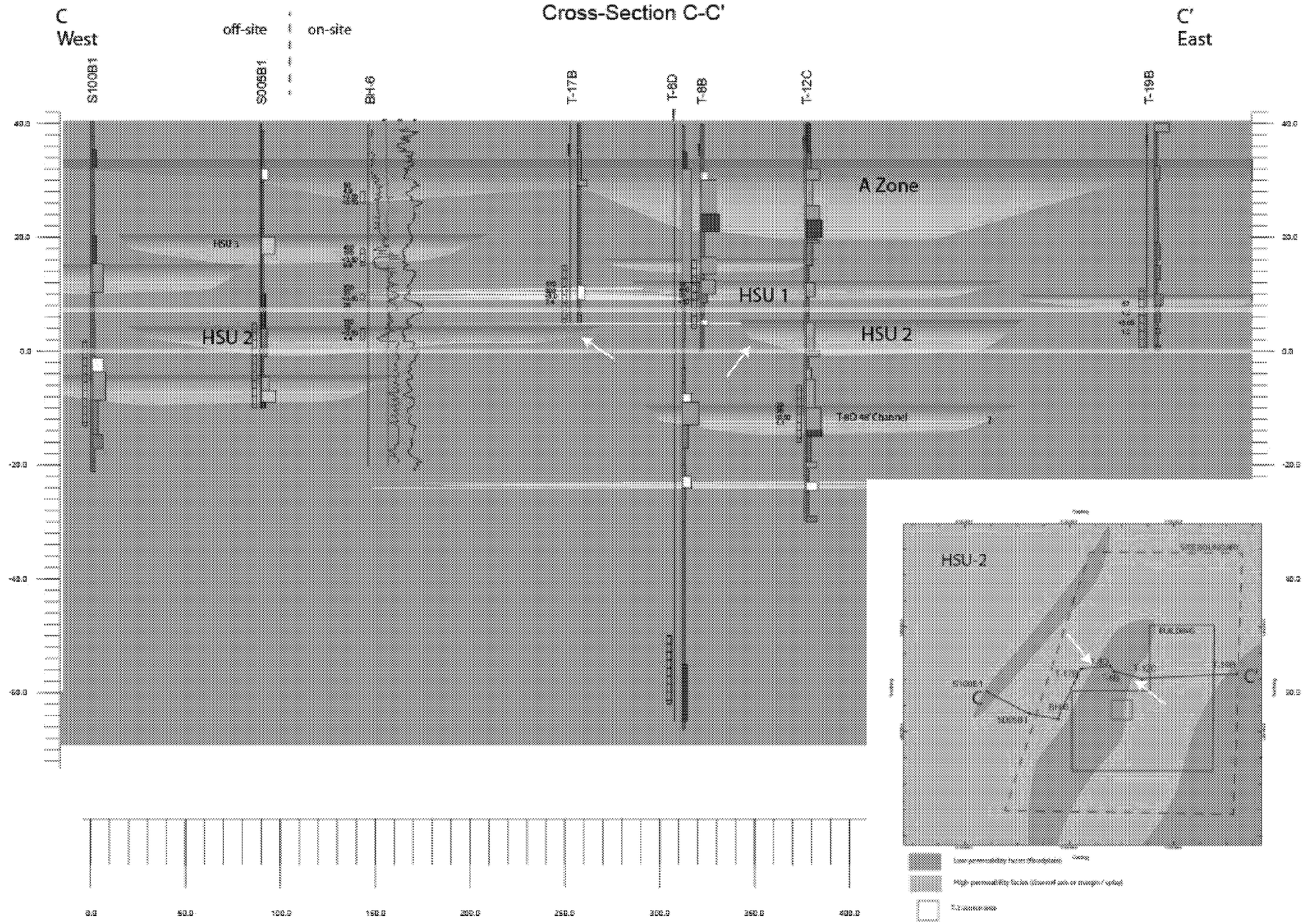
AECOM

Cross Section C-C’

- Shows area immediately downgradient of former source area, perpendicular to groundwater flow.
- Clear divide in this area between the HSU2 channel coming from offsite and HSU2 channel in the center of the site.
- Channels in Zone B1 are generally laterally discontinuous.



