Three-Dimensional Model of the Kansas River Valley from Drillers' Logs

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Kansas (Kaw) River Valley Water Resource Stressors

- Population growth and urbanization
- Business and industrial development
- Silting of reservoirs
- Climate change

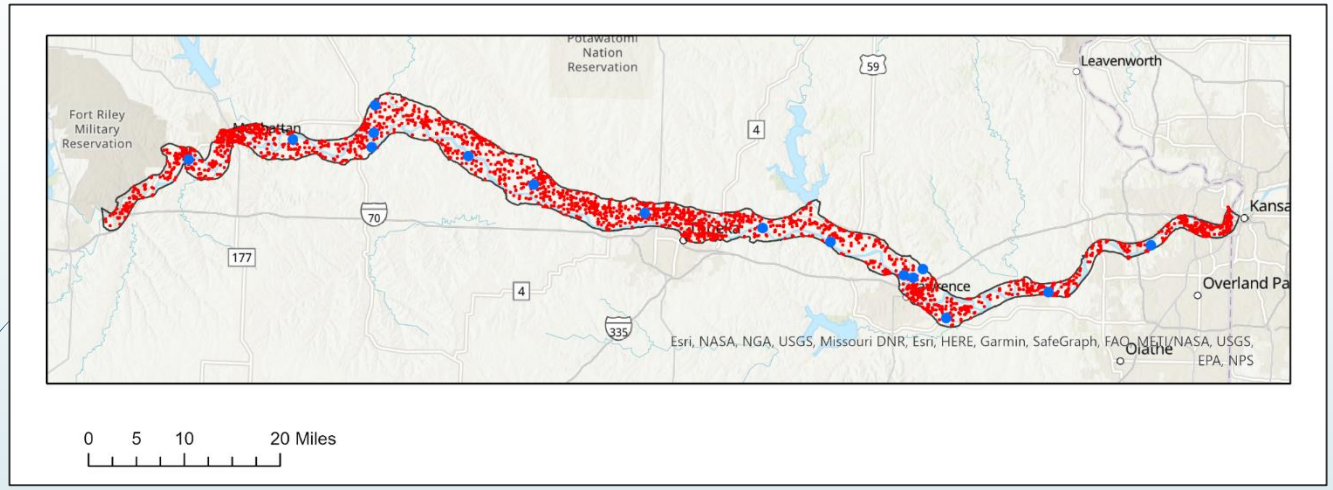
KGS Kaw Valley Work

- KWO-funded alluvial aquifer index well program (Butler *et al.*)
  - Continuously monitored water level wells
  - Geophysical characterization
  - *Sediment distribution from water well drillers' logs*
  - Next phase: groundwater flow model
- USDA-funded SAFE KAW (Zipper, Seybold *et al.*)
  - Identify actions to safeguard
    - water quantity and quality
    - rural livelihood
  - In face of climate change

WWC5 (Water Well Completion) Database

- Water well drillers submit forms for completed wells to KDHE (since 1975)
- KGS is charged by statute to archive and serve that data
  - Does so in WWC5 database
  - Well info (location, depth, owner, etc.) entered into WELLS table
  - Lithologic (sediment) logs transcribed into LOGS table
    - An ongoing and labor-intensive process
    - Much of it done by Dana Adkins-Heljeson
    - Near-verbatim transcription, with some corrections and modifications for consistency
- Scanned forms also stored so all original information is available
- Web interface: http://www.kgs.ku.edu/Magellan/WaterWell/index.html

Kaw Valley Log Locations



5,183 Kaw Valley WWC5 logs (red freckles)
Reduced to 4,945 after quality assessment; 26,067 depth intervals
16 index wells (blue circles)

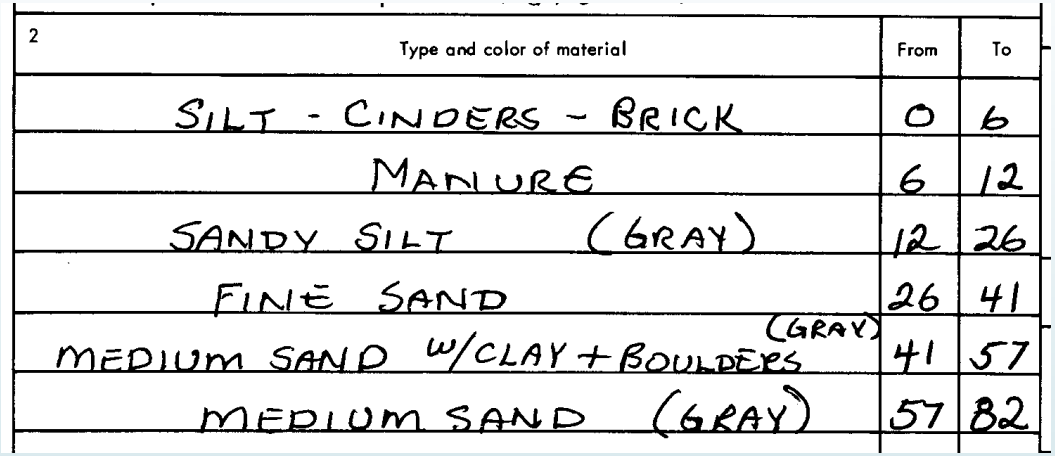
The Good, the Bad . . .

FROM	TO	LITHOLOGIC LOG
0	6.5	Lean Clay, Gray and Brown
6.5	8.5	Fine-Medium Sand, Gray and Brown
8.5	10	Sandy Lean Clay, Gray and Brown
10	13	Fine-Medium Sand, Gray and Brown
13	18.5	Sandy Lean Clay, Gray
18.5	34	Medium-Coarse Sand, Gray and Brown

FROM	TO	LITHOLOGIC LOG
0	107	Sand & Clay Layers

Removed logs with excessively thick average intervals (> 34 ft) and then excessively thick intervals (> 40 ft) individually. Thresholds are 99th percentiles of respective distributions.

