

# **Environmental Sequence Stratigraphy: A Focus on Geology for Improved Remediation Decision Making**

**Rick Cramer, PG (Burns and McDonnell); Mike Shultz (AECOM); Colin Plank (AECOM); Herb Levine (US EPA, Region 9)**

# Geology Matters

- At least 126,000 sites across the U.S. have contaminated groundwater that requires remediation
- Over **12,000** of these sites are considered "complex"
- “There is general agreement among practicing remediation professionals, however, that there is a substantial population of sites, where, due to **inherent geologic complexities**, restoration within the next 50-100 years is likely not achievable.”

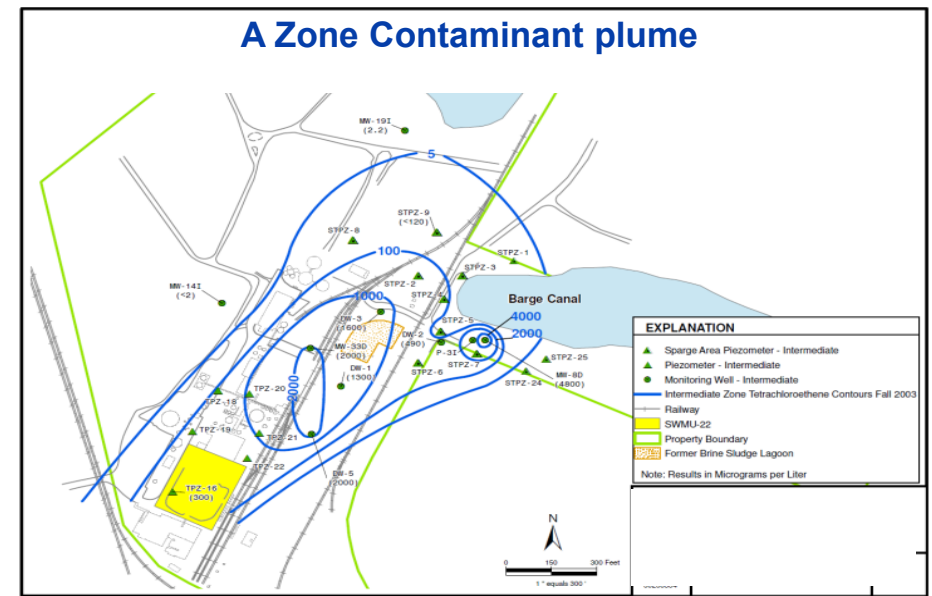
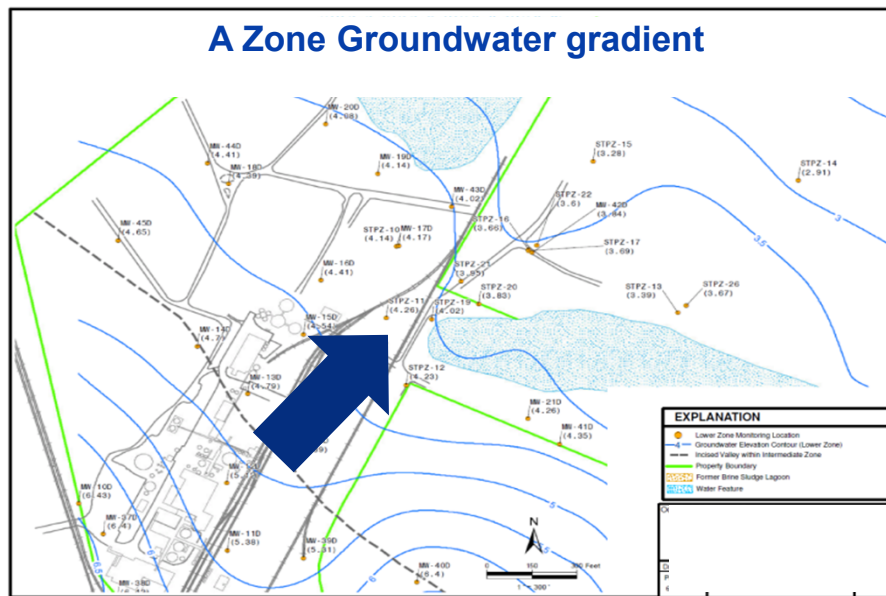
*Alternatives for Managing the Nation's Complex  
Contaminated Groundwater Sites*

*National Academy of Sciences Committee on Future Options for Management in the Nation's  
Subsurface Remediation Effort, 2013*

