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Subsurface Depositional Environment of a Site in South Dakota, and Its Role in Bioremediation Strategy

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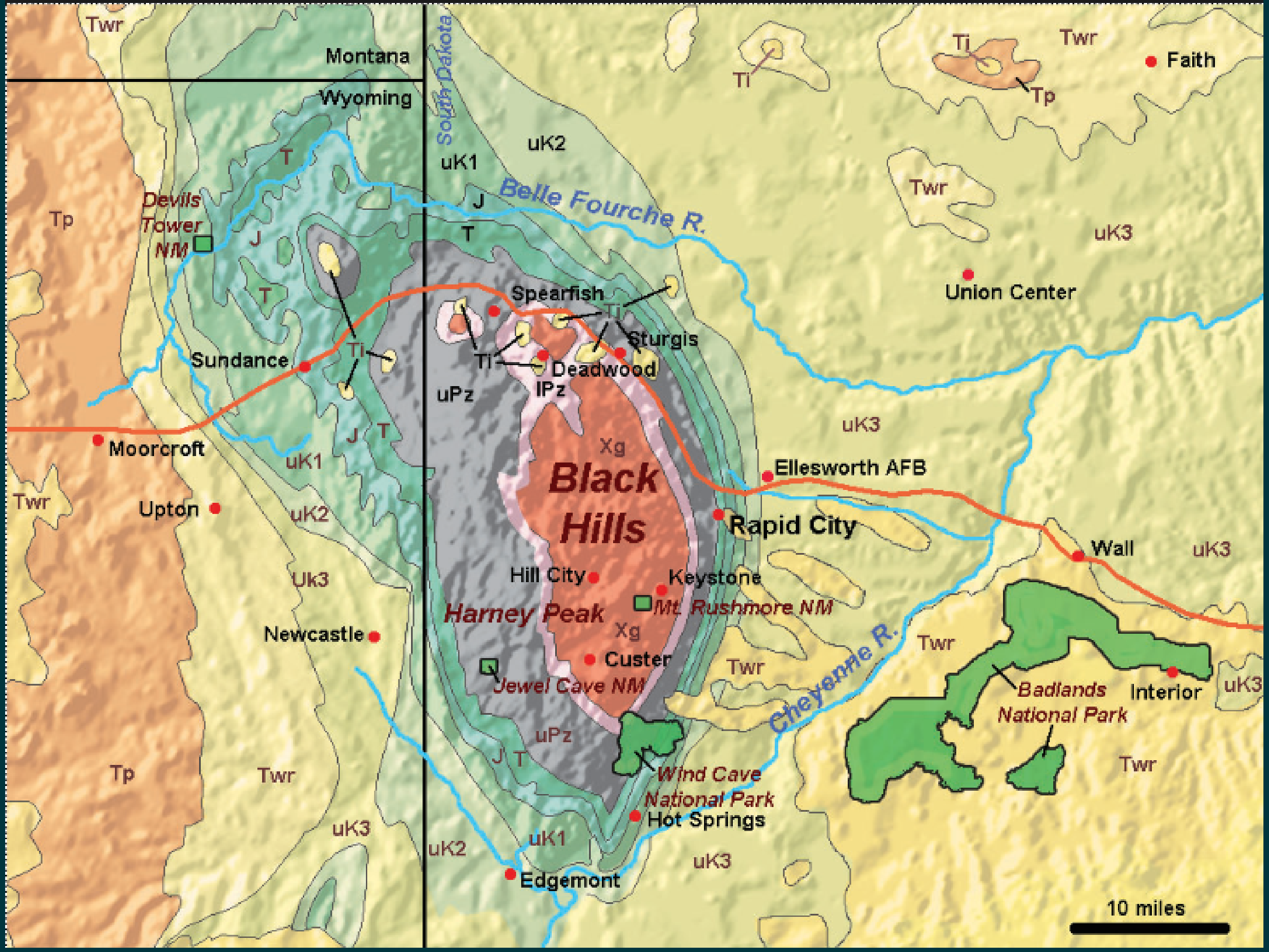
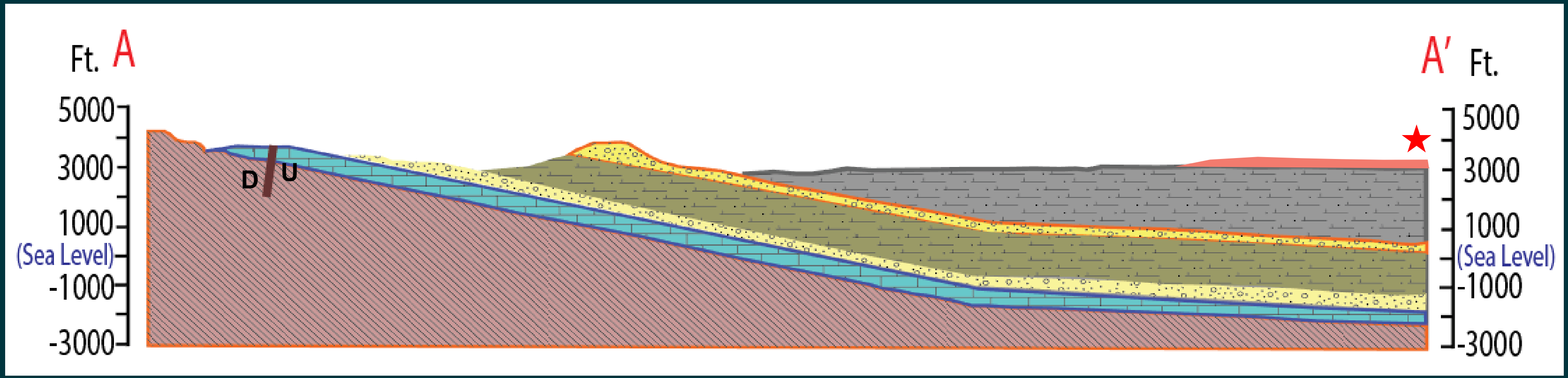
Site Regional Geology

- Uplift of the Black Hills occurred during the Paleocene and Eocene (Redden and DeWitt 2008). The event uplifted and deformed rock units of Precambrian, Paleozoic, and Mesozoic age.
- On the eastern flank of the Black Hills, these units generally dip gently to the east-northeast (USGS 1975)
- During the most recent periods of erosion, channels on the eastern flank of the Black Hills incised into bedrock and formed a series of alluvial terraces at varying elevations above the current creek beds (Plumley 1948; Stamm et al. 2013).



Regional Aquifers of South Dakota

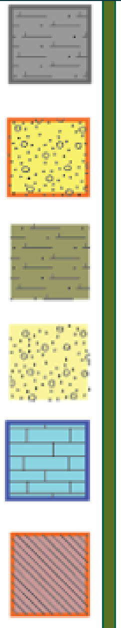
Aquifers in the Rapid City Area, SD (modified after USGS Survey, 1985)



Pleistocene-Holocene aquifer: Sandstone, silt, shale

★ Site Location

D/U Fault



Upper Cretaceous confining unit (e. g. Pierre Shale): Shale with minor limestone

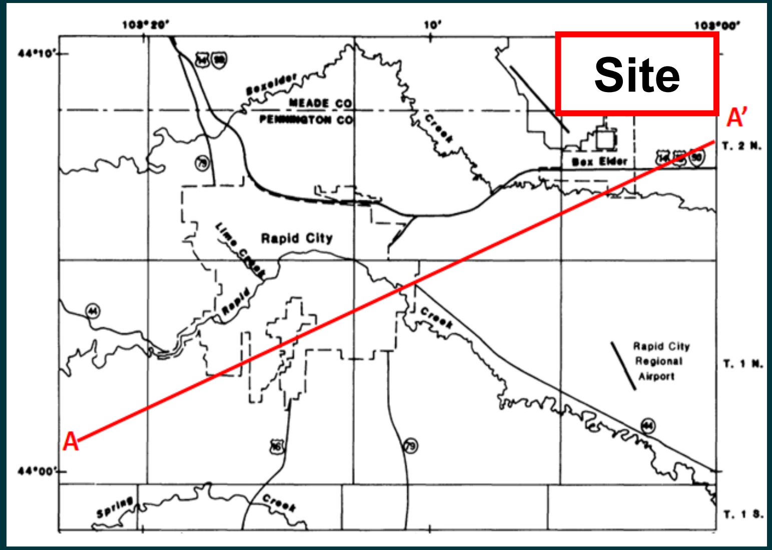
Inyan Kara Group (major lower Cretaceous aquifer): Sandstone, silt, shale

