## Water Quality and Hydrology

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### Introduction

Hinkle Creek is located 25 miles northeast of Roseburg, Oregon in the foothills of the Cascades. The watershed is almost wholly owned by Roseburg Forest Products and supports a stand of 55-year old, harvest-regenerated Douglas fir. The forest stand is typical of the kind of forests and forestland currently owned and managed by private, industrial, timberland owners in western Oregon. Thus, it represents an excellent place to test the efficacy of contemporary forest practices with regard to impacts on water quality.

The Hinkle Creek Paired Watershed Study is a nested, paired watershed study. The main study watershed has an area of 5,000 acres evenly divided into the North and South Forks of Hinkle Creek. Roseburg Forest Products has set the North Fork aside for 10 years to act as a control. The South Fork will serve as the treated watershed in the paired watershed study. Within the North Fork and South Fork watersheds, six headwater watersheds, or small watersheds drained by perennial non-fish-bearing streams, will also be established as a paired watershed study. Two of these watersheds are in the North Fork and will act as controls. Four small watersheds are located in the South Fork and will be treated.

Discharge, suspended sediment, and temperature will be measured on each of the small perennial, non-fish-bearing streams as well as at the mouths of the North and South Forks of Hinkle Creek. For the four small, perennial, non-fish-bearing watersheds being treated, the streams will be monitored at the downstream end of proposed harvest units. For the two small control watersheds, the measurements will be made at an accessible location in watershed areas comparable to the treated small watersheds.

The treatment planned for the South Fork of Hinkle Creek is intensive forest management activities using contemporary forest practices as prescribed by the Oregon Forest Practice Act rules. The first entry of harvesting activities for the South Fork of Hinkle Creek is scheduled for late 2005. The timber will be harvested in four harvest units located, at least partly, in the four study watersheds directly upstream of the stream gauging installations. For all four of the harvest units, the timber will be harvested using current forest practices that will include merchantable timber adjacent to the perennial, non-fish-bearing streams. No formal buffer strips will be prescribed.

### Methods

As previously noted, the nested, paired watershed approach is being used at Hinkle Creek to evaluate the influence of current forest practices on water quality, aquatic habitat, and fish. The concept of this approach is based on determining statistical relationships between multiple hydrologic variables between control and treatment watersheds and sub-watersheds (watershed calibration). The North Fork watershed has been established as the control watershed, while the South Fork watershed represents the treatment watershed (paired watersheds). Within these two watersheds, sub-watersheds have been instrumented to quantify inter-watershed activity (nested). Variables used to determine these relationships at Hinkle Creek are annual maximum peak flow, annual and storm sediment yield, and maximum stream temperature.

*Instrumentation*

The primary approach to hydrology data collection in the Hinkle Creek Paired Watershed Study is driven by the turbidity threshold sampling (TTS) system, developed by the Redwood Sciences Lab of the U.S. - Forest Service Pacific Southwest Research Station. Eight TTS stations were installed during summer 2003, with two stations in headwater streams of the North Fork (control), four in headwater streams of the South Fork (treatment), and two at the confluence of the North and South Forks of Hinkle Creek (Figure 1). TTS is an automated data collection and sampling system in which a data logger employs real-time turbidity and stream discharge to control a pumping sampler for suspended sediment concentration (SSC) (Lewis and Eads, 2001; Lewis, 1996). This form of automated, near-continuous data collection allows for high temporal resolution sampling during storms responsible for most of the annual sediment yield.

The TTS system is composed of a Campbell Scientific Inc. 10X data logger, a D& A, Inc. OBS-3 turbidimeter, Campbell Scientific, Inc. water temperature and specific conductivity probe, and an ISCO 3700-C automatic pump sampler. At headwater stations, a Druck, Inc. pressure transducer and a Tracom fiberglass Montana Flume are used to measure and calculate stream height and discharge, while the U.S. Geologic Survey measures discharge at the confluence locations. The TTS system uses pre-selected turbidity thresholds and minimum discharge conditions to collect discrete stream water samples during storm conditions. Statistical relationships between discrete SSC samples and the near-continuous in-stream turbidity values can then be used to model near-continuous suspended sediment transport.

Starting in spring 2001 and continuing to the present, stream temperature probes have been installed throughout Hinkle Creek to measure low-flow, high-temperature summer conditions. A total of 45 Vemco temperature probes have been installed in the North Fork, South Fork, and main stem of Hinkle Creek. In addition, capacitance rods have been installed in various locations throughout the North and South Fork streams to measure inter-watershed stream heights for greater spatial resolution of hydrologic activity.

Stream and riparian inventories were conducted during summer 2004. Stream gradient, wetted width, percent cover, and large woody debris were evaluated for headwater streams in the North and South Fork watersheds. These data will be used to determine 1) similarities of in-stream and riparian habitat between the study watersheds, 2) characterizes stream channel morphology and habitat prior to and after harvest, and 3) an evaluation of the influence of in-stream large woody debris on stream energy and sediment transport.

