Maximizing Insight and Data Capture from Borehole Logs: The Graphical Approach to Geologic Logging and Its Benefits

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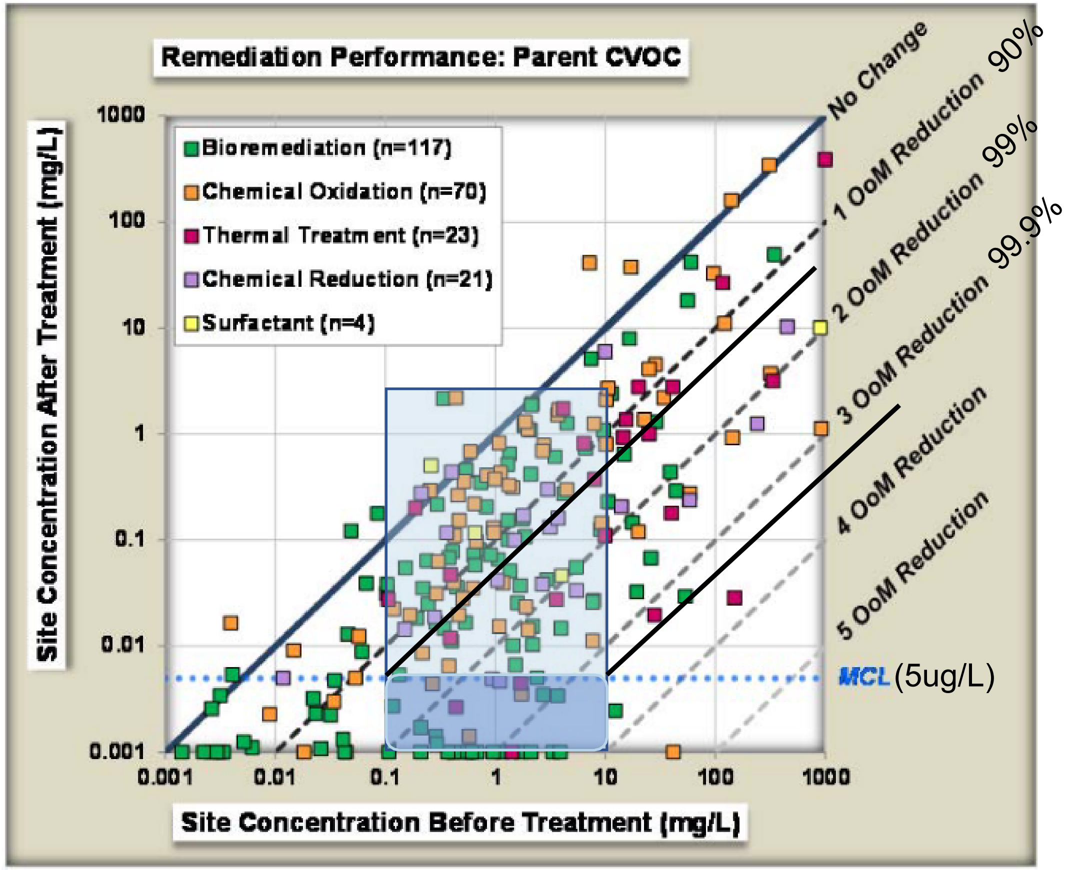
The Problem: Remediation Performance Often Does Not Meet Remediation Expectations

- Remediation success often requires destruction/removal of ~95-99.9% of the mass
- The actual median reduction in concentration achieved by applied technologies is closer to 90%



McGuire et al. 2016, ESTCP project ER-201120

A Major Obstacle For Performance : The Inherent Complexity of the Subsurface

Complexity Consists of:

Lithologic Heterogeneity

- Scale of detection vs. reality

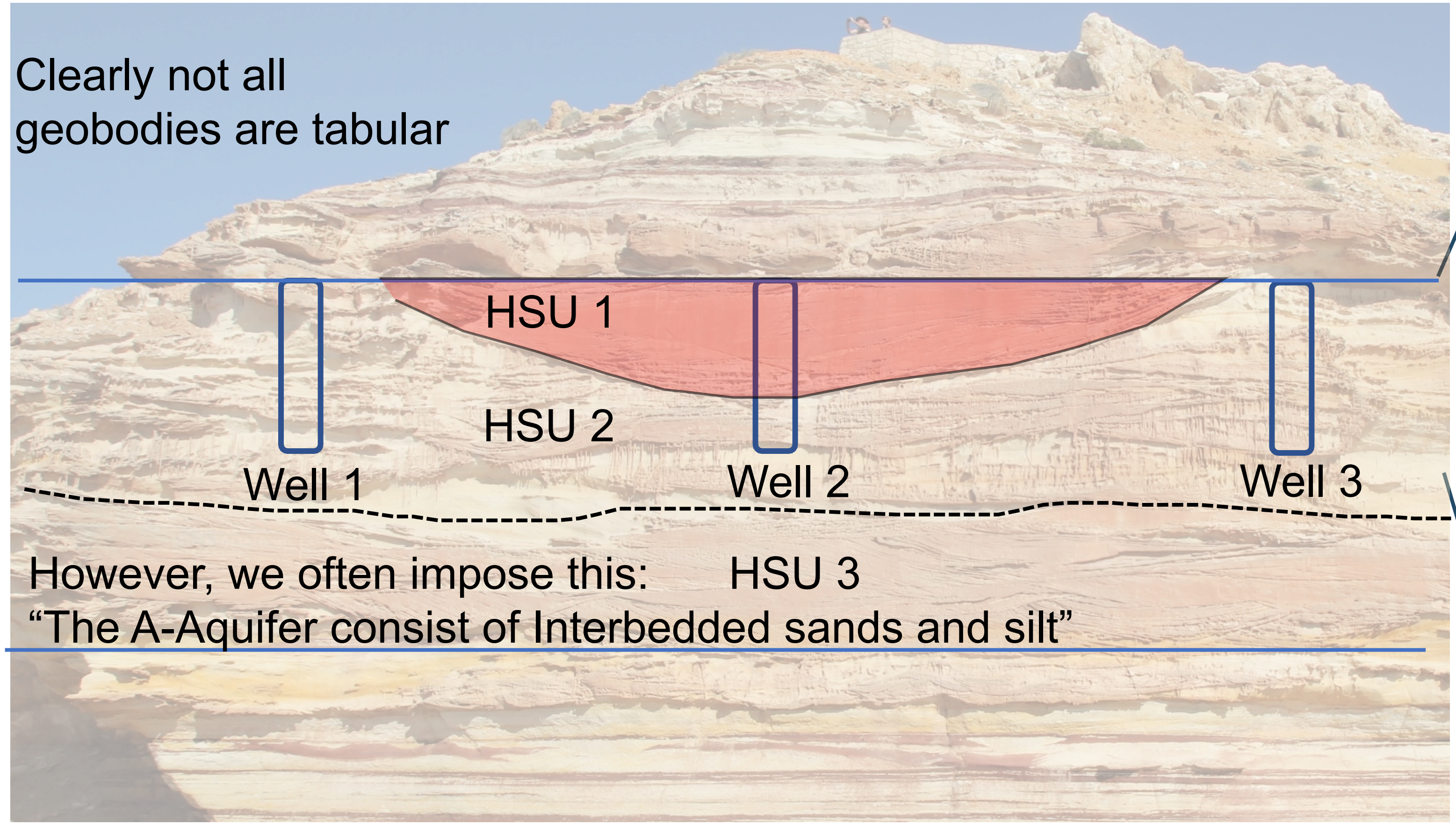
Stratigraphic Geometry

- Real vs. Interpreted Hydro stratigraphic unit continuity

Van Etten Creek, Oscoda, MI

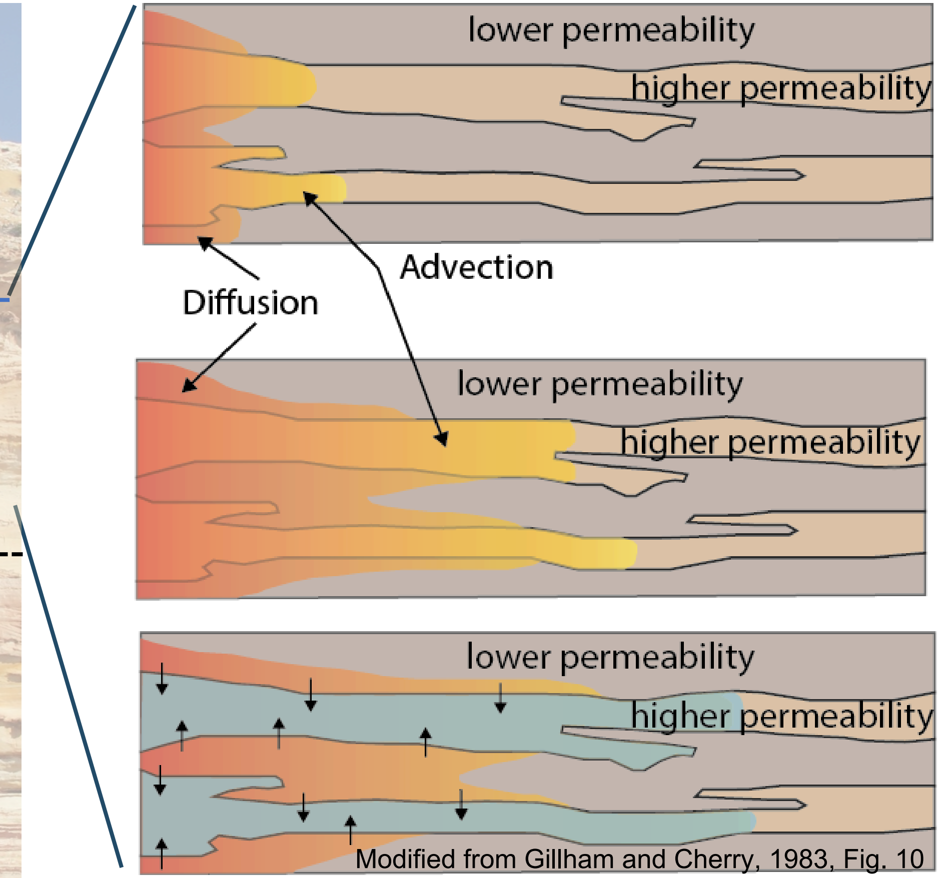
Impacts of Geometry and Heterogeneity

Geometry



Depositional geometry of HSU's can significantly impact hydraulic connectivity, well performance, and/or amendment efficacy and so must be addressed.

Heterogeneity



Diffusion of mass into fine-grained storage zones can lead to back diffusion and prolonged remediation time frames

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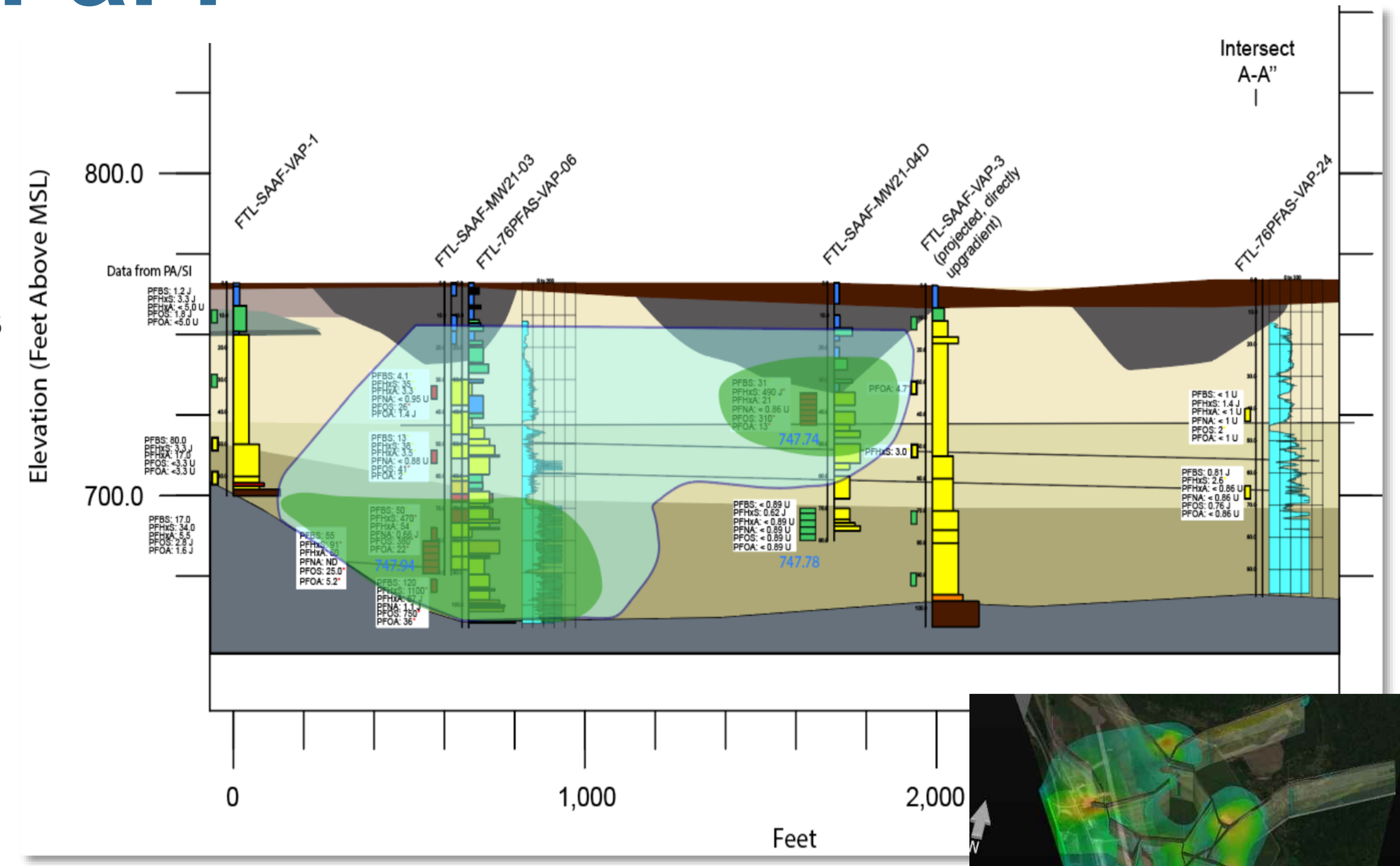
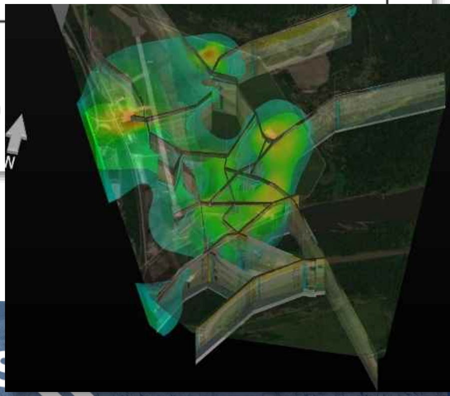
How Have We Tackled These Aspects of Complexity So Far?

- High-resolution site characterization (HRSC):
  - High-resolution in Z-dimension
    - Insight into heterogeneity and mass at a range of scales
  - Proxy data requires calibration to high-quality lithologic logs
- Advanced methods in stratigraphic correlation
  - Environmental Sequence Strat. and facies-based interpretations of HSU continuity
  - Leveraging HRSC and other new and legacy site data





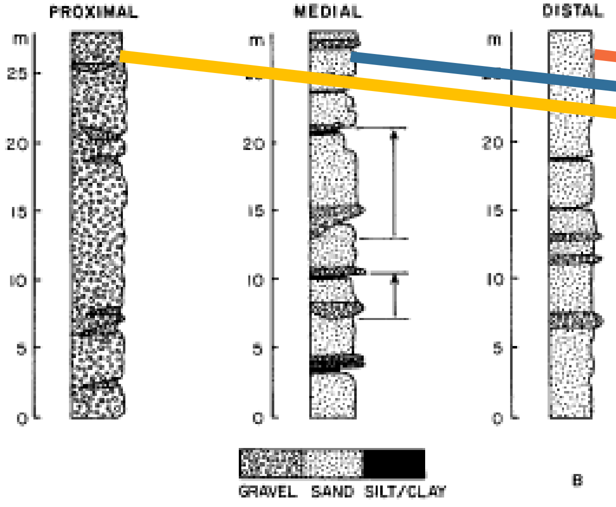
Environmental Sequence Stratigraphy (ESS) and Facies-Based Correlations

***Facies Analysis**: Characterization of geo bodies according to unique Lithological, Physical, and Biological Attributes*

Facies Model (Modern Analogue):
Distributive Fluvial System
(outwash fan)