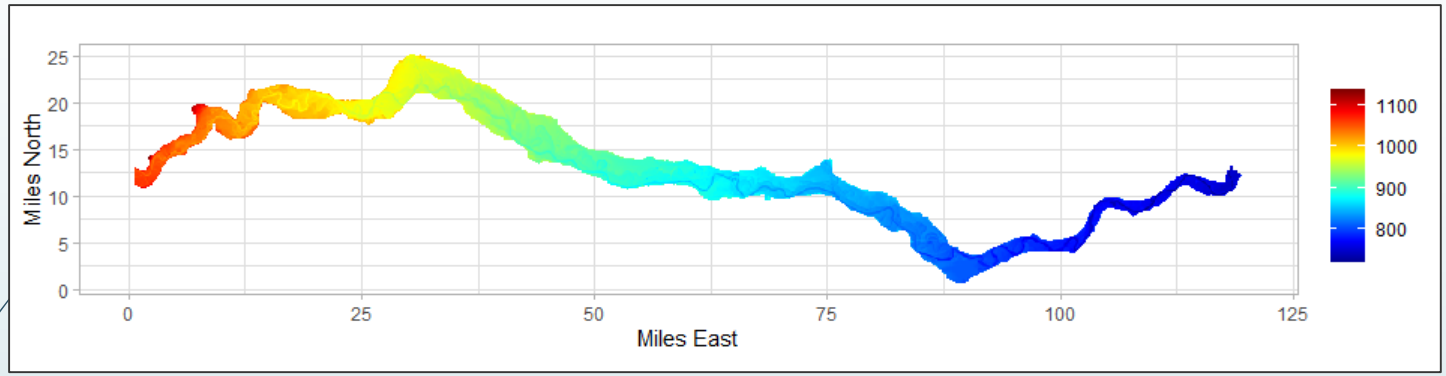
. . . and the Ugly



2 Type and color of material	From	To
SILT - CINDERS - BRICK	0	6
MANURE	6	12
SANDY SILT (GRAY)	12	26
FINE SAND	26	41
MEDIUM SAND W/CLAY + BOULDERS (GRAY)	41	57
MEDIUM SAND (GRAY)	57	82

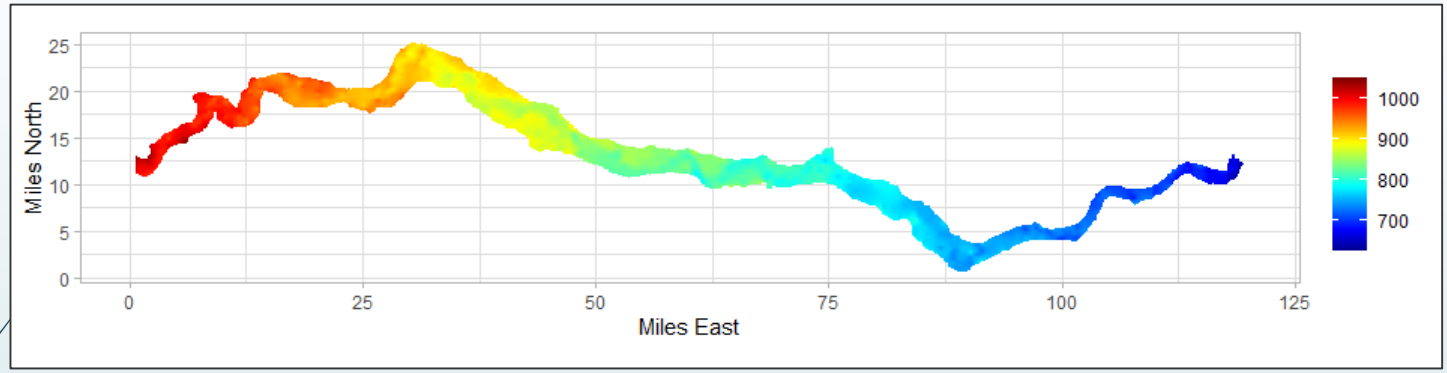
Removed intervals containing obviously "artificial" material individually
Some ambiguity: e.g., pea gravel at surface likely landscaping, etc.

Land Surface Elevation (feet a.s.l.)



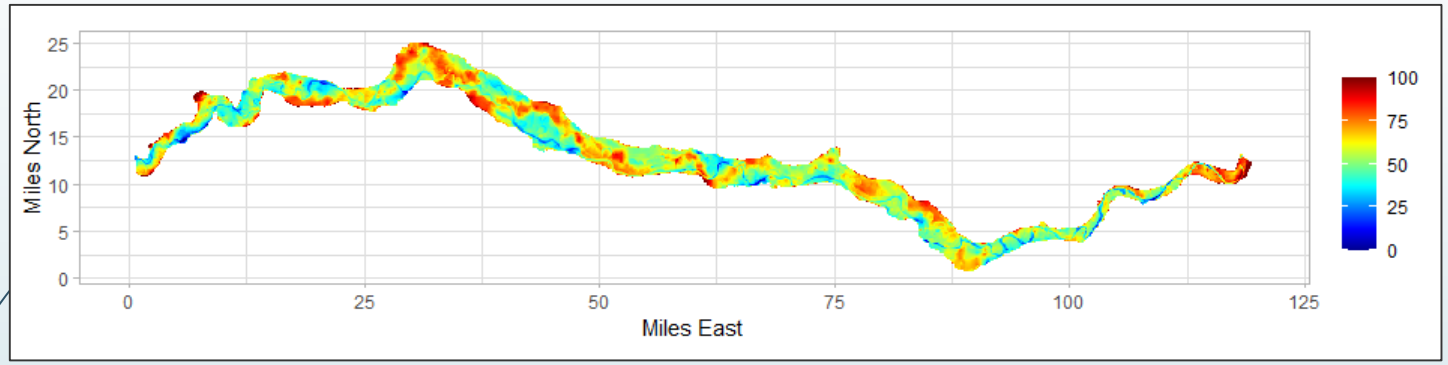
- LiDAR elevation averaged over 200 m x 200 m grid cells (200 m ≈ 660 ft)
- Same grid used throughout analysis

Bedrock Elevation (feet a.s.l.)



- Surface interpolated from
  - 1,118 bedrock elevations (depths picked from logs converted to elevation)
  - 216 bottom-of-log elevations for logs with no bedrock contact where initial bedrock surface was > 10 feet above bottom of log
- Numbers are for final dataset after removing outliers identified through cross-validation interpolation