Steady state tracer analyses were conducted directly below the headwater TTS stations during summer 2004 to characterize hyporheic exchange in the wetted perimeter and stream bottoms. Three hundred meter reaches of these fish bearing streams were injected to steady state with Rhodamine WT. Discrete stream water samples were collected at fixed time intervals at 25-m, 75-m, 150-m, 225-m, and 300-m with automatic pump samplers (ISCO 3700-C). Synoptic samples were collected at 10-m intervals after steady state was reached to describe subsurface contributions to the reach. Continuous concentrations were monitored at the bottom of the reach with the Turner Designs, Inc. 10-AU temperature compensated fluorometer. Data from the tracer studies will be used to model hyporheic exchange and subsurface contributions of these reaches in effort to describe the preferential use of these areas by resident trout.

*Watershed Calibration*

Discharge, sediment yield, and temperature measured throughout the watershed are used as independent variables for watershed calibration. Data collected within the control and treatment watersheds have been analyzed with least squares regression to determine statistical relationships. These relationships will be used to predict the treatment effect of timber harvesting within the South Fork watershed.

## Preliminary Results

The results presented in this paper represent findings for the first year of hydrology and sediment collection and three years of stream temperature. Annual runoff, annual maximum peak flow, and annual sediment yield for the six headwater watersheds are presented in Table 1. Annual runoff ranged from 128-cm at Demerrsman Creek to 59-cm at Fenton Creek (Figure 2). Annual maximum peak flow, the maximum discharge during a given period, was measured on December 13, 2003 at all of the watershed outlets. Values ranged from 7.8 l/s/ha at BB Creek to 3.9 l/s/ha at Fenton Creek (Figure 3).

Six primary storms were identified for Water Year 2004, occurring during the months of December, January, and late February to early March (Figure 4). Approximately 60% of the annual sediment was transported during these six storms. Annual sediment yield ranged from 747 kg/ha for Clay Creek to 201 kg/ha for Fenton Creek (Figure 5).

Daily maximum temperatures for three years (2002, 2003, and 2004) are presented in Figure 6. Daily maximum temperature for all points is plotted versus distance from the Hinkle Creek drainage divide. For all years, temperature increases and distance increases.

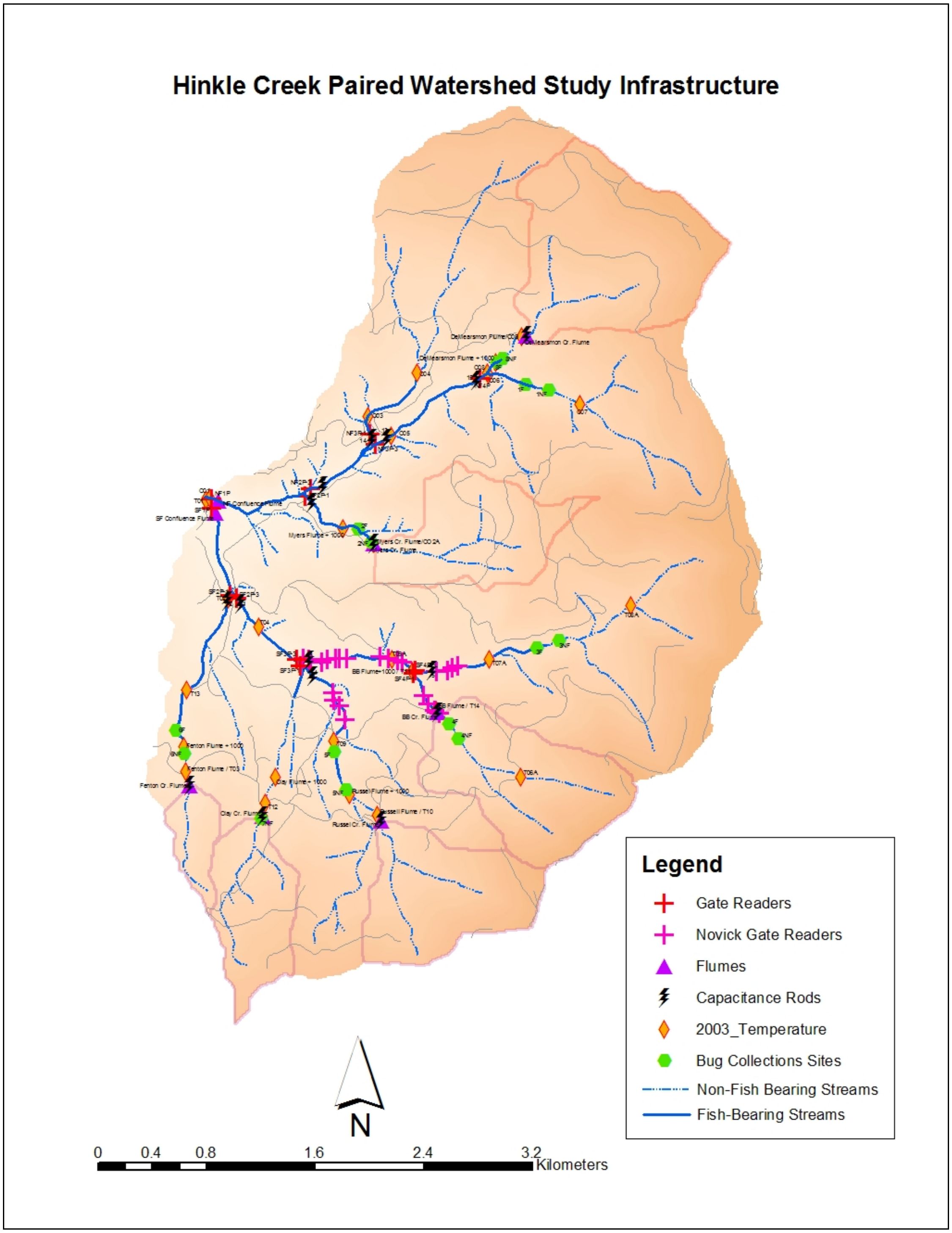


Figure 1: Instrumentation infrastructure of the Hinkle Creek Paired Watershed Study.

