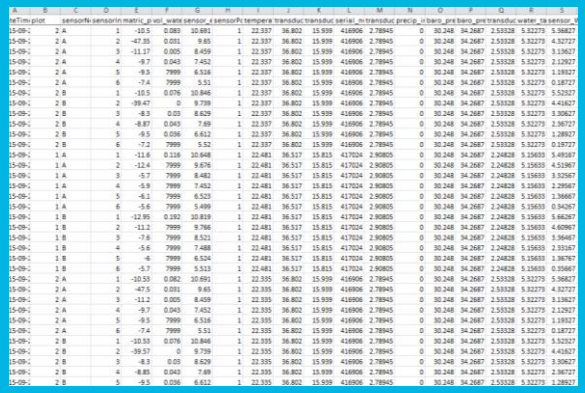
Capillary Rise Study

Interactive Visualizations of 5 Million Sensor Measurements of the Capillary Fringe Lead to an Optimized Soil Remedy



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Thursday April 12, 2018

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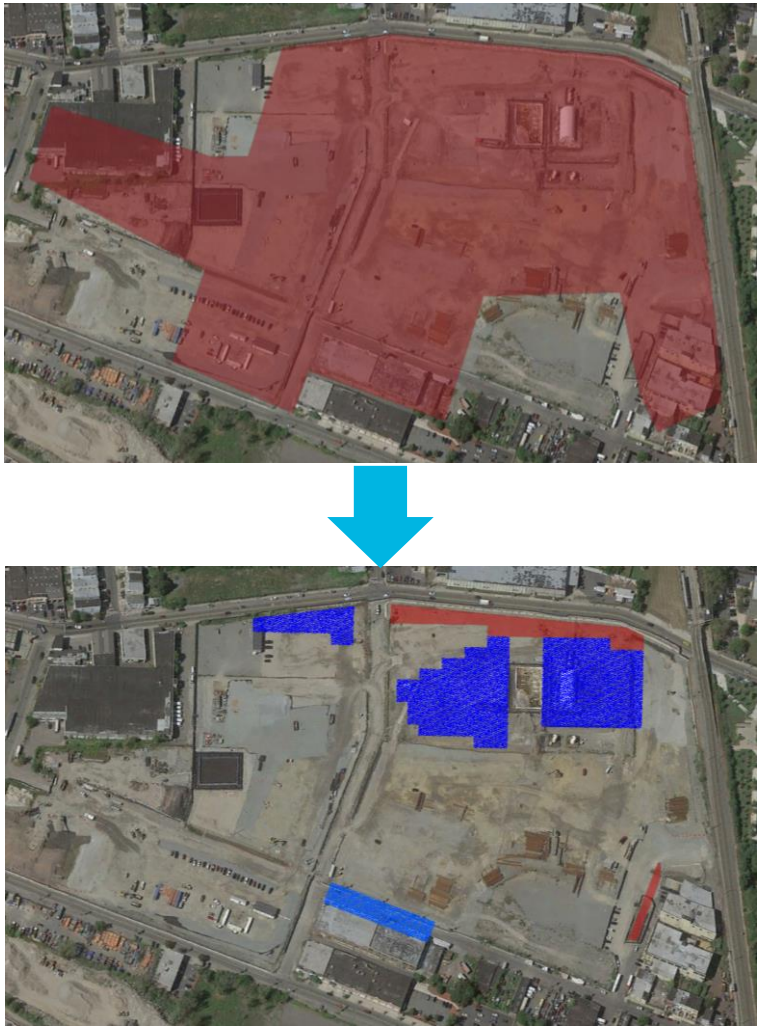
Big Problems and Little Problems

– **BIG PROBLEM**
  - Regulator required 28 acres of impervious liner above GW plume

– Little Problem
  - Field study for alternatives to liner generated a massive amount of difficult to analyze data

– Little Solution
  - Create custom interactive data viewer

– **BIG SOLUTION**
  - Regulator accepted 0.8 acres of impervious liner and 3.6 acres of washed stone capillary break



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Field Study Objectives

1. **Determine the height of the capillary fringe in dense grade aggregate (DGA) backfill material at the site.**
2. **Determine the height of the capillary fringe in topsoil backfill material at the site when placed in sufficient thickness to hydraulically connect with the saturated zone of the capillary fringe.**
3. **Evaluate the effectiveness of an engineered capillary break on limiting the height of the capillary fringe in backfill material at the site.**

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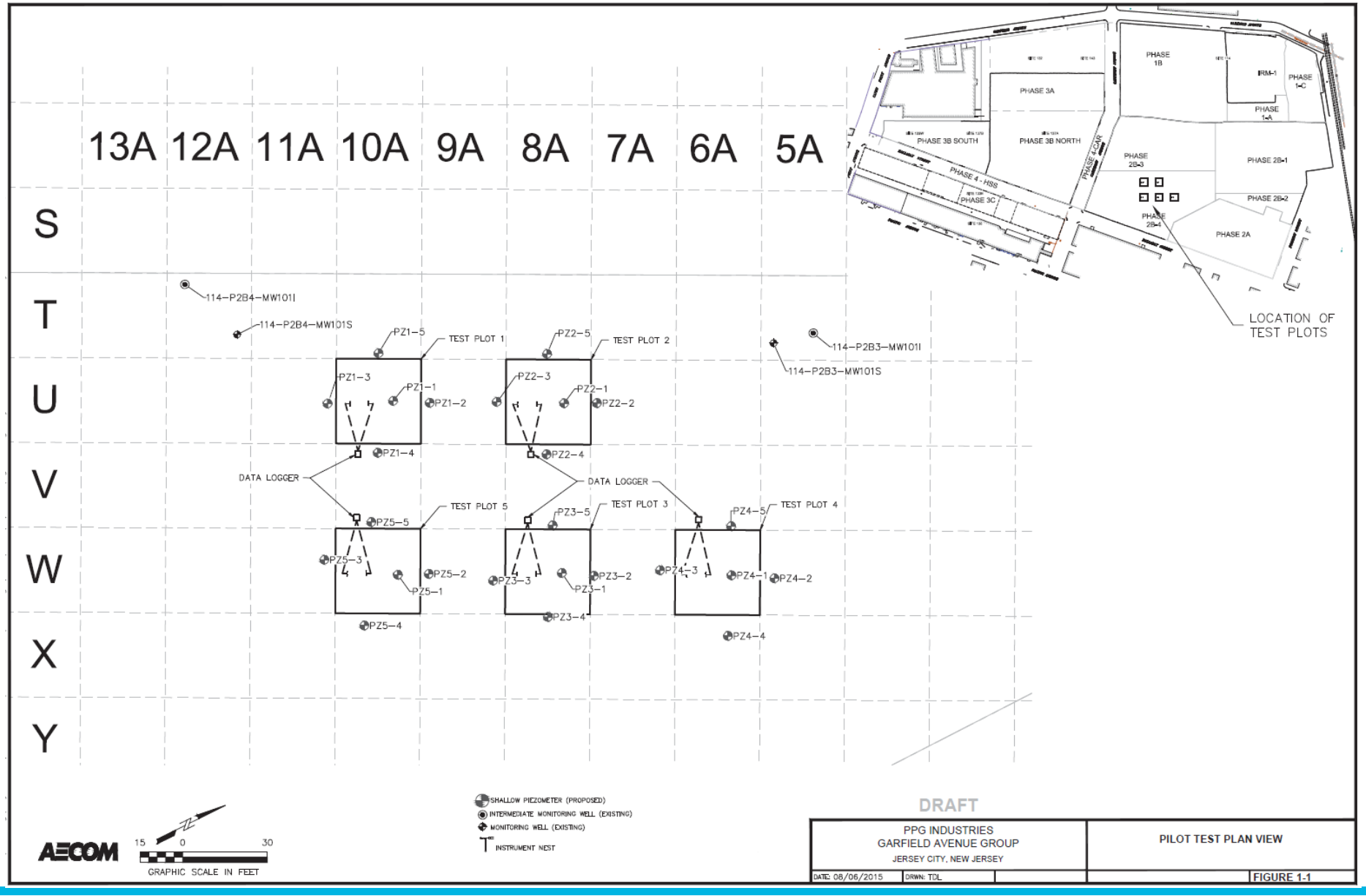
Test Plot Layout