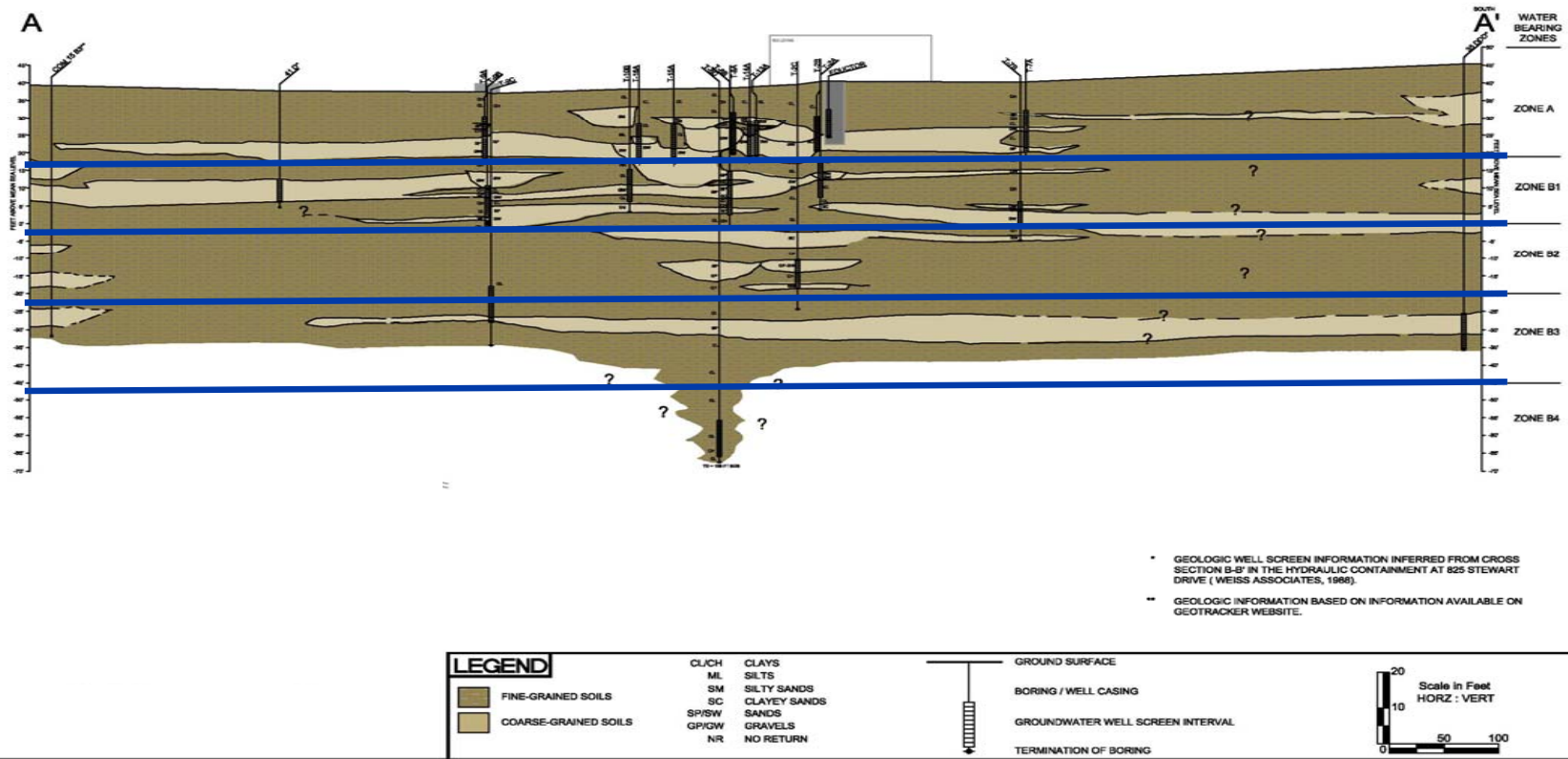


# Traditional Approach to the Subsurface

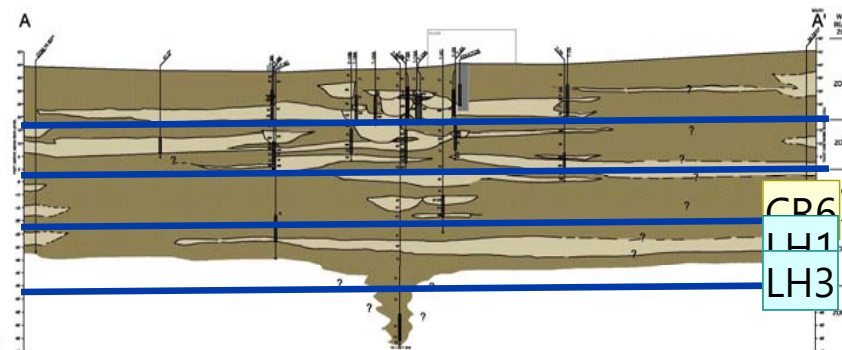
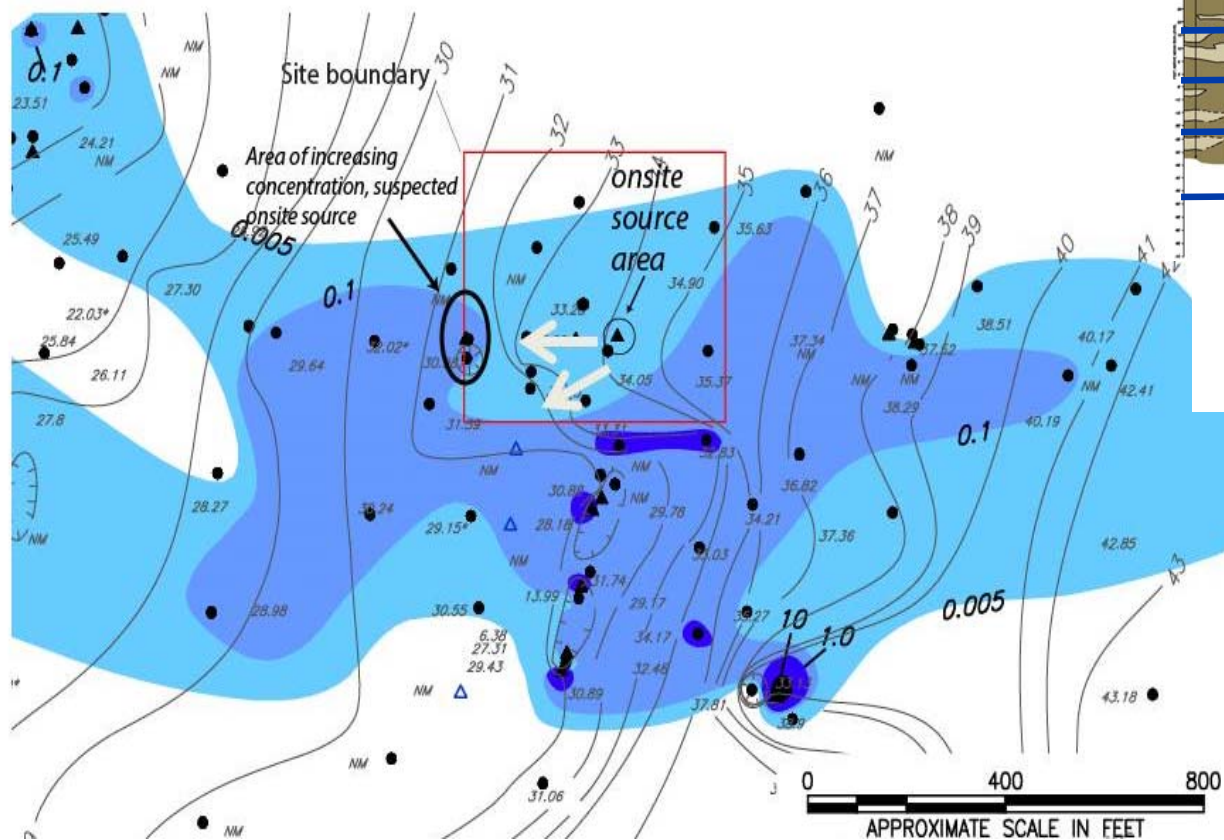
This is what we are doing now...state of the practice