Table 1: Annual run off, annual maximum peak flow, annual sediment yield, and sediment yield percentages for 6 Hinkle Creek headwater watersheds.

| **Watershed** | **Run Off** | **Max. Peak Flow** | **Sediment Yielc** | **Sediment Yield in 6 Storm** |
|---|---|---|---|---|
| | (cm) | (l/s/ha) | (kg/ha) | (%) |
| DeMerrsemar | 128 | 5.7 | 324 | 63 |
| Meyers | 87 | 4.0 | 295 | 57 |
| BB | 123 | 7.8 | 281 | 59 |
| Russell | 81 | 4.7 | 244 | 68 |
| Clay | 127 | 4.7 | 747 | 50 |
| Fenton | 59 | 3.9 | 201 | 58 |

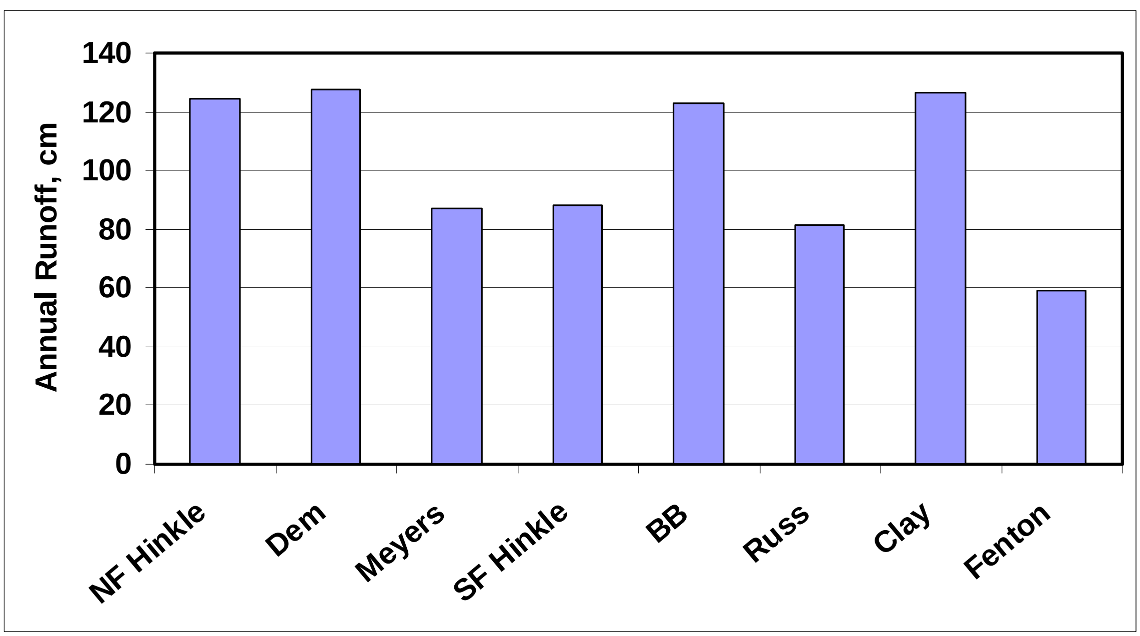


Figure 2: Annual runoff for 8 Hinkle Creek watersheds.

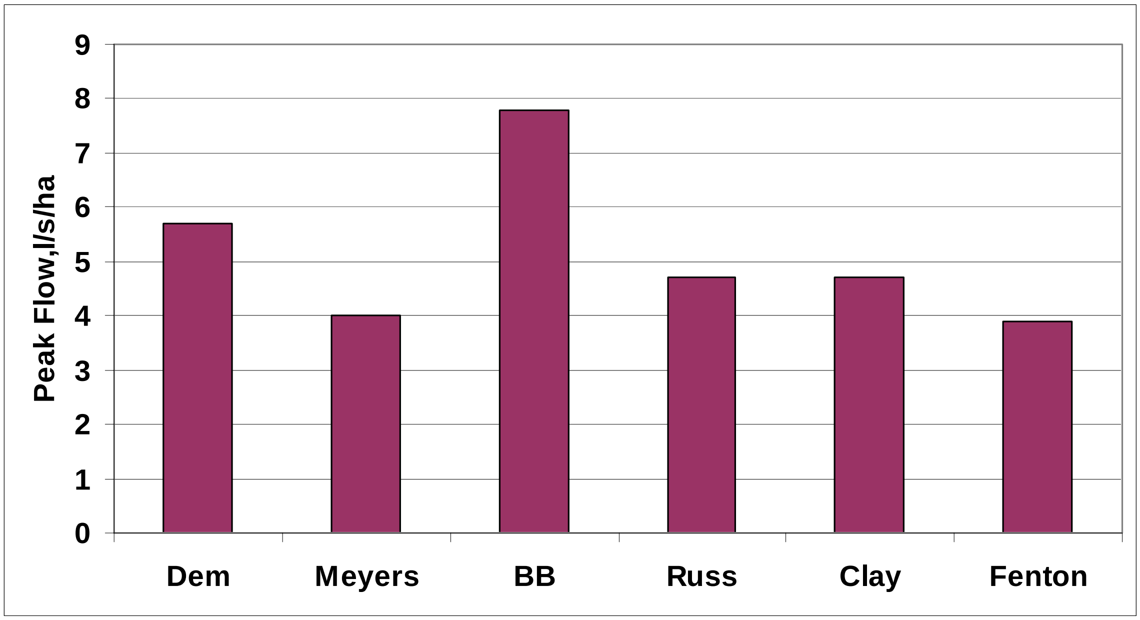


Figure 3: Annual maximum peak flow for 6 Hinkle Creek headwater watersheds.