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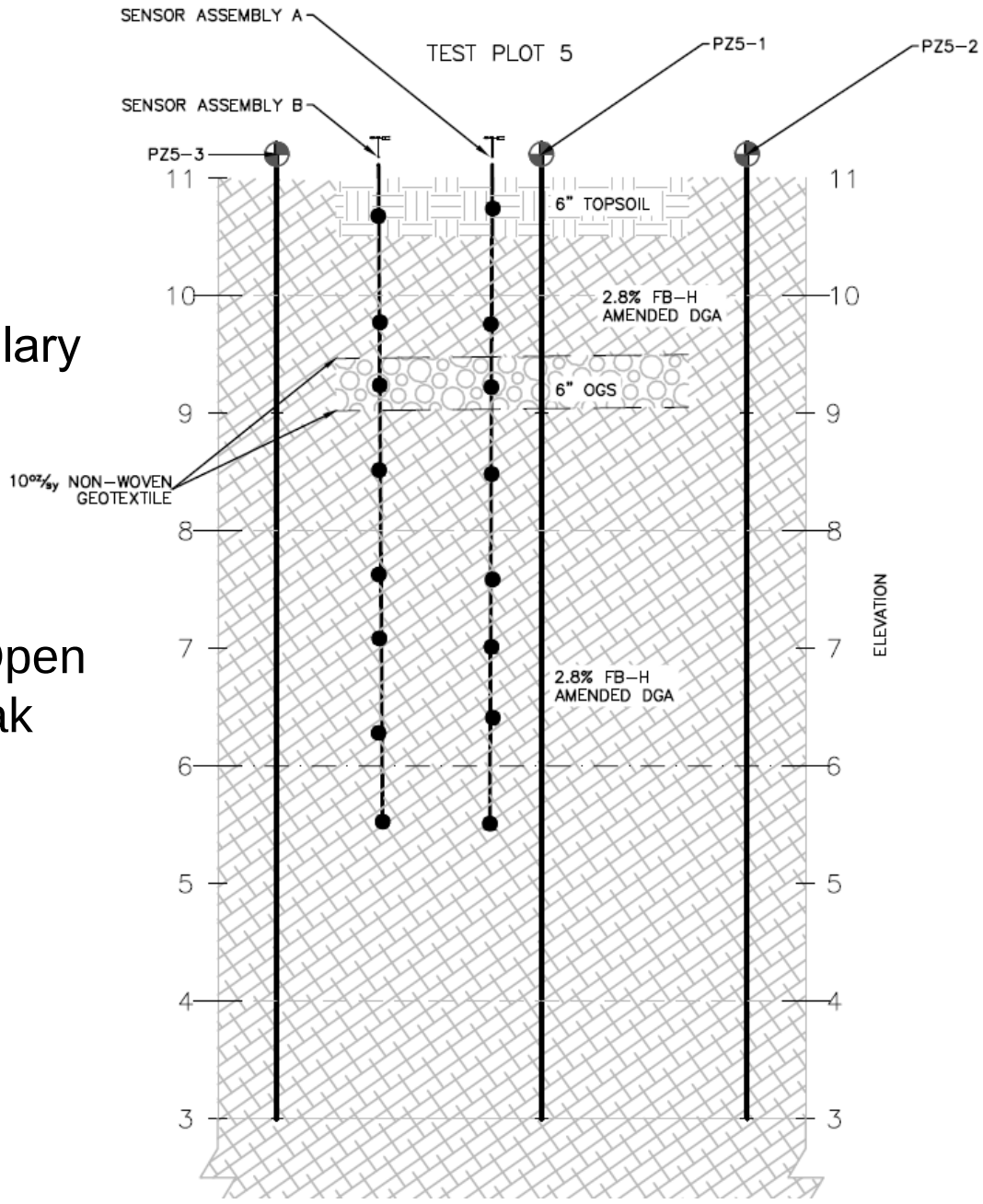
Test Plot Construction

– Test Plot 5
  - Amended DGA
  - 6” Open Grade Stone Capillary Break from El. 9 to El. 9.5
  - 6” of topsoil at surface

– Objective
  - Evaluate effectiveness of Open Grade Stone Capillary Break



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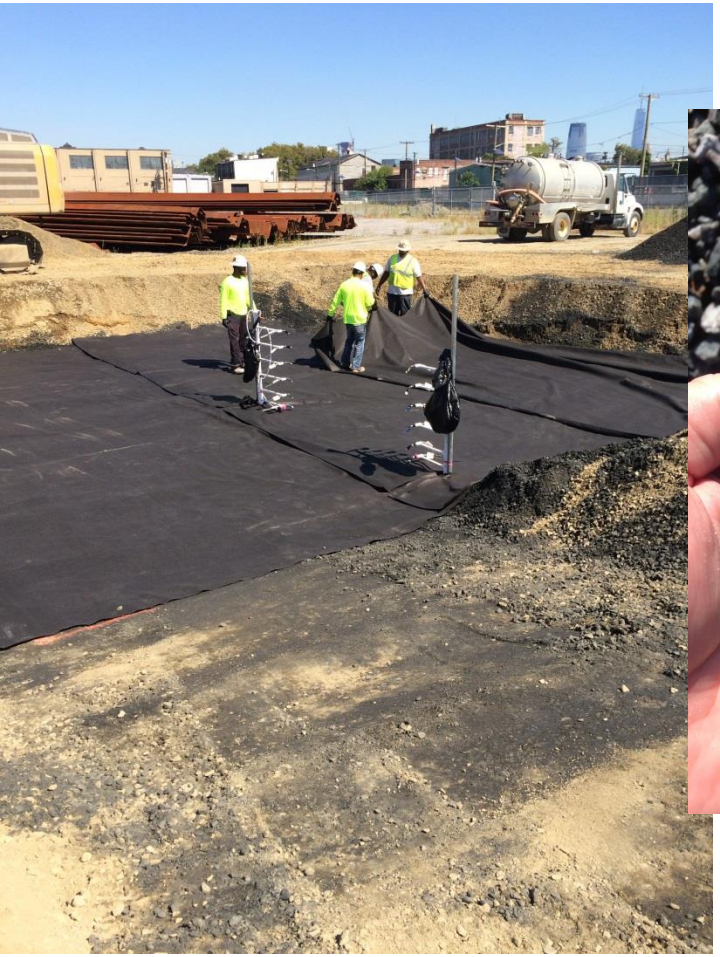
Amended DGA

Capillary Break Layers



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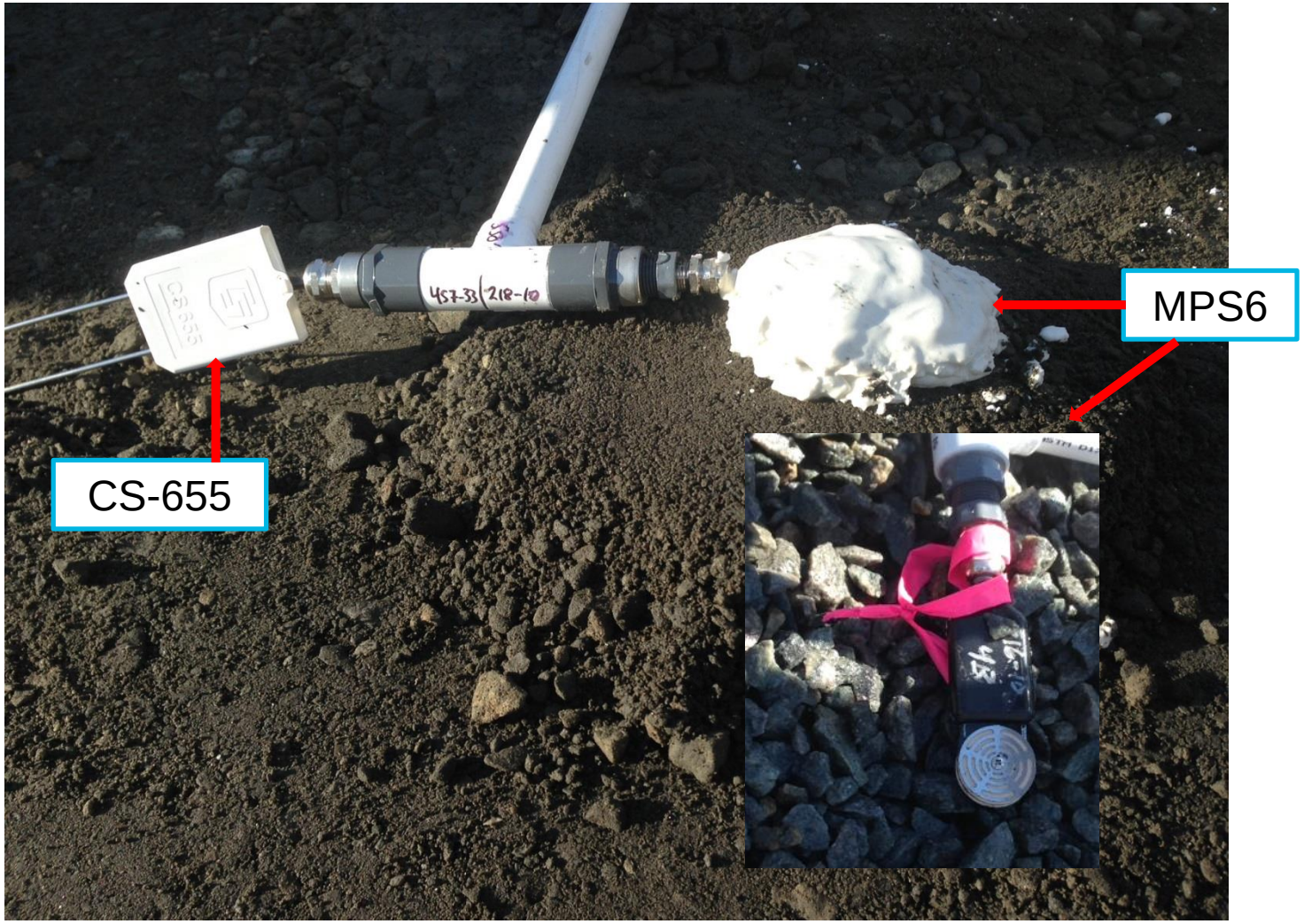
Sensor Placement



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Data Collection Progress

- Sensor Types
  - CS-655 – Volumetric Water Content Sensor
  - MPS-6 – Matric Tension Sensor
  - Water Level Transducers
    - Water Level Transducers in Piezometers
    - Water Level Transducers in Shallow Wells
  - Meteorological

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Data Collection and Processing

- 129 sensors in the field recordings readings every hour
  - 5 soil plots (experimental groups)
  - 2 sensor nests per plot
    - 6 or 8 sensors levels per nest
    - 2 sensors per level
  - 5 transducers (piezometers) per soil plot
- Weather station recording 8 values every 15 minutes – used to normalize / interpret transducer data
- 1,410,360 complete records generated
  - 1 record per sensor location per hour

