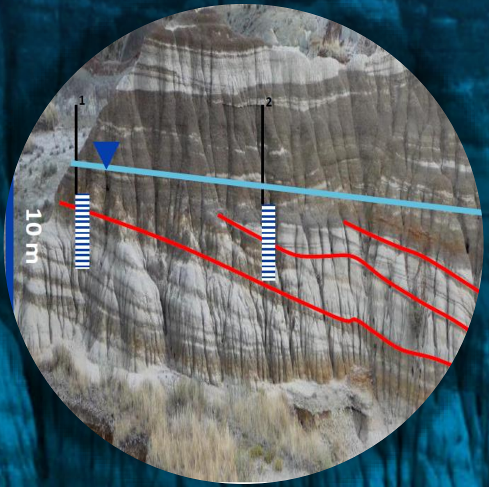
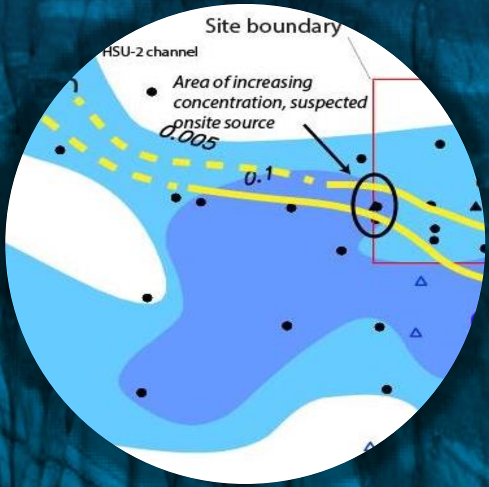
Best Practices for Environmental Site Management

A Practical Guide for Applying Environmental Sequence Stratigraphy (ESS) to Improve Conceptual Site Models





UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Presented to

CLU-In

April 3, 2018

BURNS & McDONNELL

US EPA Emphasis on Geologic Based CSMs and Remediation Based Geology

- **Motivation**: Determine why some Superfund site remediation efforts are not successful. Are there a set of circumstances or characteristics common for these sites that prevent attaining cleanup standards?

- **Identified issue**: Contaminant flux is often limited to geologically controlled flow zones. Imperative to identify these flow zones to assure successful remedial efforts.

- **Goal**: Provide remediation industry and regulators with an approach for applying proven geologic principles and methods to locate flux zones.

- **Expectations**: Site managers reconsider conceptual site models (CSMs) following new EPA guidance.

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US EPA Emphasis on Geologic Based CSMs and Remediation Based Geology

- EPA is committed to applying stratigraphic analysis to our hazardous waste sites. It is our expectation that stratigraphic analysis utilizing the methods presented in this new EPA guidance be considered at each site.
- EPA has advocated updating existing conceptual site models when new data are obtained. This new EPA guidance presents a methodology utilizing existing data, new data are not necessarily required to perform this analysis.
- Updating existing conceptual site models can occur at any time, from EPA's perspective this can occur in the near term.
- Stratigraphic analysis is best conducted by experienced stratigraphers. EPA will be writing into contracts for conceptual site models developed on our behalf be prepared in collaboration with a stratigrapher.
- EPA's expectation is for work products and reports submitted to our agency also be checked by an knowledgeable and experienced stratigrapher.

US EPA Geology Initiative

- Best Practice series of papers, two completed three in prep
- BEST PRACTICES FOR ENVIRONMENTAL SITE MANAGEMENT, *A Practical Guide for Applying Environmental Sequence Stratigraphy to Improve Conceptual Site Models*
- BEST PRACTICES FOR ENVIRONMENTAL SITE MANAGEMENT, *Contents of a Groundwater Monitoring Report*
- BEST PRACTICES FOR ENVIRONMENTAL SITE MANAGEMENT, *A Framework for Characterizing Groundwater/Surface Water Interaction*
- BEST PRACTICES FOR ENVIRONMENTAL SITE MANAGEMENT, *Geology Characterization of Hazardous Waste Sites*
- BEST PRACTICES FOR ENVIRONMENTAL SITE MANAGEMENT, *Groundwater Sampling Methods*
- Stay tuned, publication and training announcements will be made in EPA's TechDirect

General Benefits of ESS Approach

- Identify groundwater flow paths and preferential contaminant migration pathways
- Map and predict contaminant mass transport (high permeability) zones and matrix diffusion-related storage (low permeability) zones
- Identify data gaps and determine a focused HRSC program, if needed
- Optimize groundwater monitoring program
- Improve efficiency and timeliness of remediating contaminated groundwater
- Reduce cost of remediation

US EPA Geology Initiative

- 90% of mass flux contaminant transport at Superfund sites has been shown to be through 10% of aquifer material.
- A site conceptual model that accurately reflects the geologic plumbing is essential for remedy selection and implementation.
- Site conceptual models that do not consider depositional environment tend to incorrectly interpret the geologic plumbing which leads to faulty remedy selection/design and unnecessarily lengthy cleanups.

EPA/600/R-17/293
September 2017

EPA United States Environmental Protection Agency **Groundwater Issue**

Best Practices for Environmental Site Management:

A Practical Guide for Applying Environmental Sequence Stratigraphy to Improve Conceptual Site Models

Michael R. Shultz[1], Richard S. Cramer[1], Colin Plank[1], Herb Levine[2], Kenneth D. Ehman[3]

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[1]Burns & McDonnell
[2]U.S. EPA
[3]Chevron Energy Technology Company

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 on the application of the geologic principles of sequence stratigraphy and facies models (see "Definitions" text box, page 2) to the characterization of stratigraphic heterogeneity at hazardous waste sites.

Application of the principles and methods presented in this issue paper will improve Conceptual Site Models (CSM) and provide a basis for understanding stratigraphic flux and associated contaminant transport. This is fundamental to designing monitoring programs as well as selecting and implementing remedies at contaminated groundwater sites. EPA recommends re-evaluating the CSM while completing the site characterization and whenever new data are collected. Updating the CSM can be a critical component of a 5 year review or a remedy optimization effort.

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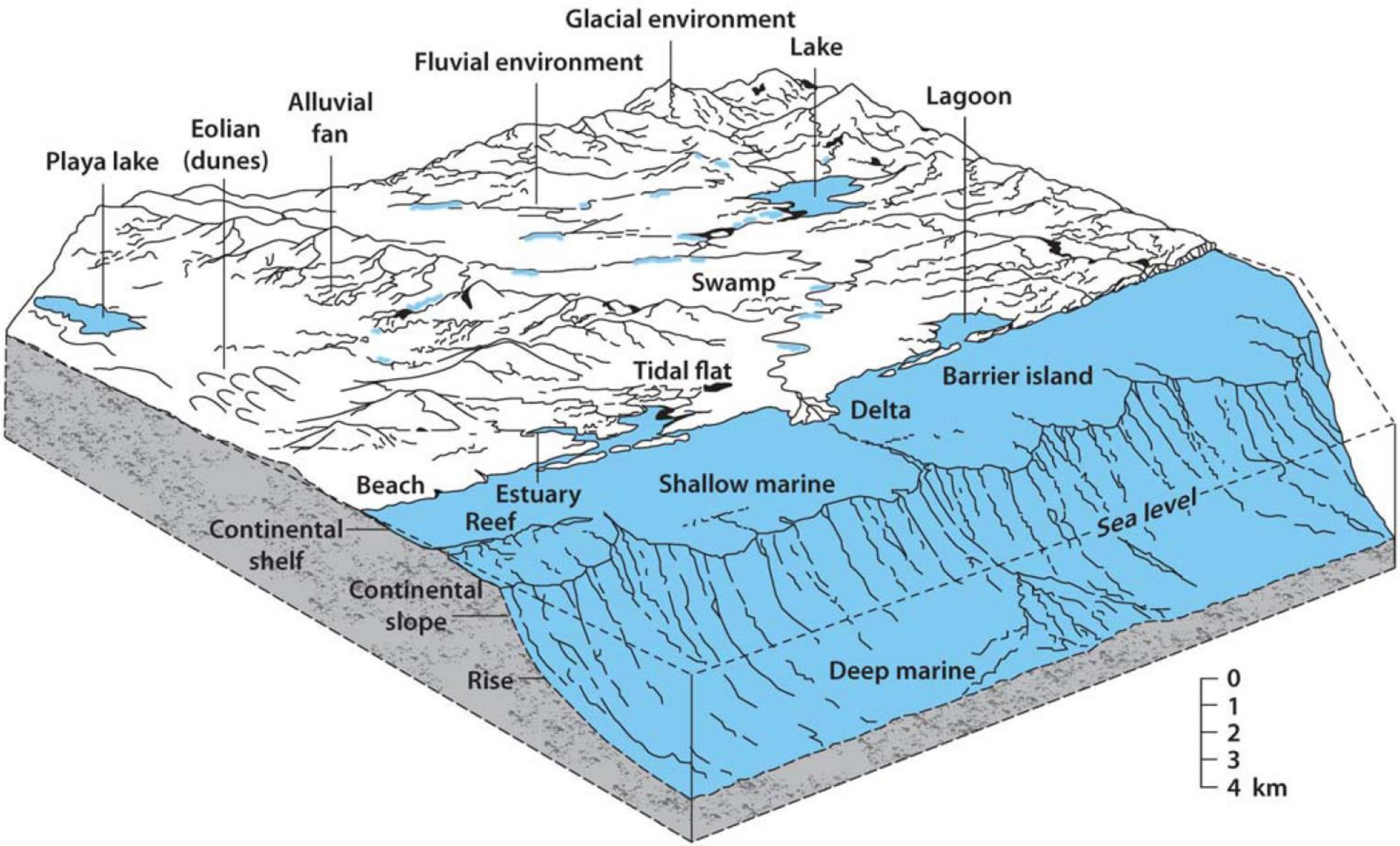
Focus on Depositional Environments



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Stratigraphic “Rules of Thumb”

Interpretation Methodology and Stratigraphic “Rules of Thumb”

While there is no substitute for experience in application of facies models and sequence stratigraphy for accurate stratigraphic interpretation, the following generalized “rules of thumb” are presented to assist practitioners in the groundwater remediation community to improve subsurface correlations and prediction.

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Case Studies

APPENDIX A

Case Studies

- #1: Fluvial channel deposits, Silicon Valley, California; Contaminant pathways related to commingled VOC plumes **A2**
- #2: Glacial Outwash Channel Systems, Northeast US; DNAPL source for VOC groundwater impact **A12**
- #3: Glacial terrain, till and lacustrine deposits, Upper Midwest US; LNAPL and dissolved phase impact at a manufacturing facility **A15**
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Presentation Outline

- Paradigm Shift ➔ Remediation Geology
- Why Environmental Sequence Stratigraphy (ESS) (The Challenge of Subsurface Heterogeneity)
- What is ESS?
- Case Studies
  - Silicon Valley groundwater remediation project
  - Kirtland AFB, Albuquerque NM

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Paradigm Shift ▶ Remediation Geology

A Definition of Geology

The science that deals with the earth's physical structure and substance, its history, and the processes that act on it.

Geology (stratigraphy) defines the subsurface “plumbing” that is the primary control of groundwater flow and contaminant transport.

Just like there are specialties in the field of medicine…

MD

general practice OB/GYN anesthesiology neurology cardiology

orthopedic gastroenterology dermatology psychiatry

pediatrics seismology oncology podiatry urology

radiology ophthalmology pathology hematology

Stratigraphy, Subset of Geology: Interpretation of stratified rocks

Geology

mineralogy economic geology geophysics stratigraphy marine geology

volcanology geochemistry structural geology sedimentology

paleontology seismology hydrogeology petroleum geology tectonics

engineering geology geomorphology igneous petrology metamorphic petrology

Traditional Focus on Engineering

Unified Soil Classification System: Standard Practice for Classifying Soils

(Chart from ASTM)

D 2487 – 06

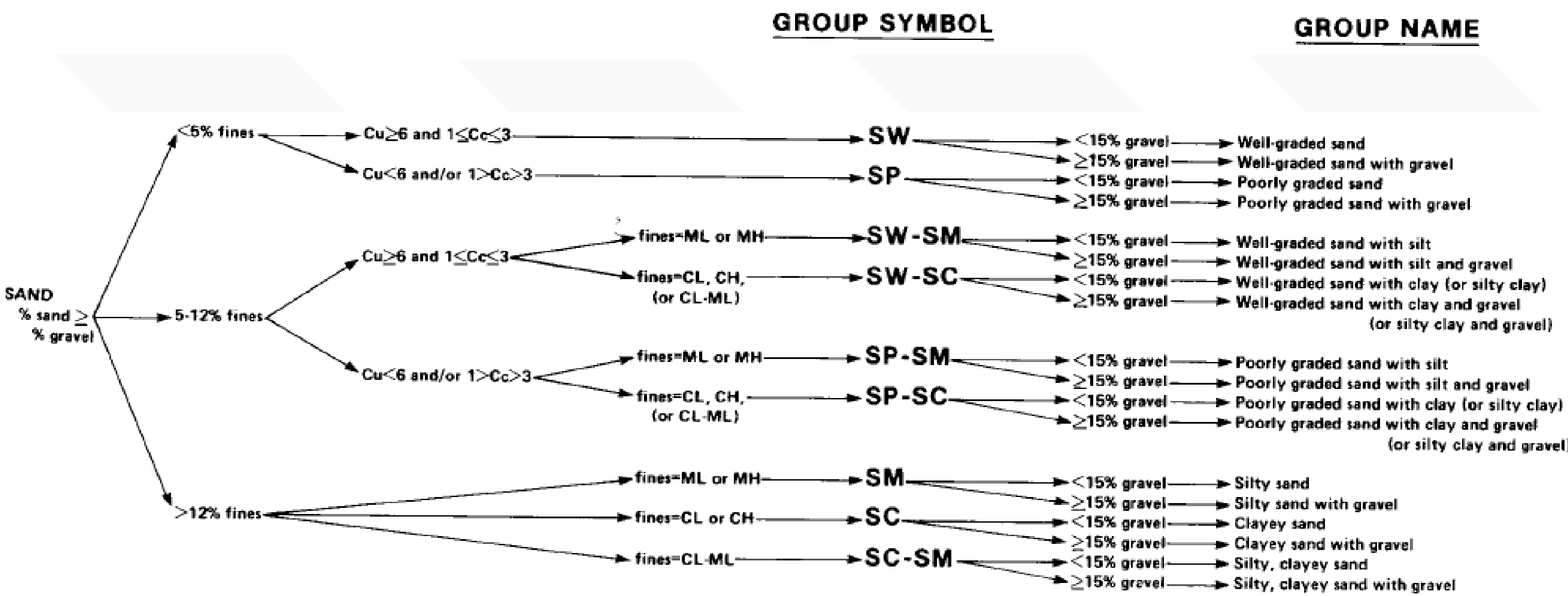
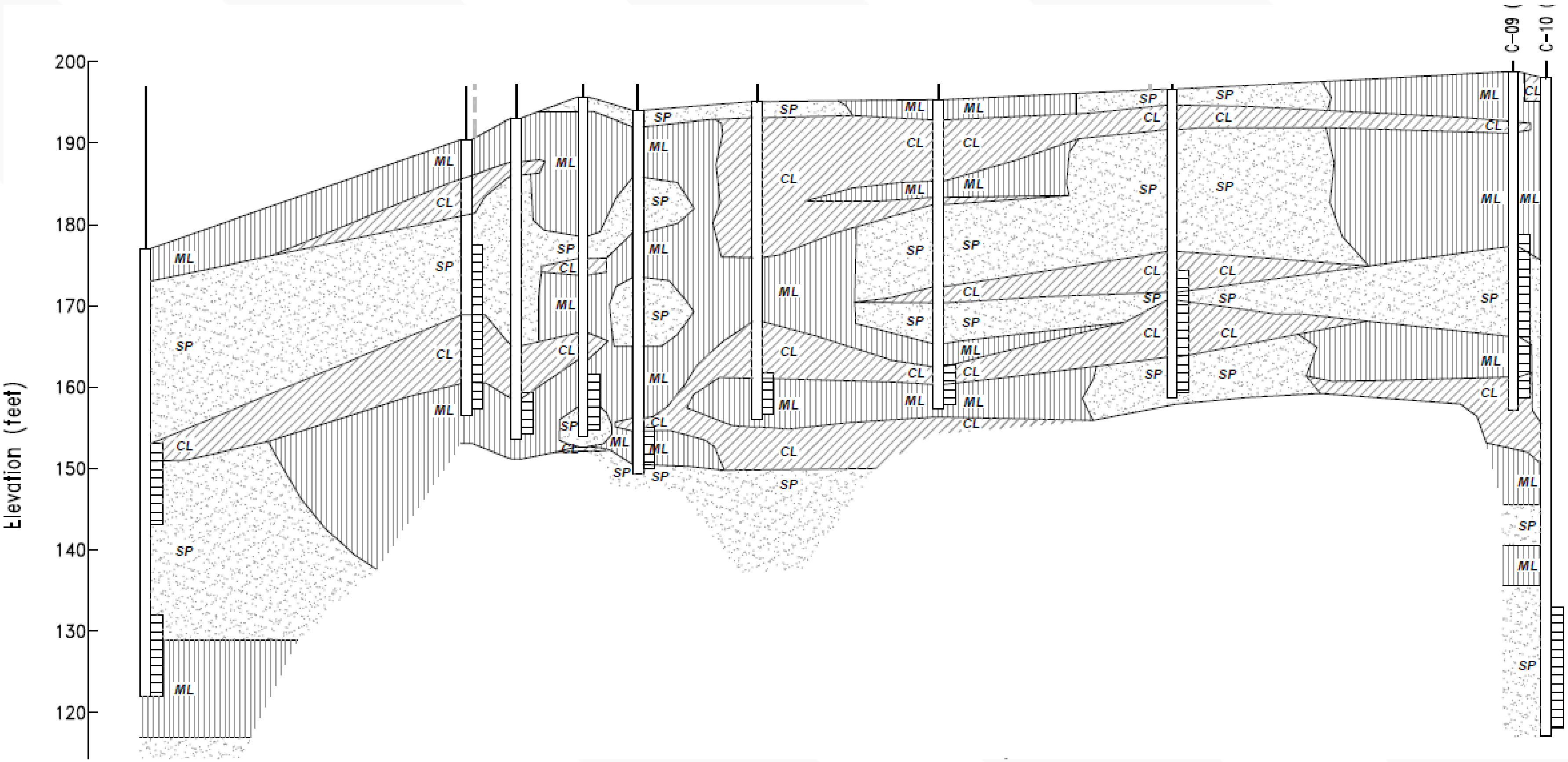


FIG. 3 Flow Chart for Classifying Coarse-Grained Soils (More Than 50 % Retained on No. 200 Sieve)

Lithostratigraphic Correlations

Connect sands to sands, clays to clays



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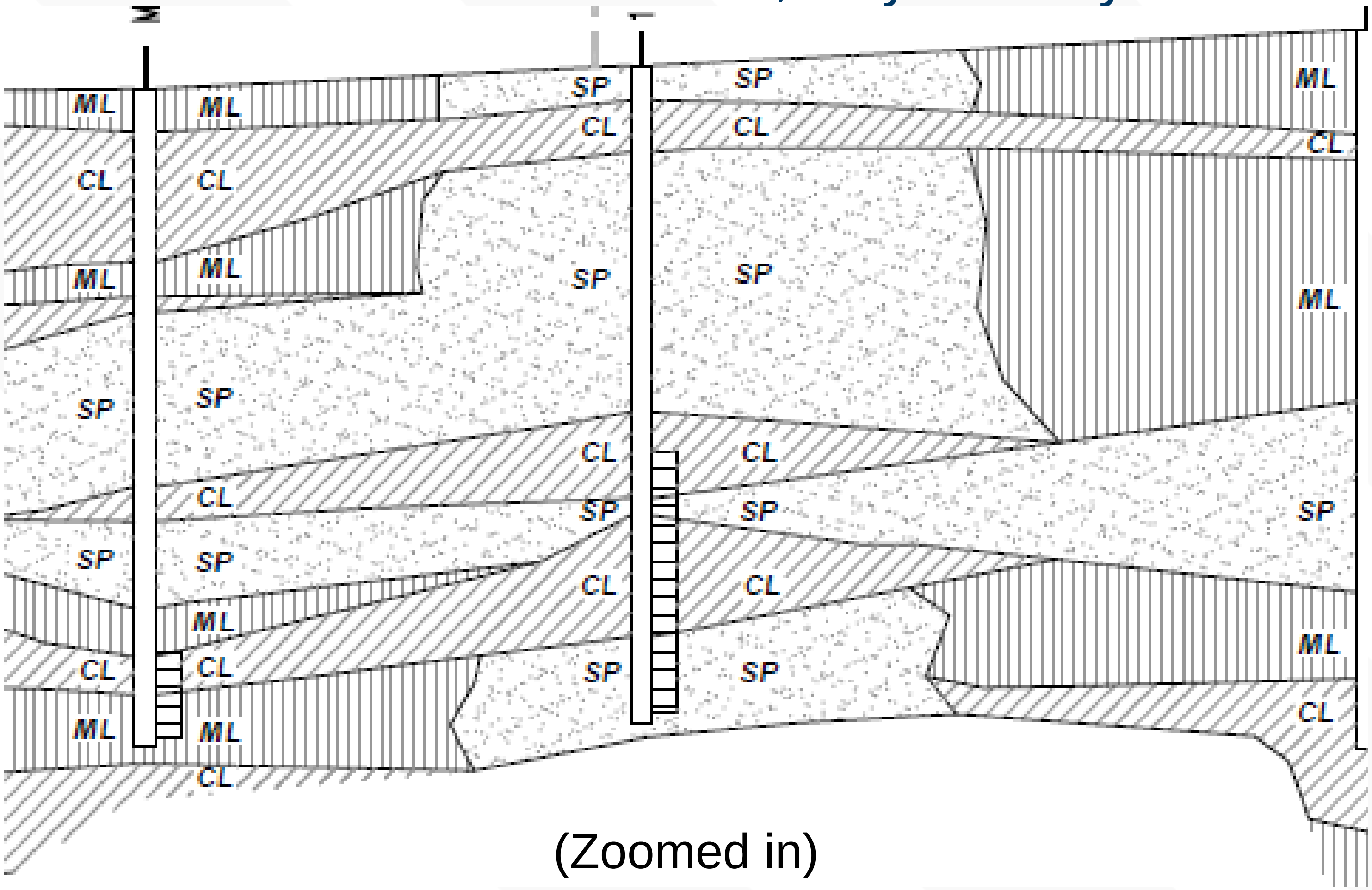
Lithostratigraphic Correlations

Connect sands to sands, clays to clays



(Zoomed in)

Groundwater Production Industry
Traditional Approach to the Subsurface

Water supply studies based on assumptions of homogeneous and isotropic conditions, steady-state observations

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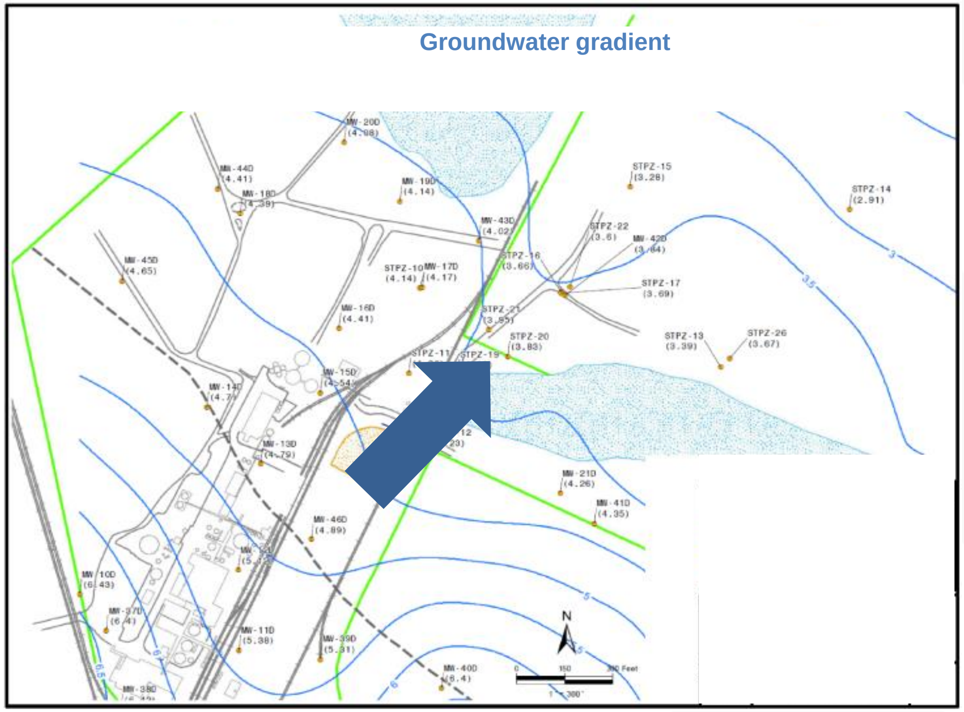
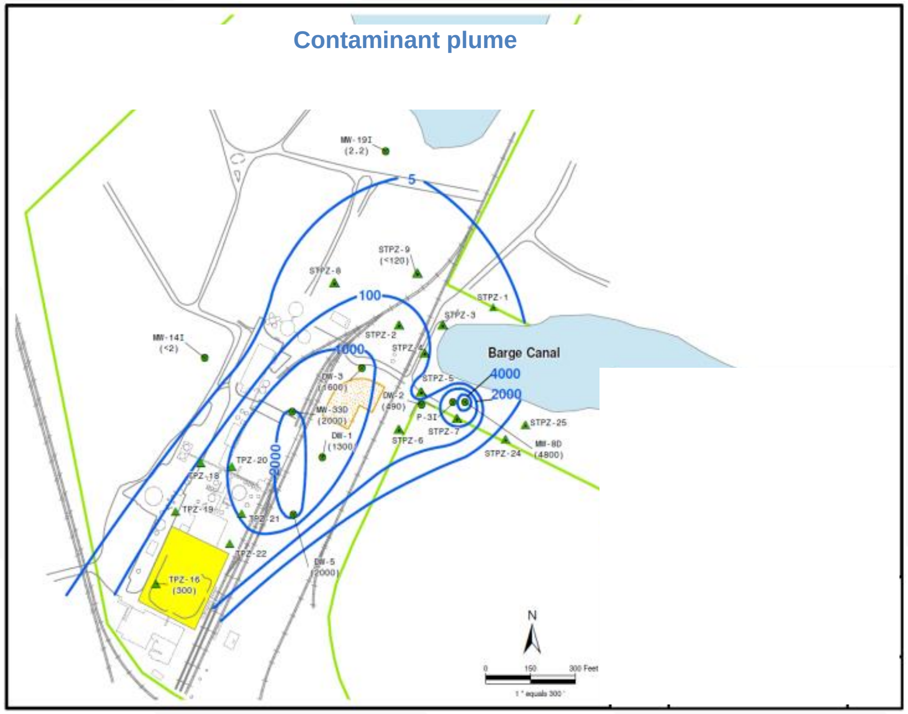
Traditional Focus on Hydrology

State of the practice is to apply Darcy's law, assume **homogeneous and isotropic** conditions witin layers of interest

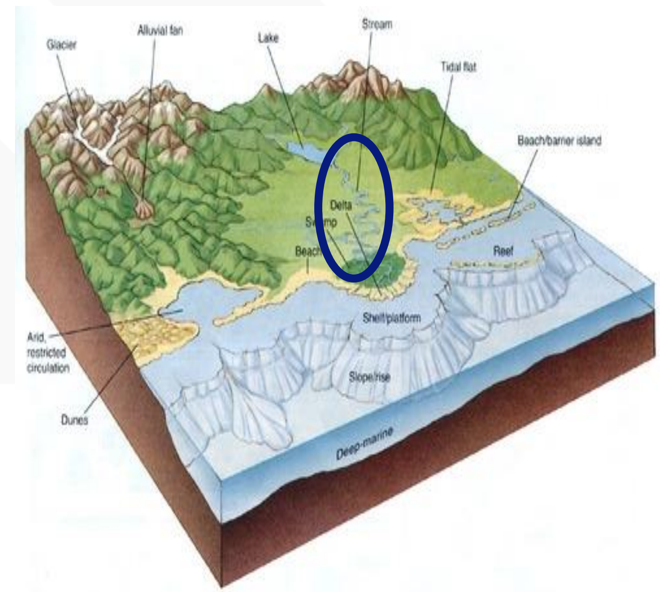




Why
Environmental Sequence Stratigraphy
(ESS)?