Predictable Successions of Grainsize and Environment

Boring Logs



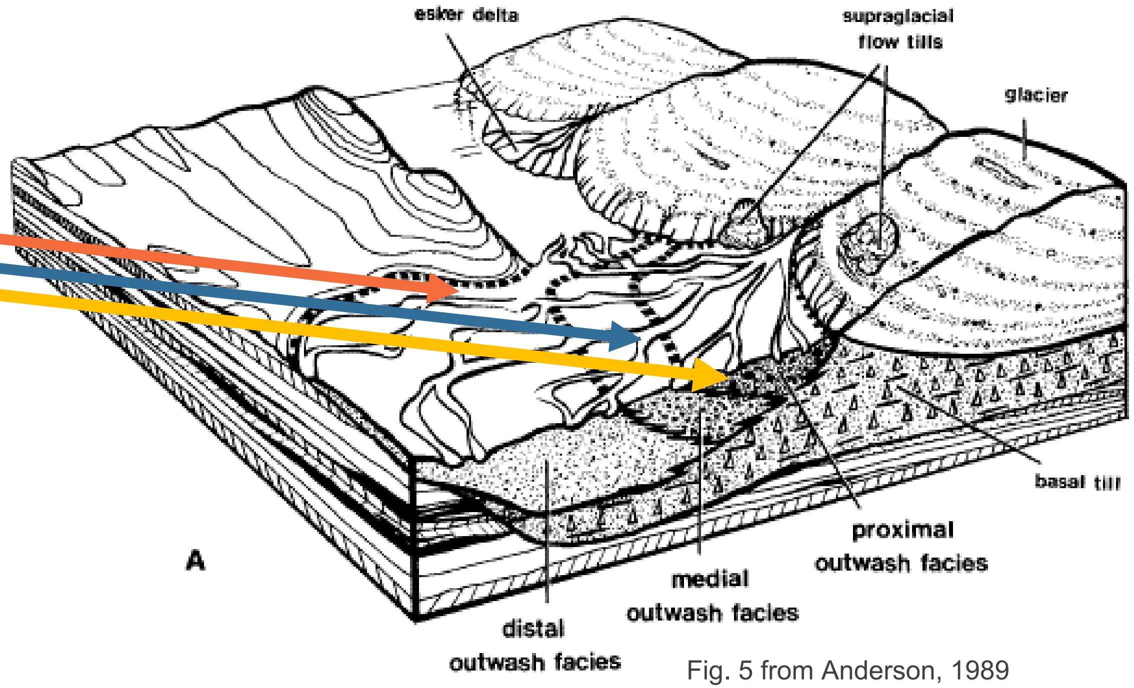
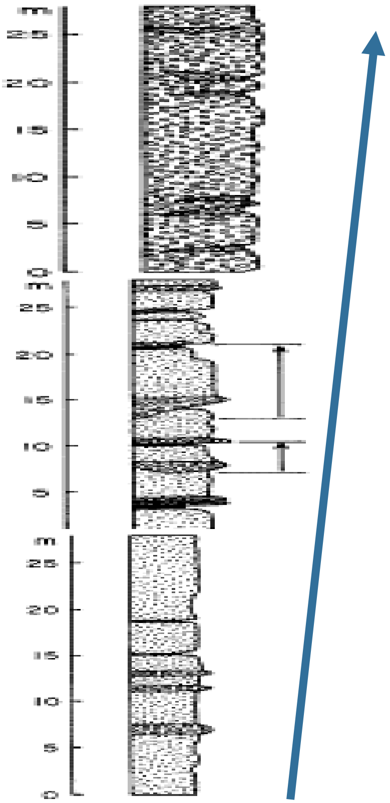


Fig. 5 from Anderson, 1989



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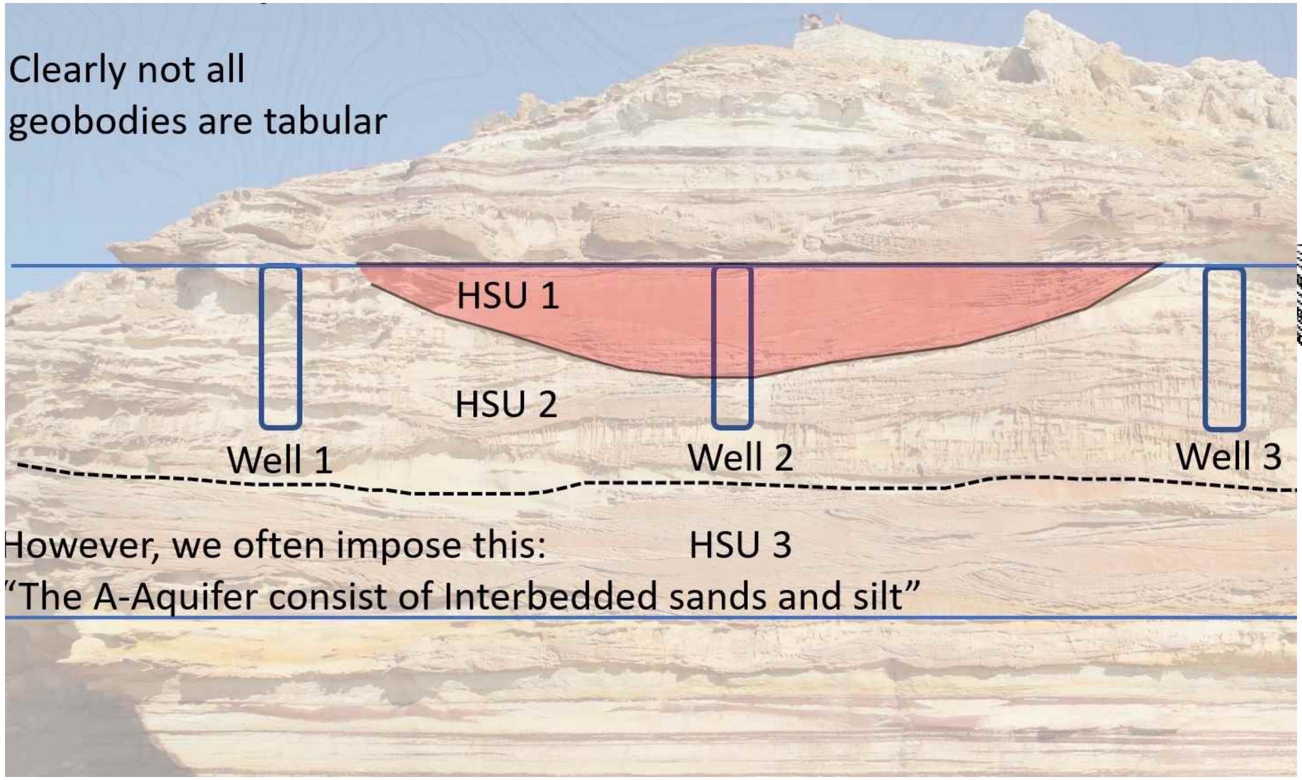
Facies Models Are Key: Geology Controls the Distribution of Permeability Contrasts



Facies Model:
Distributive Fluvial System
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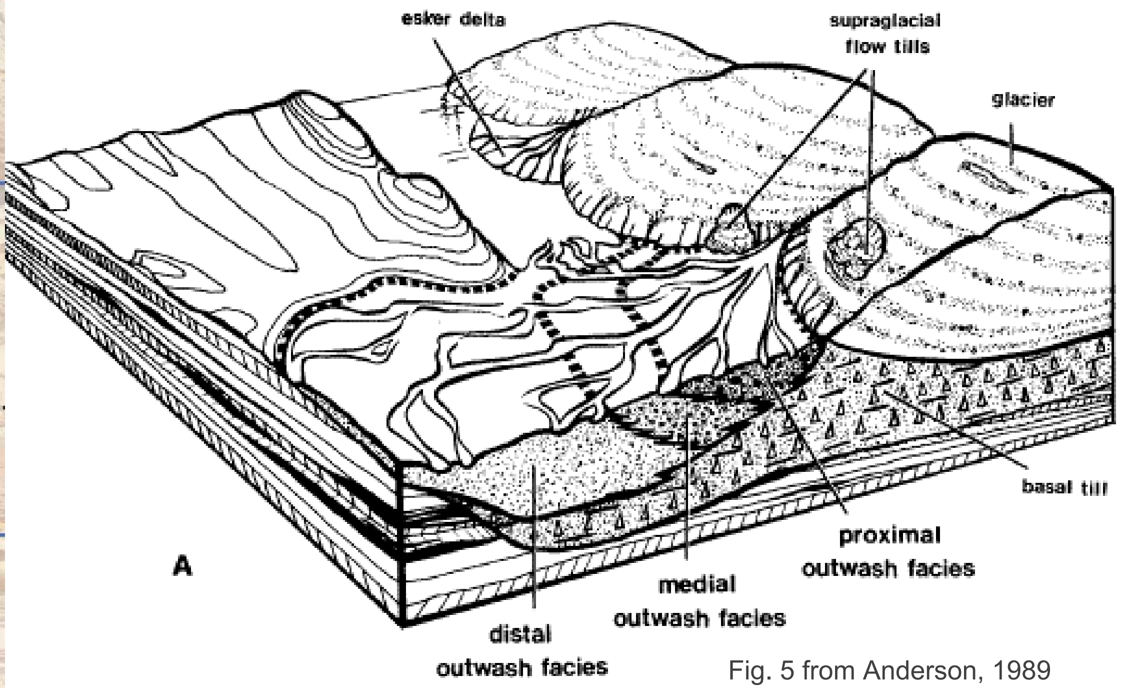