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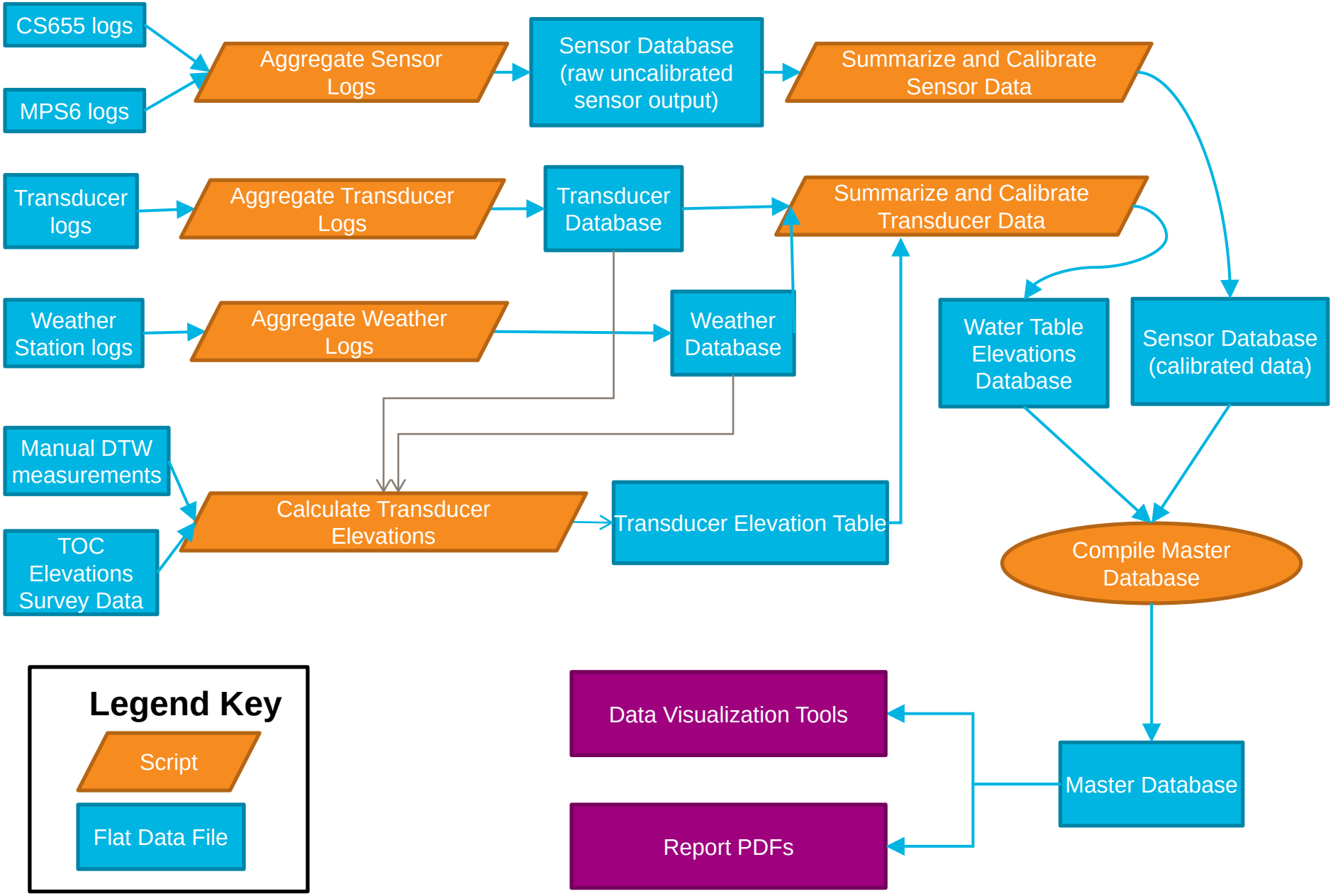
CS655 logs
MPS6 logs
Aggregate Sensor Logs
Sensor Database (raw uncalibrated sensor output)
Summarize and Calibrate Sensor Data
Transducer logs
Aggregate Transducer Logs
Transducer Database
Summarize and Calibrate Transducer Data
Weather Station logs
Aggregate Weather Logs
Weather Database
Water Table Elevations Database
Sensor Database (calibrated data)
Manual DTW measurements
TOC Elevations Survey Data
Calculate Transducer Elevations
Transducer Elevation Table
Compile Master Database
Legend Key
Script
Flat Data File
Data Visualization Tools
Report PDFs
Master Database

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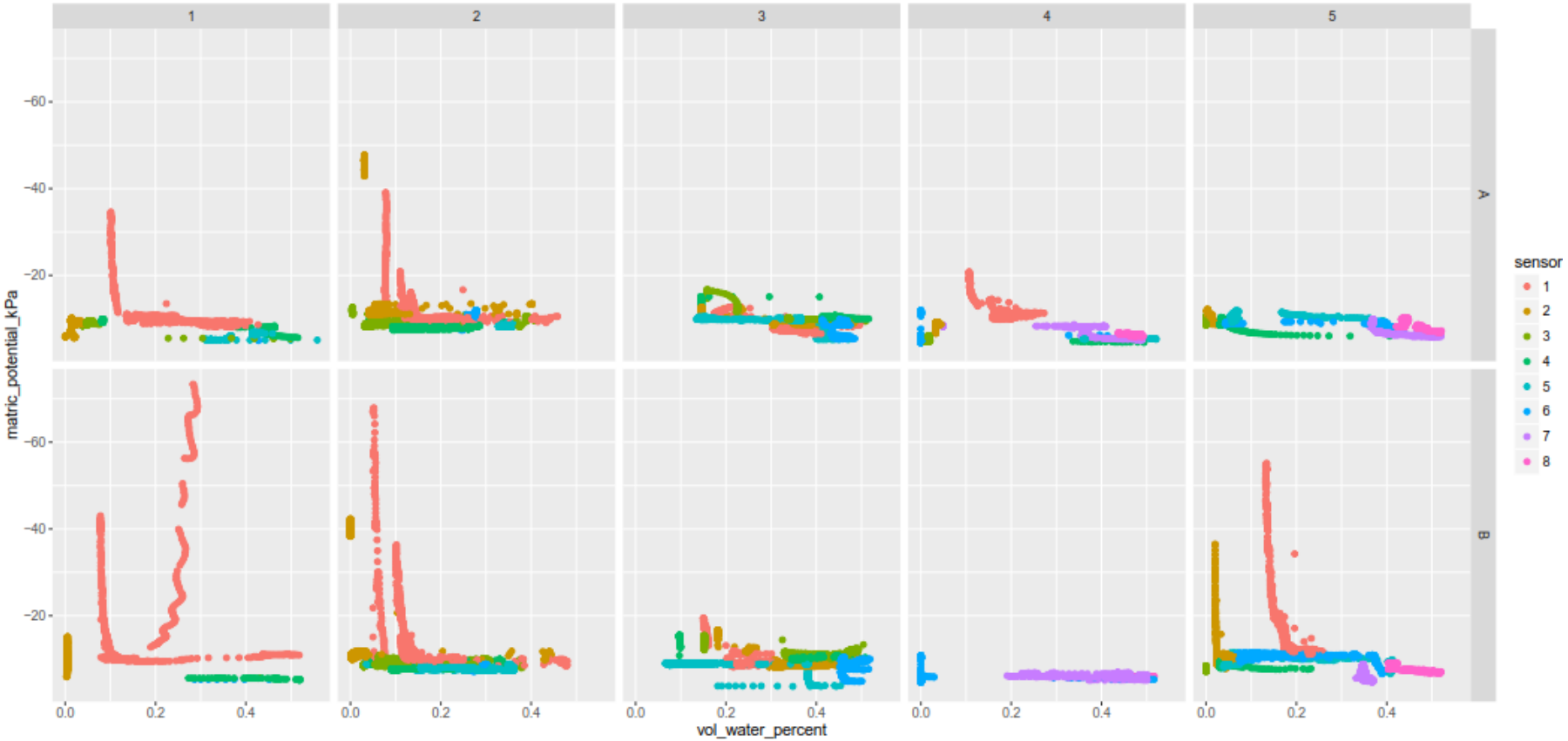
Data Visualization Issues



No patterns visible in planned graphics.