Permian- Triassic-Jurassic confining unit: Shale, minor limestone, sandstone

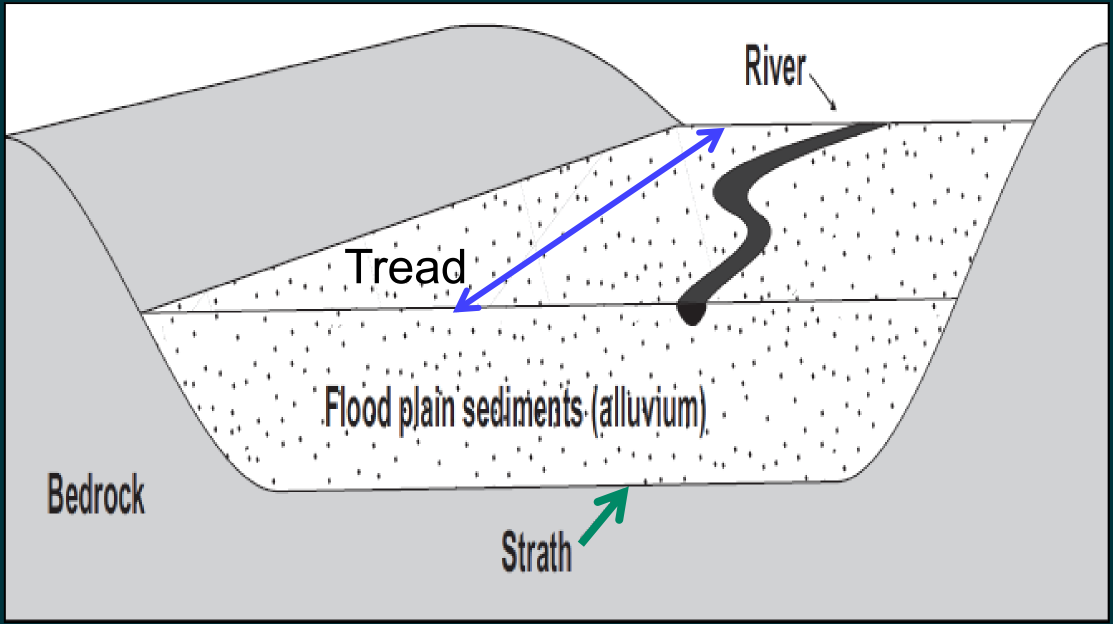
Minnelusa Formation (major Pennsylvanian aquifer): sandstone & dolomite

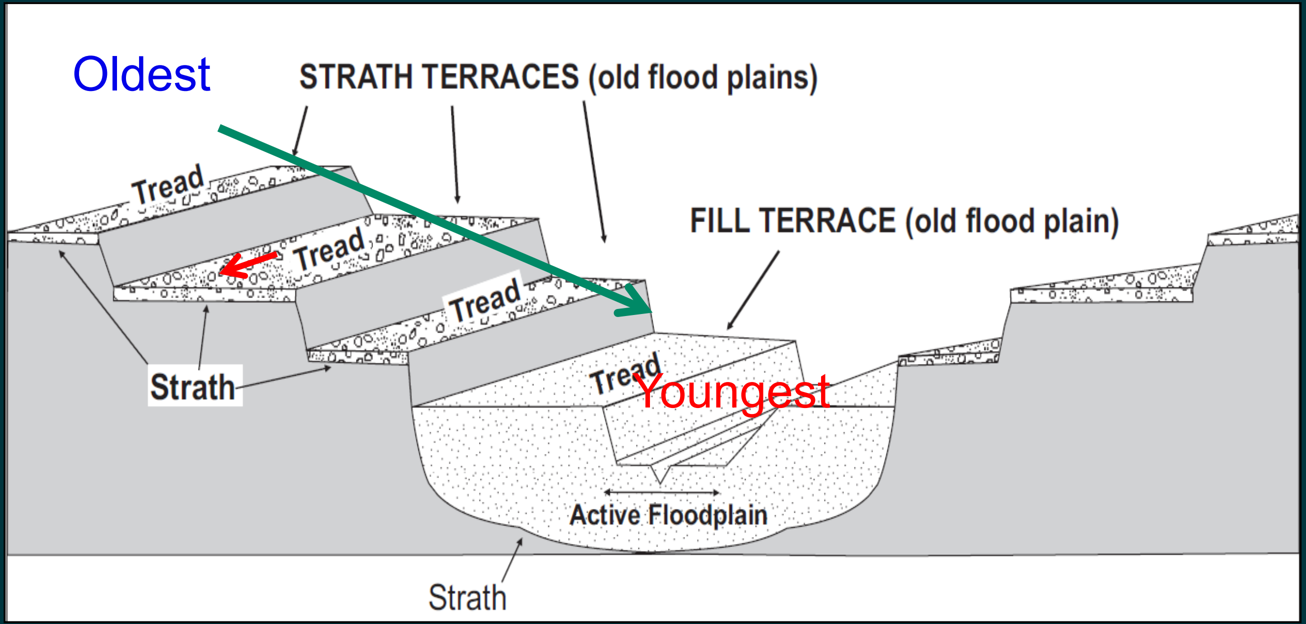
Madison Limestone (major Mississippian aquifer): limestone & dolomite

Deadwood Formation (minor Precambrian aquifer): schist, Limestone, sandstone , and shale



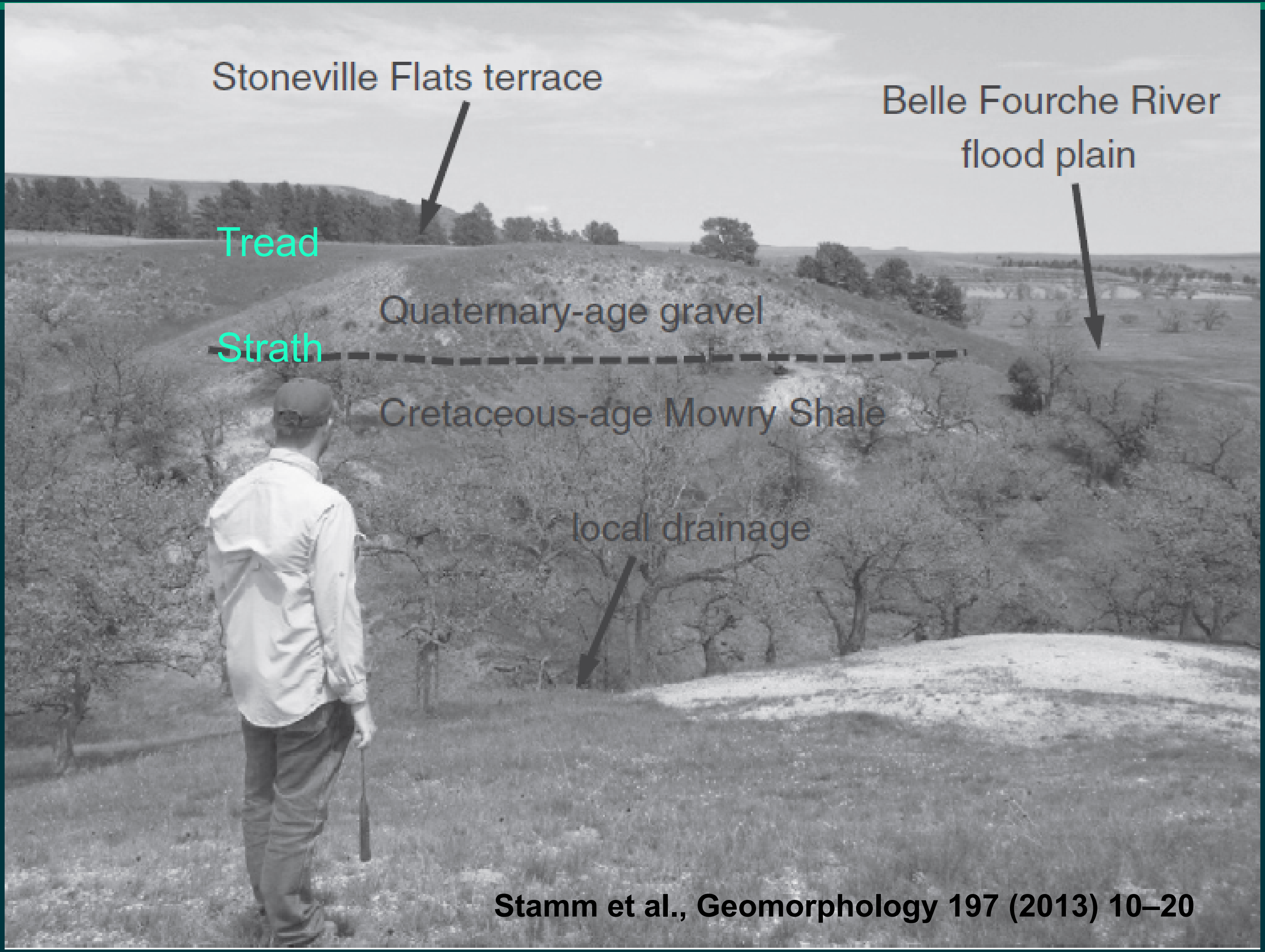
Concept of Strath Terraces

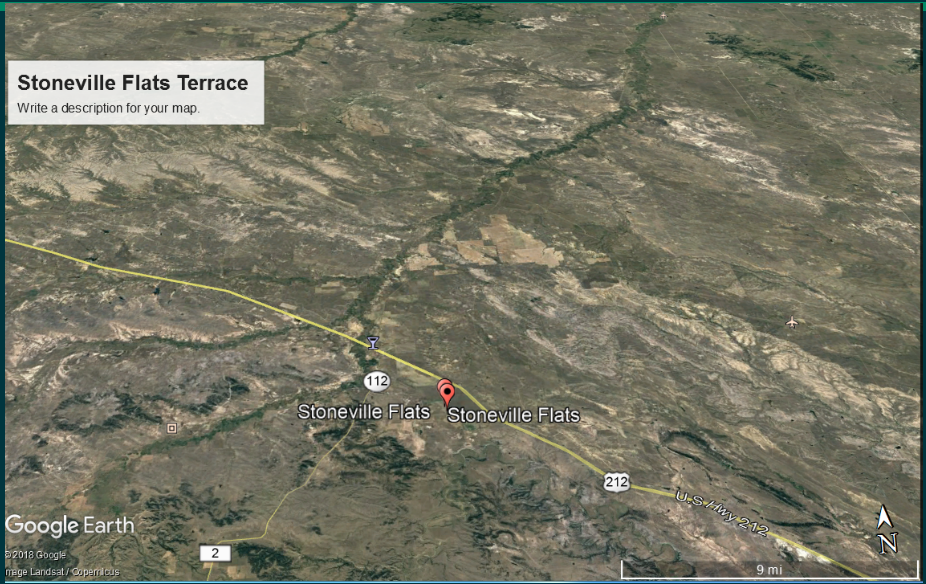




- The contact of the river deposits with the eroded bedrock surface below them is called the strath. The top of a strath is called a 'tread'.
- Straths terraces represent old, stranded (remnant) floodplains of a channel that were previously flowing at a higher elevation
- Along-valley strath terrace profiles can be used to determine in what direction the river was flowing when the terrace deposits were still part of the active floodplain.