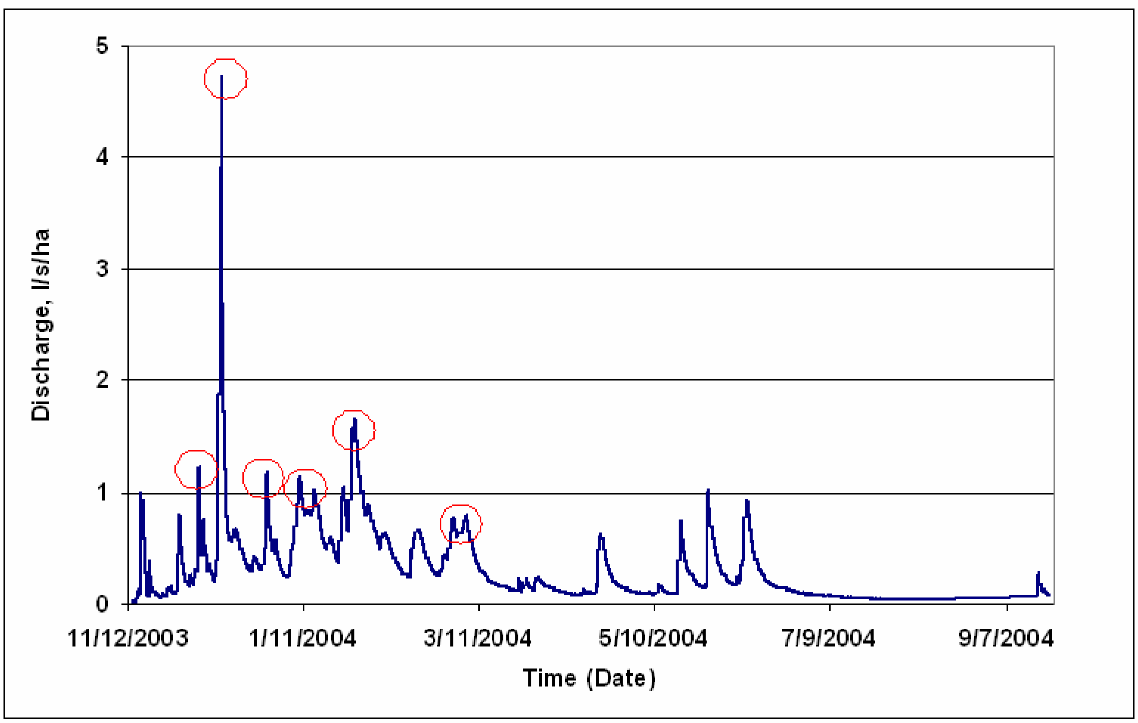


Figure 4: Annual hydrograph for Russell Creek with six storm peaks noted in circles.

