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How Much is Enough? Flow Duration as a Parameter for Determining Mitigation Success in Headwater Stream Systems

Kevin Tweedy, PE - Technical Service Manager for Ecosystem Restoration
ktweedy@mbakercorp.com

Creating value by delivering innovative and sustainable solutions for infrastructure and the environment.

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Background

- **In 2007, an information paper was issued by the US Army Corps of Engineers (USACE) and the North Carolina Division of Water Quality (NCDWQ) that allowed for the restoration of Coastal Plain riparian headwater wetland valleys to provide compensatory stream mitigation.**
- **This information paper recognizes that in the Coastal Plain many headwater stream systems have been ditched and channelized to improve drainage. In their pre-disturbance condition, it is unlikely that these systems would have had defined channels; therefore, a restoration approach seeking to construct a meandering channel would not be appropriate.**

PLEASE NOTE: The following document is in draft and subject to change. While the information contained herein may be used for planning purposes, final plans should be coordinated with the Ecosystem Enhancement Program, The Corps of Engineers and/or The NC Division of Water Quality as appropriate.

INFORMATION REGARDING STREAM RESTORATION
With Emphasis on the Coastal Plain

Prepared By:

US Army Corps of Engineers,
Wilmington District, Regulatory Division
And
North Carolina Department of Environment and Natural Resources,
Division of Water Quality

Version 2
April 4, 2007

DRAFT

This document is intended to provide general information to compensatory mitigation providers for use when planning or evaluating potential stream mitigation projects; particularly in the coastal plain (defined as the Middle Atlantic Coastal Plain Ecoregion as shown on Griffith, et. al. 2002) of North Carolina. The term "stream" as used in this document, means that the flow of water is contained in a natural channel or bed with identifiable banks and, in its unaltered state on the coastal plain, usually has adjacent wetlands. This document is meant to complement the April 2003, Stream Mitigation Guidelines, prepared by the Corps of Engineers Wilmington District, Environmental Protection Agency, the North Carolina Division of Water Quality and the North Carolina Wildlife Resources Commission (US Army Corps of Engineers, 2003).

INTRODUCTION

The decision whether to purse any potential mitigation site should hinge on what can reasonably be accomplished considering current site conditions, and site constraints. Mechanically returning a site to a historic condition may not be possible or in some cases even preferable. The primary consideration must be what functions need to be returned or improved upon. Designers must then examine to what degree they can control those factors contributing to the loss or degradation of those identified functions. Together, these considerations should indicate whether a project is viable and ultimately determine the goals of the project.

Site Selection Considerations

1

Previous Research – Headwater Valleys

Little technical guidance was available to determine whether a headwater approach or single-thread channel should be designed for a given site.

A research project was initiated to evaluate headwater reference sites that covered a range of channel morphologies.

Previous Research – Headwater Valleys

Divided headwater reference reaches into three categories by channel form:

- Poorly Defined
- Moderately Defined
- Well Defined



Previous Research – Headwater Valleys

<u>Poorly Defined Reaches:</u>

- Defined valley with evidence of periodic surface flow.
- Channel bed and bank features are not identifiable, or are poorly defined and present for only short distances.
- Appear more as linear wetlands that flow.