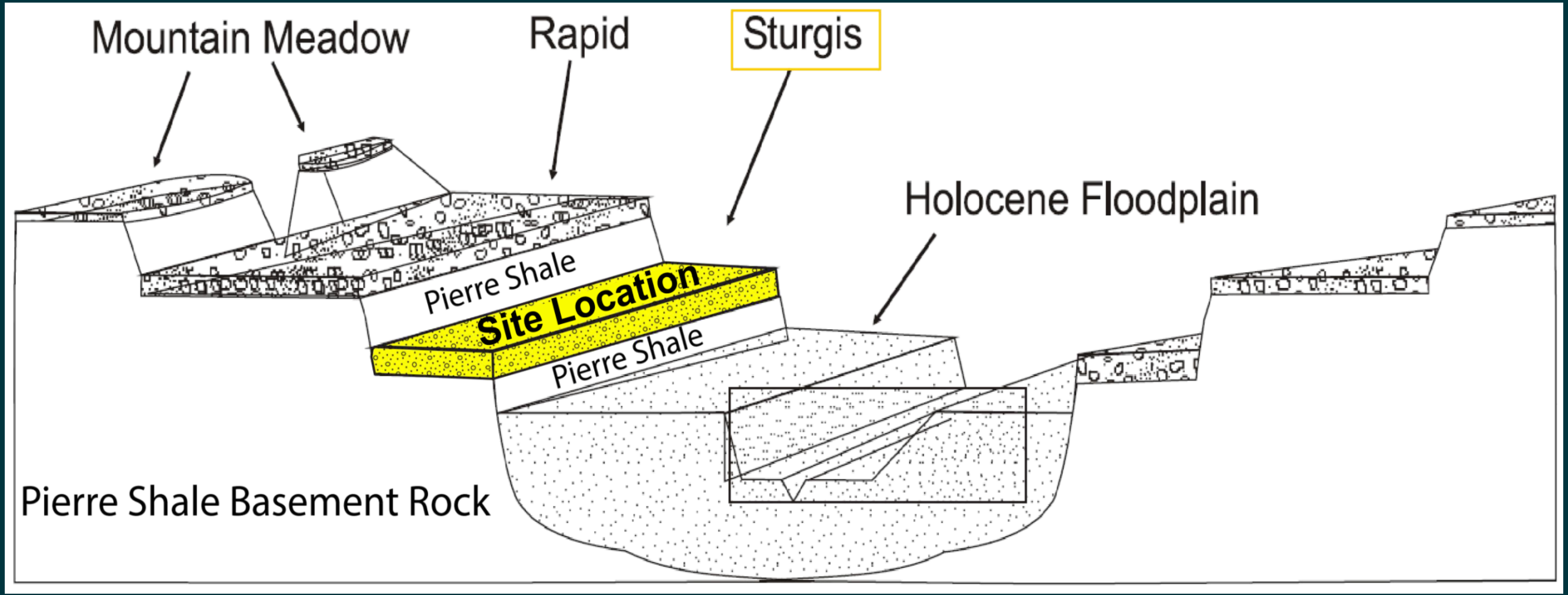
Concept of Strath Terraces: Outcrop Example





Stoneville Flats Terrace (strath terrace) developed on Cretaceous-age Mowry Shale, example from Wyoming

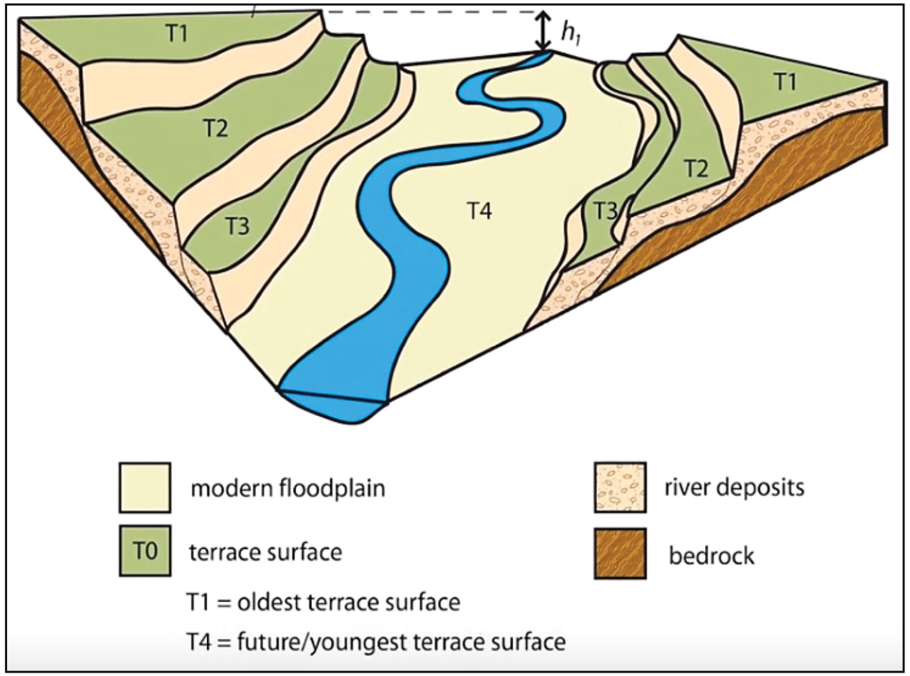
Strath Terrace of South Dakota



- Terrace are correlated regionally between South Dakota, Wyoming and Montana
- Site is on the Sturgis Strath Terrace, dipping southeast
- Timing of fluvial deposition on the correlates with the late Wisconsinan/ Pinedale glaciation and the Last Glacial Maximum.