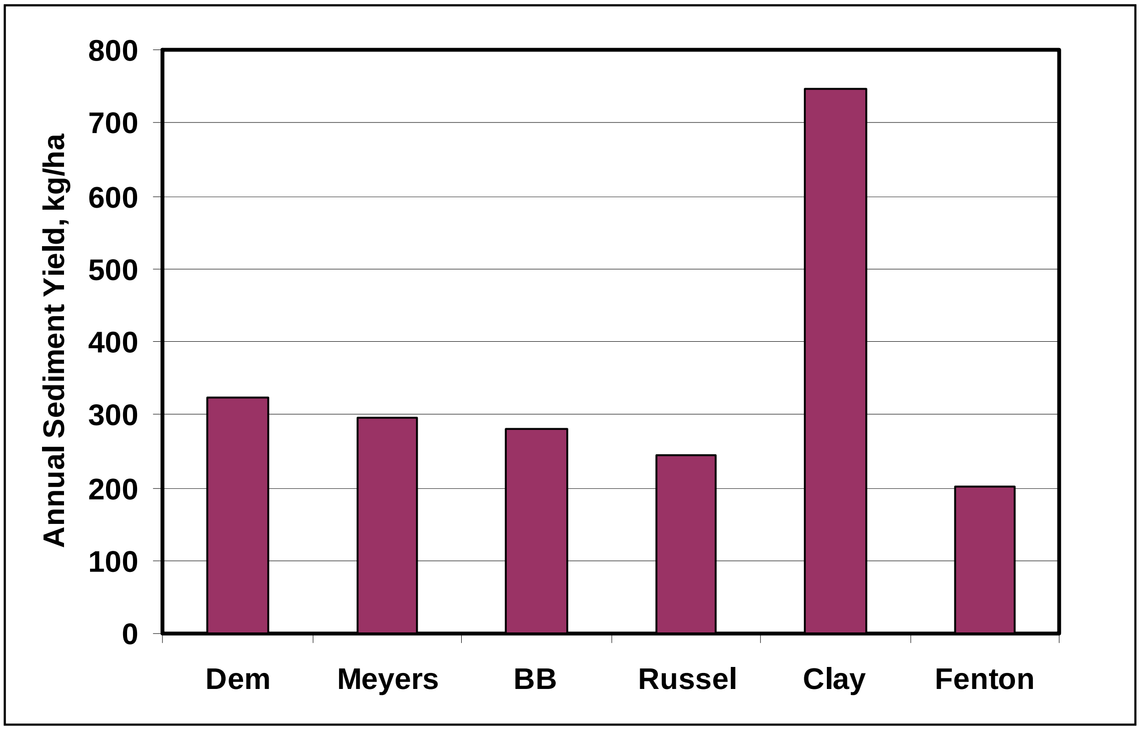


Figure 5: Annual sediment yield for 6 headwater watersheds within Hinkle Creek.

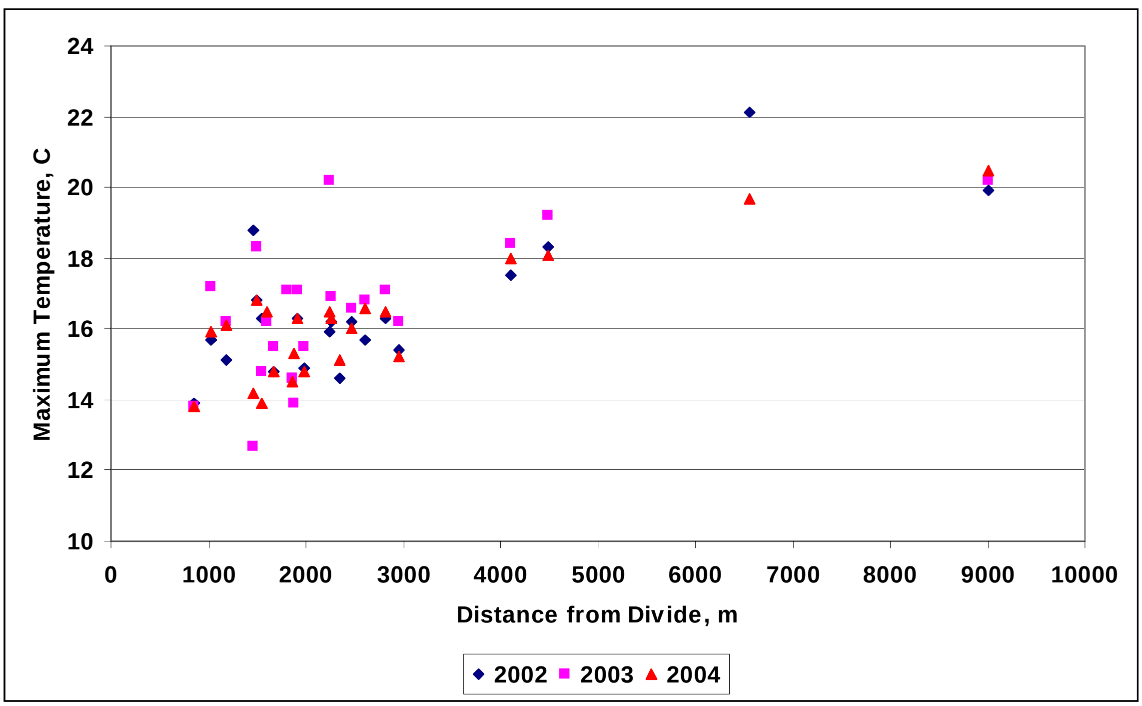


Figure 6: Daily maximum stream temperatures from drainage divide for three years.

Analysis of the first year of calibration data is underway. Variable such as instantaneous peak flows, quickflow volumes, storm sediment yield, and maximum summer temperatures have been compared to establish relationships between the control and treated watersheds before treatments occur. Figure 7 shows the relationships between Meyers Creek, a control watershed, and the four treatment watersheds for peak flows. The relationships are composed of only six data points. Similar relationships were developed for sediment yield for the six storms. Figure 8 shows the relationships between Meyers Creek, a control watershed, and the four treatment watersheds for storm sediment yield.

Temperature relationships for the North Fork and South Fork watersheds are presented in Figure 9. The relationship is composed of 11 points, identified as independent, non-auto-correlative daily maximum temperatures for three years.

