Assessing How Hydrologic Isolation of Coal Mine Spoils Affects Streamflow Mechanisms and Water Chemistry Using Open Source Wireless Technology

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The Problem

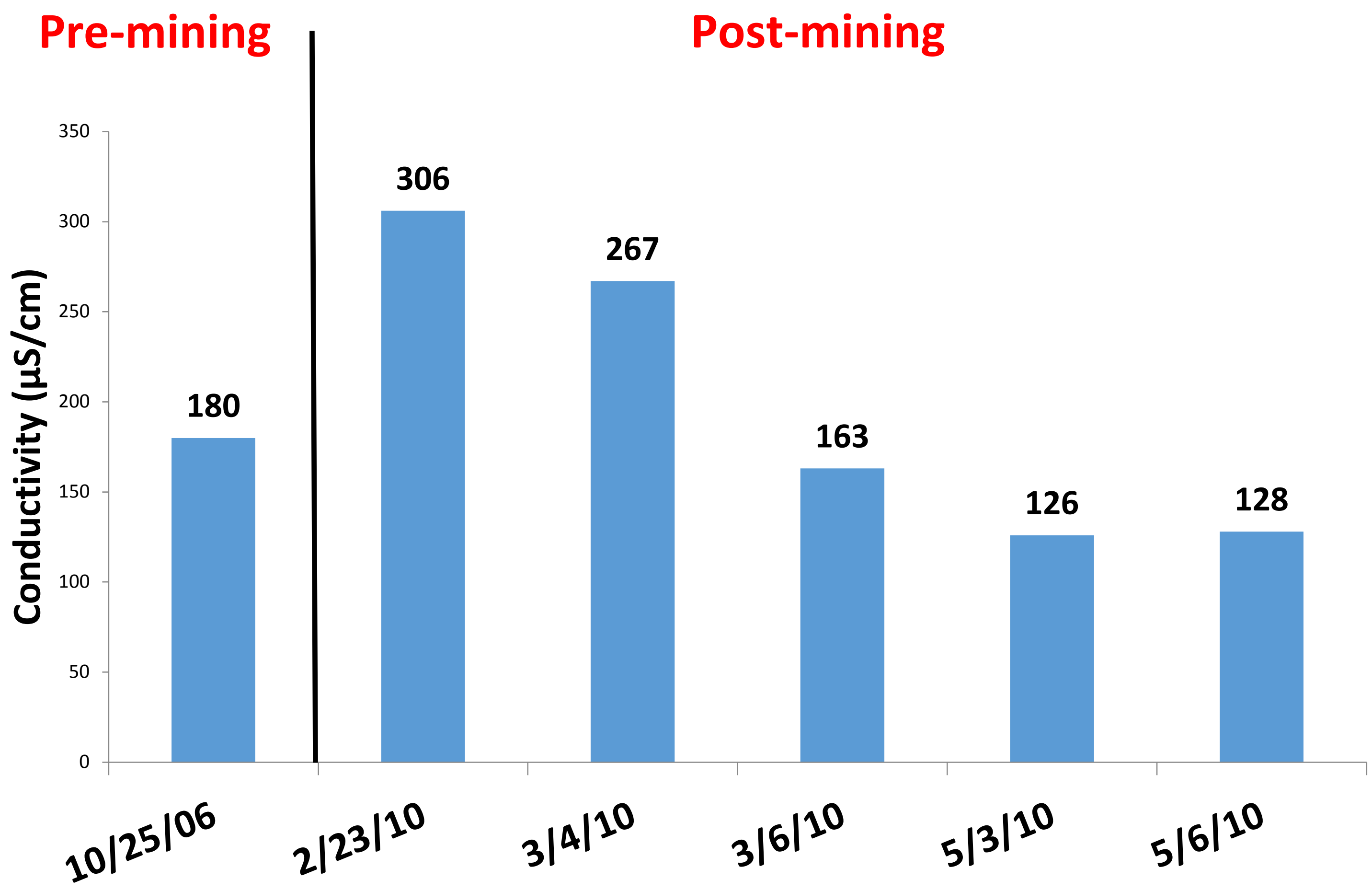
- Elevated ionic strength (measured as specific conductance (SC))
  - Reference streams: **30-260 µS/cm**
  - Below SCM/VF sites: **159-2720 µS/cm**

Bryant et al. 2000

The Problem

- VFs linked to high conductivity
  - Ionic signature: Ca^{2+}, Mg^{2+}, SO_4^{2-}, HCO_3^-
- Long-term and cumulative
- No practicable source control technologies
- Research gaps
  - Mine spoil hydrology
  - Solute production and transport

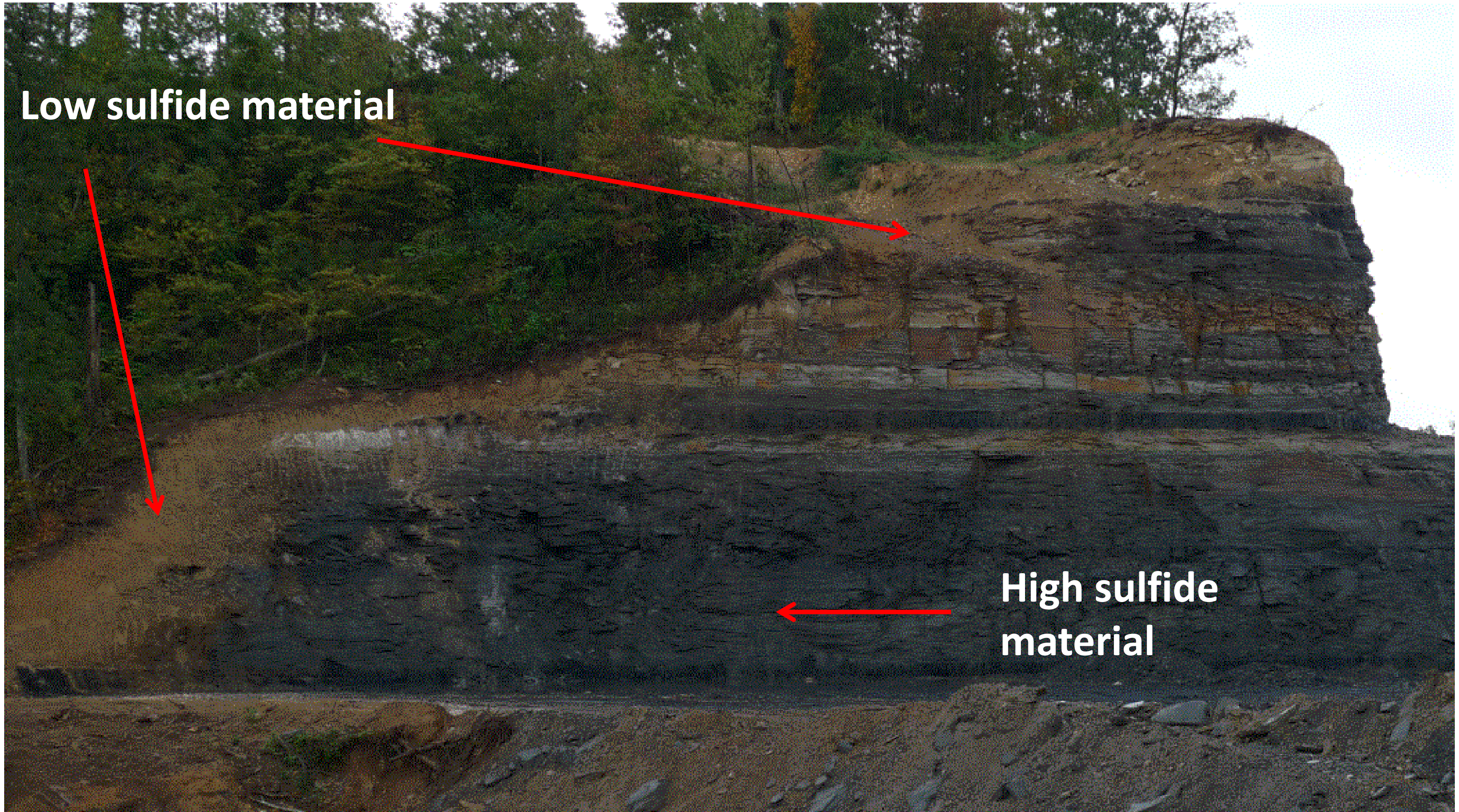
Towards a Solution



R. Warner, unpublished data

Hydrologic Isolation Method

- ***A priori*** **identification of (non-) reactive spoil**



Hydrologic Isolation Method

Eastern Kentucky Experimental Valley Fill Site Data Collection

E. KY Experimental V/F Site

Research Hypothesis

Hydrologic flowpaths can be discriminated by the chemical composition of the leachate