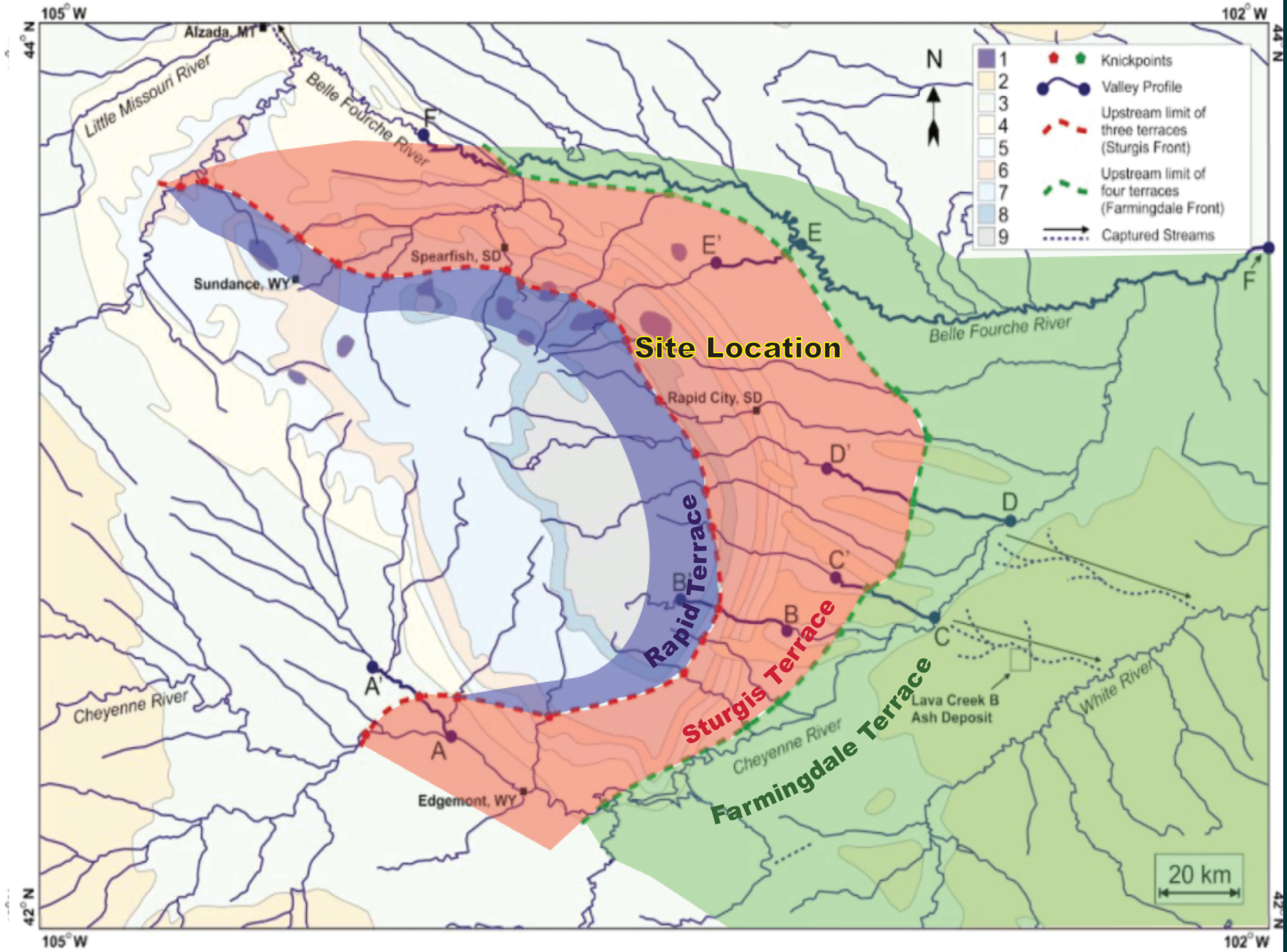
Strath Terrace of South Dakota

A

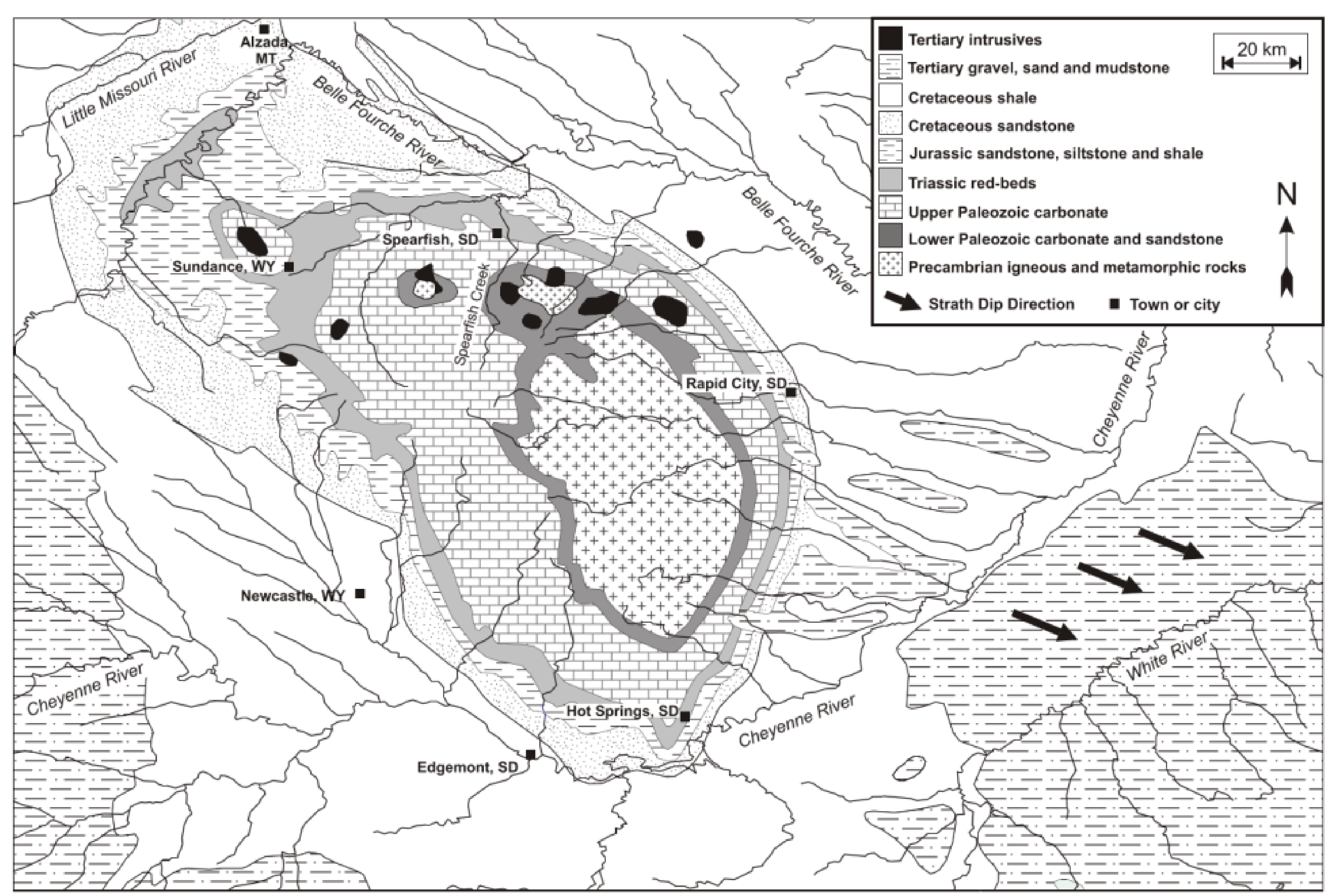


Concept Of River Terraces

B



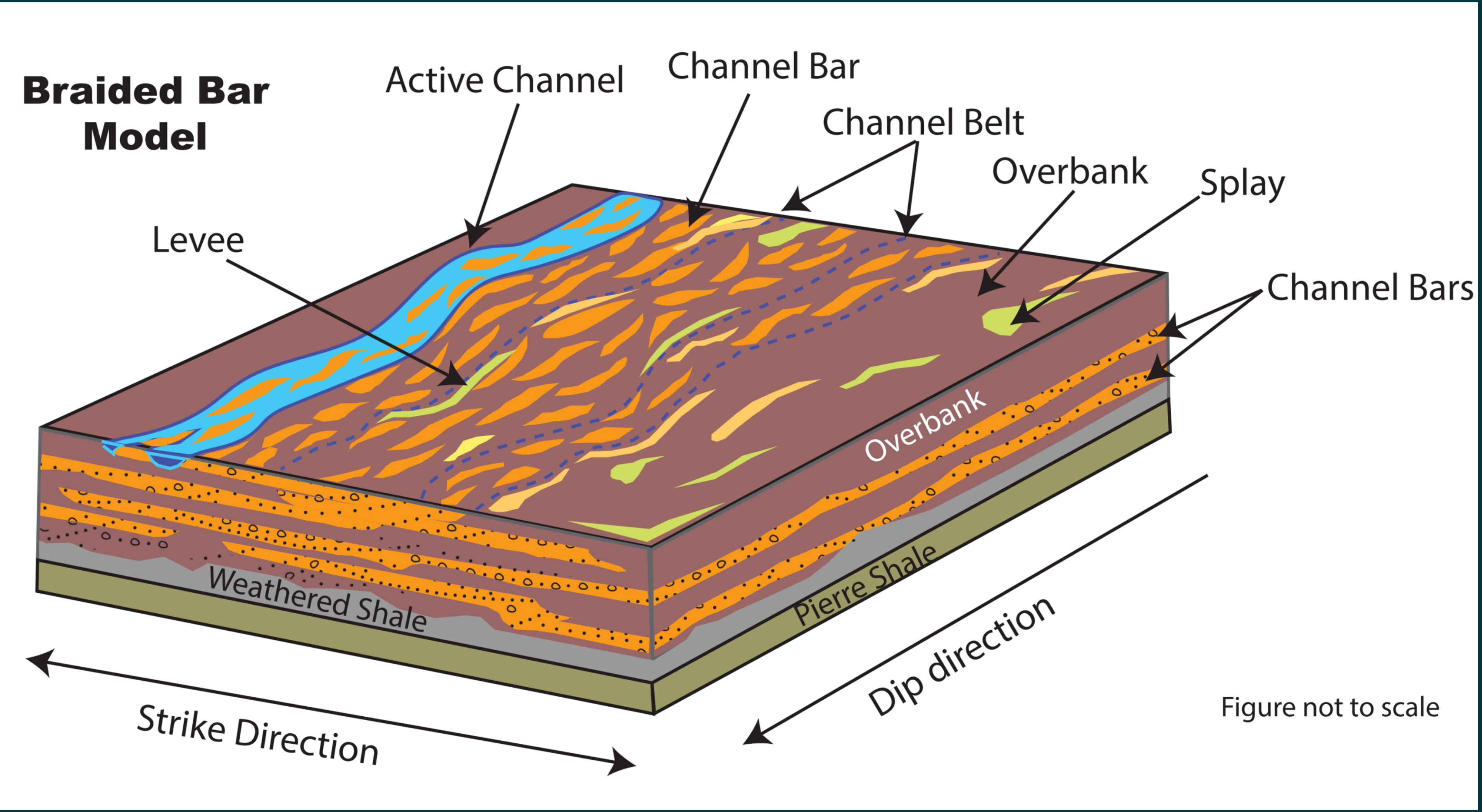
Regional Stratigraphic Dip



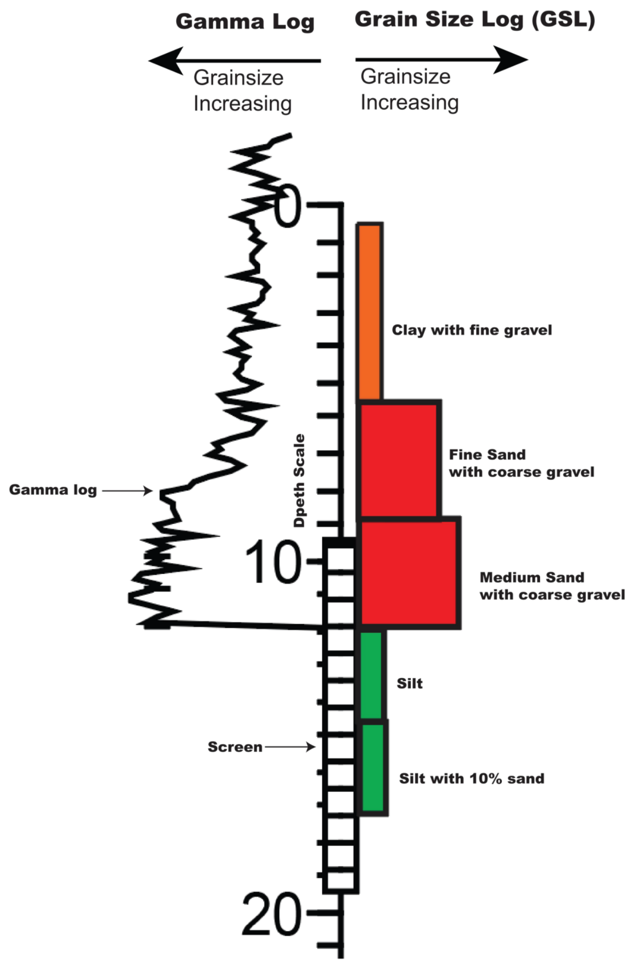
Strath Dip Direction: Southeast

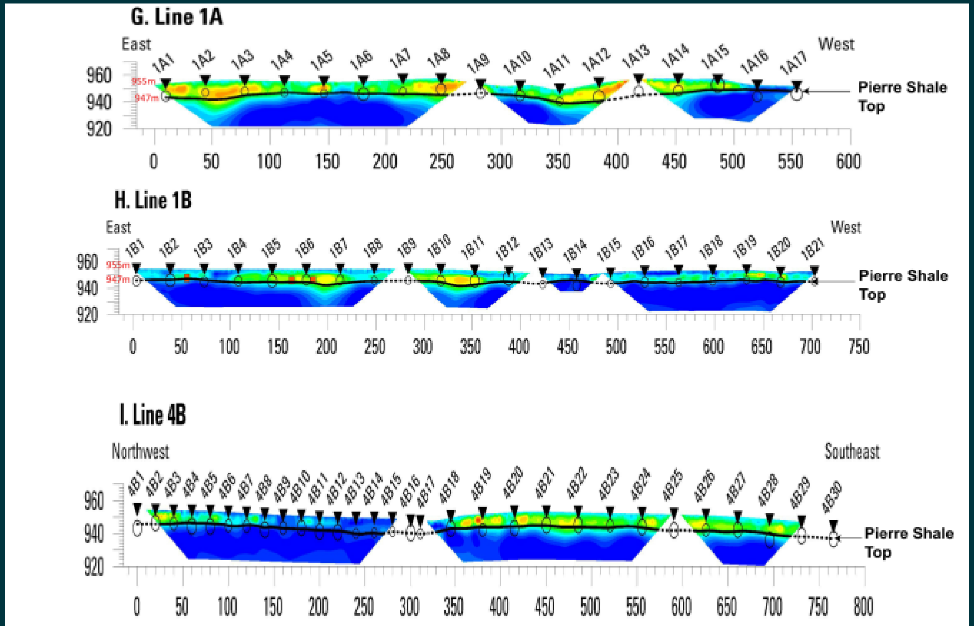
Zaprowski et al., 1999

