Effectiveness of Best Management Practices for Water Quality
Forest Plan Monitoring – Aquatic Synthesis
Tongass National Forest
Progress Report – July 2007

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Background

Attainment of Alaska Water Quality Standards is a Tongass Forest Plan objective (USFS 1997). The Forest Plan Standards and Guidelines incorporate Best Management Practices (BMPs) for protection of water quality (USFS 2006). The Forest Plan monitoring program includes an Aquatic Synthesis with a goal to evaluate the effectiveness of Forest Plan Standards and Guidelines in protecting aquatic resources at the watershed scale (Thompson 2004). This report provides a preliminary evaluation of BMP effectiveness using water quality data.

Turbidity, sediment, and temperature are the three water quality parameters most likely to be affected by forest management activities in Southeast Alaska (MacDonald et al 1991). We are not directly monitoring sediment because it is difficult and costly to reliably monitor (Sidle and Campbell 1985, Paustian 1987, MacDonald and Smart 1993). Turbidity and temperature are relatively inexpensive to reliably measure with continuous instruments.

We established a set of three case study watersheds[1] as part of the Aquatic Synthesis (Map 1). Upper East Fork Shaheen Creek (Shaheen) reflects pre- and post-treatment conditions as roads and timber harvest progress according to the Forest Plan. Chanterelle Creek serves as a long term reference with no roads or timber harvest. Scary Creek is a cumulative effects treatment with existing timber harvest and road system.

Continuous water quality, stream stage (water depth), and meteorological instruments were installed near the mouth of each case study watershed in 2004. Fish Management Indicator Species (MIS) monitoring reaches and Tier III stream habitat survey reaches have also been established in each watershed (USFS 2005). This report presents preliminary results of water quality monitoring from July 2004 through October 2006. We are within a calibration period for evaluating reference conditions across the watersheds. The results and evaluation presented in this report are provisional and subject to revision as additional data are collected and analyzed.

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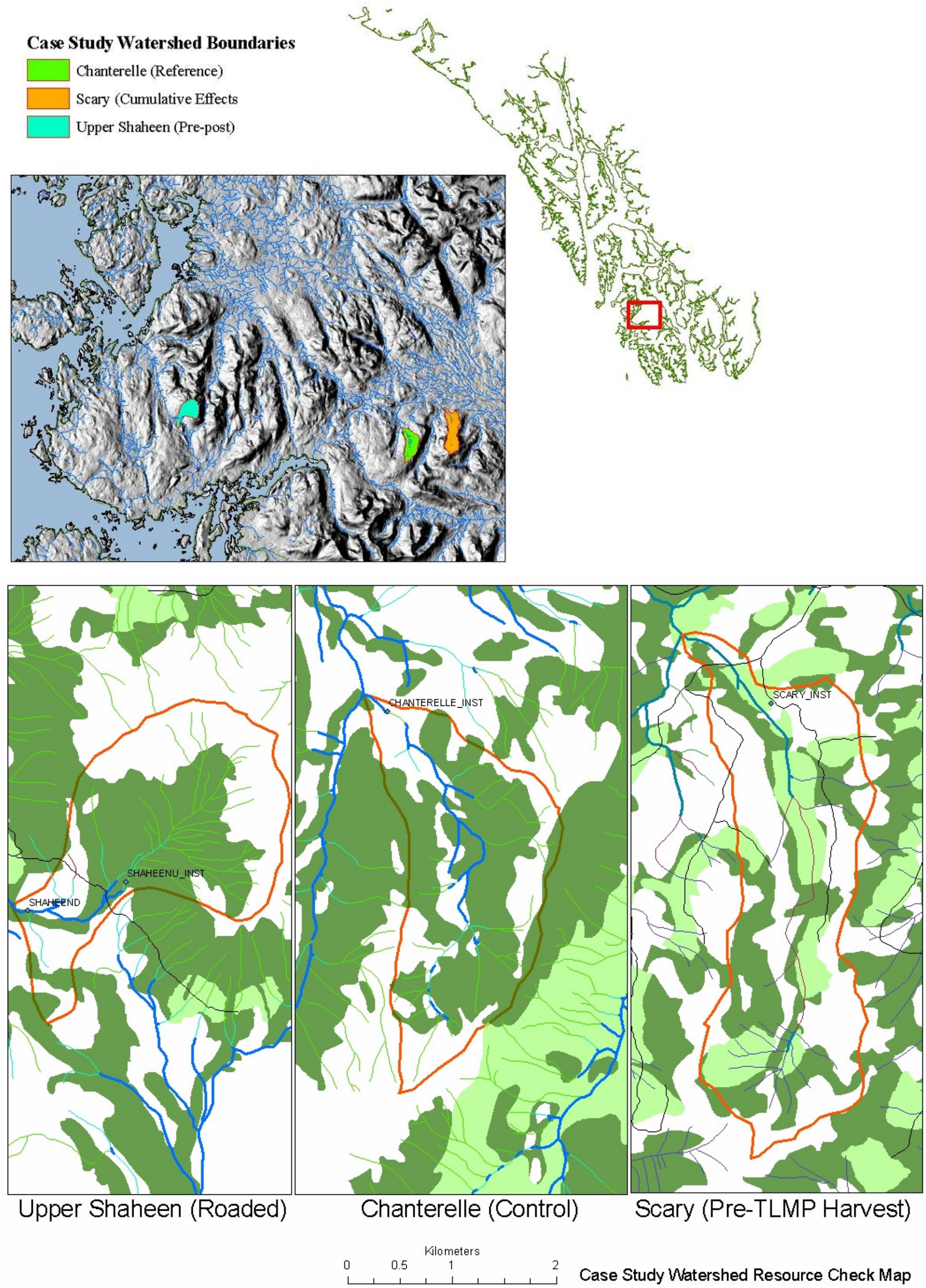
[1] Original plans--developed in consultation with state and federal agencies—called for three sets of case study watersheds. Funding constraints and lack of accessible, suitable, matching watersheds limited the Aquatic Synthesis to one set. Thompson (2004) summarizes the criteria and selection process for the case study watersheds.

Map 1. Case study watersheds, Prince of Wales Island. Detail displays forested (dark green), clearcut (light green) and non-forested (white) vegetation.



Objectives

This report summarizes progress and findings most relevant to two specific objectives expressed in our study plan (Thompson 2004)[2]:

i. Determine the baseline characteristics of stream temperature and turbidity data collected near the mouth of each case study watershed.
ii. Compare turbidity measurements up and downstream of new road construction across Shaheen Creek.