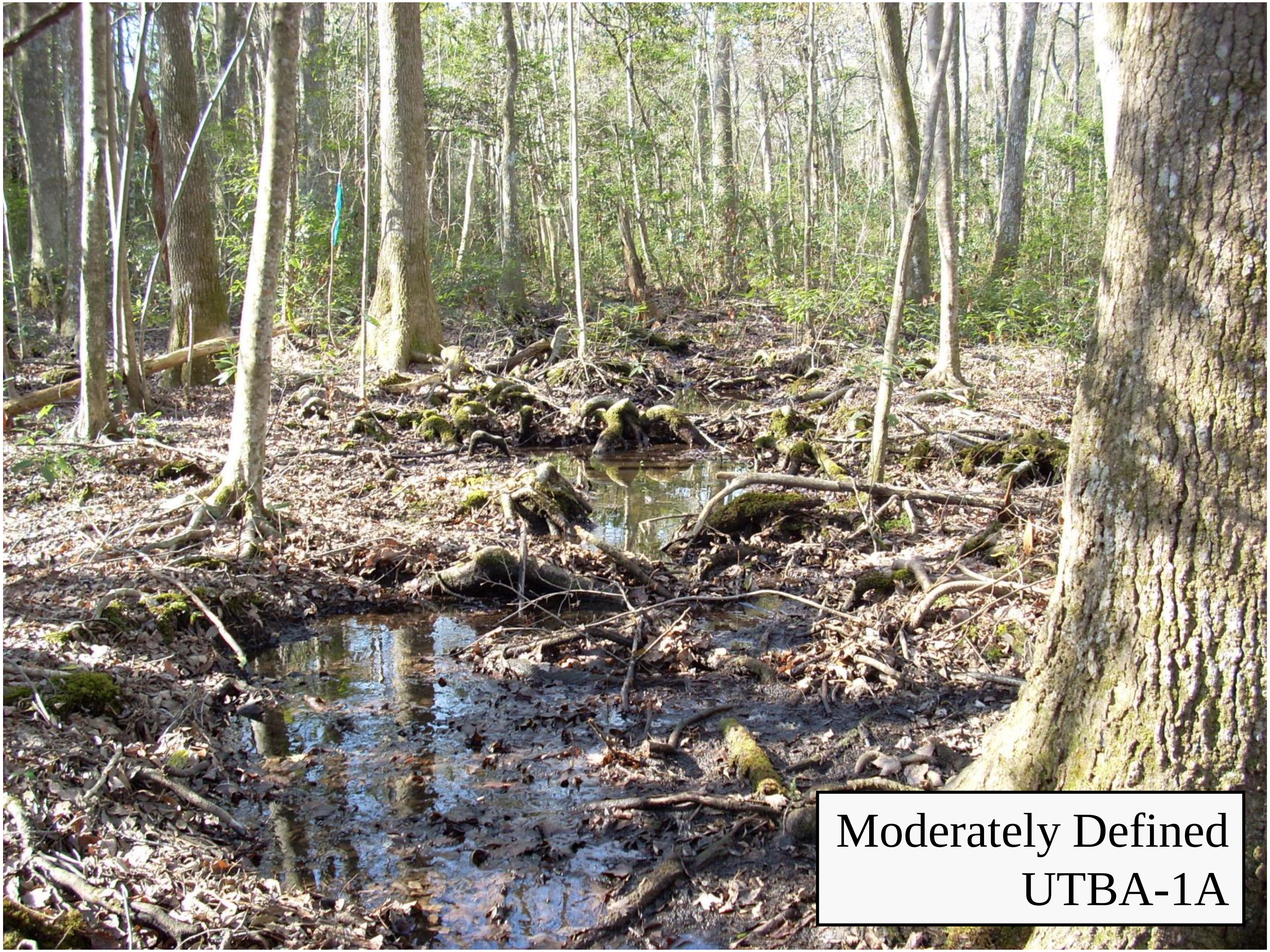
Previous Research – Headwater Valleys

Previous Research – Headwater Valleys

Moderately Defined Reaches:

- Relatively consistent bed and bank features, but channel dimensions (cross-sectional area and shape) are highly variable.
- Flows often transition from one to multiple channels along its flow path.
- Channel form appears to be defined mostly through localized scour, small debris jams, and vegetation.

Previous Research – Headwater Valleys



Previous Research – Headwater Valleys

Well Defined Reaches:

- These systems can be considered "typical", single-thread reference reach quality channels.
- Channel banks are obvious and constant.
- Channel dimension is relatively constant, with alternating riffle and pool areas.
- Channel form is defined primarily through fluvial processes.