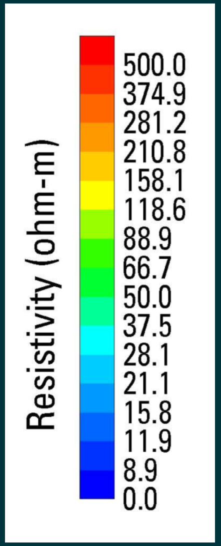
Site Depositional Model

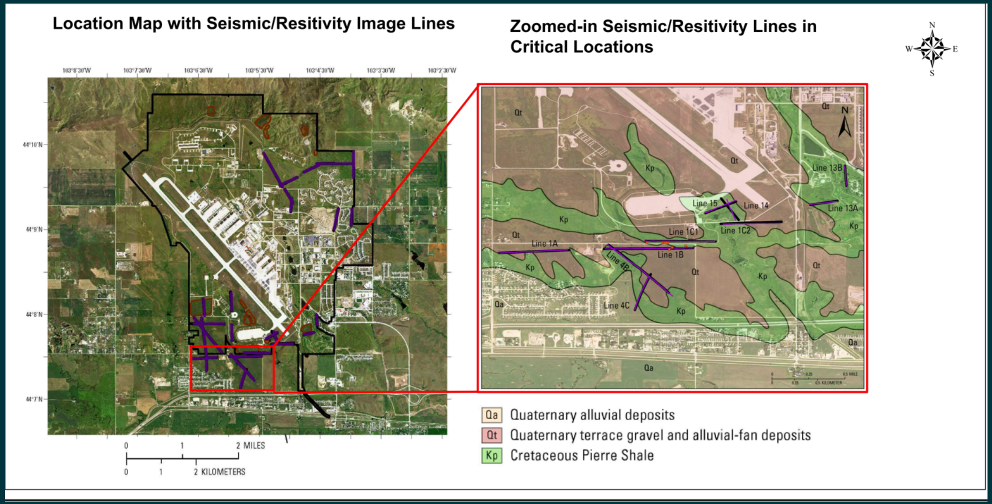


Site Lithologic and Geophysical Data

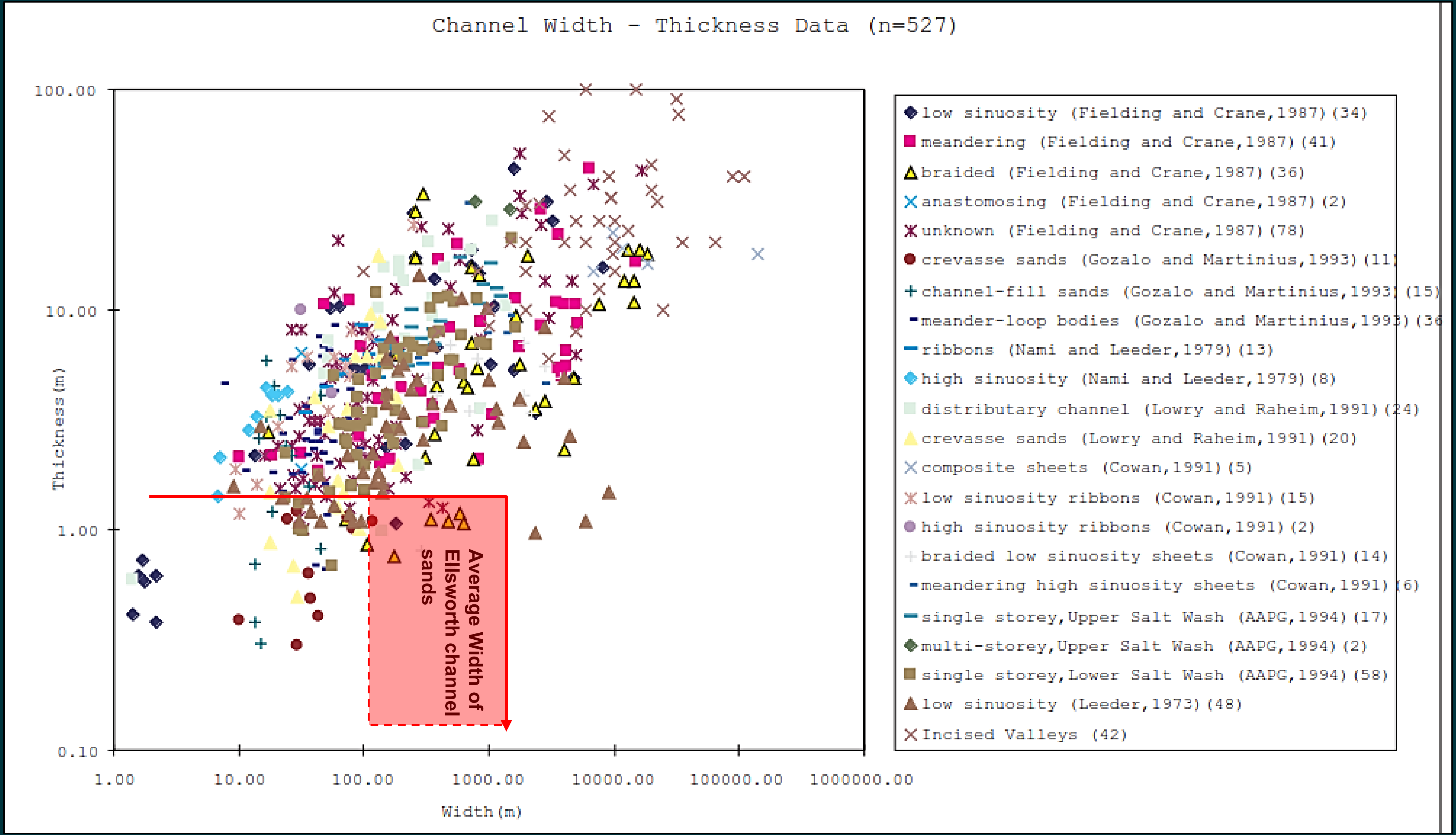








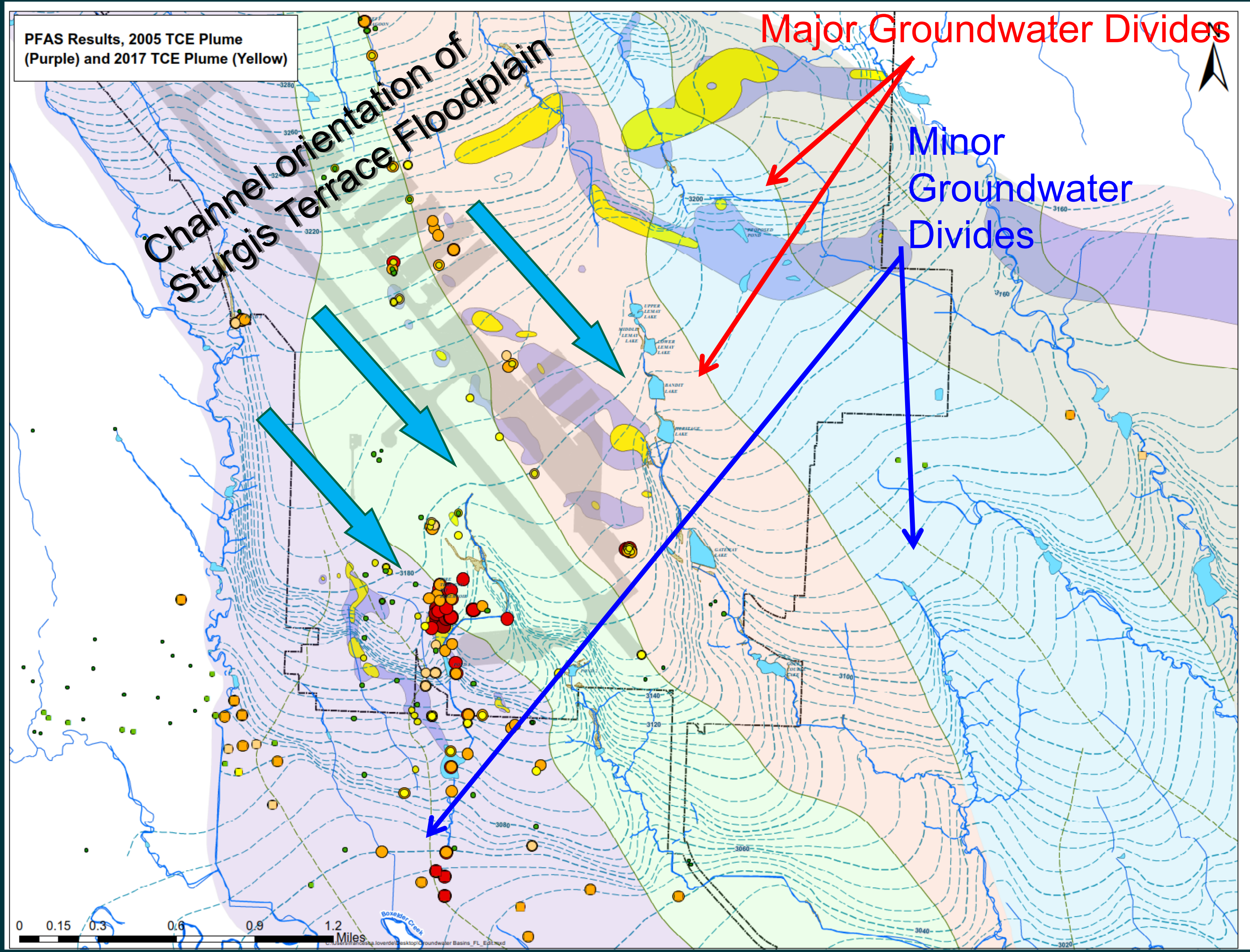
Width-thickness Aspect Ratio of Braided Bars at Site Area



Average thickness of Ellsworth paleochannel sandbodies ~5ft (~1.5m)