Watershed Descriptions

Shaheen Creek drains to the west coast of Prince of Wales Island. Scary and Chanterelle Creeks are located in the southern headwaters of the Thorne River, draining to the east coast of Prince of Wales Island. The three watersheds lie within about an eight-mile radius within the Central Prince of Wales Volcanics Ecological Subsection (Nowacki et al 2001). This is one of the most heavily managed subsections in Southeast Alaska (ibid); it contains several watersheds that have been identified as high priority for restoration plans. Table 1 displays some of the watershed attributes we considered to establish their suitability as a matching set.

Table 1. Case study watershed comparison

Watershed Attribute	Shaheen (pre-post treatment)	Chanterelle (long term reference)	Scary (cumulative effects treatment)
Basin size (ac)	1100	1020	1200
Anadromous Fish Species Verified	yes	yes – enhanced population	yes
Fish "MIS" reaches	coho salmon only (tributary)	coho salmon, resident	coho salmon, resident
Stream density (mi/sq mi)	6.9	5.7	3.4
Max - Min elevations (ft)	2900 - 600	2000 - 600	2400 – 500
Basin aspect	southwest	north	north
Wetland (ac)	200	430	480

[2] Our study plan expressed four water quality monitoring objectives; two objectives have been dropped or deferred: 1) Determine the characteristics of stream temperature collected in selected headwater streams. This Objective was dropped: headwater tributaries in case study watersheds were not suitable for monitoring as originally proposed; and 2) Characterize the amount and chemical quality of dissolved organic matter in the case study watersheds. This Objective has been deferred pending advice from scientists at the Pacific Northwest Research Station – Juneau Forestry Sciences Lab (FSL). Grab samples were collected from each watershed in 2004 and 2005. FSL analyzed the samples; we have not attempted to interpret the results.

Watershed Attribute	Shaheen (pre-post treatment)	Chanterelle (long term reference)	Scary (cumulative effects treatment)
Mass Movement Hazard Class 4 (acres)	190	60	220
Forest Plan Land Use Designation	Timber Mgt, Modified Landscape	Old Growth Reserve - Research Natural Area	Timber Mgt
Second growth (ac)	0 (except for road clearing in 2004)	0	305
Roads	0.6 miles (constructed in 2004)	0	3.36 miles

Climate

Annual precipitation on Prince of Wales Island averages more than 100 inches, but storms vary greatly within short distances. Moderate to heavy precipitation occurs year round, but peak rainfall is from September through November. Fall storms are often accompanied by high winds. We've installed tipping bucket rain gages with loggers in each watershed, but our attempts to compile monthly or seasonal rainfall totals have been plagued by data loss resulting from instrument failures and vandalism. We have not attempted to analyze winter precipitation data, since the records are not considered reliable during intermittently freezing temperatures from roughly November through April. Rainfall records are relatively complete for summer and fall of 2005 and summer and fall of 2006. This allows for storm-by-storm comparisons across the three watersheds and storm correlation to many stream stage and water quality events.

Streamflow

We are in the process of establishing stage-discharge relationships in each of the three watersheds. Stage data suggests consistency with regional patterns of small floods throughout the year in response to intense rainfall and saturated soil conditions. The largest floods occur in the fall.

Geology and Soils

Coarse geology mapping places all three watersheds in volcanic lithology (andesite breccias), but ground reconnaissance indicates more complexity due to glacial transport of other rock types and the presence of carbonate rock and karst features near the mouth of Shaheen Creek.

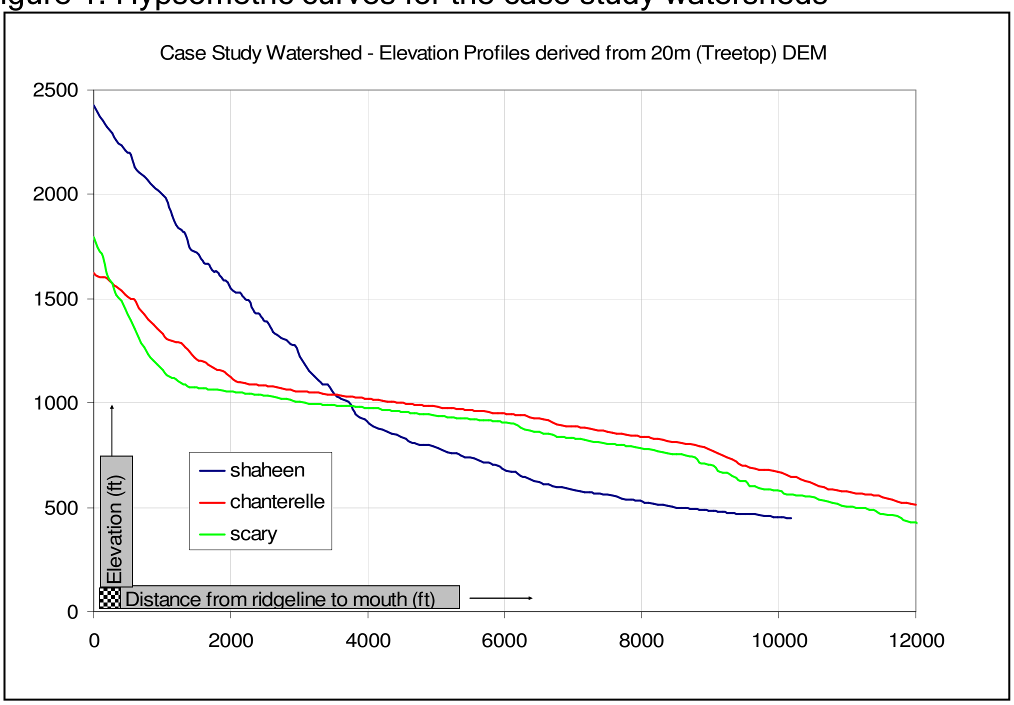
Mayn (2004) provided soil and landslide analysis for the watersheds. Scary and Shaheen have steeper slopes and higher mass movement potential than

Chanterelle. Scary has the highest number of landslides, several of which have deposited material in the valley bottom and streams. Most of the landslides mapped in Shaheen are in upper elevation headwater source areas. Only one landslide has been mapped in Chanterelle. Stream reconnaissance noted channel sideslope and/or stream bank erosion in all three watersheds.

Basin Morphometry

In general, all three watersheds are typical U-shaped glaciated basins. Figure 1, a hypsometric curve (or elevation profile), illustrates the difference between Shaheen, which has a continuous concave profile, and the other two watersheds. Shaheen's higher basin relief probably increases stream power, resulting in greater sediment transport capacity in Shaheen compared to the other two watersheds. Both Scary and Chanterelle contain a reach of cascading gorge that separates upper from lower watersheds.

Figure 1. Hypsometric curves for the case study watersheds



The cascades (Figure 2) are a barrier to fish migration and isolate resident fish populations in the upper watersheds. No such discrete barrier exists in Shaheen. All three watersheds contain resident fish, but because Shaheen does not have an isolated resident fish population, it is not suitable for resident fish MIS monitoring.