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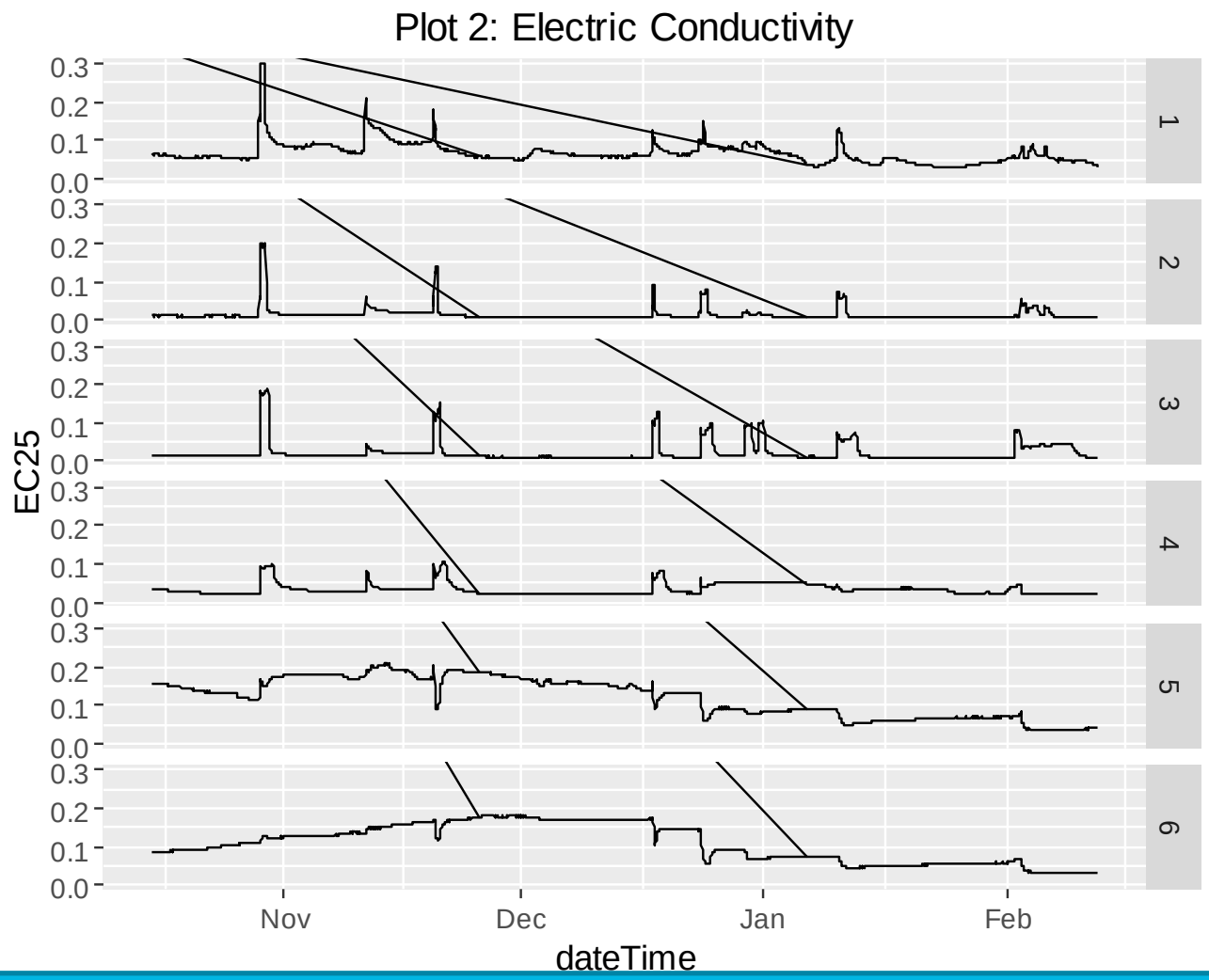
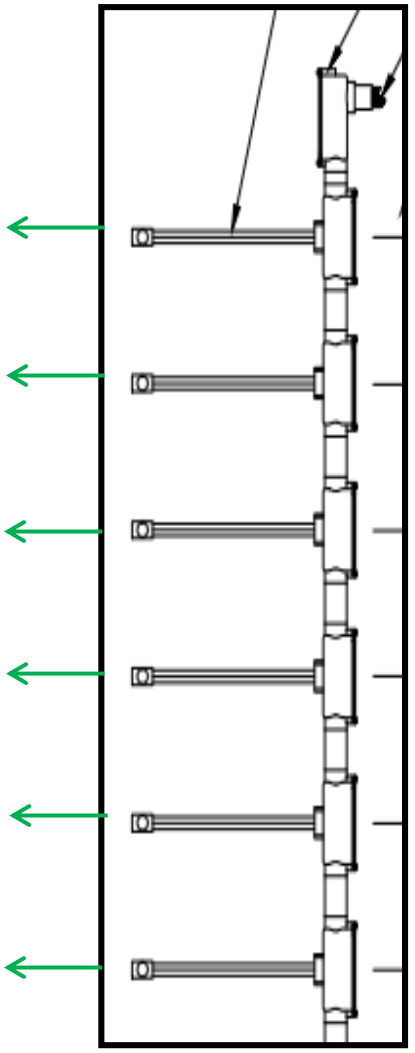
Visualization - Sensor Output





Temperature Normalized Electrical Conductivity over Time - Stacked by Sensor Position.

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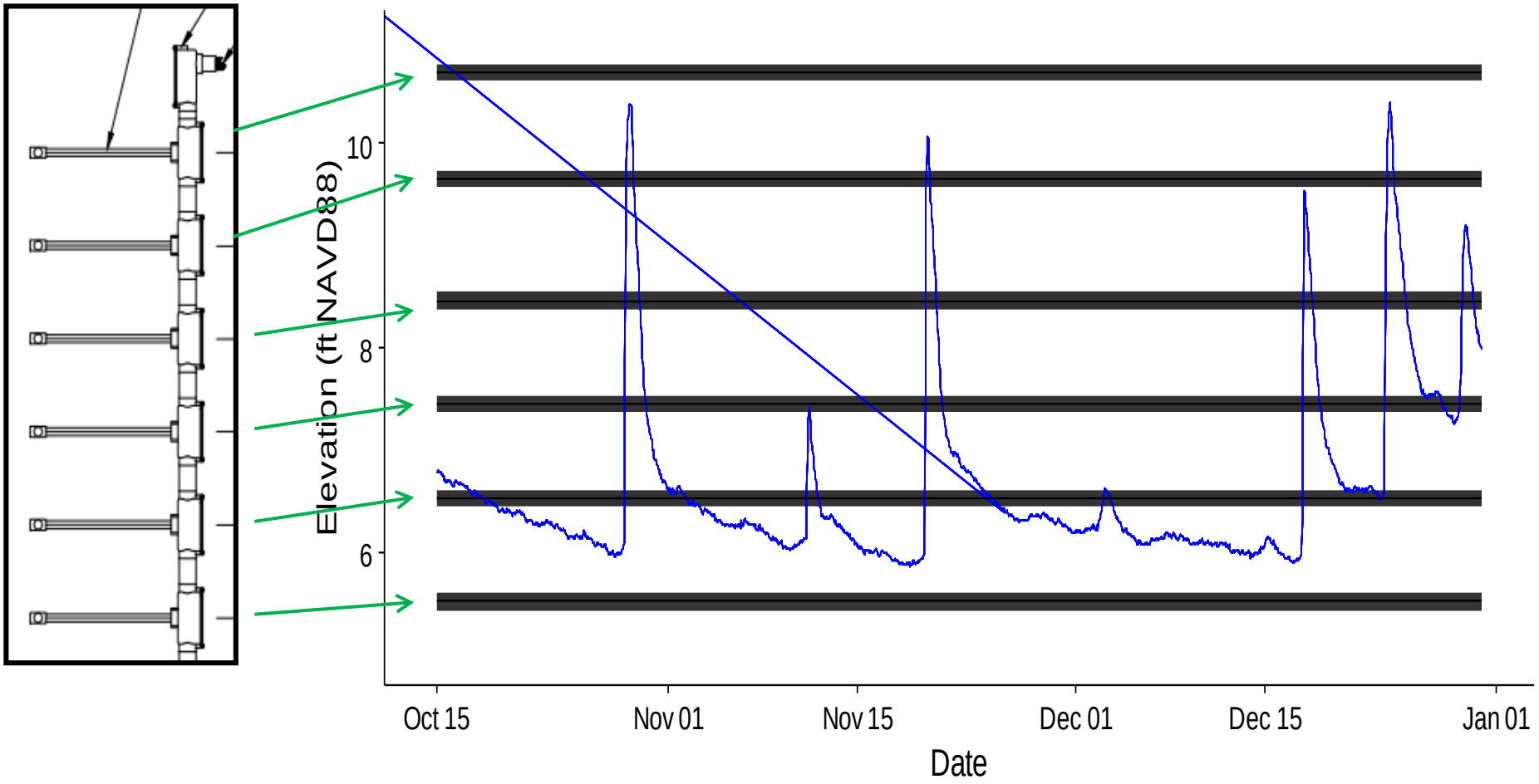
Visualization - Sensor Elevations Relative to the Water Table



Water Elevation over Time – With Sensor Elevations.

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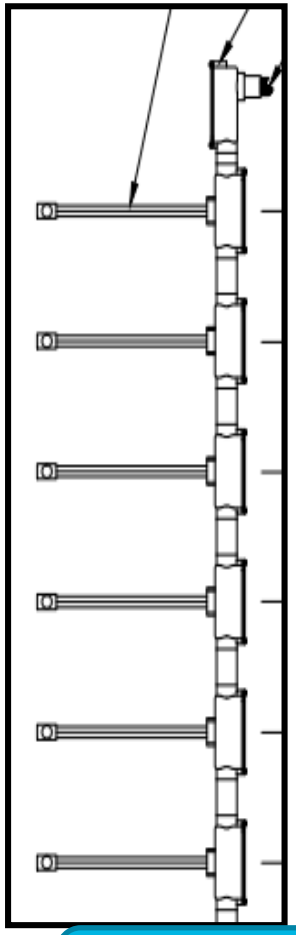
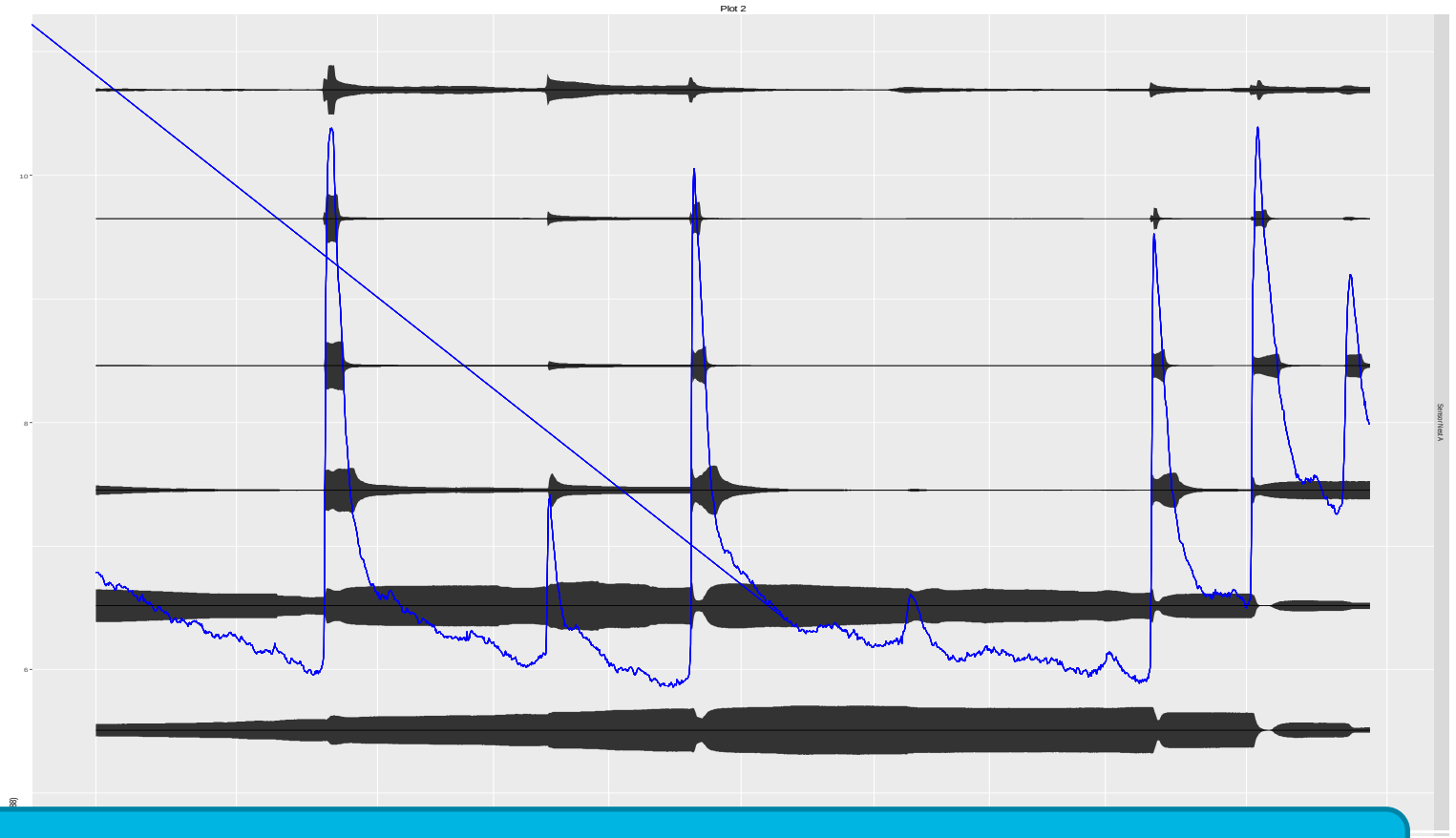
Visualization – Sensor Output relative to Groundwater Elevation