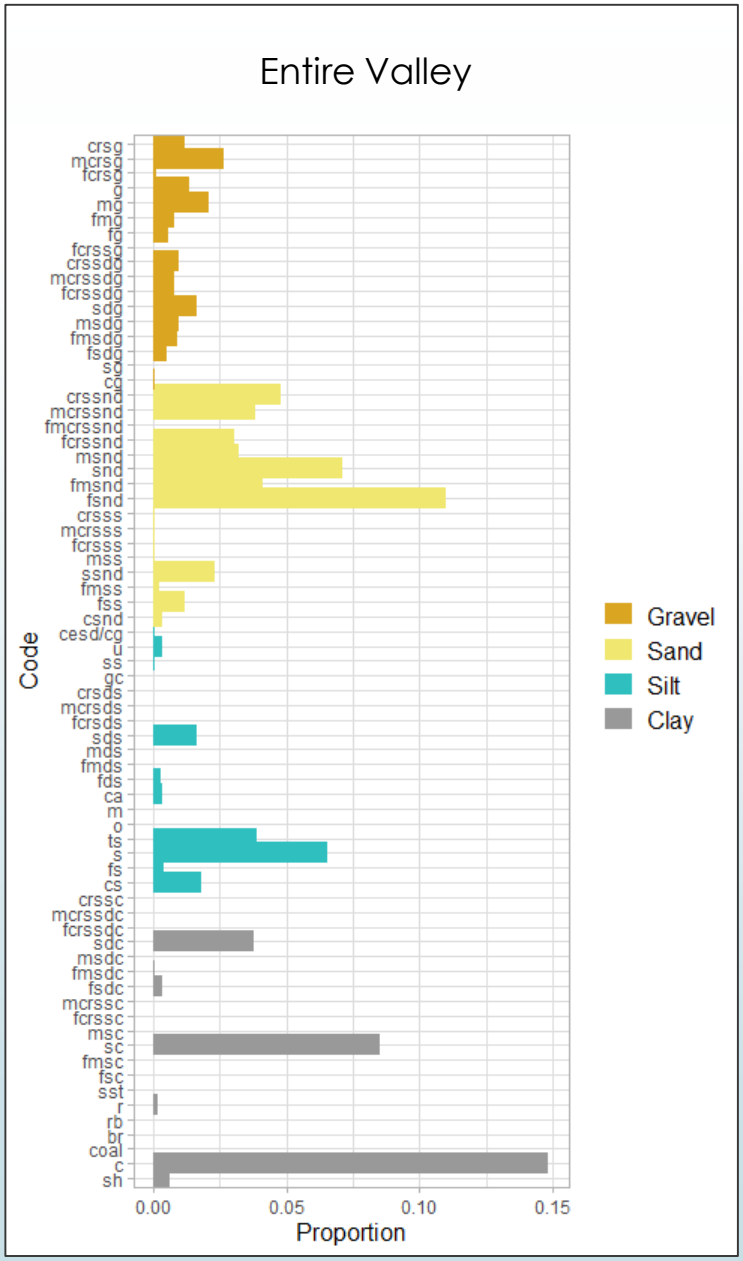
Sediment Thickness (feet)



- Land surface elevation – bedrock elevation

Classifying Logs

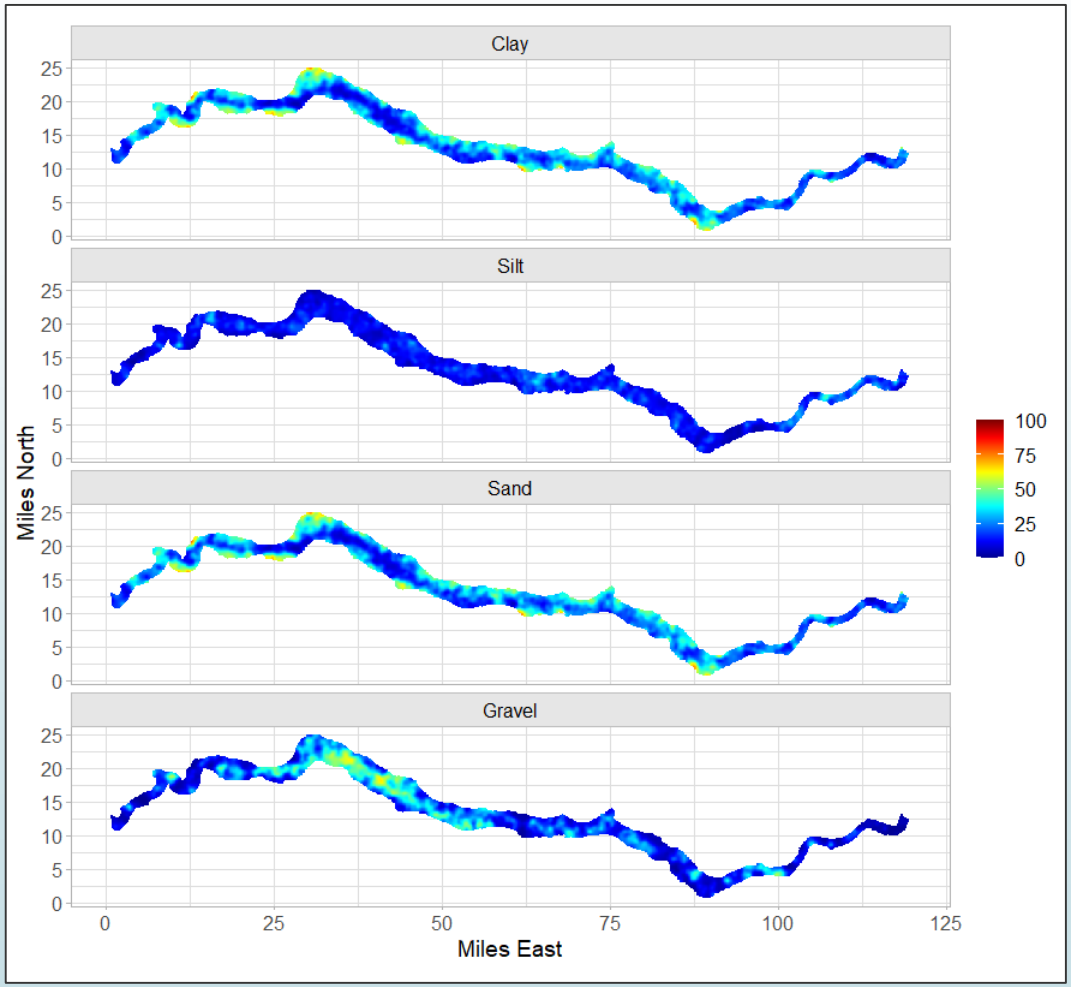
- Sediment descriptions represented as mixtures of 71 standardized lithology codes
  - ex: "fine sand and silt" represented as 60% fsnd and 40% s
- 71 codes lumped into fewer categories on a project-specific basis
  - Here clay, silt, sand, gravel
- Entire valley:
  - 15% gravel
  - 41% sand
  - 15% silt
  - 29% clay