Figure 2. Typical cascade between upper and lower watersheds (Chanterelle)

Vegetation and Wetlands

Johnson (2004) completed a detailed GIS-based vegetation comparison of the three watersheds. They exhibit similar vegetation patterns. The subalpine and ridgelines are comprised of mountain hemlock stands, heathlands and forb/sedge meadows. Shrub fields of Sitka alder and salmonberry are present on steep hillslopes in recurrent slide zones, with mountain hemlock and Sitka spruce forests located in a similar topographic position. Western hemlock and hemlock-spruce forests are on the well-drained soils of the backslopes, with wet soil inclusions and the associated plants indicative of wet soils within these stands. Similar stands dominate the lower elevations with the addition of yellow cedar and red cedar. Areas of compact glacial till can be found on the toeslopes and valley bottoms, where forested wetland and low site index forests are found. The till deposits produce non-forested wetlands (fens and bogs) on benches and valley bottoms. Scary has the most diverse vegetation of the three watersheds, due to recurrent slide zones. Scary and Chanterelle contain the most extensive wetland acreage.

Fish Populations

Anadromous fish species (coho salmon) have been verified in each of the case study watersheds. The coho salmon population in Chanterelle is enhanced by a fish ladder in the mainstem of Rio Roberts. Each watershed also contains populations of resident cutthroat trout and Dolly Varden char.

Management

No timber harvest has been planned at this time in Shaheen. However, the Record of Decision for Control Lake EIS (1998) approved the extension of Road 2050000 across Shaheen Creek and into the adjacent watershed (Kogish, tributary to Shinaku Creek) to access the Kogish Timber Sale in 2004. Log hauling was completed in 2006. The road will eventually be placed into storage; stream crossing structures removed. Current road density in Scary is just over 1.5 miles per square mile. Most of the timber harvest in this watershed took place prior to the current Forest Plan, between 1988 and 1993. The riparian area at the mouth of the watershed was harvested in 1966. Cumulative harvest in this watershed approaches 22% of the total acreage. No road construction or timber harvest is authorized in Chanterelle under the current Forest Plan.

Methods

Instrument Sites

We selected instrument installation sites following US Geological Survey guidance for continuous water quality monitors (Wagner et al 2000). All three streams are dynamic, with mobile cobbles and large woody debris. Site selection balanced the need for a protected stream bank in a uniform stream reach with stable cross-section and instrument pool. All sites can be characterized as *Moderate gradient Mixed control* process group (Paustian 1992). Figure 3 displays photographs of the three main instrument sites. A fourth instrument is installed upstream of Road 2050000 in Shaheen Creek.

Data Collection and Management

We use infrared optical backscatter turbidity sensors (D&A Instruments OBS-3A[3]). The OBS-3A integrates the turbidity sensor, a pressure transducer (for stream stage or water depth measurement) and a temperature sensor into one housing with an automatic data logger. In-stream temperature loggers (Onset Hobo Stowaways[3]) are also installed near the turbidity sensor. Instruments have remained relatively stable (with reference to surveyed benchmarks), and no data loss has occurred from the three main sites.

We collected reference grab samples near the sensors immediately prior to data uploading to verify logged values during field inspection. Reference temperatures were obtained with hand held thermometers and consistently validated logged temperature data within 0.5^{o} C or less. Stream temperature data required no conditioning prior to analysis.

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[3] Manufacturer name provided for information only. No endorsement is implied.

Reference turbidities were measured with a portable Hach 2100P turbidity meter. The values obtained from the two types of turbidimeters are not directly comparable, but the reference data consistently verified the clear water conditions that prevail in these three streams, and help identify data anomalies.

Figure 3. Case study watershed instrument sites. Arrows point to instruments.

Shaheen Instrument Site

Chanterelle Instrument Site

Scary Instrument Site

We set the turbidity instruments to measure their parameters for thirty seconds beginning every fifteen minutes and log the average and standard deviation values. A single data point, or record, represents a fifteen minute interval.

We conditioned the continuous turbidity data by removing isolated records (less than fifteen minutes each) of elevated turbidity during periods with no correlating storms or road construction activities.[4] Isolated turbidity spikes may be caused by floating debris, reflected sunlight, bubbles, or even fish investigating the instrument housing (Downing 2005). Lewis (1996) required two consecutive records of a particular threshold to avoid ephemeral spikes. Following consultation with the instrument manufacturer (Downing 2007) upward linear shifts were applied to the data to compensate for data drift where negative values were recorded.

Application of State Water Quality Standards

Water bodies in Alaska are protected for all uses; the most stringent numeric criteria apply in accordance with Alaska Water Quality Standards (ADEC 2006). For stream temperature the most stringent criteria is aquatic life; for turbidity it is drinking water.

Stream temperatures "may not exceed 20^{o} C at any time. The following maximum temperatures may not be exceeded, where applicable:

Migration routes 15^{o} C
Spawning areas 13^{o} C
Rearing areas 15^{o} C
Egg & fry incubation 13^{o} C

For all other waters, the weekly average temperature may not exceed site-specific requirements needed to preserve normal species diversity or to prevent appearance of nuisance organisms." (ibid)

"Turbidity may not exceed 5 nephelometric turbidity units (NTU) above natural conditions when the natural turbidity is 50 NTU or less, and may not have more than a 10% increase in turbidity when the natural turbidity is more than 50 NTU, not to exceed a maximum increase of 25 NTU." (ibid)

The Alaska Forest Resources and Practices Regulations (ADNR 2004) govern nonpoint source pollution activities such as road construction for timber harvest. The Forest Service BMPs (USFS 2006) are consistent with these state regulations, which are intended to prevent degradation of water quality. As defined in 11 AAC 95.900, degradation does not include "… temporary, localized, and reparable decreases in water quality…" (ADNR 2004)

[4] Unusually high standard deviations recorded for these intervals provide additional support for questioning these records.

Our analysis compared temperature data to the state-established numeric thresholds. For turbidity data, we assumed that Chanterelle Creek, our un-managed reference watershed, would reflect natural conditions and compared data from the other two watersheds to Chanterelle data. Data collected upstream of Road 2050000 in Shaheen Creek also reflect natural conditions.