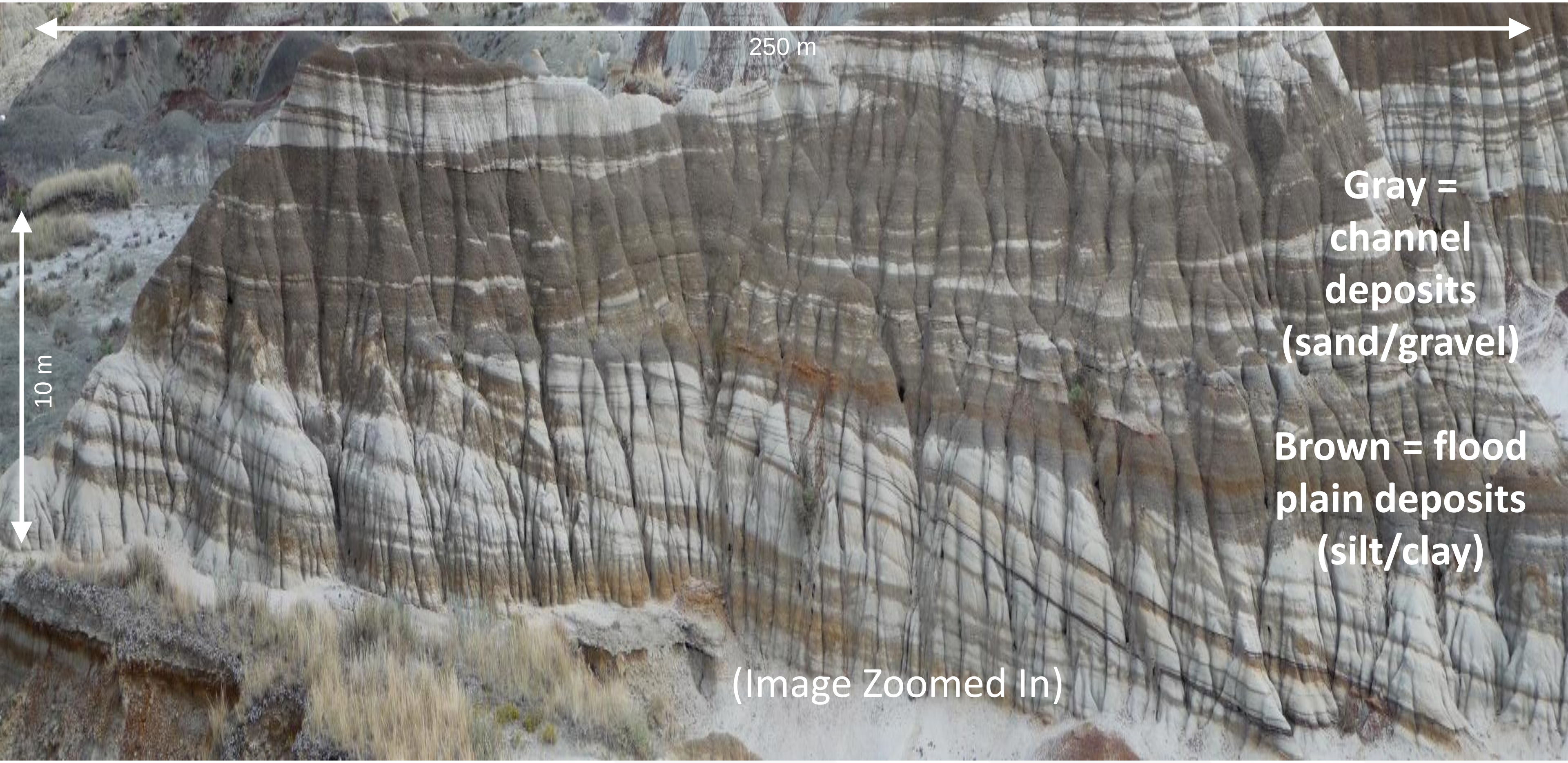
The Challenge of Subsurface Heterogeneity

The Problem of Ignoring Aquifer Heterogeneity



- Outcrop analog of meandering fluvial deposits
(Upper Cretaceous Horseshoe Canyon Formation, Alberta, Canada)

The Problem of Aquifer Heterogeneity



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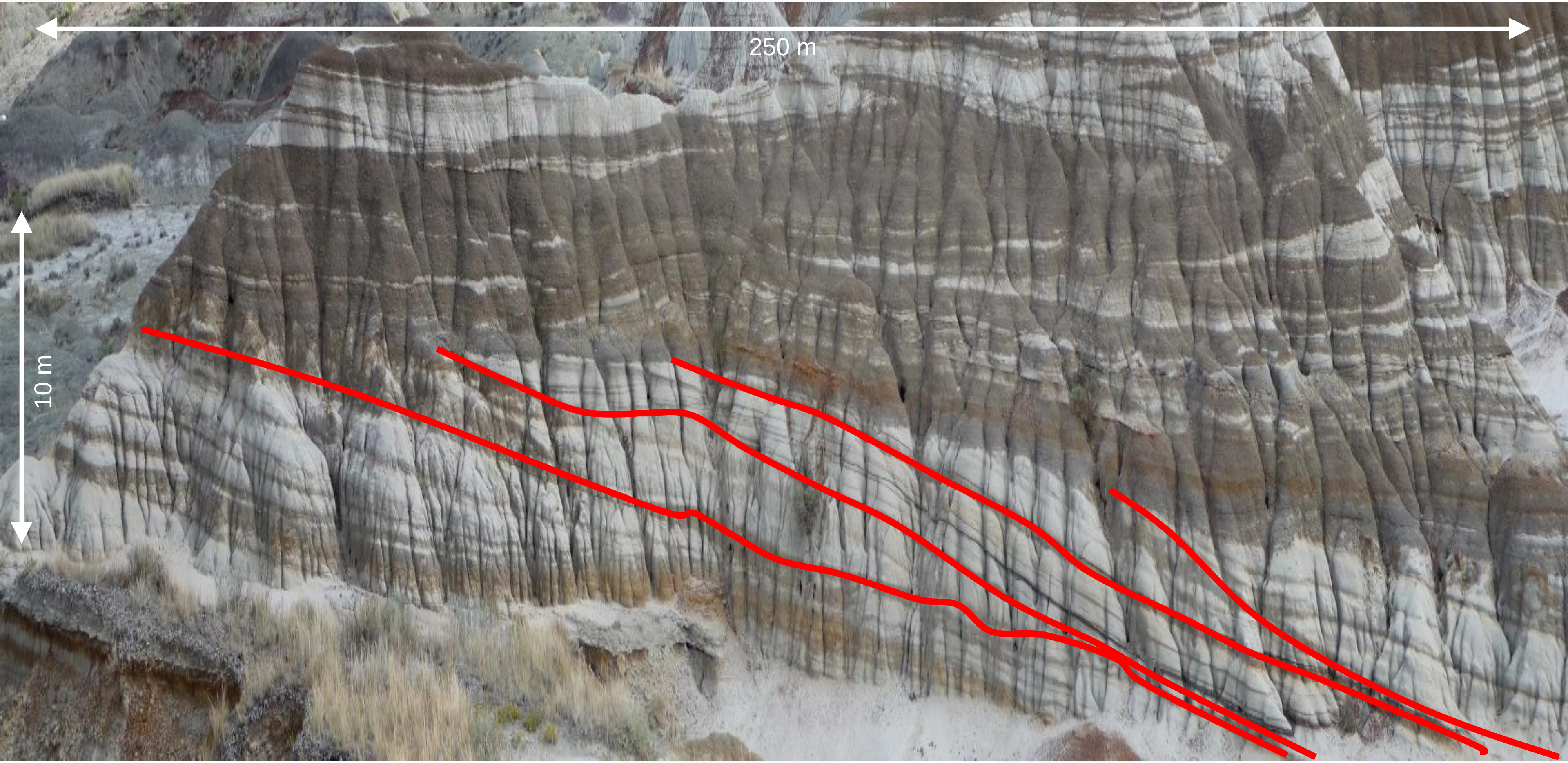
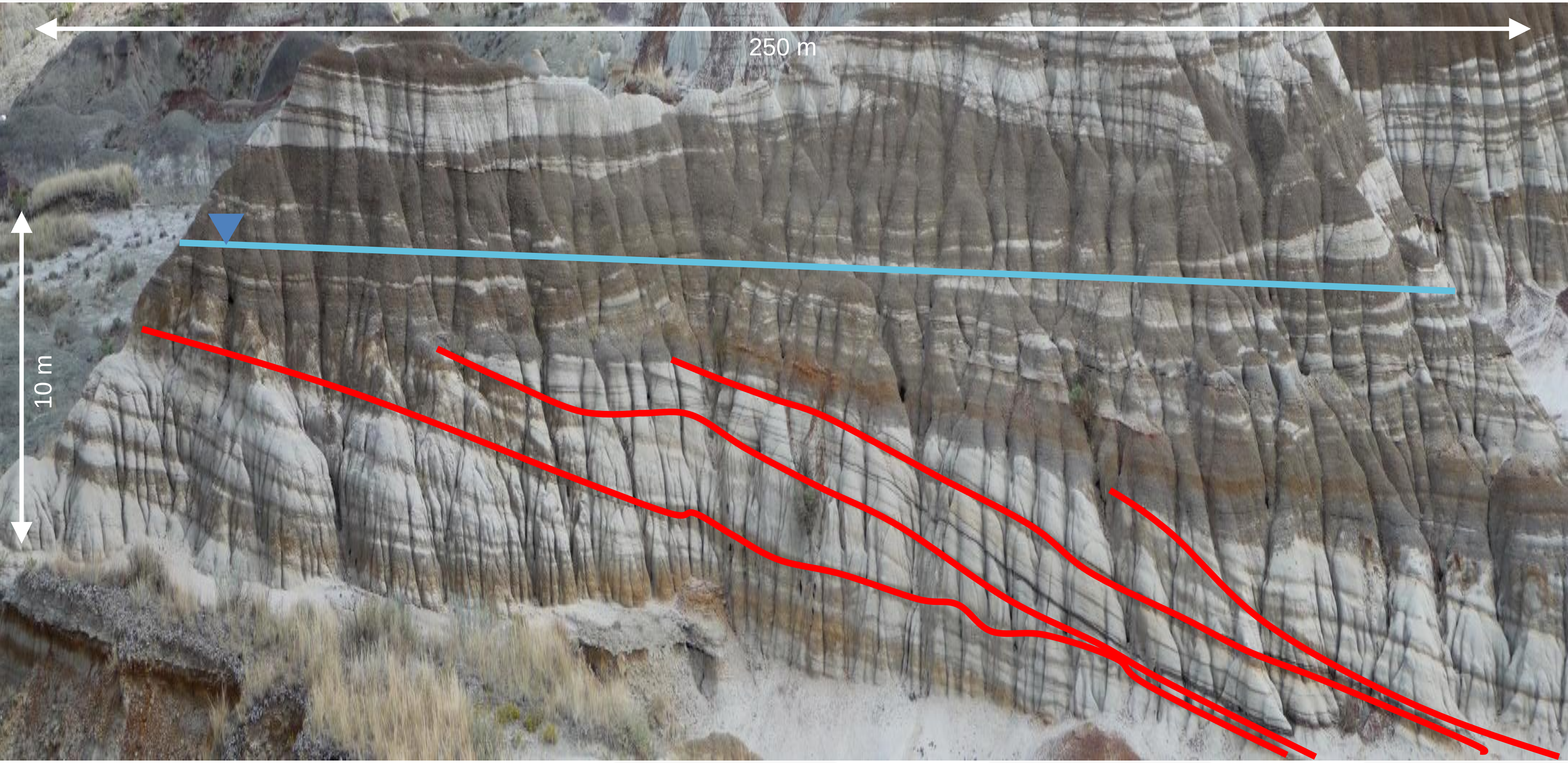
The Problem of Aquifer Heterogeneity



The Problem of Aquifer Heterogeneity



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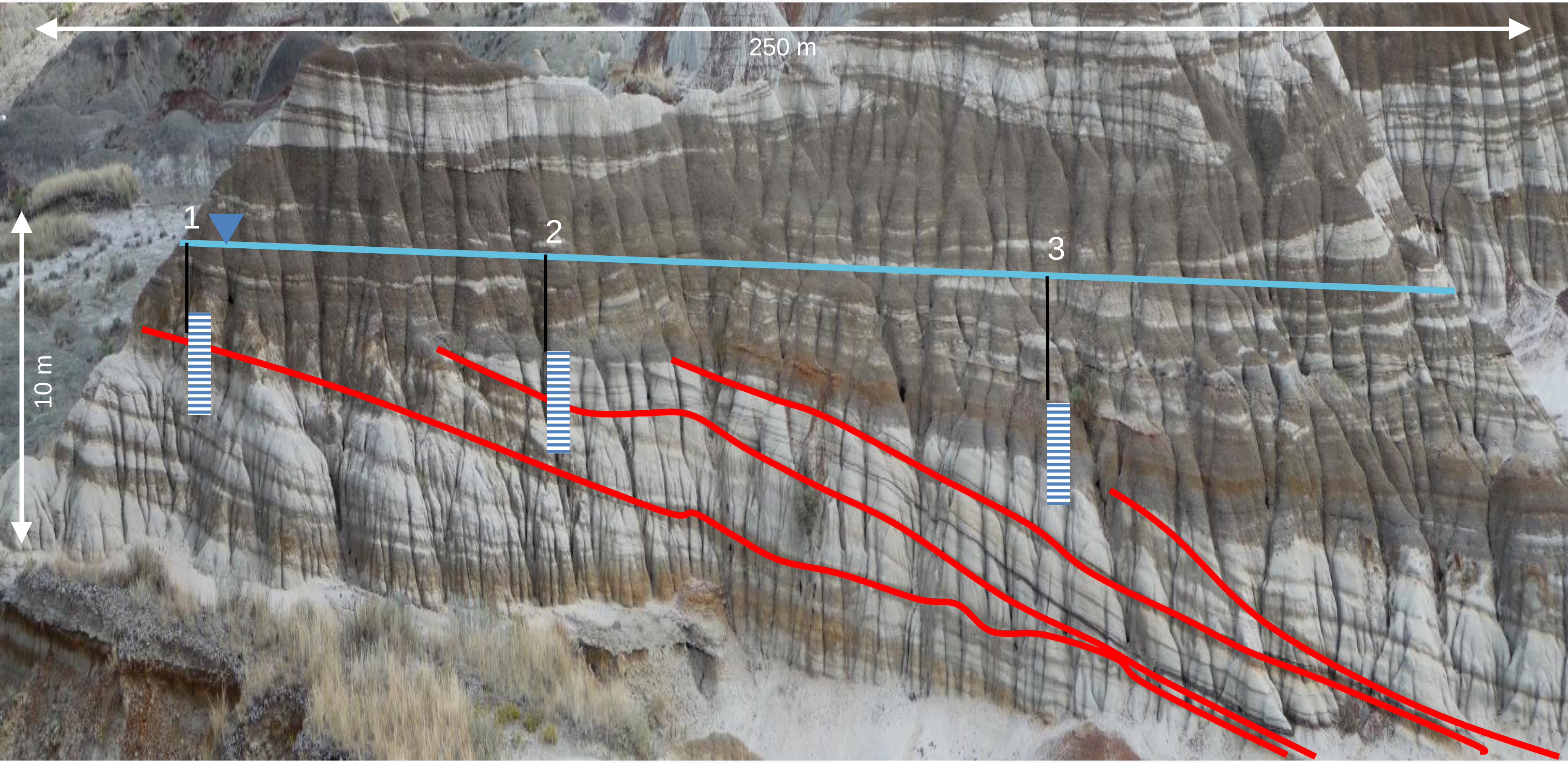
The Problem of Aquifer Heterogeneity



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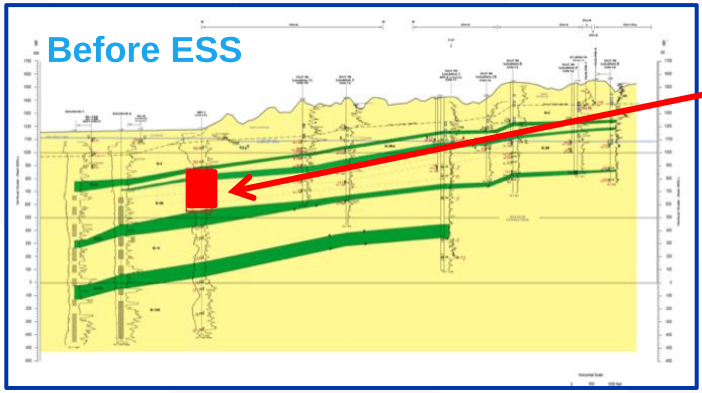
Cost Savings Example: Optimize Plume Containment Remedy

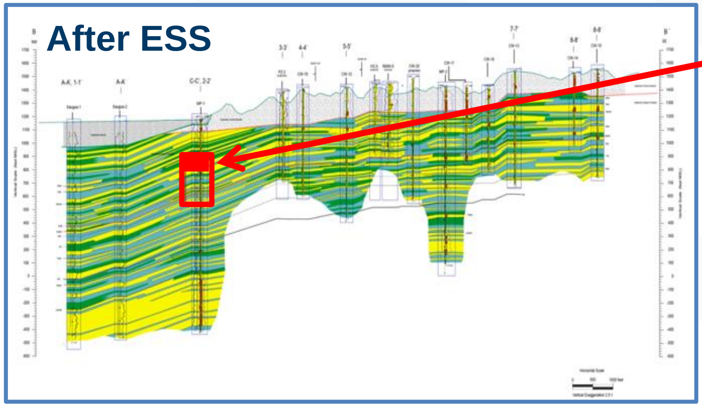


125' extraction interval (includes non-impacted strata)

Remediation System Design (Before ESS)

- 12 extraction wells
- ~200 gpm per well
- 1,261 million gallons per year

Total cost = $82 million



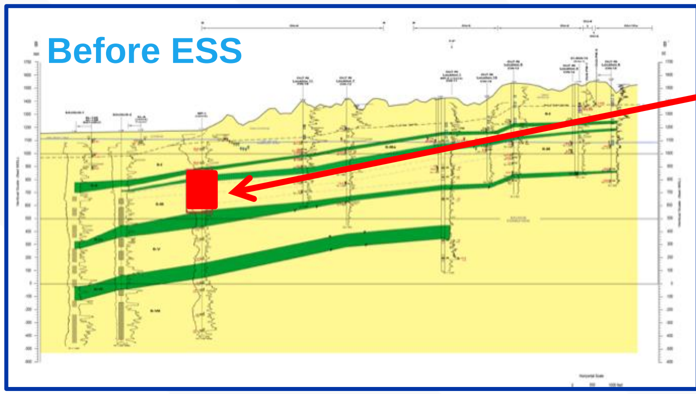
35' extraction interval (impacted strata only)

Estimated Remediation System Cost (After ESS)

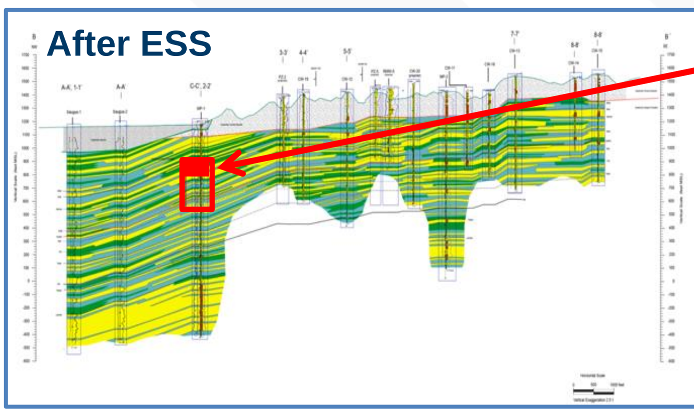
- 13 extraction wells
- 46 gpm per well
- 314 million gallons per year

Total cost = $26.5 million

Cost Savings Example: Optimize Plume Containment Remedy



125' extraction interval (includes non-impacted strata)



35' extraction interval (impacted strata only)

Significantly reduced quantity of extracted groundwater (by 75%)

Significantly reduced cost of remediation (by >$50 million)

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Geology/Heterogeneity Matters

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."

Alternatives for Managing the Nation's Complex Contaminated Groundwater Sites
National Academy of Sciences Committee on Future Options for Management in the Nation's Subsurface Remediation Effort, 2013

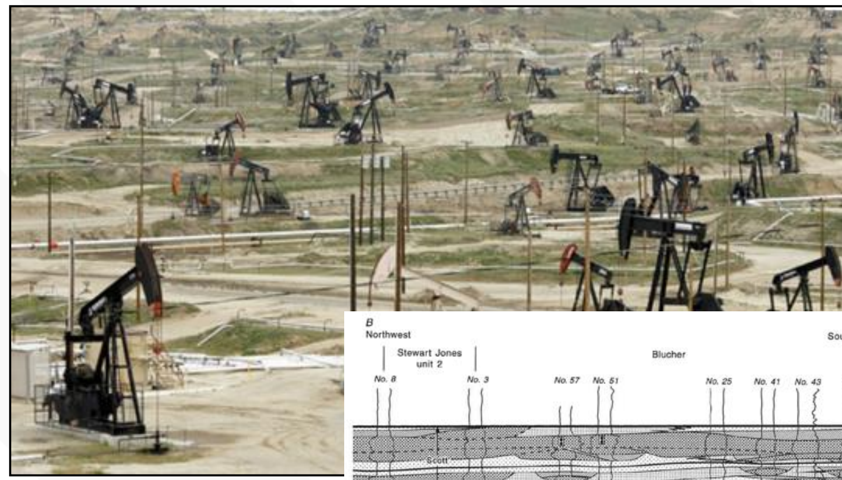
What is ESS?

Emergence of Petroleum Geology in the Oil Industry

Early days of exploration and production, once oil reservoir was discovered, production was limited by facilities capacity (**engineering focus**).

As production declined, **geology** became increasingly critical for economical operations.

Billions of dollars have been invested in research and development of stratigraphic controls on fluid flow.



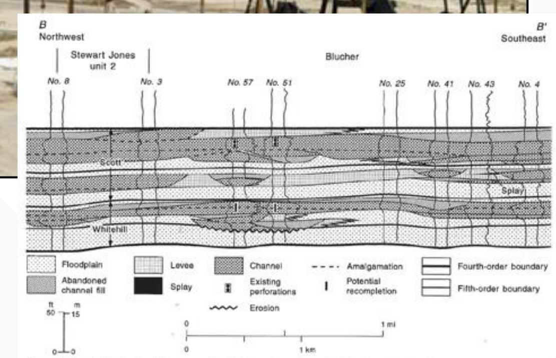


Figure 3. Dip-oriented stratigraphic cross section B-B' through amalgamated channel sandstones and floodplain shales in the Scott/Whitehill intermediate-frequency unit in T-C-B field. Note that the four high-frequency units, the lower and upper Whitehill and the lower and upper Scott, exhibit a successive increase in thickness from the lower Whitehill to the upper Scott. See Figure 4a for location. From Knox and McRae (1995).