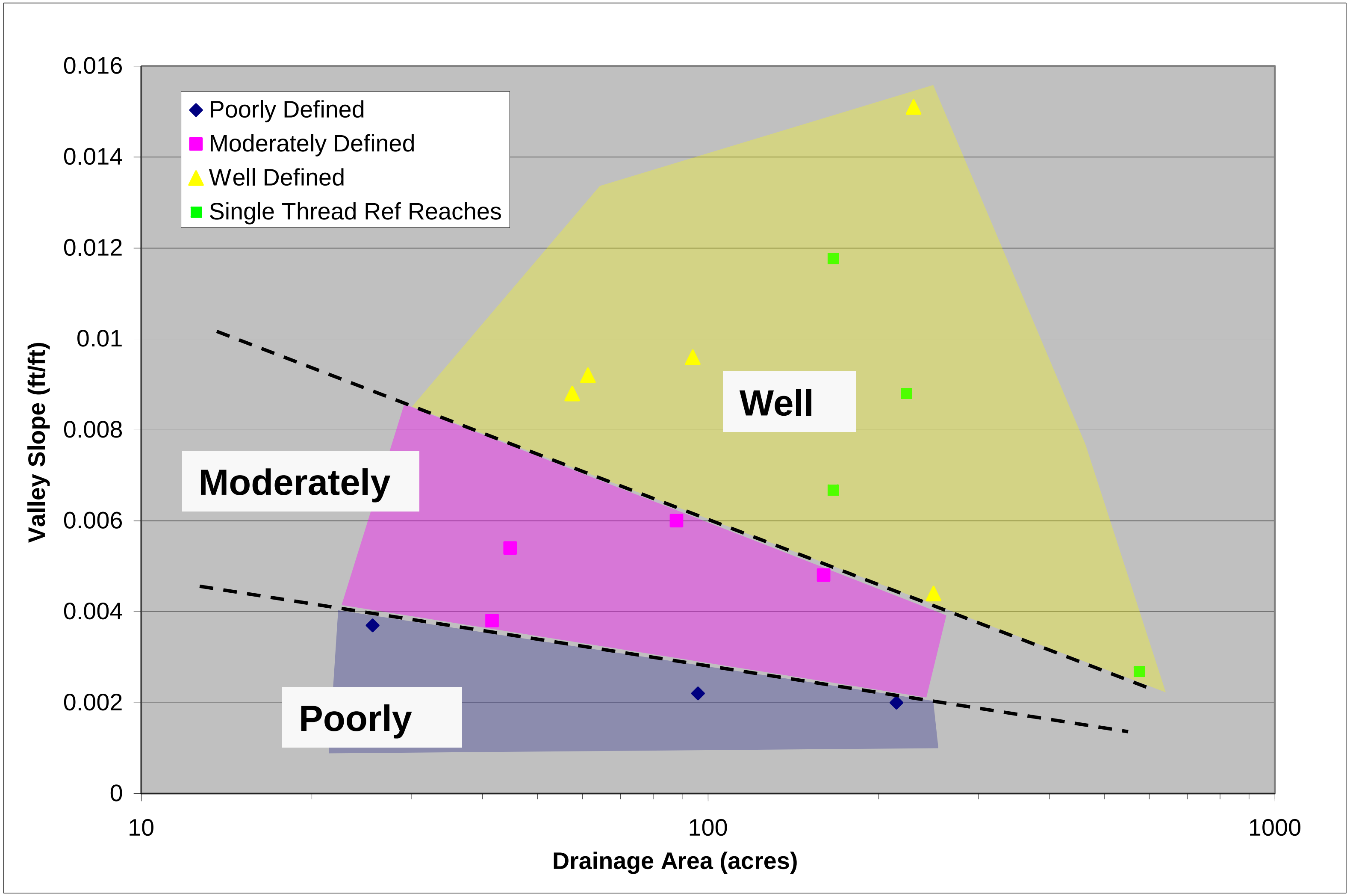
Previous Research – Headwater Valleys

Well Defined
UTBR-2C

Previous Research – Headwater Valleys

Previous Research – Headwater Valleys

Research lead to development of a design tool that can be used to predict appropriate channel form, based on drainage area and valley slope.



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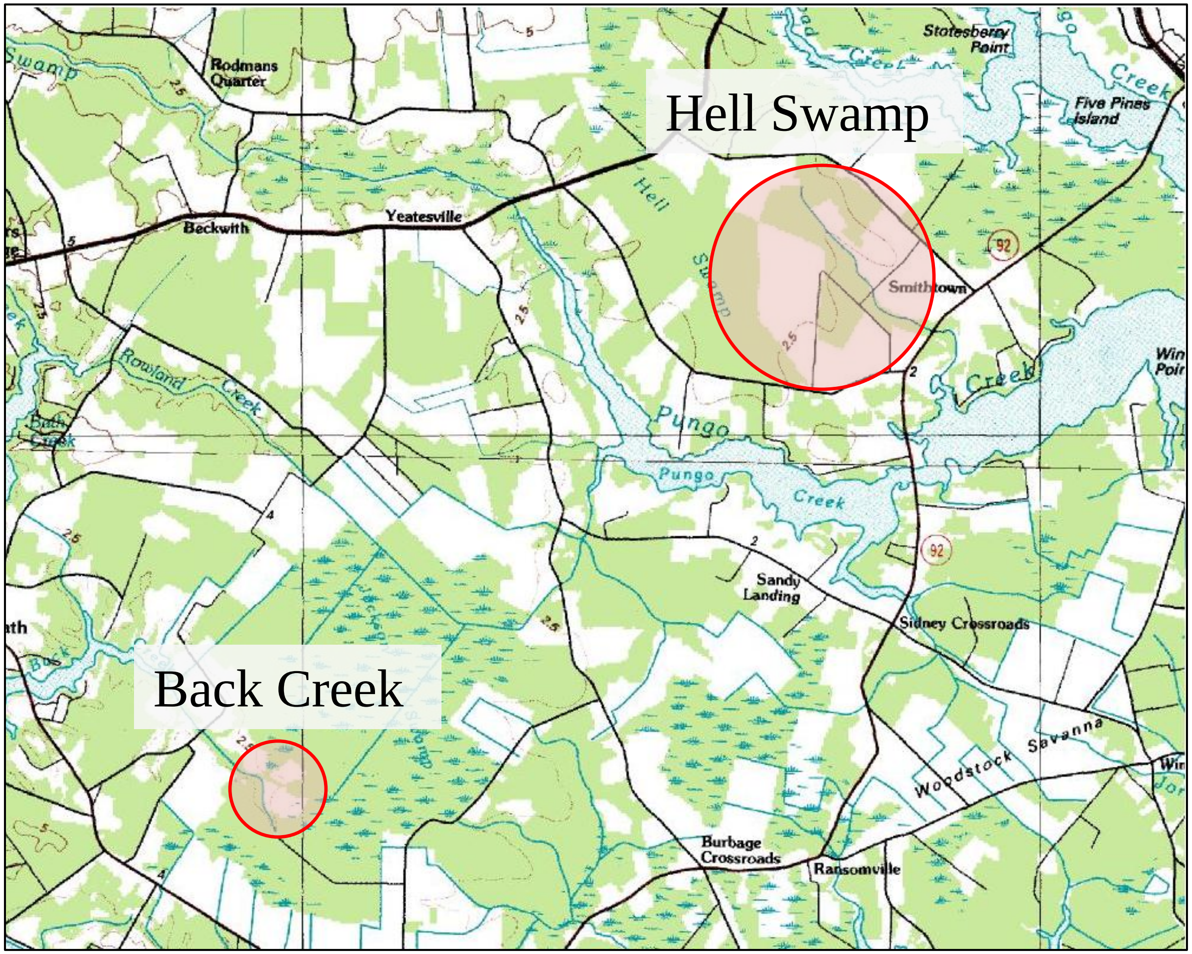
Completed Projects Using Headwater Design Approach



Hell Swamp
- 1,300 acres
- 19,800 ft of stream
- Completed 2010

Back Creek:
- 217 acres
- 8,200 ft of stream
- Completed 2009

Project Monitoring

Morphology
- cross-sections
- longitudinal profiles

Vegetation
- plots and quadrants

Hydrology
- groundwater wells
- rainfall
- surface flows

Hell Swamp (post-restoration) – Winter 2010

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Project Monitoring

Morphology
- cross-sections
- longitudinal profiles

Vegetation
- plots and quadrants

Hydrology
- groundwater wells
- rainfall
- surface flows

Hell Swamp (post-restoration) – Winter 2010

Project Monitoring – Success Criteria

<u>Hydrologic Success Criteria (stream credit) -</u>

- **Must document two flow events per year in at least 3 of the 5 monitoring years.**
- **Demonstrate stability.**