Visualizing four variables in one graph:

+ Time
+ Sensor Value (Violin Plot)
+ Sensor Elevation
+ WT Elevation





Combined Data Visualization

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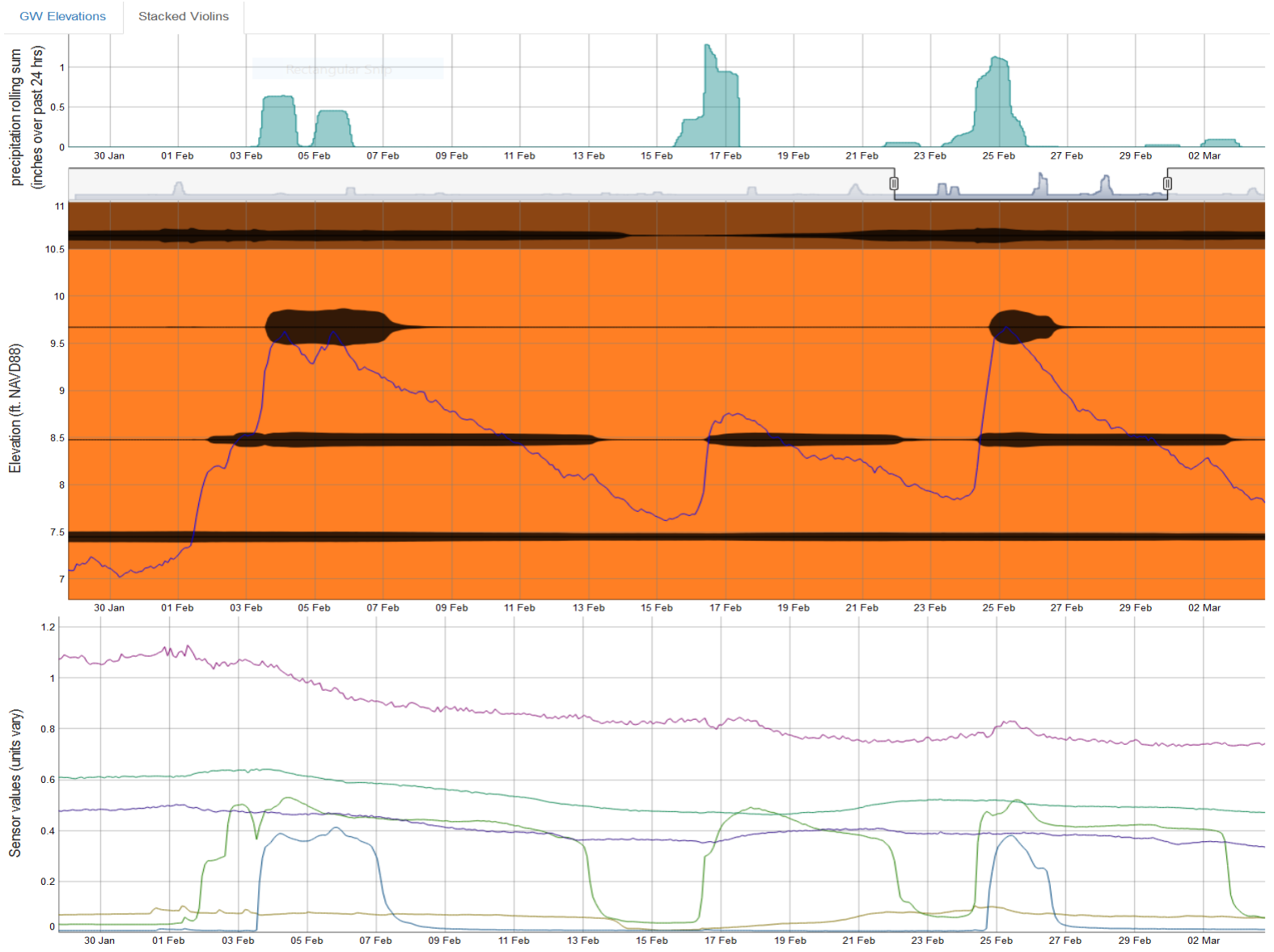
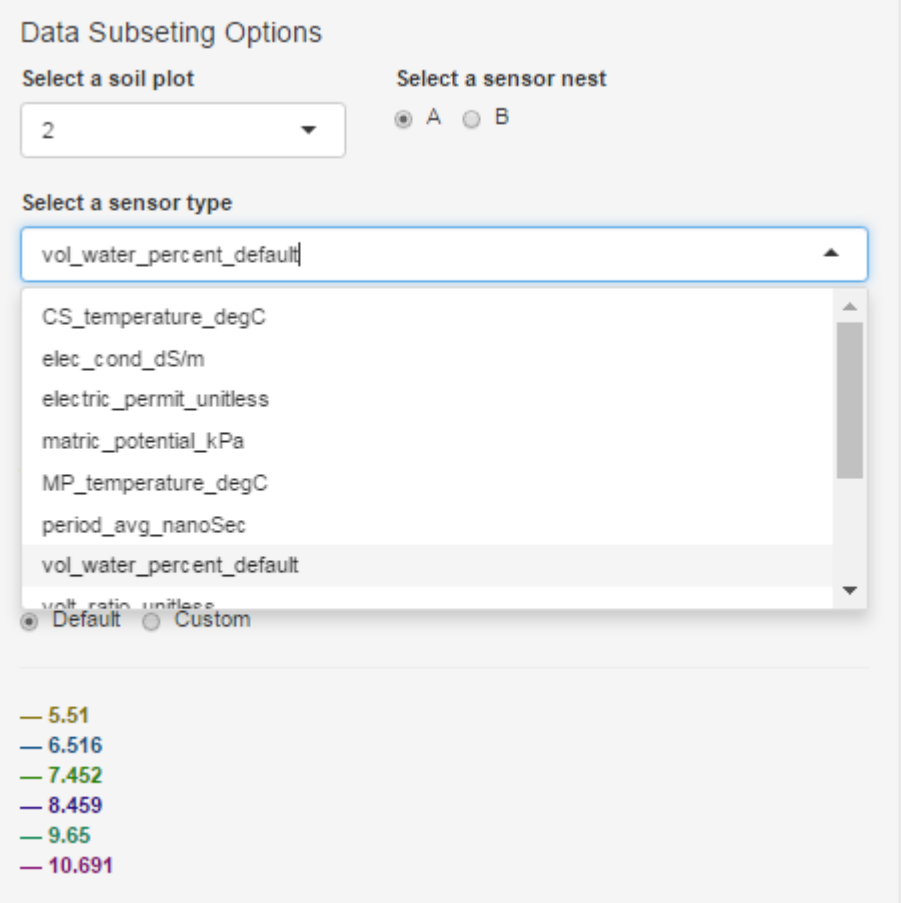
Visualization - Precipitation, GW, and Sensor Data