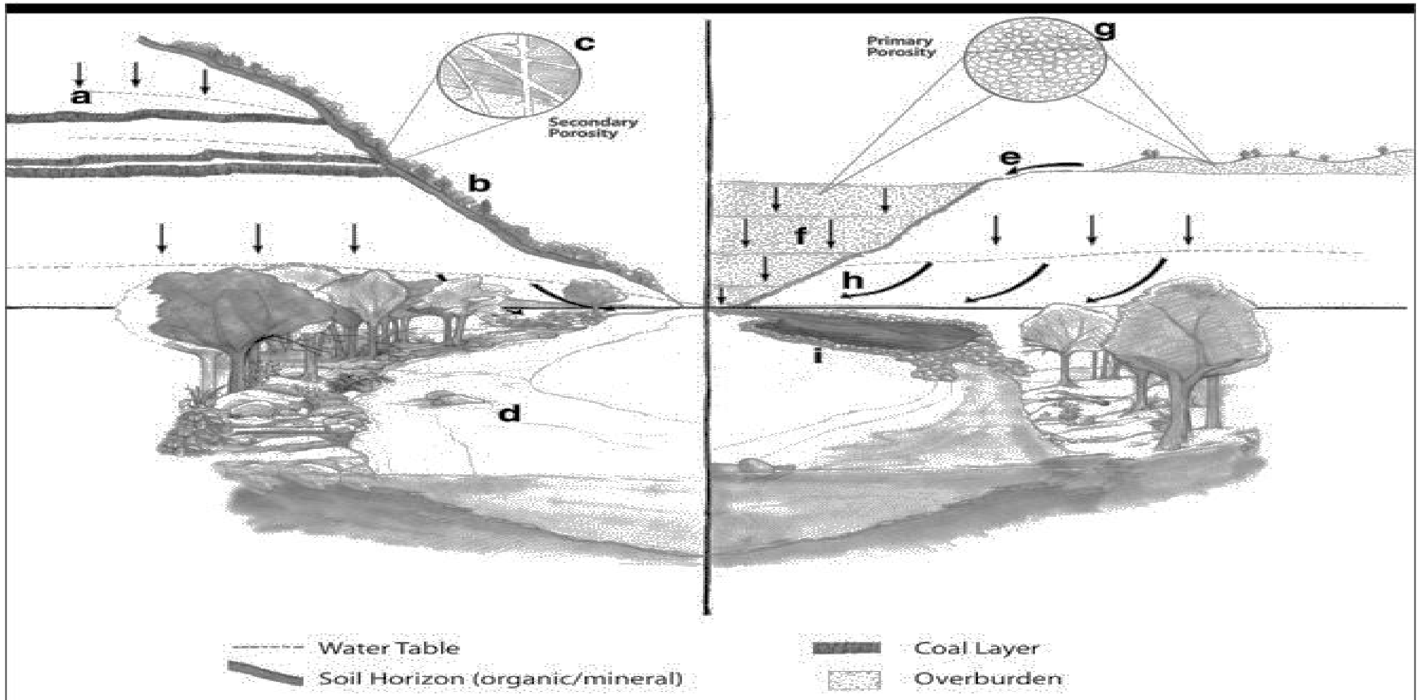


Figure from Griffith et al. (2013)

Dynamic End Member Mixing Analysis

Data from Panola Mountain Research Watershed (PMRW), Georgia (Cary 2011)