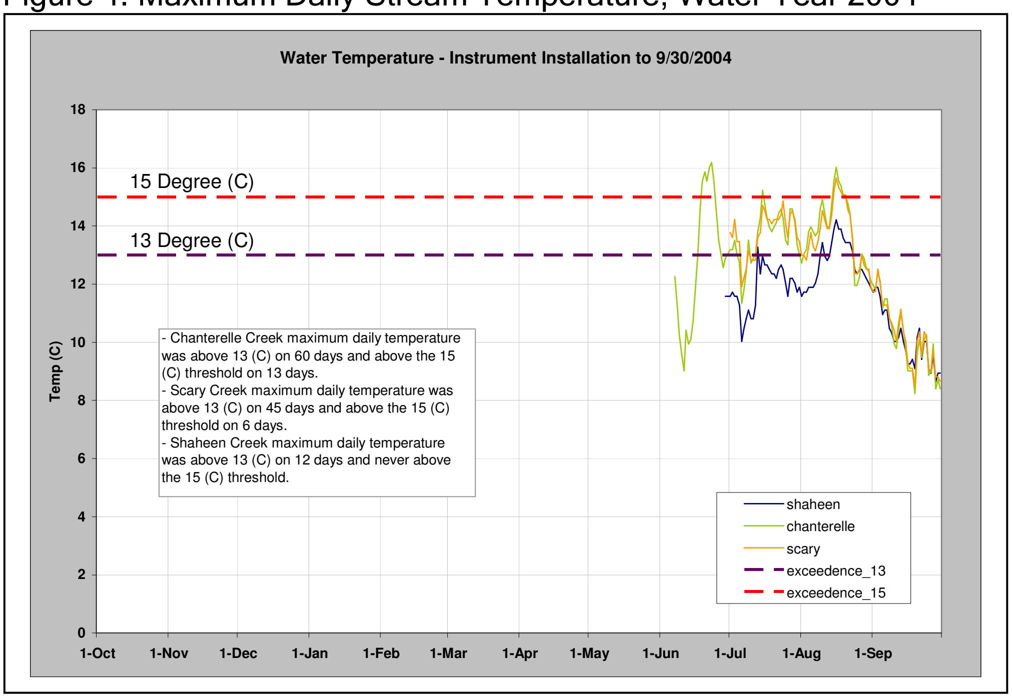
Provisional Results

<u>Baseline Stream Temperature</u>

During the data collection period, no management activities occurred in any of the watersheds that would be anticipated to affect stream temperature. Our temperature instruments are located at the bottom of pools, best characterized as rearing areas. We did not measure temperature in adjacent riffles (spawning areas). The following tables compare data to both rearing (15° C or 59° F) and spawning (13° C or 55° F) stream temperature thresholds. Stream temperature was below 20° C (68° F) at all times during the period of record in the case study watersheds. All three streams had winter minimum temperatures near 0.0° C.

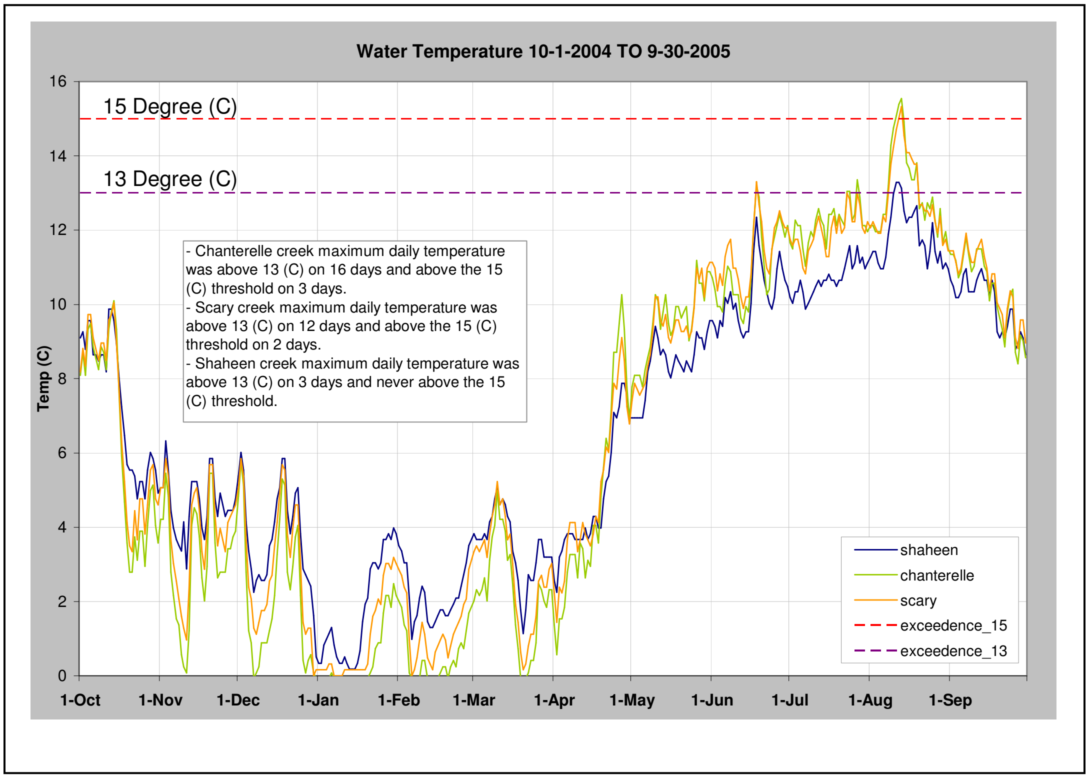
Summer of 2004 was hot and dry. The National Weather Service reported record high air temperatures throughout Southeast Alaska, averaging 4 degrees above normal for May through August. Numerous daily high air temperature records were set in the last half of June. Chanterelle and Scary exceeded both the 13° C and 15° C thresholds during the summer of 2004 (Figure 4). Shaheen exceeded only the 13° C threshold. The peak stream temperature was 16.2° C, recorded in Chanterelle Creek on June 23, 2004.