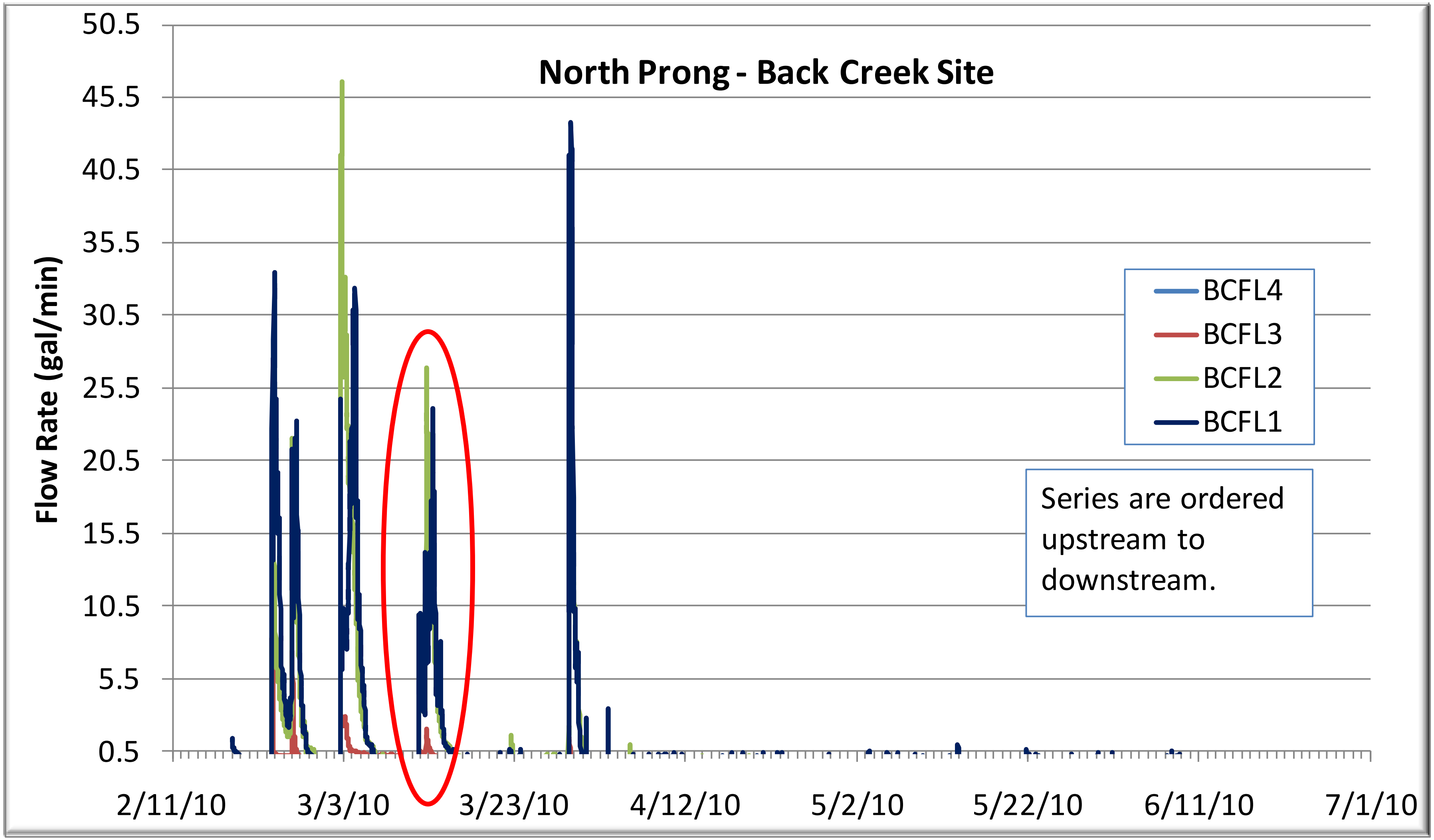
- **No requirement for duration or magnitude of flow, so what is appropriate?**
- **Likelihood that success criteria would evolve and become more quantitative over time seemed likely (*new monitoring and success criteria expected before end of 2011*).**
- **How do we even measure such small flows?**