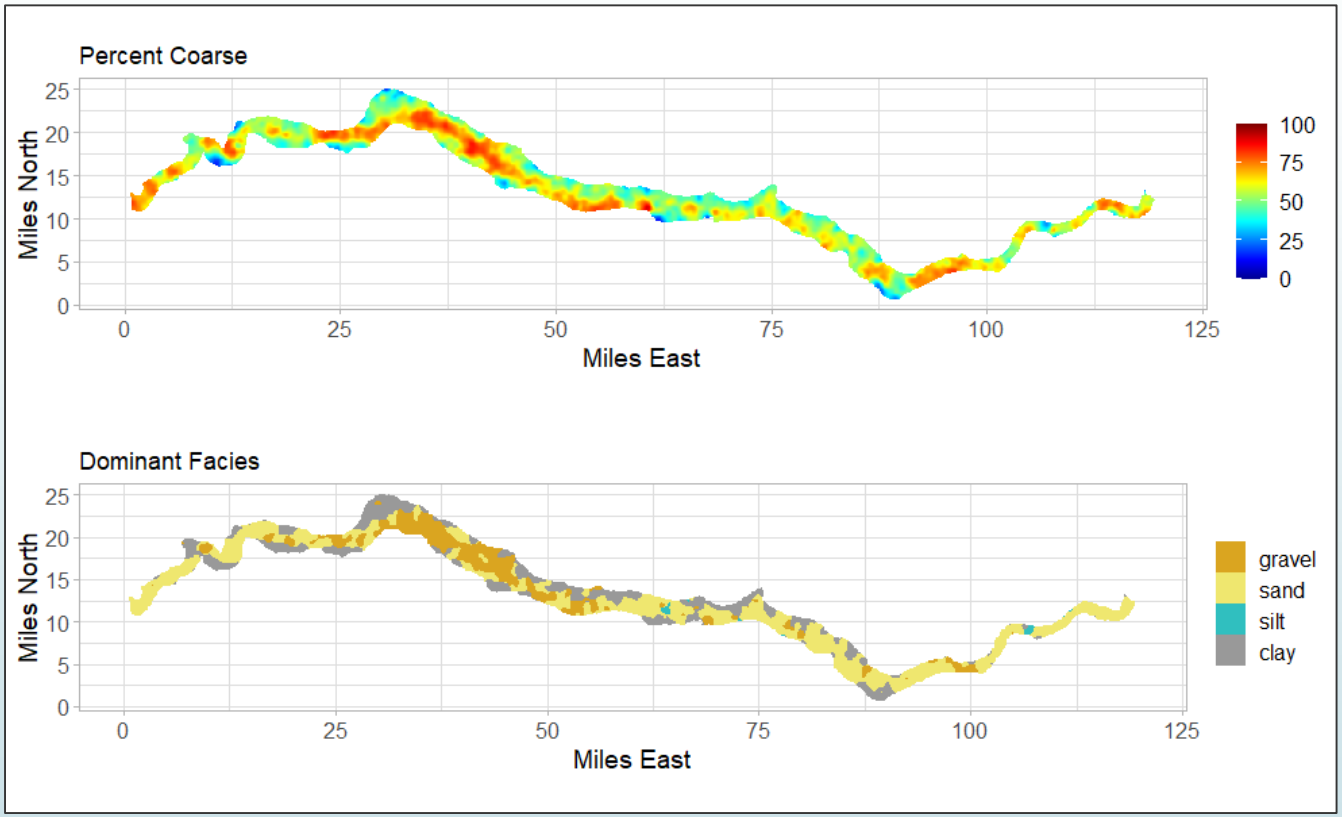
2D Analysis

- Facies (category) percentages between land and bedrock computed over 200 m x 200 m grid cells containing logs
- Facies percentages interpolated to empty grid cells (those with no logs) to fill grid
- Some smoothing applied to reduce interpolation artifacts
- Facies percentage summary measures:
  - Percentage coarse (sand & gravel) or fine (silt & clay)
  - Footage coarse or fine
  - Dominant (majority) facies (discrete)
  - Percentage-weighted average facies (continuous)