Figure 4. Maximum Daily Stream Temperature, Water Year 2004



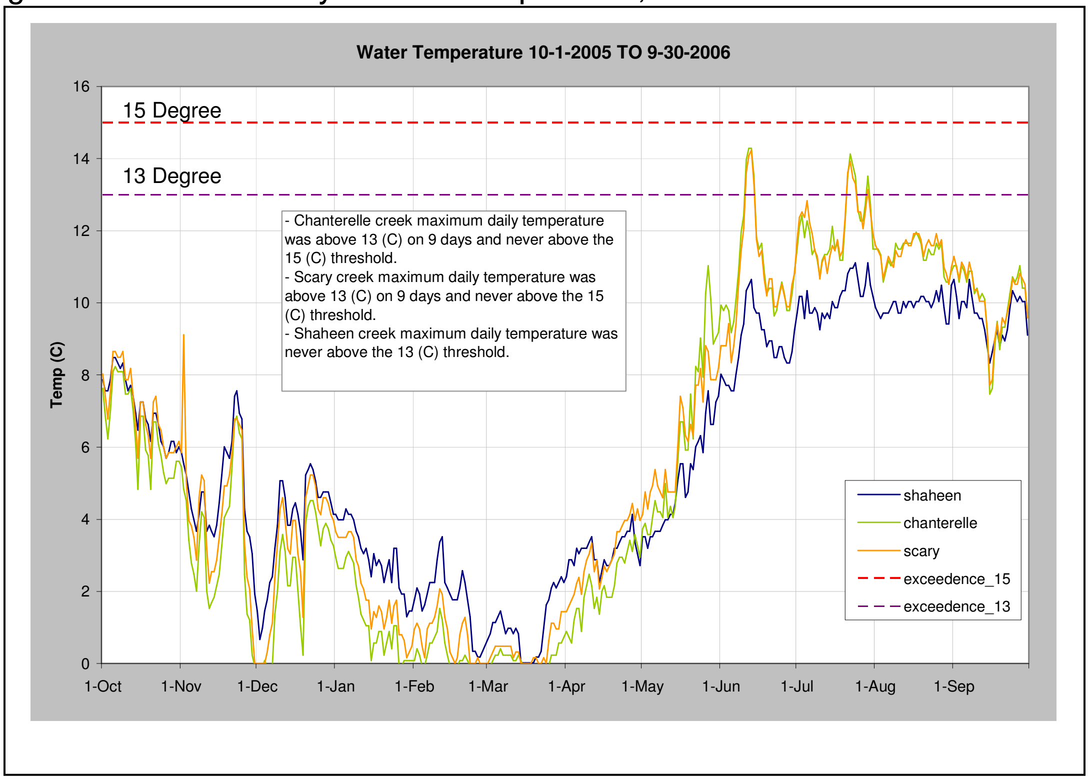
The summer of 2005 tended to be warmer than normal, but did not see the extremes of 2004 in air or stream temperatures. Again, Chanterelle and Scary exceeded both the 13° C and 15° C thresholds, but for fewer days than in 2004 (Figure 5). Shaheen exceeded the 13° C threshold on two days. The peak stream temperature was 15.5° C, recorded in Chanterelle Creek on August 13, 2005.

Figure 5. Maximum Daily Stream Temperature, Water Year 2005



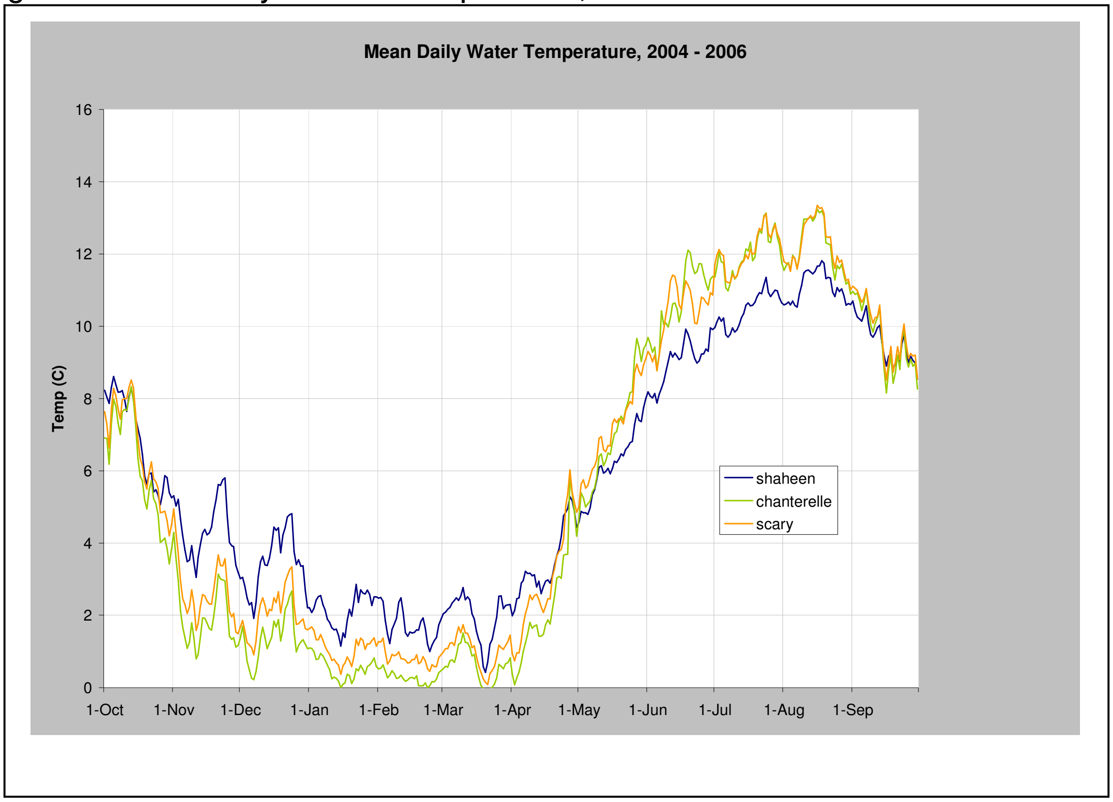
Maximum air temperatures were slightly cooler than normal throughout 2006. Stream temperature did not exceed 15° C at any of the three sites (Figure 6). Chanterelle and Scary exceeded the 13° C threshold in June and July. Shaheen remained well below maximum stream temperature thresholds throughout the summer. The peak stream temperature was 14.3° C, recorded in Chanterelle Creek on June 12 and 13, 2006.

Figure 6. Maximum Daily Stream Temperature, Water Year 2006



An examination of the mean daily temperatures across all three streams for the available period of record (Figure 7) suggests that Shaheen stream temperature is somewhat moderated when compared to Chanterelle and Scary, which are very similar to each other. Shaheen Creek tends to be warmer in the winter and cooler in the summer than Chanterelle and Scary. There are several plausible explanations related to differences between Shaheen and the other watersheds. As illustrated by Figure 1, higher basin relief and mean elevation could increase snow pack and extend snow melt contributing to cooler summer stream temperatures in Shaheen. It is also possible that, despite our efforts to rule out karst influence in this basin, karst may be present and providing groundwater that would moderate stream temperature year-round. The northerly aspects of Chanterelle and Scary watersheds may contribute to cooler winter stream temperatures than in Shaheen which has a southerly aspect. Greater wetland acreage in Chanterelle and Scary watersheds probably increases surface and near surface water exposure to solar radiation, leading to warmer summer mean and maximum stream temperatures in these watersheds than in Shaheen.

Figure 7. Mean Daily Stream Temperature, Water Years 2004-2006.