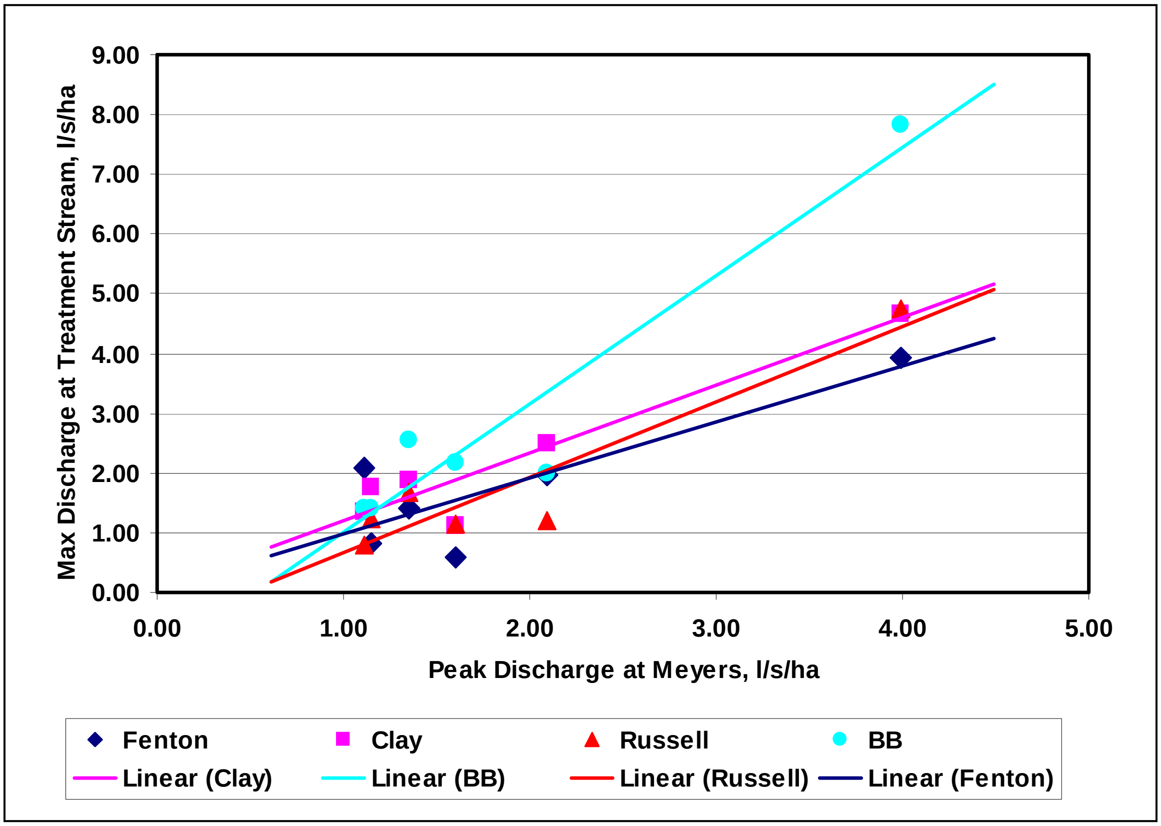


Figure 7: Headwater watershed peak flow calibration curves for the Hinkle Creek Paired Watershed Study.

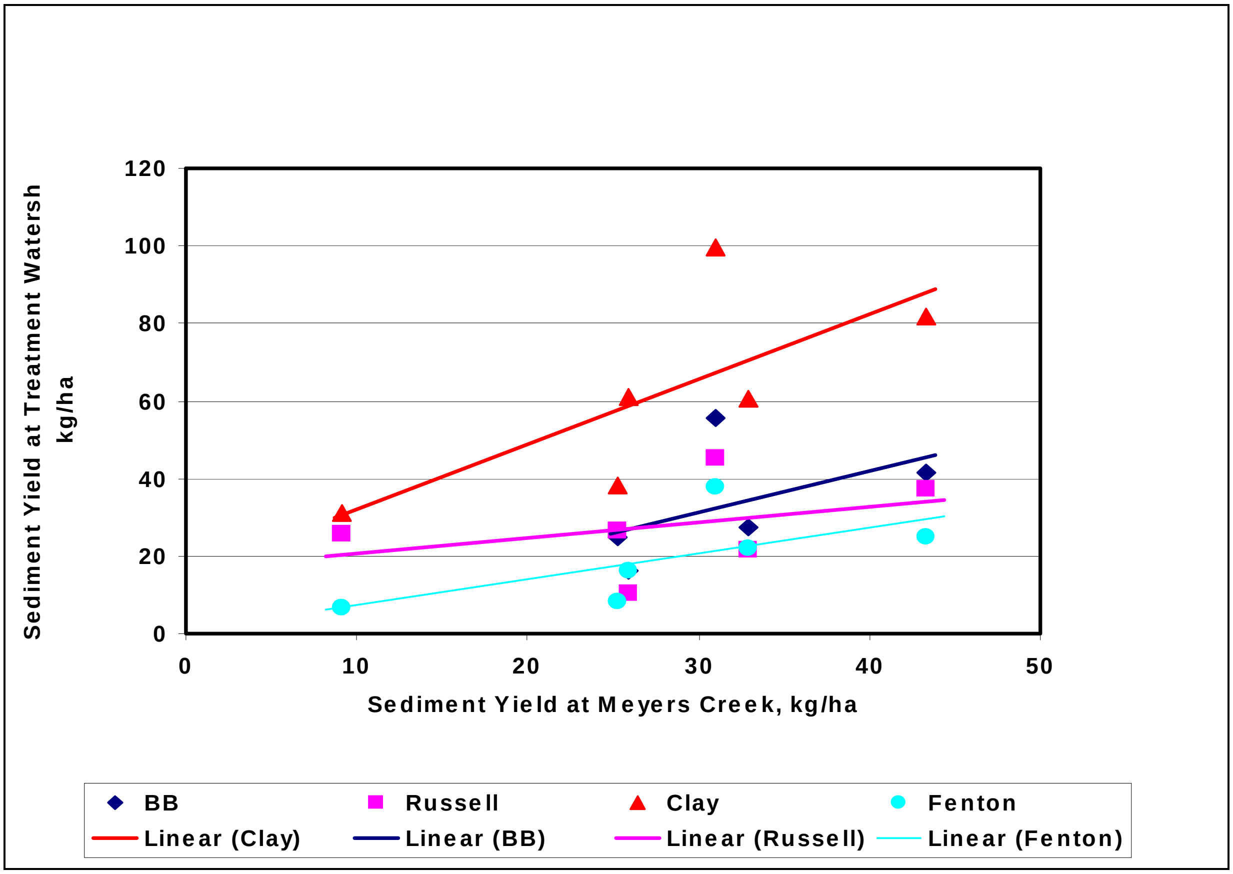


Figure 8: Headwater watershed sediment yield calibration curves for Hinkle Creek Paired Watershed Study.