# Original CSM



# Original CSM – B1 Zone

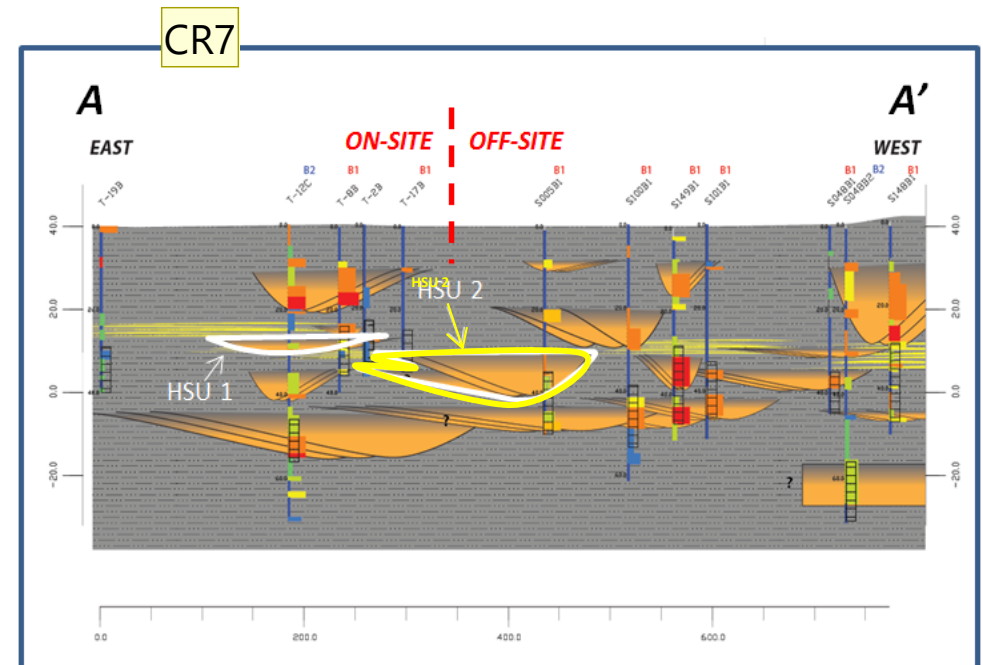
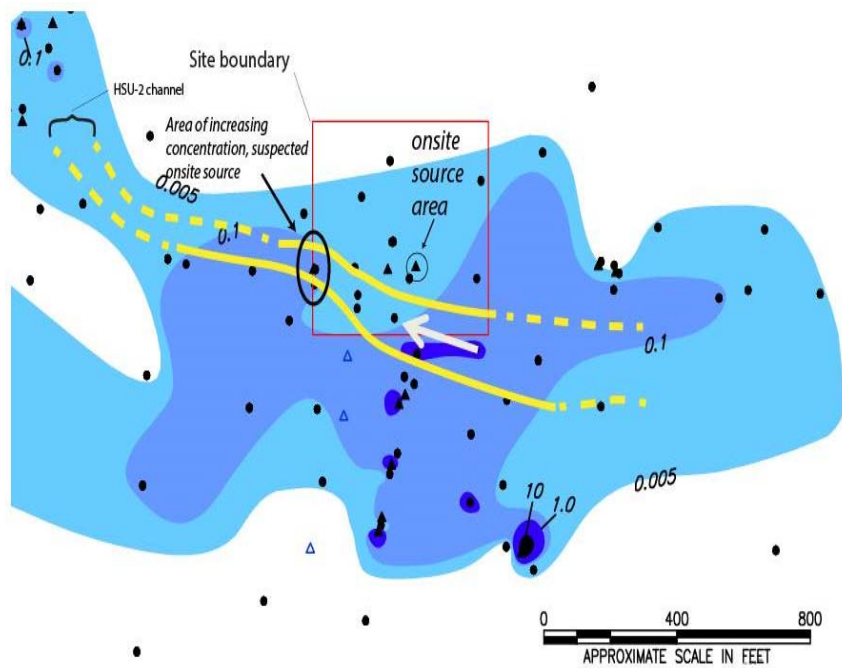


## Slide 5

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- CR6** Rotate figure, North arrow needs to be same orientation as regional...same shape as TRW site  
Cramer, Rick, 9/20/2016
- LH1** add boundaries of the other sites, AMD, Philips, that reinforces the idea of comingling plumes introduced in slide 5.  
Levine, Herb, 9/21/2016
- LH3** also, need legend  
Levine, Herb, 9/21/2016

# Geologic Best Practice ESS-Based CSM





## Slide 6

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- CR7** Also need to rotate figure and include north arrow.  
Show xsection line A-A'  
Cramer, Rick, 9/20/2016
- CR8** include additional xsections that show where the channel is going  
Cramer, Rick, 9/20/2016



# Geology-Based CSM

Based on geology processes

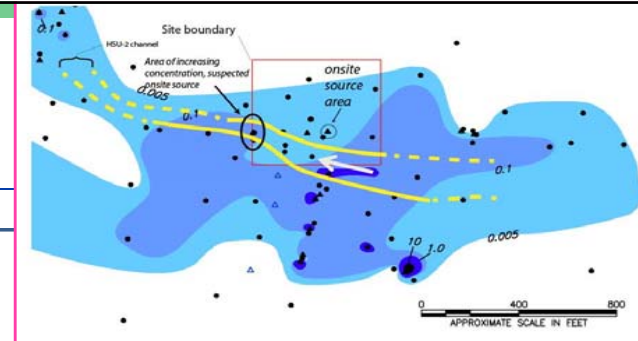
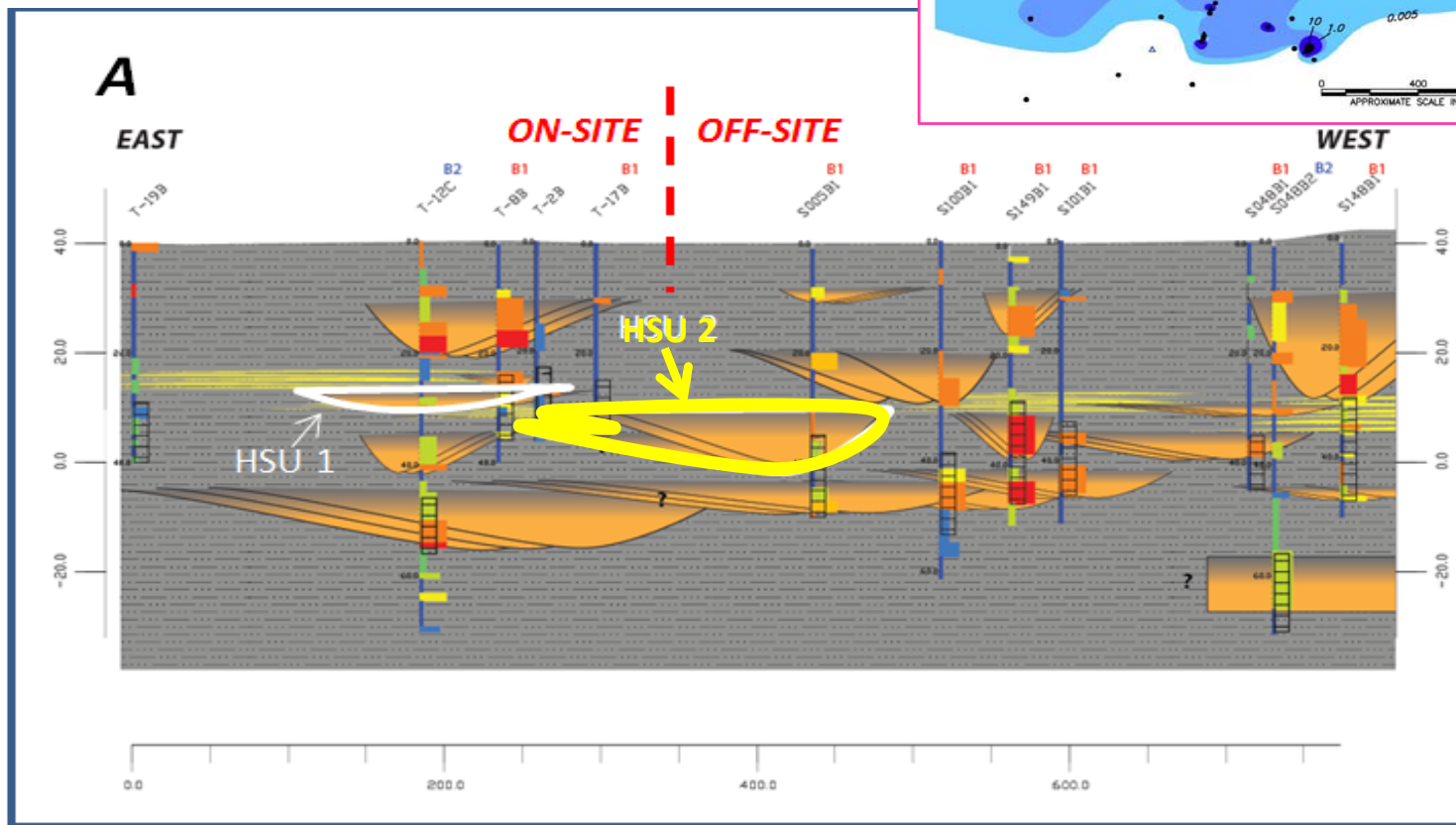
No longer need to assume  
heterogeneity = homogeneous