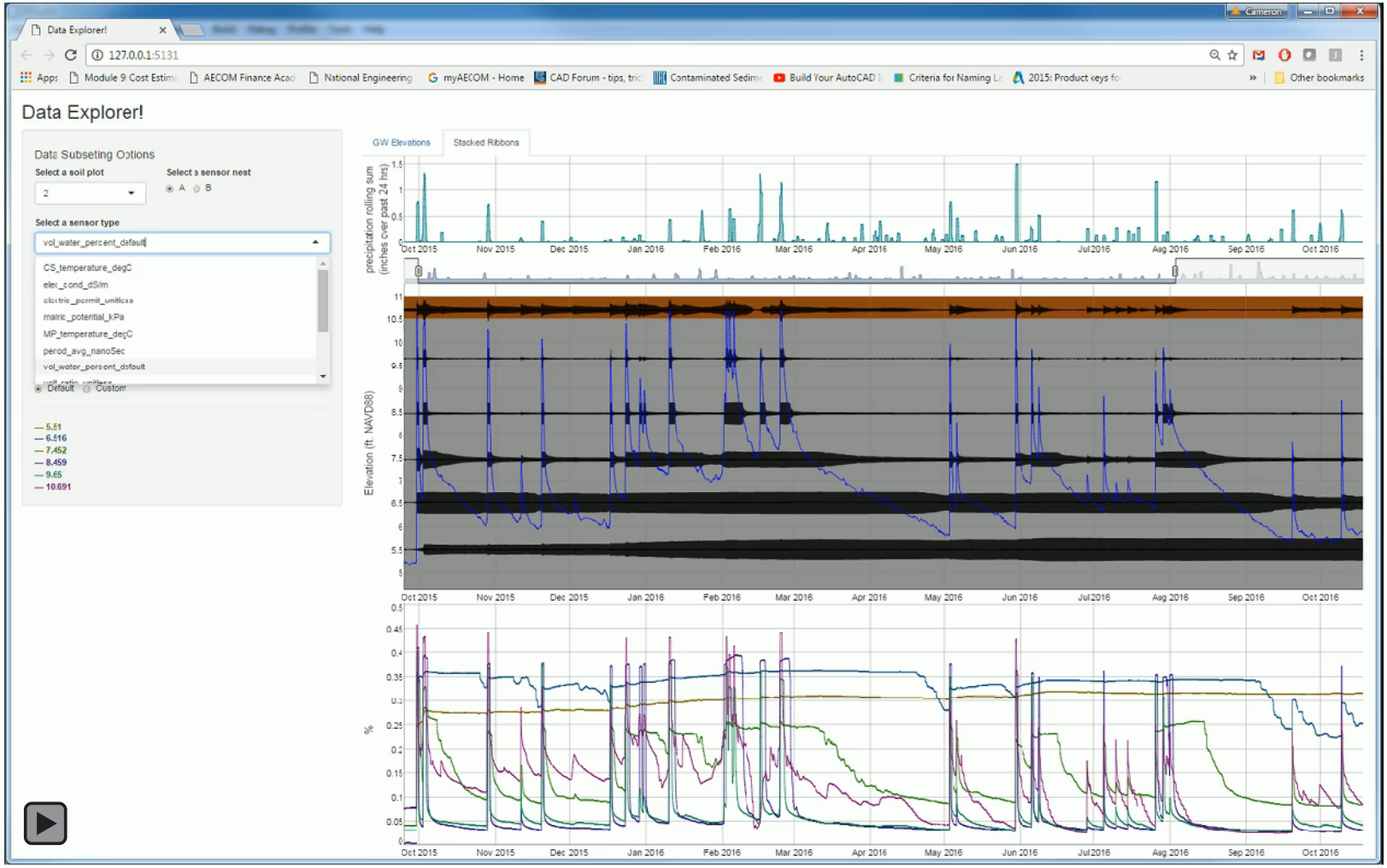


Interactive Tool

– Allows easy visualization of any variable collected



Video of Tool Operation



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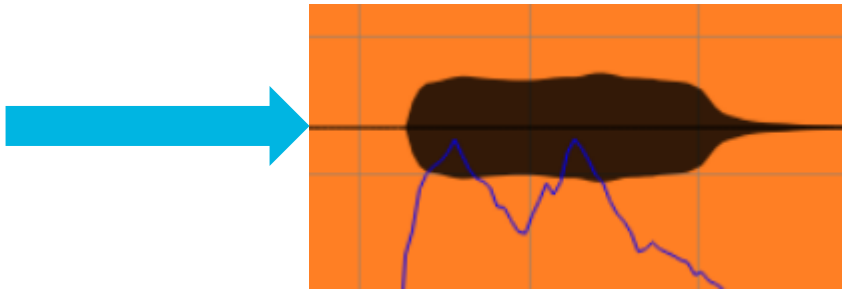
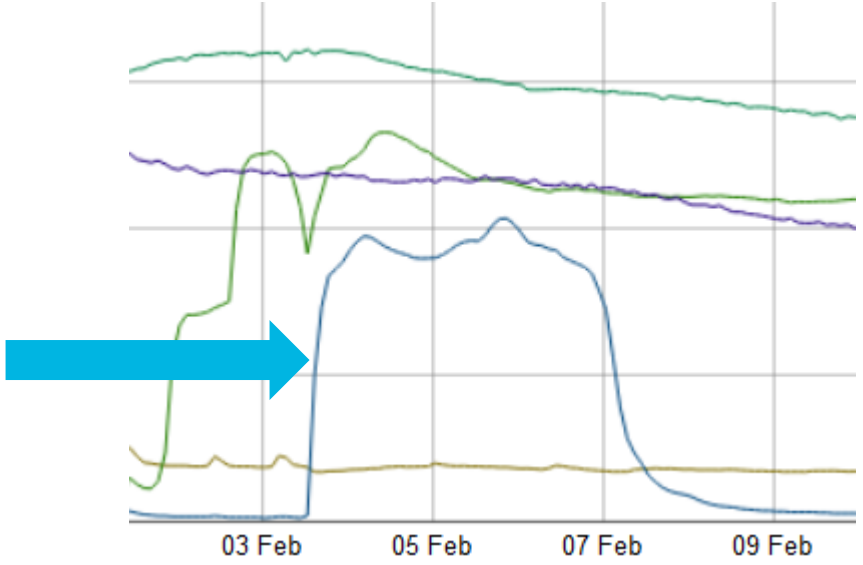
Interpretation – Identify Sustained Sensor Change Above Water Table

- Sustained increases in EC indicate saturation.
- Saturation above the water table means the sensor is in the capillary fringe,





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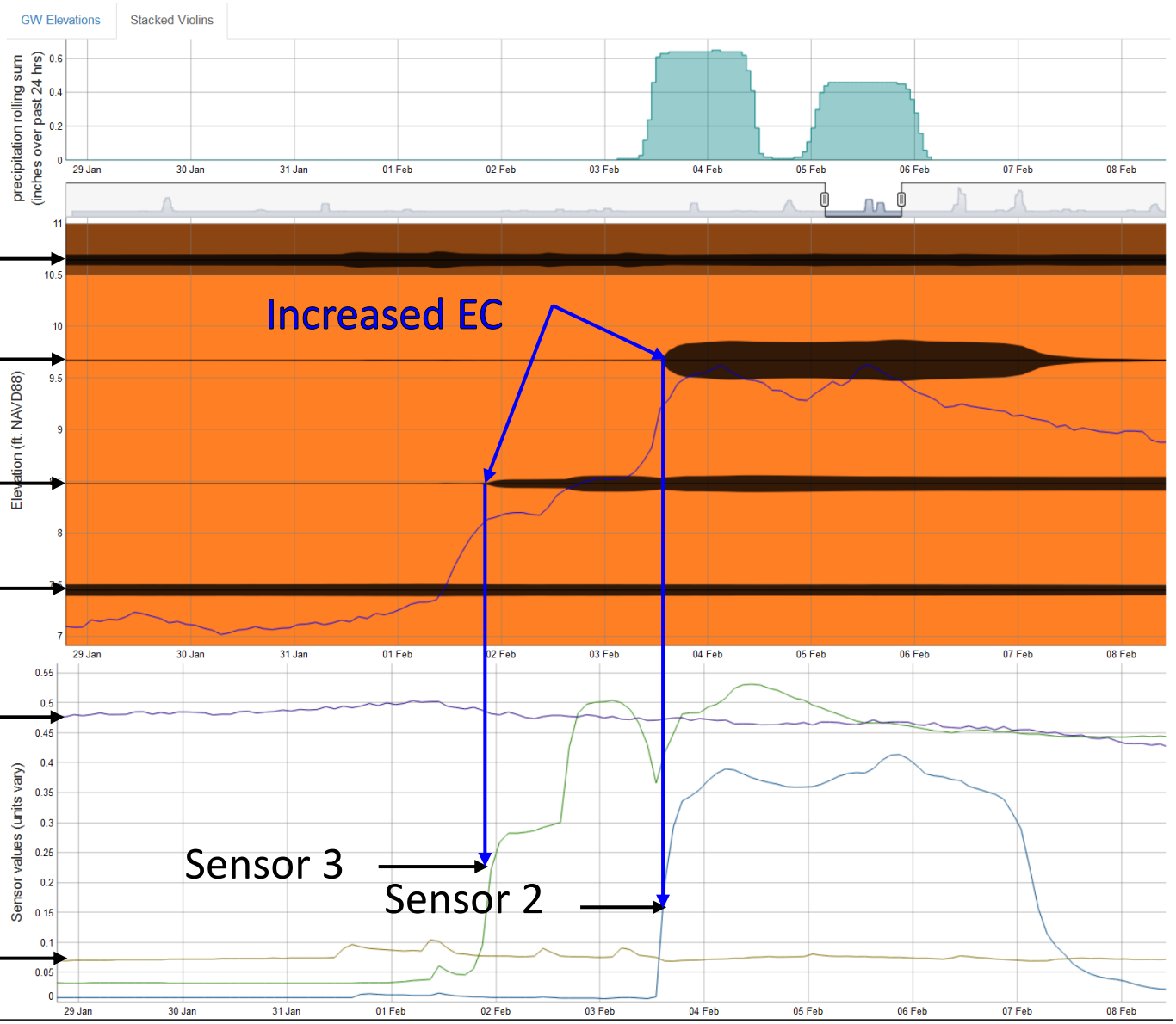
Interpretation - Water Table Changes

Sensor 5/6 below water table not shown.