2D Facies Percentages



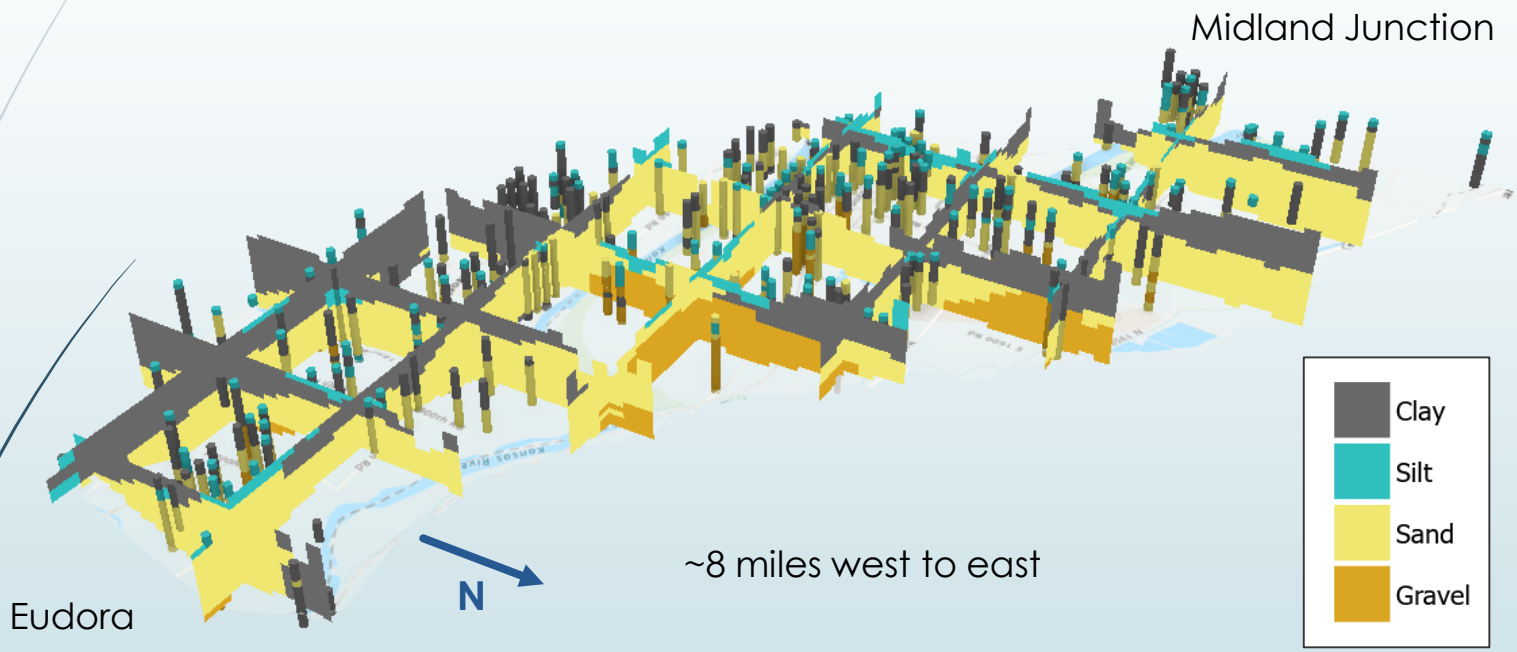
Summary Measures



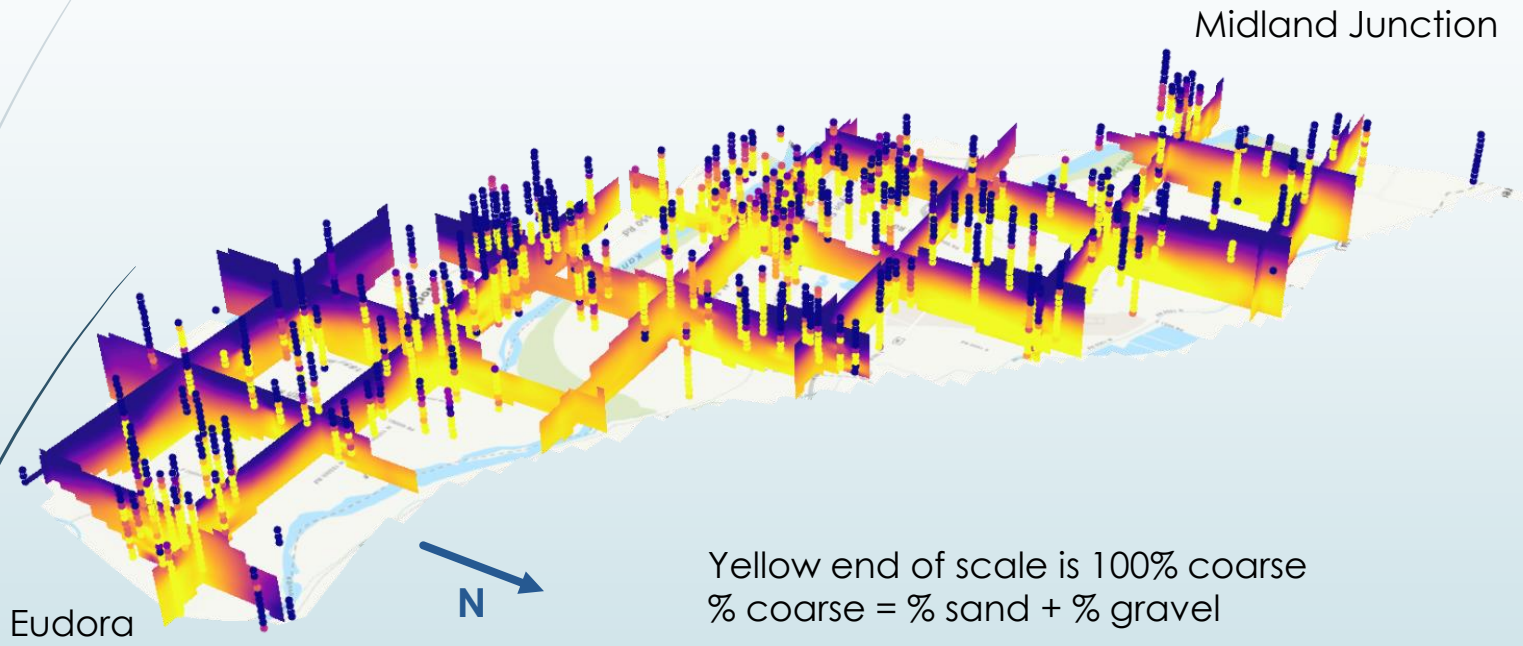
3D Analysis

- 3D grid cells are 200 m x 200 m x 5 ft (pardon my footric)
- Facies percentages computed over grid cells containing logs
- Then interpolated in 3D to fill grid and smoothed a bit
- Same summary measures can be computed