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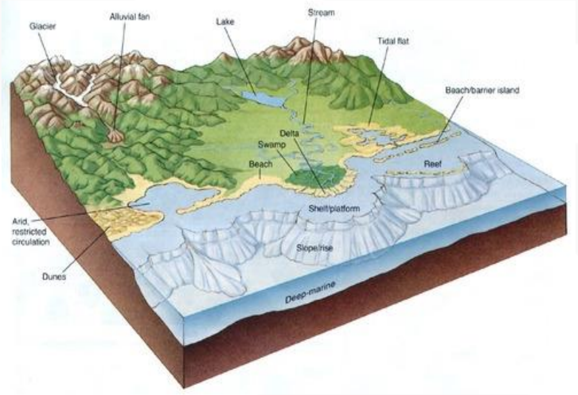
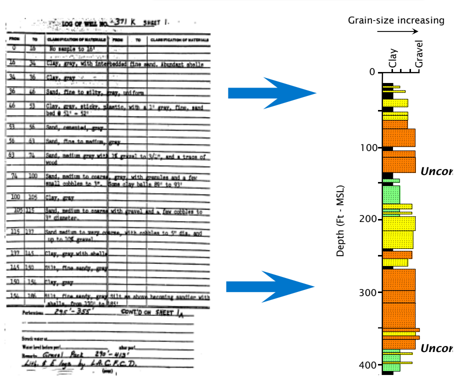
The Environmental Sequence Stratigraphy (ESS) Process

1



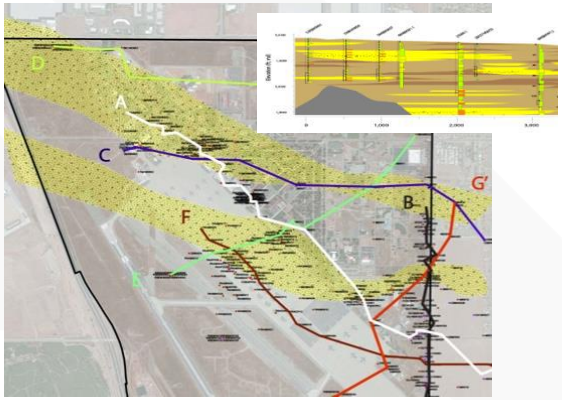
Determine depositional environment, which is the foundation of the ESS evaluation

2



Leverage existing lithology data: format to emphasize vertical grainsize distribution

3



Map and predict in 3-D the subsurface conditions away from the data points

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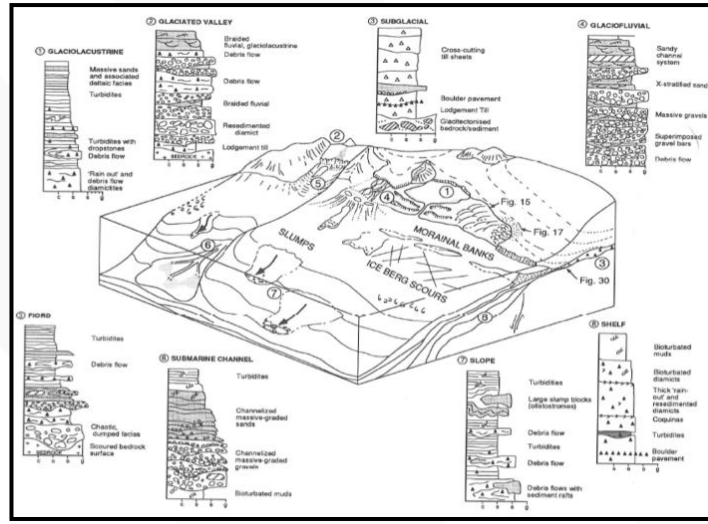
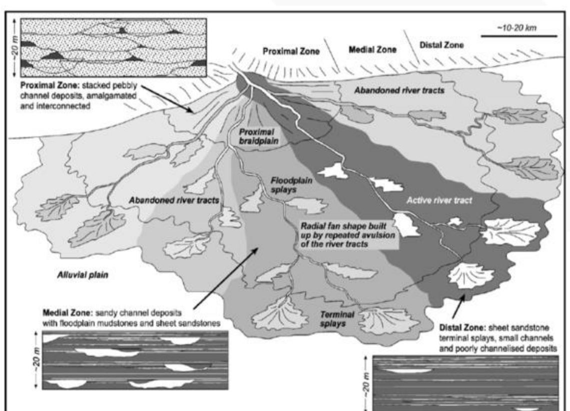
ESS Is About Pattern Recognition

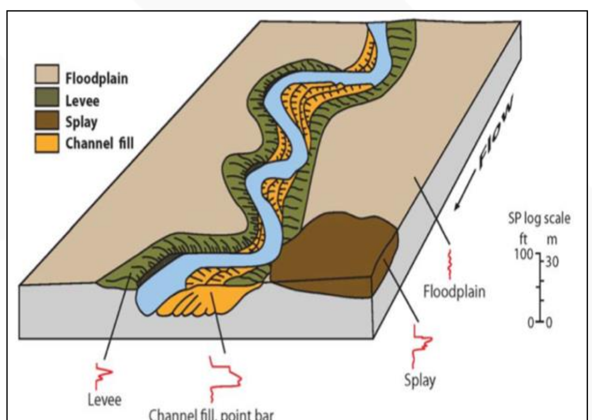
Glacial depositional systems



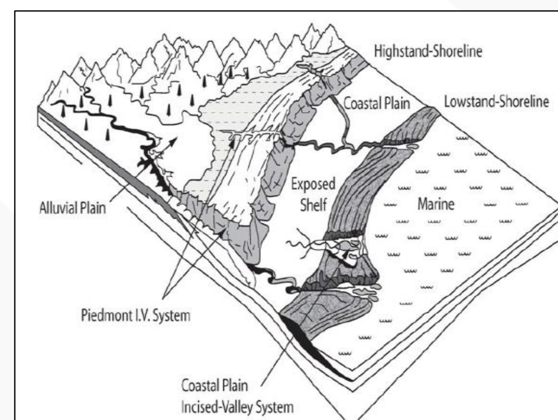
Alluvial fan facies model



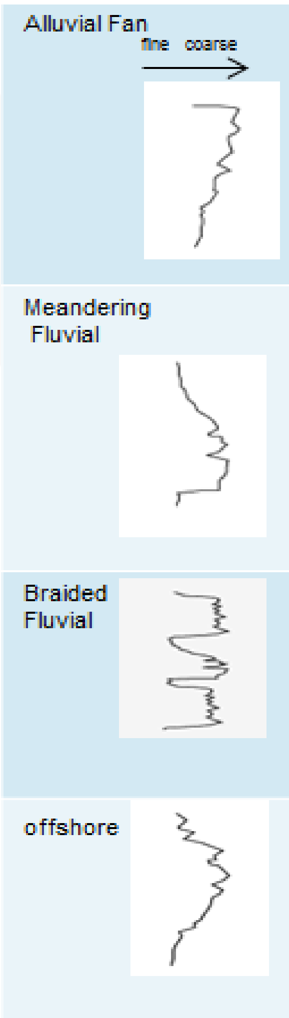
Meandering river facies model

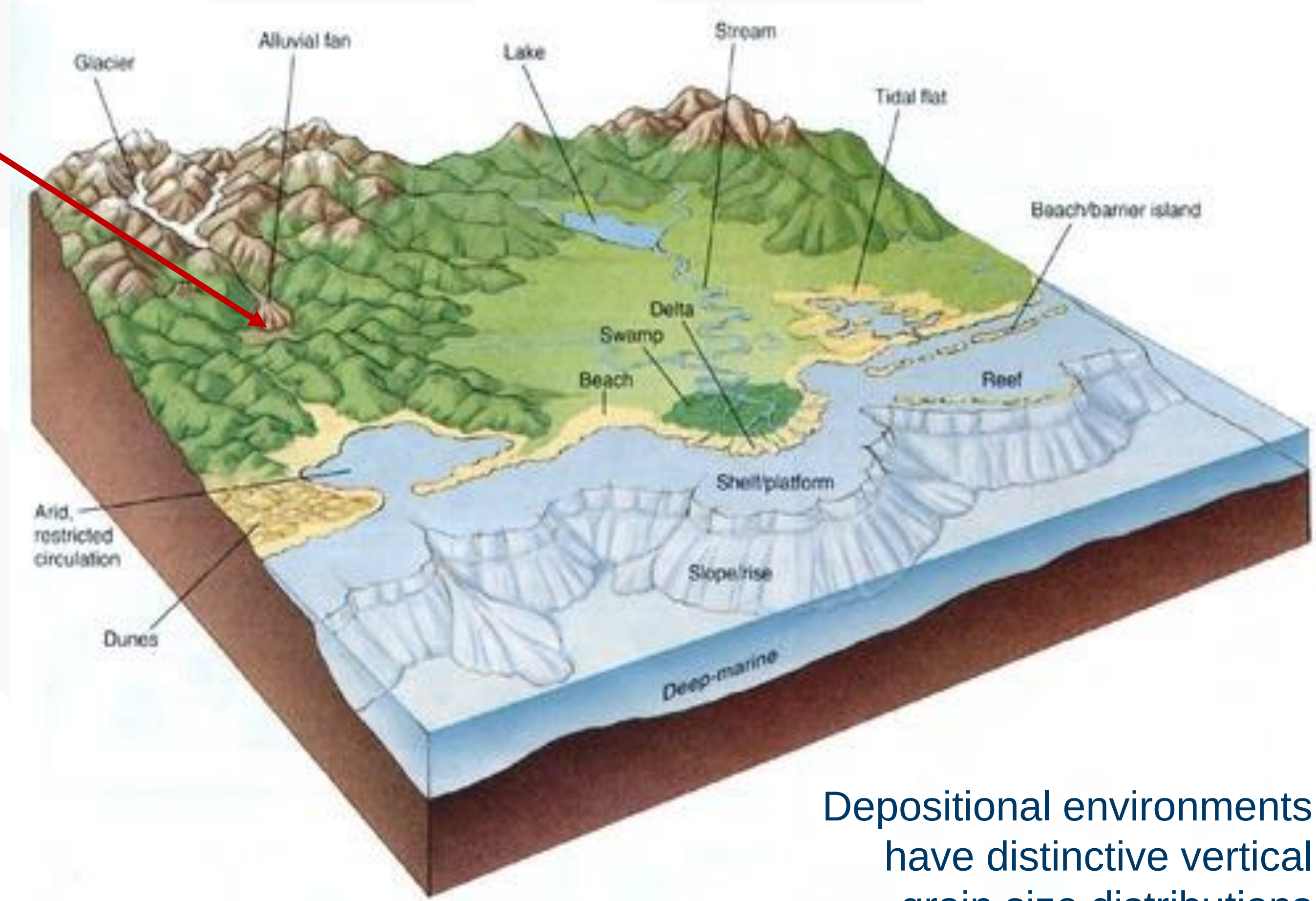


Coastal depositional systems



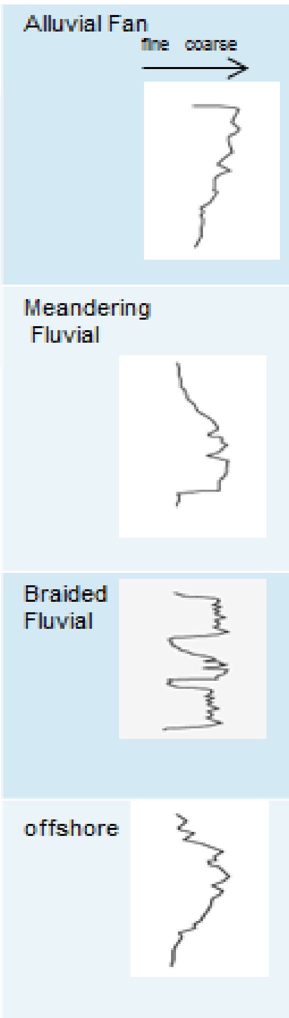
ESS Is About Pattern Recognition

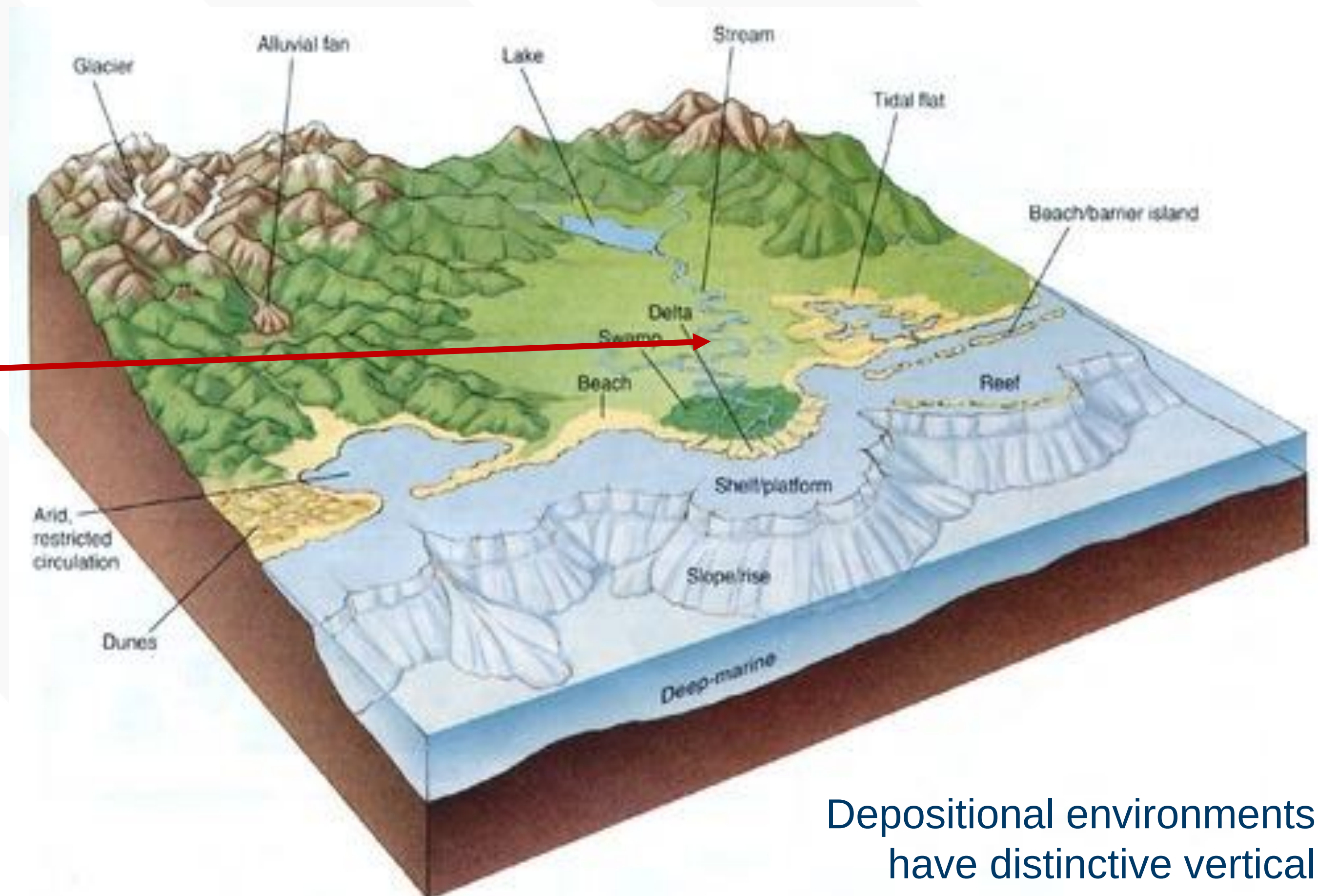




Depositional environments have distinctive vertical grain size distributions

ESS Is About Pattern Recognition





Depositional environments have distinctive vertical grain size distributions

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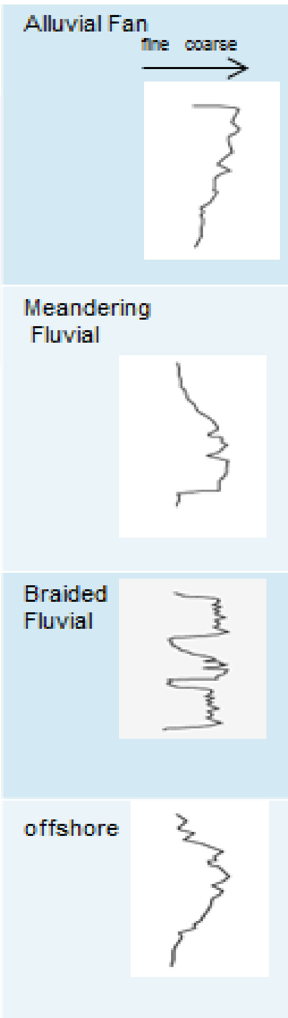

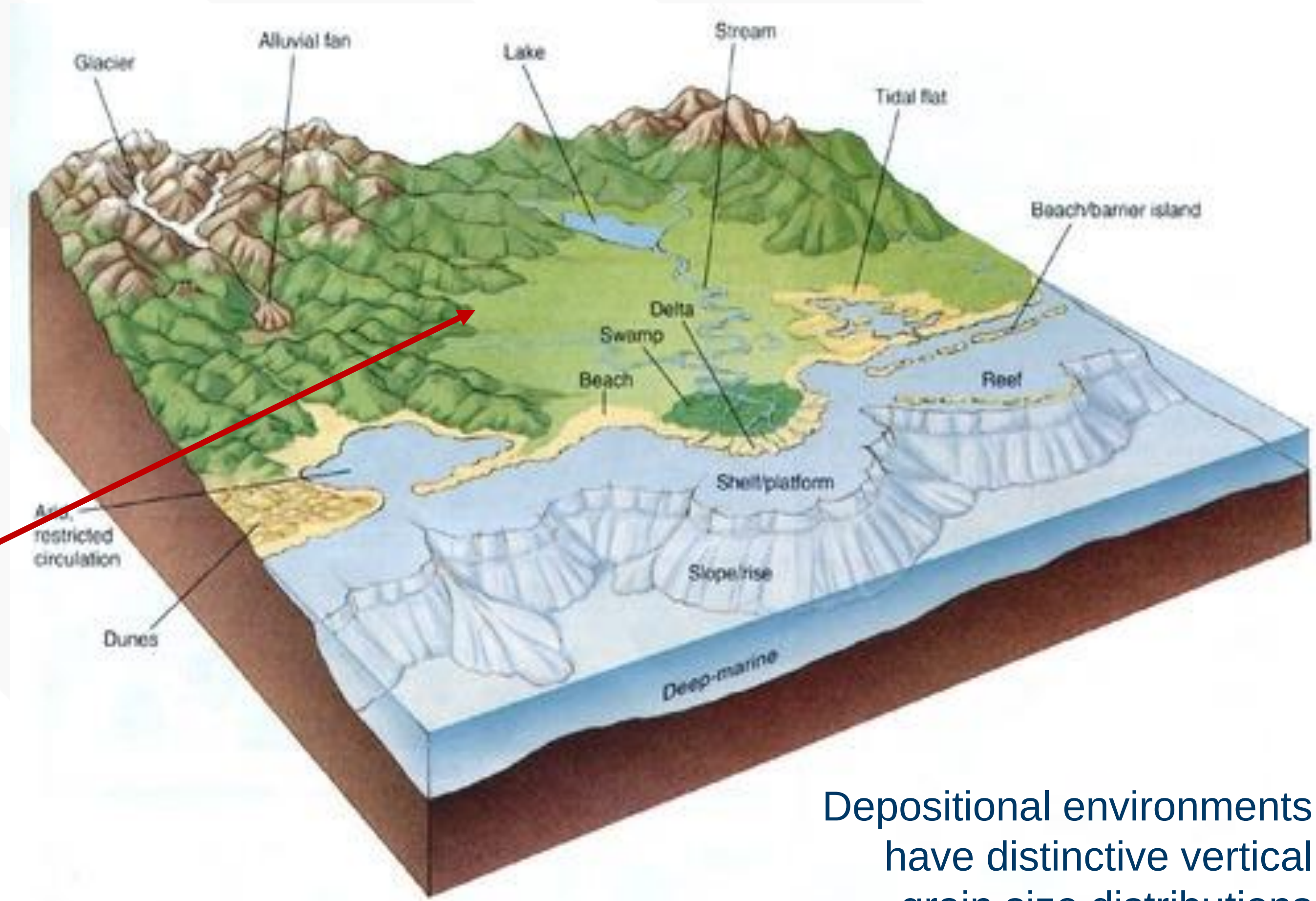

Depositional environments have distinctive vertical grain size distributions

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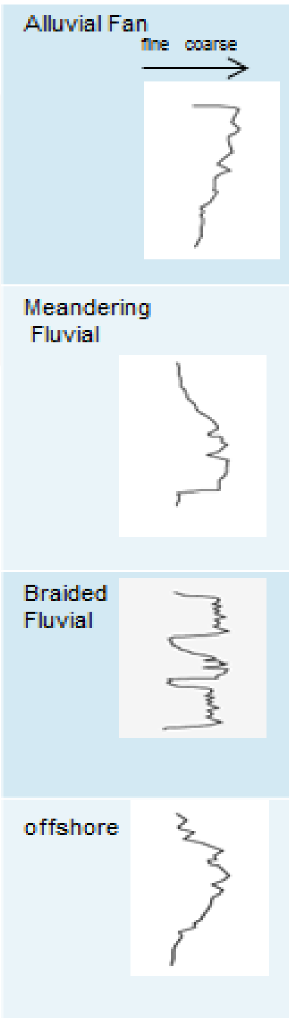
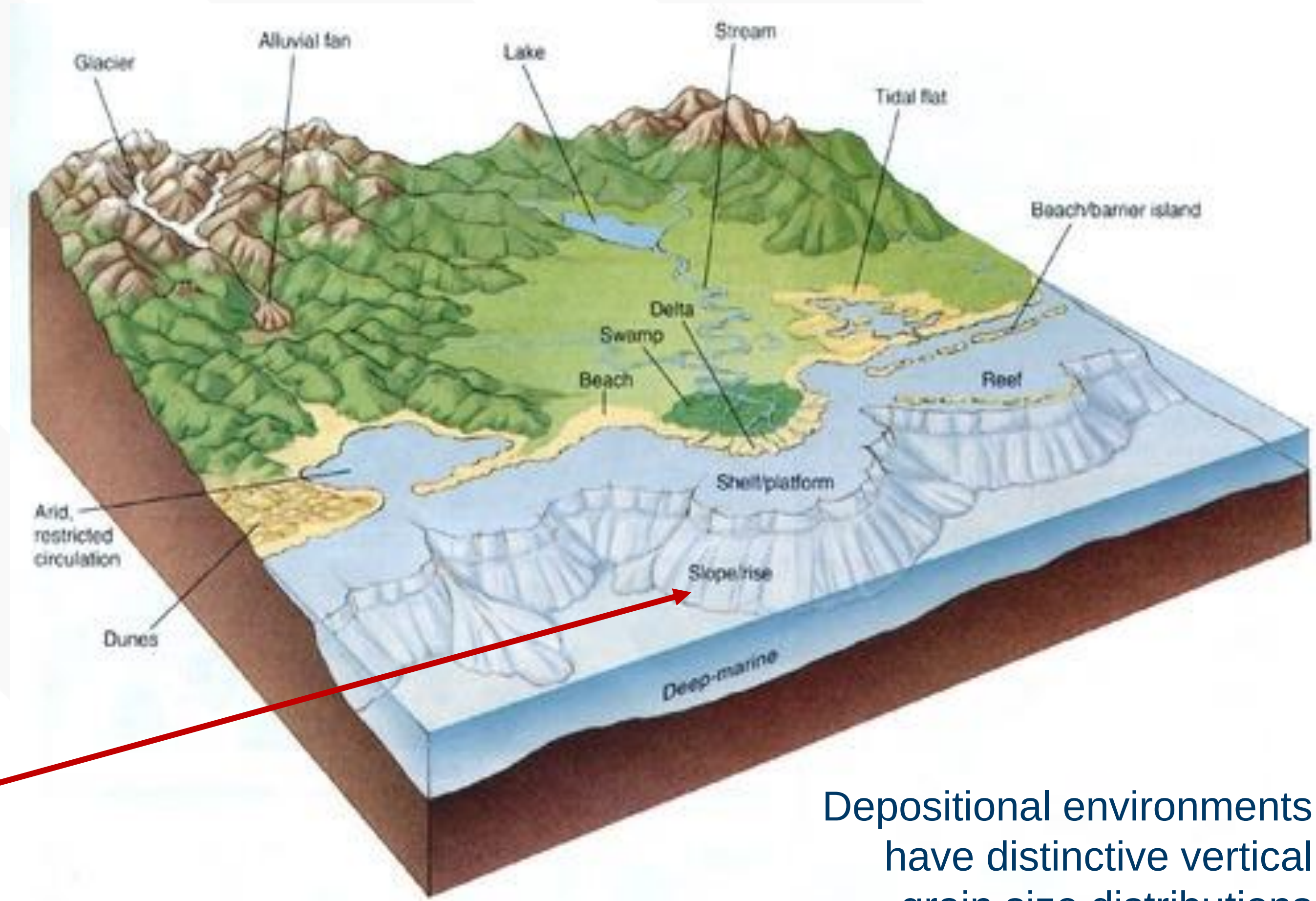


