

Confounding Factors and Lessons Learned: Monitoring the Hydrology of Headwater Streams of the Gulf Coastal Plain



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Background

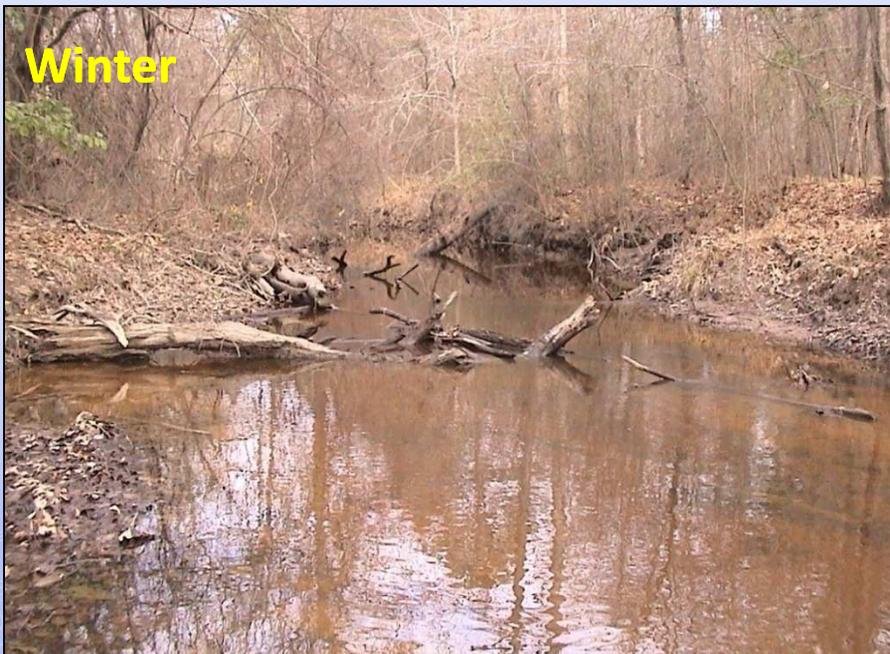
Importance of monitoring headwater streams

- Headwaters represent more than two-thirds of the total stream length of river networks.
- Their role in linking the upland and riparian landscape to downstream ecosystems on a regional scale is well-established.
- Therefore, the cumulative impacts of headwater alteration can lead to large-scale water quality problems downstream.

Background

Research need in coastal plain headwaters

- Although extensive research on forested headwater streams has been conducted in topographically variable areas, fewer studies examine low-gradient headwater systems that often become intermittent during the summer, such as those existing on much of the Gulf coastal plain.



Study goal

- Determine watershed-scale effectiveness of timber harvesting Best Management Practices (BMPs)
- This goal was not met due to difficulty in quantifying stream discharge.
- The objectives of today's discussion are to discuss why hydrology was difficult to quantify and what we have learned from this experience.
- **Problems include:**
 - Sporadic, storm-event dominated flow regime
 - Beaver dams, debris dams, and impoundments

