AEM Data Applications for Improving Stratigraphy of a Flood-MAR Model

CWEMF Annual Meeting 2023

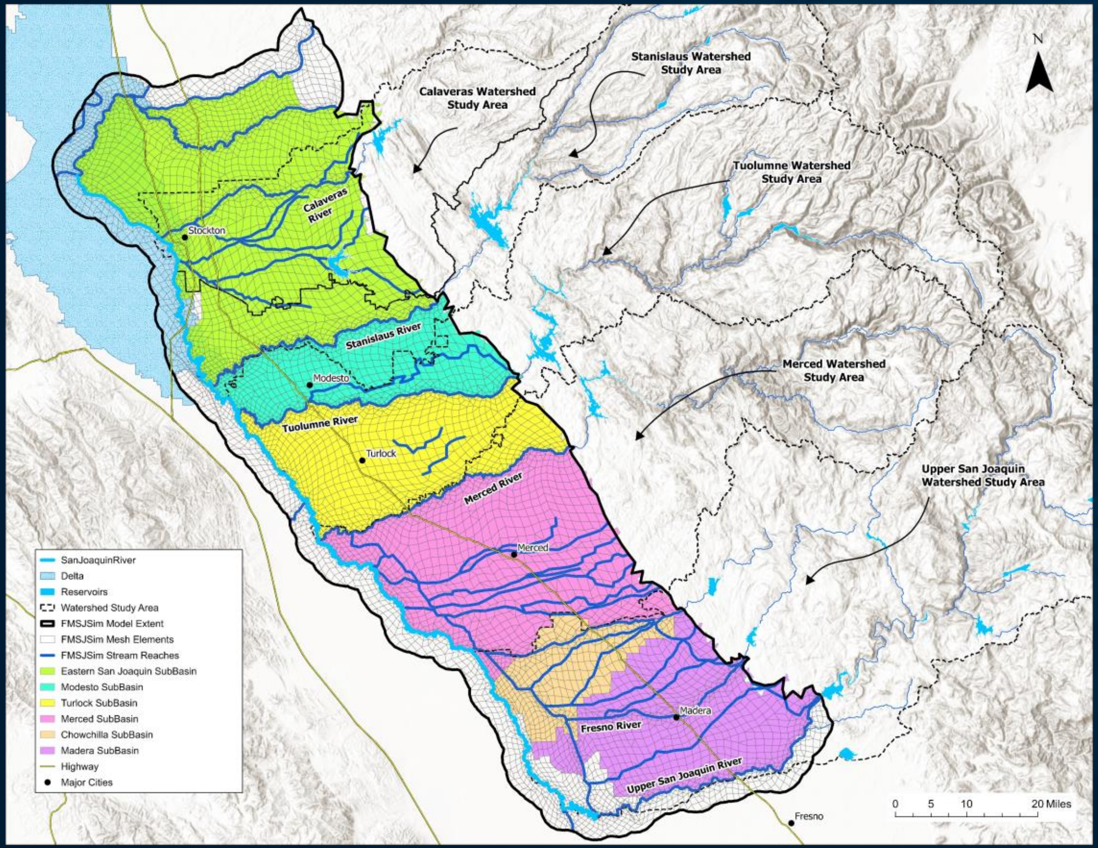
April 17, 2023

presented by Woodard & Curran

Outline

- Goals and Metrics of Success
- Defining a Lithology-Based Layer
- Incorporation of AEM data
- Summary of Findings

FloodMAR-San Joaquin Simulation Model



- Total model area = 4,530 sq miles
- Avg element area = 340 acres
- 100 stream reaches
- Monthly time step
- Modifications from C2VSimFG:
  - Streams system
  - Water demand
  - Water supply
  - **Aquifer layering**

Goal

Better understand impacts to:

Surface-Groundwater Interactions

Groundwater Dependent Ecosystems

Domestic Wells

Metrics of Success

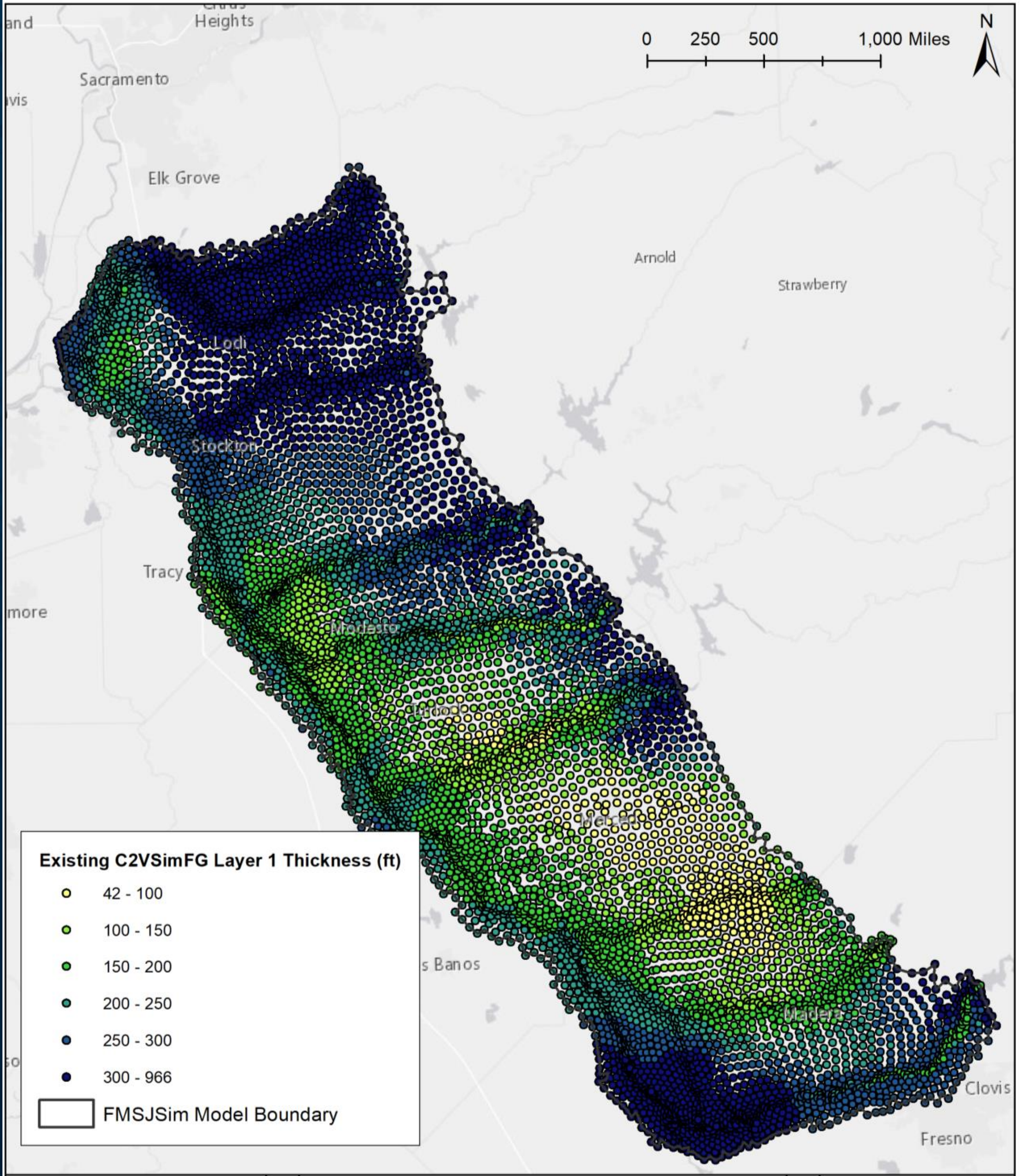
- Develop **regional approach** to layer building, with local refinements that improves upon existing layering approach
- Ensure smooth transitions between model layers and data source zones, based on **subsurface data**
- Adapt approach to the FloodMAR **project schedule**
- Develop a framework that can inform **future applications** and models

Existing C2VSimFG Stratigraphy

- Based on CVHM texture model, plus additional well logs
- Existing Layer 1 is too thick for the goals of this effort

Subbasin	Minimum Layer 1 Thickness (ft)	Maximum Layer 1 Thickness (ft)	Average Layer 1 Thickness (ft)
Eastern San Joaquin	147	966	326
Modesto	106	587	221
Turlock	66	371	178
Merced	42	627	163
Chowchilla	53	276	157
Madera	82	569	220

Source: DWR



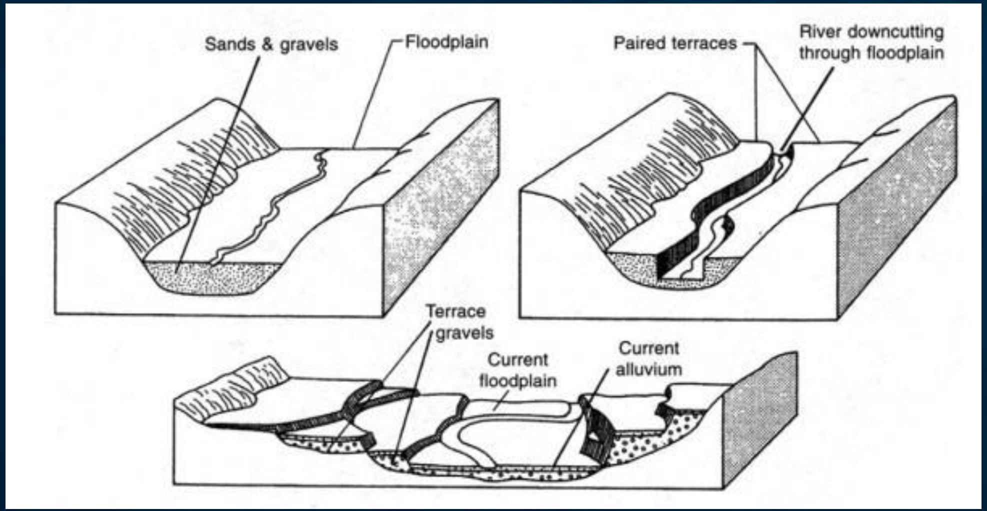
Stratigraphy Modifications

- Refined stratigraphy with a sharper **focus on the shallow subsurface** to develop a lithologically-based new Layer 1 **representing shallow alluvium**
- Data Sources Available:
  - California Geological Survey geologic maps
  - USGS Corcoran Clay depth and thickness
  - GSP HCMs and Cross Sections – best available review of literature
  - Provisional Inverted AEM dataset – newly available!

What exactly is “alluvium”?

*“A **general term** for clay, silt, sand, gravel or similar **unconsolidated** detrital material*, deposited during comparatively **recent geologic time** by a stream or other body of **running water**, as a sorted or semi-sorted sediment...”*

- USGS, 2023



Source: (Poole and Sims, 2007)

*”Detrital material” in this context refers to particles derived from pre-existing rock through weathering/erosion

Defining Shallow Alluvium

Which suite of formations best represent alluvium deposits for FloodMAR applications?