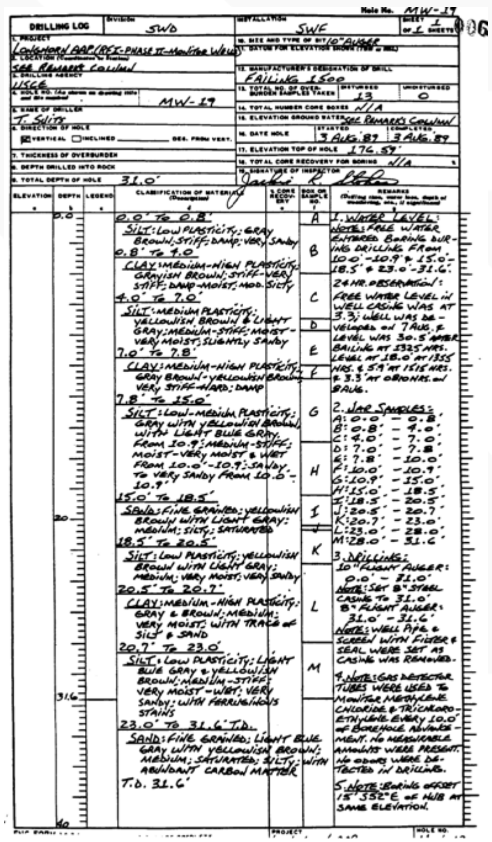


Depositional environments have distinctive vertical grain size distributions

ESS Is the Means to Optimize Existing Data

Lithology data is not being used to its full capacity

Boring Logs



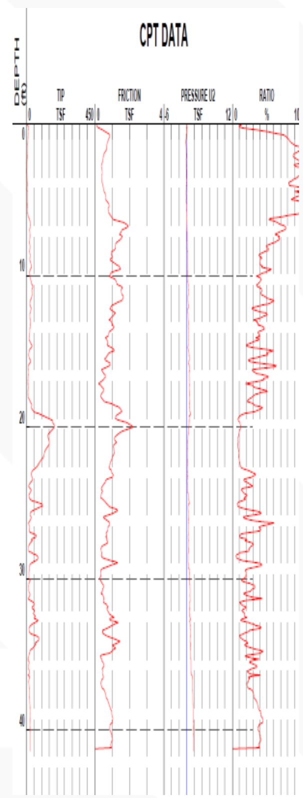
Hole No. MW-19

DRILLING LOG	DIVISION SWD	INSTALLATION SWF	SHEET 1 OF 1 SHEETS

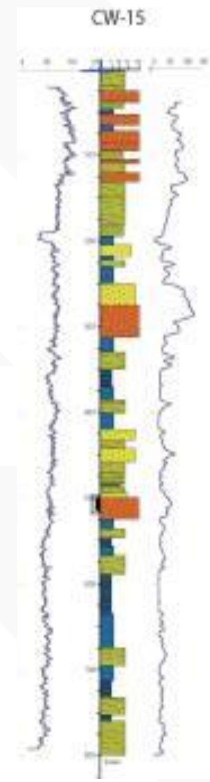
1. PROJECT: LONGHORN AAP (RFI-PHASE II-MONITOR WELLS)
2. LOCATION (Coordinates or Station): SEE REMARKS COLUMN
3. DRILLING AGENCY: USCE
4. HOLE NO. (As shown on drawing title and file number): MW-19
5. NAME OF DRILLER: T. SOLITS
6. DIRECTION OF HOLE: [x] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE: 31.0'
10. SIZE AND TYPE OF BIT: 10" AUGER
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL: FAILING 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 13, UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES: N/A
15. ELEVATION GROUND WATER: SEE REMARKS COLUMN
16. DATE HOLE: STARTED 3 AUG. '89, COMPLETED 3 AUG. '89
17. ELEVATION TOP OF HOLE: 176.59'
18. TOTAL CORE RECOVERY FOR BORING: N/A %
19. SIGNATURE OF INSPECTOR: Jackie R. [signature]

ELEVATION	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
	0.0		0.0' TO 0.8' SILT: LOW PLASTICITY; GRAY BROWN; STIFF; DAMP; VERY SANDY		A	1. WATER LEVEL: NOTE: FREE WATER ENTERED BORING DURING DRILLING FROM 10.0'-10.9' & 15.0'-18.5' & 23.0'-31.6'. 24 HR. OBSERVATION: FREE WATER LEVEL IN WELL CASING WAS AT 3.3; WELL WAS DEVELOPED ON 7 AUG. & LEVEL WAS 30.5' AFTER BAILING AT 1325 HRS. LEVEL AT 18.0' AT 1355 HRS. & 5.9' AT 1515 HRS. & 3.3' AT 0810 HRS. ON 8 AUG.
			0.8' TO 4.0' CLAY: MEDIUM-HIGH PLASTICITY; GRAYISH BROWN; STIFF-VERY STIFF; DAMP-MOIST; MOD. SILTY		B	
			4.0' TO 7.0' SILT: MEDIUM PLASTICITY; YELLOWISH BROWN & LIGHT GRAY; MEDIUM-STIFF; MOIST-VERY MOIST; SLIGHTLY SANDY		C	
			7.0' TO 7.8' CLAY: MEDIUM-HIGH PLASTICITY; GRAY BROWN-YELLOWISH BROWN; VERY STIFF-HARD; DAMP		D, E, F	
			7.8' TO 15.0' SILT: LOW-MEDIUM PLASTICITY; GRAY WITH YELLOWISH BROWN, WITH LIGHT BLUE GRAY FROM 10.9'; MEDIUM-STIFF; MOIST-VERY MOIST & WET FROM 10.0'-10.9'; SANDY, TO VERY SANDY FROM 10.0'-10.9'		G, H	2. JAR SAMPLES: A: 0.0 - 0.8', B: 0.8' - 4.0', C: 4.0' - 7.0', D: 7.0' - 7.8', E: 7.8' - 10.0', F: 10.0' - 10.9', G: 10.9' - 15.0', H: 15.0' - 18.5', I: 18.5' - 20.5', J: 20.5' - 20.7', K: 20.7' - 23.0', L: 23.0' - 28.0', M: 28.0' - 31.6'
	20		15.0' TO 18.5' SAND: FINE GRAINED; YELLOWISH BROWN WITH LIGHT GRAY; MEDIUM; SILTY; SATURATED		I, J	
			18.5' TO 20.5' SILT: LOW PLASTICITY; YELLOWISH BROWN WITH LIGHT GRAY; MEDIUM; VERY MOIST; VERY SANDY		K	3. DRILLING: 10" FLIGHT AUGER: 0.0' - 31.0' NOTE: SET 8" STEEL CASING TO 31.0'. 8" FLIGHT AUGER: 31.0' - 31.6' NOTE: WELL PIPE & SCREEN WITH FILTER & SEAL WERE SET AS CASING WAS REMOVED.
			20.5' TO 20.7' CLAY: MEDIUM-HIGH PLASTICITY; GRAY & BROWN; MEDIUM; VERY MOIST; WITH TRACE OF SILT & SAND		L	
	31.6		20.7' TO 23.0' SILT: LOW PLASTICITY; LIGHT BLUE GRAY & YELLOWISH BROWN; MEDIUM-STIFF; VERY MOIST-WET; VERY SANDY; WITH FERRUGINOUS STAINS		M	4. NOTE: GAS DETECTOR TUBES WERE USED TO MONITOR METHYLENE CHLORIDE & TRICHLOROETHYLENE EVERY 10.0' OF BOREHOLE ADVANCEMENT. NO MEASURABLE AMOUNTS WERE PRESENT. NO ODORS WERE DETECTED IN DRILLING.
	40		23.0' TO 31.6' T.D. SAND: FINE GRAINED; LIGHT BLUE GRAY WITH YELLOWISH BROWN; MEDIUM; SATURATED; SILTY; WITH ABUNDANT CARBON MATTER. T.D. 31.6'			5. NOTE: BORING OFFSET 15' S52°E OF HUB AT SAME ELEVATION.

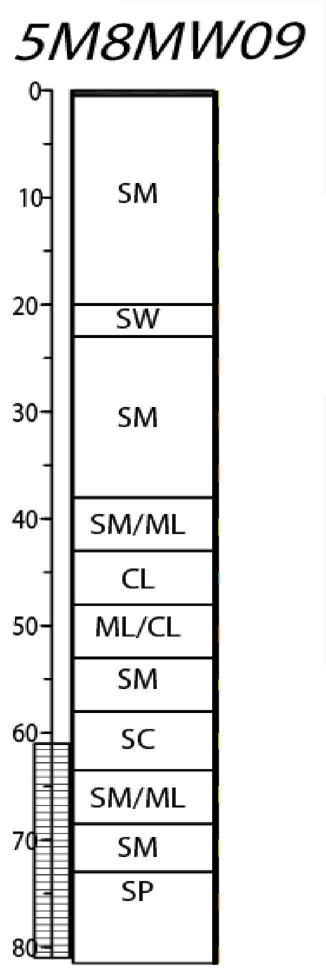
CPT Logs



Geophysical Logs



Getting More from Existing Site Data



- “All we have are these lousy USCS boring logs”
- USCS is not a geologic description of the lithology
- Different geologists
- Different drilling methods
- Different sampling intervals
- Etc.

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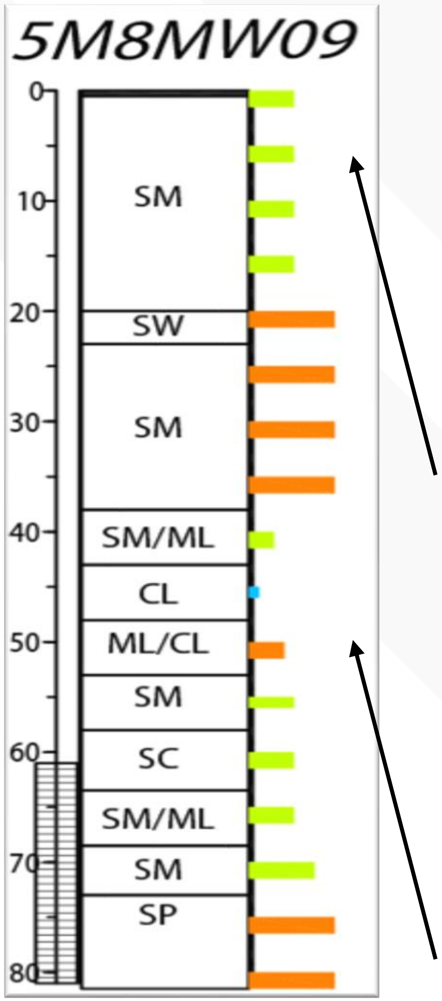
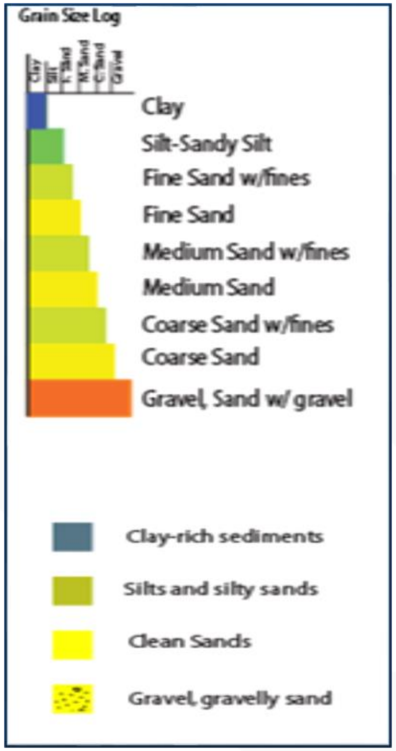
How to Find Buried Channels with Existing Data





Graphic Grain-Size Logs (GSLs)

- Existing data is formatted for stratigraphic interpretation
- Reveals the “hidden” stratigraphic information available with existing lithology data

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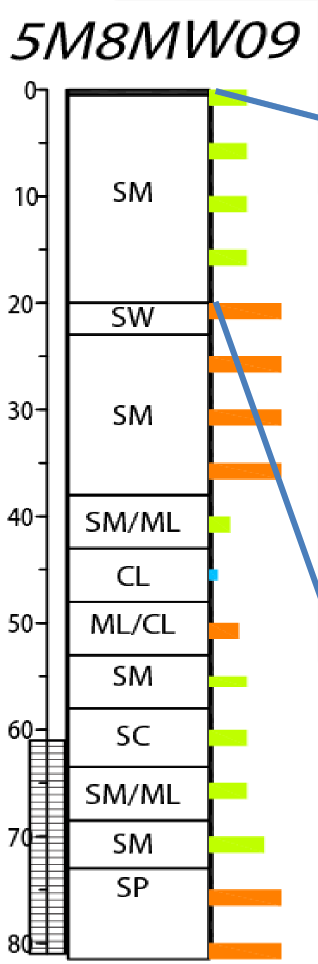
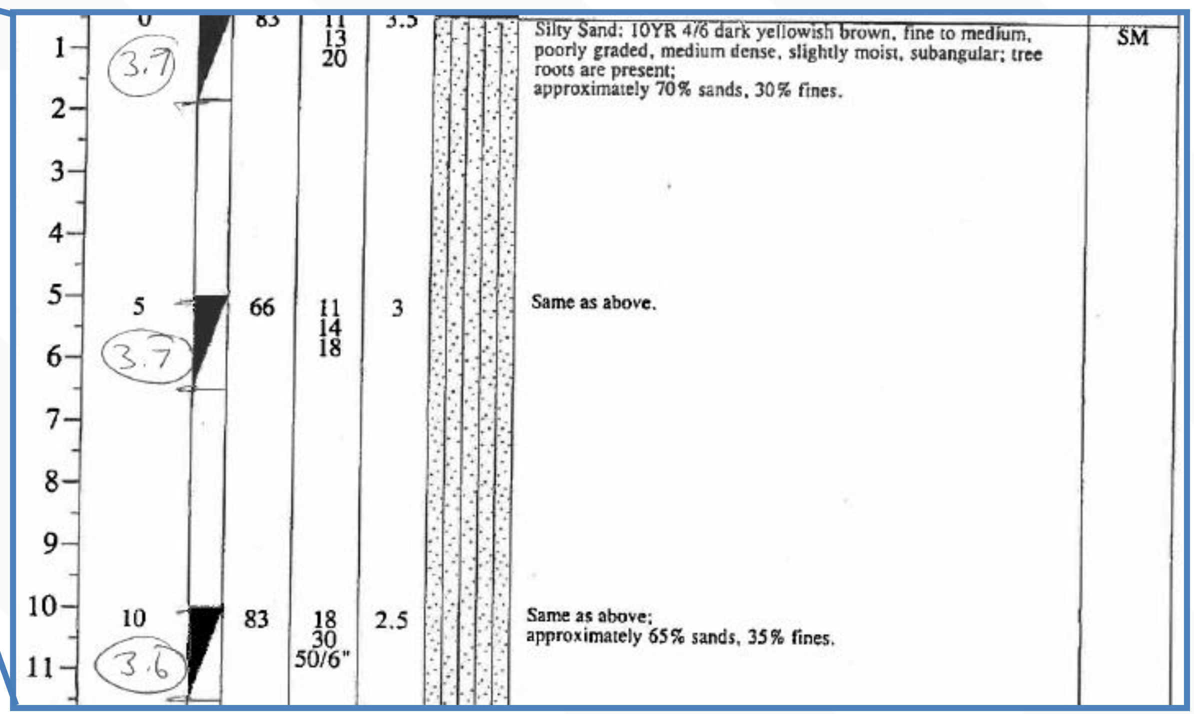
How to Find Buried Channels with Existing Data



This SM interval is a fine to medium-grained silty sand



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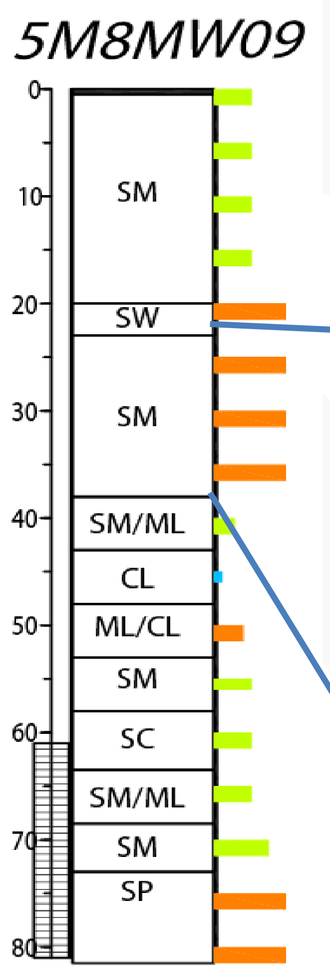
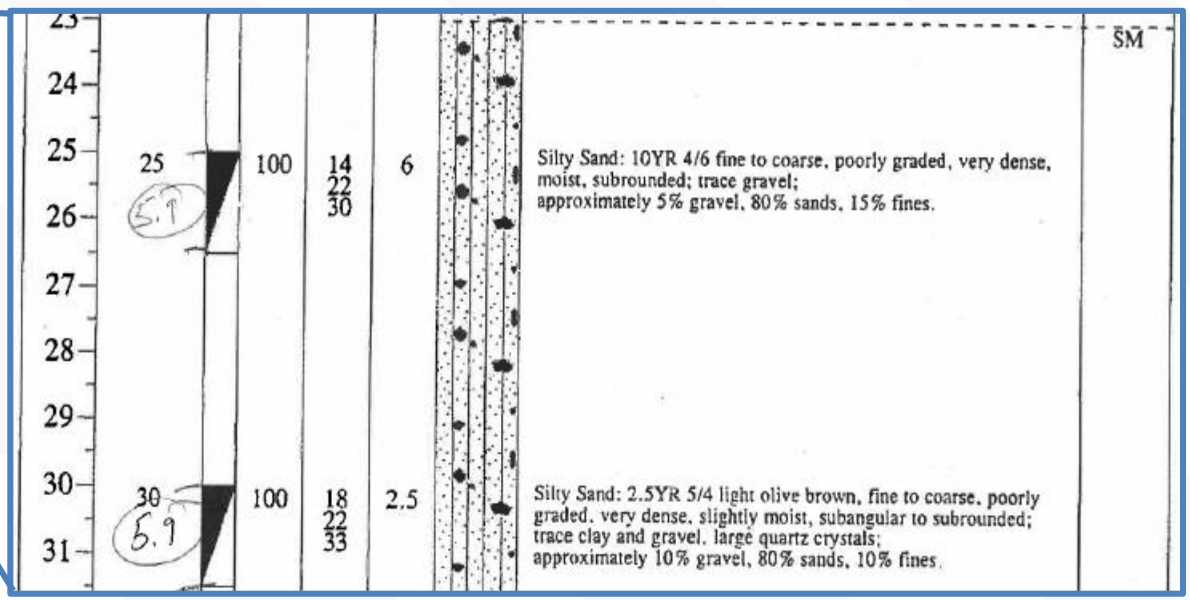
How to Find Buried Channels with Existing Data



This SM interval is a fine- to coarse-grained silty sand with gravel, representative of a channel deposit.



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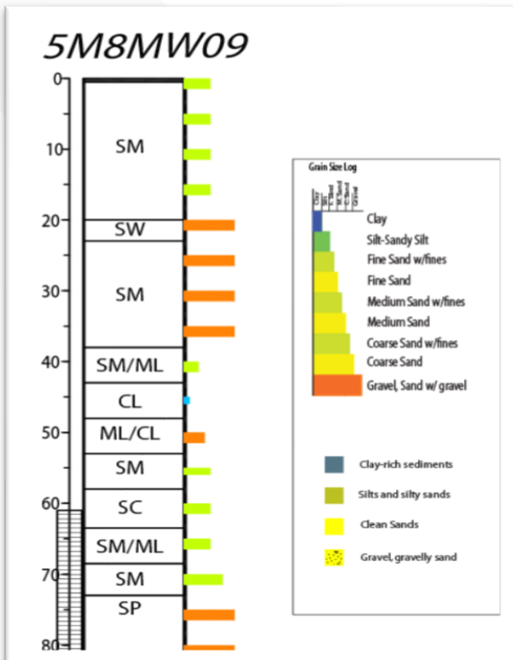
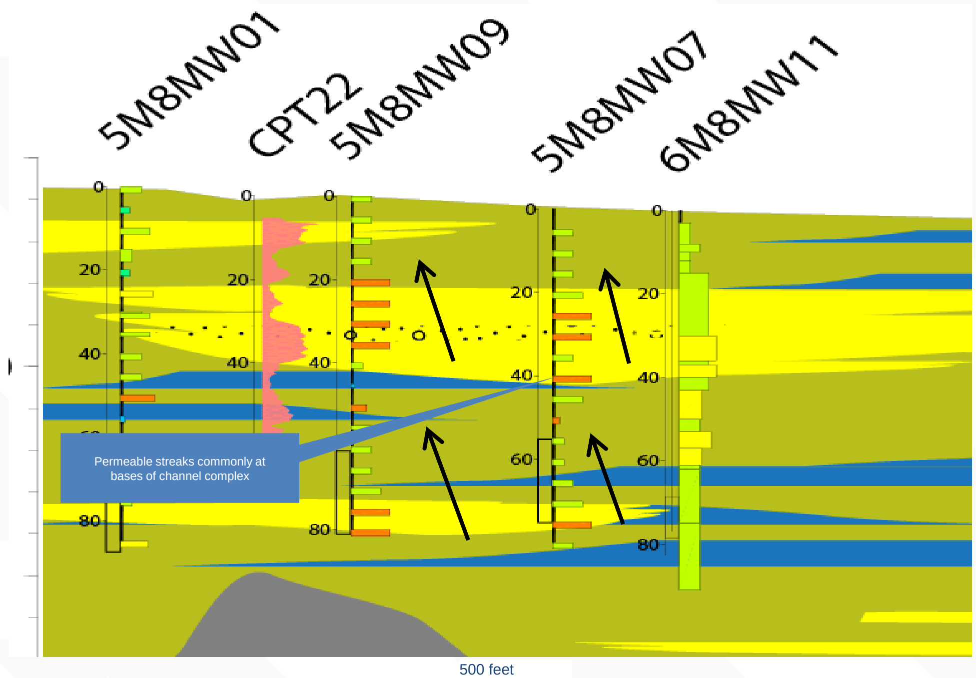
How to Find Buried Channels with Existing Data

1. Reformat existing data to identify sequences, and
2. Apply facies models, stratigraphic "rules of thumb" to correlate and map the subsurface, predict character of heterogeneity present





Example from GW site in S. CA, USA

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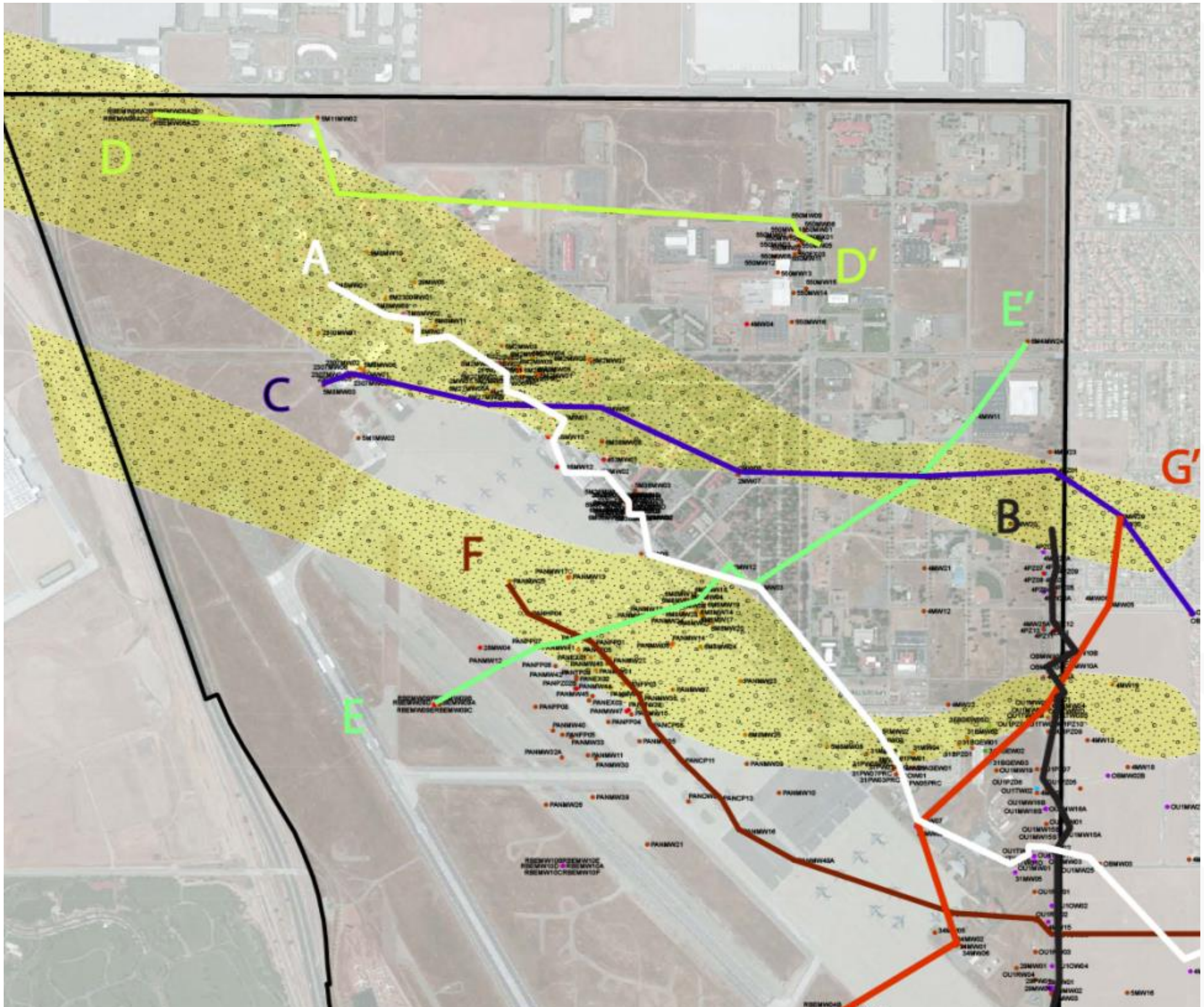
Mapped Buried Sand Channels



Yellow = channel deposits (sand/gravel)

Gray = flood plain deposits (silt/clay)

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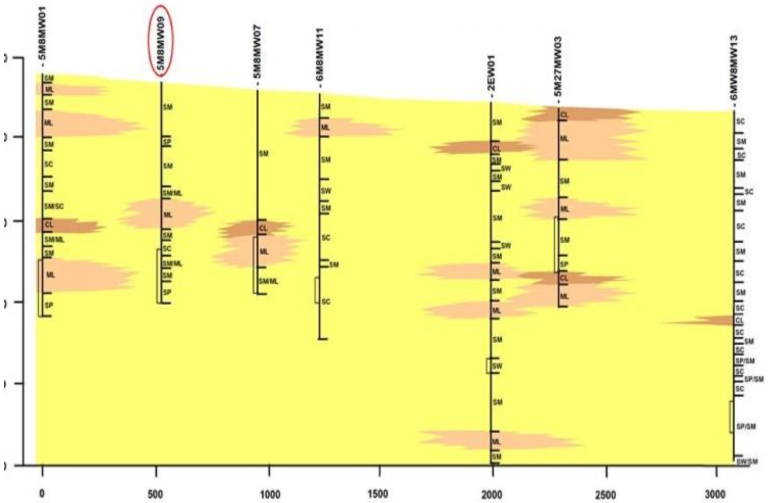
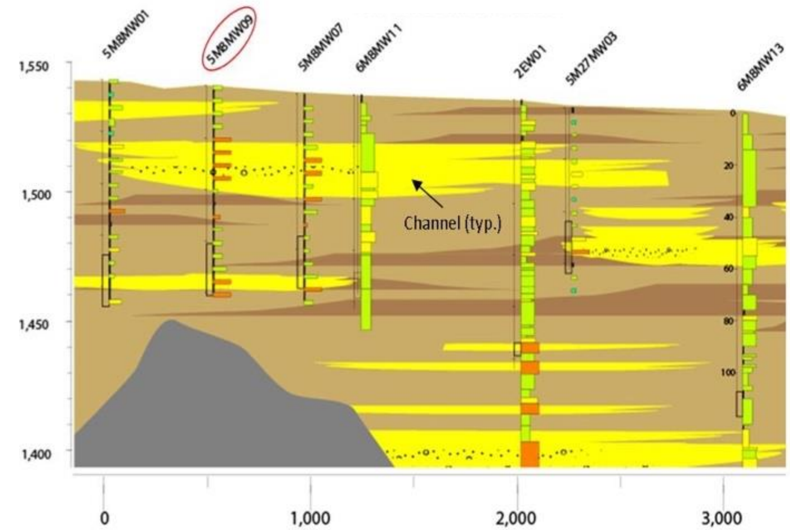
Mapped Buried Sand Channels