# Benefits of a Geology-Based CSM

Defines subsurface “plumbing”,  
contaminant pathways

Critical to successful remedy  
selection, design, and  
performance

# Best Practice, ESS-based CSM: Defines buried channels



CR11

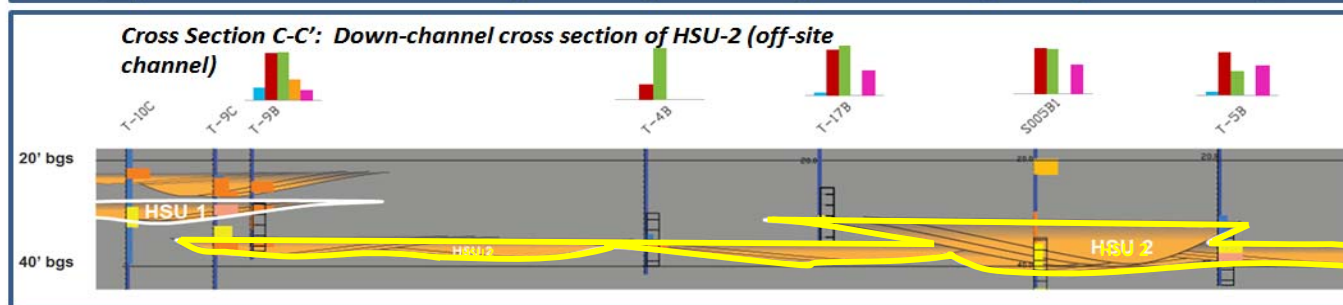
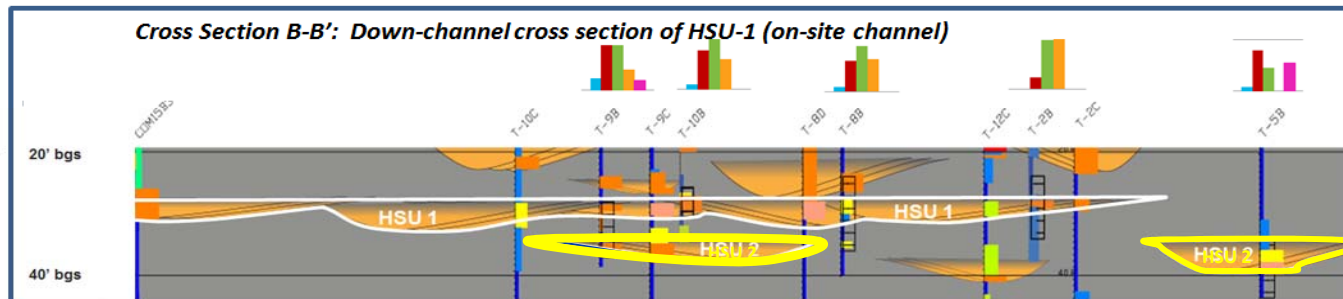
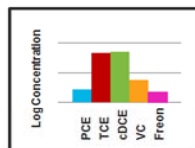
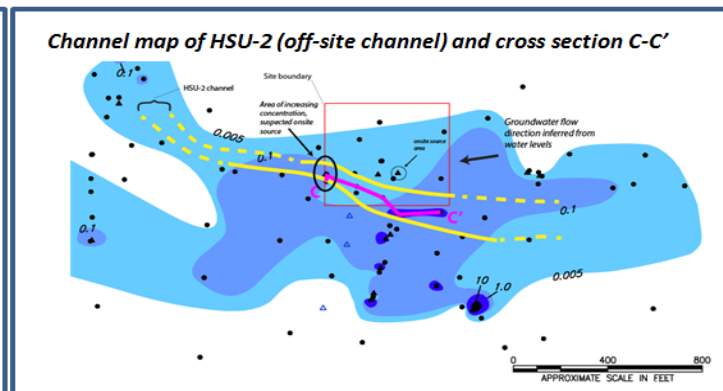
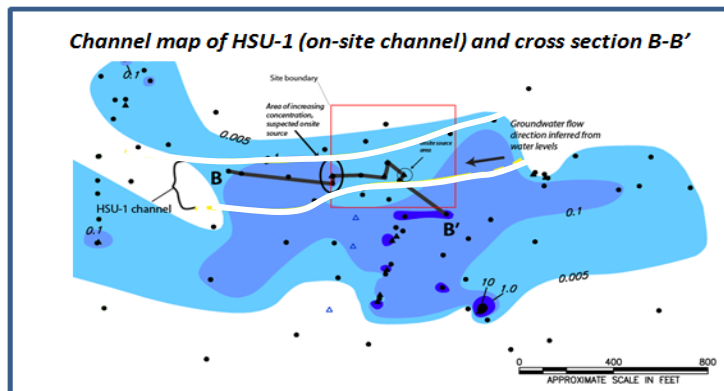
## Slide 9

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### CR11

On xsection, Start with pointing out the gray is the fine grained floodplain matrix that doesn't move water and embedded within are the stream channels that do move water

Cramer, Rick, 9/20/2016



# Geology-Based CSM

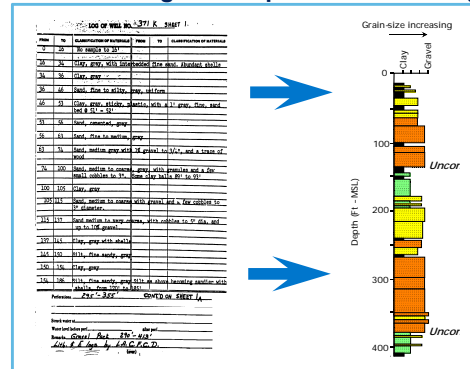
## Environmental Sequence Stratigraphy (ESS) Process



1

**Determine depositional environment** which is the foundation to the ESS evaluation

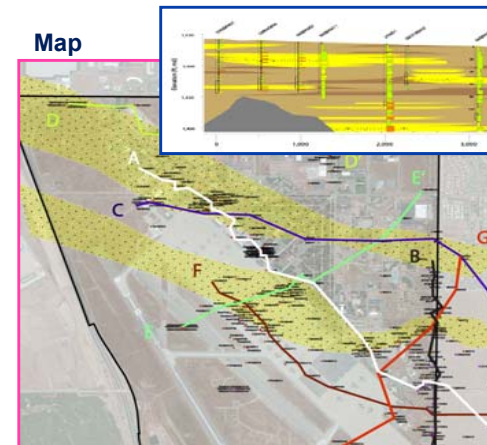
### Borehole Log to Graphic Grainsize Log