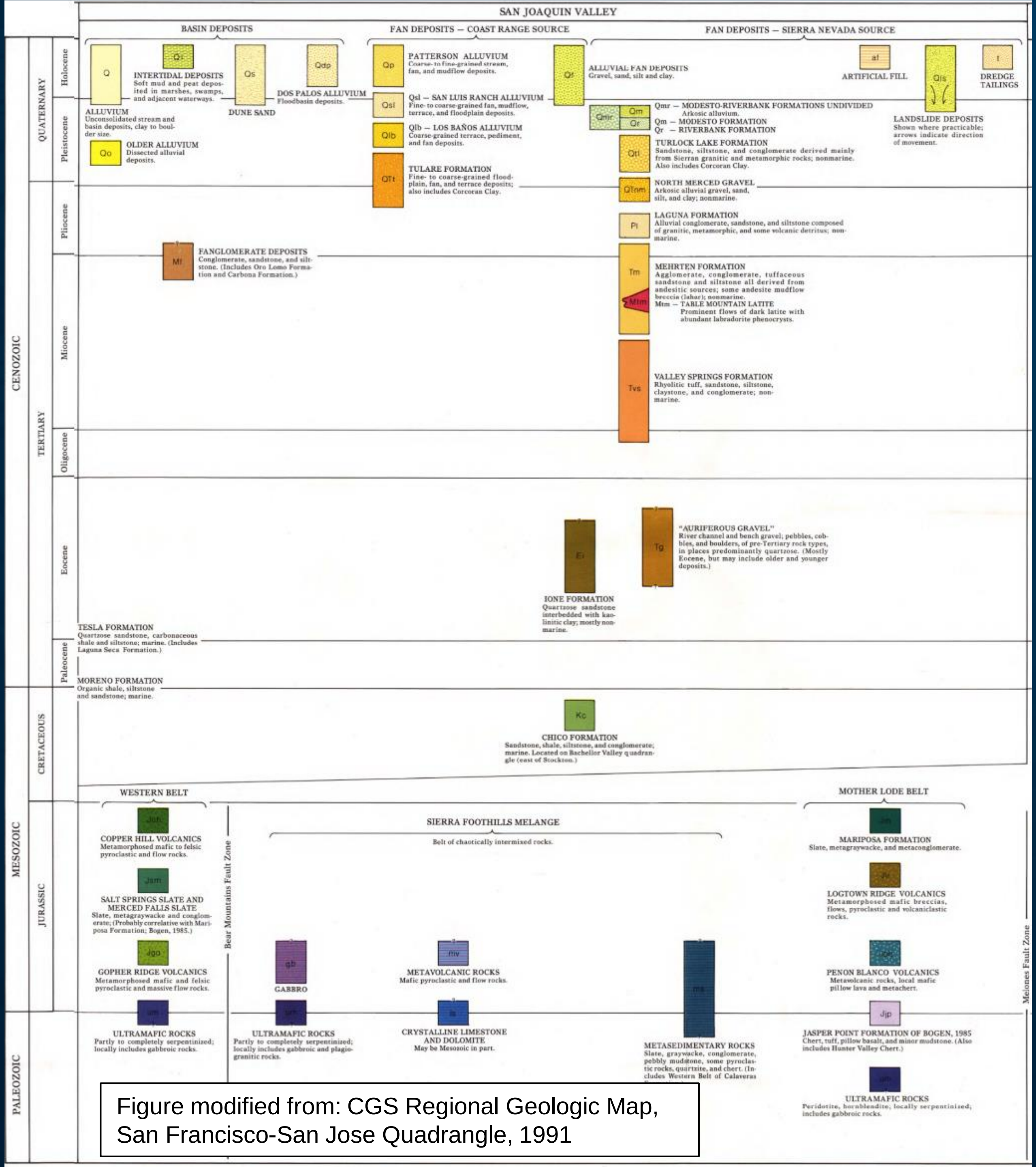


Figure modified from: CGS Regional Geologic Map, San Francisco-San Jose Quadrangle, 1991

SURFACE

Shallow

Deep

Source: California Geological Survey

Defining Shallow Alluvium

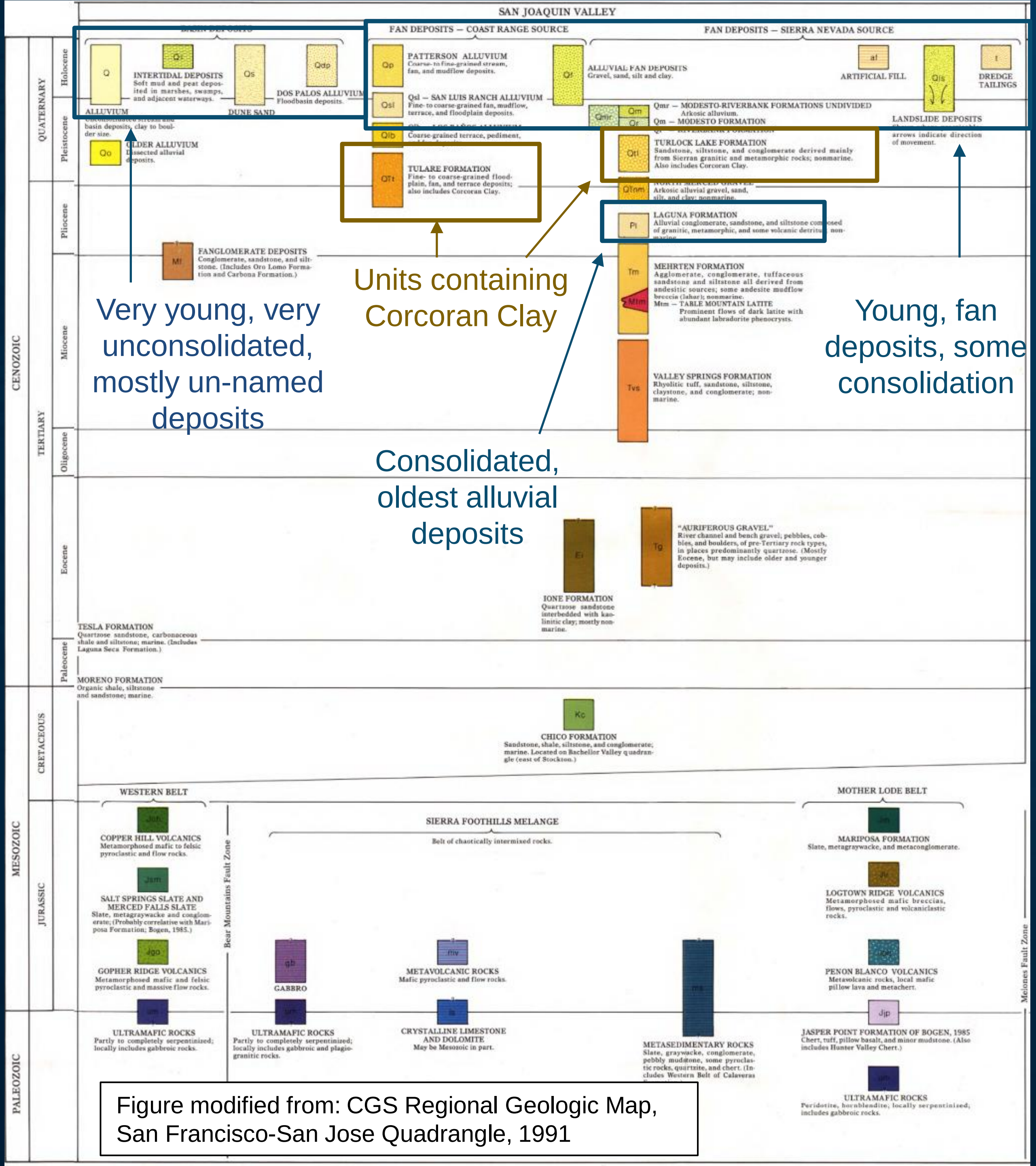


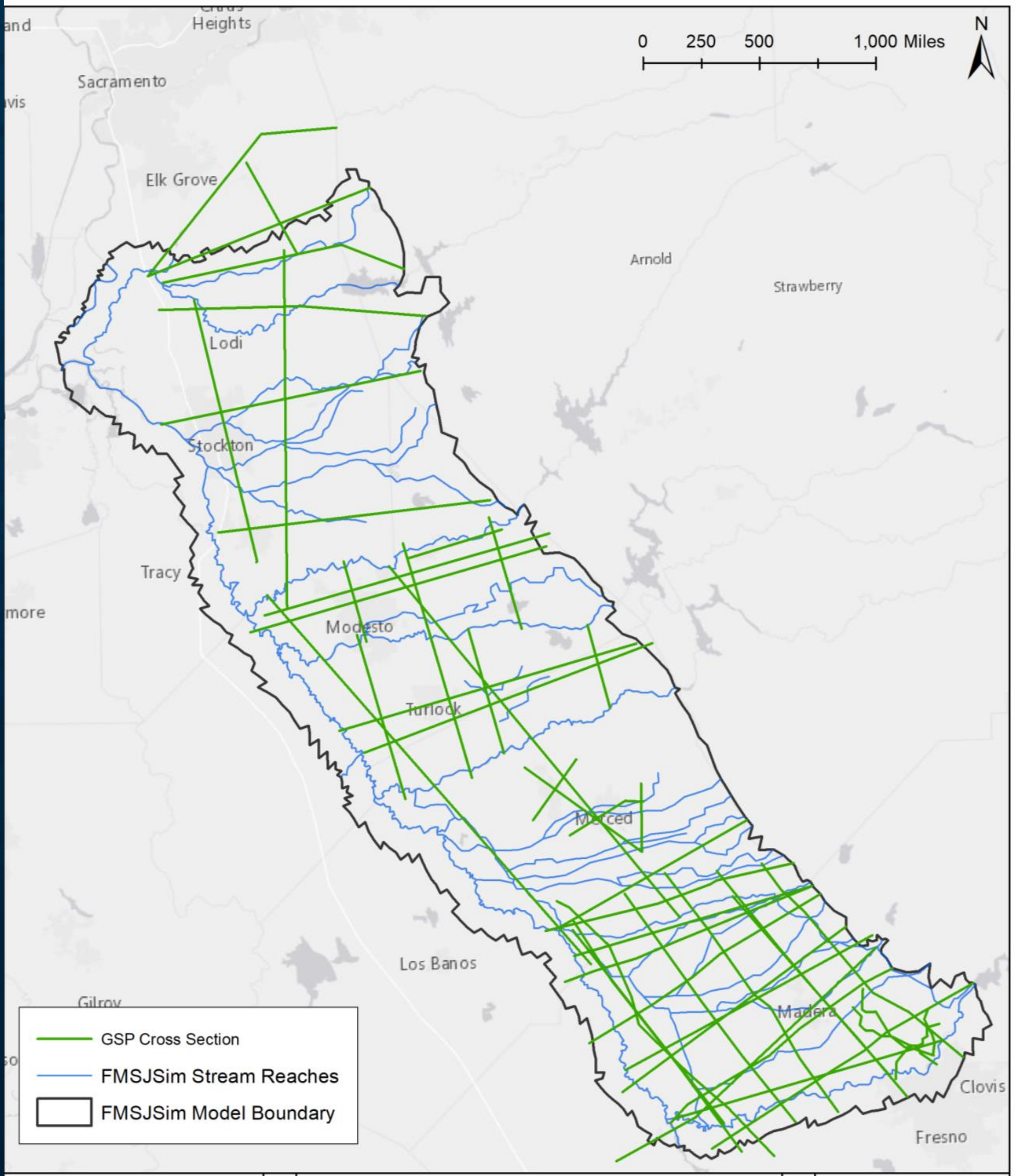
Figure modified from: CGS Regional Geologic Map, San Francisco-San Jose Quadrangle, 1991

Source: California Geological Survey

Defining Shallow Alluvium

Ideal Layer has:

- Useful extent across model area
- Useful thickness in basin areas and along streams
- Captures coarse deposits that interact with surface
- Includes formations of similar alluvial rock types
- Regionally consistent



Defining Shallow Alluvium

Most “young” and “old” alluvium

- Modesto
- Riverbank
- Turlock Lake (above Corcoran)
- Tulare (above Corcoran)
- Victor
- Un-named young fan deposits