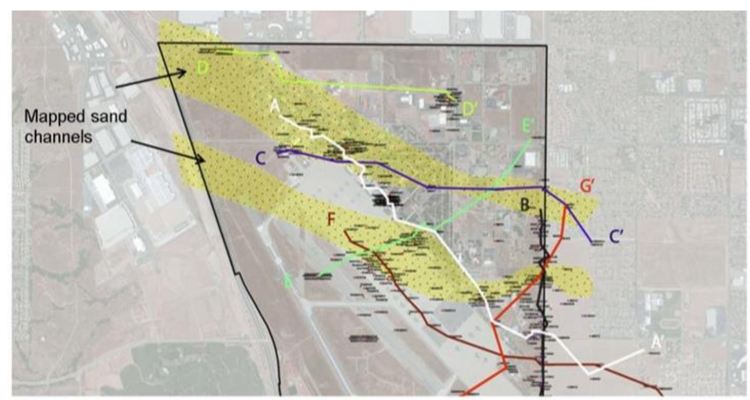
USCS-Based Cross Section



VS

ESS-Based Cross Section





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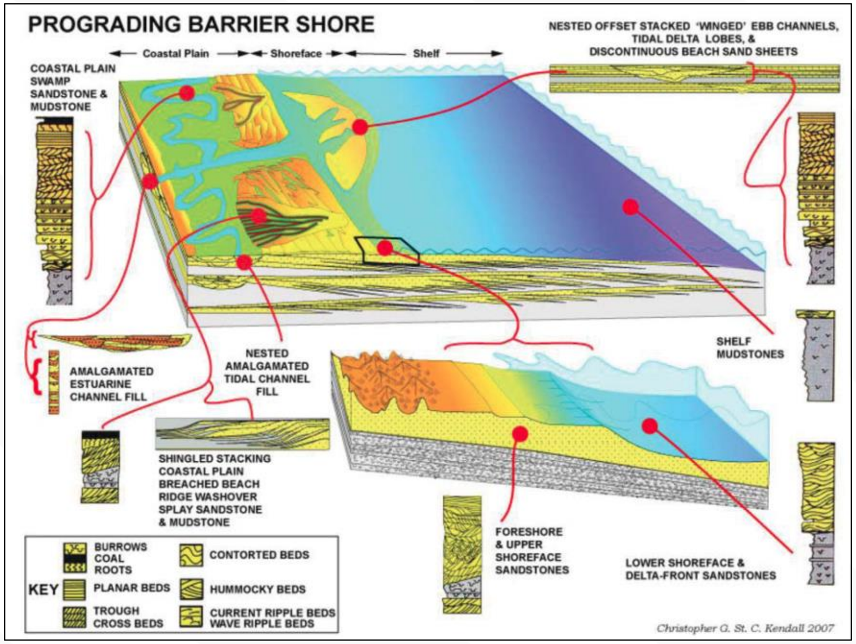
Stratigraphic “Rules of Thumb”

DEFINITIONS

Sequence Stratigraphy: The study of sedimentary deposits in the context of their depositional environments and changes in relative sea-level, sediment supply, and available sediment storage areas.

Facies Model: Conceptual construct describing the processes acting in a particular depositional environment to transport, deposit, and preserve sediment, usually presented as a three-dimensional block diagram illustrating the organization of sedimentary bodies in the stratigraphic record.



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Stratigraphically Defensible Interpretation: "Rules of Thumb"

- Interpretation must consider depositional environment, facies model
- Patterns, not "tops"
- Consider erosional events
- Correlate clays
- Look for paleosols
- Channels have erosive bases, flat tops
- Increasing heterogeneity with clay content in fluvial systems
- Vertical heterogeneity is an indicator of lateral heterogeneity (fluvial systems)
- Look for Maximum Flooding Surfaces (coastal settings)
- Avoid the "mounded clay"
- Avoid "Pillars"

“Pillar Facies”

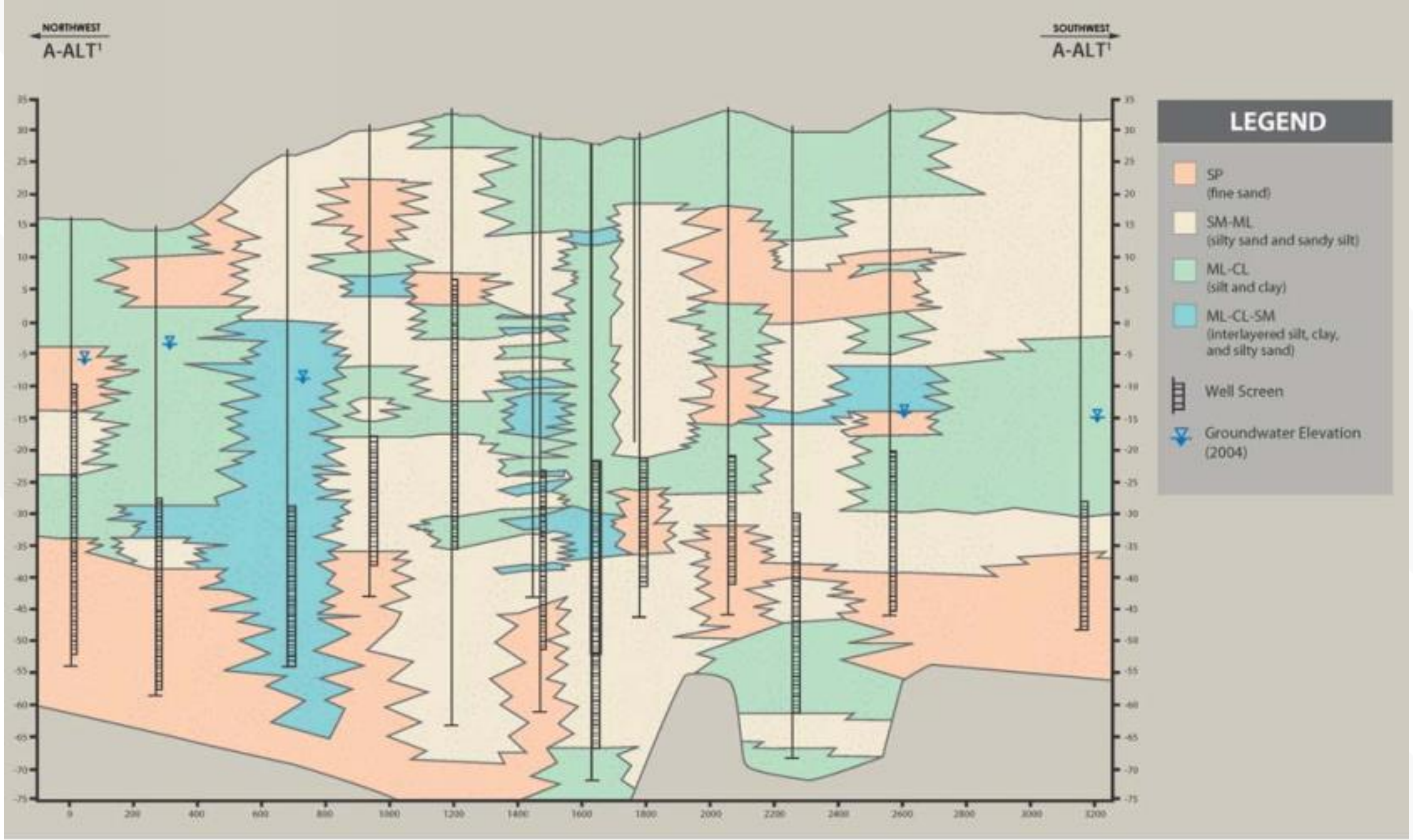
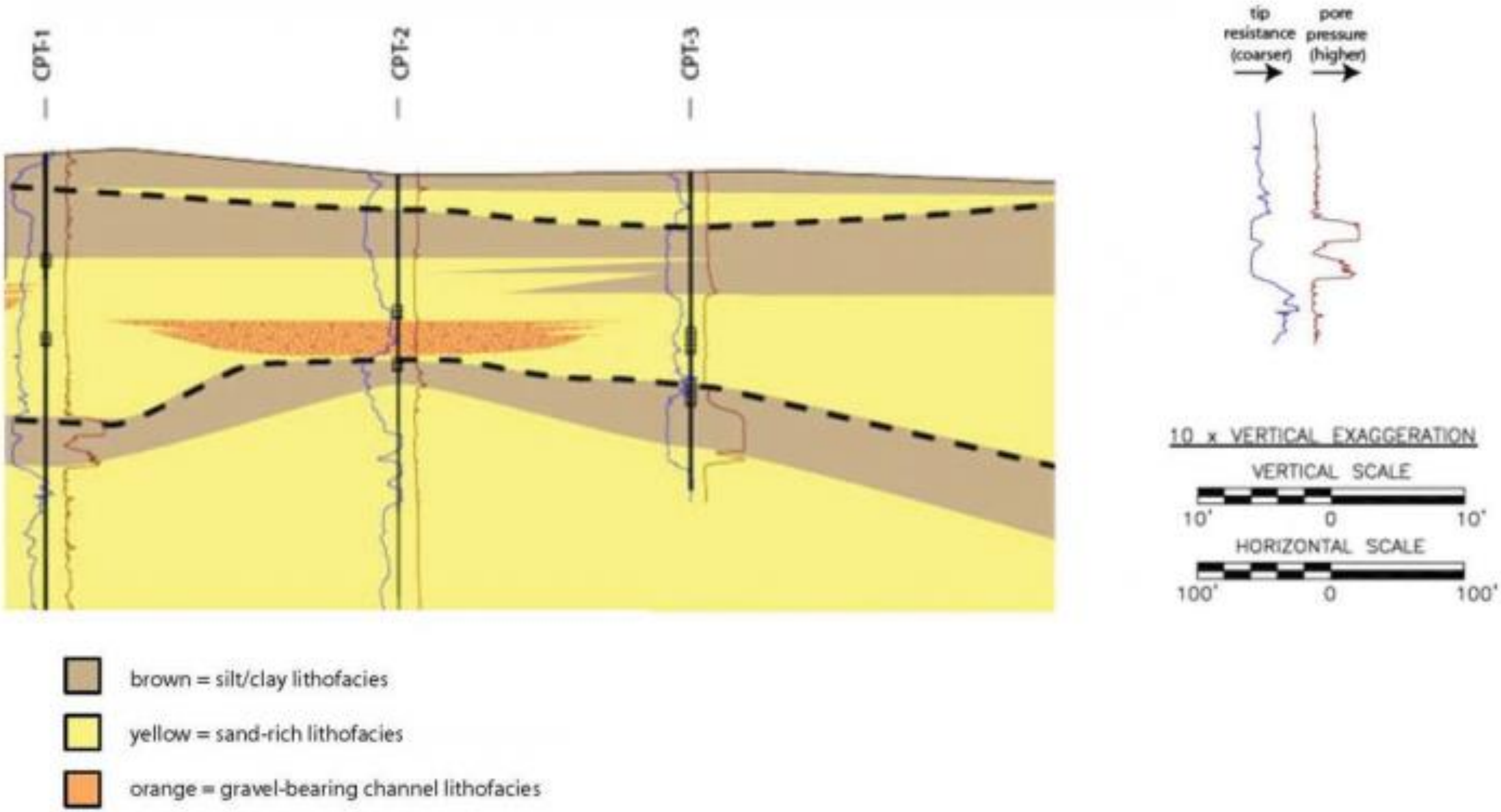
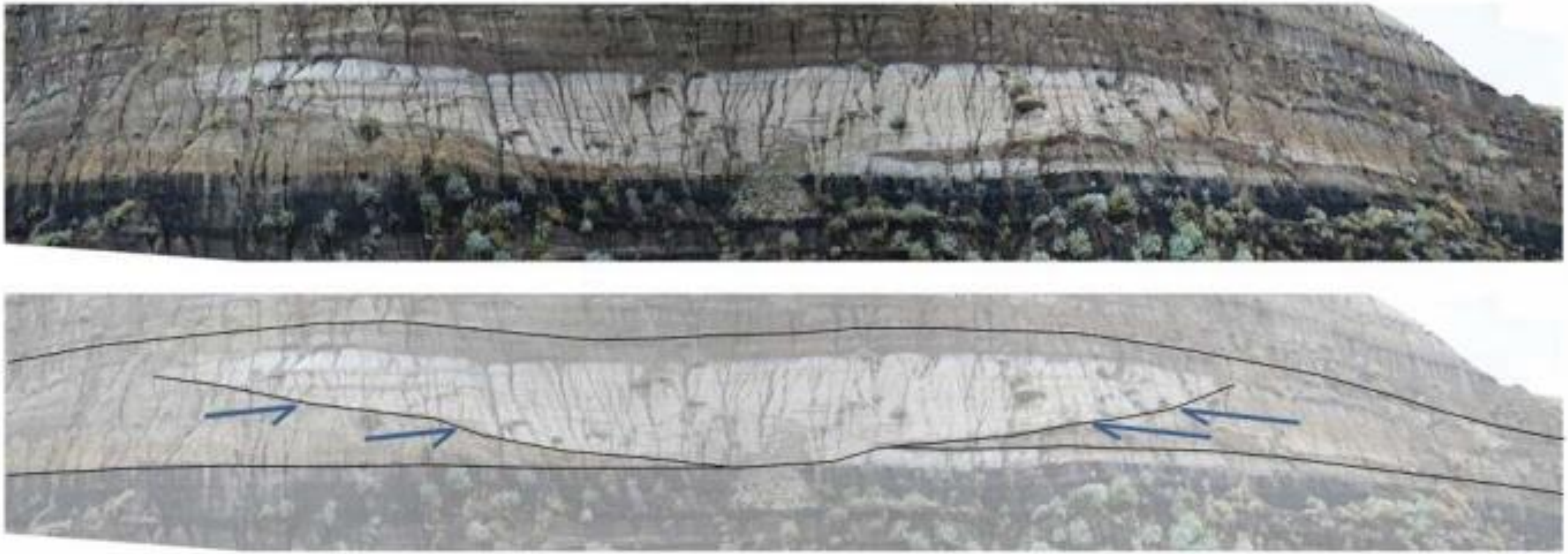


Figure 10. Cross section showing a common mistake in correlating subsurface data. Interpreted vertical facies patterns (“pillars”) corresponding to individual borehole locations with interfingering facies changes laterally. This cross section reflects biases in USCS classification between different geologists or vintages of data collection, is not geologically defensible, and is of extremely limited utility in understanding subsurface conditions.

The "mounded clay"



The "mounded clay"



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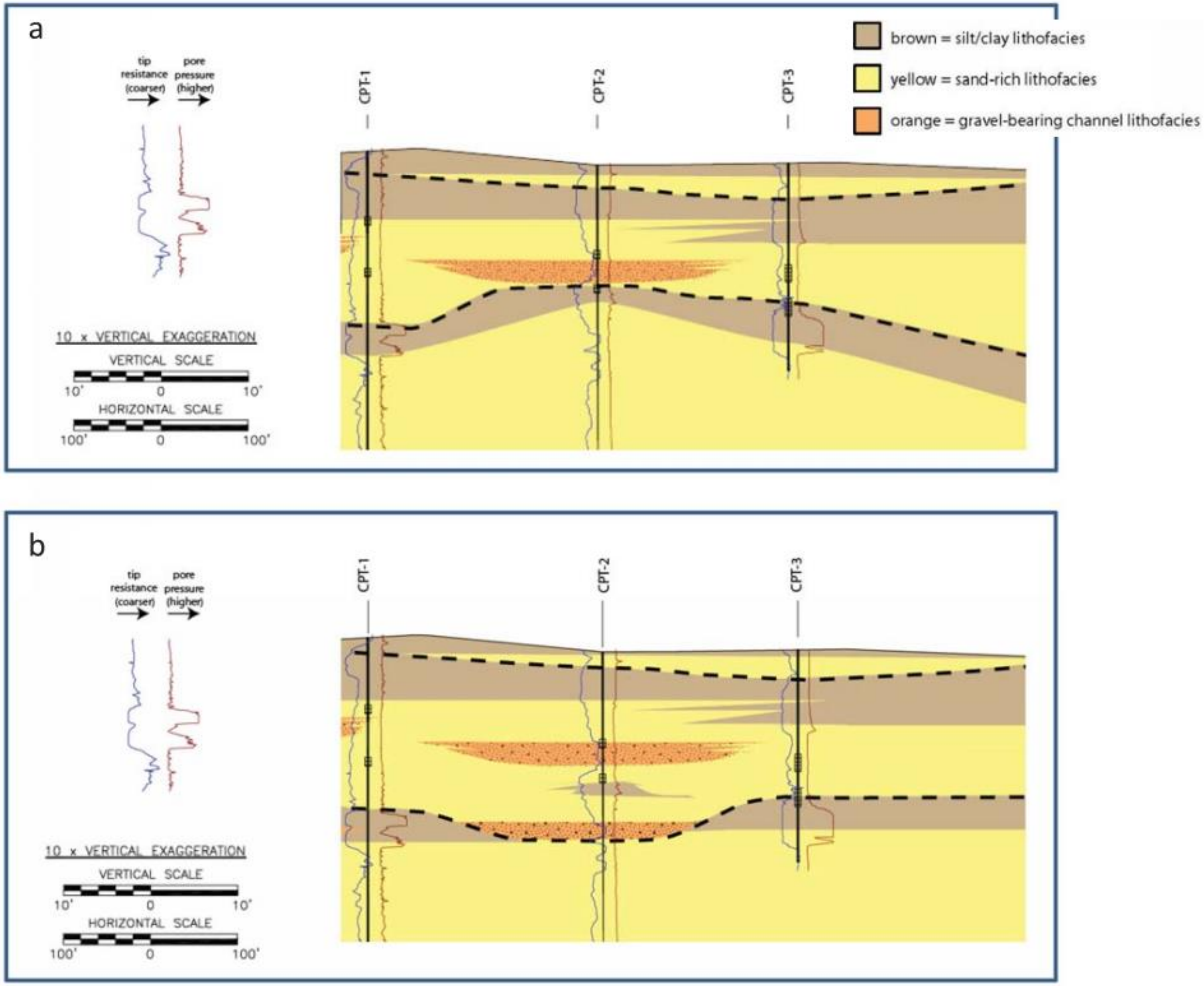
The "mounded clay"



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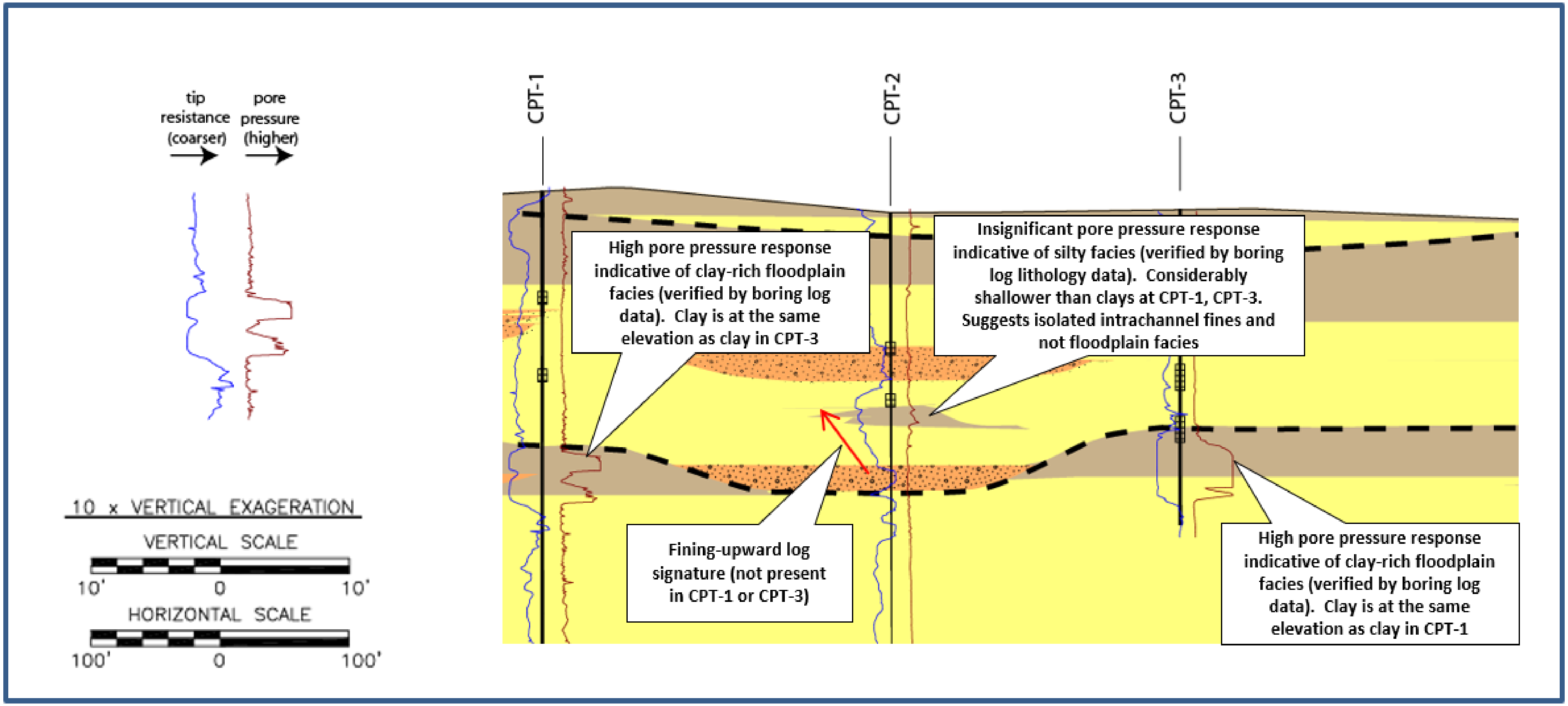
Updated CSM



tip resistance (coarser)
pore pressure (higher)
10 x VERTICAL EXAGERATION
VERTICAL SCALE
10'
0
10'
HORIZONTAL SCALE
100'
0
100'
CPT-1
CPT-2
CPT-3
High pore pressure response indicative of clay-rich floodplain facies (verified by boring log data). Clay is at the same elevation as clay in CPT-3
Insignificant pore pressure response indicative of silty facies (verified by boring log lithology data). Considerably shallower than clays at CPT-1, CPT-3. Suggests isolated intrachannel fines and not floodplain facies
Fining-upward log signature (not present in CPT-1 or CPT-3)
High pore pressure response indicative of clay-rich floodplain facies (verified by boring log data). Clay is at the same elevation as clay in CPT-1

Q&A Break

Case Studies

Case Study
Silicon Valley Commingled Plumes

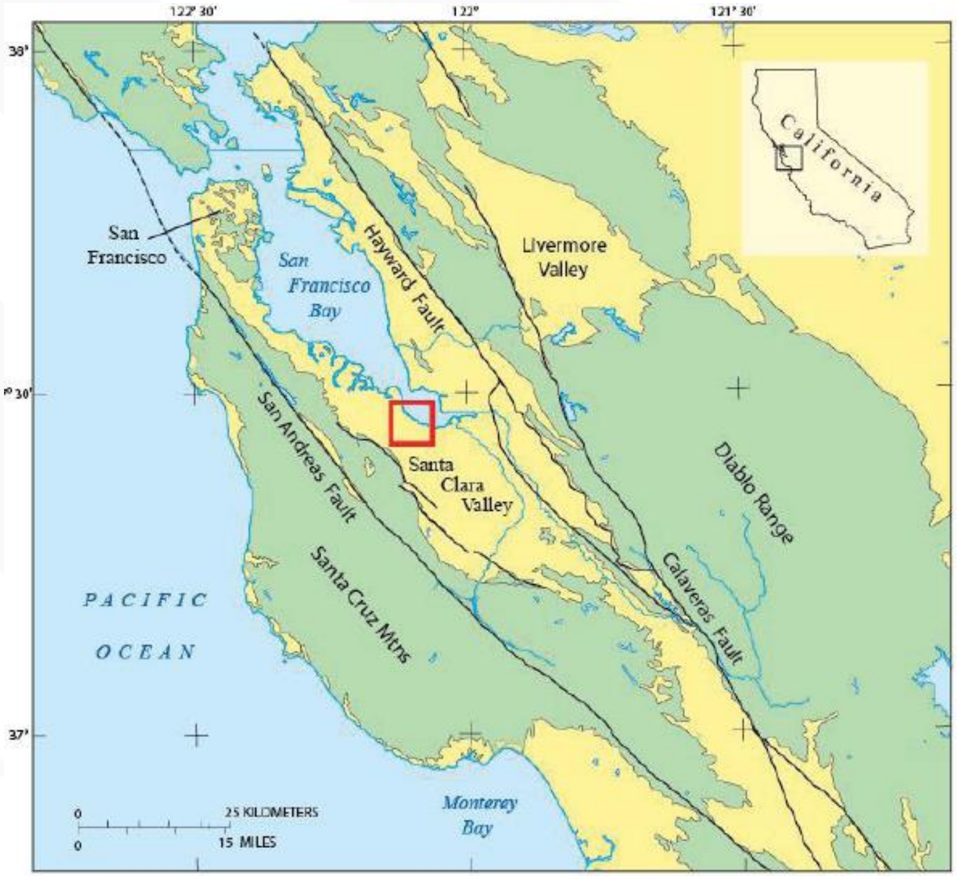
Former Semiconductor Manufacturing Site: VOC groundwater plume commingled with neighboring plumes

Scale: Less than 10 acres, approximately 100 feet depth of investigation

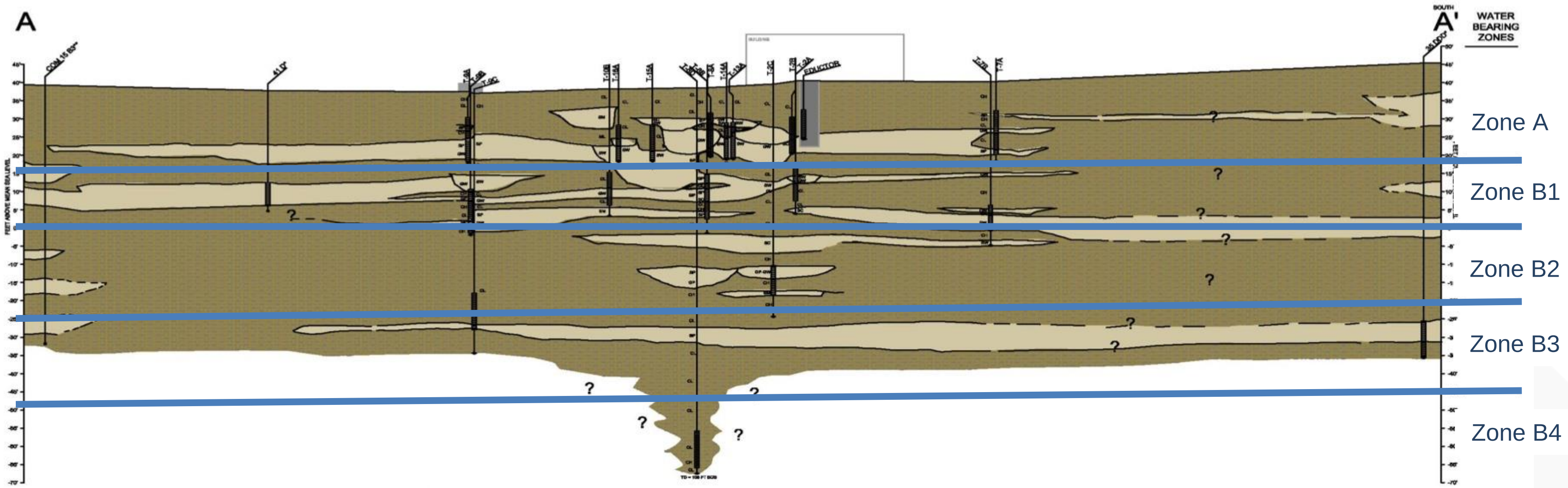
Geology: Meandering / anastamosing stream (buried sand channels)

Lithology Data: Borehole logs

Approach: In response to five-year review, use ESS to define contaminant migration pathways from off-site sources



Silicon Valley Site: Original CSM



* GEOLOGIC WELL SCREEN INFORMATION INFERRED FROM CROSS SECTION B-B' IN THE HYDRAULIC CONTAINMENT AT 825 STEWART DRIVE (WEISS ASSOCIATES, 1988).