The Flat Creek Study

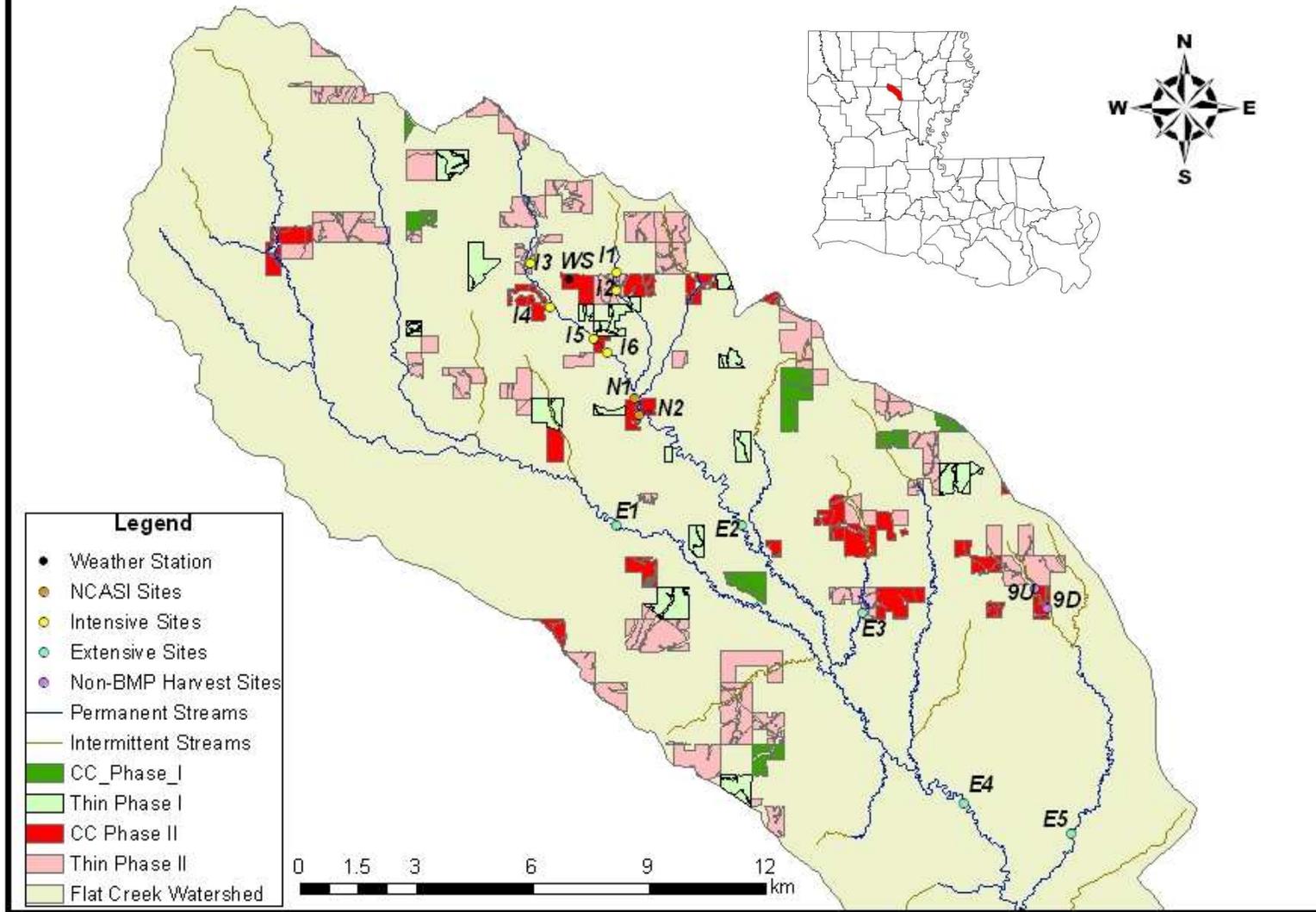
- Do harvesting BMPs protect and/or improve water quality beyond the plot-scale in headwaters of the Gulf Coastal Plain?

- **Research approach:**
 - Paired watershed, Before-After-Control-Impact (BACI) design

 - Rating curves were developed from Dec. 2005 – Sep. 2007 (Pre-Harvest) and Oct. 2007 – Dec. 2009 (Post-Harvest) at 15 previously ungaged locations.

 - Streamflow measurements were made at monthly intervals and during storm events.

Harvesting & Monitoring Locations within the Flat Creek Watershed



Flow measurement techniques and equipment

□ When streams were wadeable:

- USGS mid-section velocity-area method
- Acoustic Doppler Velocimeter (ADV)
(FlowTracker, SonTek/YSI, Inc.,
San Diego, CA, USA)



□ When they were not wadeable:

- Acoustic Doppler Current Profiler (ADCP),
two-man pull method
- (Rivercat, SonTek/YSI, Inc.,
San Diego, CA, USA)



Water level monitoring equipment

□ Intensive sites

- Pressure transducer
- 6712 automatic water sampler (Teledyne ISCO, Lincoln, NE, USA)



□ Extensive sites

- Pressure transducer
- HOBO water level logger (Onset Computer Corporation Bourne, MA, USA)



Water level monitoring equipment

□ Non-BMP harvest sites

- Staff gage
- ISCO



□ NCASI sites

- Pressure transducer
- 6920 V2 Water quality sonde (YSI, Inc., Yellow Springs, OH, USA)



Problems in maximizing utility of stage-discharge rating curves (SDRCs)

From one extreme to the next....



How do you measure such high flow?