Fig. 5 from Anderson, 1989

Accurate Facies Analysis Depends on High Quality Observations From Borings

Data Types (After Catuneanu, 2006; Reineck & Singh, 1975)	Common	Uncommon	Never
Facies Model/Modern Analogue	■		
Sedimentary Lithology (Core)	■		
Grainsize description and/or visual % estimate	■	■	
Vertical Grading Trends	■		
Paleocurrent Indicators/Physical Sediment Structures		■	
Pedologic data (Soil indicators: color, organics, mineralogy, cementation)		■	■
Ichnology (biologic trace fossils), biostratigraphy			■
Outcrops/Exposures		■	
Well Log (Gamma log motifs)		■	
Direct Push Data (CPT, HPT, EC)	■		
Clay Minerology			■

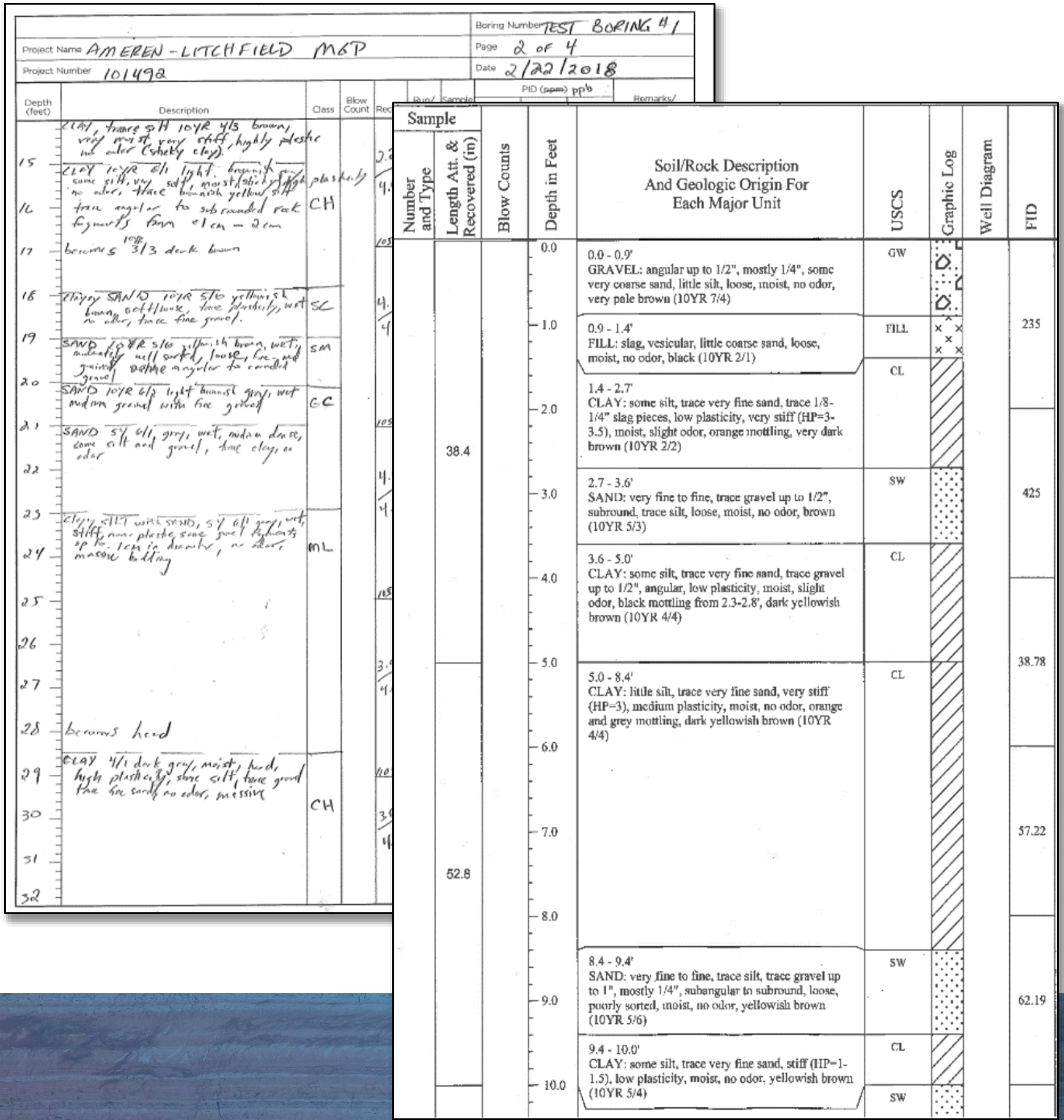
Improved Log Quality is Key

Facies Analyses in Environmental Industry are frequently conducted using practitioner's best judgement at a 50% Data Deficit

Improving Log Quality: Tools We Use to Collect Geologic Data From Borings

- Hand lens
- Grain size charts
- Munsell color charts
- Acid
- Soil knife
- Reference documents
- ***Logging Form***

Our Data Collection Tool is *Flawed*


Project Name AMEREN - LITCHFIELD MGP
Project Number 101492
Boring Number TEST BORING #1
Page 2 of 4
Date 2/22/2018

Sample: Number and Type	Length Att. & Recovered (in)	Blow Counts	Depth in Feet	Soil/Rock Description And Geologic Origin For Each Major Unit	USCS	Graphic Log	Well Diagram	FID
			0.0	0.0 - 0.9' GRAVEL: angular up to 1/2", mostly 1/4", some very coarse sand, little silt, loose, moist, no odor, very pale brown (10YR 7/4)	GW			
			1.0	0.9 - 1.4' FILL: slag, vesicular, little coarse sand, loose, moist, no odor, black (10YR 2/1)	FILL			235
	38.4		2.0	1.4 - 2.7' CLAY: some silt, trace very fine sand, trace 1/8-1/4" slag pieces, low plasticity, very stiff (HP=3-3.5), moist, slight odor, orange mottling, very dark brown (10YR 2/2)	CL			
			3.0	2.7 - 3.6' SAND: very fine to fine, trace gravel up to 1/2", subround, trace silt, loose, moist, no odor, brown (10YR 5/3)	SW			425
			4.0	3.6 - 5.0' CLAY: some silt, trace very fine sand, trace gravel up to 1/2", angular, low plasticity, moist, slight odor, black mottling from 2.3-2.8', dark yellowish brown (10YR 4/4)	CL			
	52.8		5.0–8.0	5.0 - 8.4' CLAY: little silt, trace very fine sand, very stiff (HP=3), medium plasticity, moist, no odor, orange and grey mottling, dark yellowish brown (10YR 4/4)	CL			38.78 / 57.22
			9.0	8.4 - 9.4' SAND: very fine to fine, trace silt, trace gravel up to 1", mostly 1/4", subangular to subround, loose, poorly sorted, moist, no odor, yellowish brown (10YR 5/6)	SW			62.19
			10.0	9.4 - 10.0' CLAY: some silt, trace very fine sand, stiff (HP=1-1.5), low plasticity, moist, no odor, yellowish brown (10YR 5/4)	CL / SW			

- Inconsistent data capture
  - Often missing critical data for geologic interpretation
- Long logging times (or incomplete logs)
- Loss of data for thin intervals
- Text format inhibits comparison with HRSC data & real time decision making
- Digitization is inefficient

Geologic data/insight are never fully utilized

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Graphical Approaches to Logging Promote High-Quality Data Capture