2

**Leverage existing lithology data** to interpret between boreholes

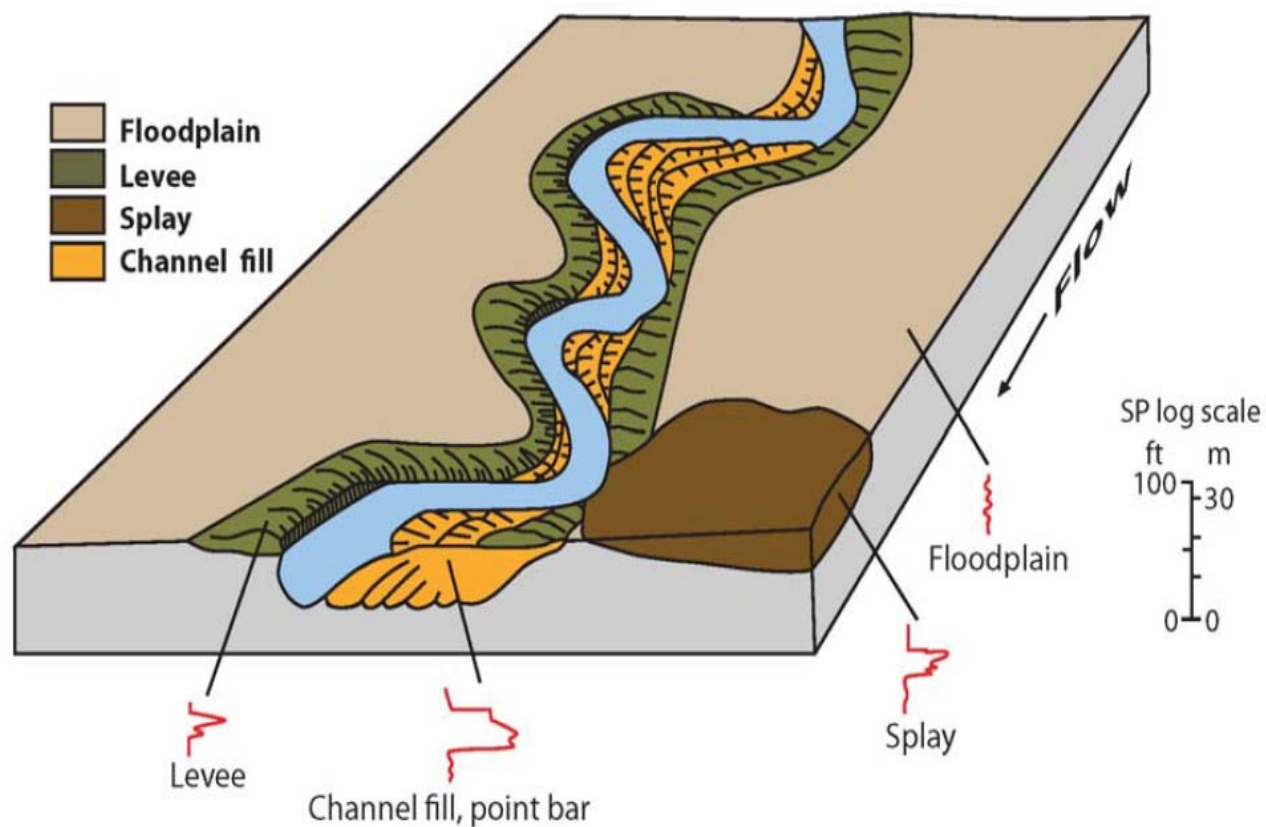
### Cross Section



3

**Map the buried channels** to predict contaminant migration

## Example of buried channel depositional





## Slide 12

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**CR10**

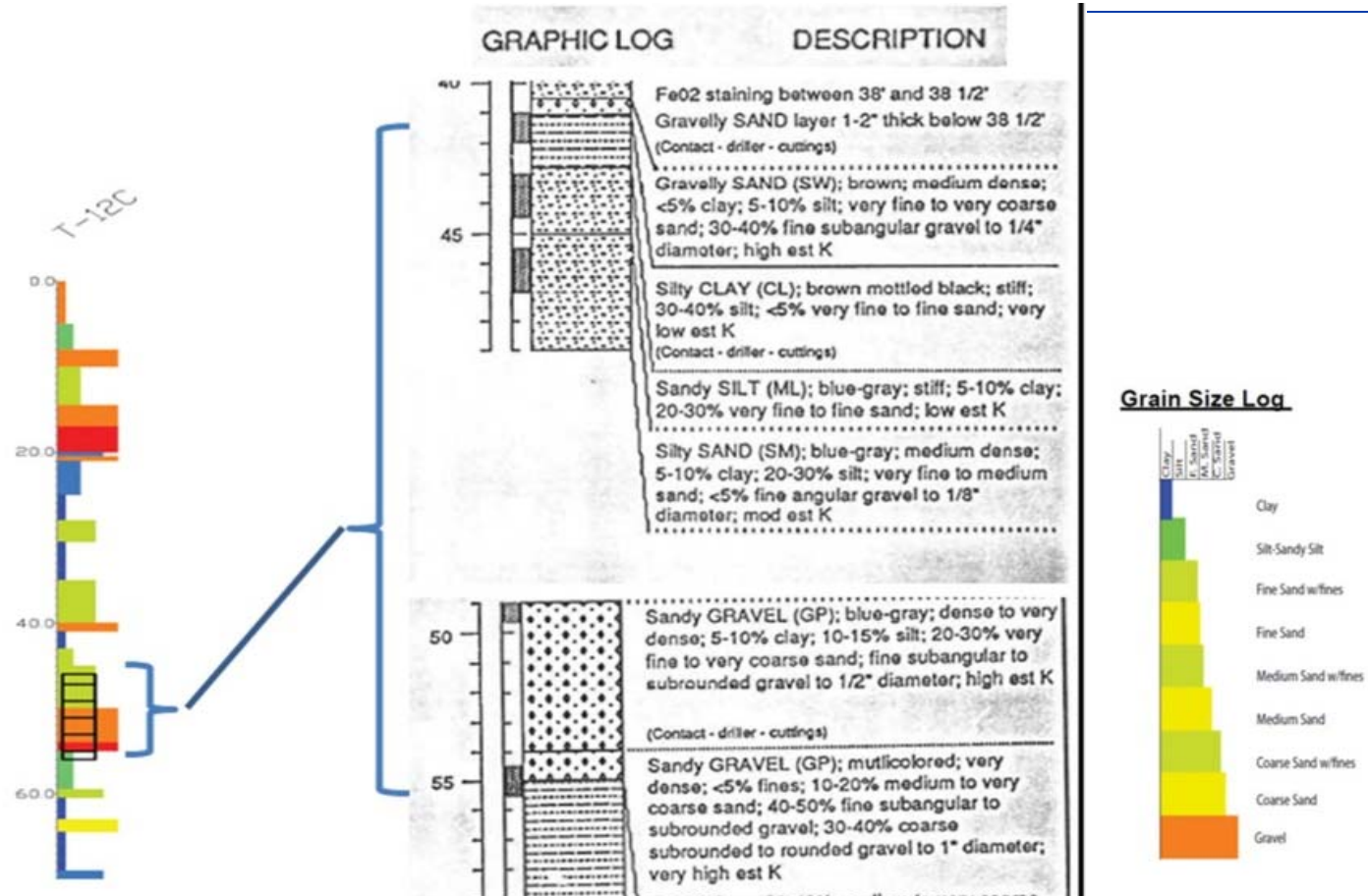
Cramer, Rick, 9/20/2016