Problems in maximizing utility of SDRCs

Measuring discharge at flood stage



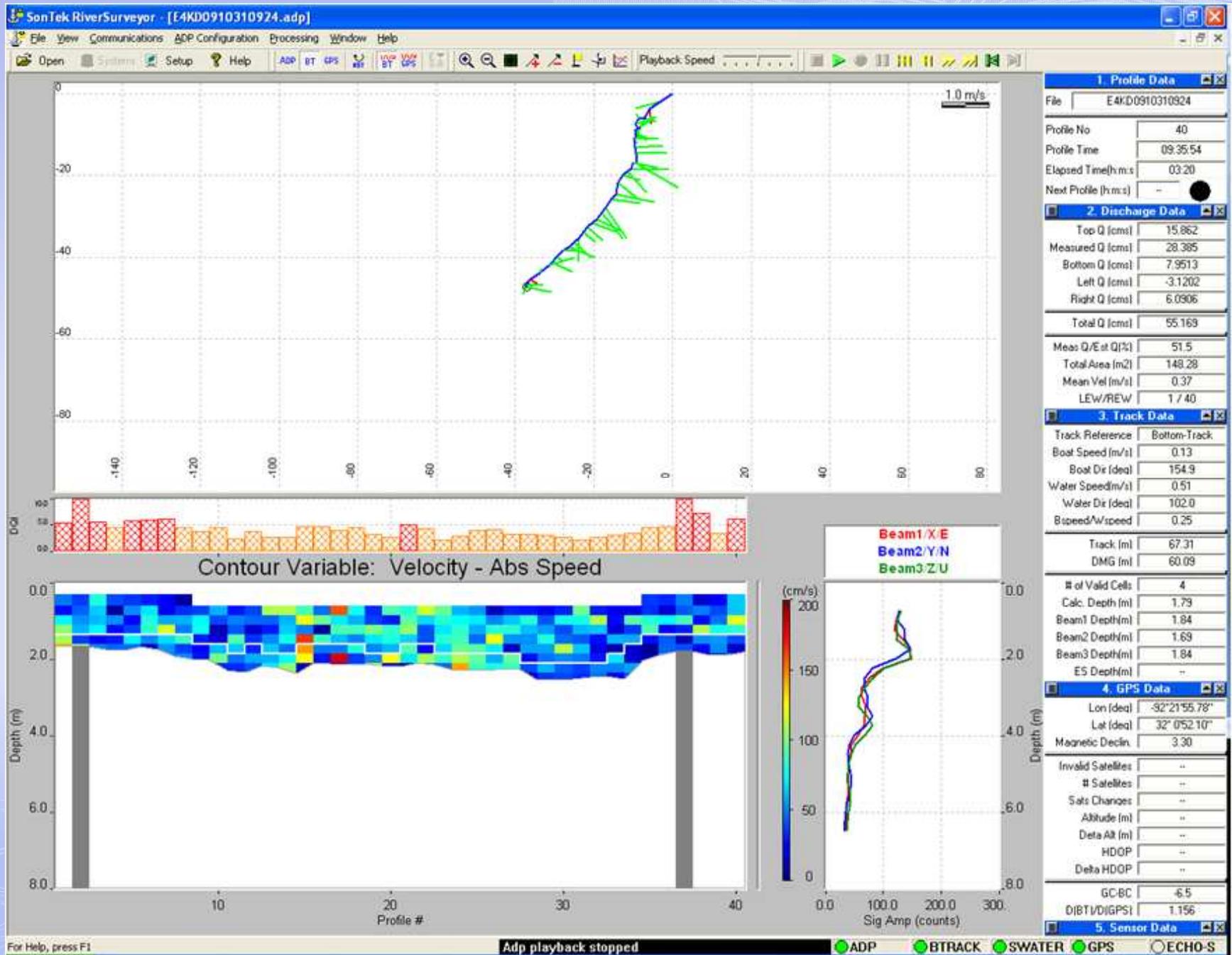
- ❑ Wading discharge measurements were made successfully at two of our headwater sites. This was not one of them!

Problems in maximizing utility of SDRCs

Measuring discharge at flood stage



- ▣ ADCP towing was used to measure flood stage discharge at six monitoring locations.