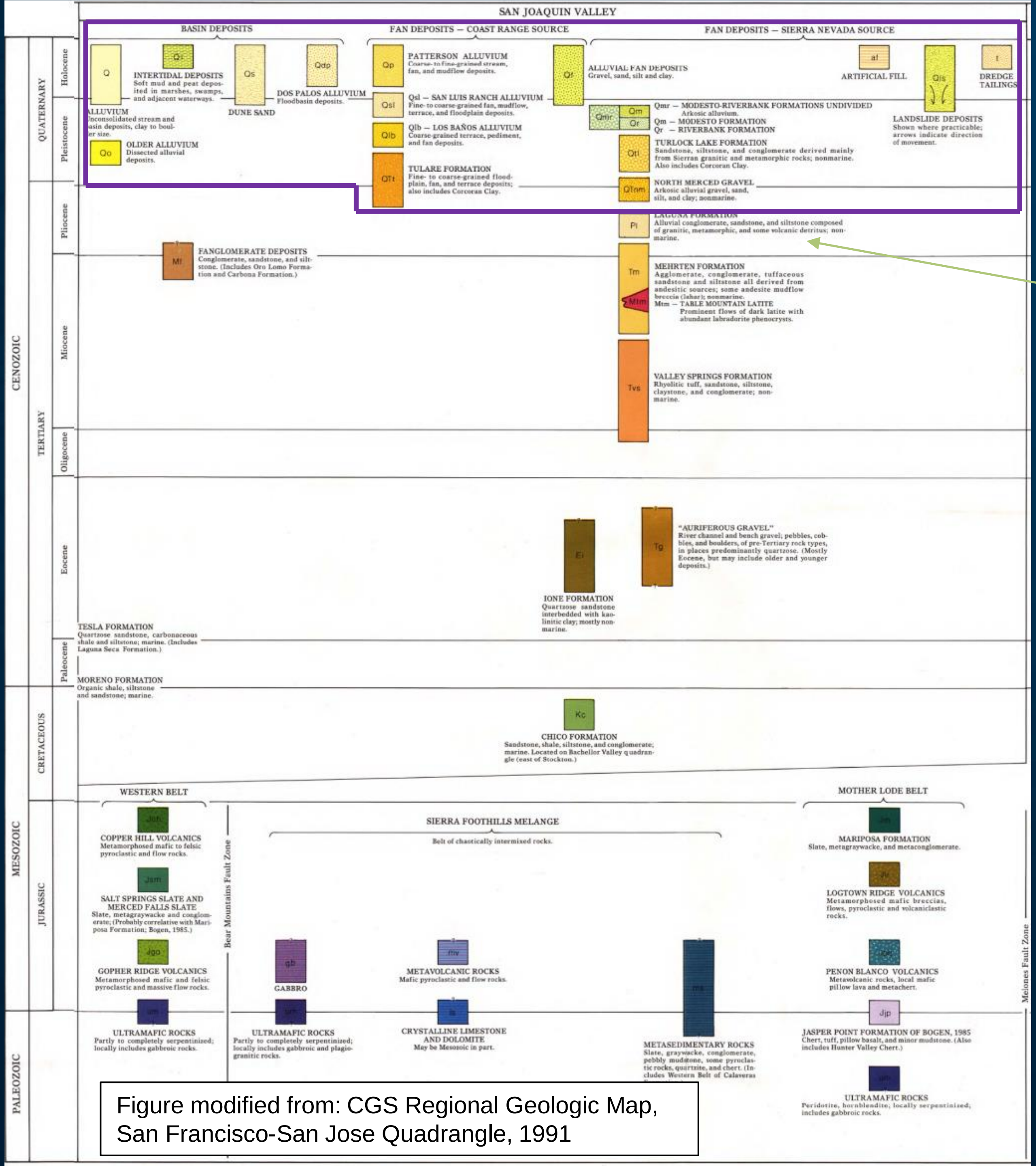


Figure modified from: CGS Regional Geologic Map, San Francisco-San Jose Quadrangle, 1991

Laguna Formation not included

Source: California Geological Survey

Limitations of a Lithology-Based Layer

- Inconsistent studies across large model area
  - Level of detail
  - Interpretation of formations
- Ideal formation depths are too shallow in some areas (<20 ft) and too deep in others (400 ft +)
  - Corcoran Clay falls within alluvial deposits at about 200 ft at San Joaquin River
  - Difficult to meet all modeling requirements

Sources: Modesto GSP, Turlock GSP

Add Modeling Assumptions

Corcoran Clay

At each groundwater node:

Layer 1 Thickness =

Min(**150 feet** or ½ * (Depth to Clay))

Results in:

- Min Thickness: 20 ft
- Max Thickness: 150 ft

Streams

At each stream node, to support IWFM computations and convergence, :

Min. Layer 1 Thickness at stream node* =

Stream Depth + **20 feet**

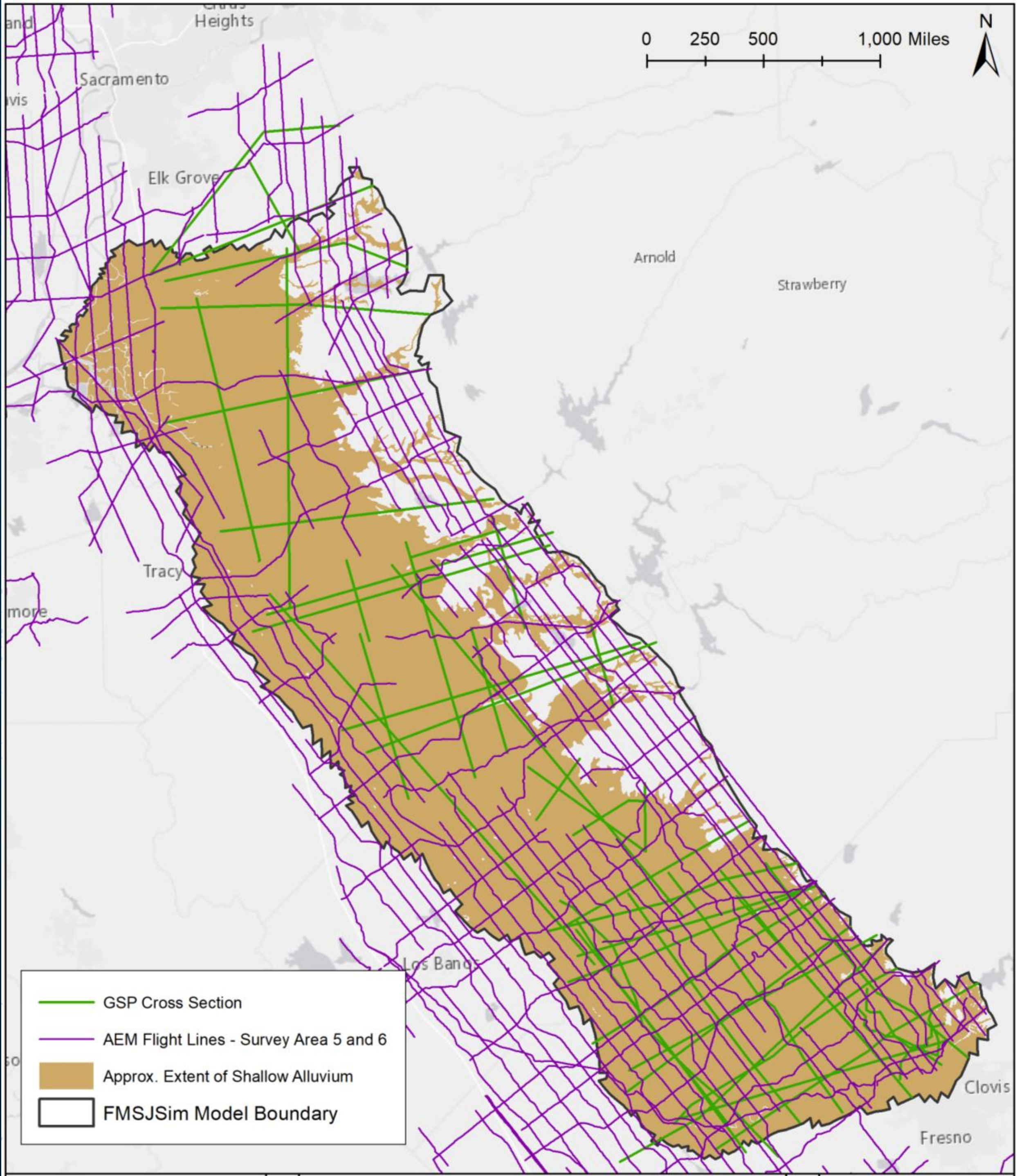
Results in:

- Min Thickness: 25 ft
- Max Thickness: 175 ft

*Rounded up to closest multiple of 5 to be sure condition will be met by an interpolation.

Opportunity to Use Provisional Resistivity Data

- Benefits
  - Relatively continuous resistivity data
  - Higher resolution than published cross sections
- Considerations
  - Challenging to translate resistivity data into formations
  - Project schedule and budget
  - Water quality and degree of saturation also impact resistivity
  - Datasets are not fully available yet



Source: DWR, Published GSPs

Validate and Refine Lithology-Based Layer

Layer 1 defined based on mapped lithology
(top of Laguna Formation)

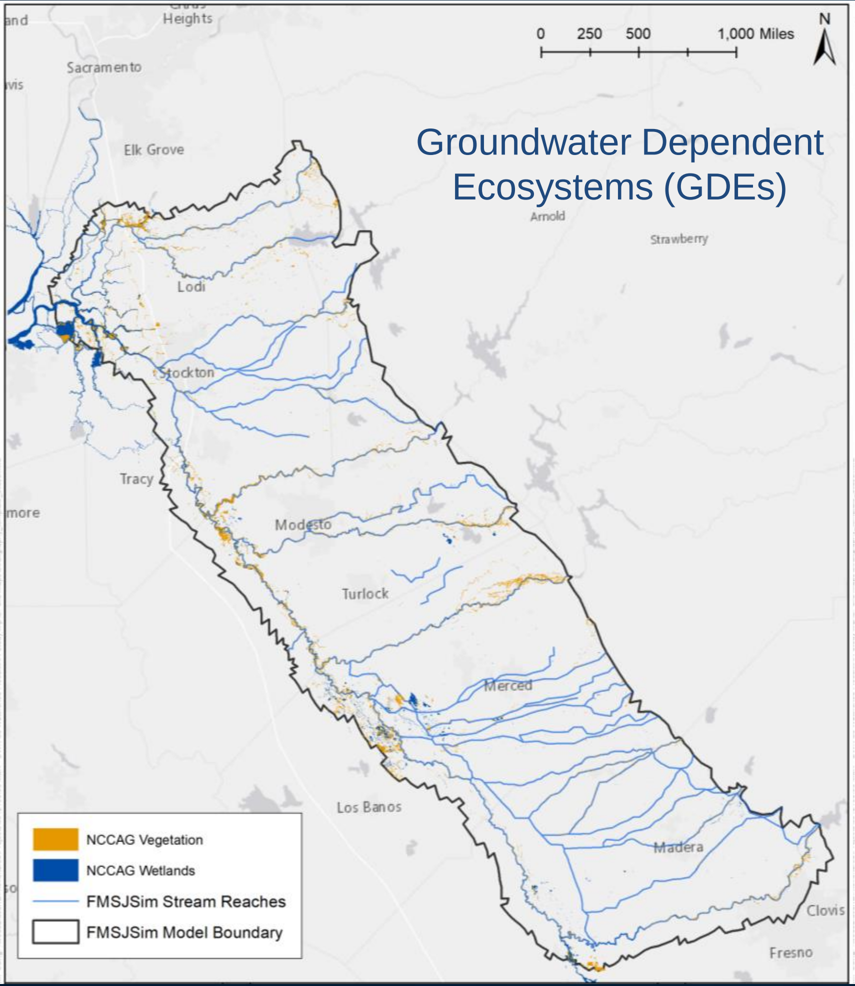
<u>Applied modeling assumptions for:</u>