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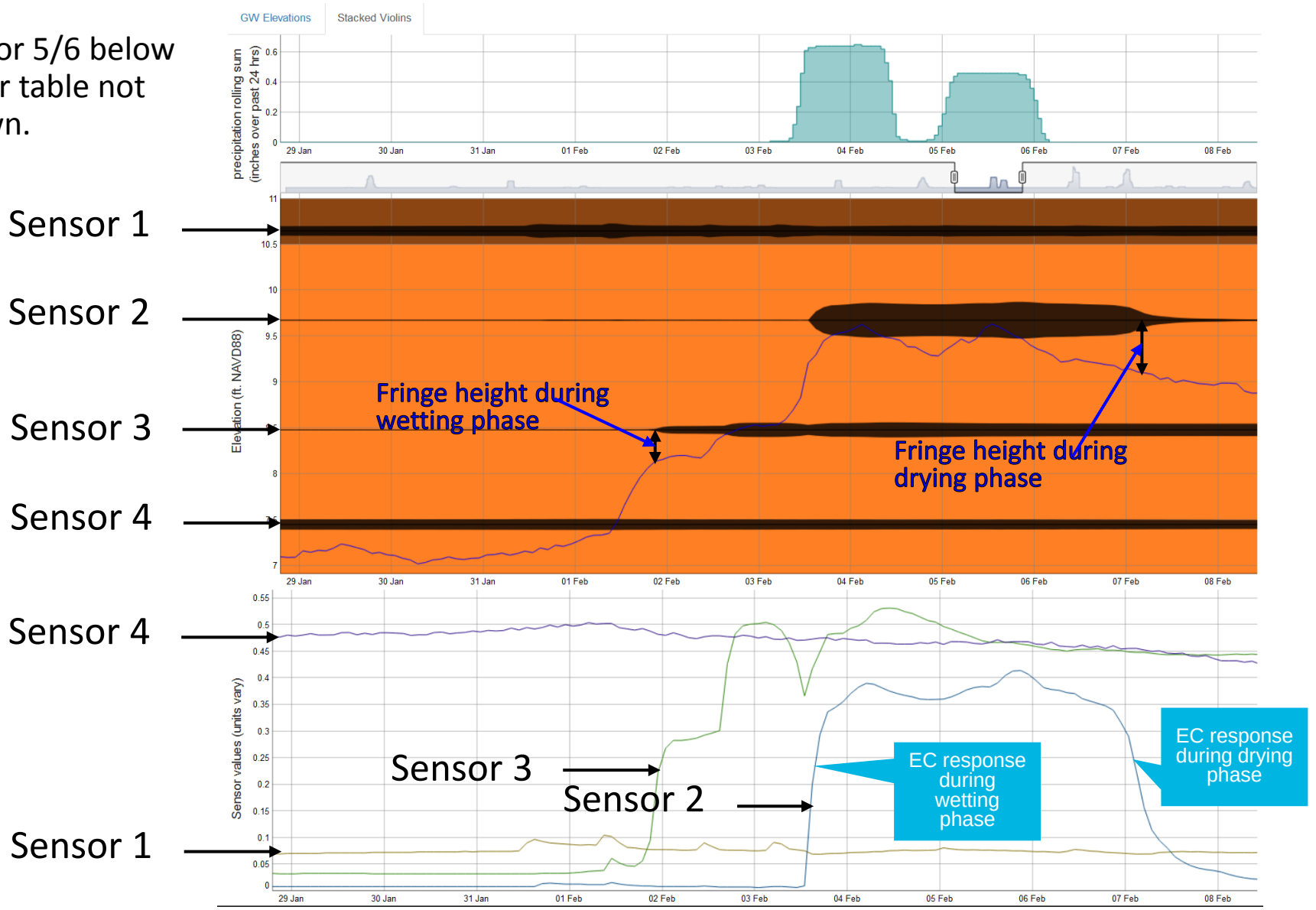
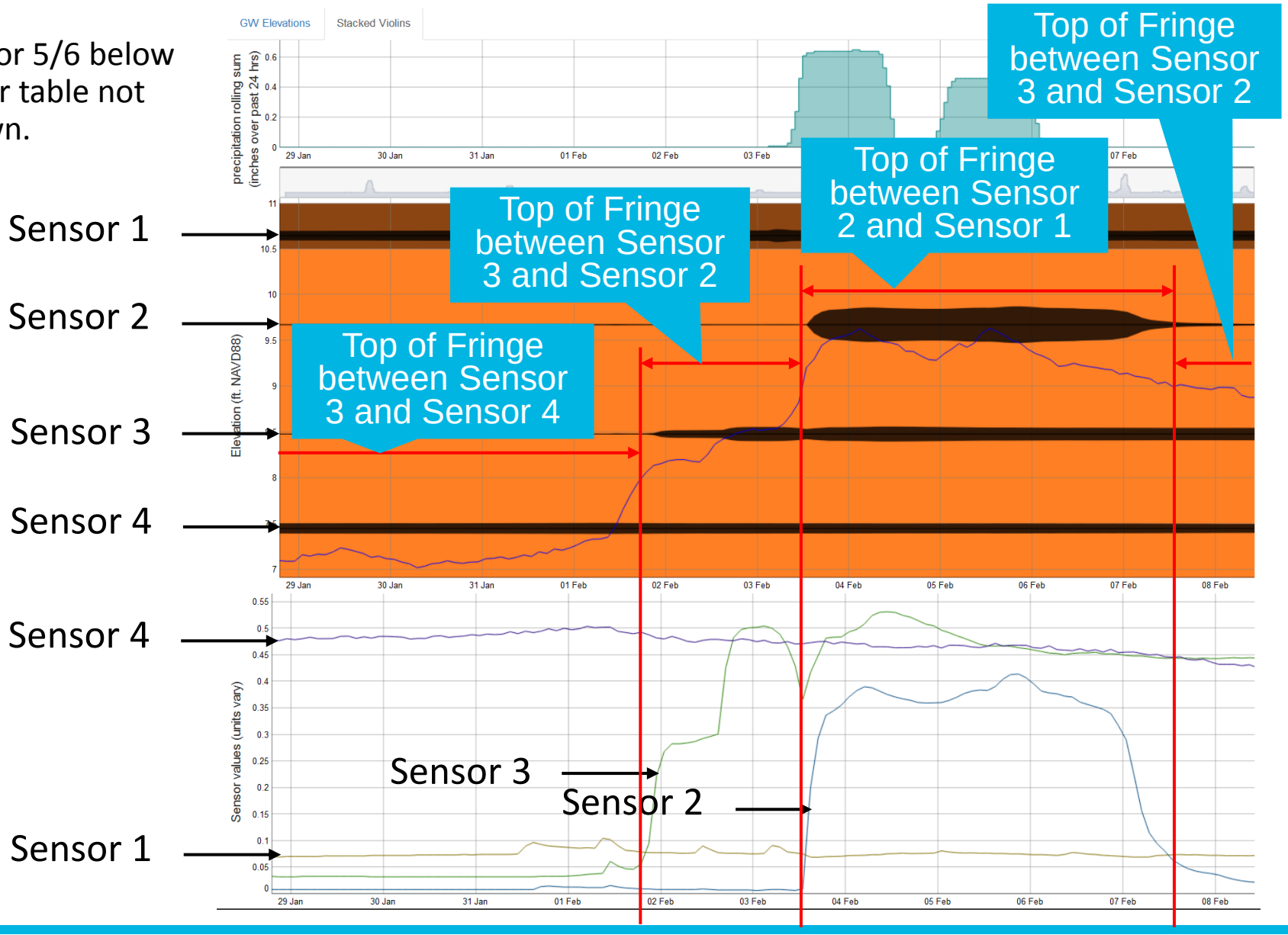
Interpretation - Water Table Changes – Wetting vs. Drying

Sensor 5/6 below water table not shown.



Interpretation - Capillary Fringe Determination

Sensor 5/6 below water table not shown.