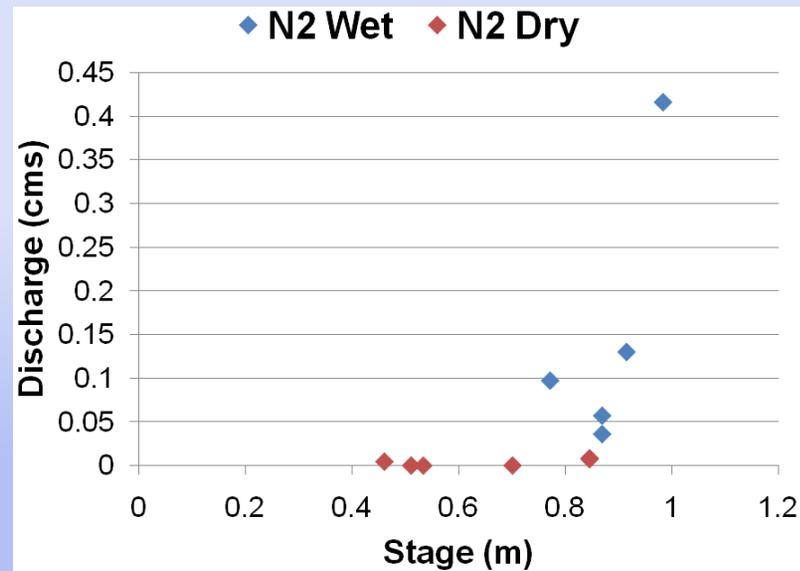
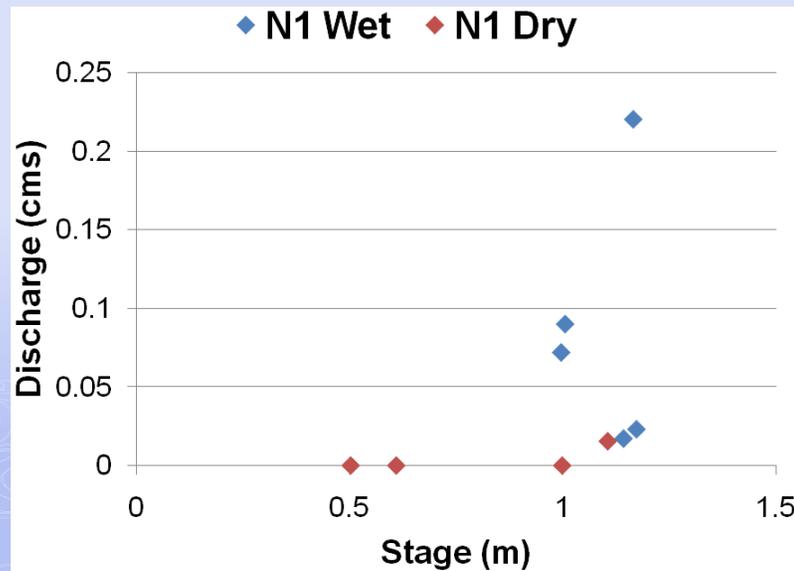


Problems in maximizing utility of SDRCs

Variability in low flow discharge measurements

□ Zero flow level

- Established during dry summer periods
- Low-flows are highly variable



Problems in maximizing utility of SDRCs

Variability in low flow discharge measurements

- Same water level, but different discharge
 - Beaver dams, debris dams, and impoundments



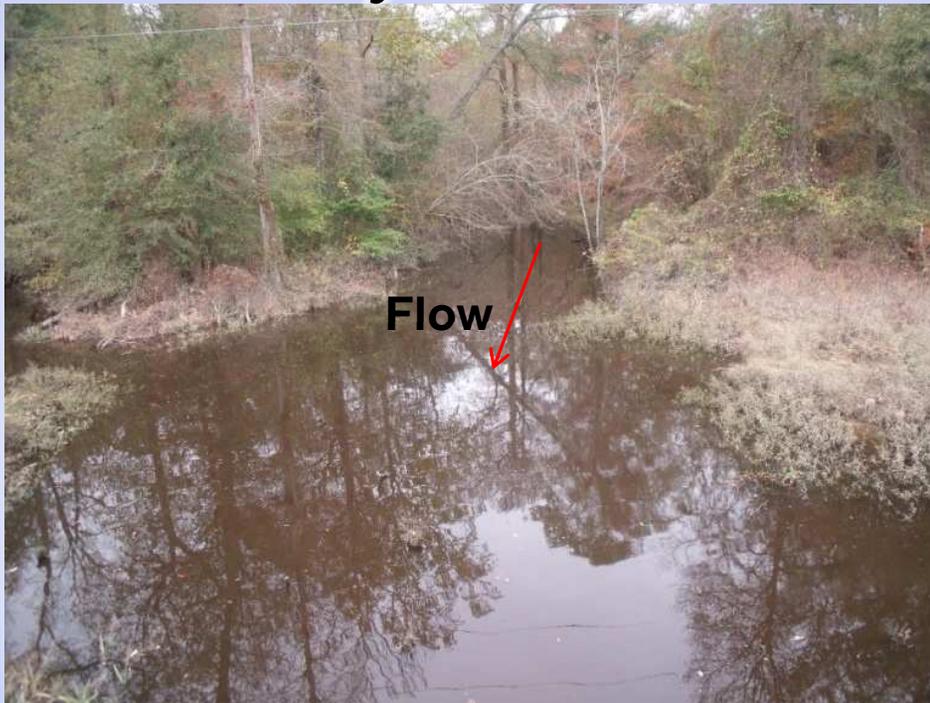
Beaver dam upstream of site I4.