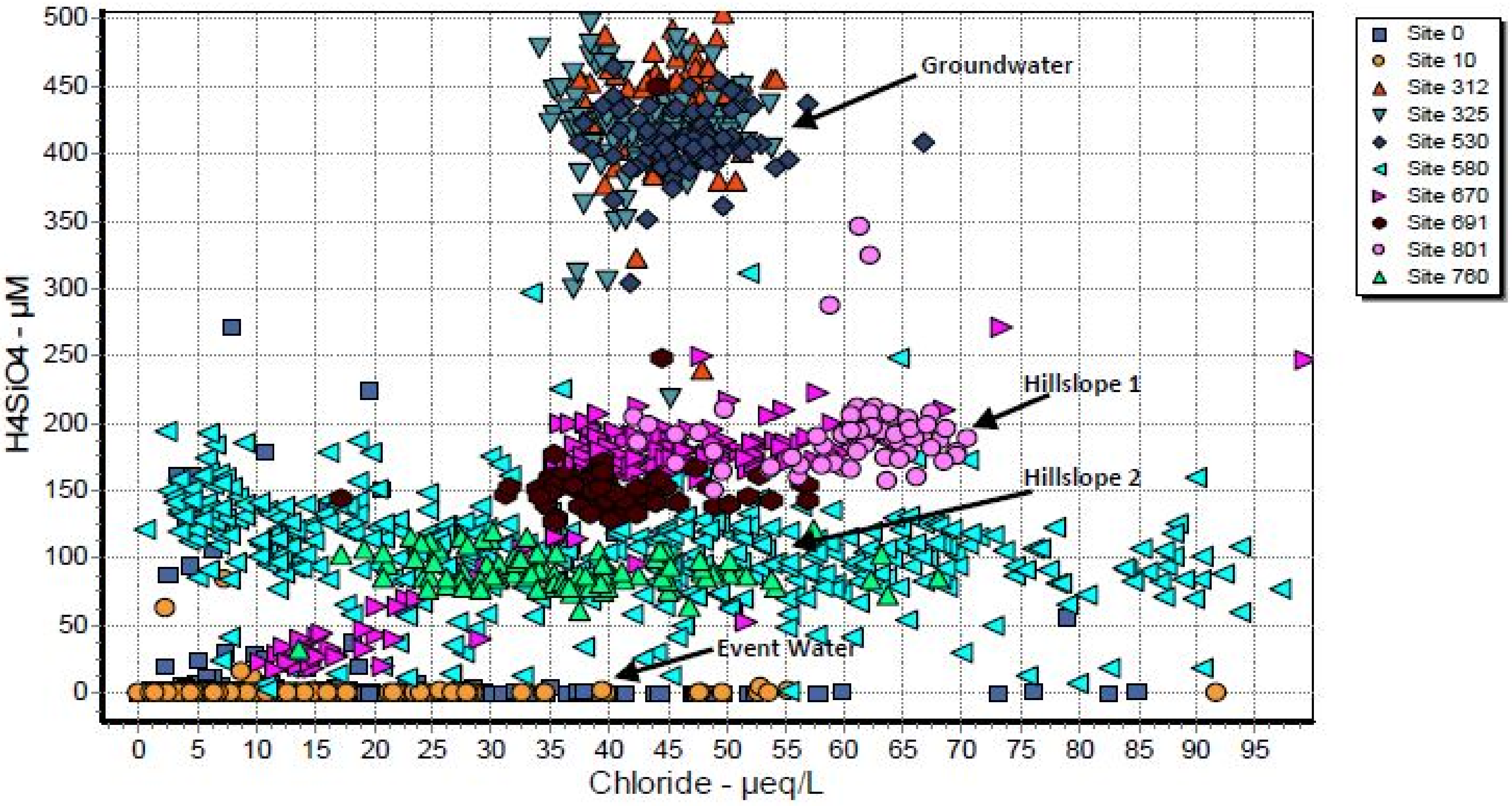
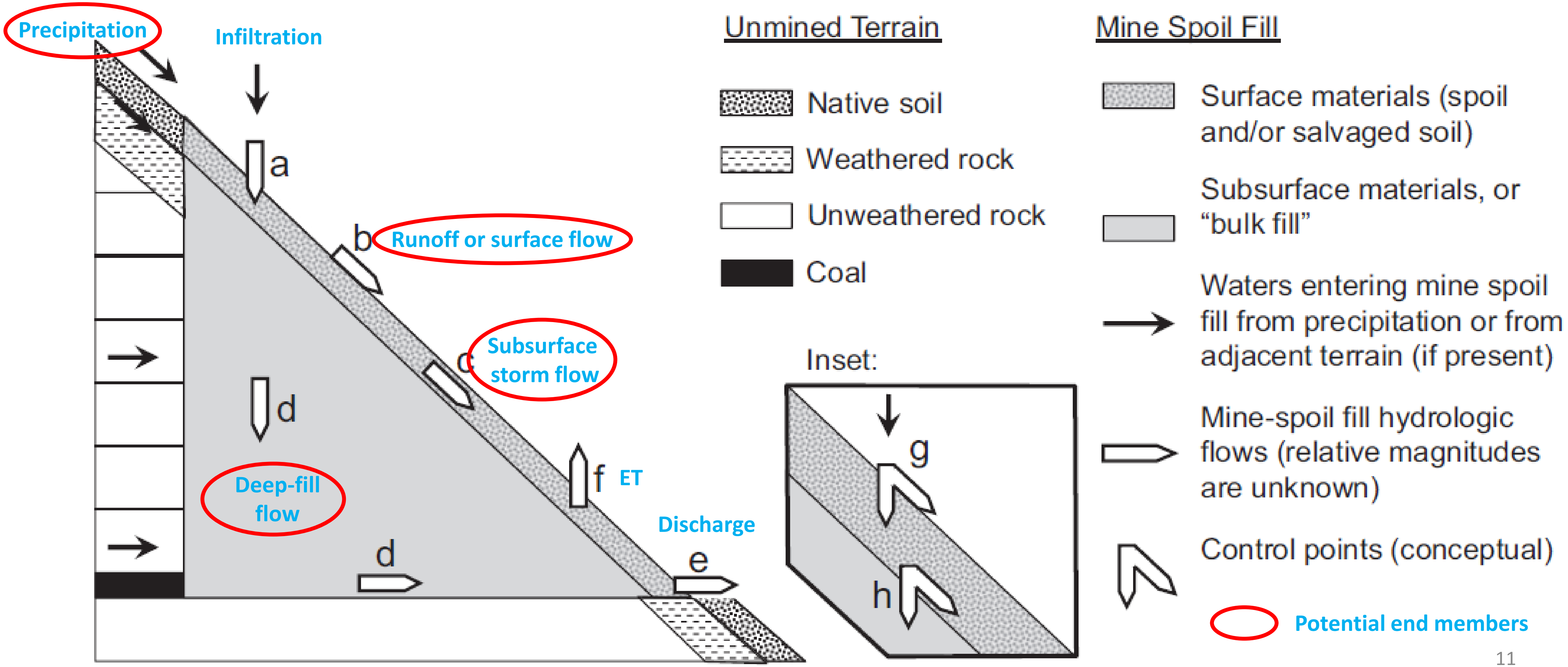
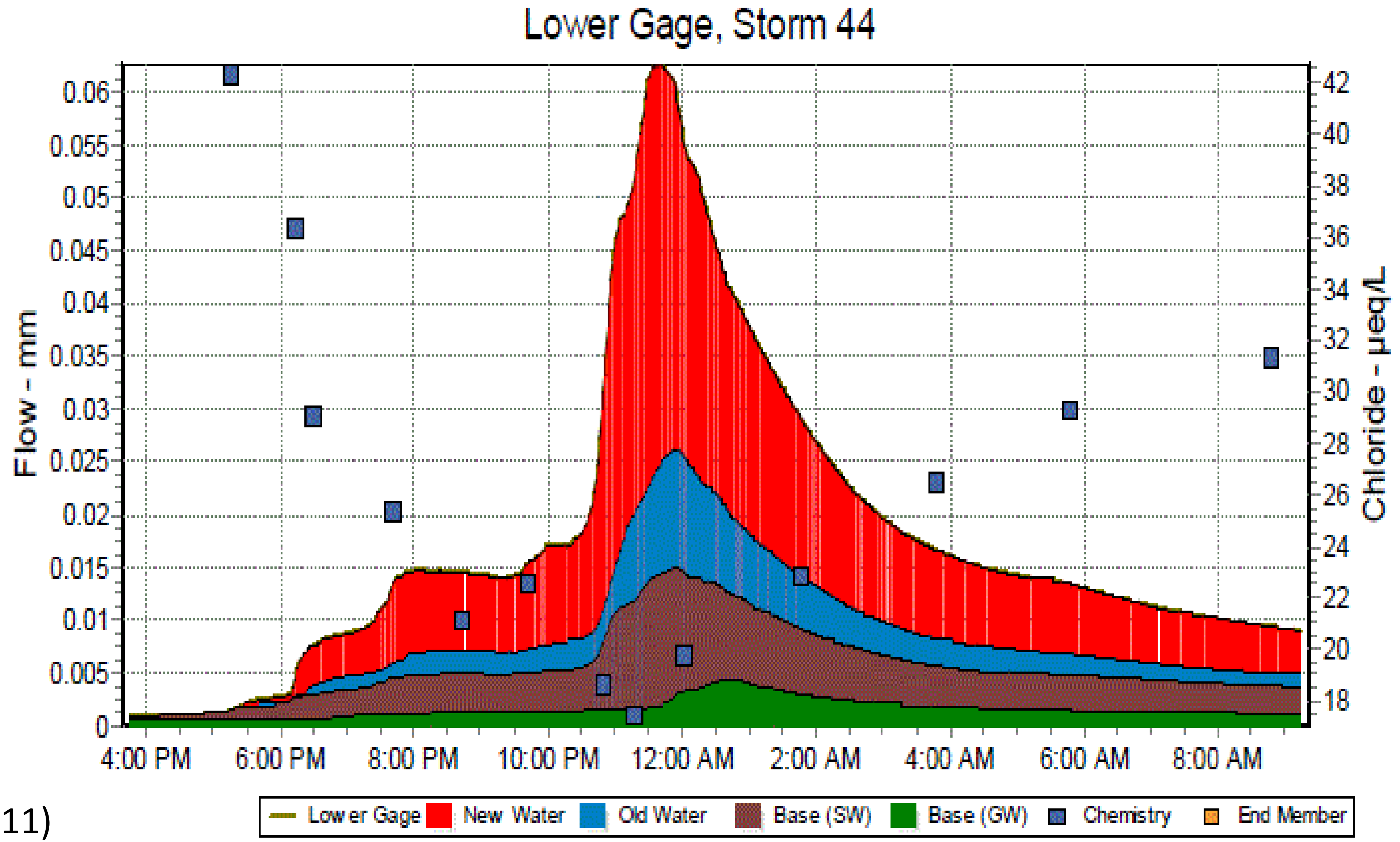


Figure 8. Chloride versus silica concentrations for end-members identified at PMRW.

Conceptual Model (*Evans et al 2015*)