** GEOLOGIC INFORMATION BASED ON INFORMATION AVAILABLE ON GEOTRACKER WEBSITE.

LEGEND

FINE-GRAINED SOILS	
COARSE-GRAINED SOILS	
CL/CH	CLAYS
ML	SILTS
SM	SILTY SANDS
SC	CLAYEY SANDS
SP/SW	SANDS
GP/GW	GRAVELS
NR	NO RETURN

GROUND SURFACE
BORING / WELL CASING
GROUNDWATER WELL SCREEN INTERVAL
TERMINATION OF BORING

Scale in Feet
HORZ : VERT
0 10 20 / 50 100

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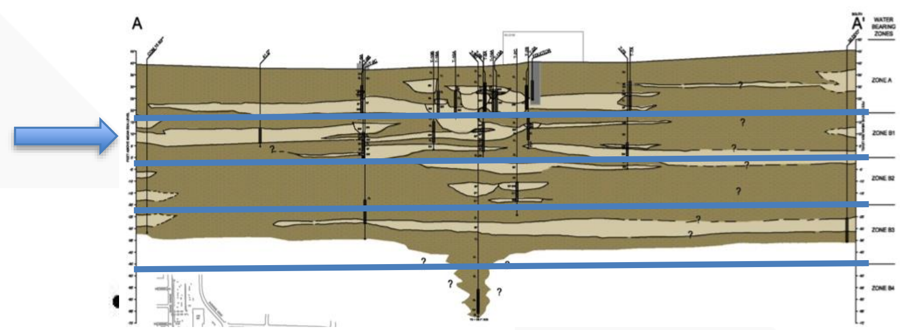
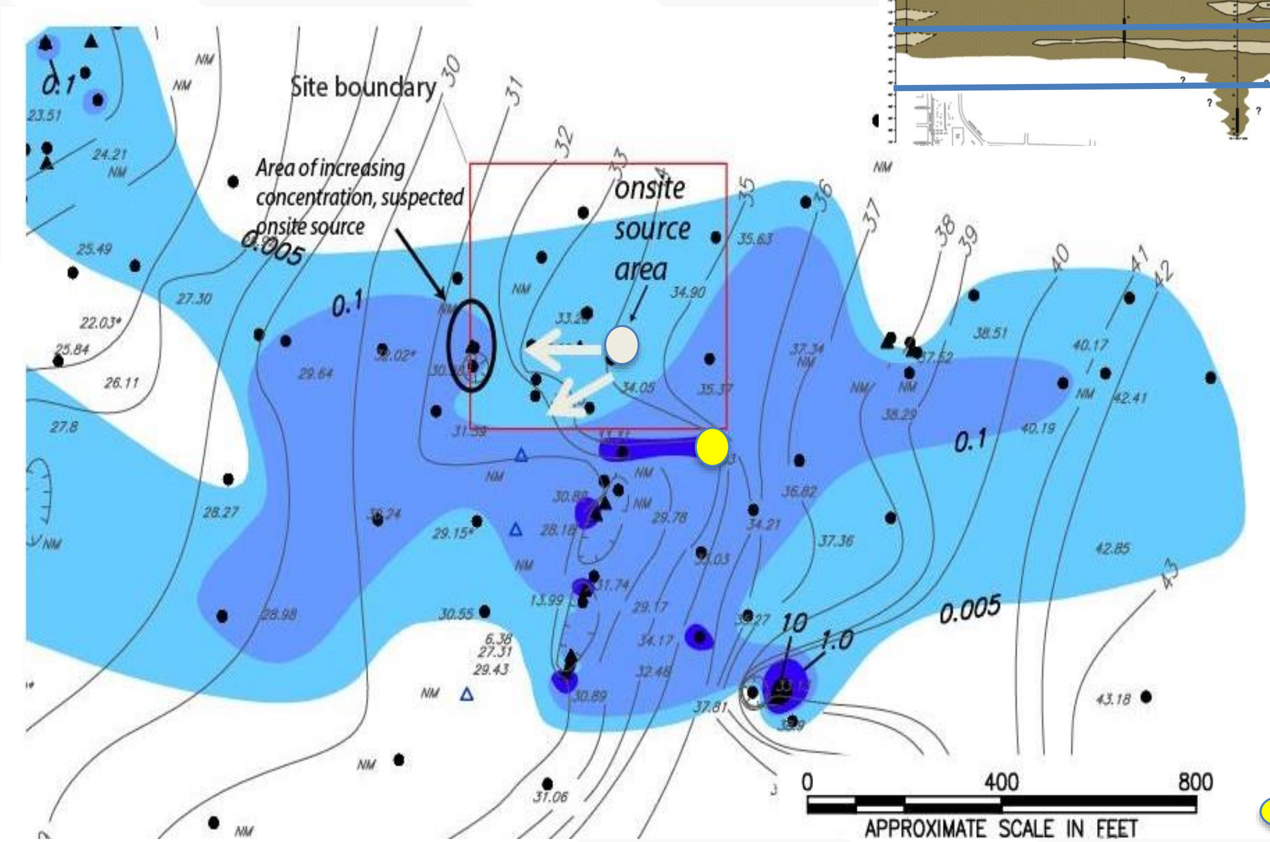
Original CSM – B1 Zone





= Off site source area

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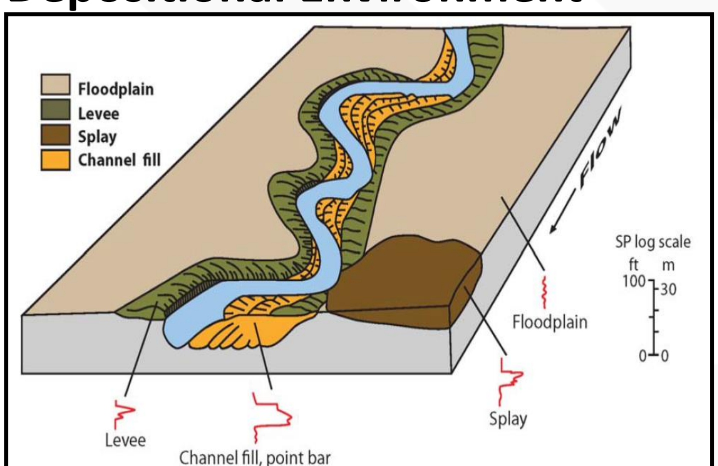
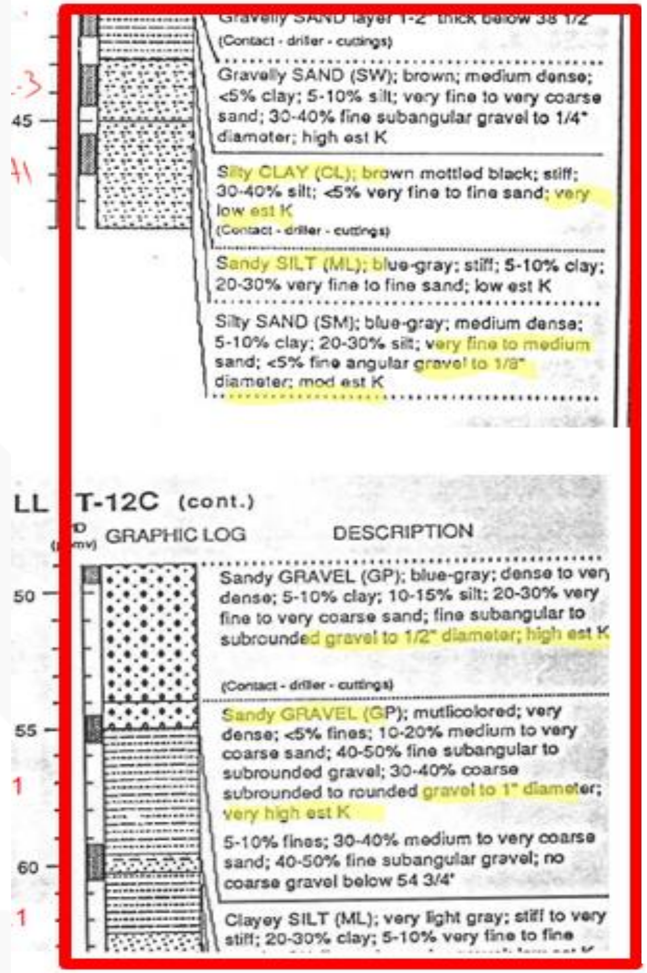
Grain Size Trends and Graphic Grain Size Logs

- Normalize different vintages of data collection, etc.
- Identify trends in maximum grain size (indicator of energy level in depositional processes)
- Example of fining upward channel deposit
- Channels migrate laterally over time (point bar deposits)
- Channel "signature" provides basis for mapping

Depositional Environment



Boring Log



(Contact - driller - cuttings)

Gravelly SAND (SW); brown; medium dense; <5% clay; 5-10% silt; very fine to very coarse sand; 30-40% fine subangular gravel to 1/4" diameter; high est K

Silty CLAY (CL); brown mottled black; stiff; 30-40% silt; <5% very fine to fine sand; very low est K

(Contact - driller - cuttings)

Sandy SILT (ML); blue-gray; stiff; 5-10% clay; 20-30% very fine to fine sand; low est K

Silty SAND (SM); blue-gray; medium dense; 5-10% clay; 20-30% silt; very fine to medium sand; <5% fine angular gravel to 1/8" diameter; mod est K

T-12C (cont.)

GRAPHIC LOG | DESCRIPTION

Sandy GRAVEL (GP); blue-gray; dense to very dense; 5-10% clay; 10-15% silt: 20-30% very fine to very coarse sand; fine subangular to subrounded gravel to 1/2" diameter; high est K

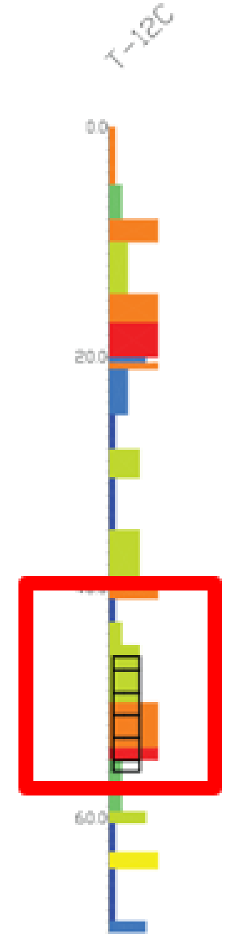
(Contact - driller - cuttings)

Sandy GRAVEL (GP); mutlicolored; very dense; <5% fines; 10-20% medium to very coarse sand; 40-50% fine subangular to subrounded gravel; 30-40% coarse subrounded to rounded gravel to 1" diameter; very high est K

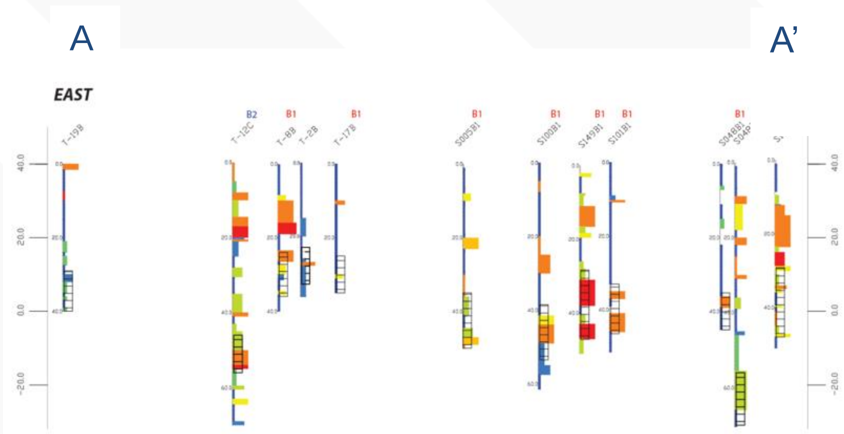
5-10% fines; 30-40% medium to very coarse sand; 40-50% fine subangular gravel; no coarse gravel below 54 3/4"

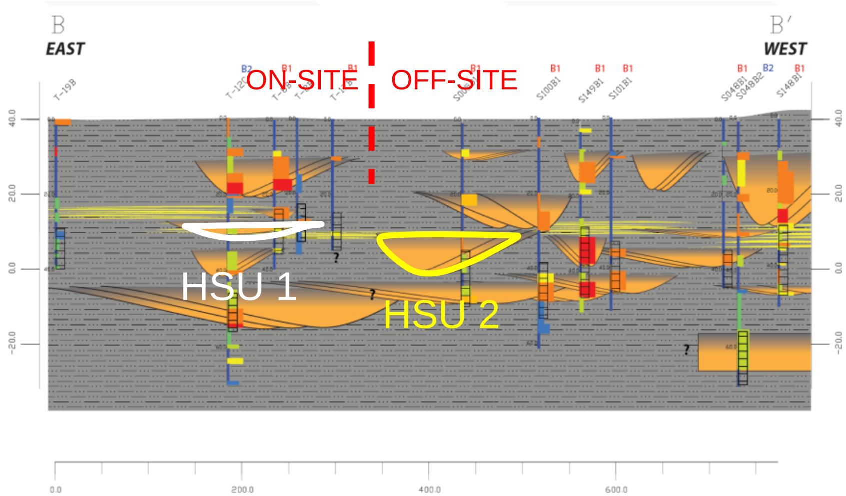
Clayey SILT (ML); very light gray; stiff to very stiff; 20-30% clay; 5-10% very fine to fine

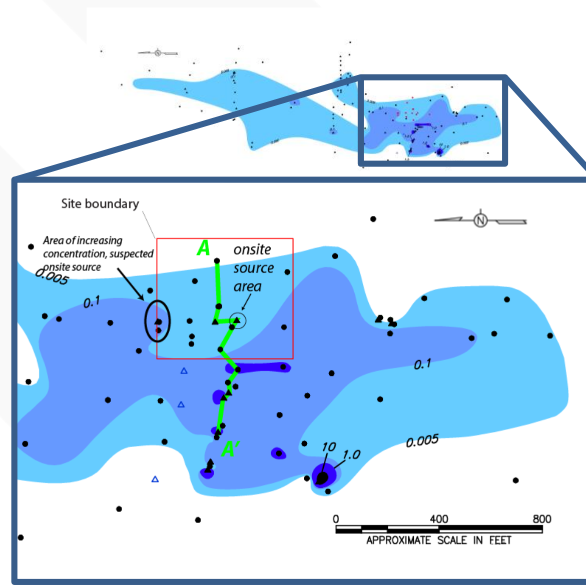
GSL

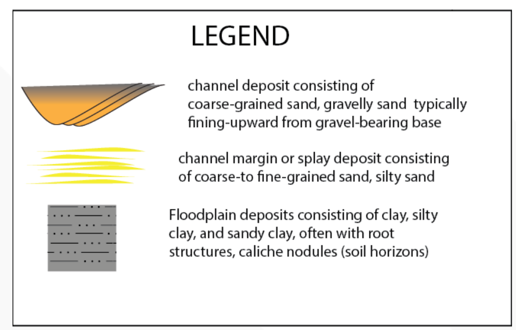


Posting GSLs and Channel Interpretation

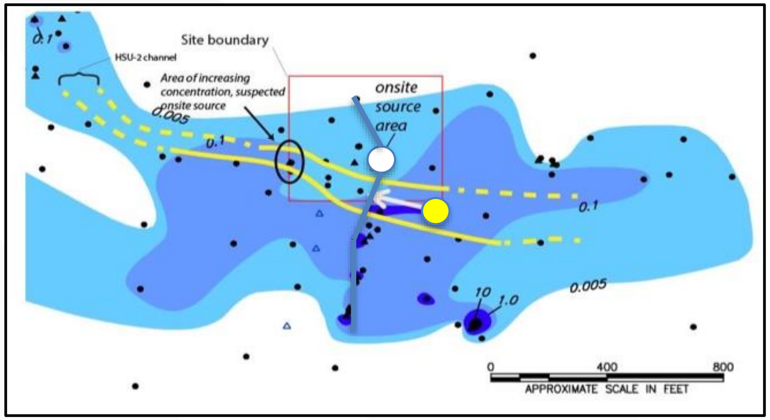


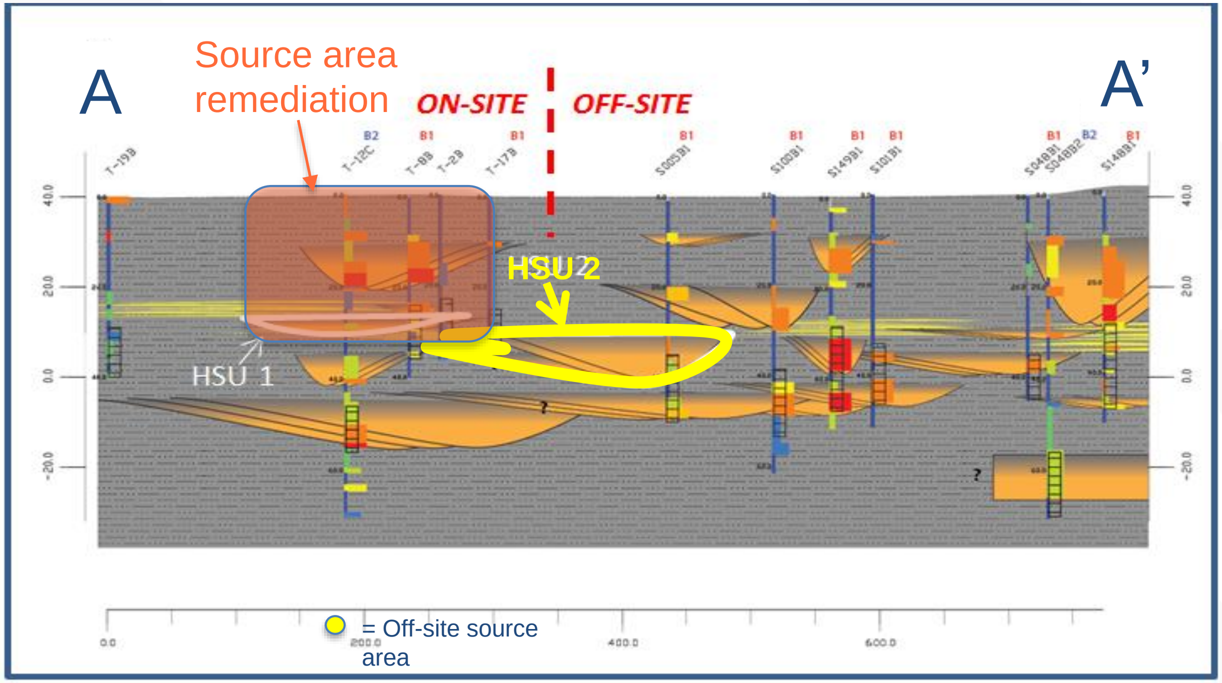






Best Practice, ESS-Based CSM: Defines Buried Channels





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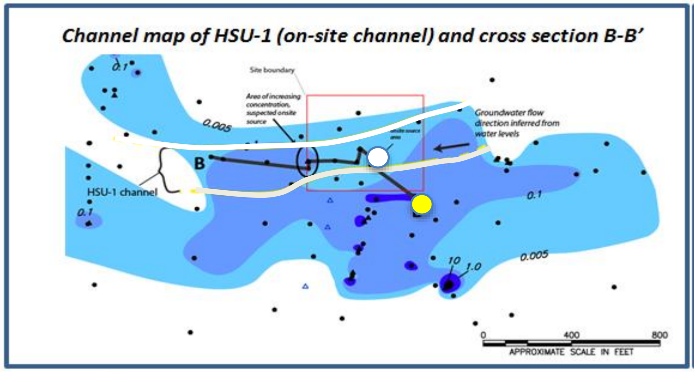
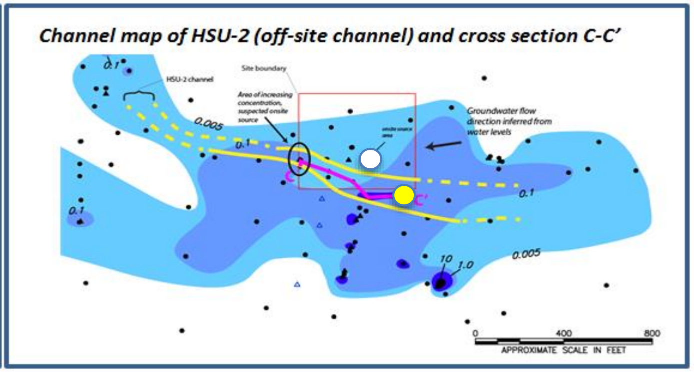
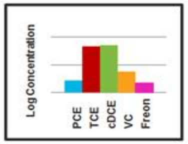
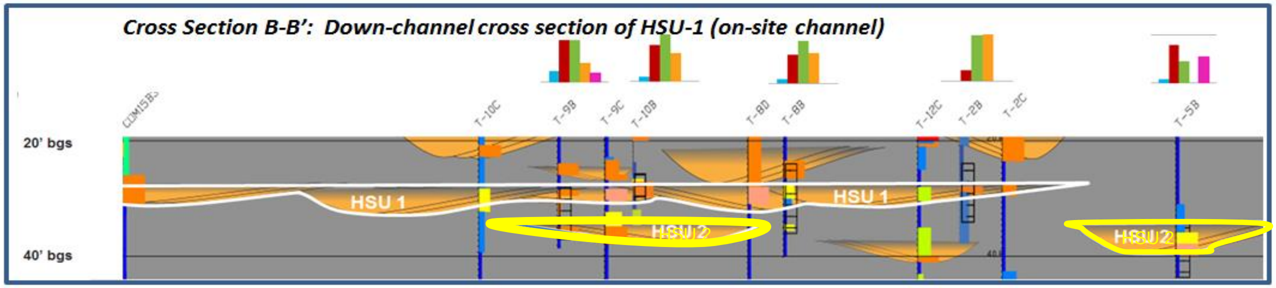
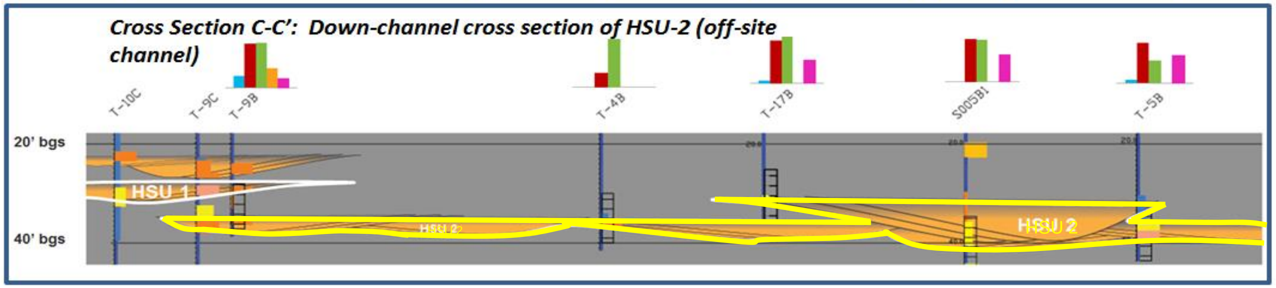
Resolve the Mystery of Commingled Plumes











