Understanding Subsurface Stratigraphy for PFAS Environmental Characterization using Modern Analogs

Junaid Sadeque (AECOM, Arlington, VA) | John Cuthbertson Ohr (AECOM, Grand Rapids, MI)

Battelle 2018 Chlorinated Conference April 8-12 | Palm Springs, CA

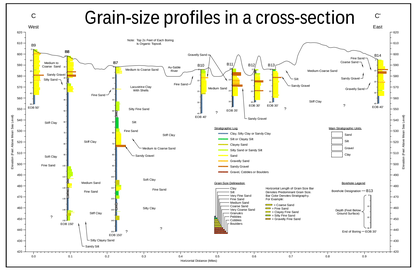
AECOM

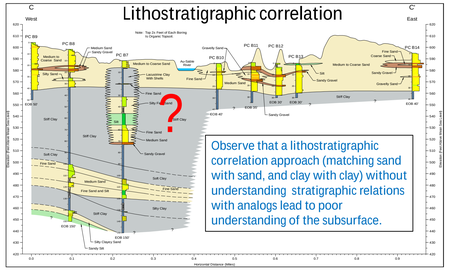
Introduction

Understanding the subsurface stratigraphy and facies architecture of a contaminated Site is essential to determining preferential contaminant flow pathways . However, limited or low-confidence borehole information in absence of continuous geophysical logs often presents a major challenge in accurately delineating the subsurface. In this study, we test if modern analogs from DEM and Google Earth images can effectively supplement subsurface interpretations where bore-hole information is insufficient.

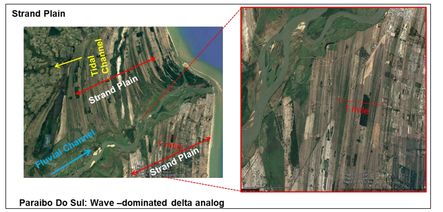
We produce stratigraphic cross-sections at the subject site that combine bore-hole information with modern analogs (DEM and Google earth images), as well as other areas with similar geological settings. Results of the study are then compared to previous lithostratigraphic interpretations at the Site.

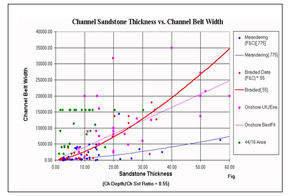
The Challenge of Subsurface Correlation





Applying Analogs from Similar Depositional Settings

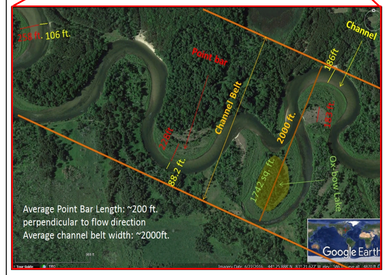




Channel width-thickness ratios from literature

Measured correlation dimensions and width-thickness ratios from present day deltaic analogs are applied to the dataset in order to generate a realistic subsurface correlation.

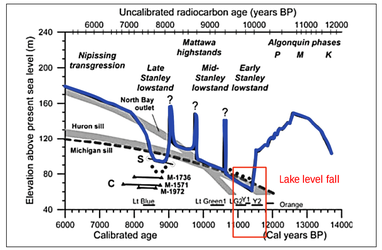
Study area for PFAS Contamination (Western Shore of Lake Huron)



Channel dimensions of present setting

Glacial History of the Study Area

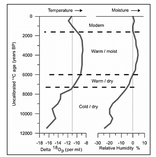
- Water bodies, ancestral to the present lakes including Lake Huron, first appeared in the southern Great Lakes basin about 18,800 years BP
- Water levels were significantly low between 11,470 and 8300 BP.
- May have risen several tens of meters for short periods due to glacial rebound and overflow of meltwater