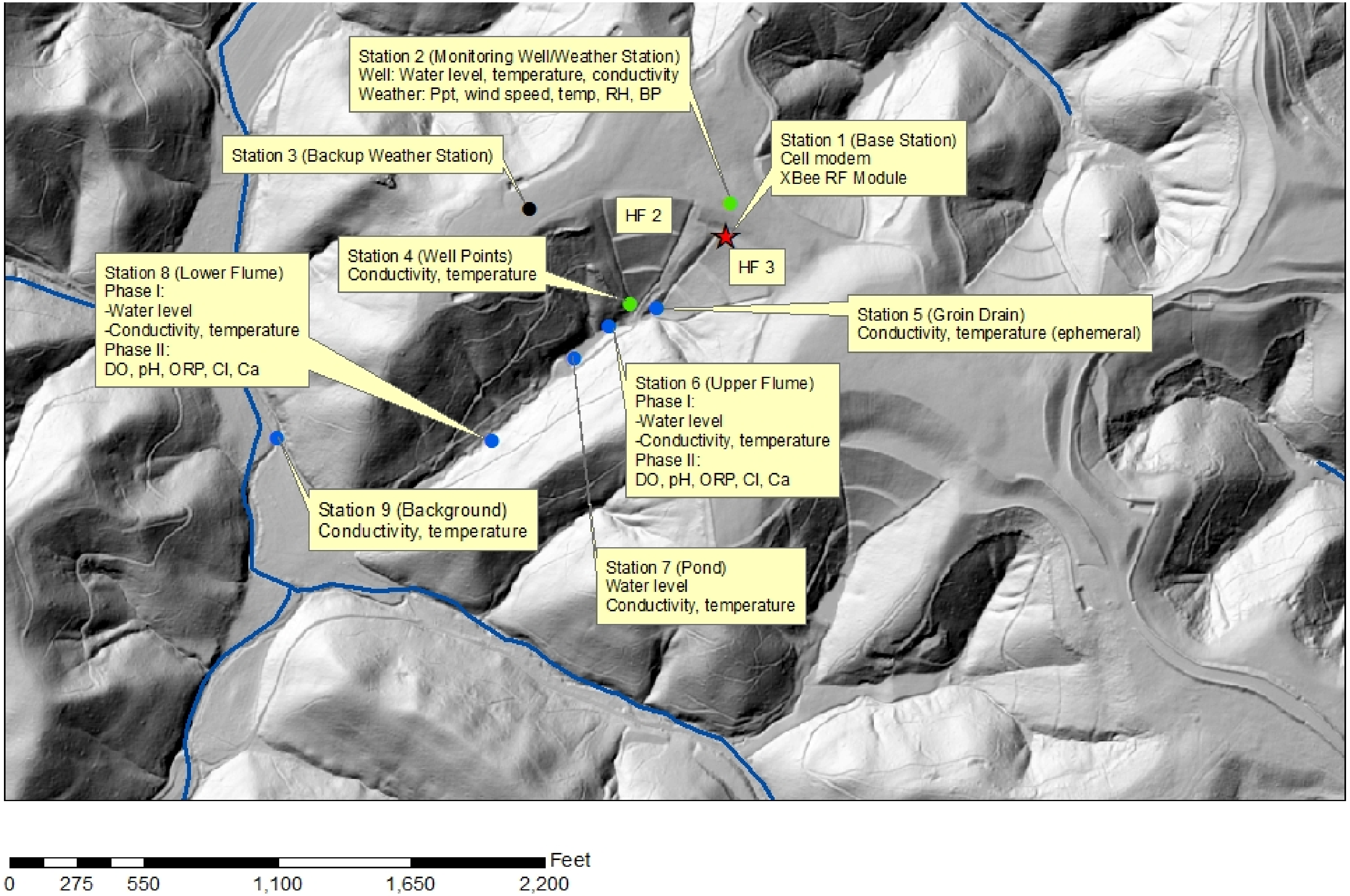


Dynamic End Member Mixing Analysis

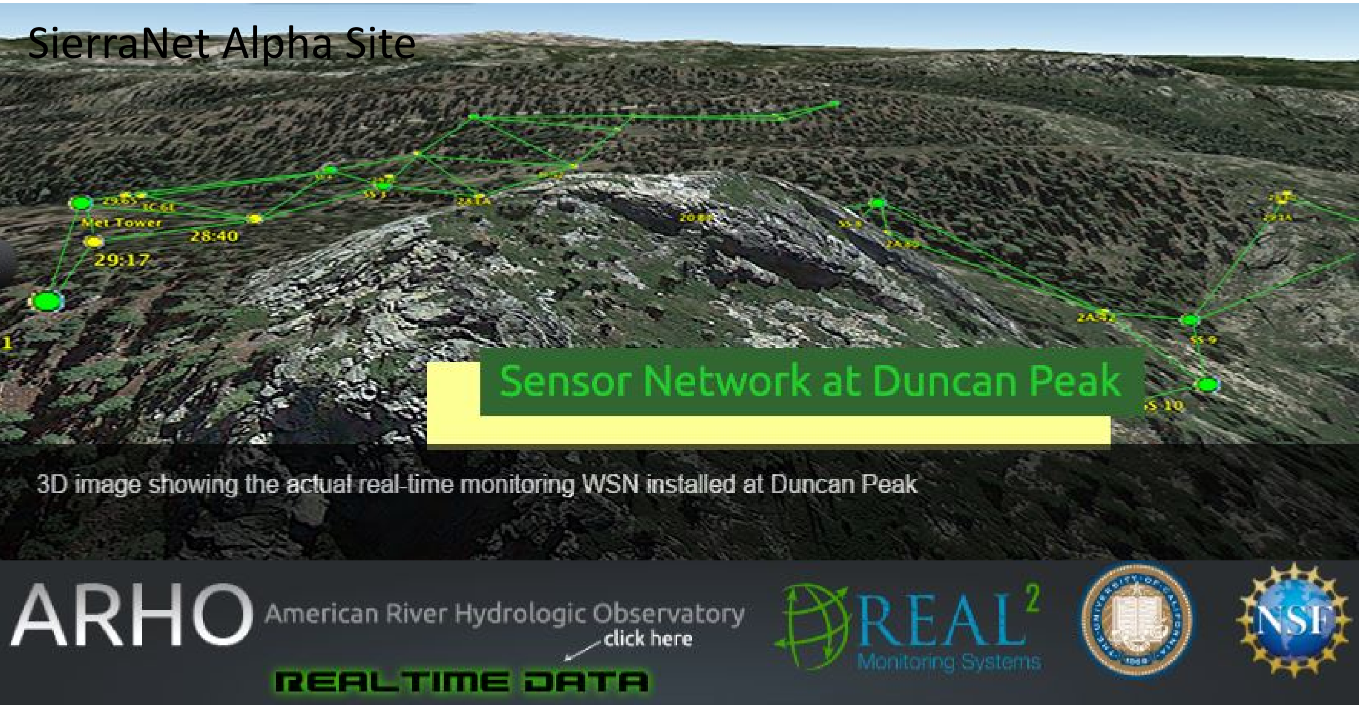


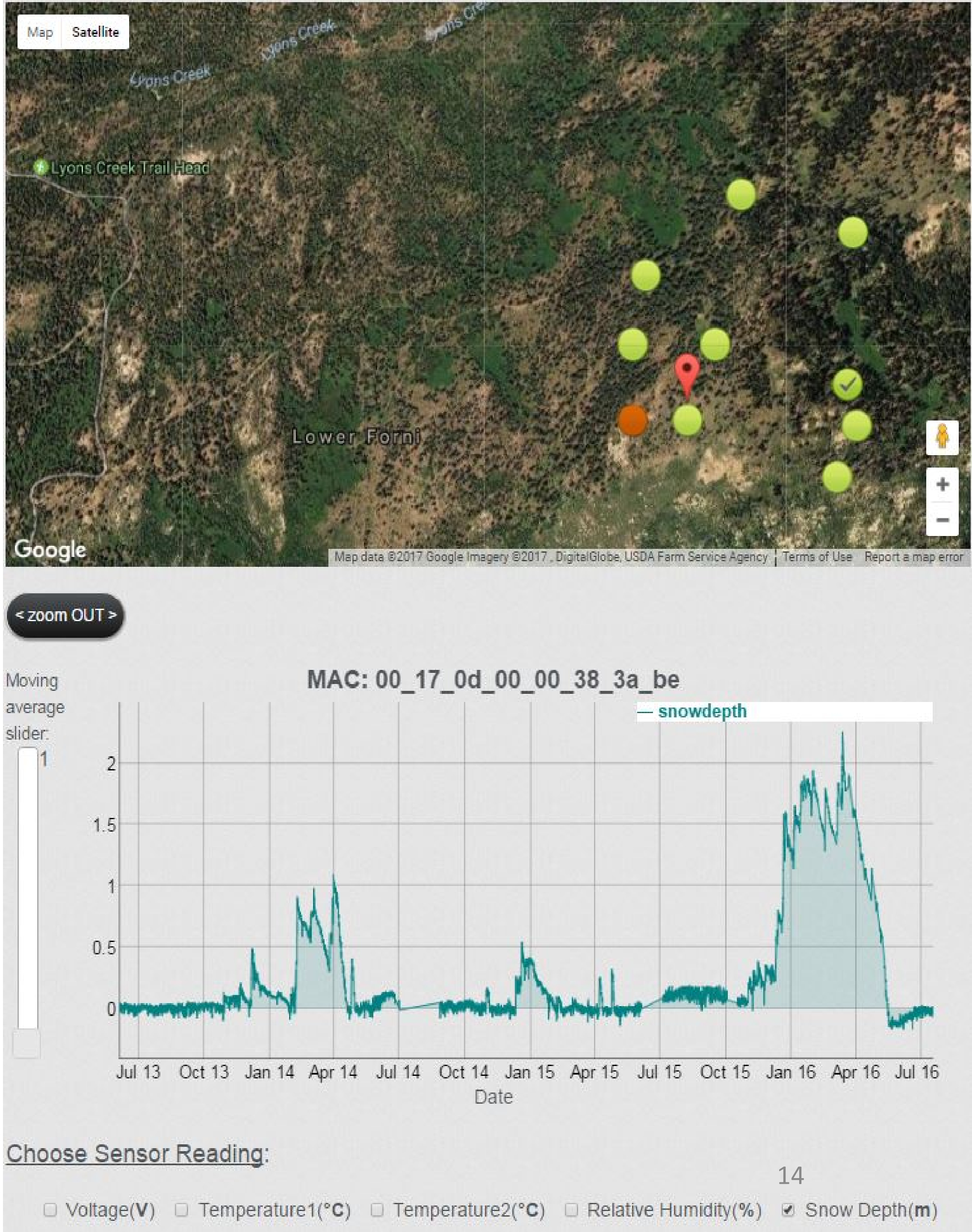
Cary et al. (2011)