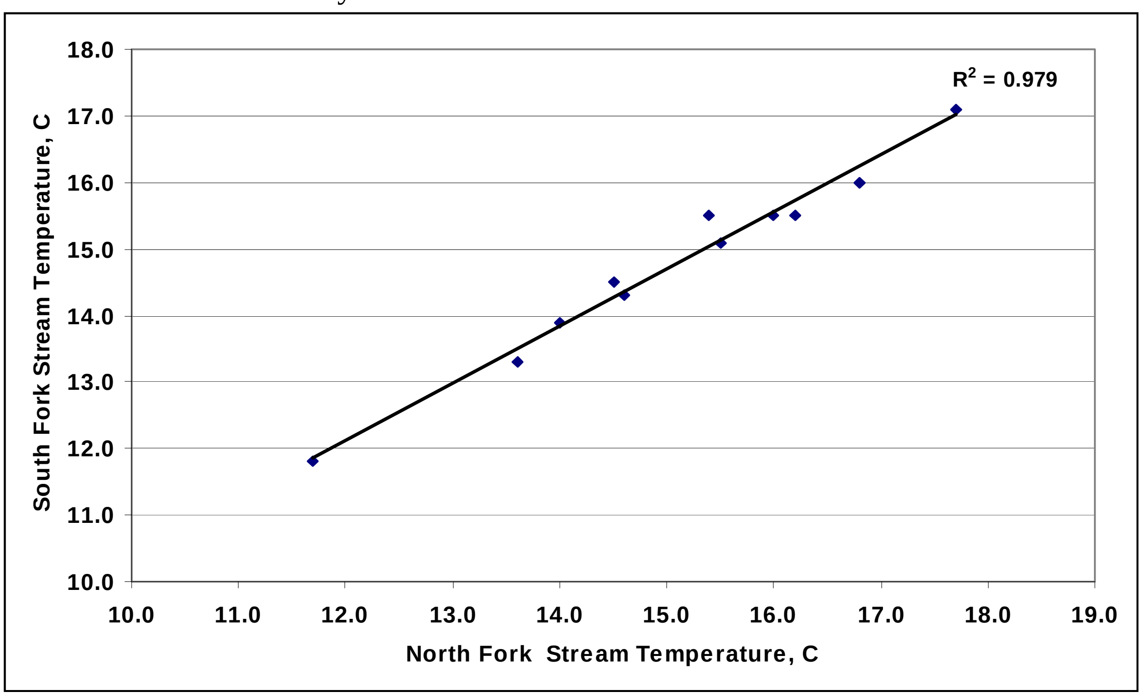


Figure 9: Daily maximum temperature calibration curves for the North Fork and South Fork confluence locations of Hinkle Creek.

Headwater stream and riparian inventory revealed similar over-story cover, 96% or greater (Table 2). Stream gradient ranged from 12% for Fenton Creek to 23% for BB Creek. Wetted width varied as a function of stream size.

Table 2: Headwater stream and riparian conditions of the Hinkle Creek.

| Watershed | Stream Gradient | Wetted Width | Cover |
|---|---|---|---|
| | (%) | (m) | (%) |
| Demerrsman | 21 | 1.5 | 96 |
| Meyers | 17 | 1.2 | 99 |
| BB | 23 | 1.3 | 98 |
| Russell | 17 | 2.6 | 98 |
| Clay | 14 | 1.5 | 99 |
| Fenton | 12 | 0.8 | 99 |

Steady-state tracer data for Meyers Creek are presented in Figure 10. These data represent continuous Rhodamine WT concentrations monitored at the 300-m station, as well as discrete time stamped ISCO concentrations at the 25-m, 75-m, 150-m, 225-m, and 300-m points. The concentration increases as dye inundates the open stream channel and hyporheic zone (rising limb of graph). When the open channel and hyporheic zone reach steady-state, synoptic sampling occurred at 10-m intervals. Analysis of these data reveals areas of increased discharge, areas where subsurface water may be entering the stream channel (Figure 11). The decreasing limb of the concentration graph (Figure 10) offers in-site of the influence of the hyporheic zone. This data can be modeled to accurately describe the total volume of the hyporheic zone on study reaches.