Headwater Hydrology

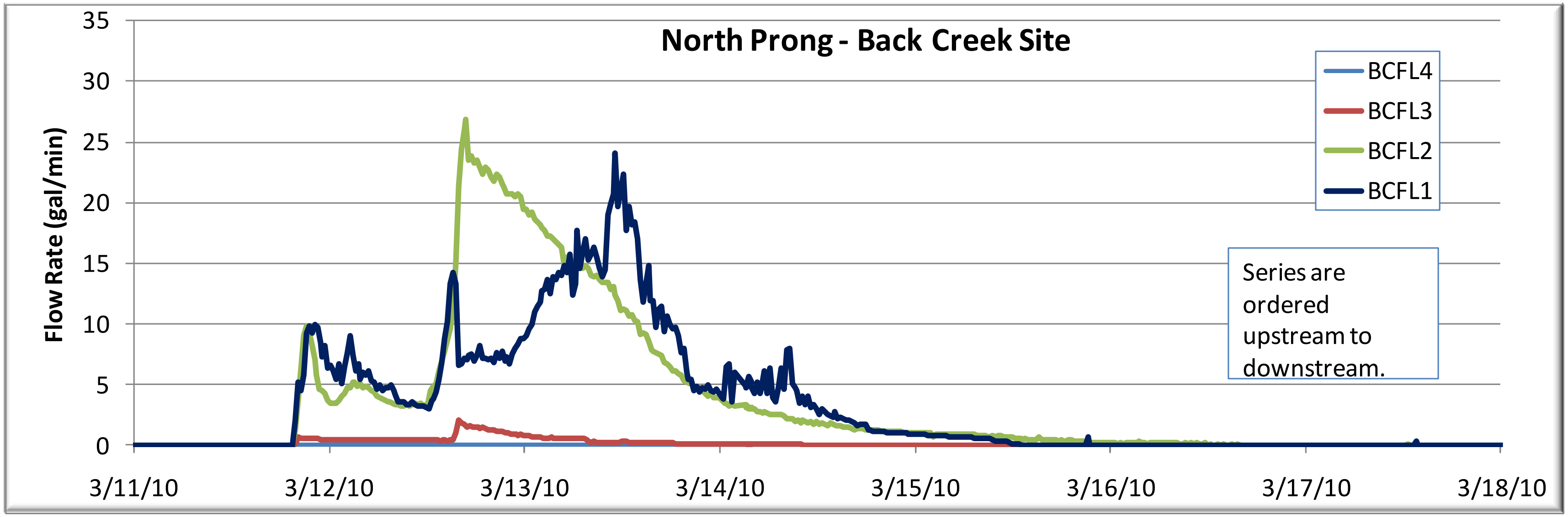
Back Creek Site – November 2009

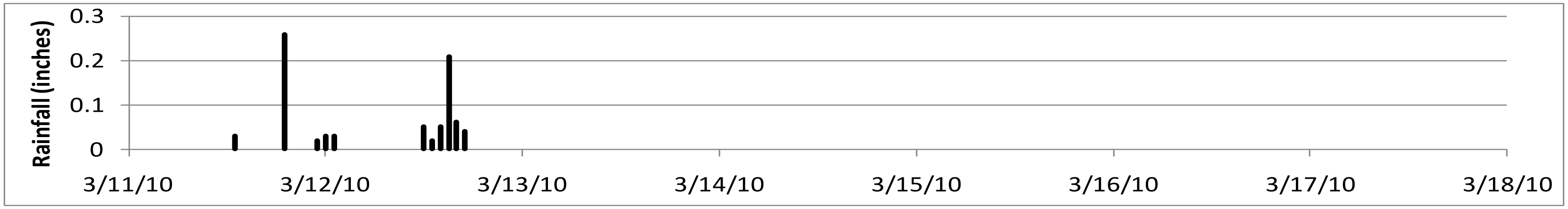
Project Monitoring – Flow Events

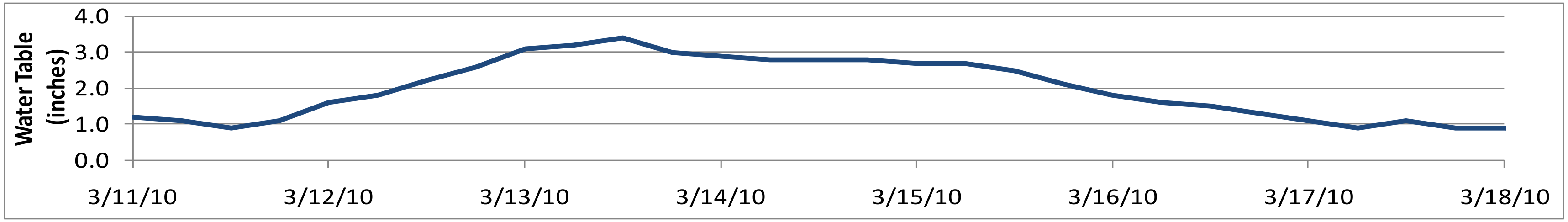
Headwater Hydrology



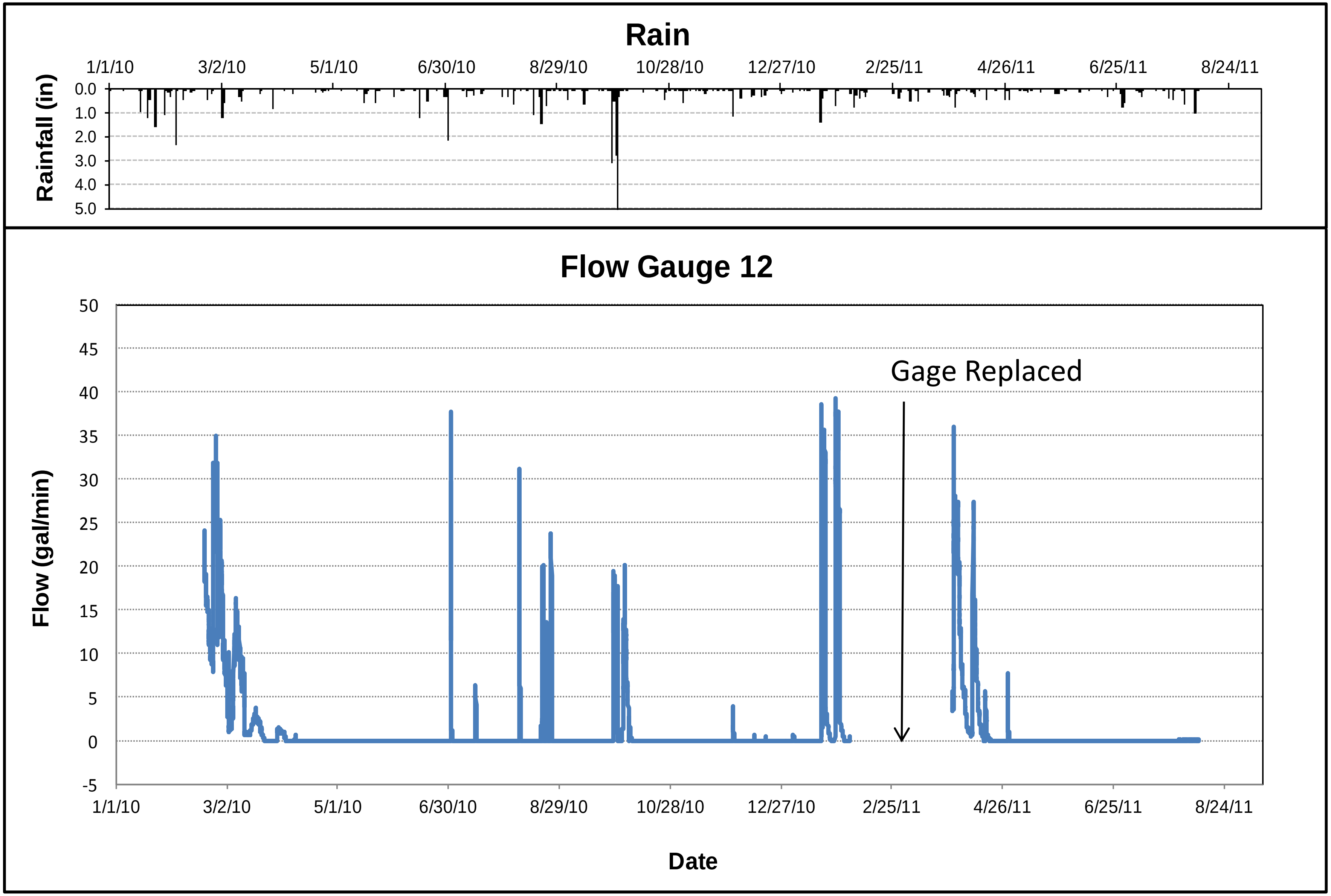
Headwater Hydrology







Headwater Hydrology

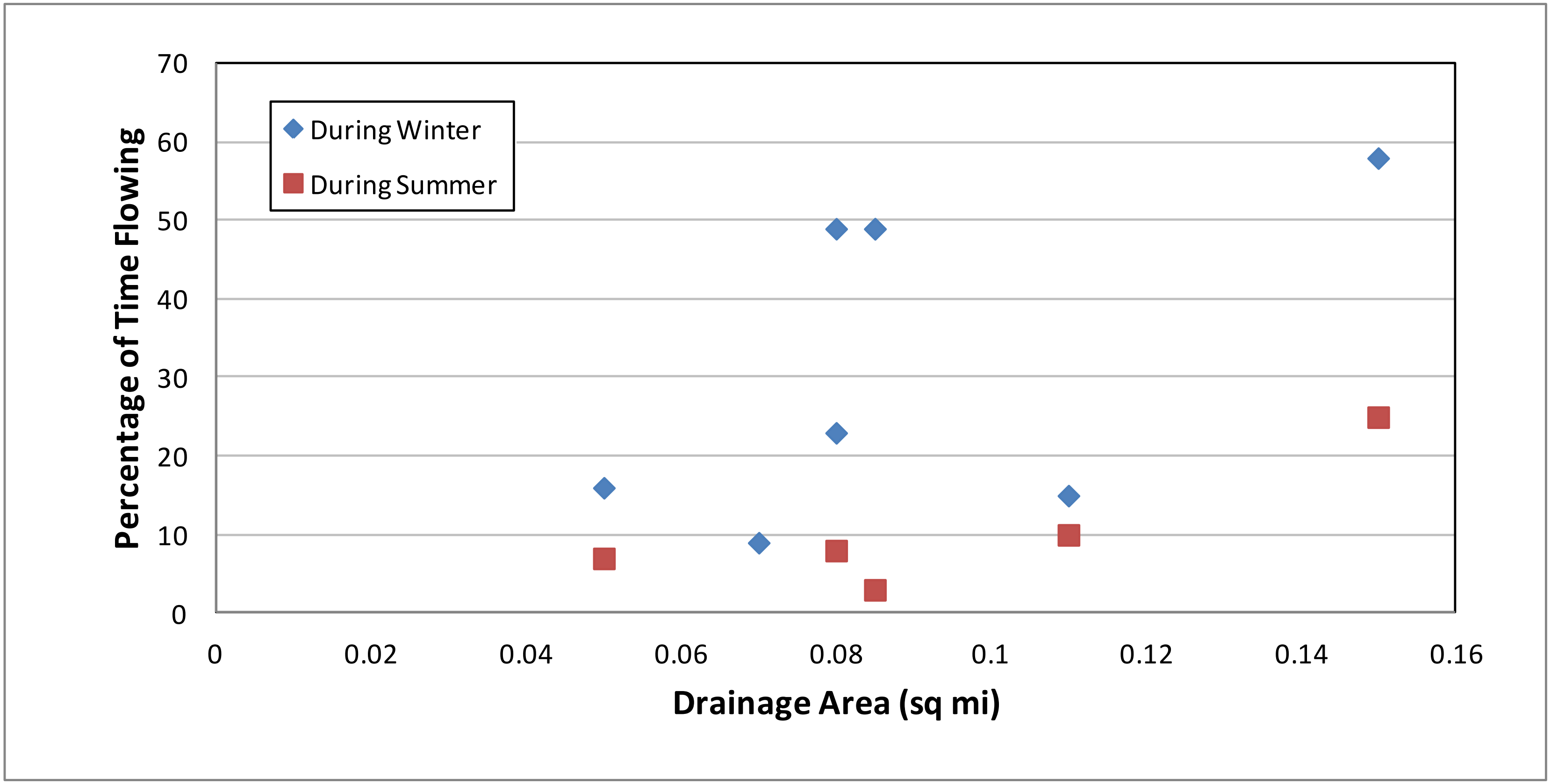


Headwater Hydrology - Complications