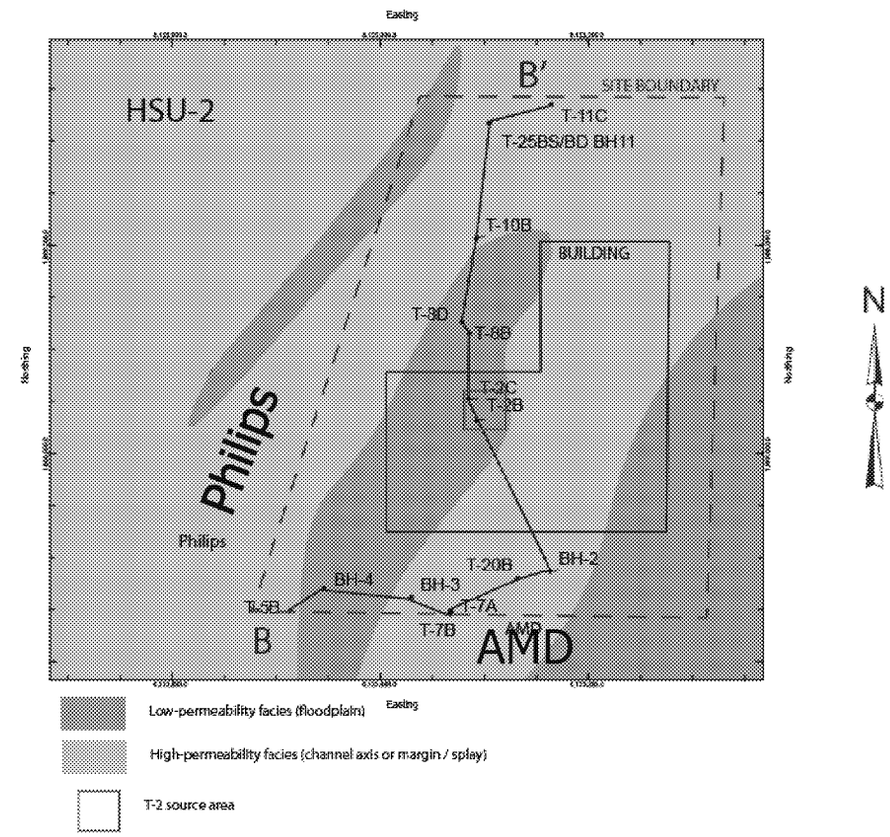
AECOM


Cross-Section C-C'
C
West
off-site
on-site
C'
East
S100B1
S005B1
BH-6
T-17B
T-8D
T-8B
T-12C
T-19B
A Zone
HSU 1
HSU 2
HSU 1
HSU 2
T-8D 48' Channel
HSU-2
C
C'
40.0
20.0
0.0
-20.0
-40.0
-60.0
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
400.0