Probable average width range: ~<300ft - ~2800ft (highest)

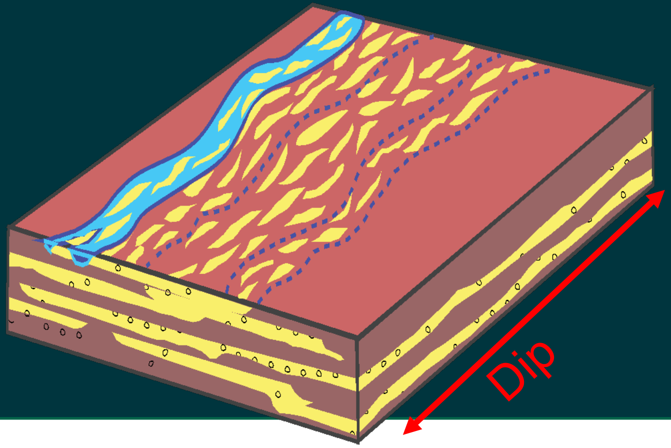
Regional Hydrogeological Basins

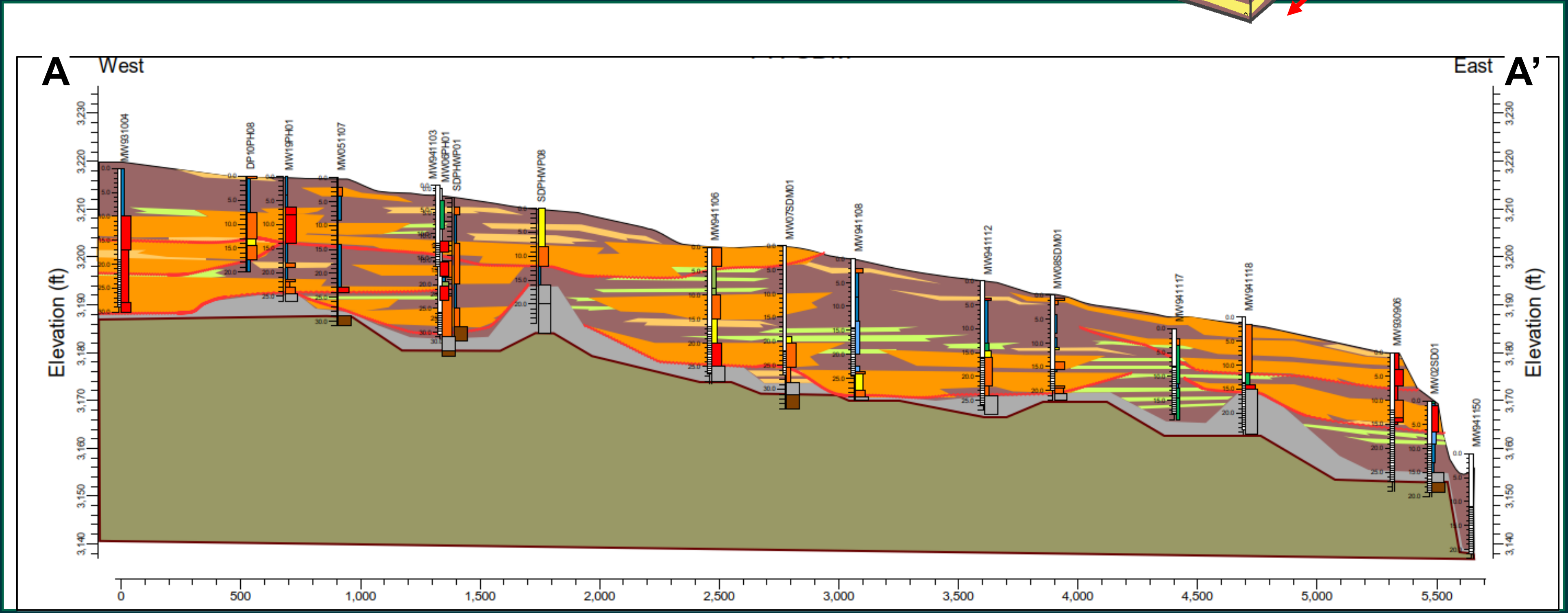


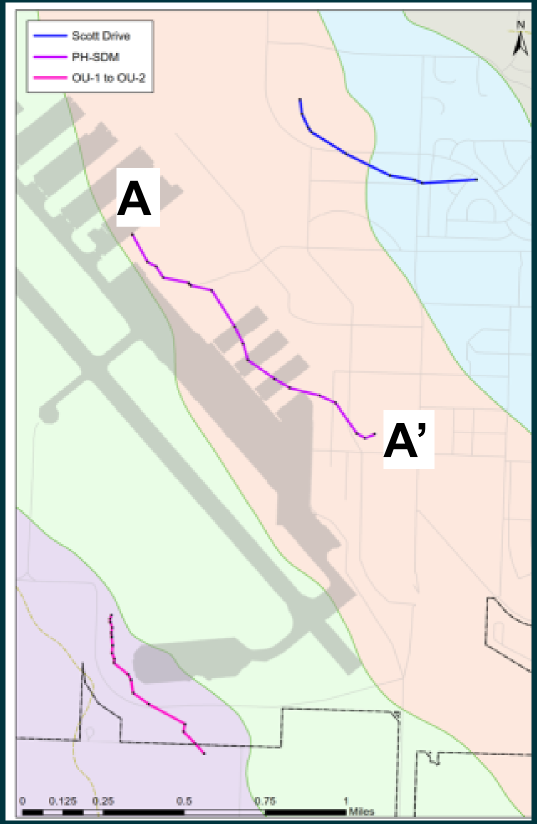
How do subsurface stratigraphy and contamination flow paths relate to the interpreted hydrogeological basins?