Eastern Kentucky Experimental Valley Fill Site Data Collection



Wireless Sensor Networks





http://glaser.berkeley.edu/wsn/network.html

WSN Components

Wireless Sensor Mesh Network

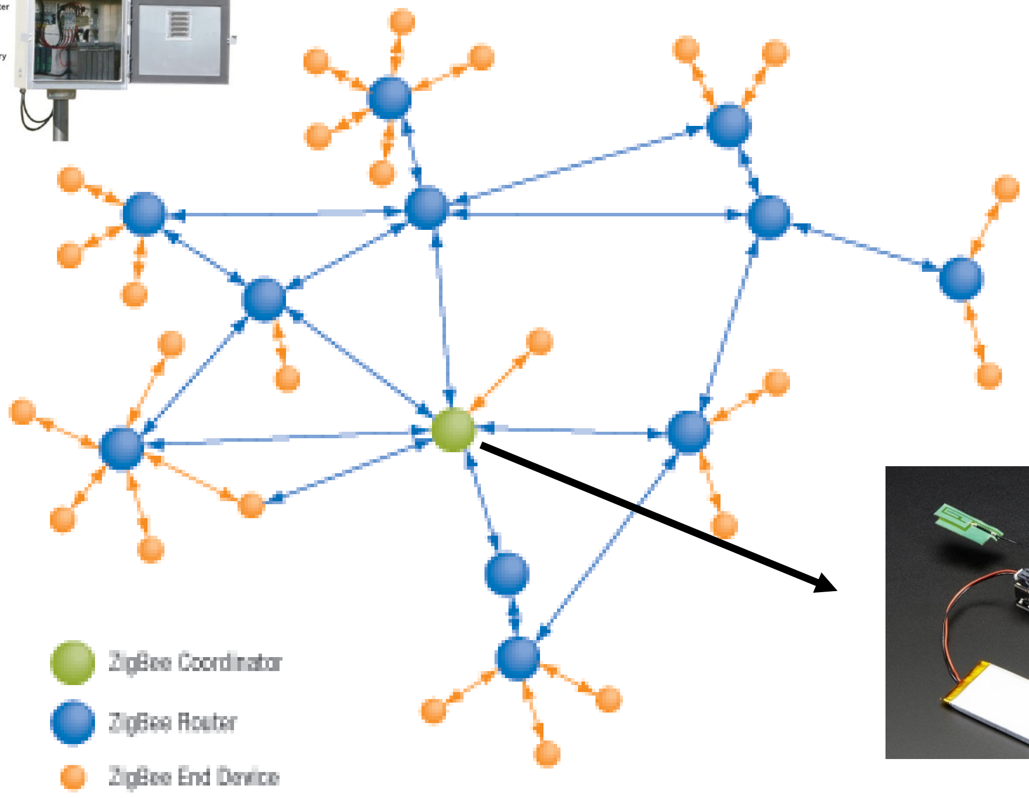
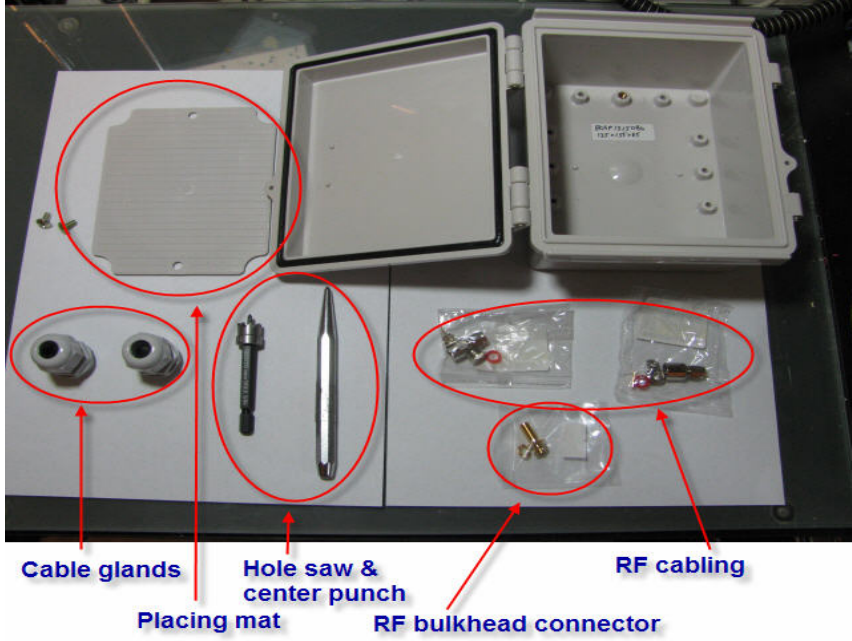
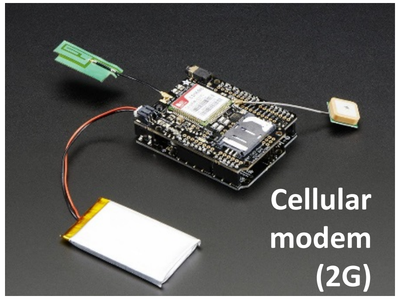


Figure 5 ZigBee/802.15.4 Mesh network and device types.

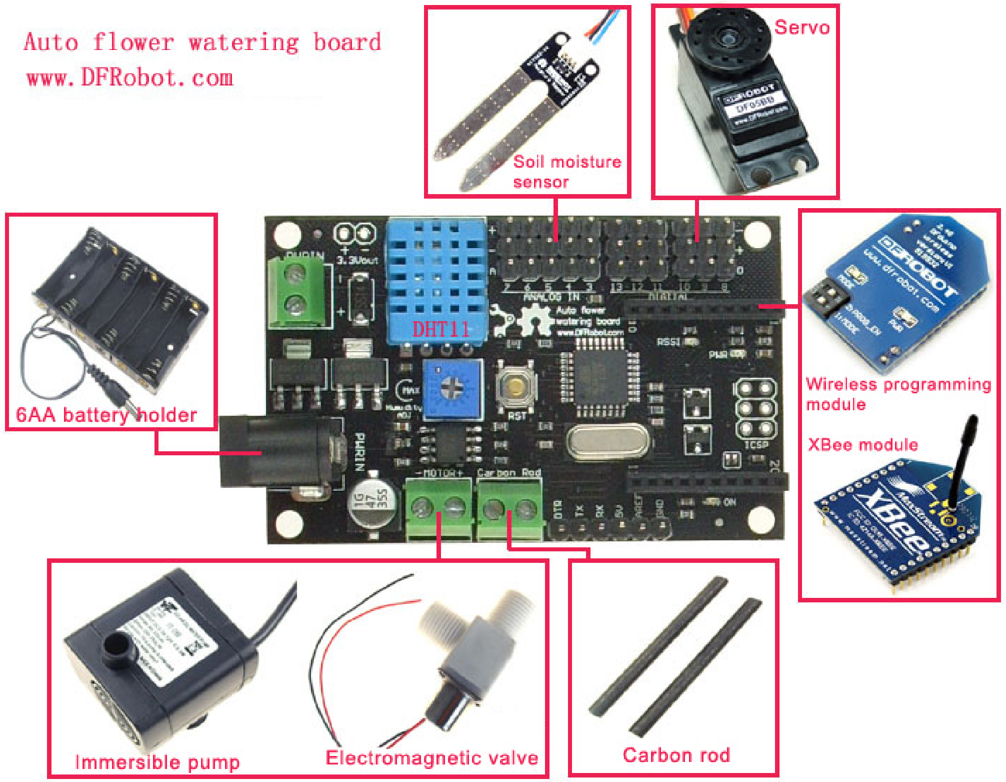
http://freaklabs.org/index.php/tutorials/hardware/weatherproof-wireless-enclosure-build-tutorial.html

Secure Enclosure





Datalogger/Sensor(s)