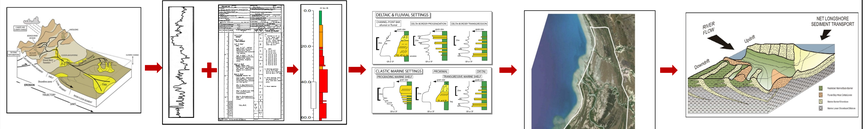
Glacial Advances

Larson, 1994; Larson and Schaetzl 2001

Climatic Control



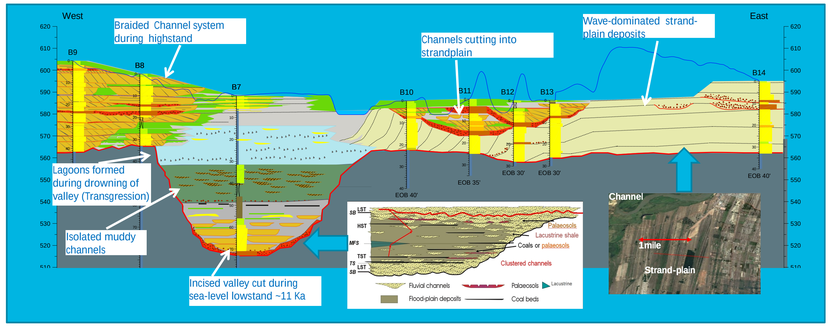
Relating Data to Analogs



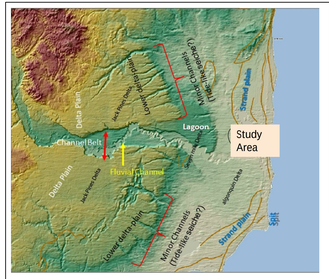
Modern analogues plays a central role in improving our understanding of subsurface facies architectures. They provide important information on size, geometry and potential connectivity of transmissve and non-transmissive units.

Determining the right analog is the greatest challenge!

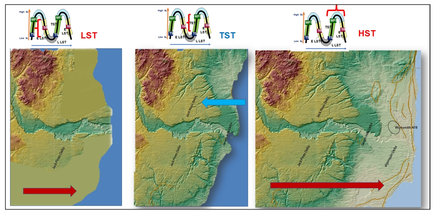
Sequence Stratigraphic Correlation



Using DEM Image as Stratigraphic Analog



DEM image revealing the geomorphology of the study area



The present day stratigraphy of the study area is largely controlled by lake-level fluctuations over time, causing progadation and retrogradation of the channel and strandplain deposits

Fluvial Dominated Phase
- Valley Incision
- Channel bars (in-valley)
- Delta plain/overbank
- Fluvial delta

Estuarine Phase
- Channel/Creek deposits
- Estuarine deposits (muddy)

Wave Dominated Phase
- Channel bars
- Overbank and splay deposits
- Strand-plains
- Wave-dominated Lagoonal deposits (muddy)

Conclusions

- The relation and connectivity of contamination flow-units cannot be understood by lithostratigraphy.
- Applying modern analogs and sequence stratigraphic principles significantly improve our understanding of the subsurface.
- The site area shows a complex stratigraphy, controlled by lake-level changes of the Lake Huron basin.
- Channel deposits and strandplain deposits are the major transmissible zones of contamination.
- The incised valley-fill deposits in the area are predominantly muddy, with isolated small channel bars.

References

- Catuneanu, O., 2007, Principles of Sequence Stratigraphy: Oxford, Elsevier.
- Giosan, L. and Bhattacharya, J.P., 2005, New Directions in Delta Research, In: Giosan, L., and Bhattacharya, J.P., (eds.). River Deltas: Concepts, Models and Examples, SEPM Special Publication, v. 83, p.3-10.
- Lewis, C.F. & W. Heil, C & Hubeny, J & King, John & Moore, Ted & K. Rea, D. (2007). The Stanley unconformity in Lake Huron basin: Evidence for a climate-driven closed lowstand about 7900 14C BP, with similar implications for the Chippewa lowstand in Lake Michigan basin. Journal of Paleolimnology. 37. 435-452.
- Larson, G. & Schaetzl, R. 2001. Origin and Evolution of the Great Lakes. Joumal of Great Lakes Research 27, 518546.
- Lowry, P. and Raheim, A., 1991. Characterisation of Delta-front sandstones from a fluvial-dominated delta system. In: Reservoir Characterisation II, eds: Lake, L.W., Caroll, H.B. and Wesson, T.C. Academic Press, Inc.