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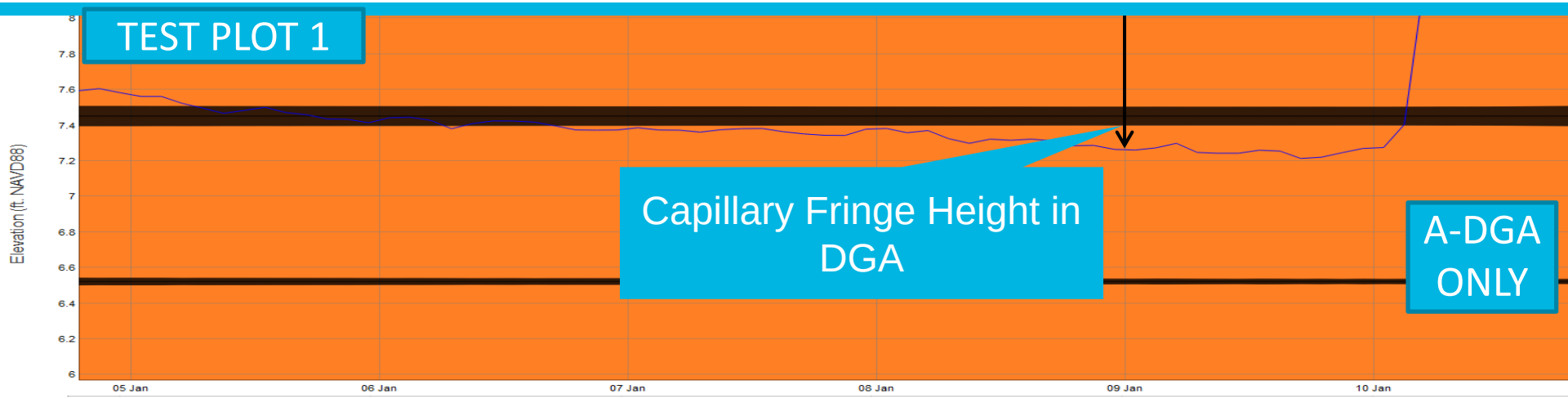
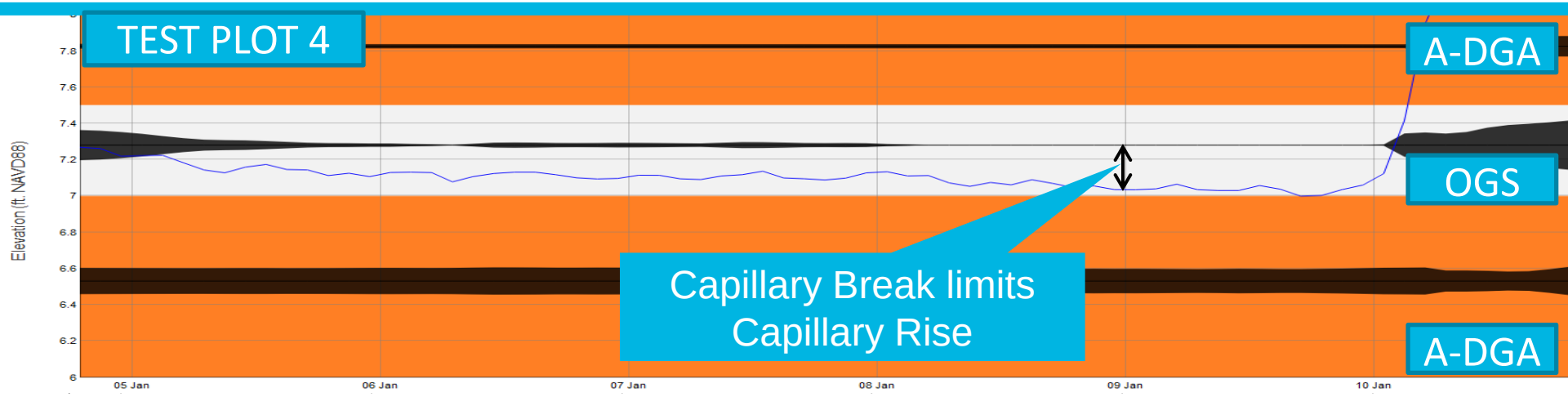
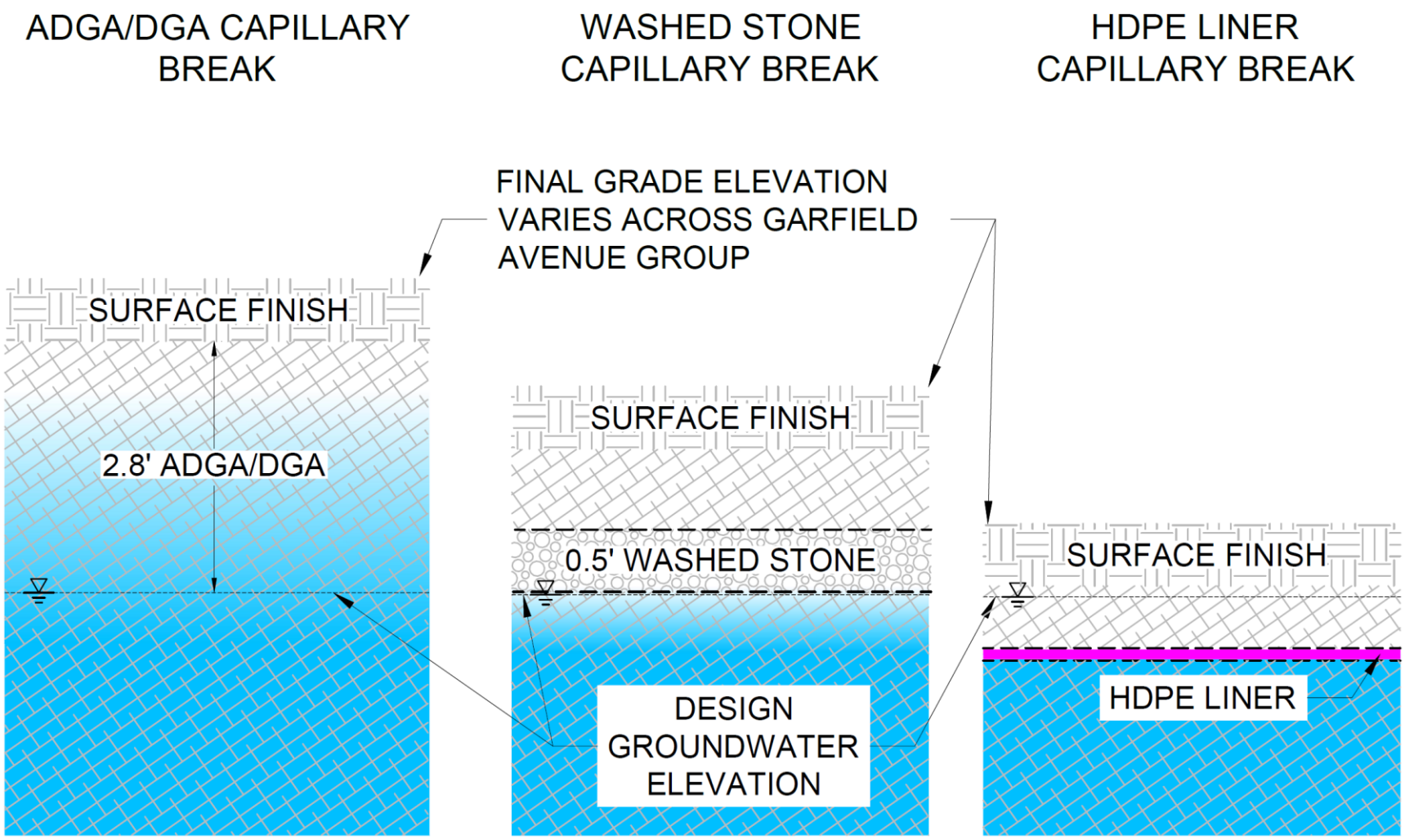
Interpretation - Open Grade Stone Capillary Break

Direct Comparison of Capillary Fringe Height shows Capillary Break Effectiveness





Capillary Break Construction Options



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Big Problem

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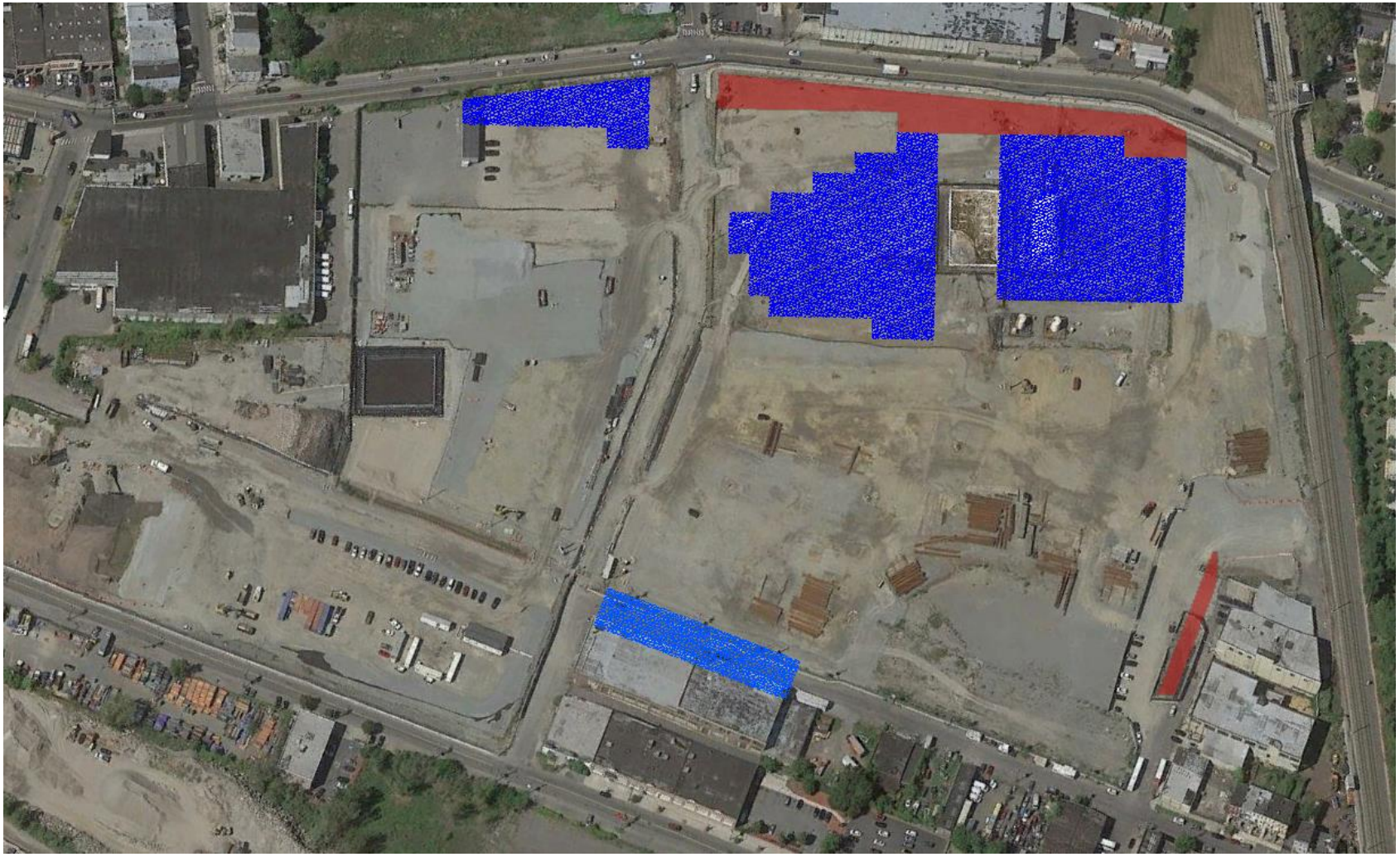
Big Solution



Questions

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Thursday March 31, 2016

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