- **Did I mention that these were small systems with very low flows?**
- **Regular cleaning is needed to remove clogs, primarily for vegetation, leaf fall, and algae.**
- **Flow patterns can shift over time (most systems being monitored are braided and diffuse flow).**
- **Need free flowing conditions. Backwater is bad for monitoring purposes.**
- **New technology, electronics in harsh environments, and all the issues that come with it.**

Headwater Hydrology

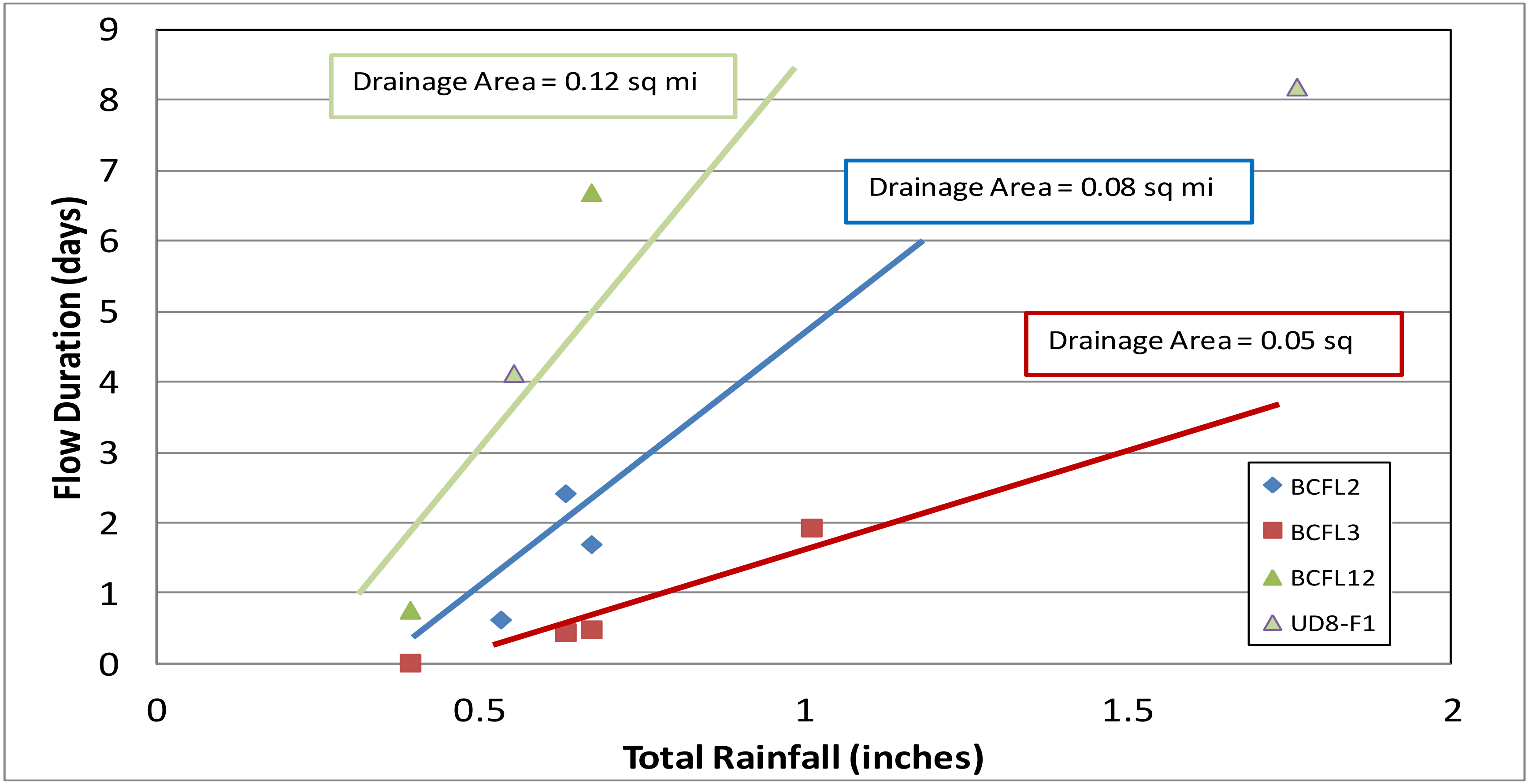
- **For small headwaters, most flow occurs in the dormant season when evapotranspiration losses are least.**
- **Cumulative duration of flow during summer is often half or less the amount that occurs in winter.**



Graph showing percentage of time that surface flow occurs during different seasons, plotted by drainage area.