Dominant Category Near Lawrence



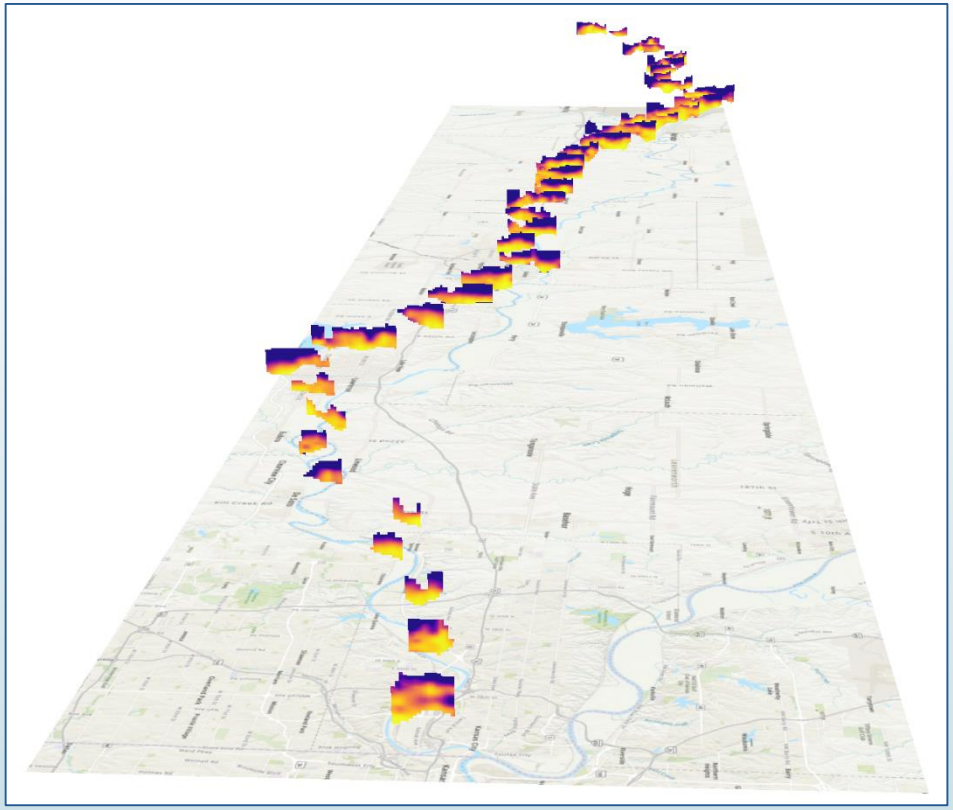
Percentage Coarse Near Lawrence



Yellow end of scale is 100% coarse
% coarse = % sand + % gravel

Percentage Coarse, Whole Valley

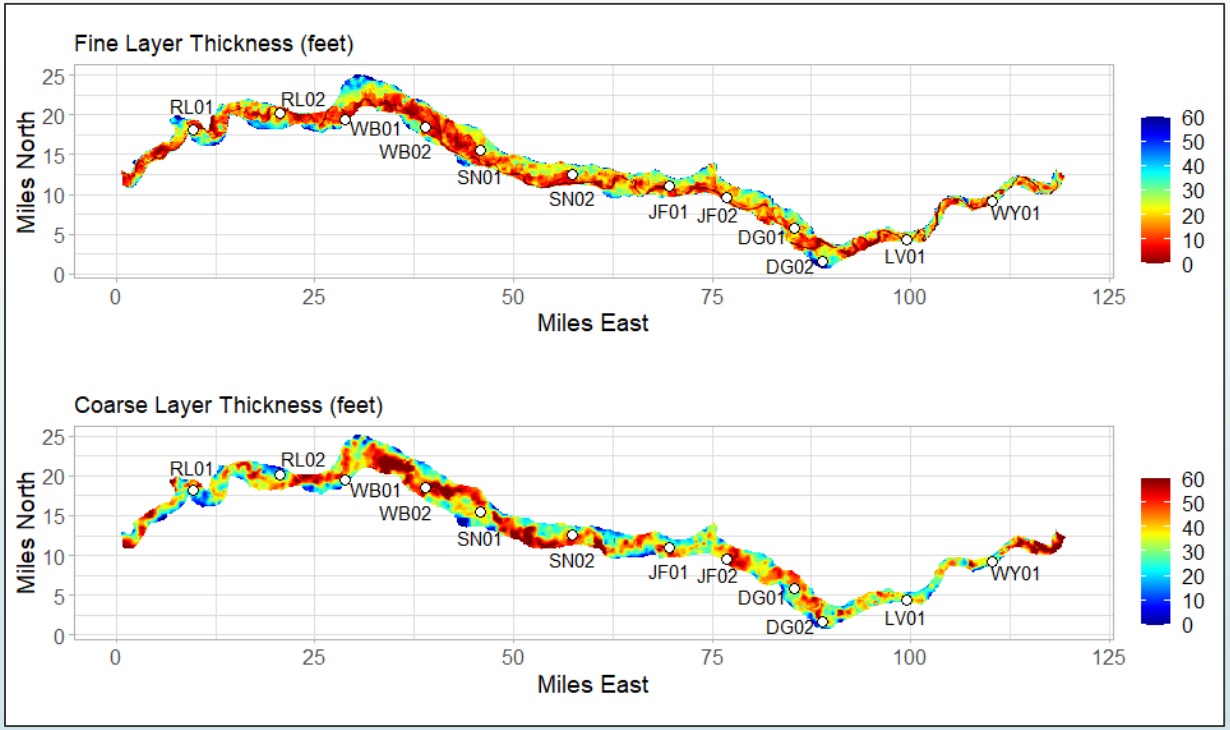
35 north-south sections at 5 km (3.1 mile) intervals from west (top) to east (bottom)



Fine / Coarse Boundary Surface

- Expect to see fine floodplain deposits overlying coarse channel deposits at most locations in valley
- Computed 50% isosurface (3D contour) for percentage coarse grid
- Simplified and generalized that isosurface to create a surface representing fine / coarse boundary elevation throughout valley
- Allows mapping of fine (upper) and coarse (lower) layer thicknesses

Fine and Coarse Layer Thicknesses



Note opposite color scales. 12 of 16 index wells shown.