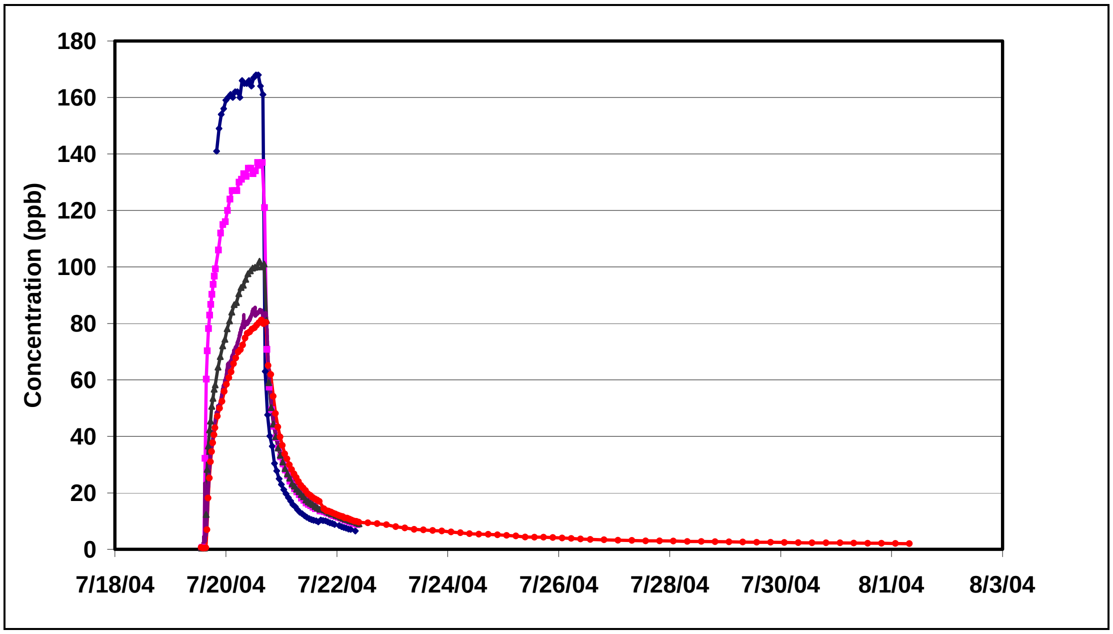


Figure 10: Steady-state tracer concentration curves for Meyers

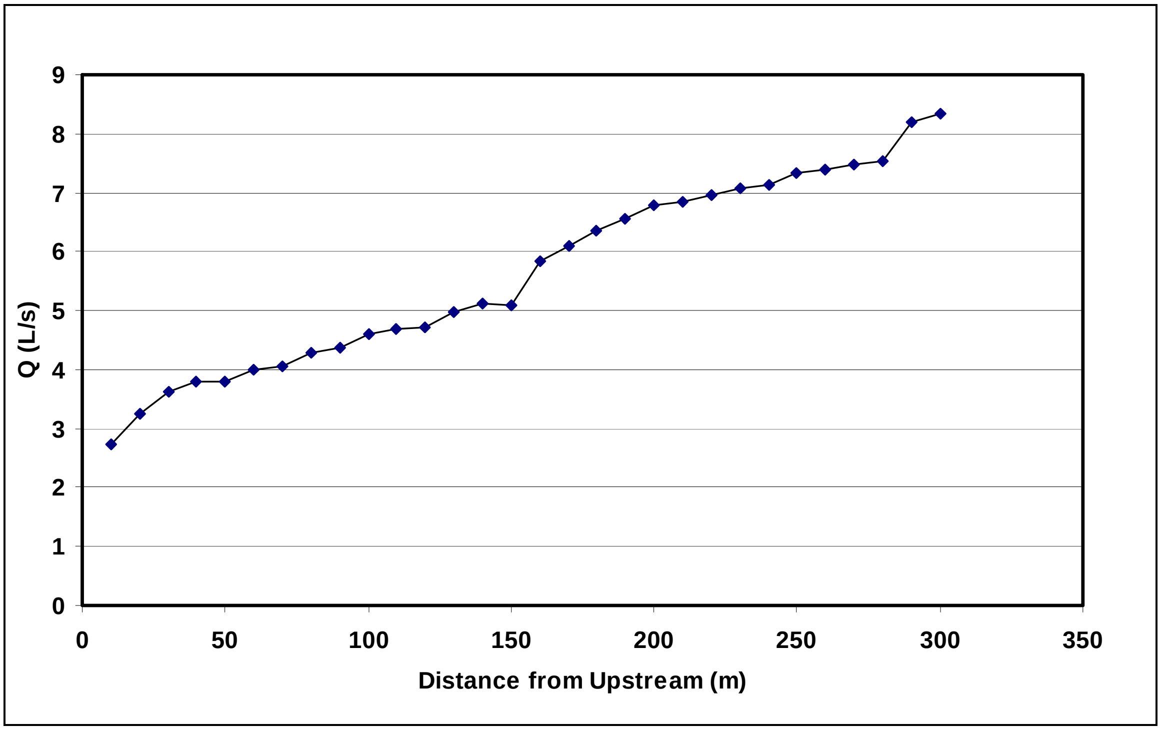


Figure 11: Longitudinal discharge of Meyers Creek, determined from steady-state analysis.

## References

Lewis, J. 1996. Turbidity-controlled suspended sediment sampling for runoff-event load estimation. Water Resources Research 32(7), 2299-2310.

Lewis, J., Eads, R.E. 2001. Turbidity threshold sampling for suspended sediment load estimation. In" Proceedings, 7th Federal Interagency Sedimentation Conference, 25-29. March 2001, Reno, Nevada. Pp. III-110 to III-117.