<u>Baseline Turbidity</u>

Turbidity is an expression of the cloudiness of water caused when light is scattered or absorbed by suspended and dissolved materials. Increased turbidity can directly reduce primary and secondary production in streams, and has been linked to decreased fish production and abundance. It affects fish physiology, behavior, and habitat (Lloyd et al 1987, Bash et al 2001). Although correlation between turbidity and sediment (suspended or settleable) has not been attempted in the case study watersheds, there is typically a positive relationship between turbidity and sediment (Sidle and Campbell 1985, Lewis 1996). While few studies have quantified sediment load in southeast Alaska, Paustian (1982) described the suspended sediment load from first- and second-order tributaries in the Kadashan watershed (Chichagof Island) as follows:

> "Fine textured sediments (1mm in diameter or smaller), carried in suspension make up 80% or more of the total sediment load for these streams. The sediment concentrations are generally low, less than 2mg/l in the summer and winter low flow periods and generally under 20 mg/l in the fall peak flow period. Nevertheless …suspended sediment [concentration] values in excess of 100 mg/l were measured during a major fall storm event."

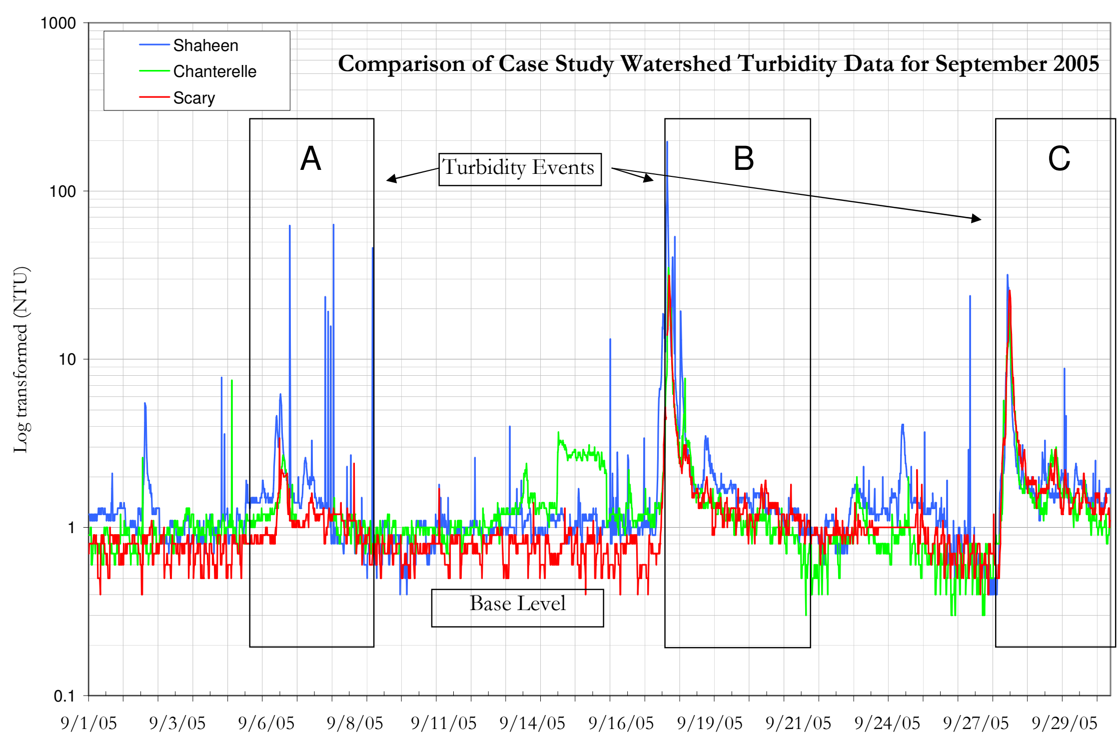
Sidle and Campbell (1985) reported high variability in total suspended solids in Bambi Creek, another second-order stream on Chichagof Island. On average, samples contained 35 percent organic matter (by weight).

During the data collection period, no management activities occurred in Chanterelle; the following management activities occurred in Shaheen and Scary watersheds and could be anticipated to affect turbidity and sediment:

- In Shaheen, road 2050000 construction (about 0.6 miles total, including three bridge installations) began in July 2004 and concluded within about two weeks, with intermittent rock haul and administrative traffic continuing through the field season. Thompson and Tucker (2005) describe the road, verify BMP implementation, and report preliminary results of turbidity monitoring up and downstream of the road.
- In Shaheen, Road 2050000 was used for intermittent log haul from the Kogish Timber Sale in an adjacent watershed in 2005 and 2006.
- In Scary, routine road maintenance and minor timber harvest occurred along the lower elevation ridgelines in 2005.

This project has accumulated over two years of continuous turbidity data with matching streamflow and rain data. The continuous data can be broken into three principle parts – a background level, storm peaks and spikes not related to flow. Figure 8 illustrates typical fall turbidity records, log-transformed to accentuate small turbidity events.

Figure 8. Comparison of turbidity data for September 2005

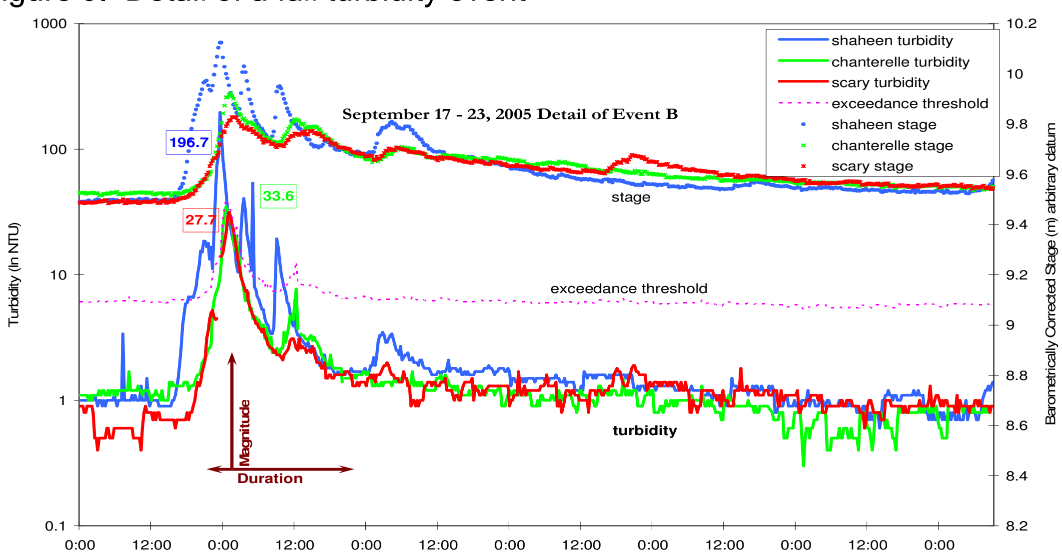


Several observations may be made regarding the baseline characteristics of turbidity data collected in the case study watersheds from July 2004 through October 2006.