Example Dip Section

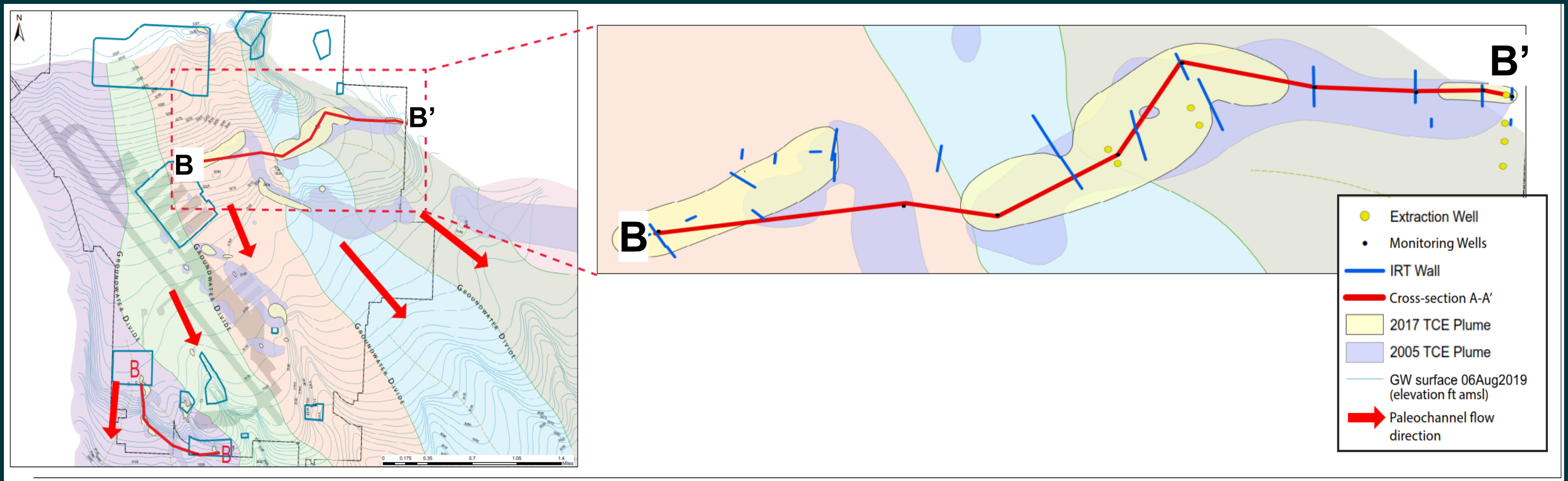
- Channel Bar Deposits (vf sand- coarse to pebbly sand)
- Crevasse Splay (vf sand-fine sand, pebbly clay)
- Levee Deposits (silt- vf sand)
- Overbank (silt and clay)
- Fractured Bedrock
- Bedrock (Pierre Shale)
- Major Fluvial Erosion