**CR9**

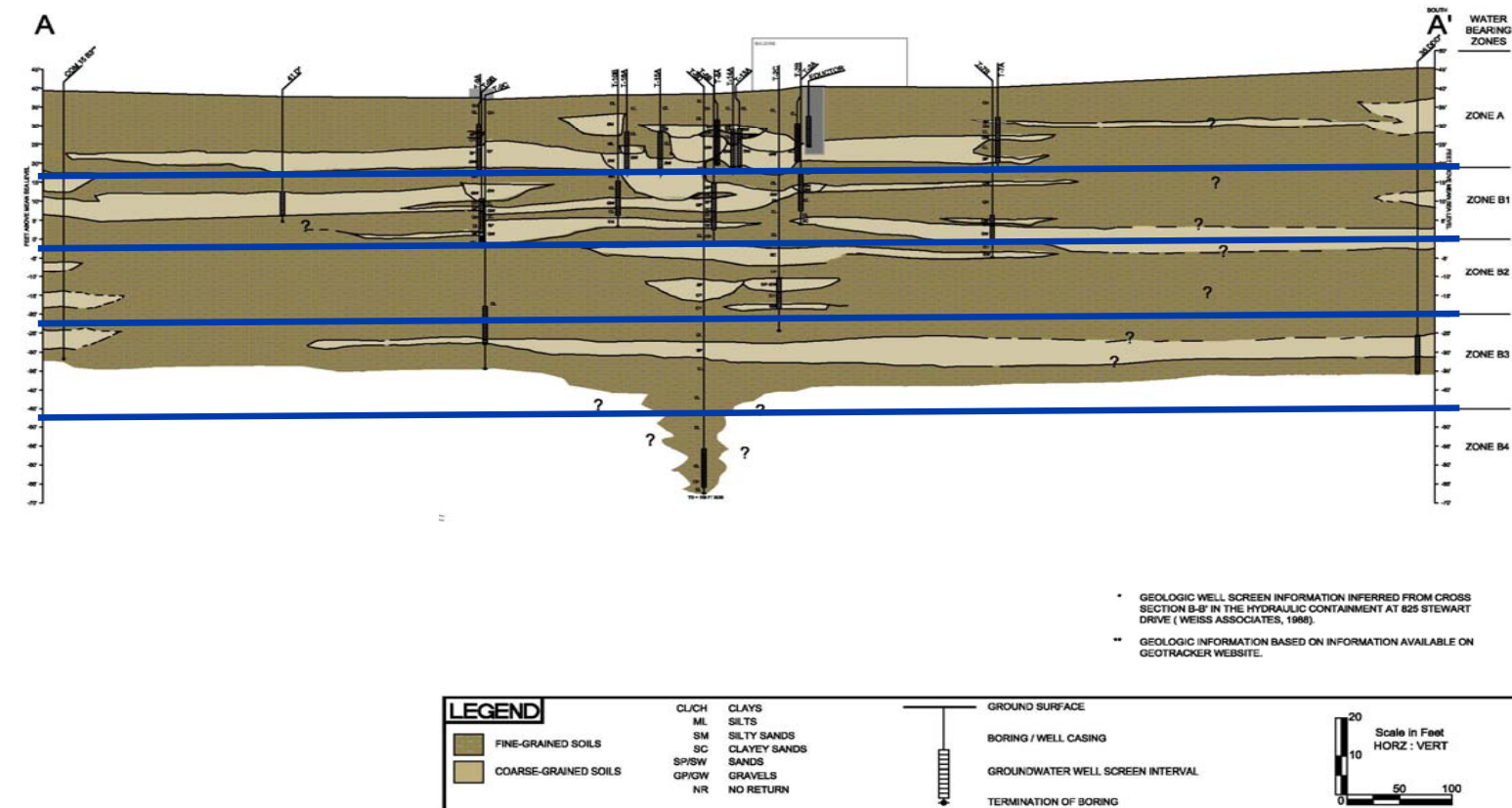
revise to take out splay

Cramer, Rick, 9/20/2016

# Fining-upward Grainsize Pattern = Channel Deposit

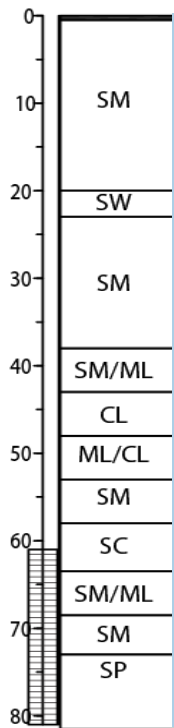


# Original CSM



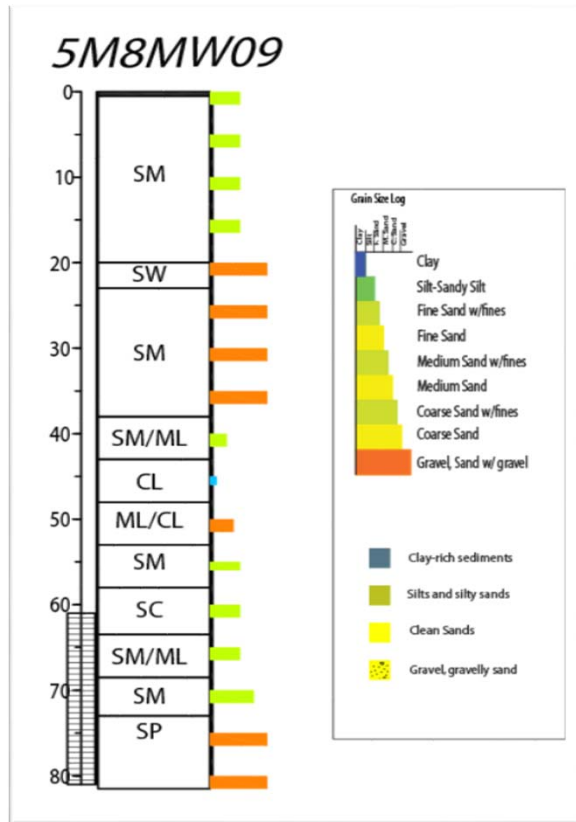
# Unleashing the Power of Existing Site Data

5M8MW09



- “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...