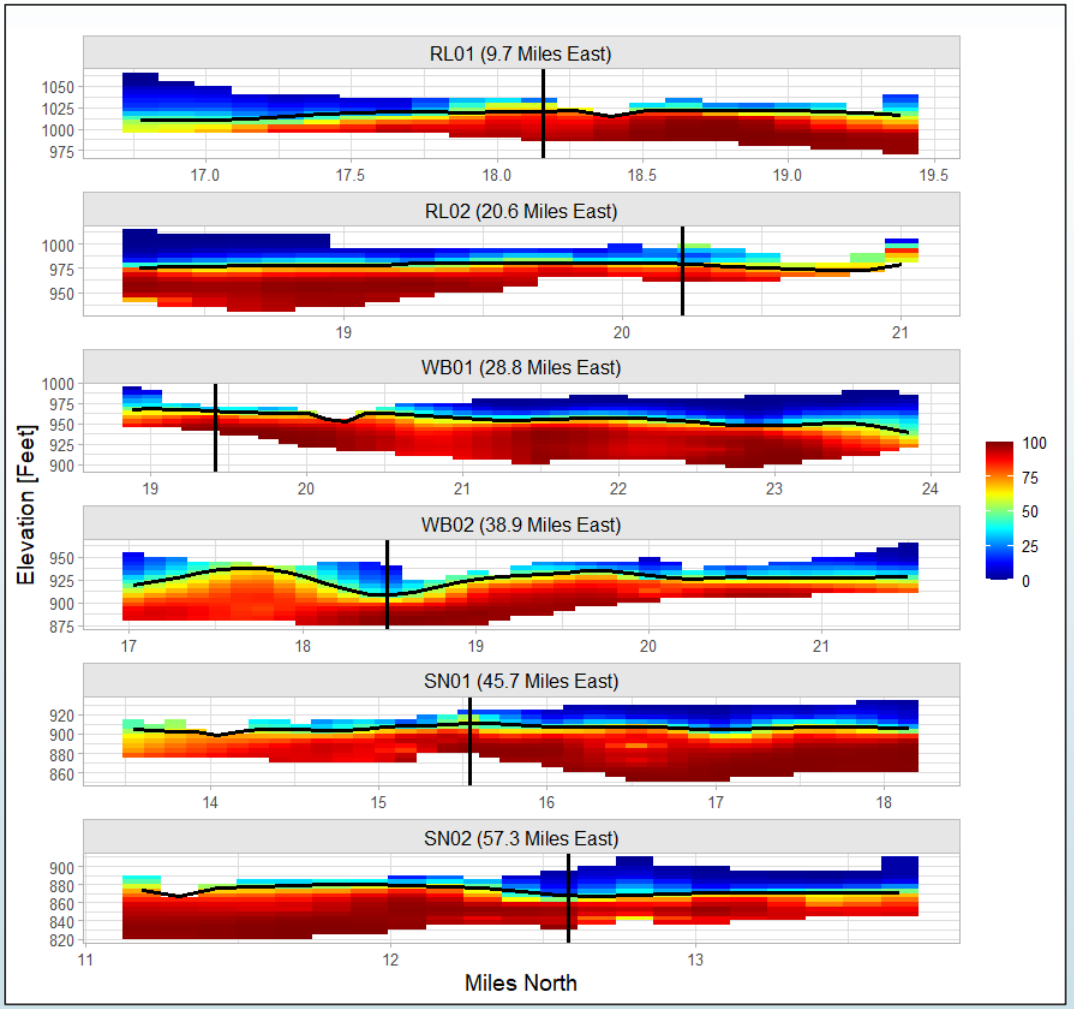
Upper Reach Index Well Sections

Color:
percent coarse

Black curve:
fine / coarse boundary

Vertical lines:
IW locations

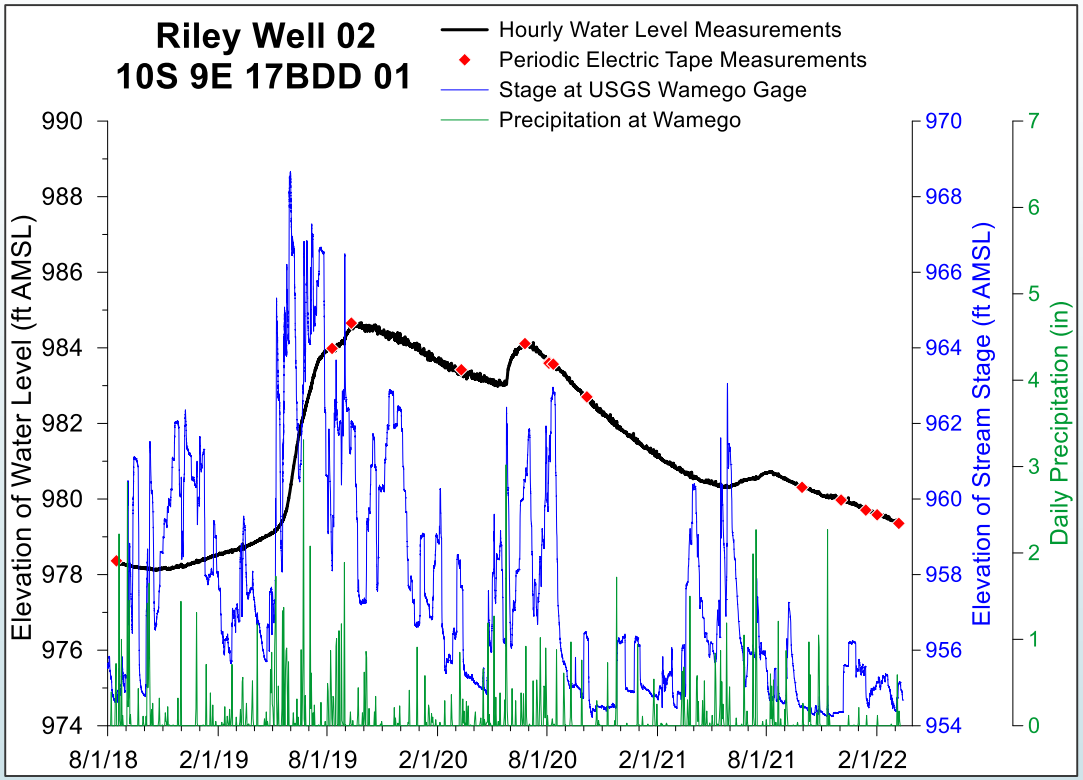
Scales vary



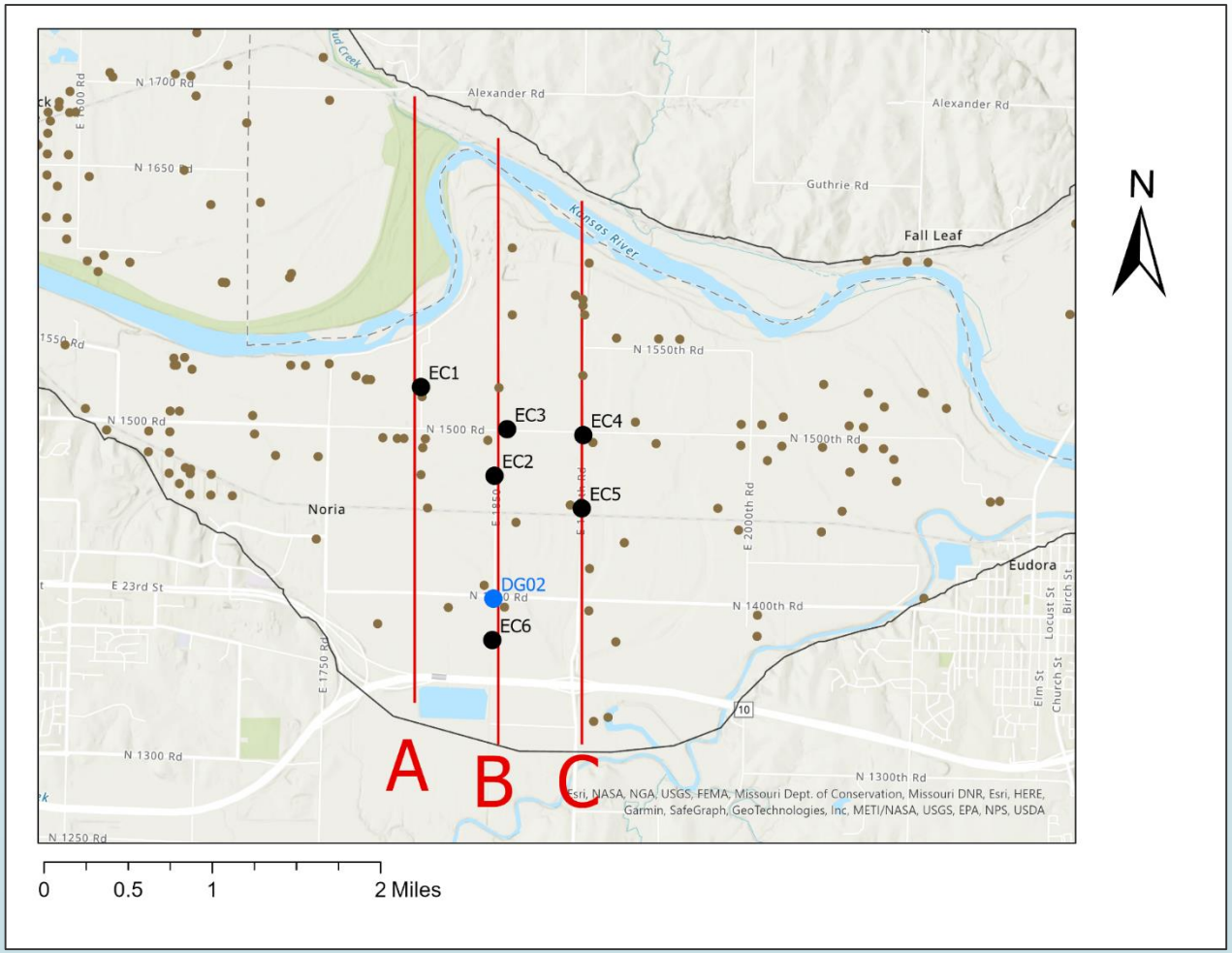
Stream-Aquifer Interactions

Hydrostratigraphy + index well + stream + PPT records = powerful framework for interpretation

(Work in progress)