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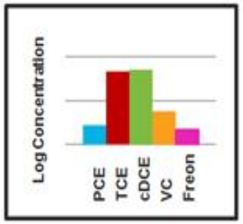
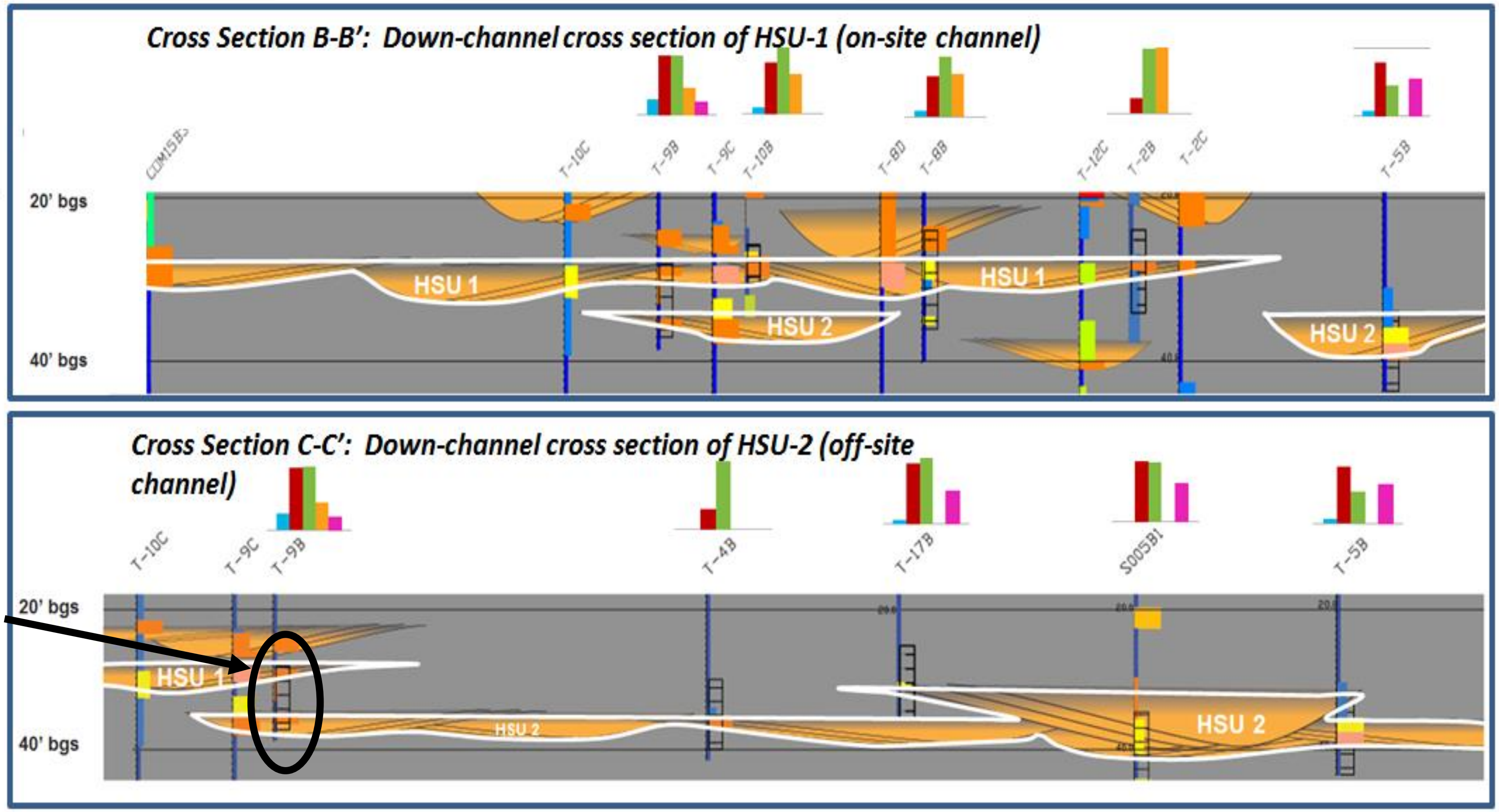
Resolve the Mystery of Commingled Plumes

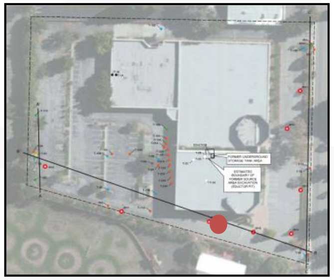


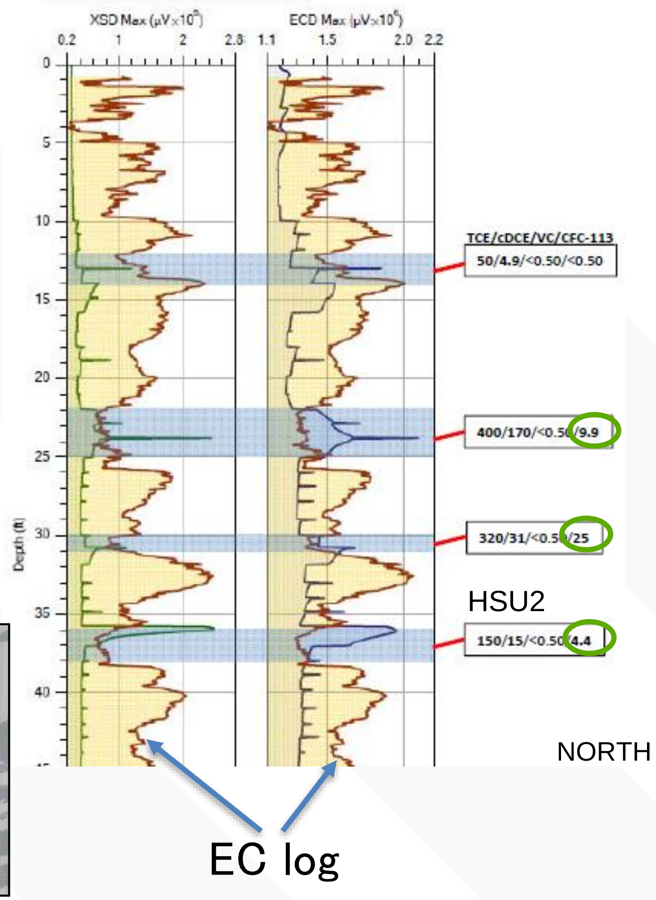


Increasing concentrations

Focused HRSC Program

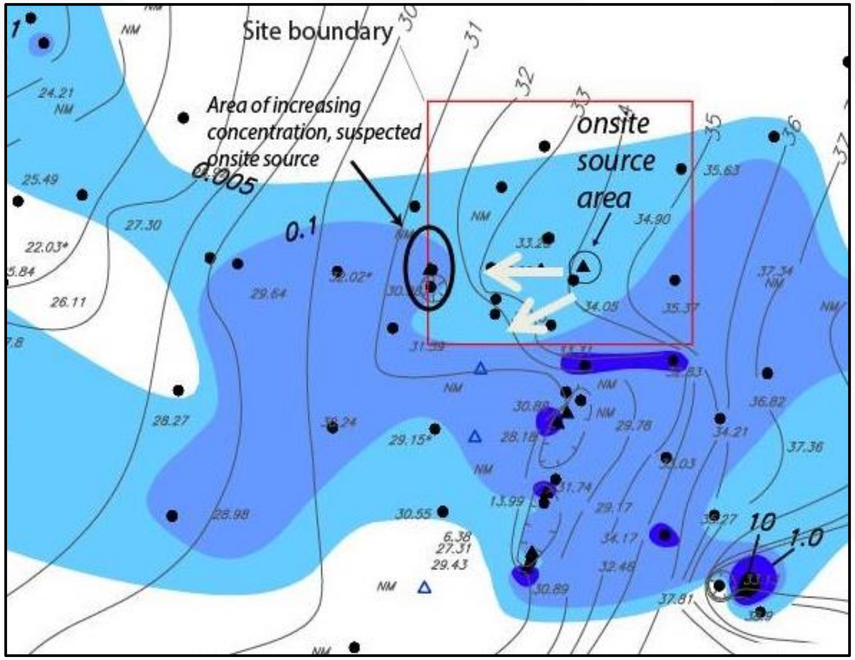
- MIP/HPT program to validate CSM, identify additional channel pathways from off-site source(s)
- Channel deposits (sand and gravel) validated as contaminant pathways
- Plume "maturity" decreases with depth



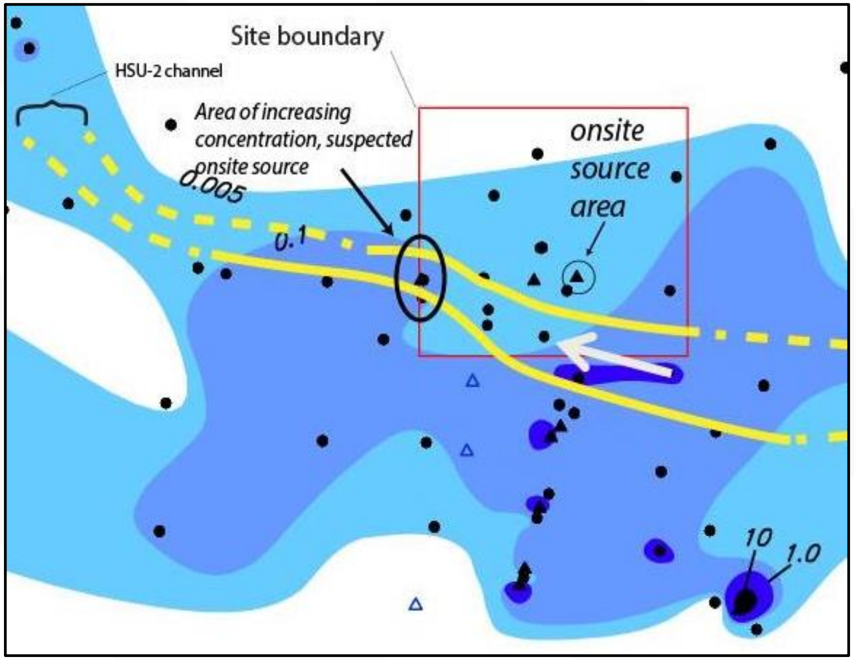


Improved CSM Defines Source of Commingled Plumes

Original CSM



ESS-based CSM



Outcomes and Contribution to EPA

New CSM reduced uncertainty and lead to resolution of a 5 year review issue.

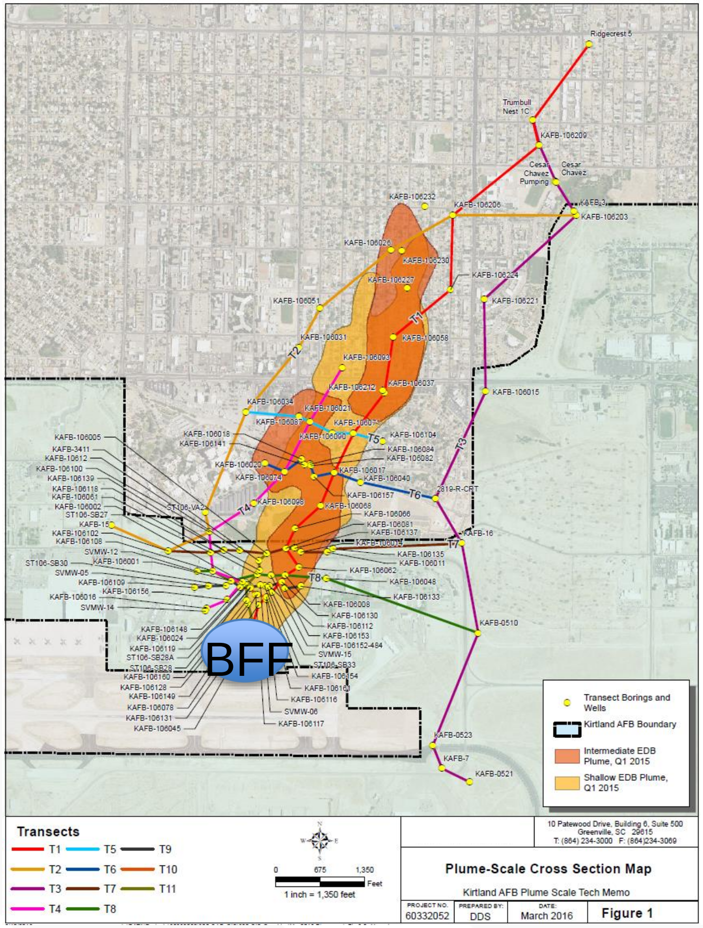
New CSM will provide rationale for monitoring well screen depth and monitoring objectives.

New CSM will result in clean up by parties responsible for each site related release.

Kirtland AFB, Albuquerque NM

Uniting Stakeholders Through Focus on Geology

- Jet fuel LNAPL up-dip, EDB dissolved phase plume in drinking water aquifer downdip
- Regional Scale: Rio Grande Rift
- Plume Scale: ~7,000 X 1,200 ft.
- Water table approx. 500’ bgs, ~1000 ft. borings
- Multiple stakeholders including the public, USGS, NMED, AF, Sandia Nat’l Labs, PBR contractor
- Public relations issues
- Technical team splintering



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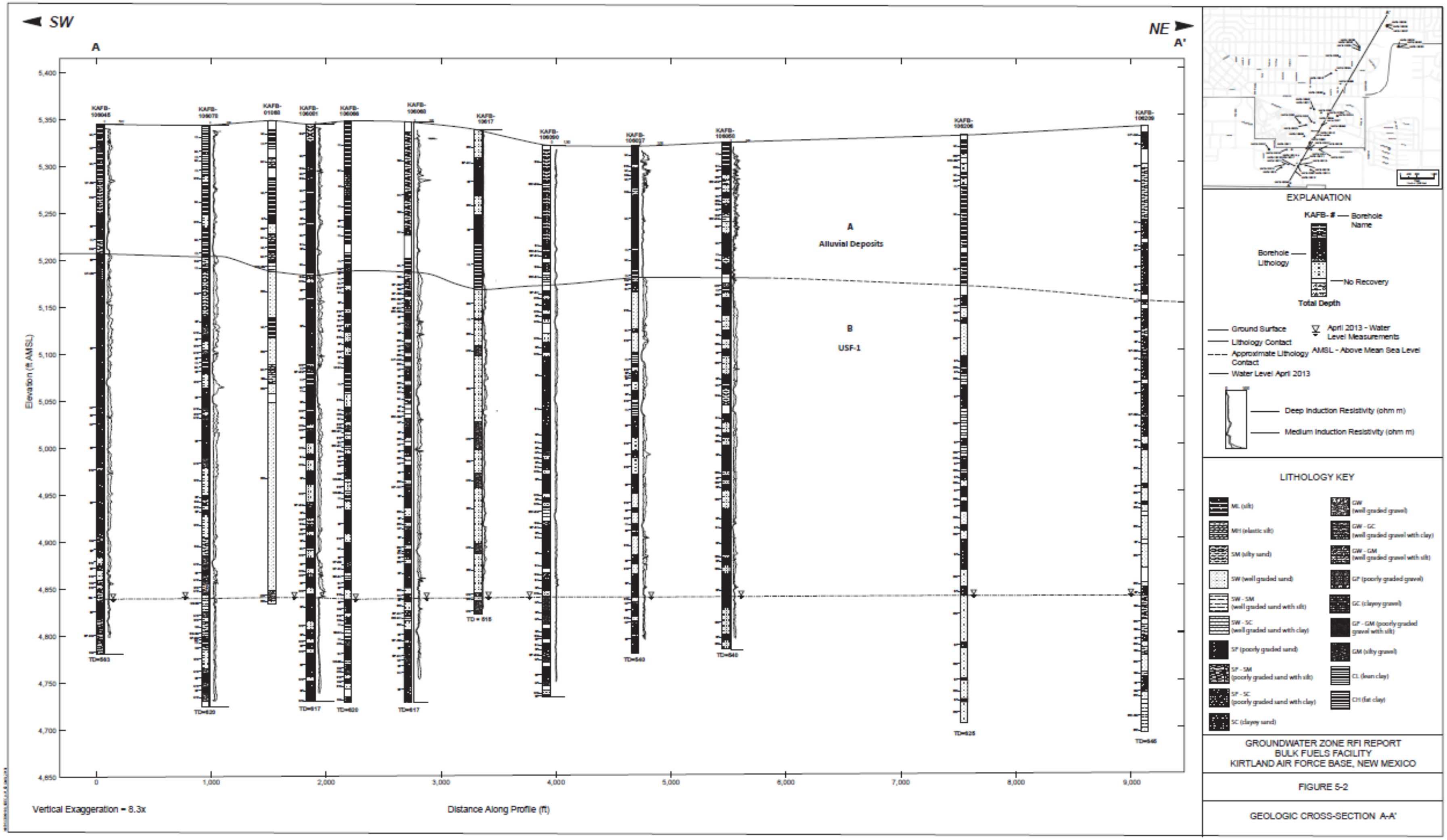
Communication Problems

- Air Force and NMED at odds
- Limited exchange of information
- Ineffective integration of data
- Political and organizational groups brought public attention to the leak
- Public perceived that nothing was being done

"If this is simply a sand box, why can't you give me a final answer?"

Kirtland AFB- Previous Section Example



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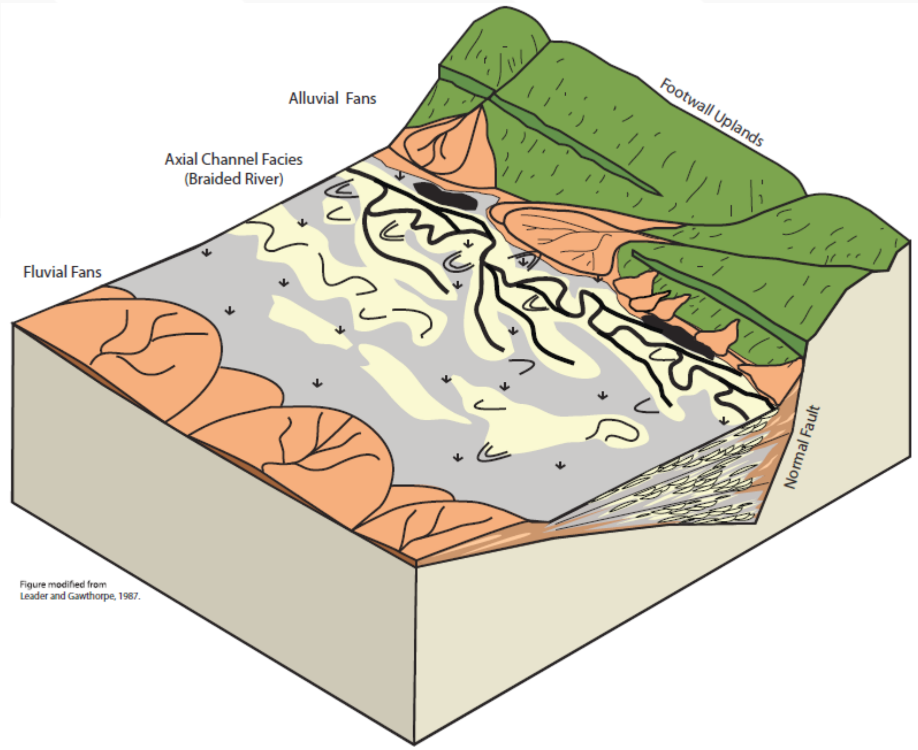
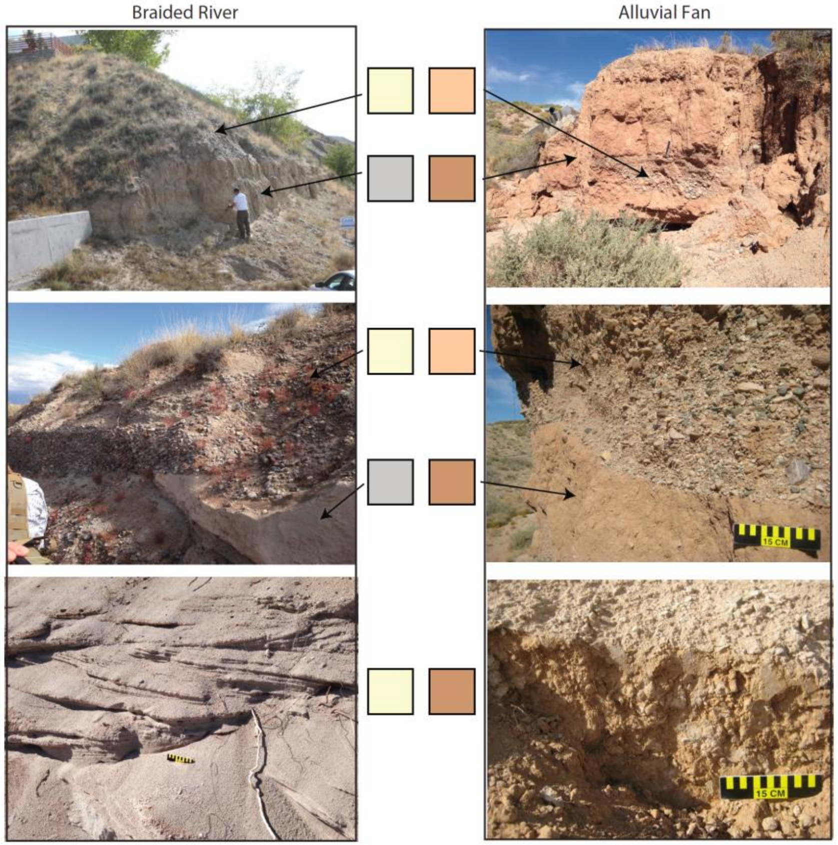
Reformulating The Approach

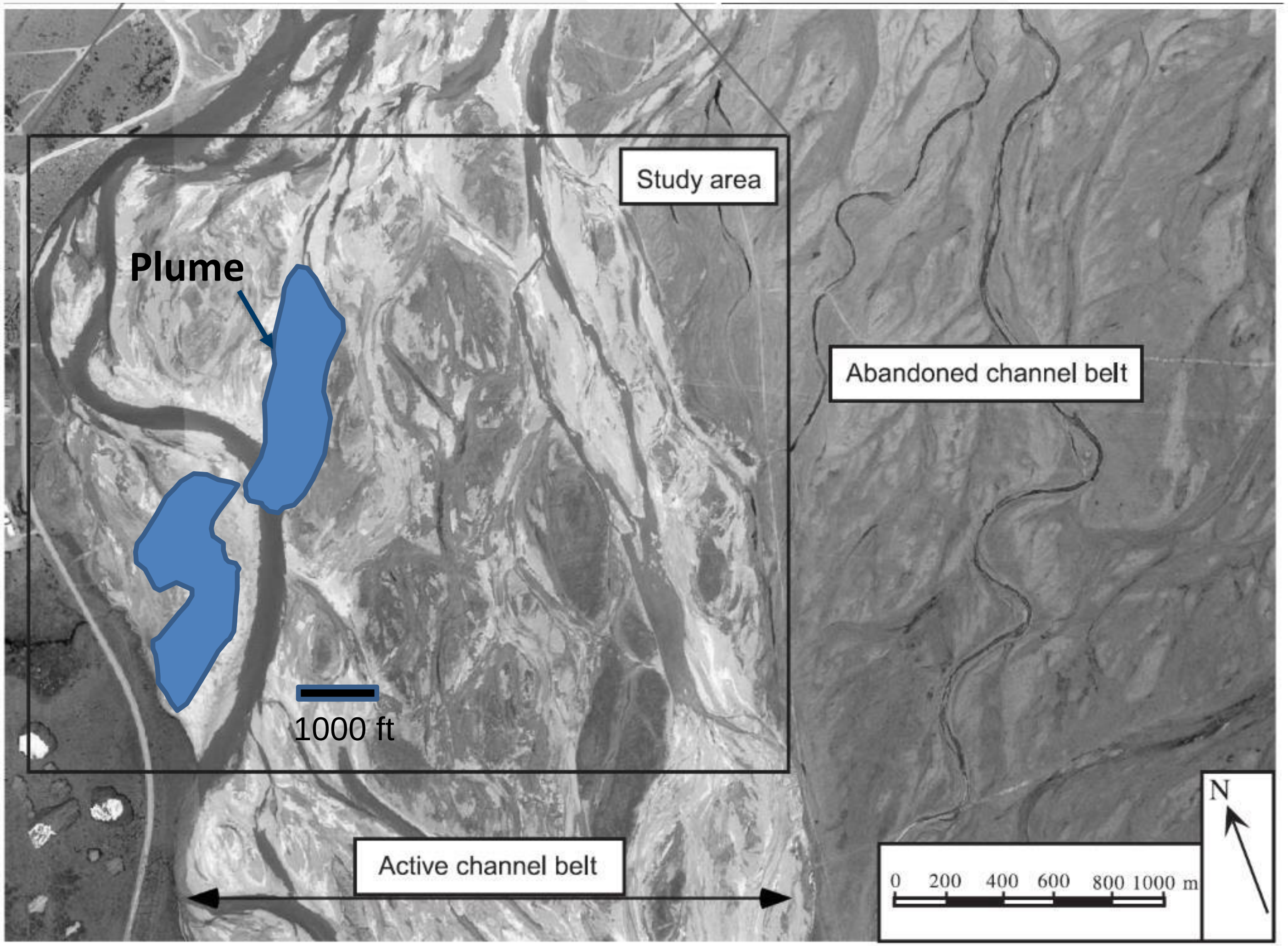
- Standup technical working groups: *Reboot Collaboration*
- Refocus on the Common Enemy:
  - *Uncertainty Created by Subsurface Heterogeneity*
- Implement a data-driven decision process for characterizing, evaluating and selecting interim measures under RCRA
- Increase public awareness and involvement through proactive and transparent communication
- Giving direct access to technical experts