E. KY Experimental V/F Site

Hydrology and Water Quality Data

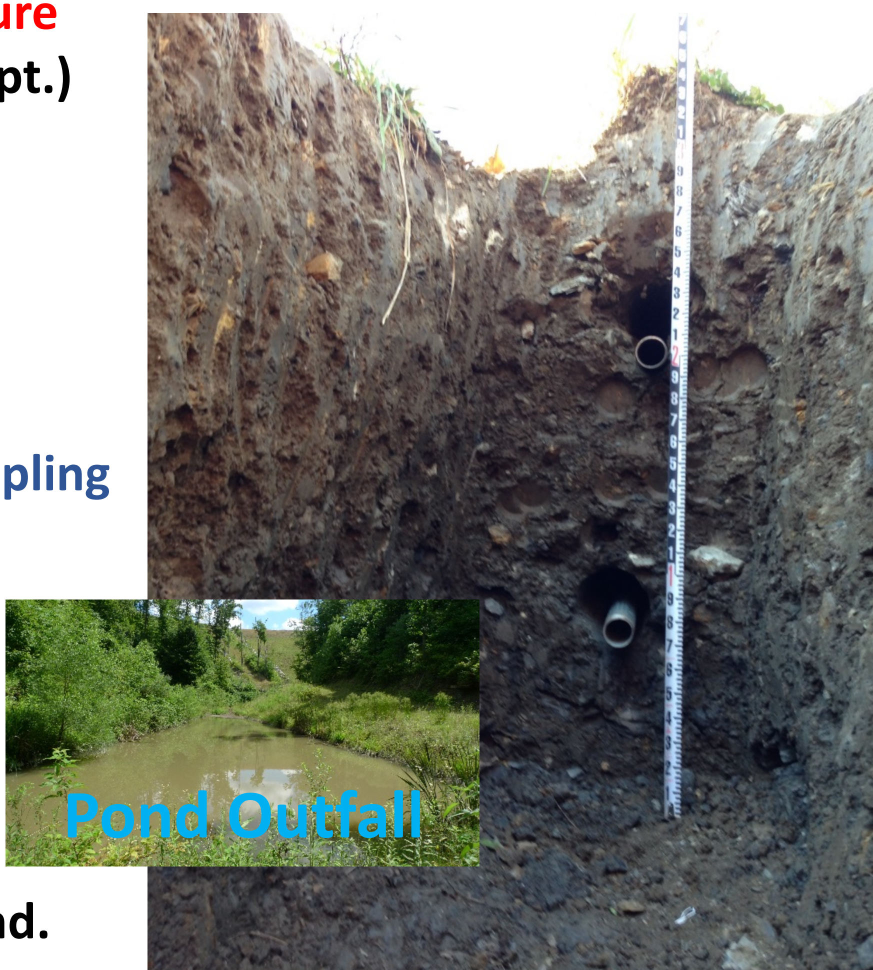
(6 to 9 mos.)

Rainfall

Surface runoff

1) Surface Water
   a) Phase I
      i. Water Level
      ii. Conductivity
      iii. Temperature
   b) Phase II (exc. ppt.)
      i. ORP
      ii. DO
      iii. pH
      iv. Ca^{2+}
      v. Cl^{-}

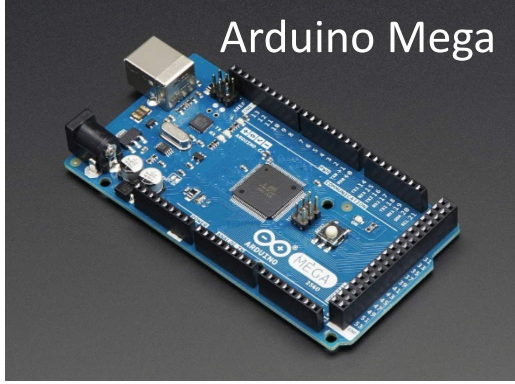
Shallow lateral subsurface flow (SLSSF)



2) Groundwater/SLSSF
   a) Phase I
      i. Water Level
      ii. Conductivity
      iii. Temp
   b) Phase II
      i. ORP
      ii. pH

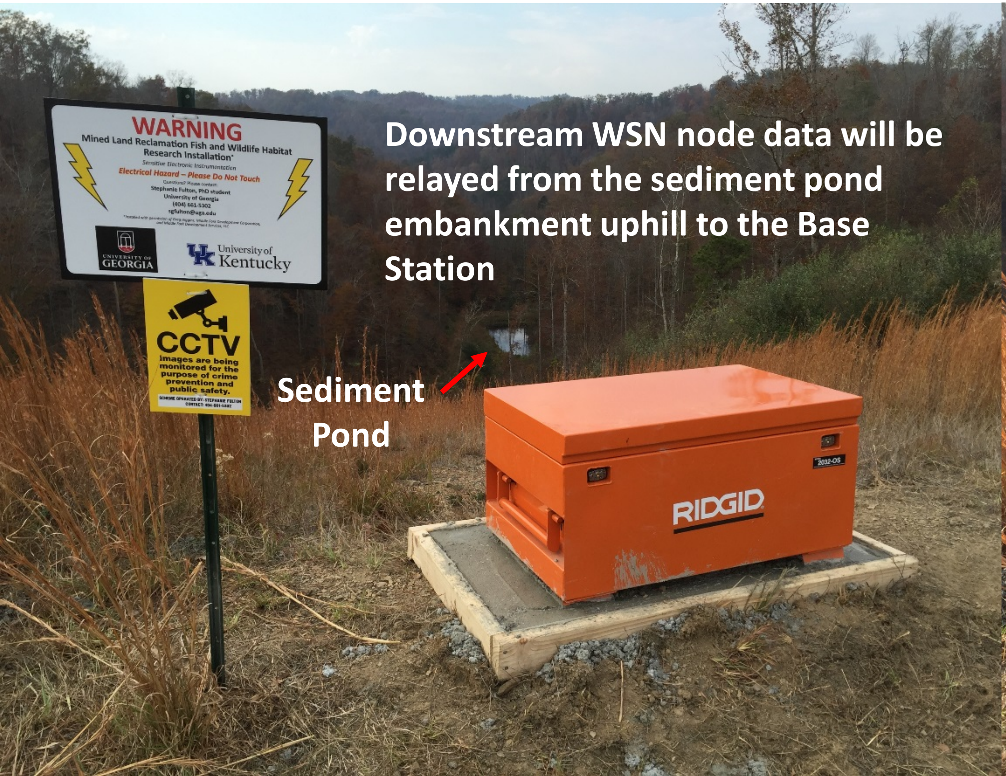
3) Monthly WQ sampling
   a) Major anions
   b) Major cations
   c) Trace metals
   d) pH
   e) Alkalinity
   f) Acidity
   g) Temp/DO/Cond.

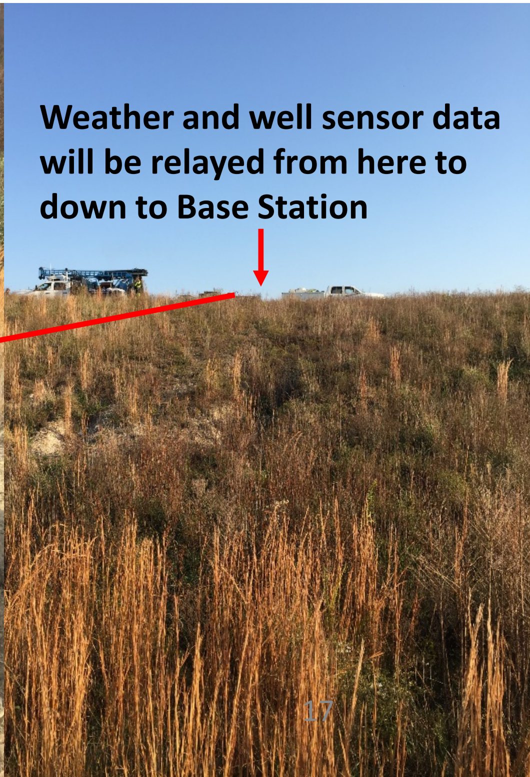
Base Station



Concrete-mounted, locking storage box; pedestal for PVC pole; signage and camouflage paint. Station will include Arduino Mega, cellular modem (GSM 2G), XBee PRO 900 MHz RF module, solar panel, 12V battery, and electrical monitoring system (and possibly future surveillance system).