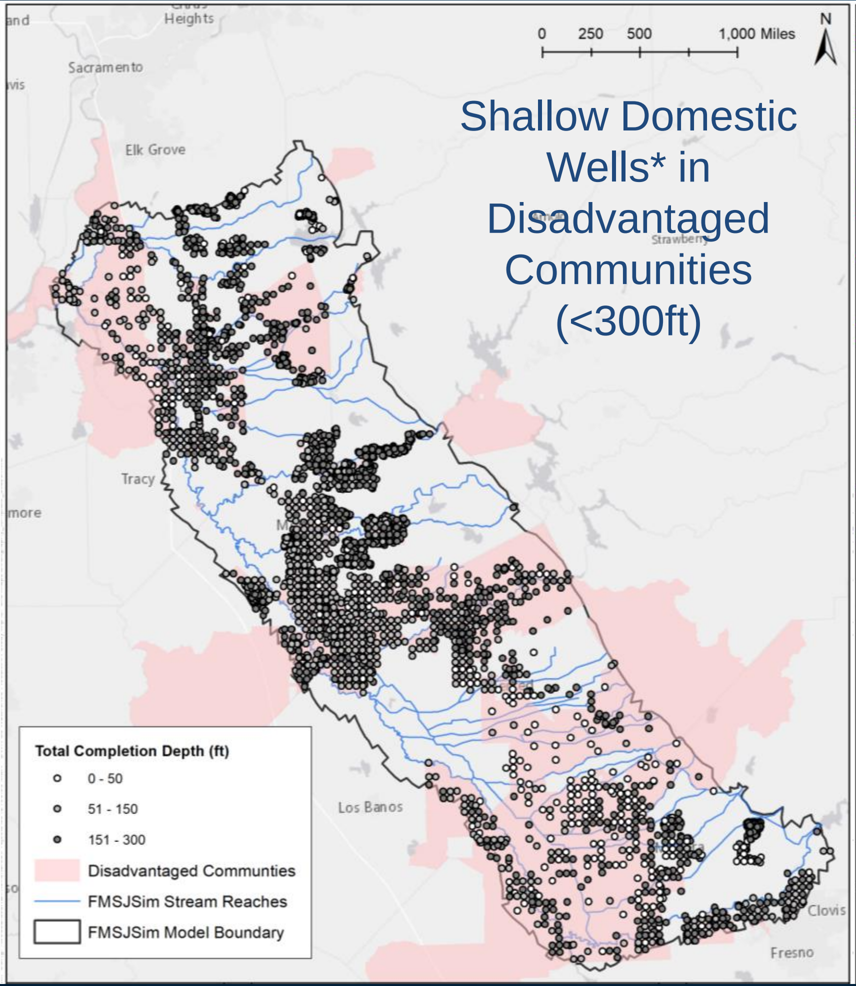
- Areas above Corcoran Clay
- Minimum thickness at streams
- Minimum model area thickness

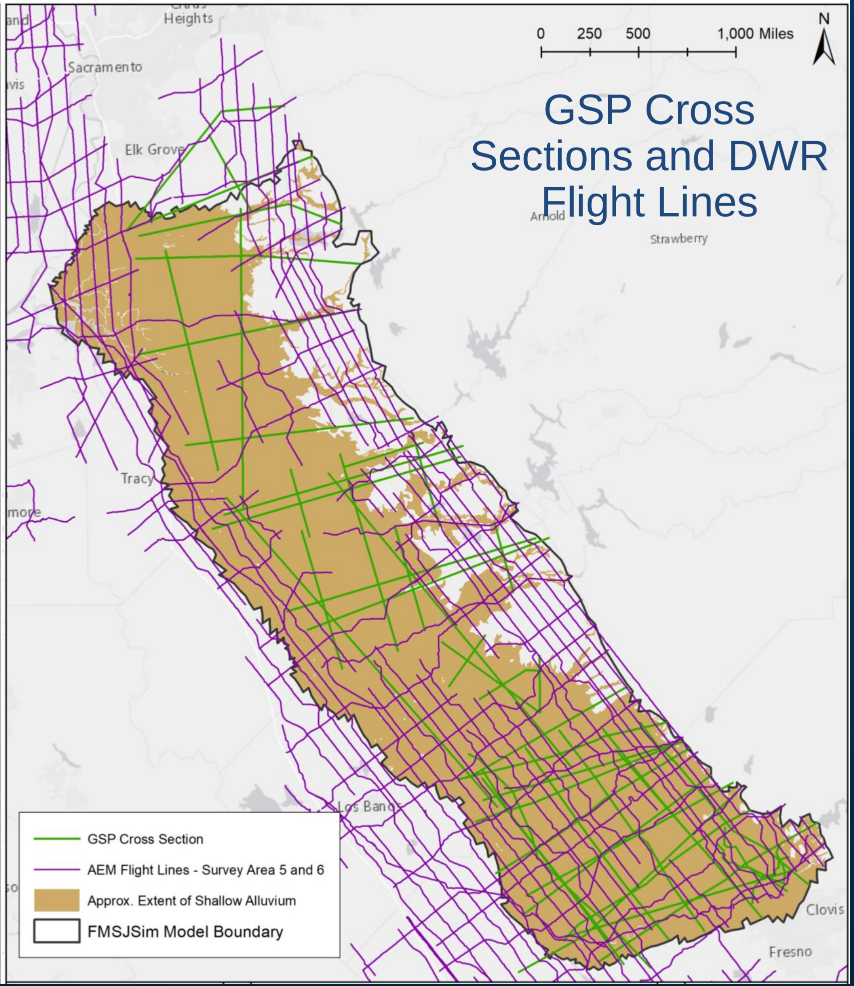
Use provisional resistivity data to validate assumptions and inform smoothing

Based on observed physical attributes

Prioritize Areas for Validation (and Refinement)



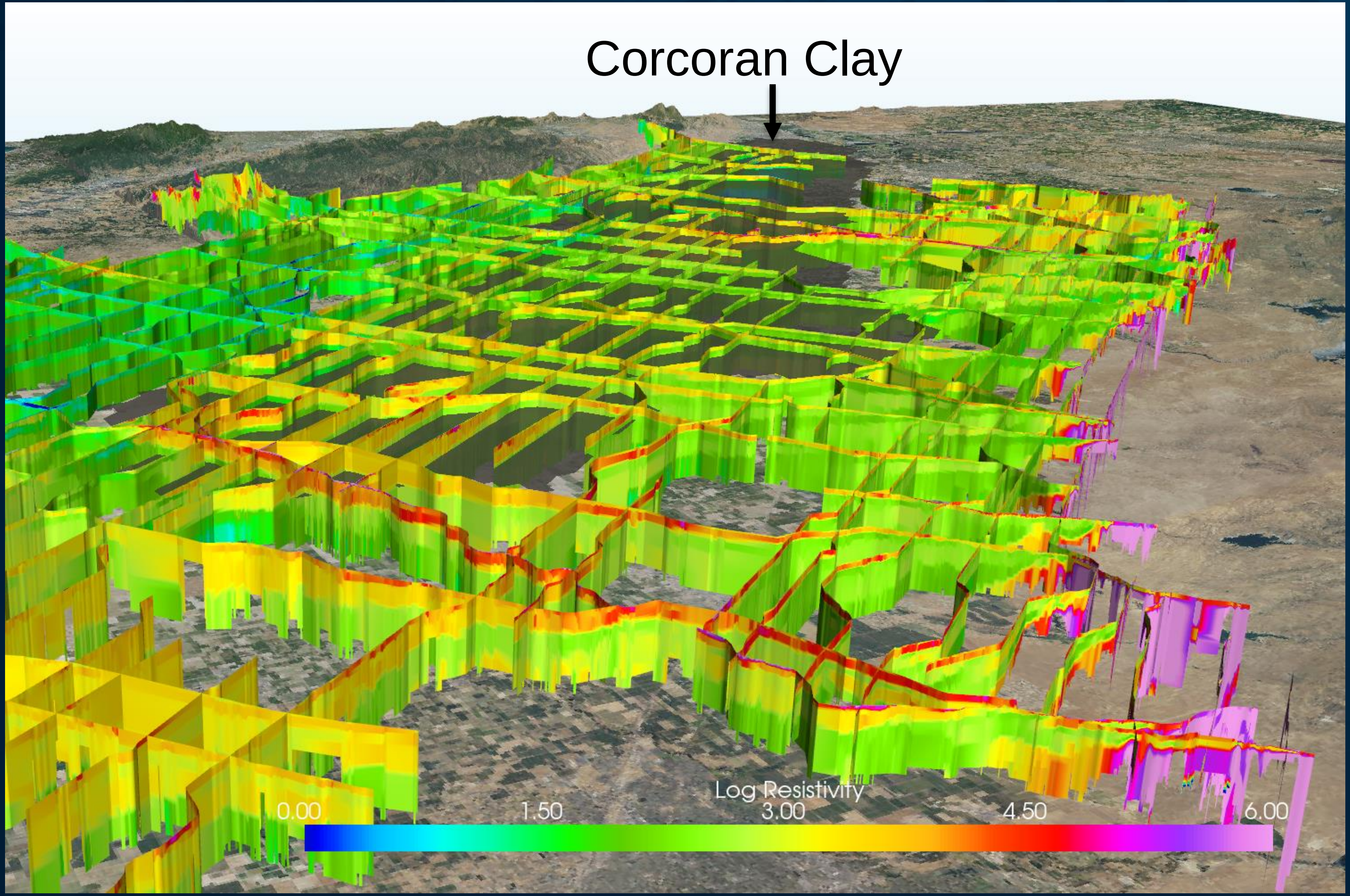




*Domestic well dataset development currently in progress by Earth Genome

Sources: (Klausmeyer, K., Howard J., Keeler-Wolf T., Davis-Fadtke K., Hull R., and Lyons A., 2018), DWR, Published GSPs

Visualize Datasets Together



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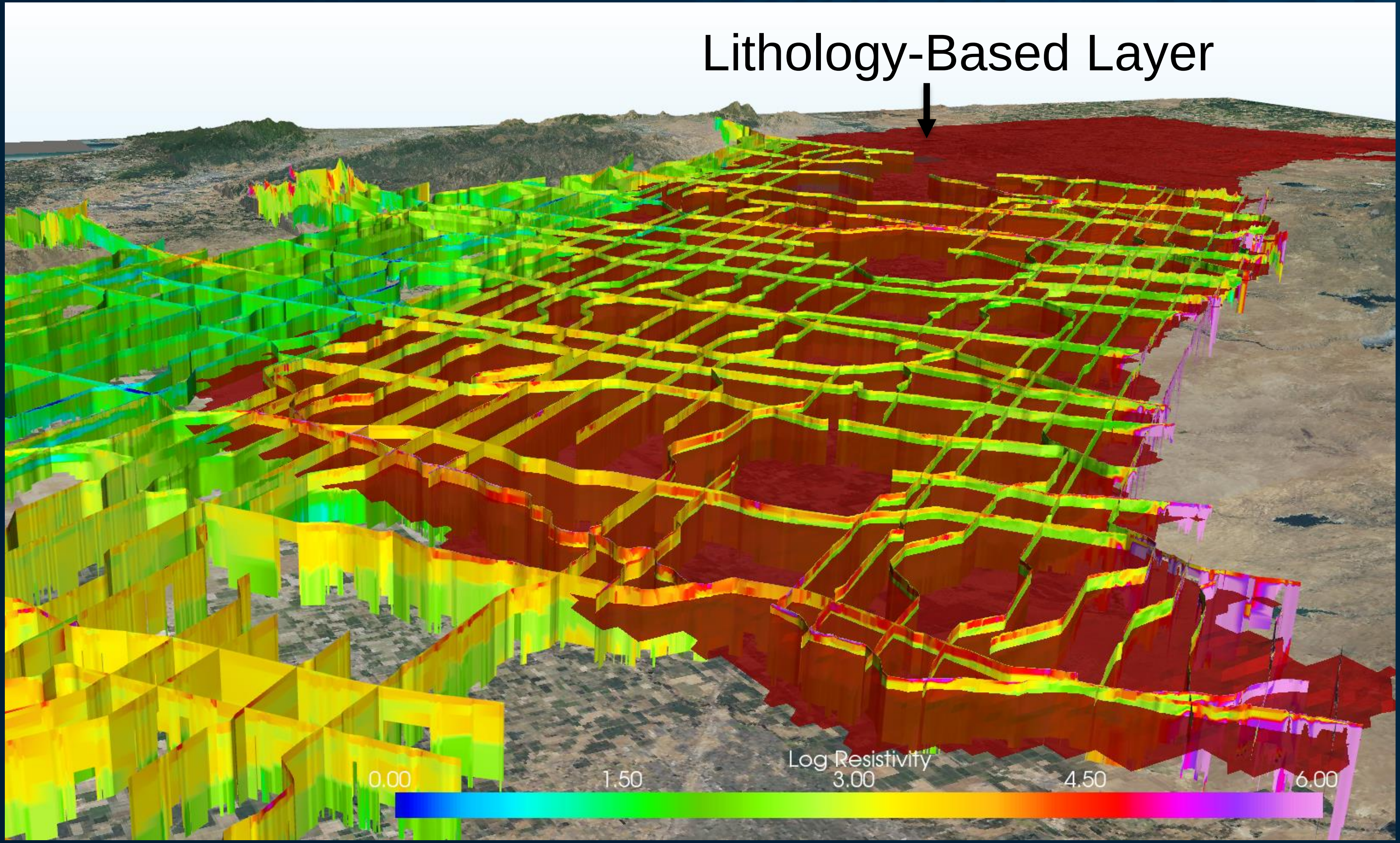