AECOM

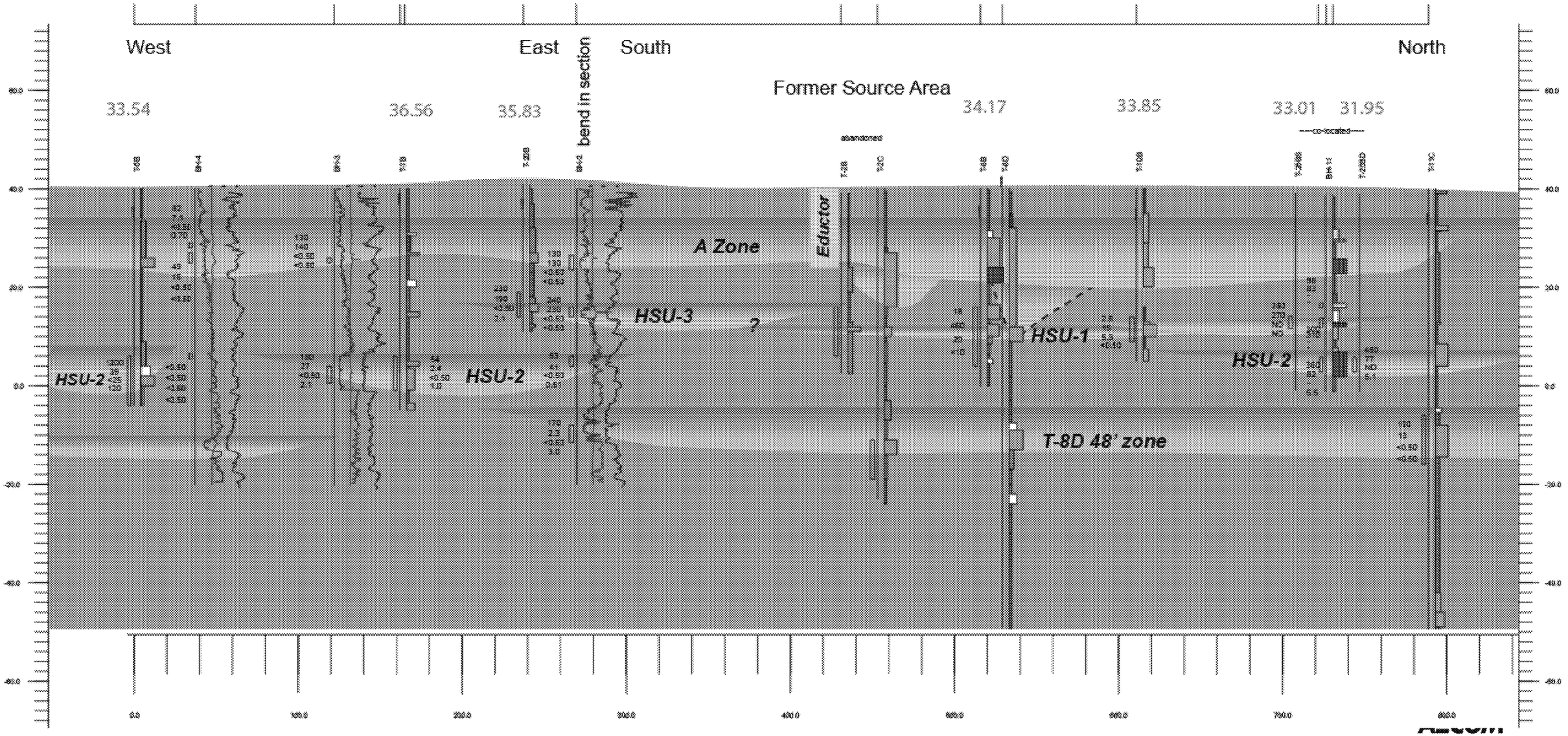
Cross Section B-B’

- Clear divide between the HSU-2 channel coming from offsite and HSU-2 channel in the center of the site, supported by water level data
- HSU-2 channel not present under former source area
- Some interaction between HSU-3 (linked with offsite contamination from AMD) and HSU-1