Debris dam downstream of site I4.

Problems in maximizing utility of SDRCs

Variability in low flow discharge measurements



Ponding effects of a sediment lip (photo taken November 21, 2009; flow rate = 8 cfs). Other sources of variability in ratings include sensor drift / bias and error in individual streamflow measurements.

Problems in maximizing utility of SDRCs

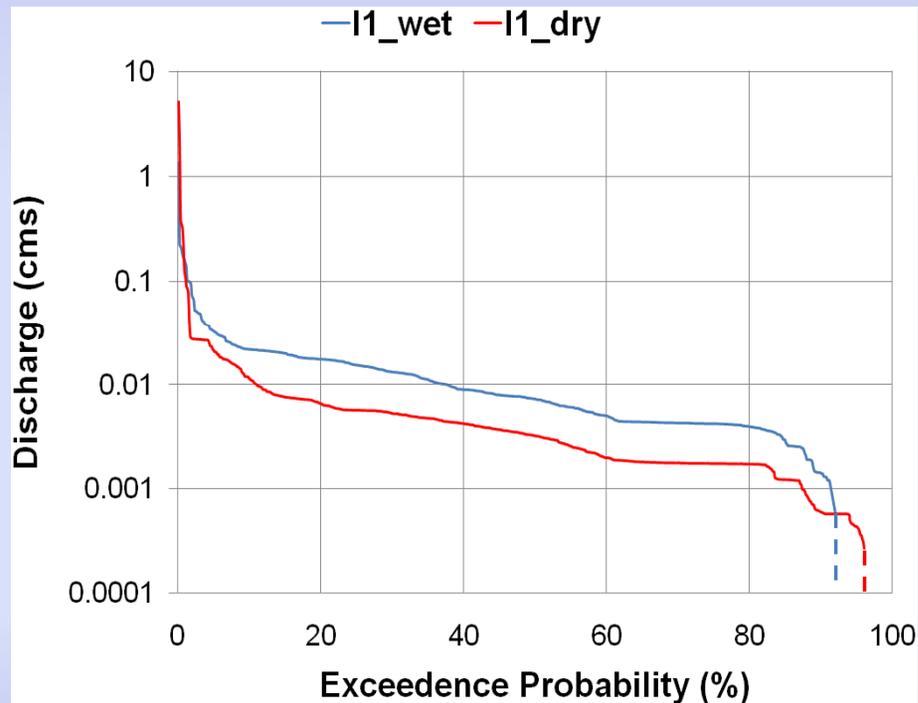
Variability in low flow discharge measurements



Streamflow frequency and magnitude analysis

- Flow Duration Curves
- Plot discharge vs. exceedence probability, P
- $P = 100 * (\text{rank} / (n + 1))$
- All sites experienced no flow conditions during the dry season (May to October)