- ✓ Base turbidity levels are near zero throughout most of the year. (90% of the values for all 3 watersheds are less than 3 NTUs)
- ✓ Turbidity spikes have a characteristic shape closely tied to streamflow. Typically turbidity rises and peaks as streams begin to rise, reflecting the rapid entrainment and transport of fine mineral and organic material in the earliest phase of a storm response as bed armor breaks up and bedload transport begins (Sidle and Campbell 1985). Prussian (2003) observed turbidity increases even more closely correlated with rain than with streamflow downstream of roads on Prince of Wales Island, reflecting potential contribution of road runoff. The graphed shape of the turbidity event is characterized by a quick rise as sediments are mobilized and a slower decay as they drop from suspension following a storm event.
- ✓ Many turbidity events between watersheds are similar in magnitude and timing and can be matched, even though rainfall between the three watersheds can be highly variable. Shaheen's position on the west side of Prince of Wales sometimes produces earlier or different storm events.
- ✓ Most storm-driven turbidity events occur in the fall and consistently peak in the 15-30 NTU range with extreme events nearing 200 NTU.

In Figure 9, a closer look at the individual storm event labeled "B" from Figure 8 shows the corresponding turbidity events that occurred in each watershed. In this case, the peak turbidity in Shaheen (196.7 NTU) is higher than the other two watersheds, but the timing and duration of the events are very similar across the three watersheds, and correspond to the rising limb of the hydrographs (stage).

Figure 9. Detail of a fall turbidity event



Higher stream power in Shaheen Creek (illustrated in Figure 1) could explain the greater magnitude of turbidity peaks in this and other floods approaching bankfull when compared to the other watersheds.

We compared turbidity levels across the three watersheds to assess the attainment of water quality standards. In this analysis, we assumed that turbidity in Chanterelle Creek--our un-managed reference watershed–reflected natural conditions as defined in the Alaska Water Quality Standards (ADEC 2006). We added the numeric thresholds (5 NTU or 10% increase over "natural" as appropriate) to the values recorded in Chanterelle, and compared the corresponding data from the managed watersheds – Scary and Shaheen. Records where the managed watersheds exceeded the turbidity threshold were counted and examined individually for consistency. A summary of the exceedance for two water years is presented below.

Site (compared to Chanterelle as reference or "natural condition")	**WY05** *– # of records exceeding criteria (% of total)*	**WY06 -** *# of records exceeding criteria (% of total)*
Scary	712 (2.2%)	153(0.4%)
Shaheen	186 (0.6%)	194(0.6%)

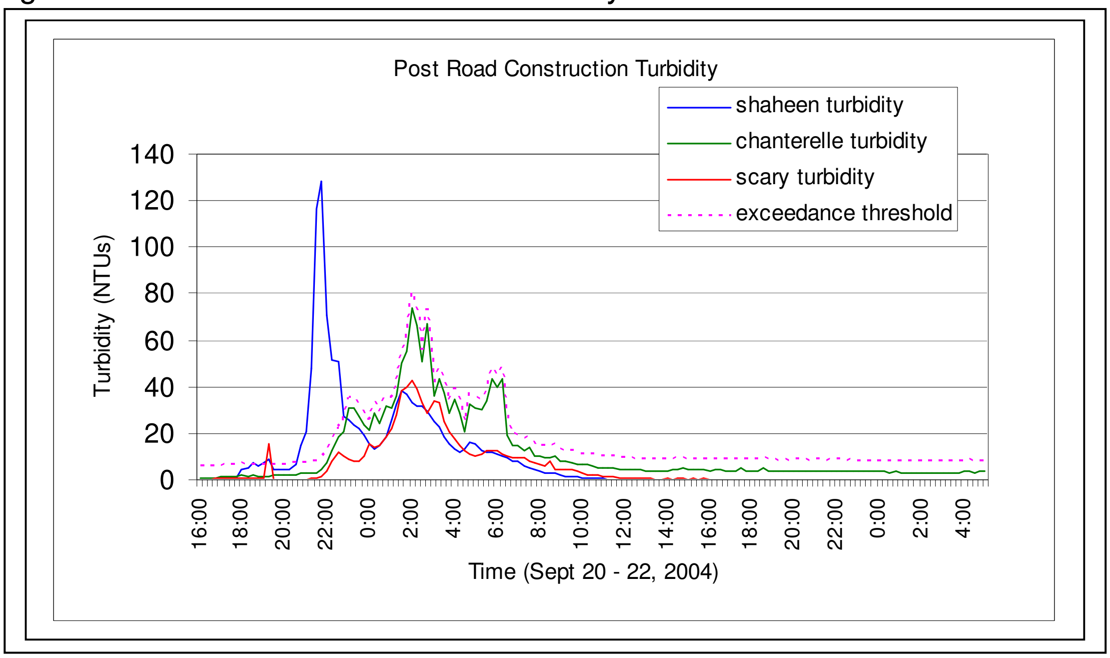
These exceedances can be separated into spikes that are independent of flow, and true flow-turbidity events. In most cases both the magnitude and numbers of exceedances are minimal where matched turbidity events can be located. There are also events where Chanterelle turbidity is higher than either Scary or Shaheen. Following work by Downing (2005a) and Lewis and Eads (In Press) turbidity events may be characterized by their magnitude (median or maximum turbidity) and their duration. Individual storm "scores" can then be compared in order to detect differences between the watersheds. The graph in Figure 9 displays three potential exceedances at Shaheen. The first peak, largest in magnitude (196.7 NTU), lasted six hours and 15 minutes. The second (peaking at 53.6 NTU) lasted for two hours, and the third (peaking at 19.3 NTU) for one hour and 15 minutes. This analysis is in progress.

Shaheen Road Construction Turbidity

Thompson and Tucker (2005) compared turbidity up and downstream of new road construction across the Shaheen Creek watershed. The analysis was hampered by instrument site differences and ultimate failure of the upstream instrument post-construction (ibid). The instrument was moved to another site upstream of the road in 2006. Data collection upstream of the road continues. For this report, we compared turbidity data collected downstream of the new road in Shaheen to data collected in the other watersheds during and after road construction.

Road construction began July 13, 2004 and was substantially complete in the watershed by July 27, 2004. The location and design of Road 2050000 (especially the use of bridges for stream crossings)–and dry weather during construction–provided ideal conditions for minimal water quality impacts. Streams were at baseflow conditions through the construction period; no turbidity events were detected at the downstream instrument until August 3 (peak of 1.4 NTU). No turbidity events exceeded 5 NTU until September 13 (peak of 5.8 NTU). Figure 10 displays the first major post-construction turbidity event, 55 days after construction. Precipitation totals for this storm range from 3.7 inches at Shaheen to 5.9 inches at Chanterelle[5].