View uphill to Monitoring Well Station

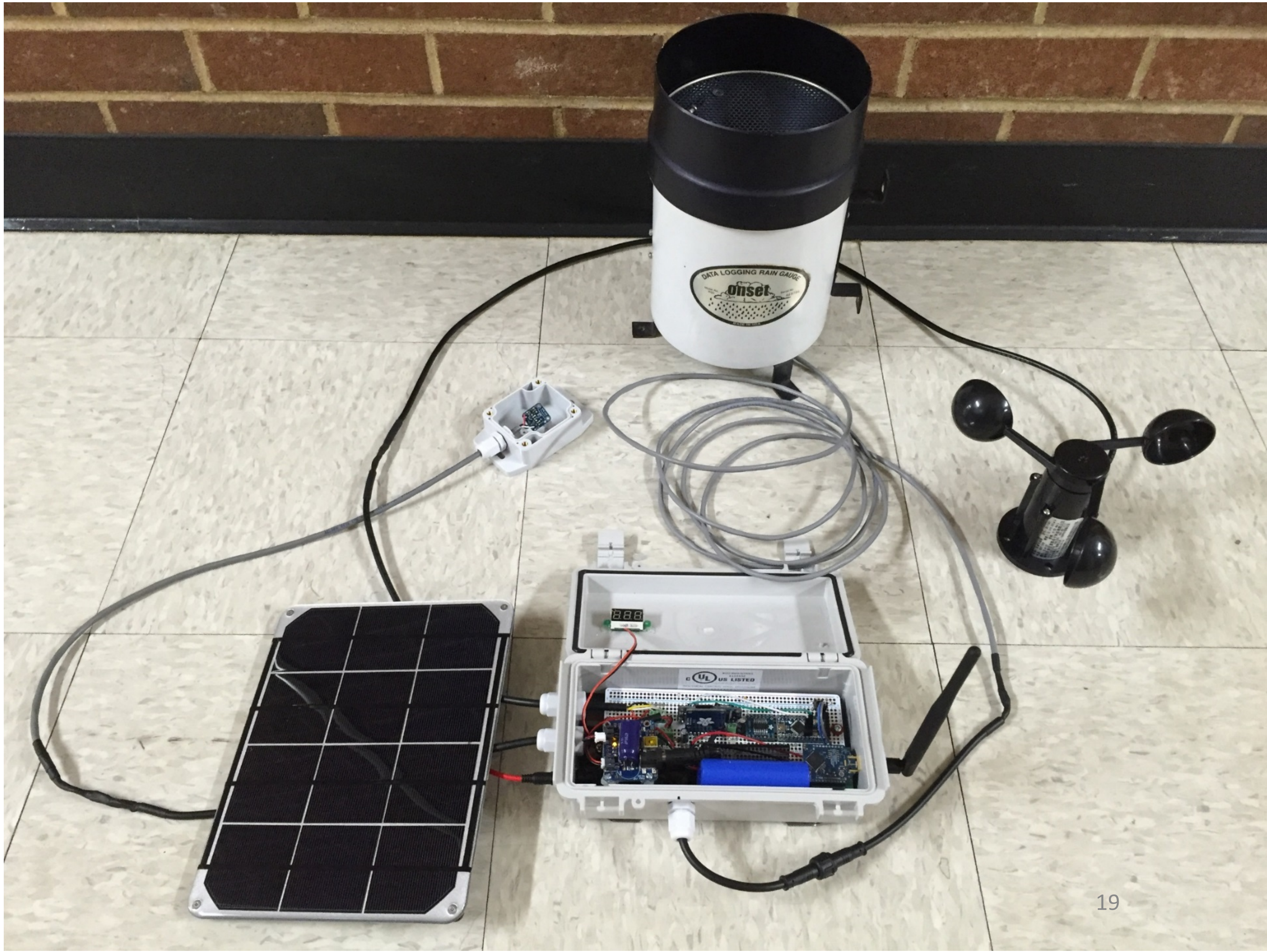





E. KY Experimental V/F Site
Monitoring Well/Weather Station
Well secured inside locked, concrete-mounted steel storage box
Weather station data logger will be pole mounted, co-located with well, and grounded
Groundwater sensor data will be relayed from groundwater table to top of well using Xbee PRO RF modules
WARNING
CCTV
TEST

Climate Data

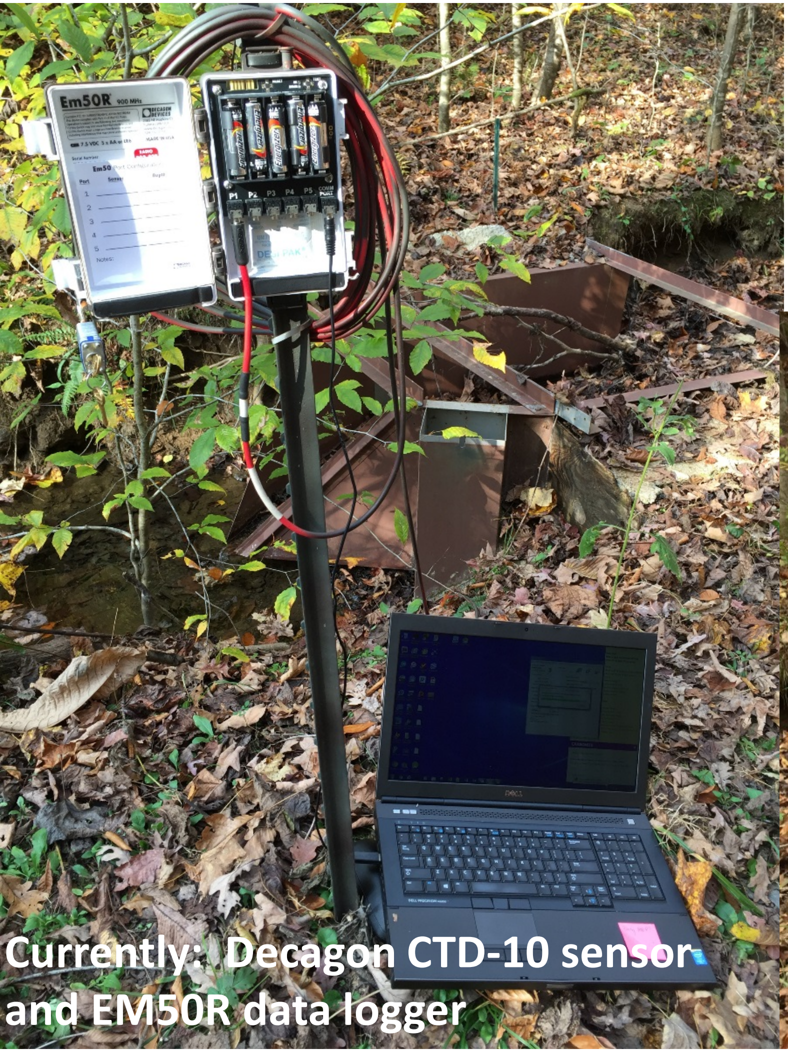
- Precipitation
- Wind speed
- Barometric pressure
- Air temperature
- Relative humidity