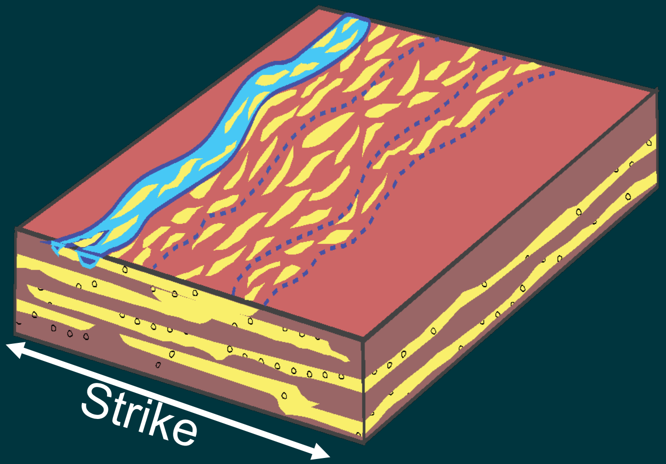


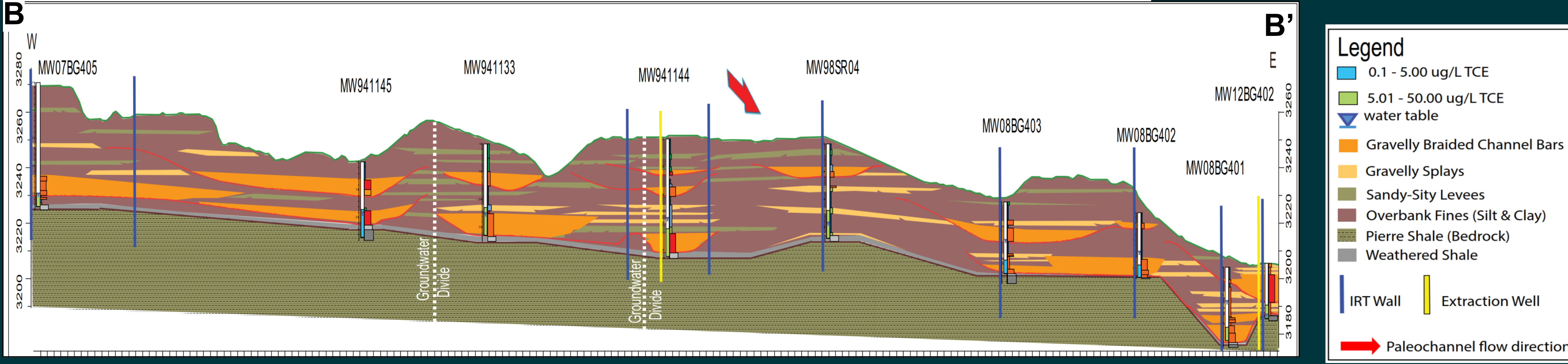




Example Strike Section

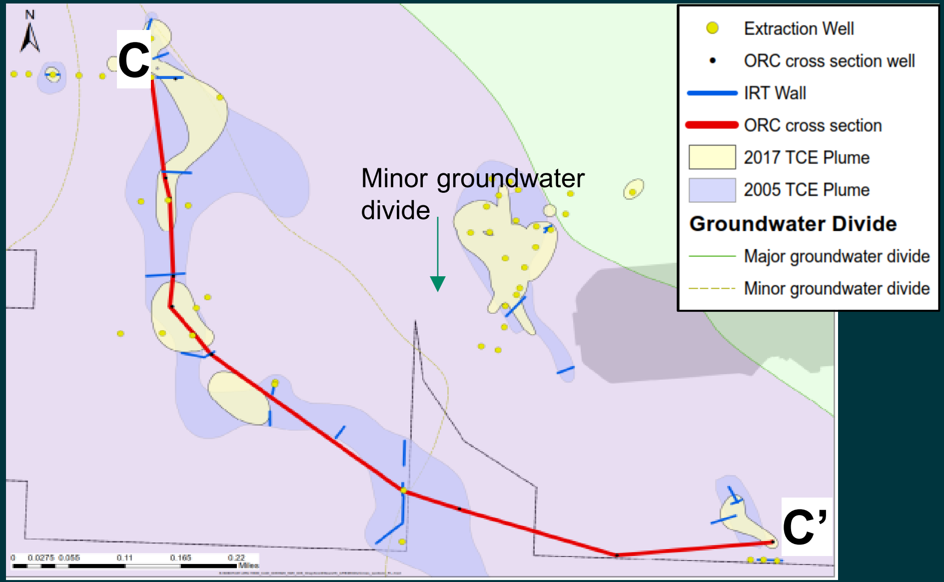


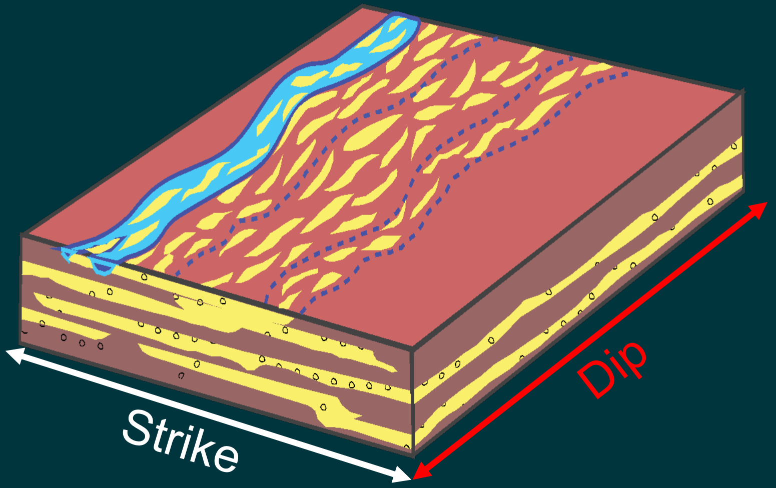


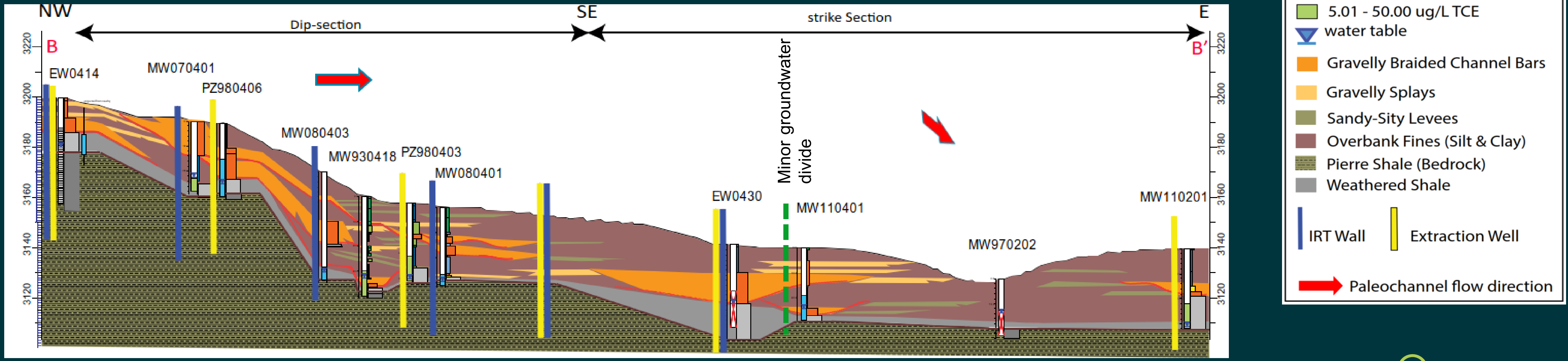


Horizontal scale ~ 1.7 miles

Example Section: Dip & Strike

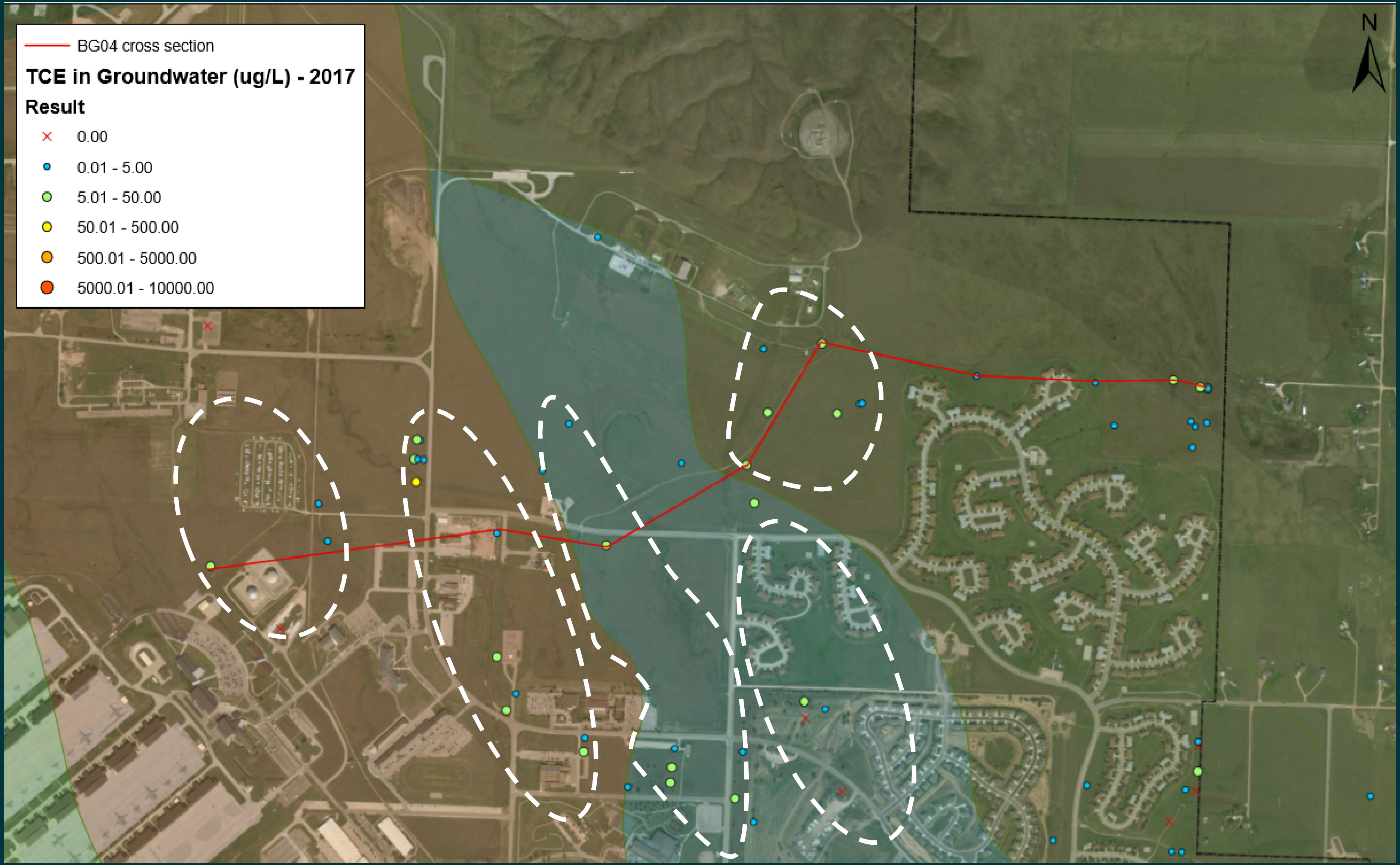






Horizontal scale ~1mile

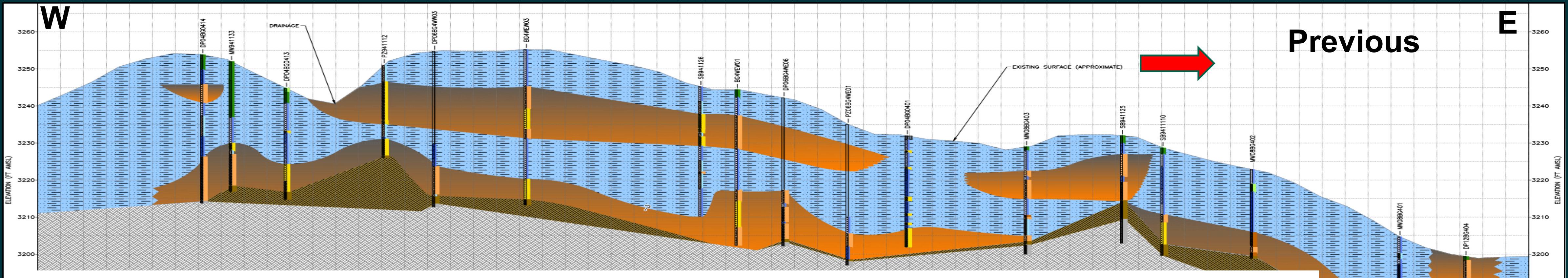
Reconsider Plume Geometry?



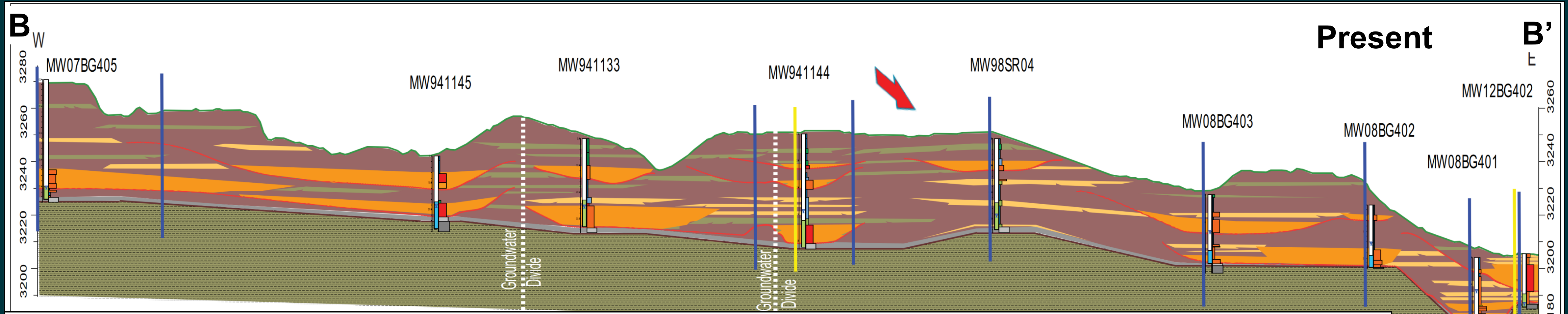
The existing chemistry data may need reevaluation based on different hydrogeological basins and the flow direction of the paleochannels within them.

Figure shows a cartoon of alternative geometries.

Comparing Cross-section with Previous Work



Continuous channel bar deposits indicating paleochannels dipping from west towards east (along the length of the plume). Channel geometry & dimension does not conform to known models



Discontinuous channel bar deposits indicating paleochannels dipping from northwest towards southeast (across the length of the plume). Channel geometry & dimension according to established braided bar models.

General Conclusion

- Determining the subsurface depositional environments is essential for a meaningful CSM
- Dimensions, orientation and interconnectivity of sand bodies directly control the movement of water and contamination through hydrogeological basins
- Generating plume shapes purely based on statistical methods (unconstrained by geology) is not advisable
- Optimal Placement of bioremediation tools (e. g. IRT) require understanding of plume migration in relation to regional and local geology

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Thank You!

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