An Example Form

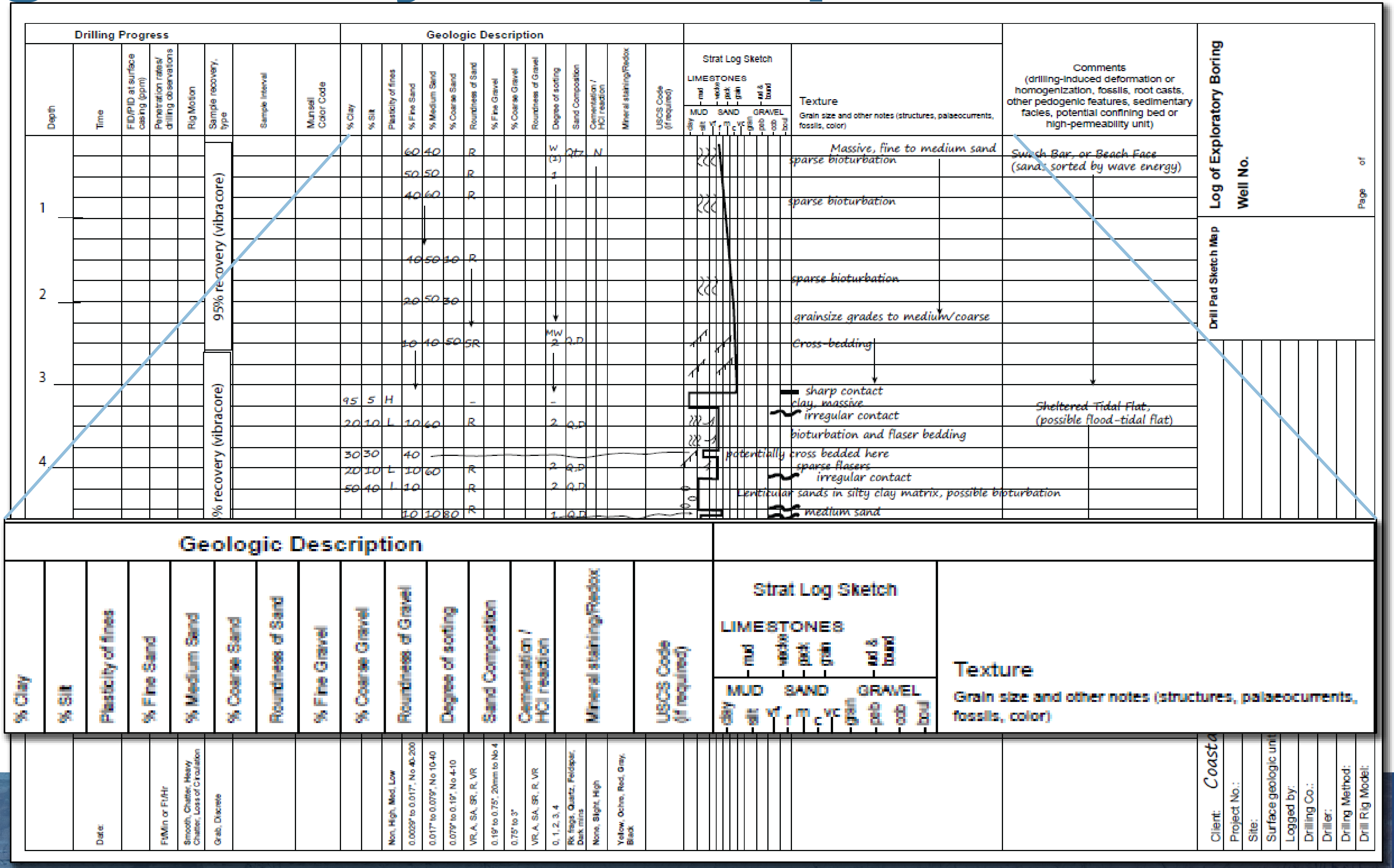
- Introduced in ~2017

A step in the right direction:

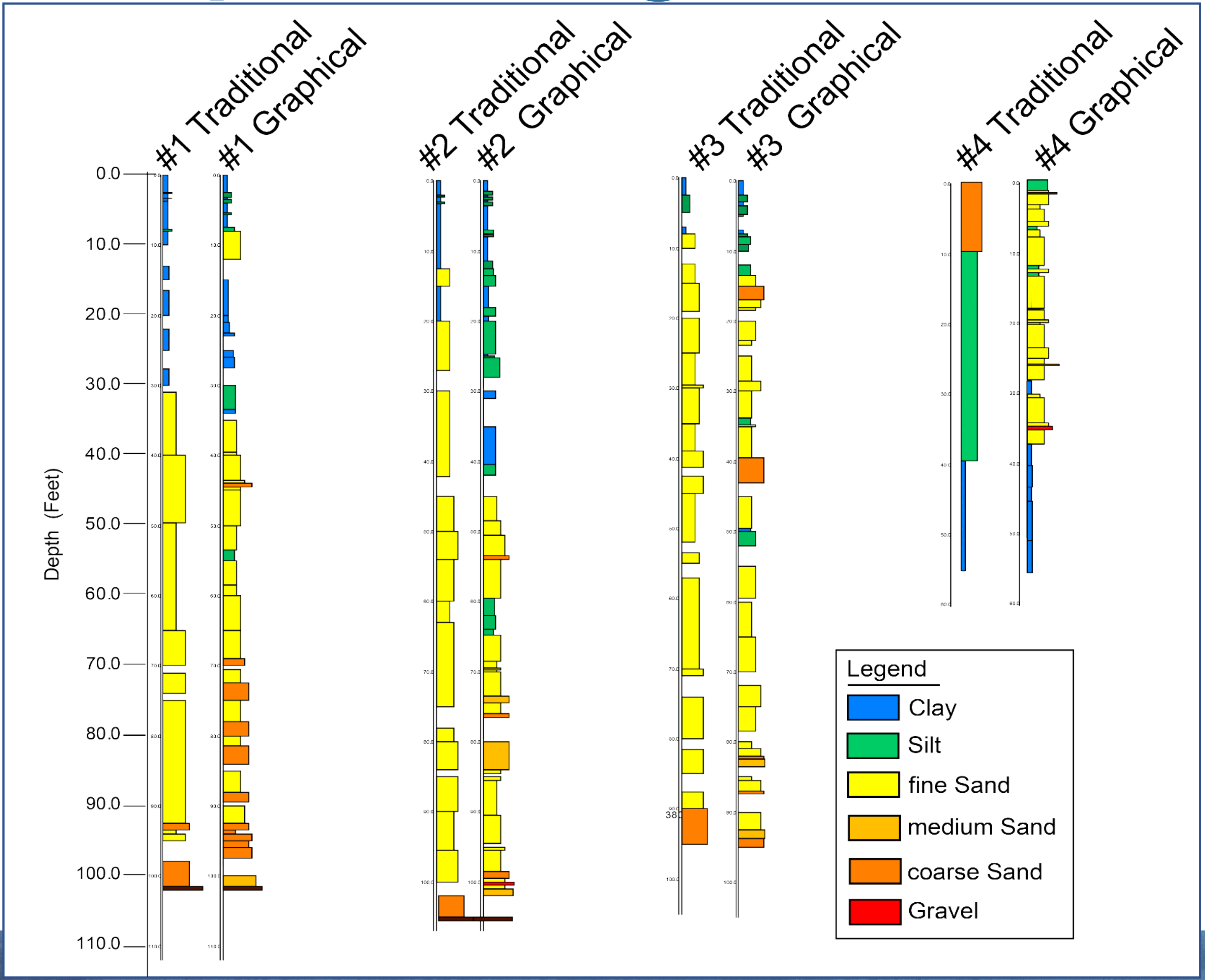
- Lots of data cues
- High-quality data
- Captured nature of contacts