Headwater Hydrology

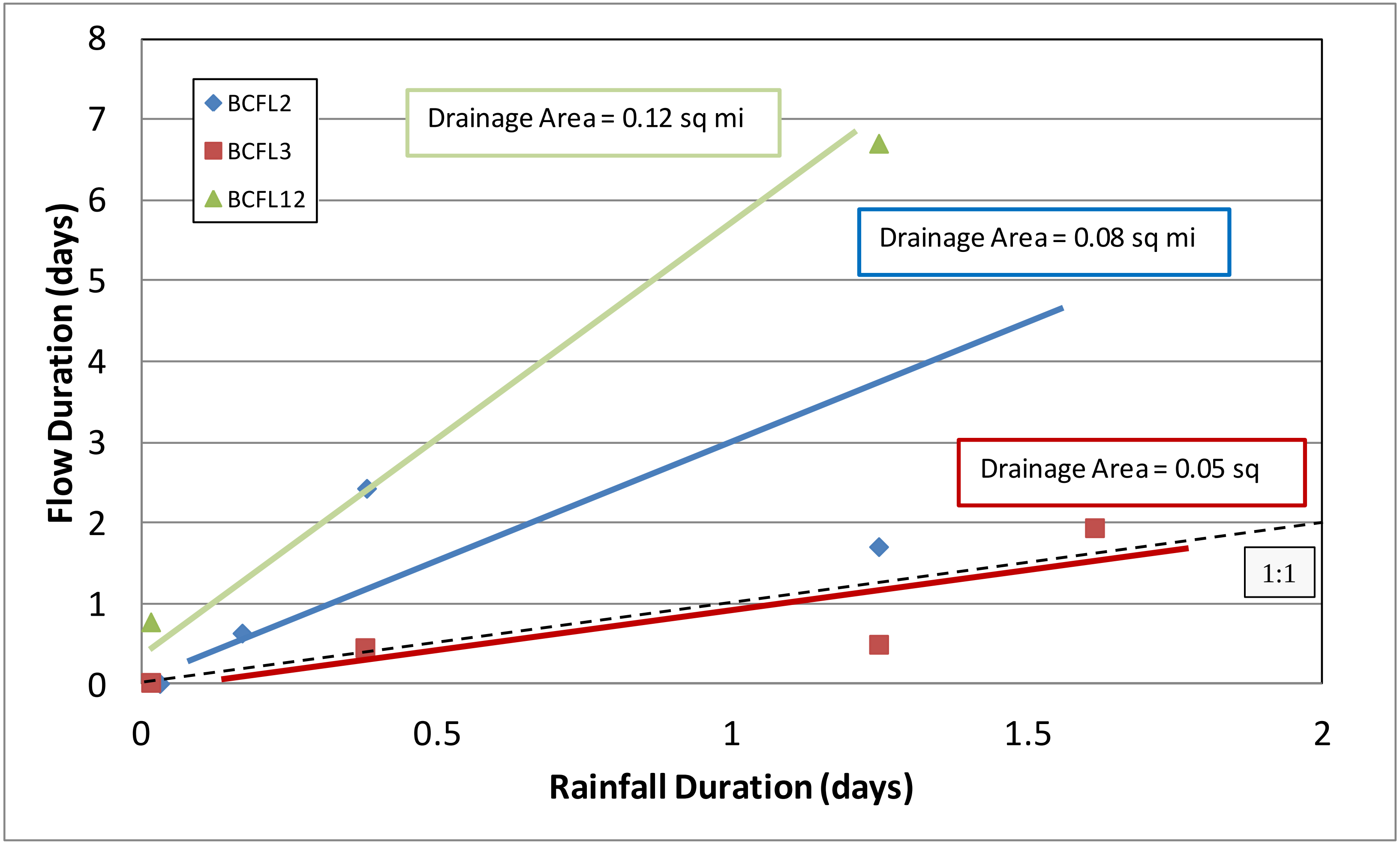
- **Relationships like the one below can be used to estimate the amount of flow that will likely be observed for a given rainfall event.**



* Data above for dormant season only.

Headwater Hydrology

- **Down to about 25 – 30 acres, flow events tend to last as long or longer than the duration of rainfall (for discrete flow events during the dormant season).**



* Data above for dormant season only.

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Conclusions

- **Flow events are highly variable and depend on drainage area, season, antecedent rainfall and moisture, slope, soils/geology, and vegetation.**
- **Monitoring small flow events is challenging.**
- **Monitoring so far has focused primarily on flow duration and relative comparisons. Absolute measurements of flow would likely require modification of flow dynamics, which has been avoided.**
- **Data and analyses presented here are <u>preliminary</u>. More data are needed over the coming seasons to verify preliminary observations.**

Conclusions

- **Most flow occurs in the winter/dormant season.**
- **For smaller drainages (25 – 50 acres), total duration of flow during the dormant season tends to be between 10% and 25%.**
- **For larger drainages (50 – 100 acres), total duration of flow during the dormant season tends to be between 25% and 50% or greater.**
- **Flow event duration during the growing season (summer) tends to be half or less of the duration during the dormant season (winter).**
- **For sites down to about 25 – 30 acres, duration of flow tends be as long or longer than the duration of rainfall (for discrete events during the dormant season).**
- **Data are highly variable.**

Conclusions

Potential New Success Criteria (some or all):

- **Demonstrating duration of flow as compared to duration of rainfall.**
- **Duration of flow as a percentage of the dormant season, growing season, or year.**
- **Revise the number of flow events that must be documented. Most monitored sites have documented significantly more than 2 events per year.**

Ultimately, the Corps of Engineers will have to decide where to draw the line for what will receive credit and what will not.

Acknowledgements

1. **PCS Phosphate and Mr. Jeff Furness, who sponsored the research presented in this paper and provided access to field sites and past data.**
2. **CZR, Inc. and specifically Ms. Julia Berger, who provided invaluable assistance with identification and review of potential reference sites, and evaluation of collected data.**

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