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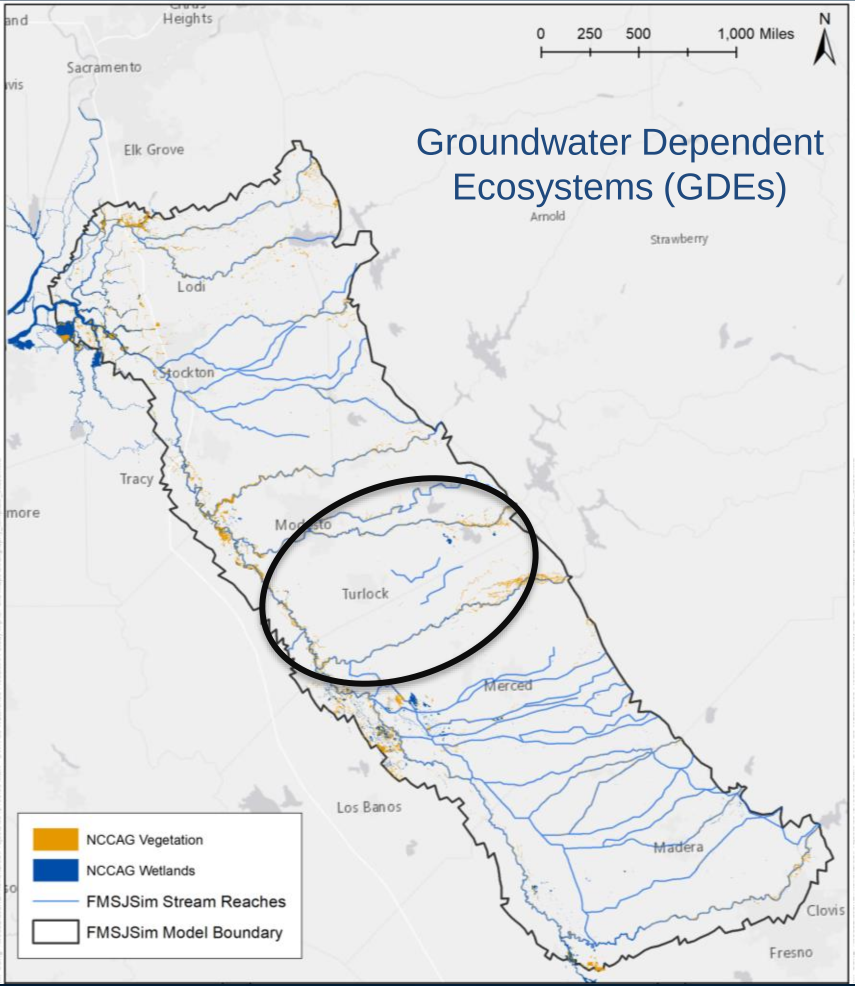

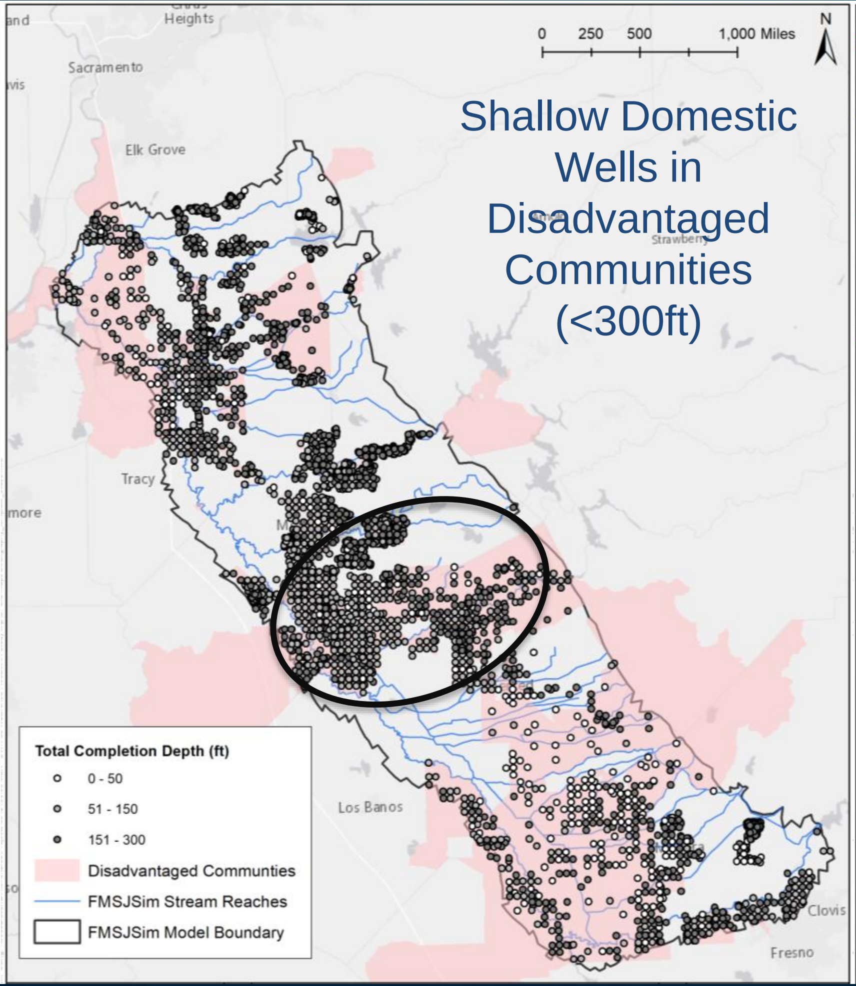

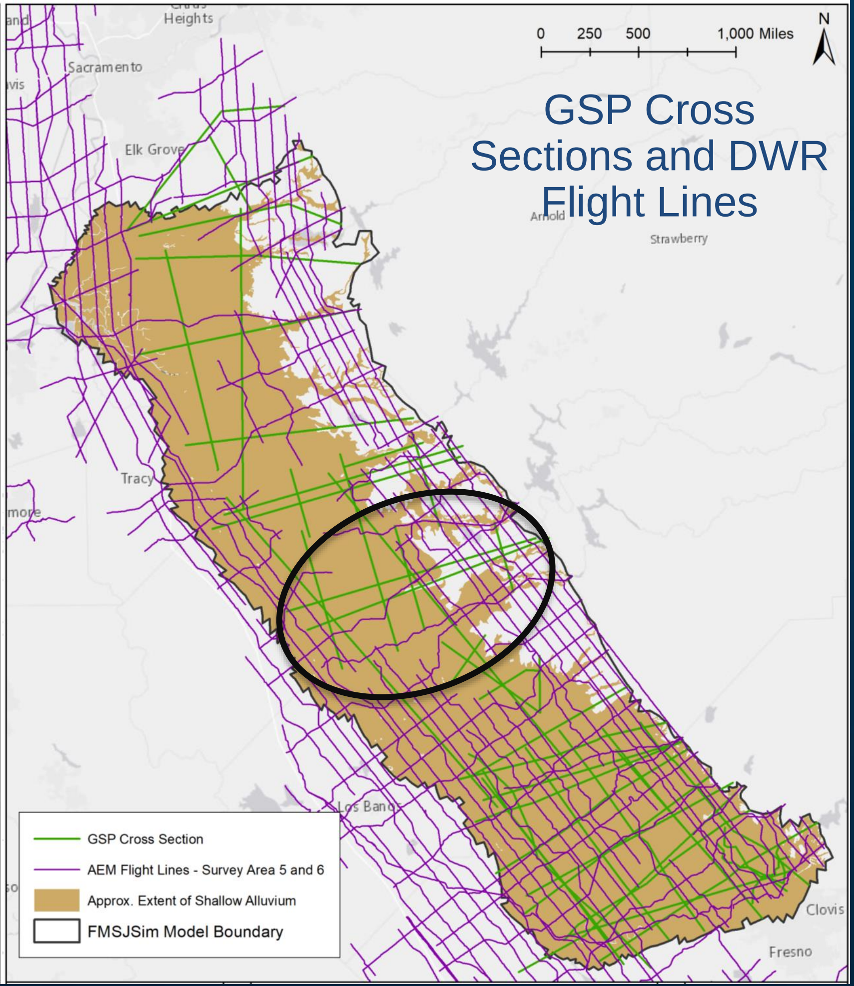

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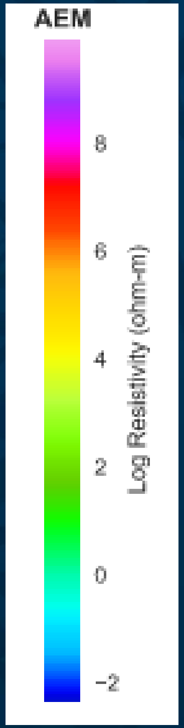
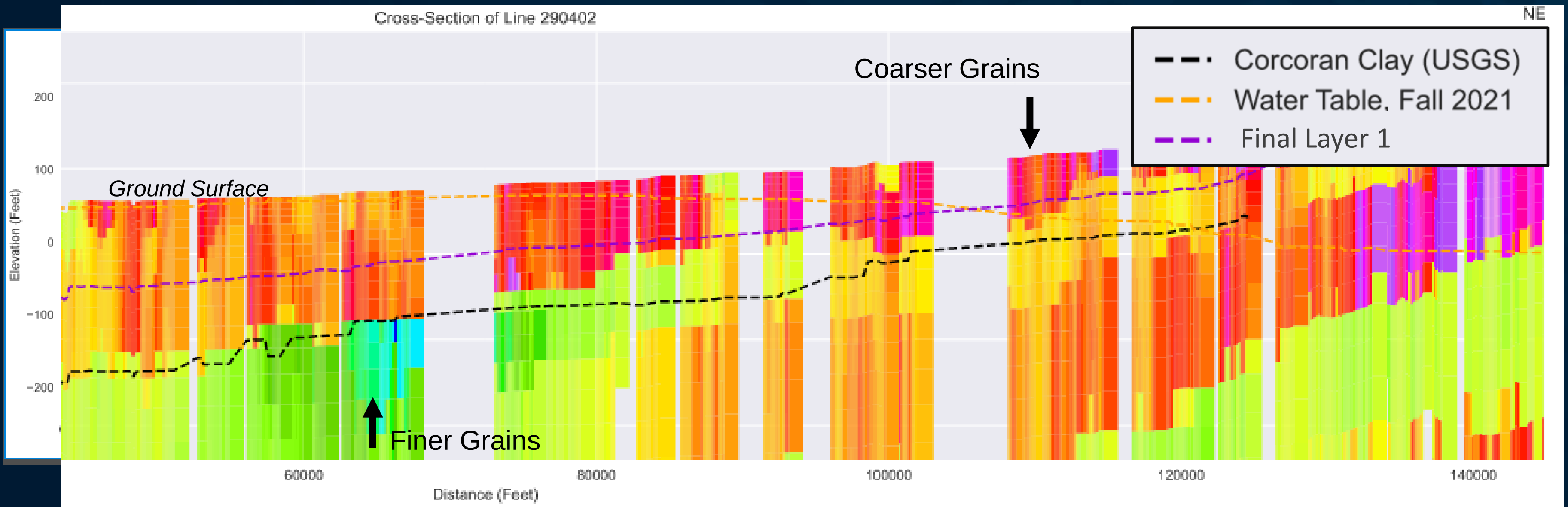
Example Validation