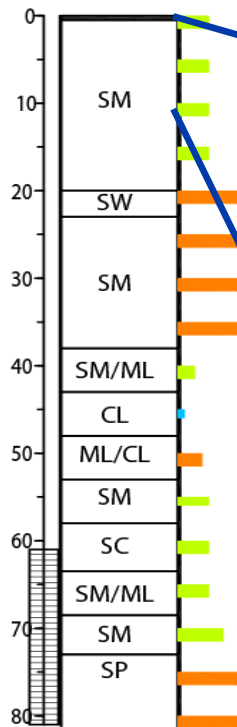
# Hidden” Stratigraphic Data



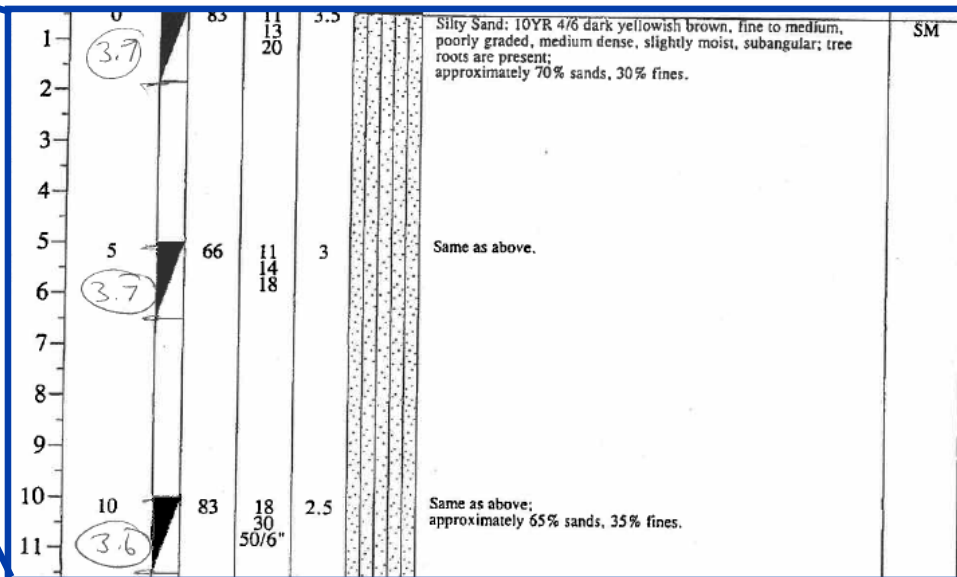
- Existing data is formatted for stratigraphic interpretation
- Reveals the “hidden” stratigraphic information that is available with existing lithology data

# “Hidden” Stratigraphic Data

5M8MW09

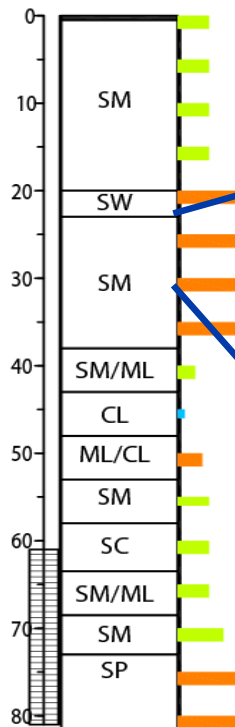


*This SM interval is a fine to medium grained Silty Sand*

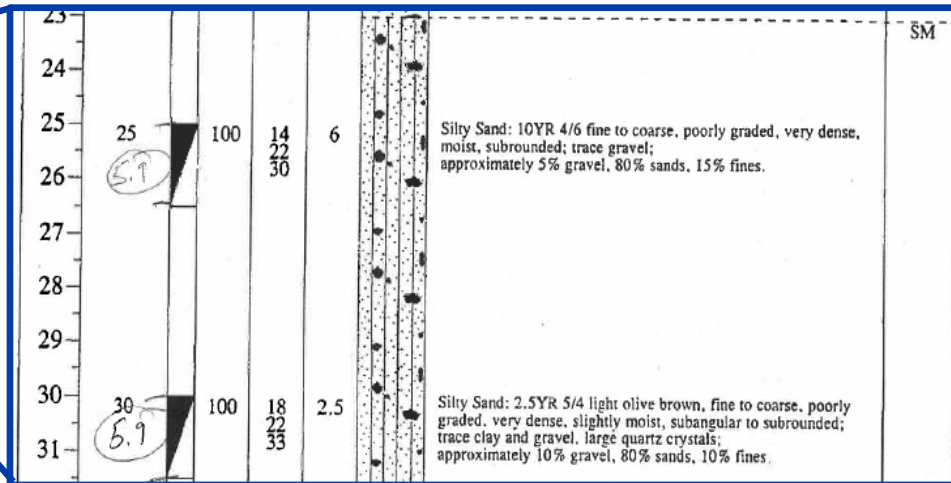


# Hidden” Stratigraphic Data

5M8MW09



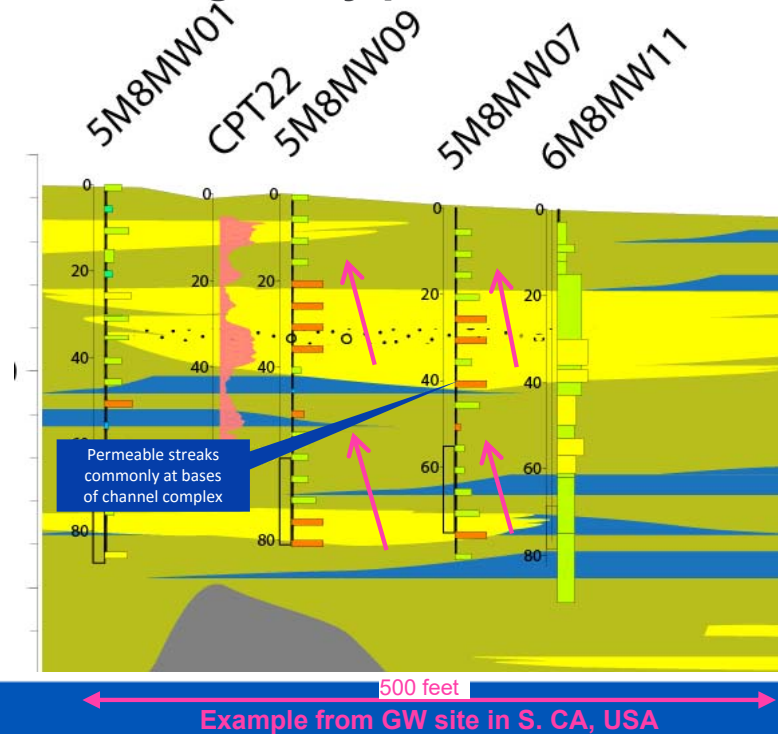
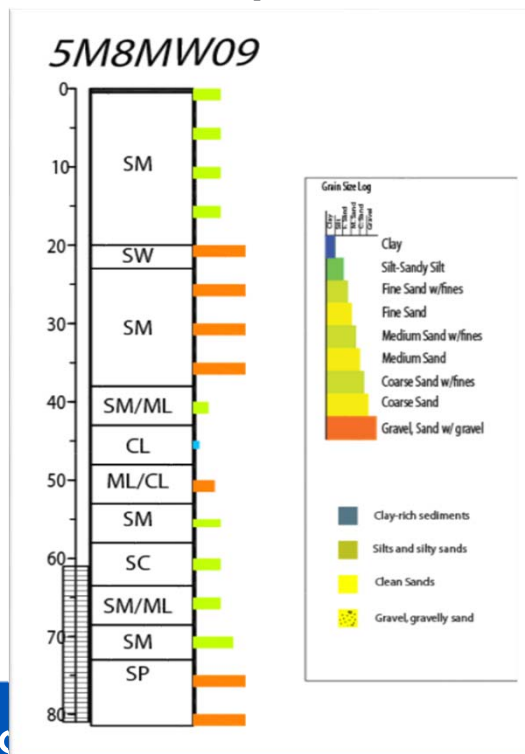
*This SM interval is a fine to coarse grained Silty Sand with gravel, representative of a channel deposit.*