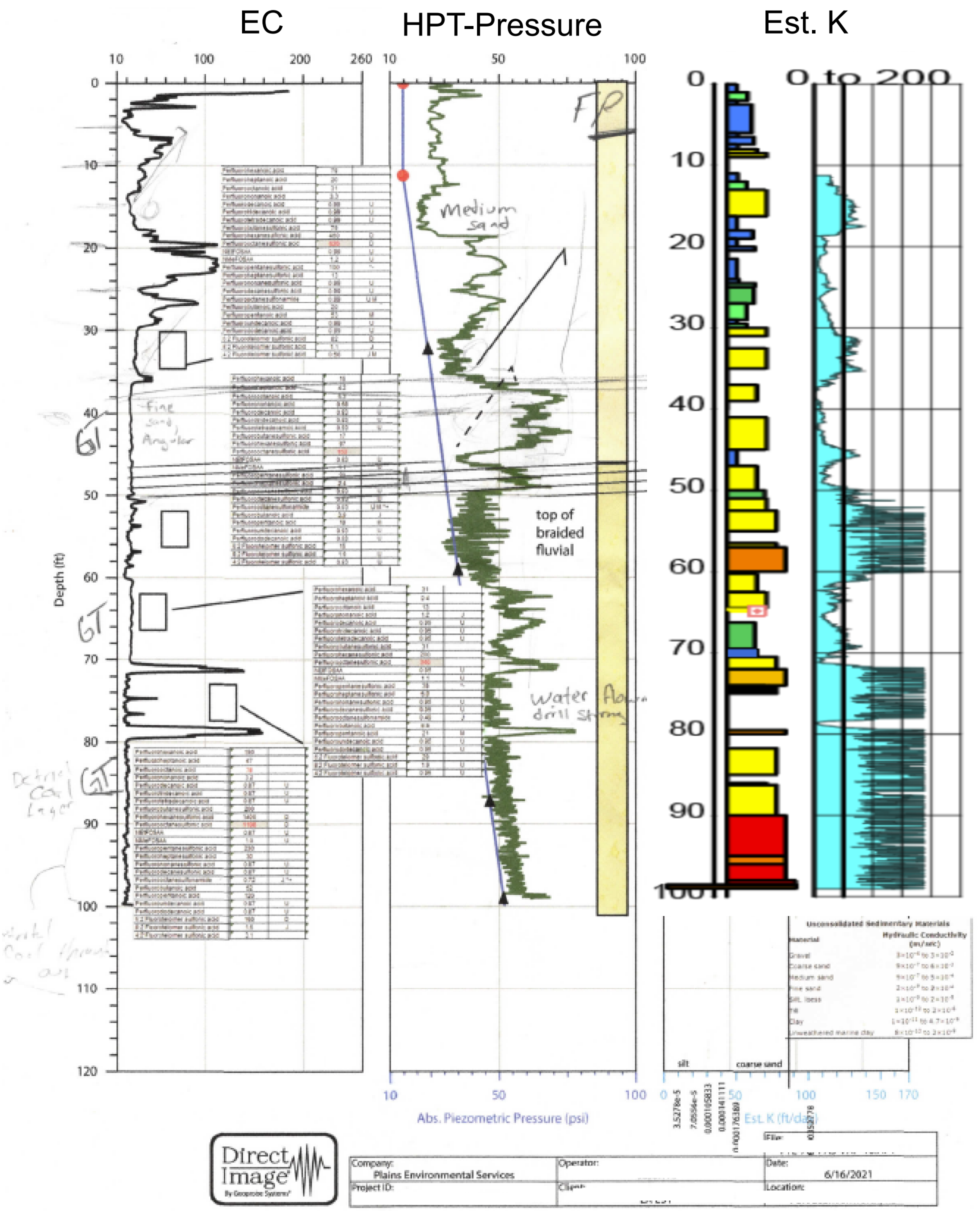
Drawbacks:

- Form was intimidating
- Difficult to make “report ready”
- Still relies on some paragraph-style input



Graphical Logs in Use





Published Approach to be Further Developed in 2023-2025 Time Frame

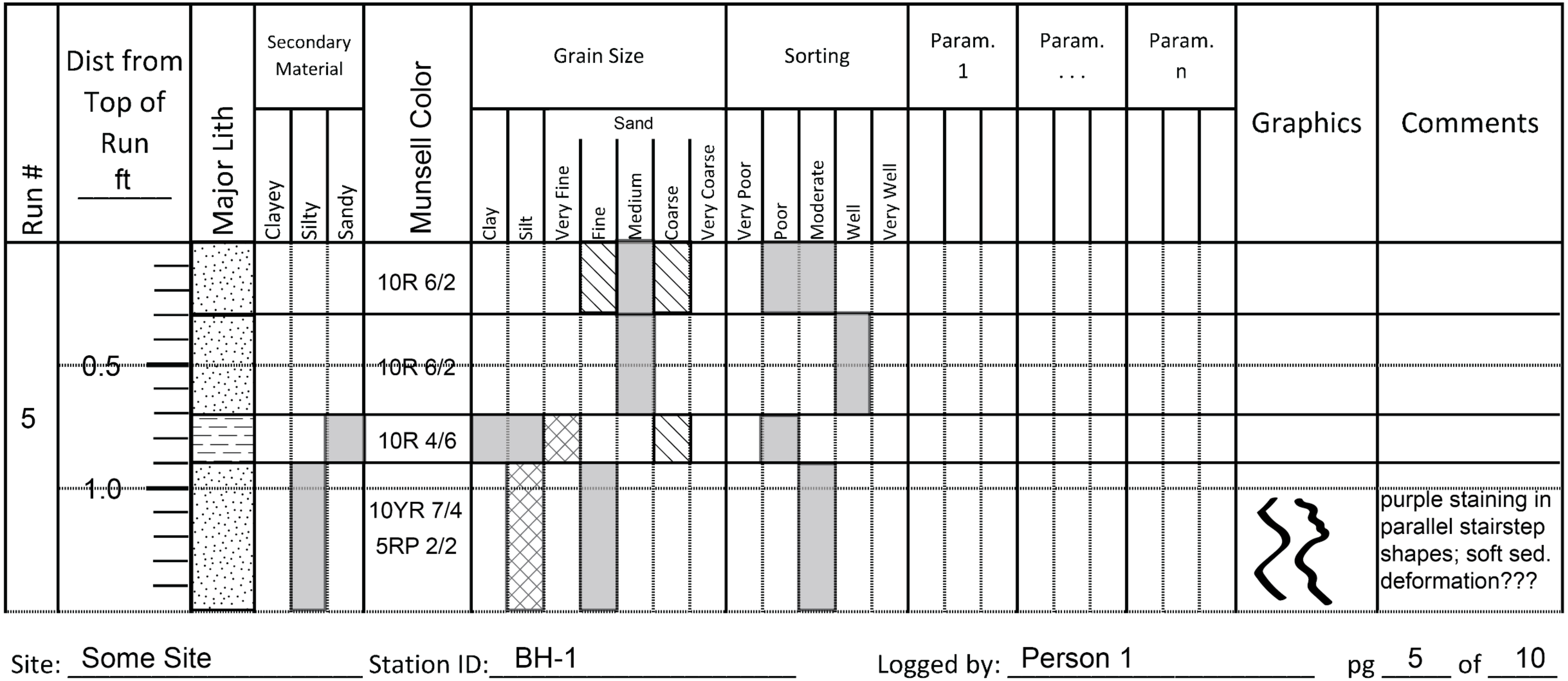
Groundwater Monitoring&Remediation

Graphical Shading Logs: An Improved Approach for Collecting High Resolution Sedimentological Data at Contaminated Sites

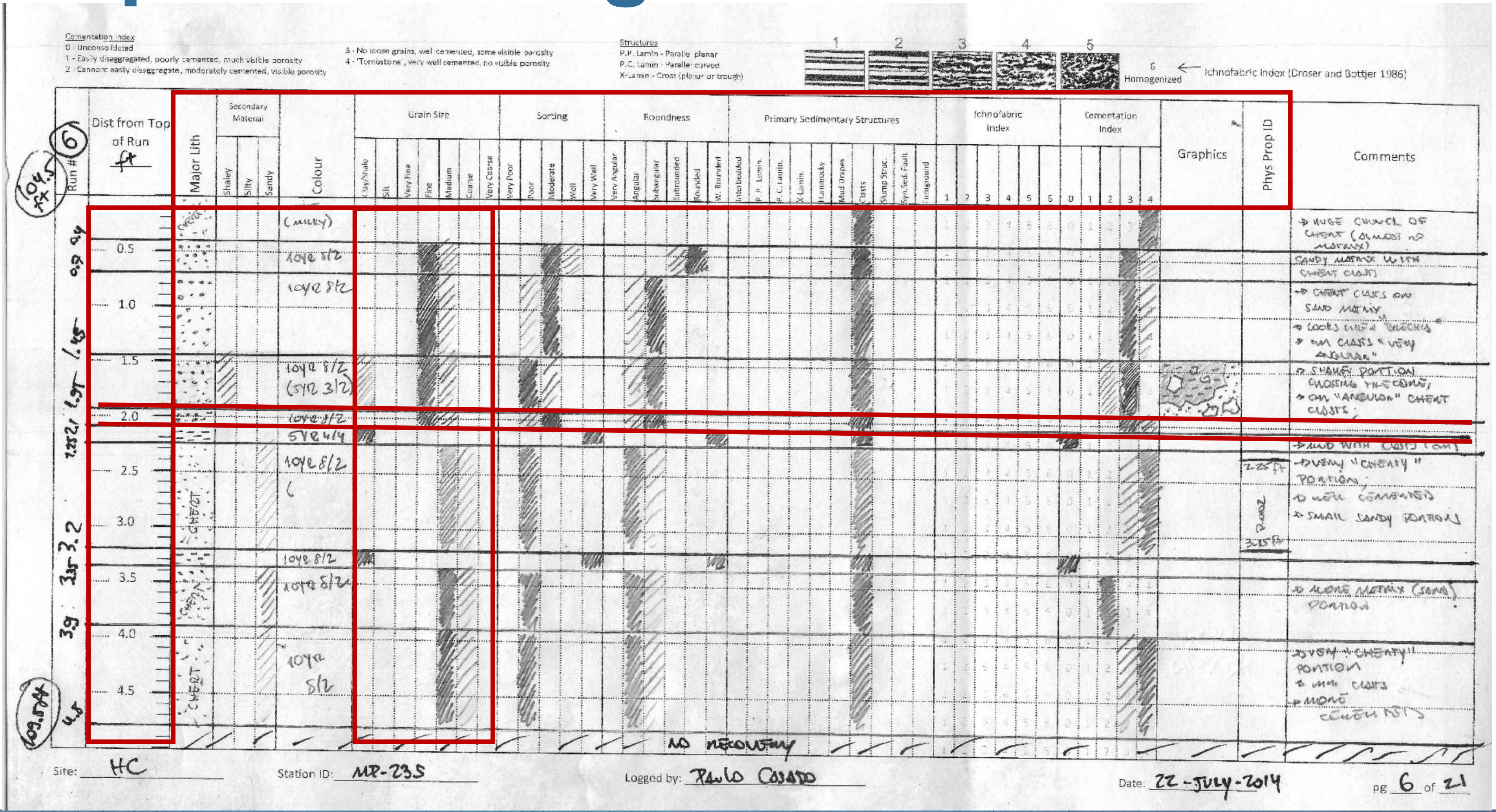
by Jessica Meyer, Jonathan Munn, Emmanuelle Arnaud, Jonathan Kennel and Beth Parker