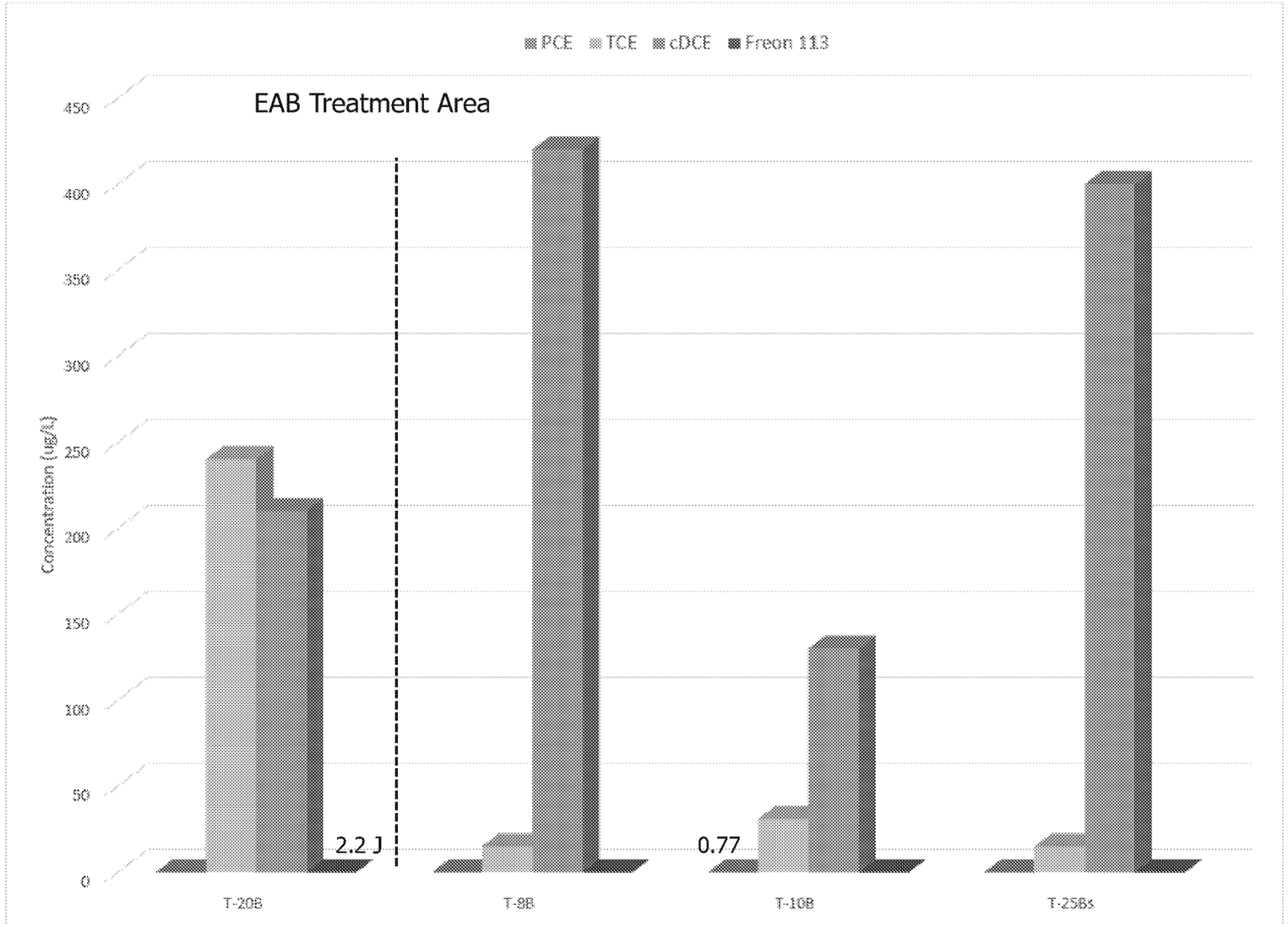
AECOM

Cross-Section B-B'