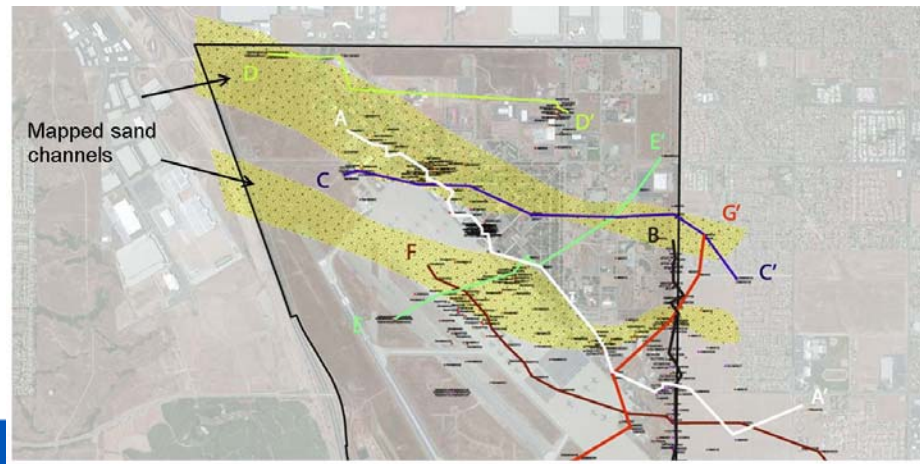
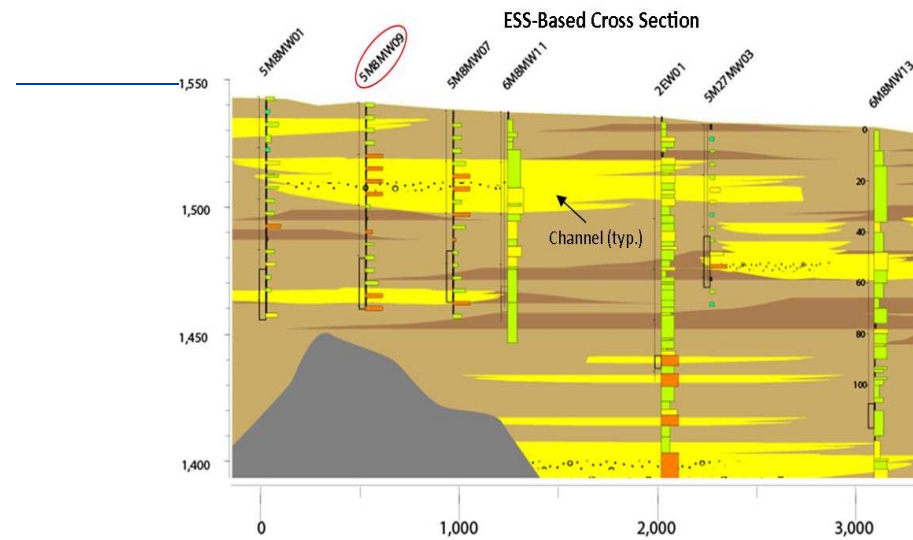
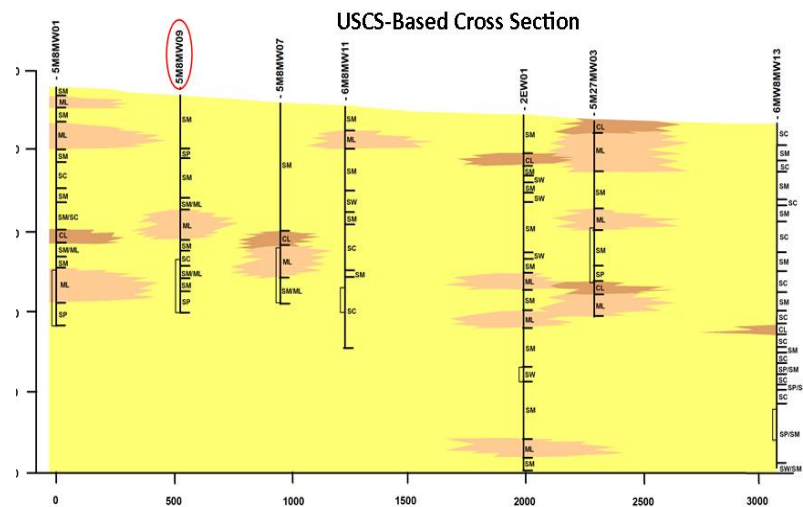


# “Hidden” Stratigraphic Data

1. Reformatting existing data to identify sequences, and
2. Applying facies models, stratigraphic “rules of thumb” to correlate and map the subsurface, predict character of heterogeneity present

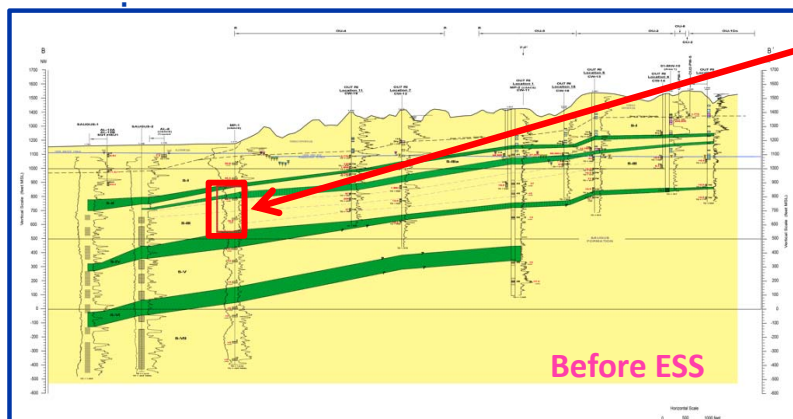






# Example: Critical to Remedy Design

ESS Outcome: Gained regulatory and stakeholder approval for wholesale modification of containment system design = \$55MM



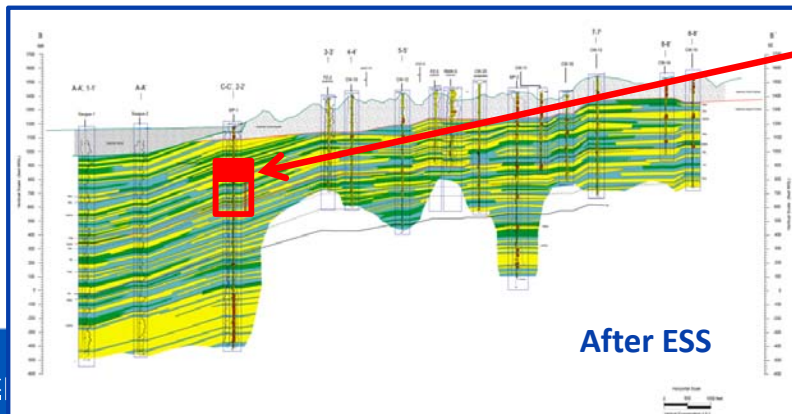
125' extraction interval; includes non-impacted strata



## Remediation System Cost (Before ESS)

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

Capital cost = \$7 MM  
Treatment cost = \$2.5MM/yr;  
30 yr = \$75 MM  
**Total cost = \$82 MM**



35' extraction interval; impacted strata only



## Remediation System Cost (After ESS)

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

Capital cost = \$2.5MM  
Treatment cost = \$800K/yr;  
30 yr = \$24MM  
**Total cost = \$26.5 MM**



# Technology Endorsed by US EPA

US EPA Technical Issue Paper presents  
ESS as a best practice for CSMs

### **Best Practice for Improving Conceptual Site Models:**

*A Practical Guide for Applying Advanced Stratigraphic  
Concepts to Contaminated Groundwater Sites*

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#### 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>

# Questions?

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