GWMR, 2022, https://doi.org/10.1111/gwmr.12521

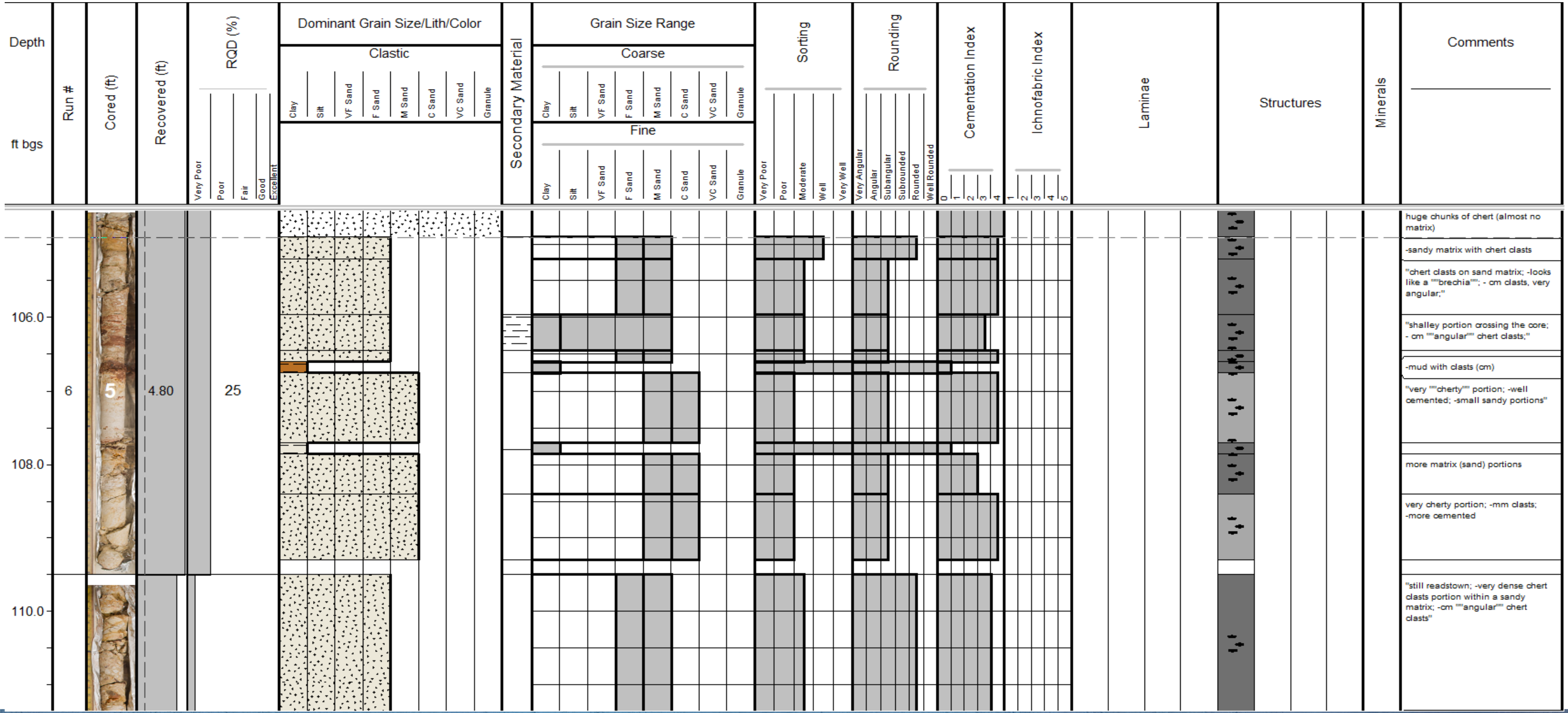
Graphical Shading Logs Provide a Next Step Solution



Example Field Log



Easy Digitization, Storage, Retrieval and Presentation of Geologic Data



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Graphical Shading Logs Provide a Solution

- Easily Learned
- Serves as a road map to guide loggers and ensure consistent collection of *all* important geologic parameters
- Facilitates efficient collection of geologic data
- Visual log immediately useful to support real-time decision making
- Data is amenable to quantitative analysis
- Is more efficient to digitize and/or make report ready

Geologic data can be used to its full potential

Proposal Number: *NA23-B1-7659*

Delivering a More Accurate, Representative, and Useful Geologic Log to the ESTCP Remediation Community

Task 1

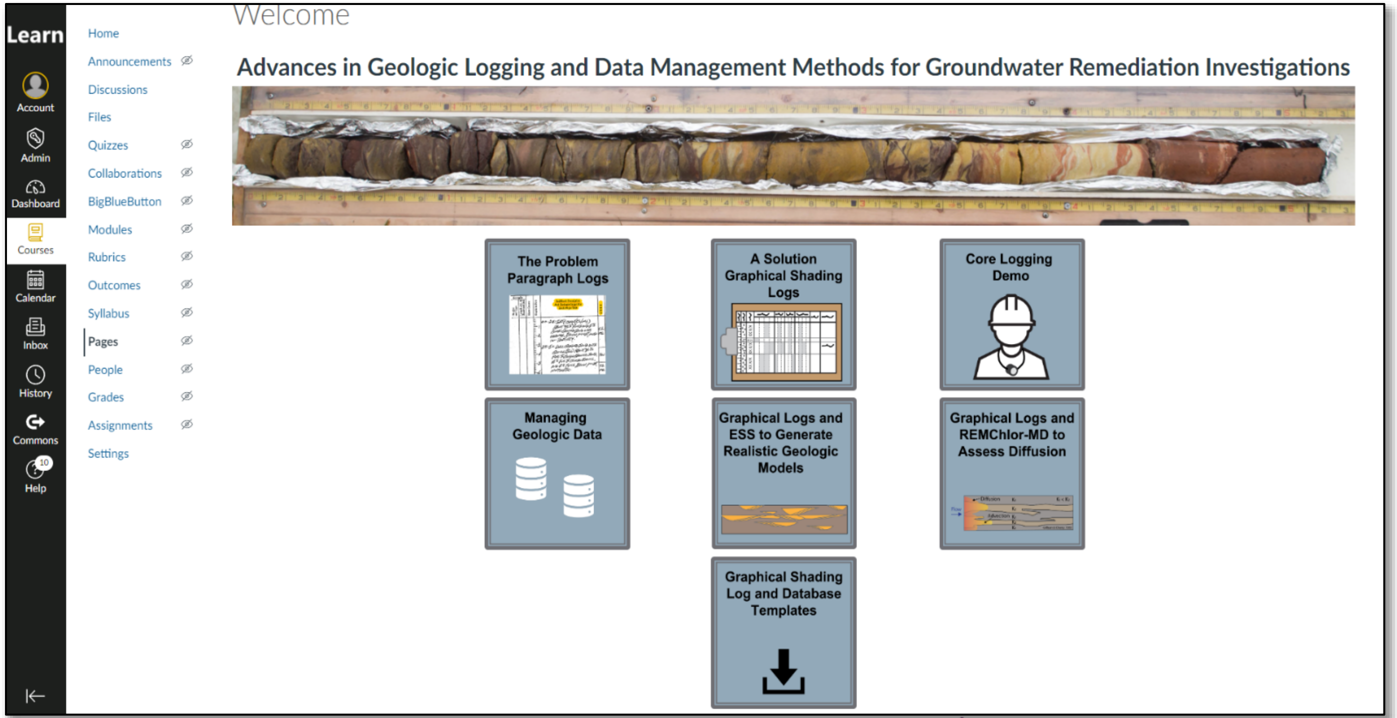
Developing Revised Forms, Reference Sheets & Open Access Tutorial for Graphical Shading Logs; Content To Support Working Professionals