Cross Section B-B' HSU-3/HSU-1

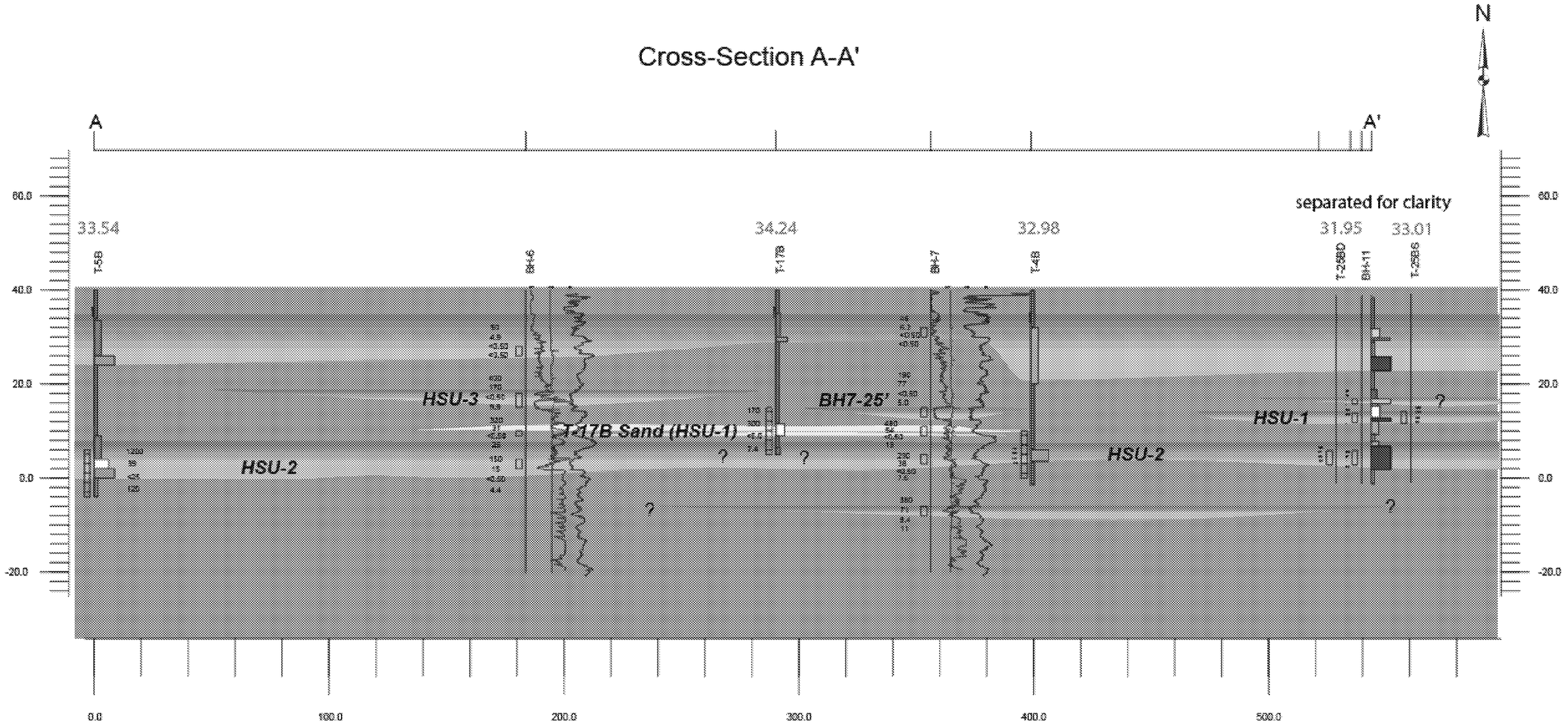
- T-20B is screened in HSU-3, but HSU-3 may intercept HSU-1
- TCE conversion to cDCE after traveling through EAB Treatment Area



Groundwater Flow

AECOM

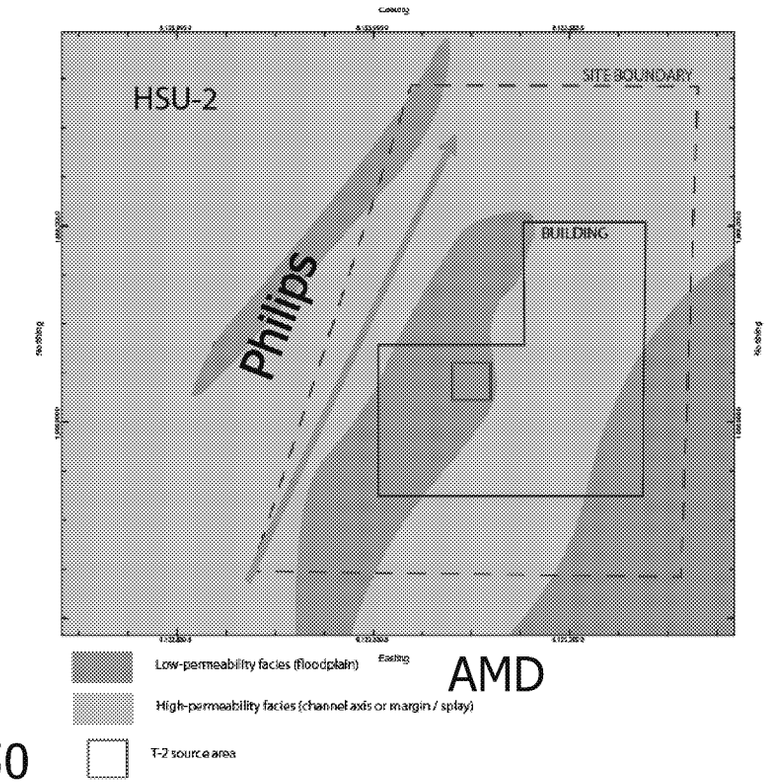
Cross-Section A-A'