Coarser
Fresher water
Less saturated

Finer
More saline
More saturated

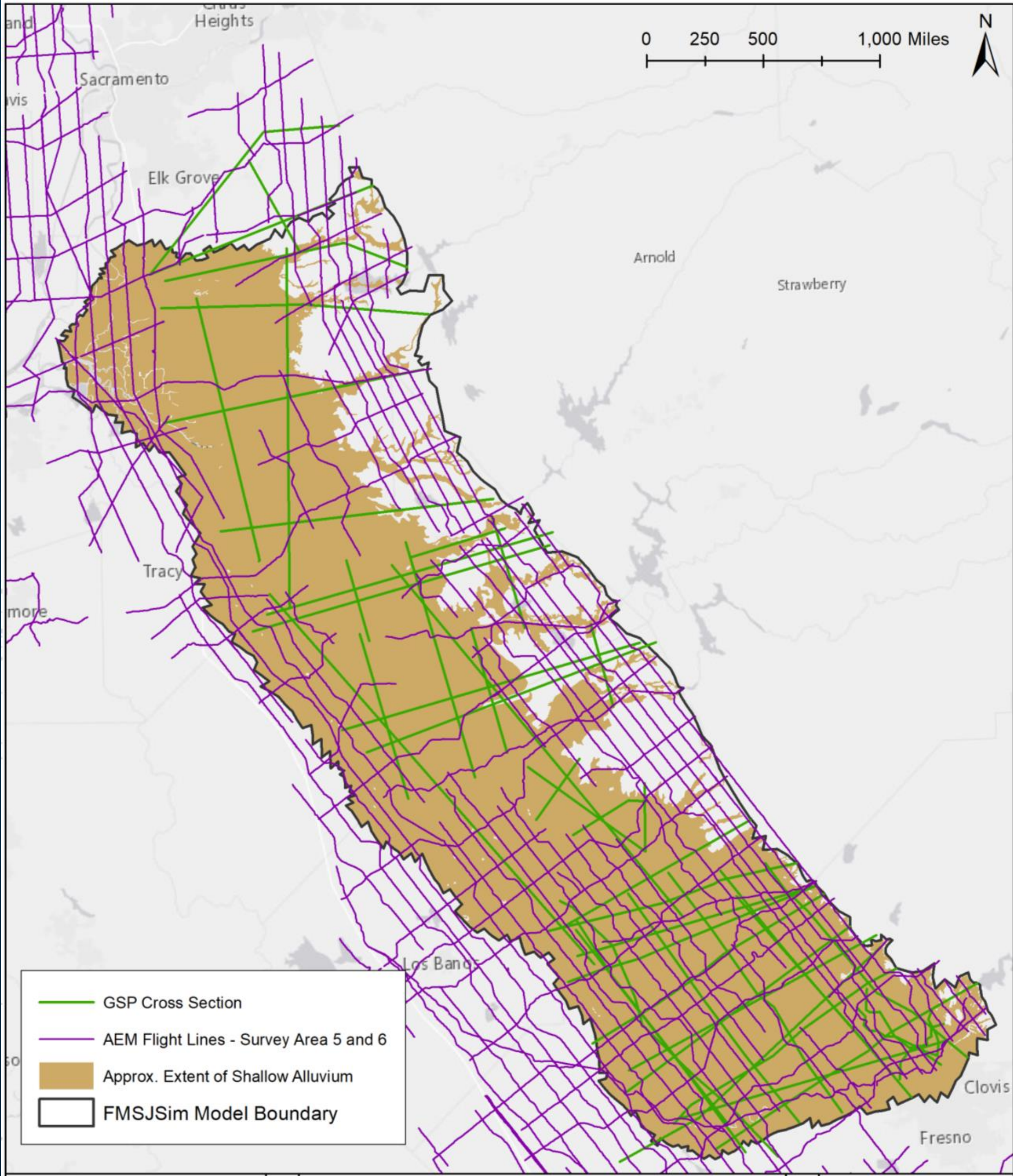




Example Refinement

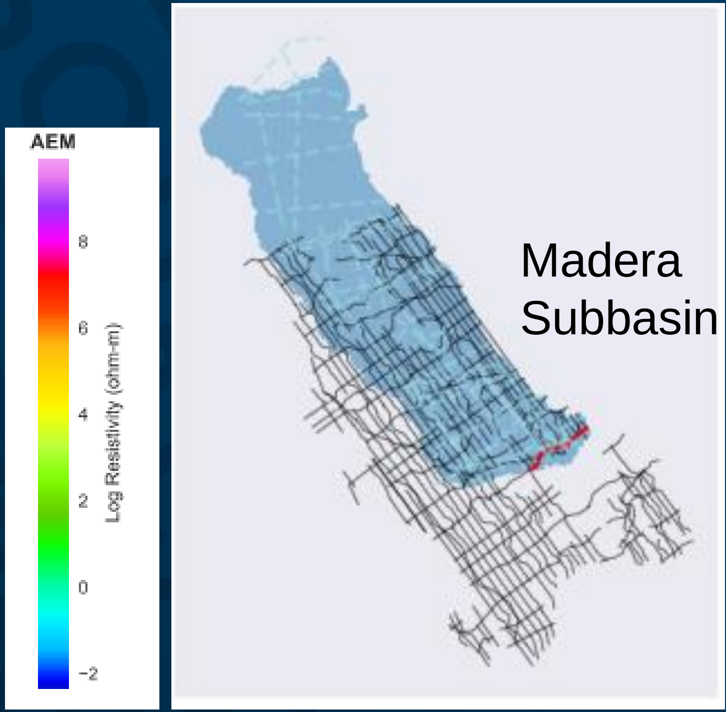
Important to Note:

- Interpretations of resistivity data were made very cautiously
- Degree of saturation was considered
- Water quality was NOT considered

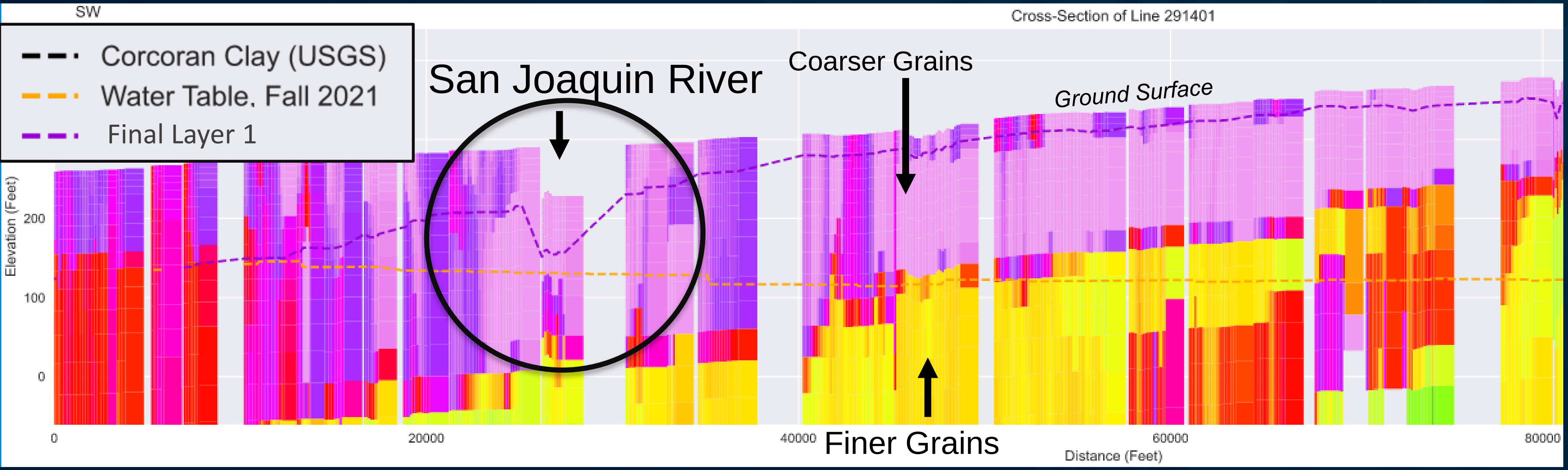


Example Refinement

- Sudden 50-70 ft drop at western river crossing could be smoothed out.
  - Relatively consistent resistivity measurements in this area
  - Above water table