Well Points

Sediment Pond

Lower Flume


Em50R
Currently: Decagon CTD-10 sensor
and EM50R data logger

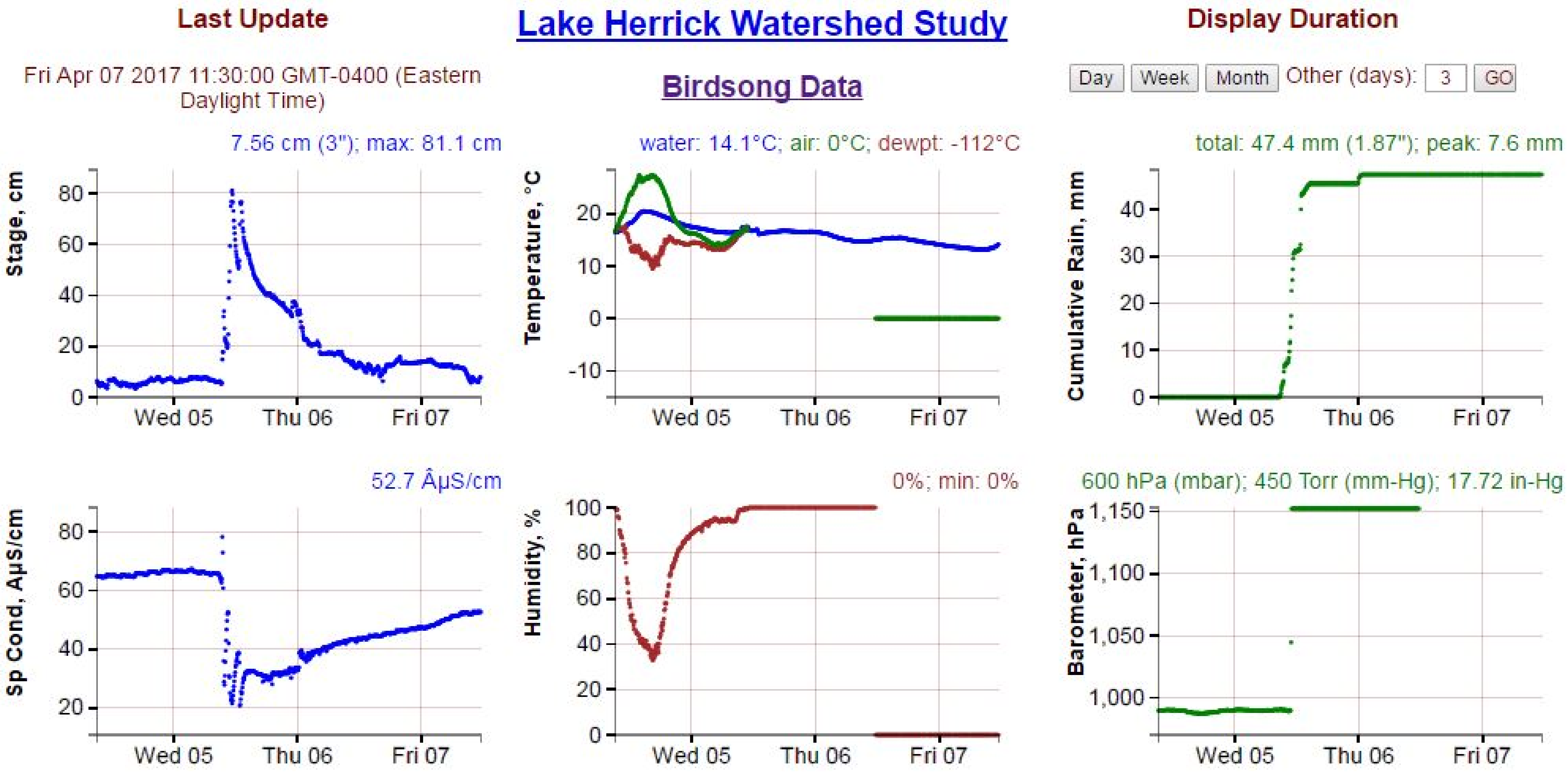

WARNING
Mined Land Reclamation Fish and Wildlife Habitat
Research Installation
Electrical Hazard – Please Do Not Touch
UNIVERSITY OF GEORGIA
University of Kentucky
CCTV
Images are being monitored for the purpose of crime prevention and public safety.

Watershed UGA Birdsong Creek Demonstration Site

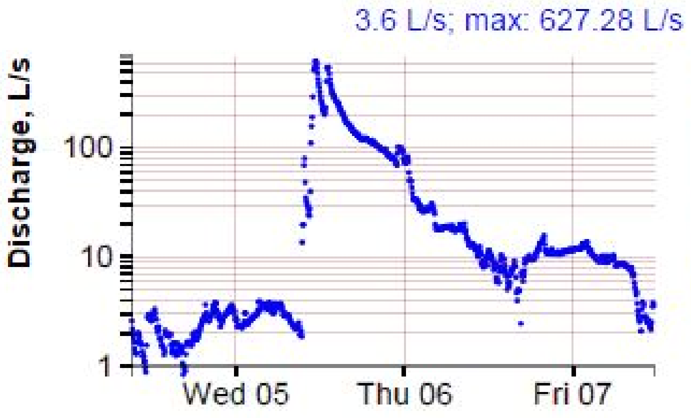
Rain Gage + XBee RF Module

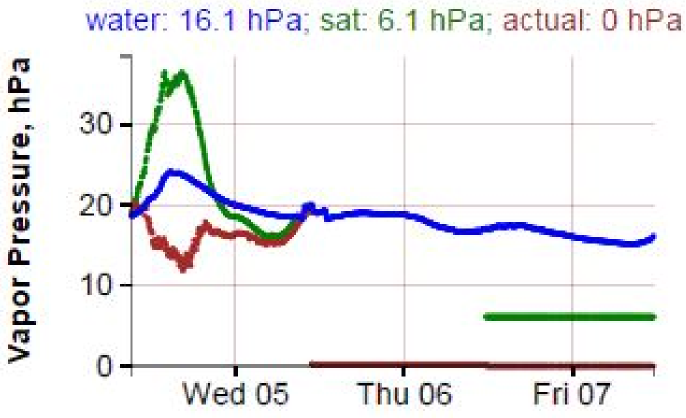
Pilot Conductivity Sampling Chamber

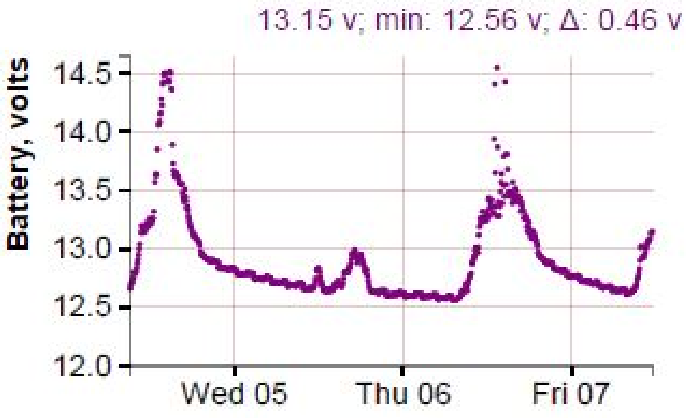
Watershed UGA - Birdsong Creek Live Datastream

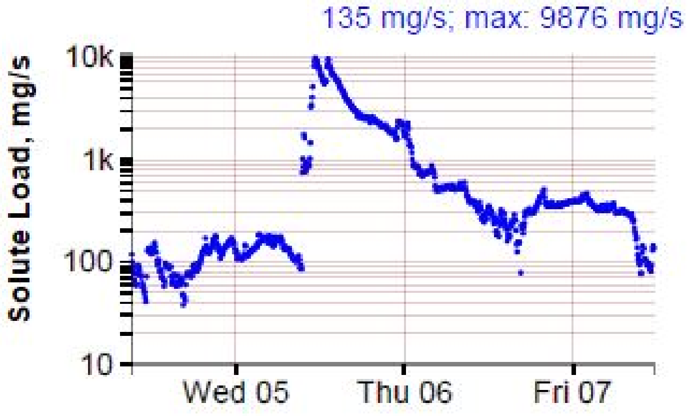


Watershed UGA - Birdsong Creek Live Datastream

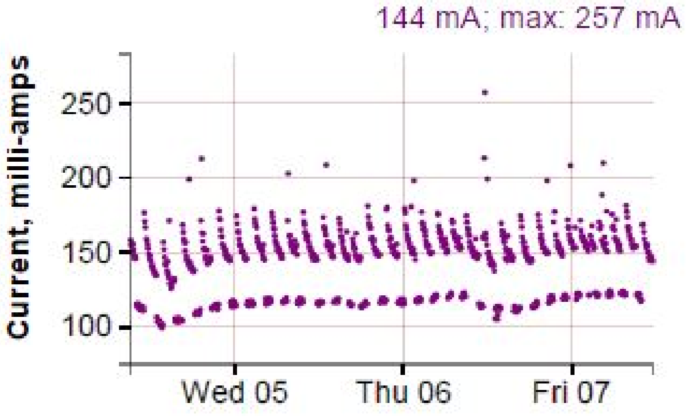








Instrumentation: John Dowd, UGA Geology
Website: Todd Rasmussen, UGA Warnell
Version 2.9 (September 01, 2016)



In Conclusion

- High resolution, continuous flow and conductivity data collected via WSN will help to:
  - Identify the important flow paths of high conductivity source waters contributing to elevated ionic strength in streams below VFs.
  - Apportion the dynamic contribution of each source to increased total dissolved solids loads throughout a storm event.
  - Increase our understanding of the impact of the hydrologic isolation technique on stream flow mechanisms.
- Study results will help inform the further refinement of spoil management and placement techniques for the construction of valley fill designed to minimize TDS-production.

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Questions?