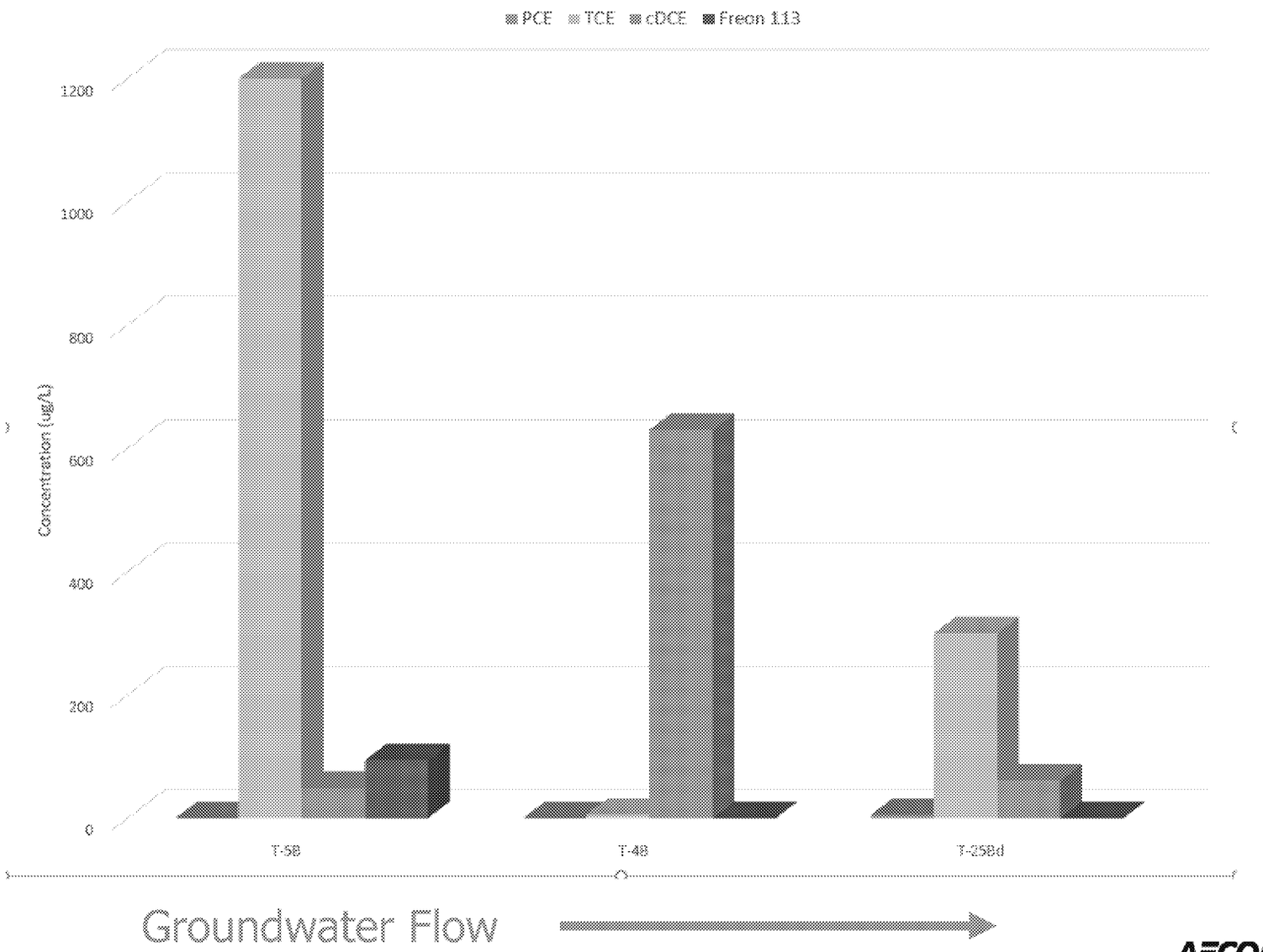


AECOM

Cross Section A-A'

- Continuous HSU-2 channel from offsite (Philips) to downgradient onsite well





AECOM

AECOM

QUESTIONS?