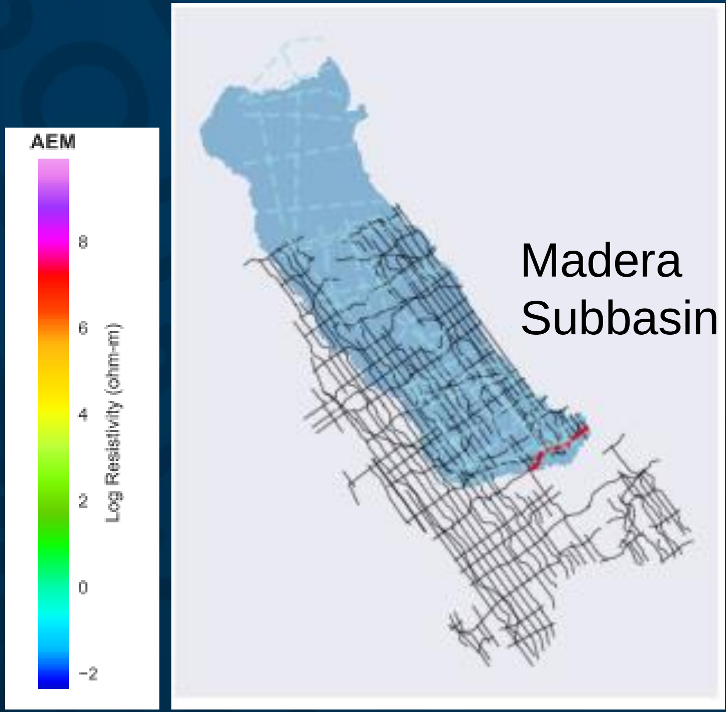


Pre-Refinement

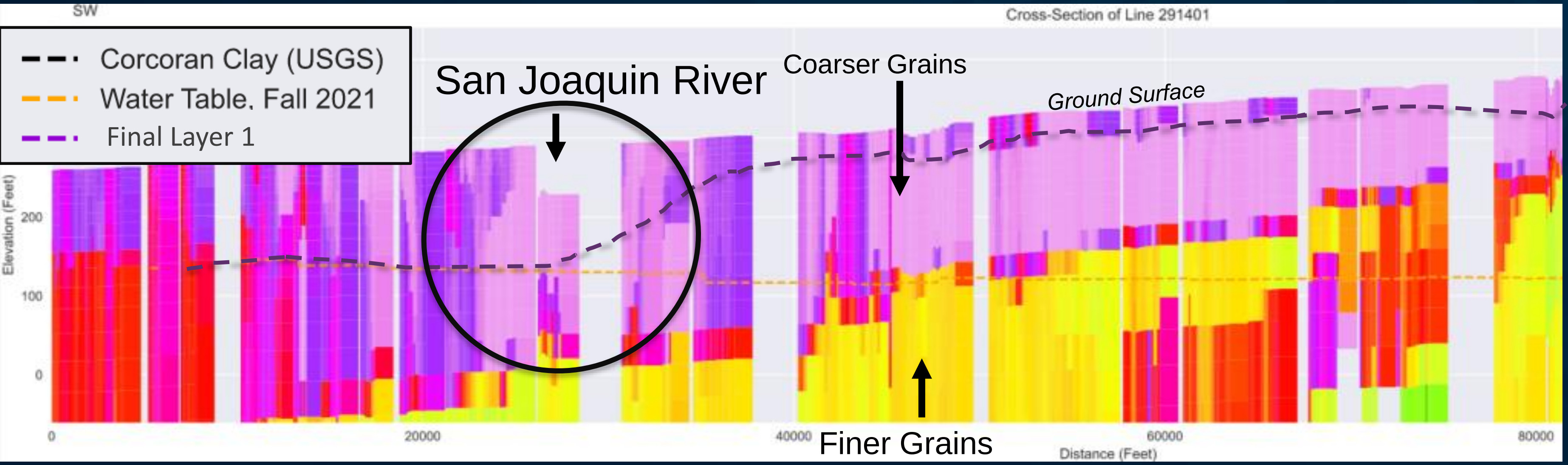


Source: DWR

Example Refinement



Post-Refinement



Source: DWR

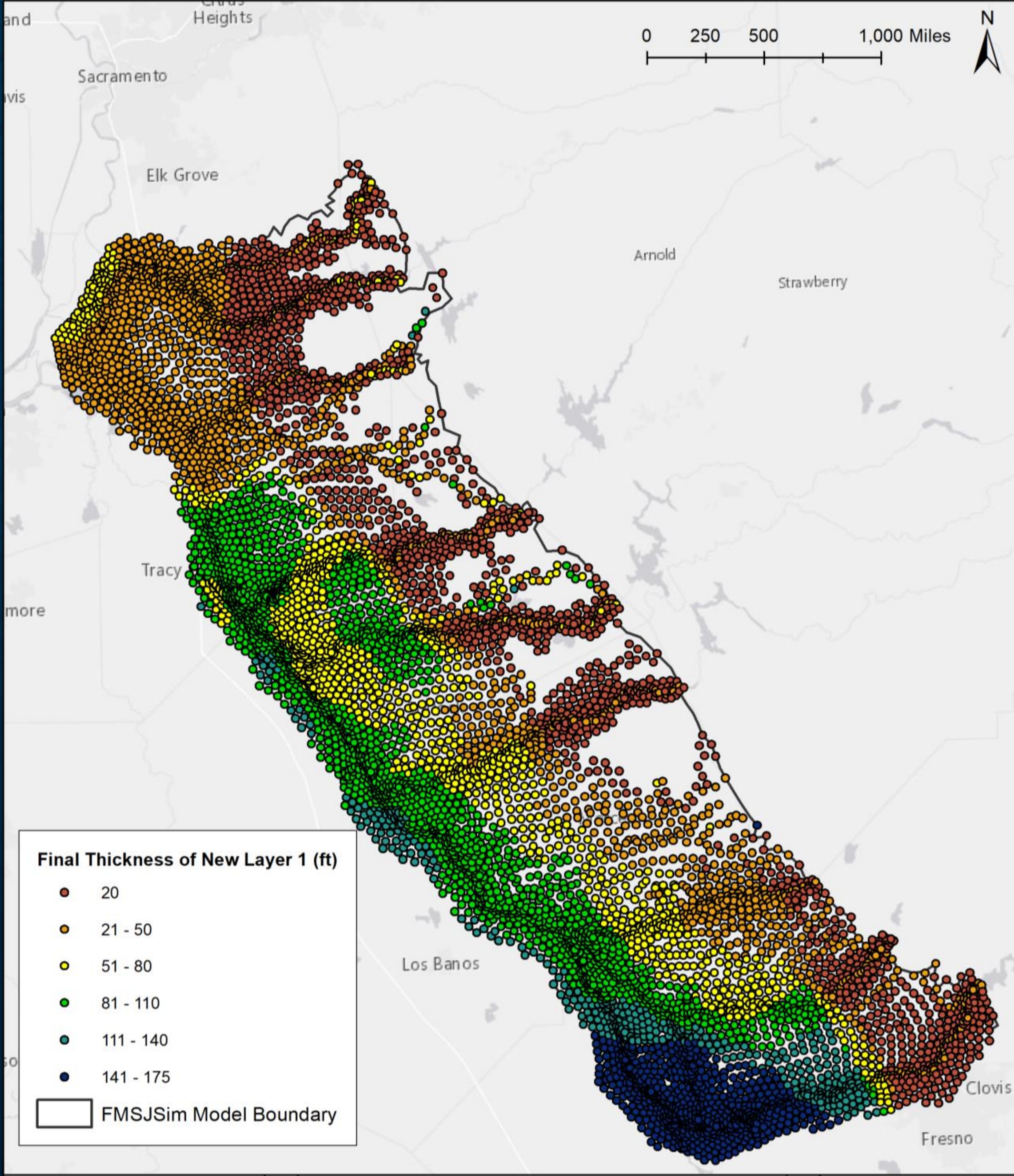
Final New Layer 1 Thickness

Min Thickness: 20 ft

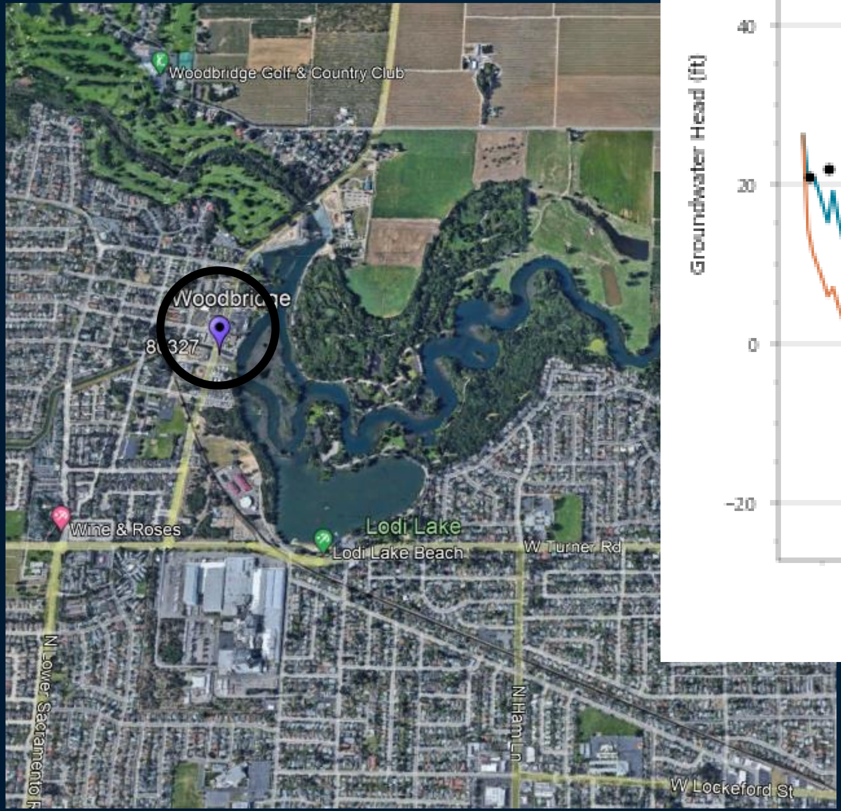
Max Thickness: 175 ft

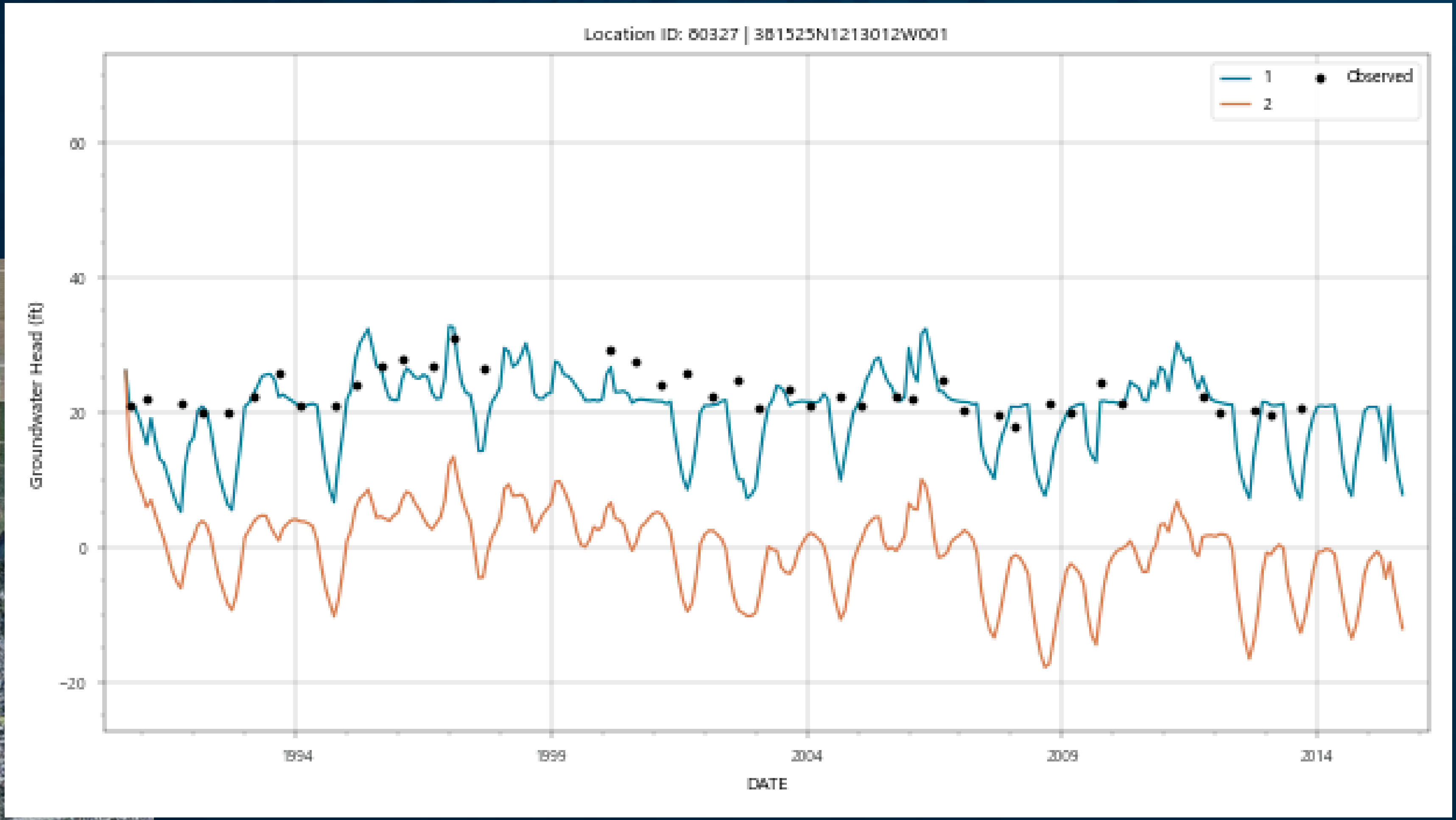
Average Thickness: 69 ft

Note: Nodes without Layer 1 have thickness = 0 ft



Integration into FMSJSim





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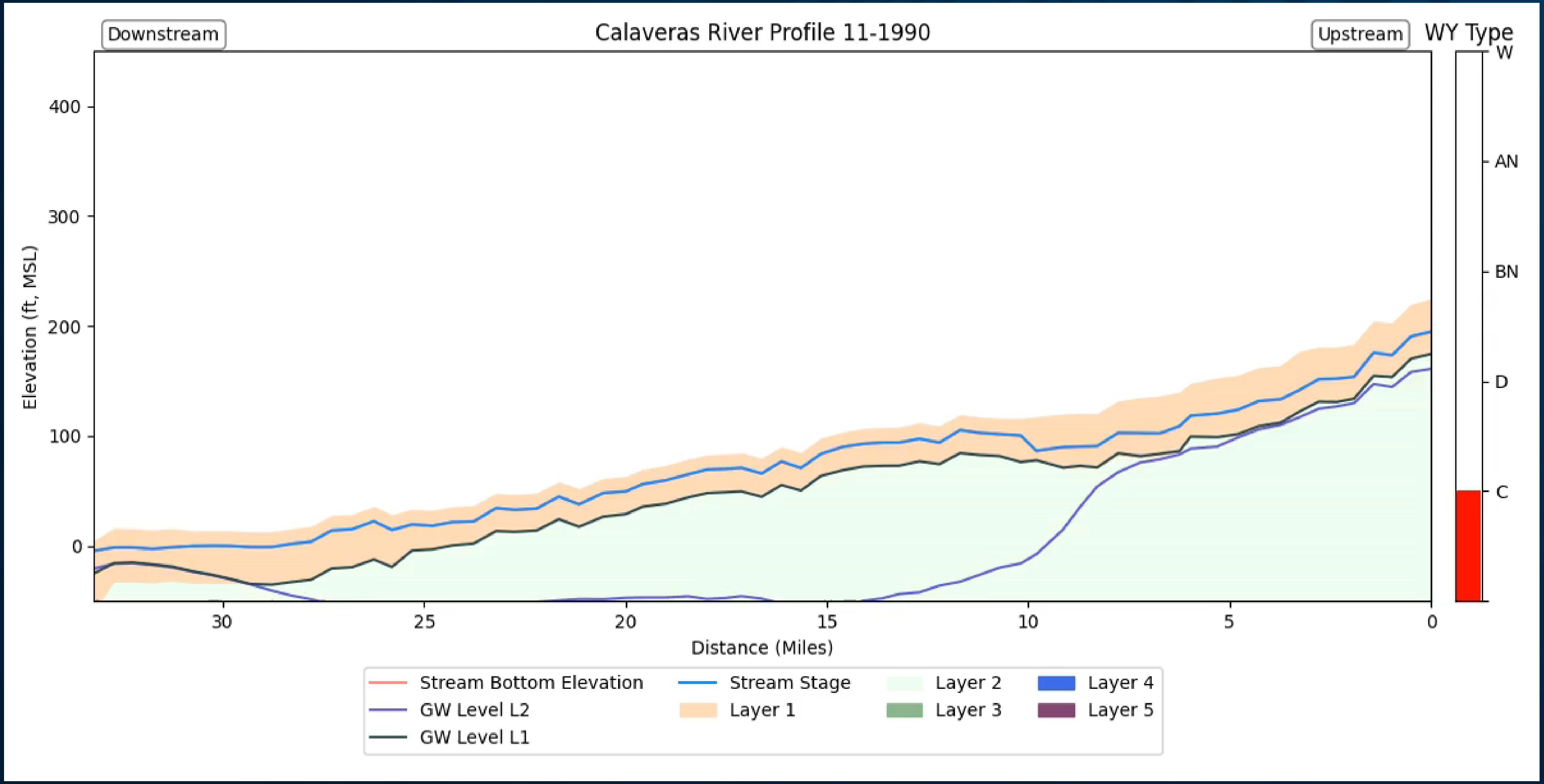
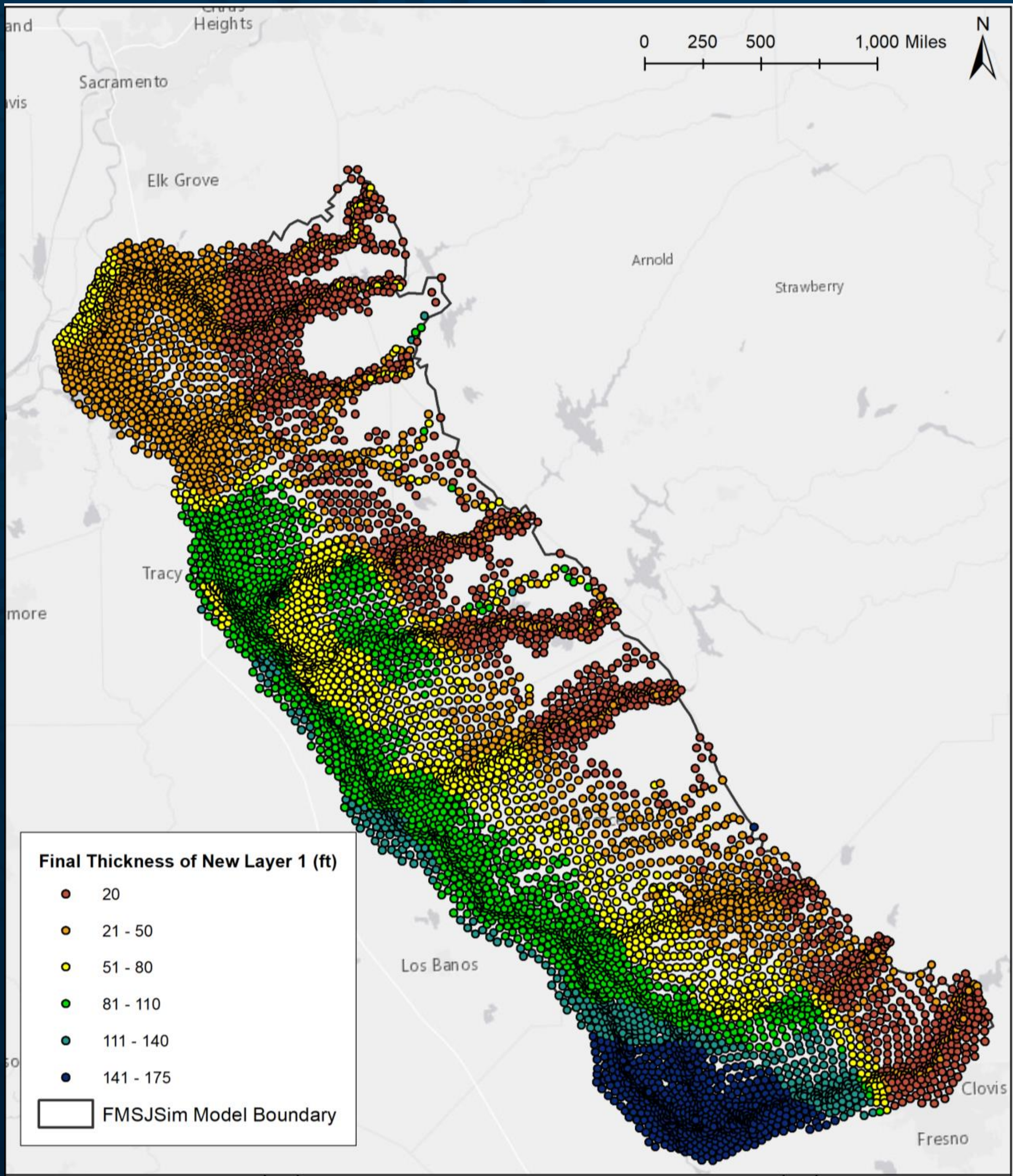


Findings

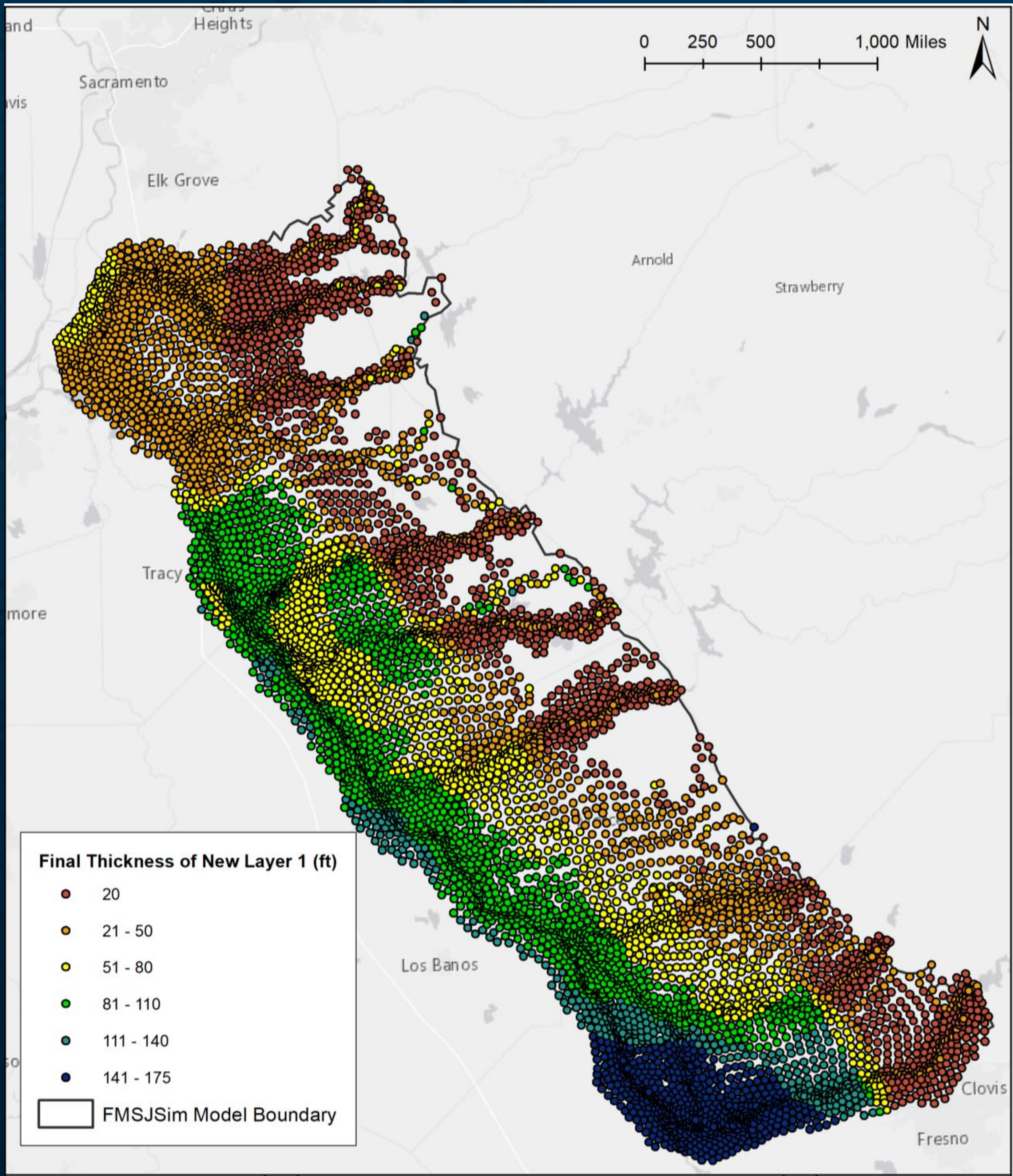
- New Layer 1 represents shallow alluvium above the Laguna Formation, with modifications for:
  - Modeling constraints
  - Depth to Corcoran Clay
- Divided former Layer 1 into two distinct functional layers



Findings

- Can use even provisional AEM resistivity data to validate lithology-based layer and refine as appropriate
- New layer improves evaluation of GDEs and stream-aquifer interactions

Future Work: Use full geophysical analysis, once completed by DWR, to support future modeling



Thank you!

Special thanks to the rest of our team who contributed to this presentation:

- Dominick Amador: Project Manager
- Jim Blanke: Technical Lead
- Jack Baer: AEM Data Processing and Visualization
- Sercan Ceyhan: Calibration Figures

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