Streamflow frequency and magnitude analysis

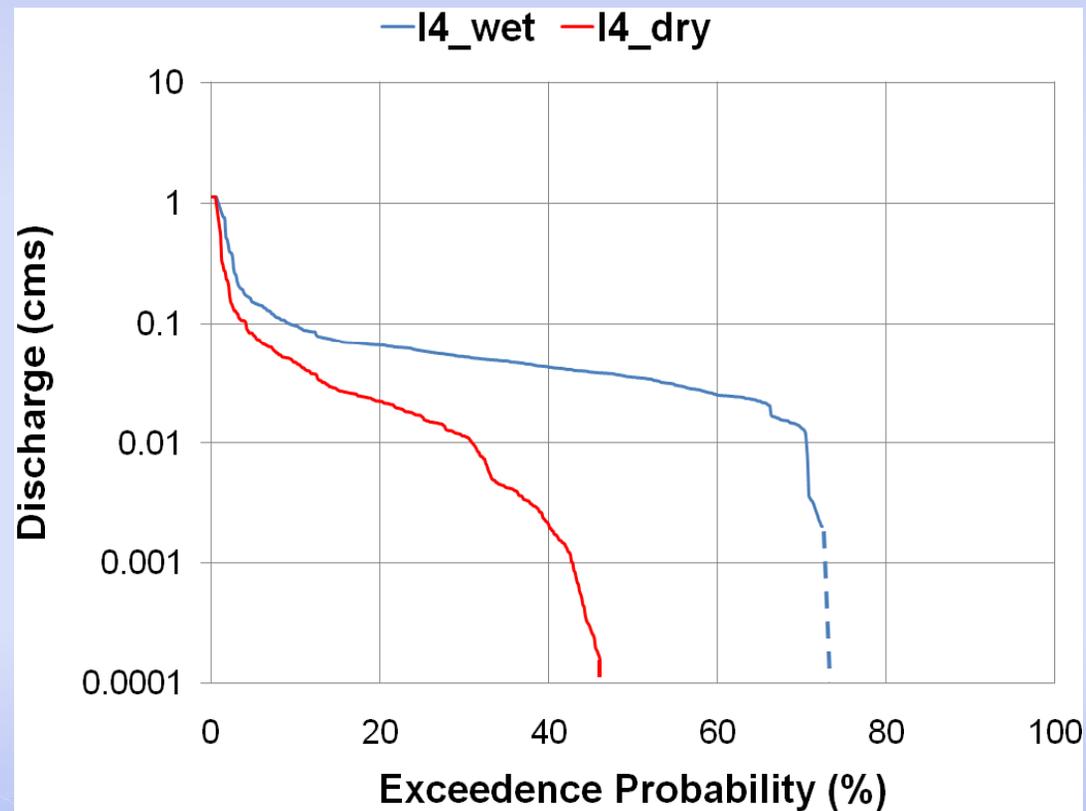


Site I1: July 17, 2008



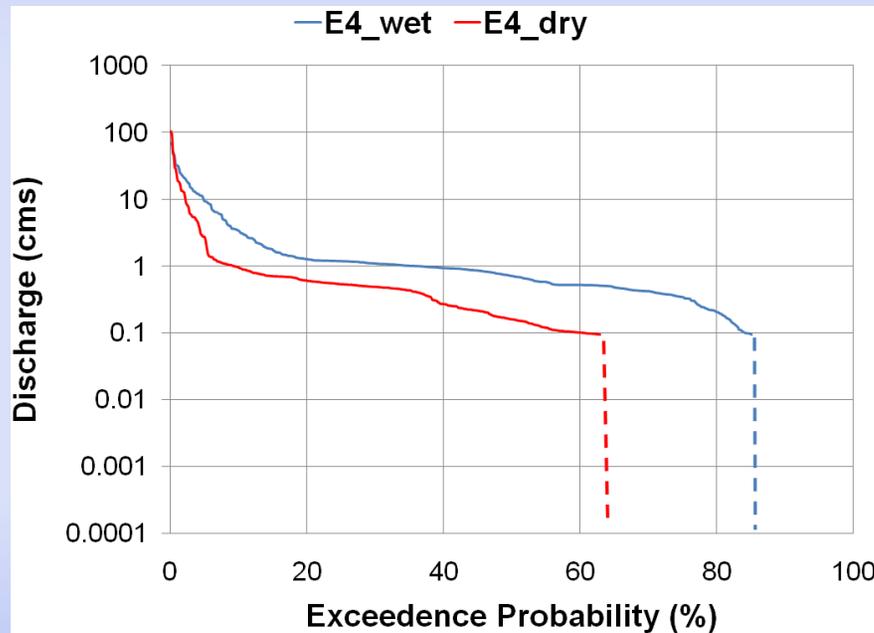
Site I1: October 30, 2009;
Flow rate = 63 cfs

Streamflow frequency and magnitude analysis



Streamflow frequency and magnitude analysis

Site E4 (effective watershed outlet)



Lessons learned:

- ❑ When developing a rating curve, be prepared to measure the full range of flow conditions.
- ❑ Diverse types of features control stage-discharge relations. Deal with them by establishing the zero flow level.
- ❑ In this region, discharge measurements of headwater streams are unnecessary during the summer months. **Storm events are most important.**

Acknowledgements

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