Task 2

Developing a Core Logging Laboratory Activity for Post-Secondary Courses;
Case Study Demonstration of Improved Remediation out comes

Task 3

Technology Transfer Assessment



Industry conference demonstrations/panel discussions, social media, ESTCP flyer, Wikipedia article, explanimation video

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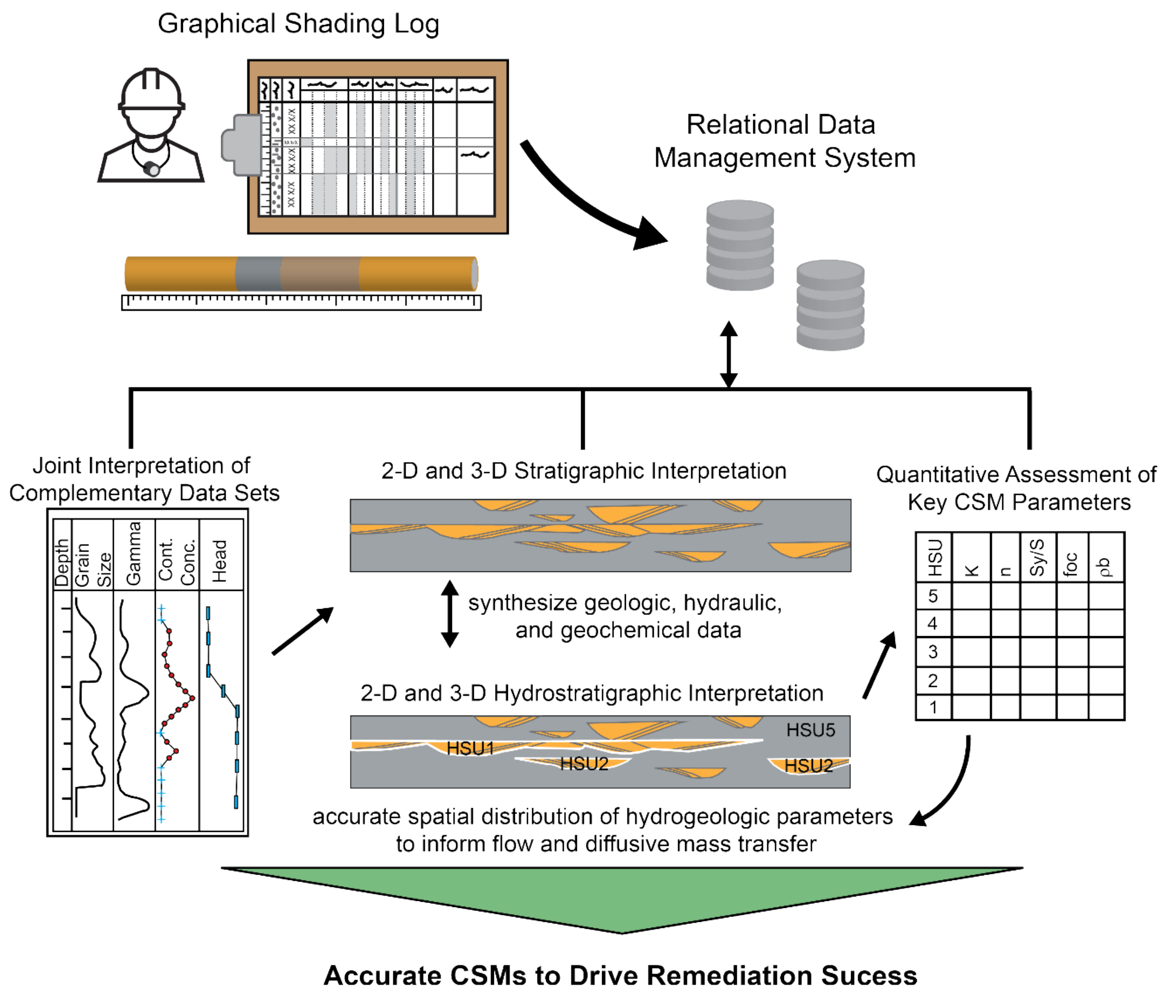
Graphical Geologic Logging: The Foundation for An Efficient CSM Workflow



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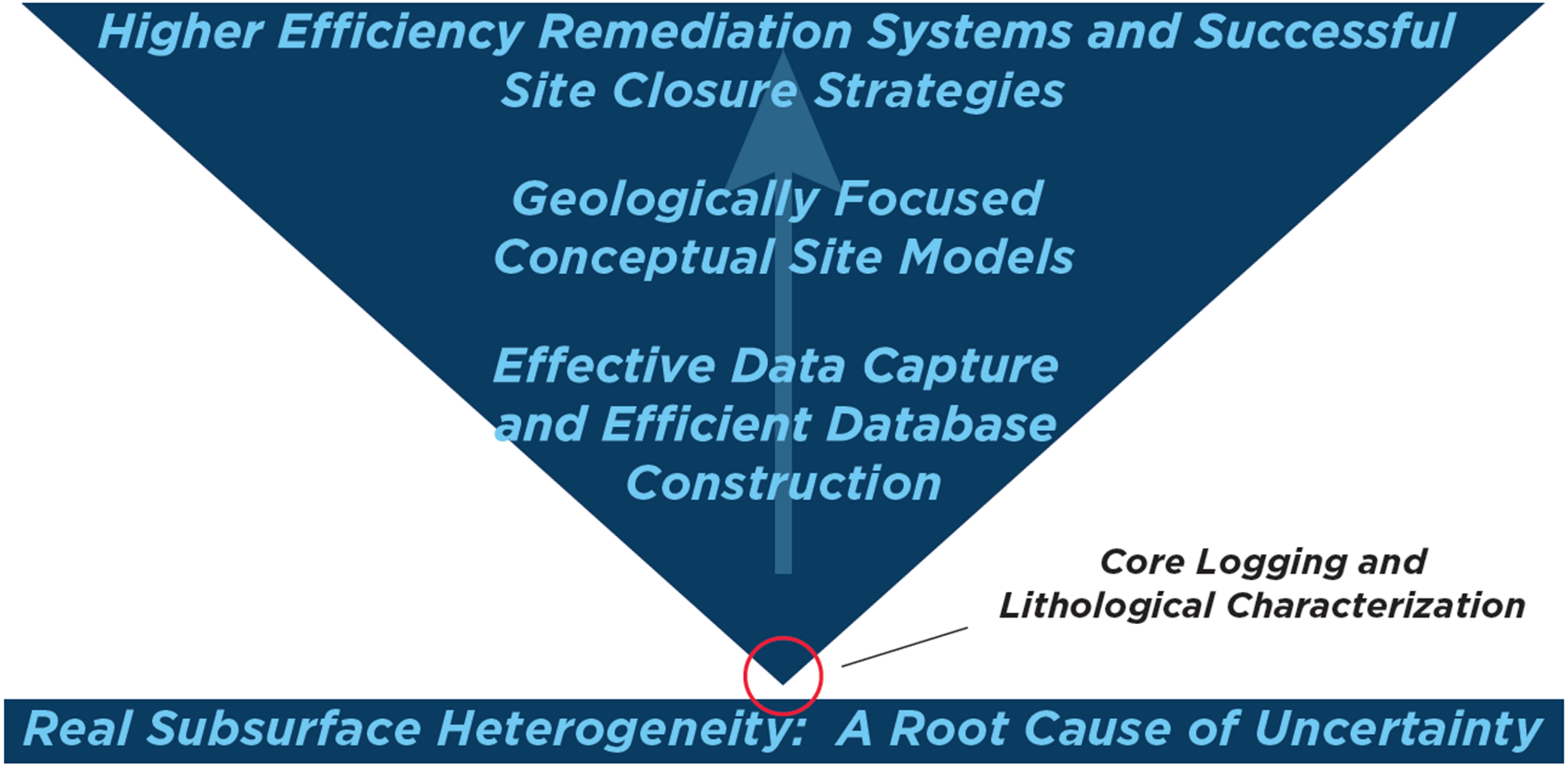
Thank you

The Geologic Log: Your Link To Reality



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