Figure 10. Post Road Construction Turbidity Event.



The peak streamflow occurred at 21:30 in Shaheen and at 23:00 at Chanterelle. In order to present a "worst case" scenario, we did not shift the data to compensate for the time lag of the storm and the resulting comparable turbidity peaks between the watersheds. Three possible post-construction exceedances in Shaheen are displayed. The first peaked at 7.2 NTU and lasted a maximum of 15 minutes. The second peaked at 8.5 NTU and lasted a maximum of 30 minutes. The third peaked at 128 NTU and lasted two hours and 15 minutes. After this third peak, two additional peaks occur below the threshold based on Chanterelle turbidity, and then turbidity levels in Shaheen returned to baseline near 0 NTU. The entire event lasted less than 16 hours. Similar events through the end of September 2006 are summarized here:

[5] Rain data for this storm was only available for Chanterelle. Estimate for Shaheen storm provided by Katherine Prussian from nearby raingages.

Date of Exceedance	Peak Shaheen Turbidity (NTU)	Event Duration
December 2, 2004	124	5 hours, 45 minutes
September 17, 2005	197	6 hours, 15 minutes
September 28, 2006	121	7 hours, 30 minutes

All other turbidity events recorded in Shaheen Creek below the road post-construction and during log haul were of much lower magnitude and shorter duration.

Although we cannot reliably attribute these turbidity events to road construction, we can assume that sediment introduced during road construction and road use would be entrained and transported by subsequent storms, and would contribute to the turbidity records downstream of the road. Provisional results suggest that turbidity (and sediment) increases during and post-road construction, and during log haul, across the Shaheen Creek watershed may not be measurable at the watershed scale when compared to natural conditions. If turbidity (and sediment) increases were detected downstream of the road, they were temporary and recovered to baseline levels without degrading water quality.

Conclusions

Stream Temperature

Baseline characteristics of stream temperature in the case study watersheds include winter minimums at or near 0.0^{o} C and summer maximums ranging from 11 to 16^{o} C.

Annual stream temperature patterns in Chanterelle and Scary Creeks are more similar to each other than to Shaheen Creek. Shaheen Creek temperatures are more moderate: warmer in the winter and cooler in the summer. Controlling factors may include karst influence, basin aspect, relief/elevation, and wetland composition.

All three watersheds exceeded the most stringent numeric criteria of the Alaska Water Quality Standards for maximum stream temperature. Chanterelle, the reference watershed with no timber harvest or roads, consistently experienced the highest maximum stream temperatures and the most days exceeding the state's maximum temperature thresholds. Scary Creek, the watershed with upland and riparian harvest and roads, had slightly fewer days exceeding maximum temperature criteria. Shaheen Creek, a pre-treatment watershed with no existing harvest, had the fewest days exceeding maximum temperature thresholds.

We intended to use the Alaska Water Quality Standards as evaluation criteria for BMP effectiveness at maintaining stream temperatures below maximum

thresholds. We found that at least two un-managed watersheds routinely exceed state-established maximum stream temperature thresholds. This finding suggests that the state's numeric criteria, as currently written and applied, may be too stringent to reflect natural conditions. Watershed characteristics and ambient weather conditions may mask any measurable effects of past upland and riparian harvest on maximum stream temperatures in Scary Creek.
We cannot use the criteria-based standards to evaluate the effectiveness of Forest Plan Standards and Guidelines in maintaining stream temperatures below maximum thresholds. Our data may provide a starting point to develop natural condition-based standards for stream temperature, if needed, following guidance recently established in the Alaska Water Quality Standards (ADEC 2006).

Turbidity

Baseline characteristics of turbidity in the case study watersheds include clear water conditions of near 0 NTU year-round in all three watersheds. Many storm events can be matched across the three watersheds to compare the responding turbidity events, which occur primarily in the fall and peak near 200 NTU in each watershed. A more detailed, storm-based analysis is in progress to discern if more subtle differences between the three watersheds can be detected. In particular, higher overall basin relief and stream power (as depicted in Figure 1) in Shaheen Creek may drive higher magnitude turbidity peaks in Shaheen relative to the other two watersheds.

We evaluated Alaska Water Quality Standards using Chanterelle Creek--the reference watershed with no timber harvest or roads—as a reference for natural conditions. A limitation of our approach is that Shaheen and Scary watersheds are not exact replicates of the Chanterelle watershed. Although the three watersheds are reasonably similar, differences in location, physical environment, and storms can produce differences in turbidity that may mask management effects. Data collection and analysis upstream of Road 2050000 is in progress. Provisional results suggest that turbidity (and sediment) increases during and after road construction, and during log haul, across the Shaheen Creek watershed were temporary and recovered to baseline levels without degrading water quality. This finding, coupled with observations of appropriate BMP implementation on site, provide assurance of compliance with Alaska Water Quality Standards for turbidity in Shaheen Creek.

The data indicate that Forest Plan Standards and Guidelines, as conveyed through standard BMPs applied to Road 2050000 construction and maintenance, were effective in maintaining water quality in Shaheen Creek.

Recommendations

We recommend continuing data collection in the case study watersheds at least through the fall storm season of 2008 to assure that our analyses accounts for inter-year differences in rainfall and air temperatures as well as driving watershed characteristics. Conductivity measurements will be used to verify karst influence in Shaheen Creek. Meanwhile we will continue with more detailed analysis of turbidity data and develop stage-discharge relationships in order to characterize streamflow across the three watersheds.

We will also continue analysis of data collected upstream of Road 2050000 to bolster comparison to "natural conditions" for turbidity in Shaheen Creek (comparison up and downstream of road will complement the comparison to reference watershed Chanterelle).

In 2009 we will produce a final report and recommendations for future watershed scale monitoring. We may consider decommissioning these instruments for use at other sites, especially if Road 2050000 storage plans continue to be deferred.

We recommend dialogue with ADEC regarding the application of Alaska Water Quality Standards for stream temperature, and options for evaluating BMP effectiveness at maintaining stream temperatures below maximum thresholds.

The turbidity conclusions of this case study cannot be reliably extrapolated to other roads and watersheds; we recommend expansion of continuous turbidity data collection efforts during instream work on a forest-wide basis. An expanded effort will strengthen our understanding of baseline turbidity and BMP effectiveness under a broader array of site and weather conditions. We are currently collecting turbidity data in Nakwasina and Clear Rivers on Baranof Island as part of a demonstration project funded by EPA. Pilot efforts are also underway during stream restoration work in Fubar and Sal Creeks on Prince of Wales Island.

We do not recommend any modifications to Forest Plan Standards and Guidelines (or BMPs) related to stream temperature (e.g. no-harvest buffers), turbidity or sediment.

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