ESS Step 1
A Depositional Model – The Framework In Which We Understand The Problem





Real World Analogs: Plume in Context of Braided River



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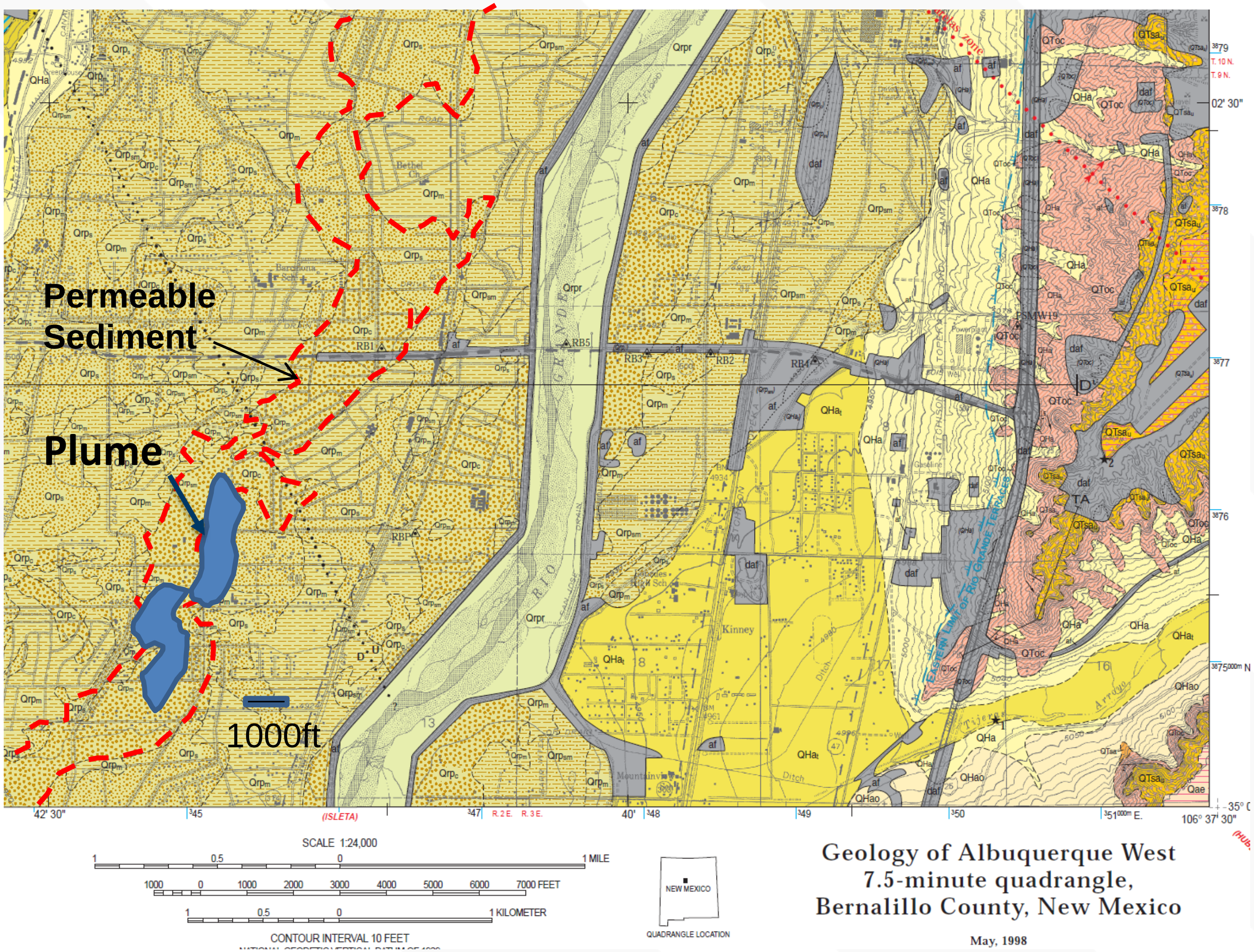
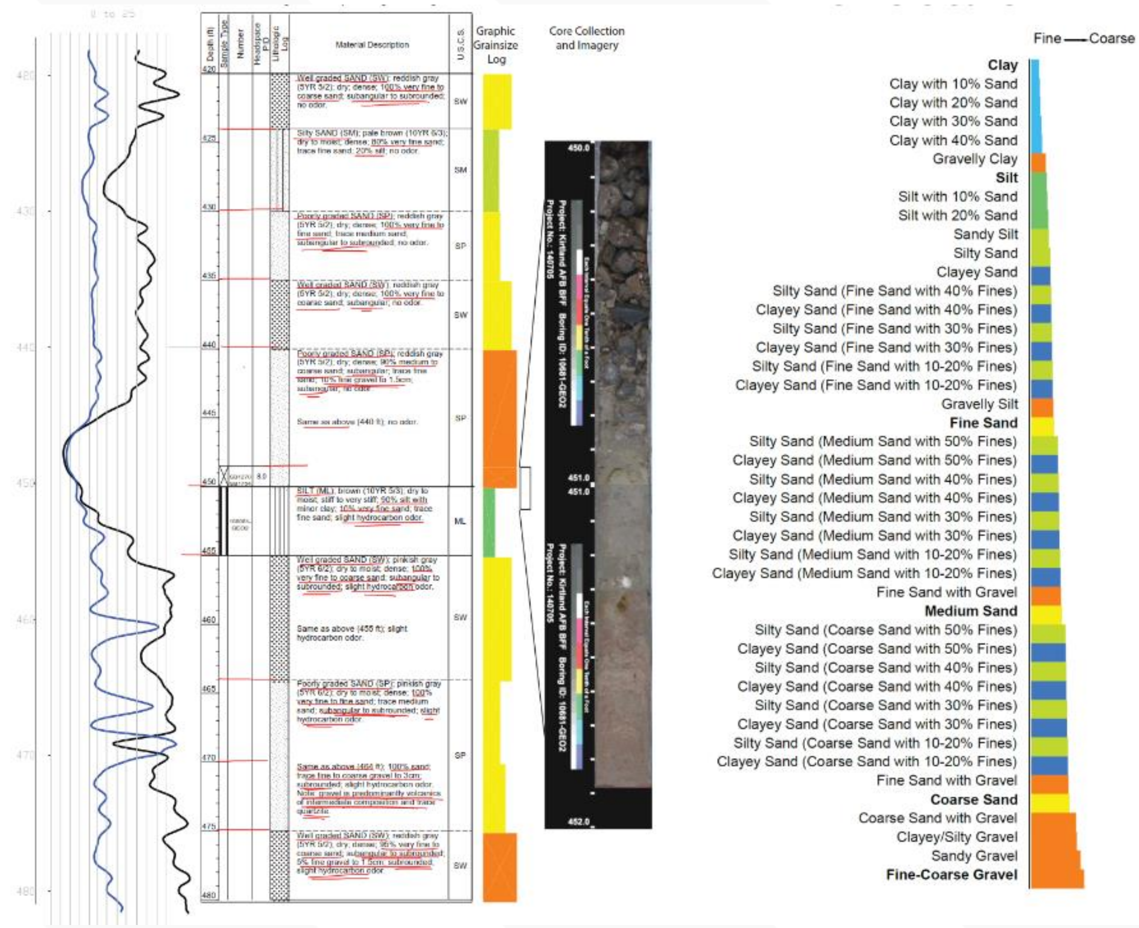
Real World Analogs: Plume in Context of Braided River



ESS Step 2
Integrating Data: Geology Anchoring The Technical Team



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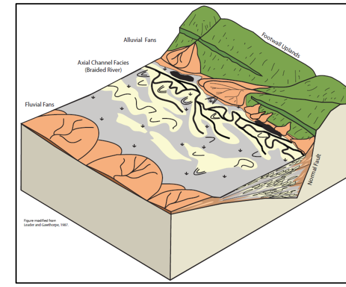
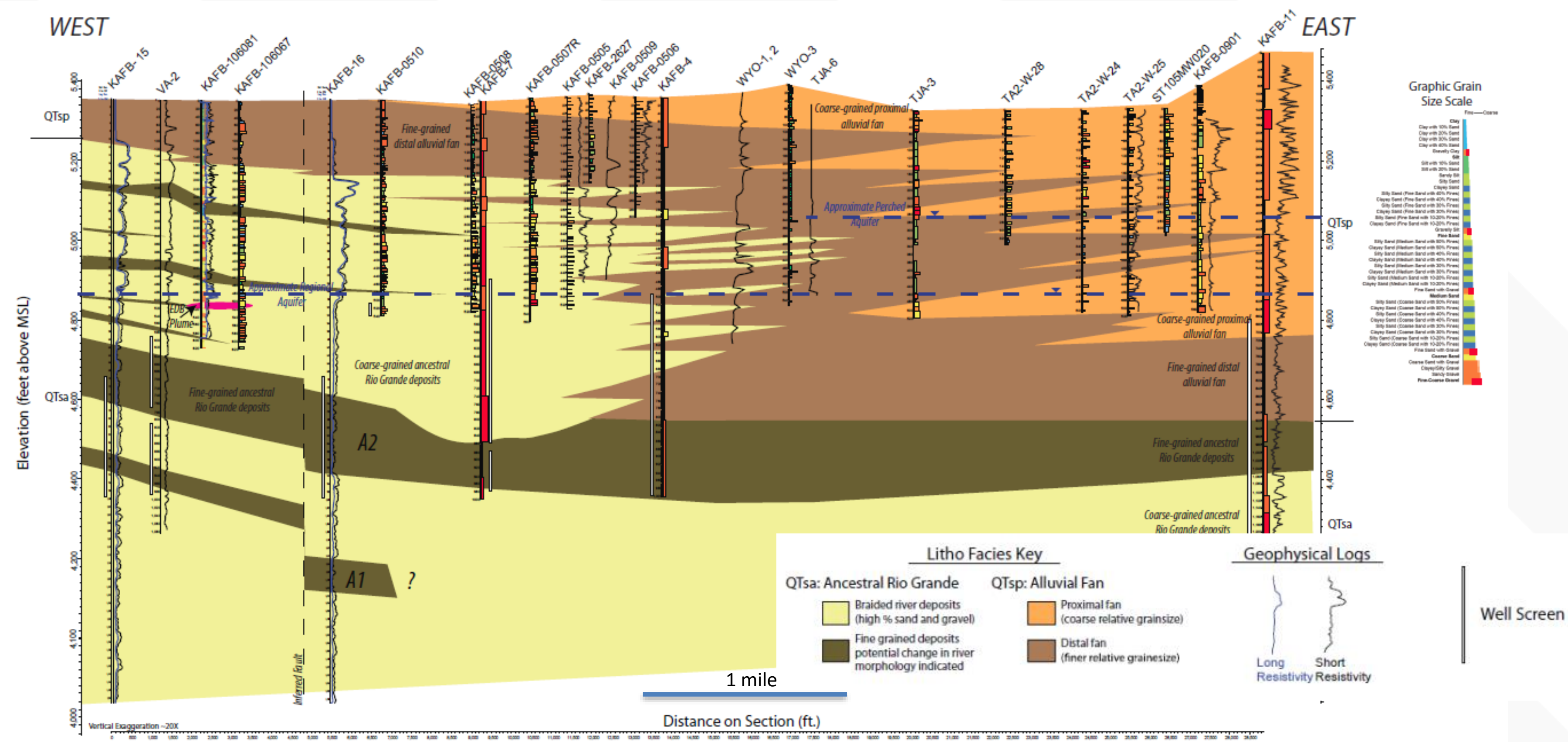
ESS Step 3
Kirtland AFB - ESS Correlation (Regional Scale)





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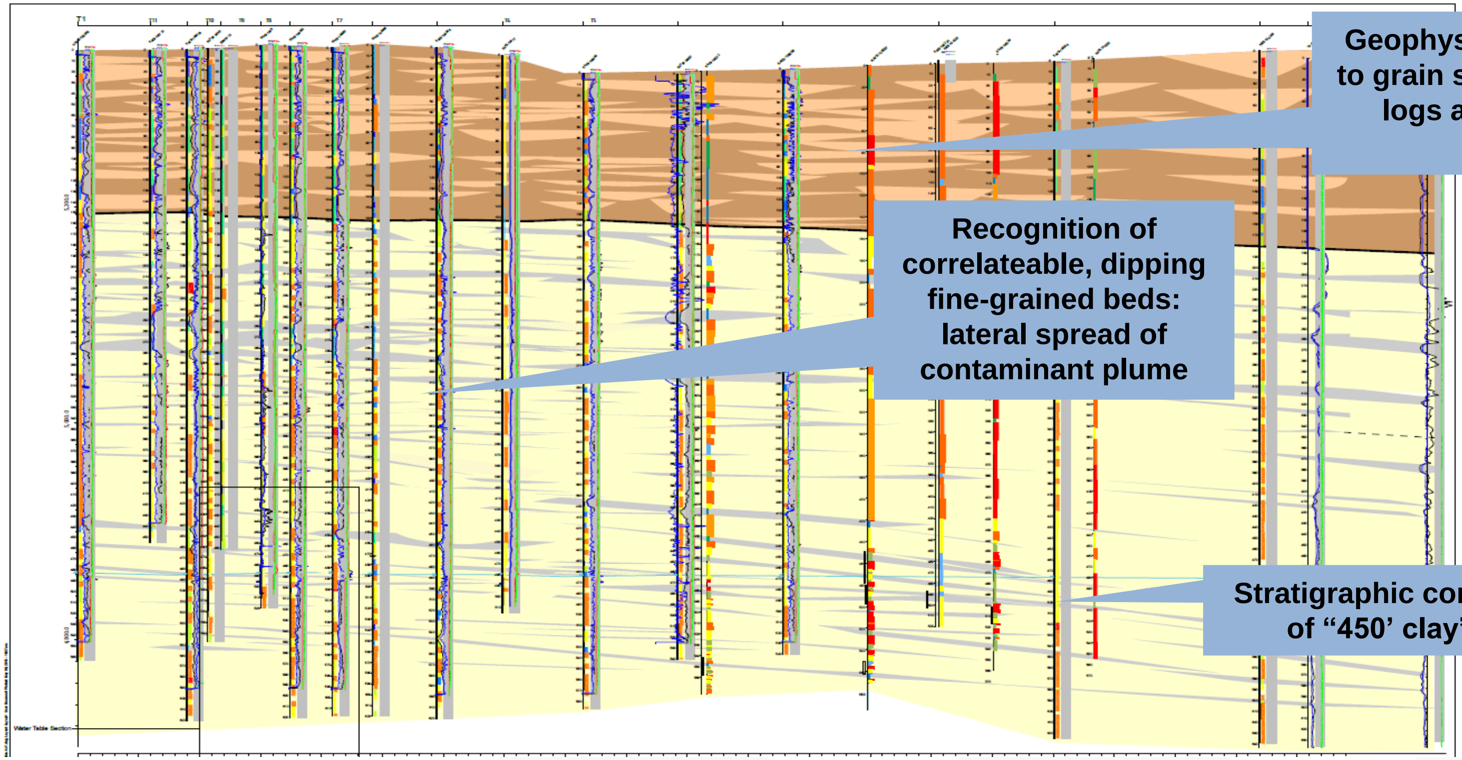
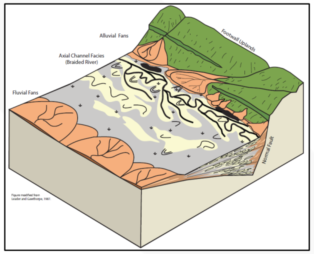
Kirtland AFB - ESS Correlation (Plume Scale)



Geophysical logs calibrated to grain size logs confirm GP logs as valid lithologic indicators

Recognition of correlateable, dipping fine-grained beds: lateral spread of contaminant plume

Stratigraphic context of “450’ clay”



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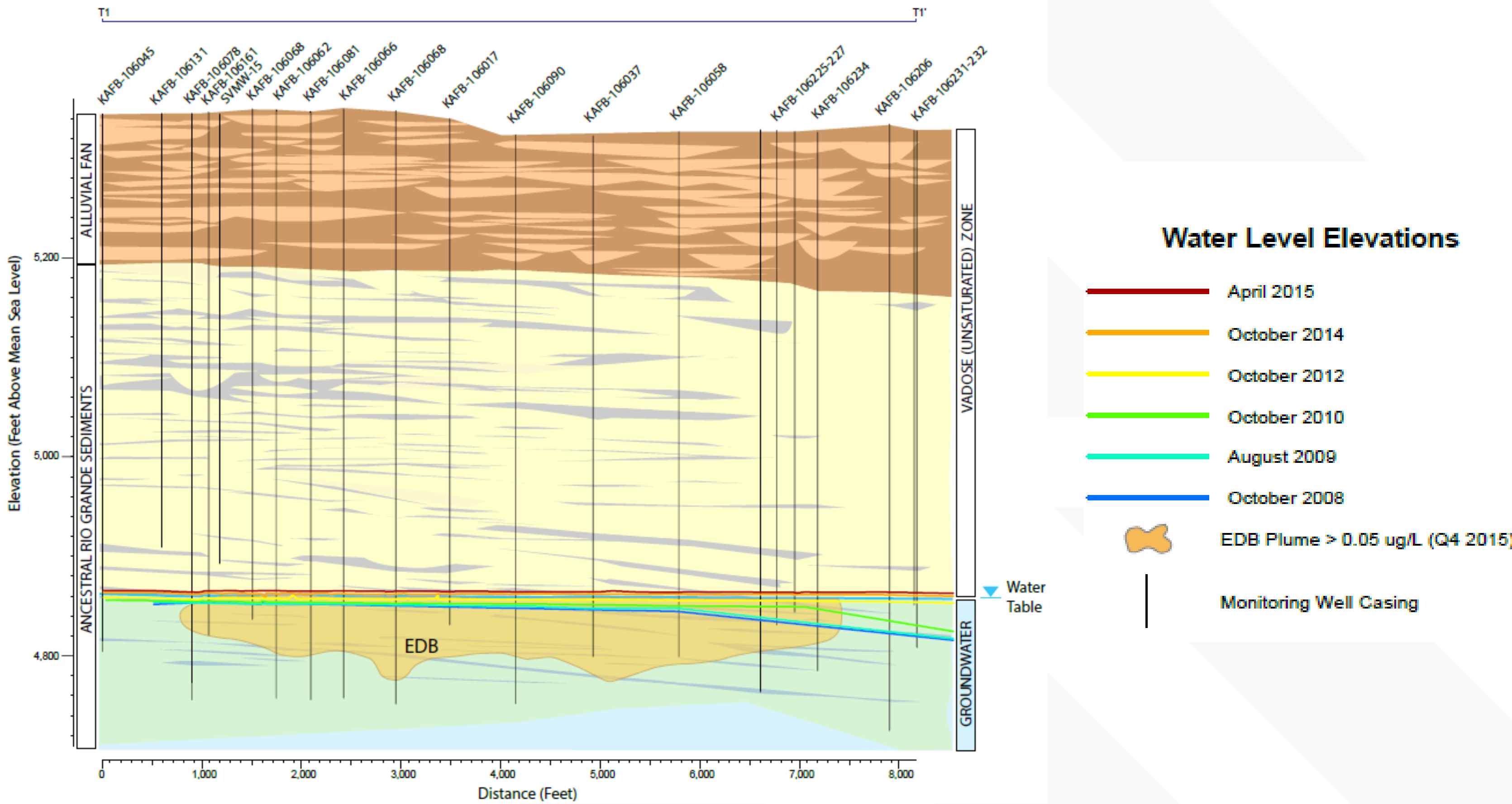
Understanding Plume Extents and Impacts of Rising Water Table



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Public Outreach
Using The CSM to Communicate

News > Community takes part in bulk fuels facility field trip

Community takes part in bulk fuels facility field trip

Posted 4/21/2015   Updated 4/21/2015   **Email story   Print story**

Like 3   SHARE

by Jim Fisher
Kirtland Public Affairs

4/21/2015 - **KIRTLAND AIR FORCE BASE, N.M.** -- Concerned citizens, local residents, geology buffs and students from the University of New Mexico and New Mexico Institute of Mining and Technology joined local agencies engaged in cleaning up the Kirtland Bulk Fuels Facility leak April 18 to learn more about the science behind the assessment and cleanup. The group visited environmental cleanup sites around Albuquerque and geologically illustrative sites near and on Kirtland.

The field trip was a collaboration between the Air Force, the New Mexico Environmental Department, U.S. Geological Survey and the Air Force Civil Engineer Center, the Air Force unit heading up the remediation efforts. Participants toured sites which were selected to help provide hands-on examples of the geological and hydrological research, assessment and an overall context for the BFF project, according to Jill Turner with NMED's Office of the Secretary.

Photos

Colin Plank (right), an earth scientist with the engineering consultant contractor, shares rocks samples with members of the community participating in a Bulk Fuels Facility field trip April 18 near Tijeras Arroyo, south of the Albuquerque International Sunport. Plank was a member of a team of specialists helping participants to understand hydrology as it relates to the BFF contamination plume. (U.S. Air Force photo by Jim Fisher)

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Communication Problems – Resolved Through Effective CSM Development

I offer my sincere and personal appreciation for your outstanding contributions to the Kirtland Air Force Base Bulk Fuels Facility cleanup effort. Your selfless dedication, professional diligence, and willingness to reach out and connect with the affected community and environmental regulators are commendable.

The Kirtland AFB Interim Measure Milestone event is but one indicator of the great progress you have helped achieve. It is also a preview of many more future successes as we work to rebuild the trust between the gracious citizens of Albuquerque and our United States Air Force.

Keep up the outstanding work!

Sincerely,

MIRANDA A. A. BALLENTINE
Assistant Secretary of the Air Force
(Installations, Environment, and Energy)

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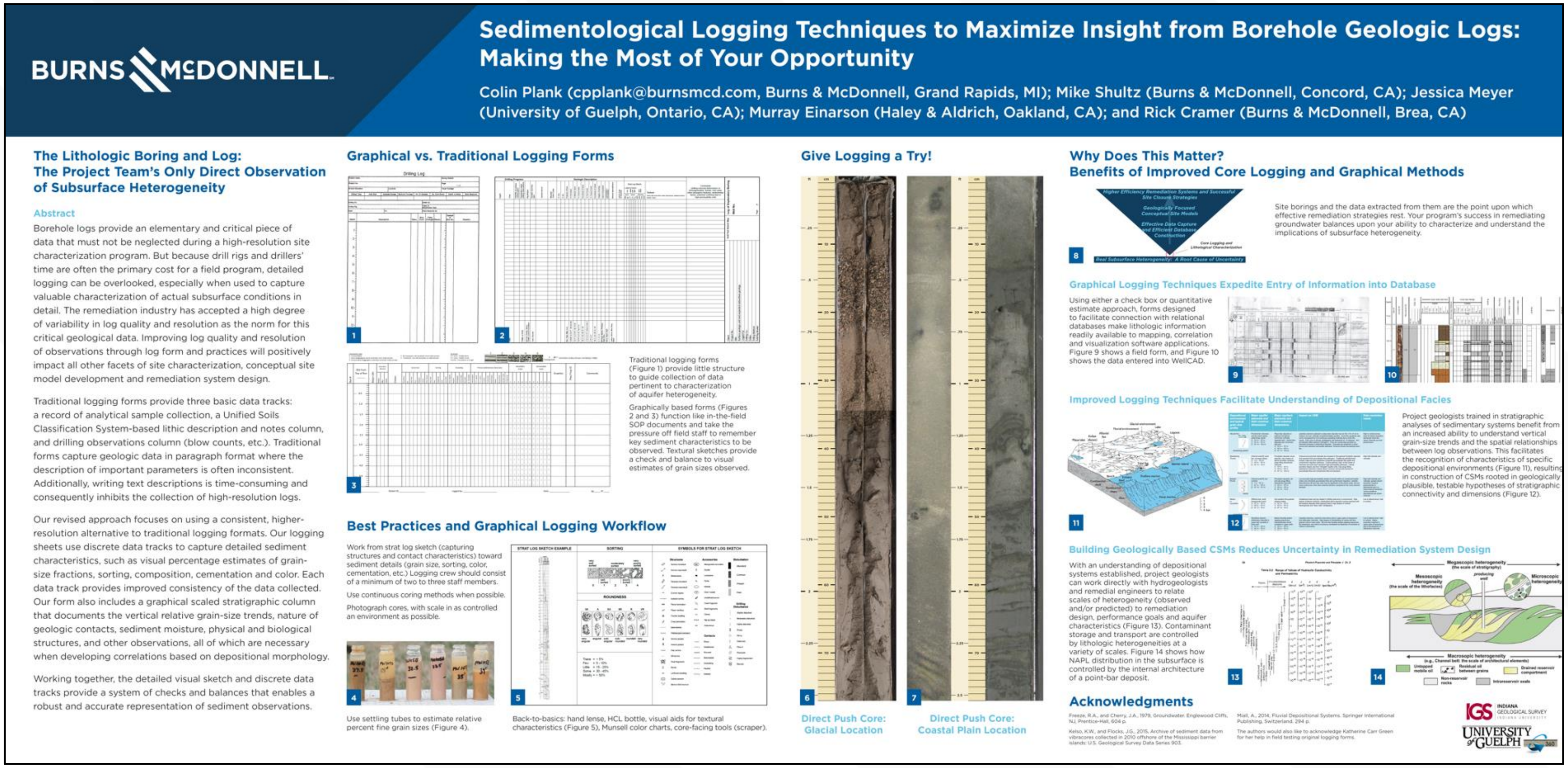
Poster: Borehole Geologic Log



Summary, ESS Benefits

Reduce uncertainty with respect to project end point and time to complete

Identify groundwater flow paths and preferential contaminant migration pathways

Map and predict contaminant mass transport (high permeability) zones and matrix diffusion-related storage (low permeability) zones

Identify data gaps and determine a focused HRSC program, if needed

Optimize groundwater monitoring program

Improve efficiency and timeliness of remediating contaminated groundwater

Reduce cost of remediation

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Thank you!

Rick Cramer
rcramer@burnsmcd.com

Mike Shultz
mrshultz@burnsmcd.com

Colin Plank
cpplank@burnsmcd.com

Herb Levine
Levine.Herb@epa.gov

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