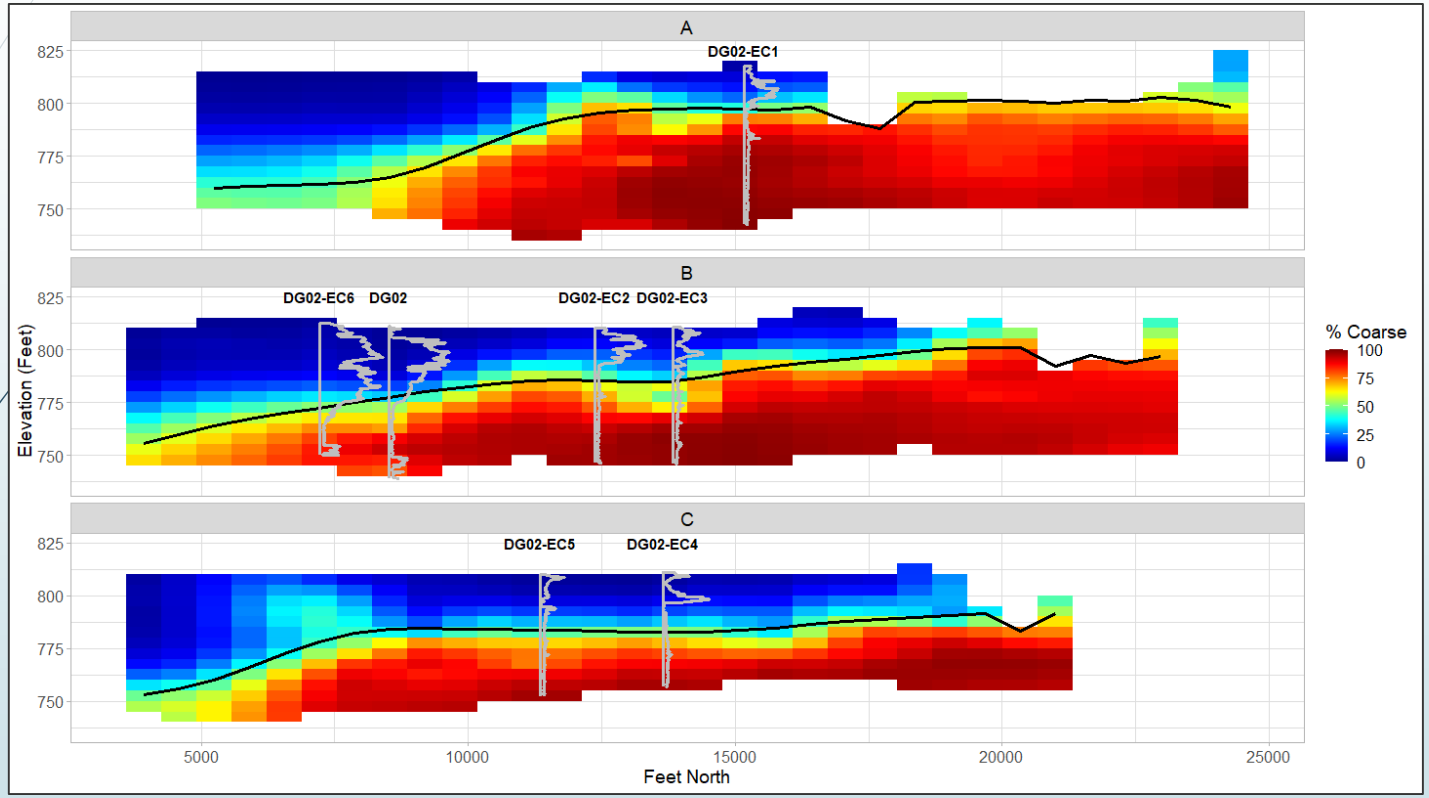
Eastern Douglas County



EC Logs
Index Well
WWC5 Logs
Cross-Sections

EC = Electrical Conductivity

Comparison with EC Logs



Higher EC in finer materials

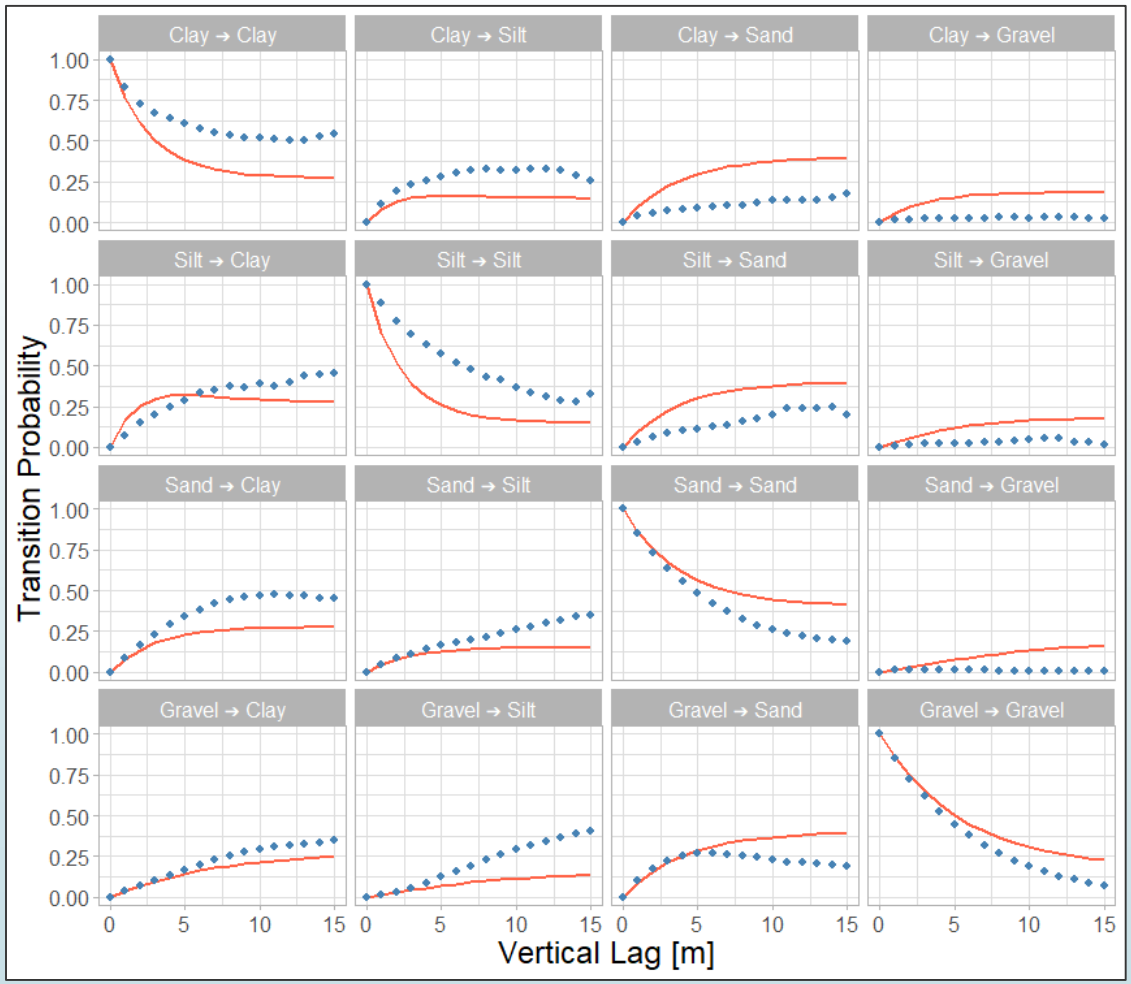
Conclusions

- Drillers' logs provide a geologically plausible picture of the sediment distribution in the Kansas River valley
- They agree pretty well with direct-push electrical conductivity profiles in the vicinity of index wells
- Jury is still out on comparison with tTEM (towed transient electromagnetic) electrical resistivity profiles near Lawrence
- Sediment distribution model developed here will be key input to upcoming groundwater flow model

Vertical Transition Probabilities (Upward)

Points:
Empirical

Lines:
Model



Horizontal Transition Probabilities

Points:
Empirical

Lines:
Model