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EXECUTIVE SUMMARY

Substrate core samples were taken at seven sites from five streams in the East Kootenay Region of British Columbia over a six year period from 2003-2008. The purpose of this project was to collect and analyze stream substrate materials in order to produce trend data valuable in monitoring the condition of stream reaches identified as critical for Bull Trout spawning. This project expands, and was based on, a similar study on the Wigwam River carried out from 1998-2002 (Tepper, 2002).

Analysis of materials less than 6.35 mm collected from substrate core samples over the six year study period indicate a significant amount of variability, both within and between sampling sites. The percent of fines less than 6.35 ranged from a low of 23% at the Bighorn Creek site to 47% at the White River (km 63) site, with a mean of 35% (± 7%, 95% confidence interval) between all 7 sites over the six year period.

While variance between both individual samples and sites was significant, there was a lack of statistically significant change in average percent of materials less than 6.35 mm at each location. This relative stable trend data does not indicate site specific increases in fines over the course of the study. This result is interesting given documented instability, intensive resource based activities and other natural and anthropogenic events occurring within these watersheds. However, it should be reiterated that the study period documented bedload composition over only six years and it is suspected that significant changes may occur over longer periods of time.

Another interesting result of the study data is the correlation between fine material percentage and documented bull trout spawning at each site. With the exception of one site, locations with low fines in the substrate correlated with both documented spawning and visually confirmed abundance of healthy alevin and eggs uncovered from redd mound gravels.
ACKNOWLEDGEMENTS

Funding was provided by the Bonneville Power Administration (BPA) under the umbrella project "Monitor and Protect Bull Trout for Koocanusa Reservoir"; BPA project number 2000-004-00. The author wishes to acknowledge all the individuals involved in this project over the past 5 years, including both BC Ministry of Environment staff and the staff from Artech Consulting Ltd., who contributed significantly to data analysis.
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1.0 INTRODUCTION
The Wigwam and White Rivers as well as Skookumchuck Creek, are important stream fisheries in the East Kootenay region of British Columbia, supporting healthy populations of bull trout (*Salvelinus confluentus*) and westslope cutthroat trout (*Oncorhynchus clarki lewisi*). The Wigwam River has been characterized as the single most important bull trout spawning stream in the Kootenay Region (Baxter and Westover 2000), and has been the focus of numerous studies in the last ten years (Westover and Conroy 1997; Cope 1998; Kohn Crippen Consultants Ltd. 1998; Westover 1999a; Westover 1999b; Cope and Morris 2001; Cope, Morris and Bisset 2002). The White River and Skookumchuck Creek have also been identified as primary spawning systems for upper Kootenay River bull trout populations (Westover, 2003) and, similar to the Wigwam River, several studies have been conducted in both systems related to population dynamics and spawning migration timing, as well as habitat assessments and monitoring (B.C. Ministry of Environment; Cope, 2002; Cope, Morris, 2003; Cope, 2003). Bighorn Creek is a significant tributary to the Wigwam and has been identified as an important spawning/rearing stream for both bull trout and westslope cutthroat trout (B.C. Ministry of Environment; Cope, 2000; Westover, 2003). Blackfoot Creek is a tributary to the White River and has been identified as one of the primary spawning systems utilized by bull trout in the lower reaches of the White River system (B.C. Ministry of Environment; Masse, 2000; Westover, 2002; Cope, 2003).

Although bull trout populations in the East Kootenay region remain healthy, bull trout populations in other parts of British Columbia and within their traditional range in the north-western United States have declined. As such, bull trout were blue listed as vulnerable in British Columbia by the B.C. Conservation Data Centre (Cannings, 1993) and remain a species of special concern. Bull trout in the north-western United States, within the Columbia River watershed, were listed as threatened in 1998 under the Endangered Species Act by the U.S. Fish and Wildlife Service.

In 2002, the BC Ministry of Environment applied to and received funding from the Bonneville Power Administration (BPA) to assess and monitor the status of wild, native stocks of bull trout in tributaries to Lake Koocanusa (Libby Reservoir) and the upper Kootenay River. The purpose
of this report is to summarize one of the many studies undertaken to “Monitor and Protect Bull Trout for Koocanusa Reservoir” (BPA Project Number 2000-04-00).

1.1 Objectives
The objectives of this study were to assess the quality of stream-bed substrates used by bull trout for spawning in five specific watersheds, providing one potential measure of future impact to bull trout spawning habitat from natural event occurrence (i.e. wildfires), resource extraction and additional disturbances.
2.0 STUDY AREA

The area included in this study is located in the southern portion of the East Kootenay Region of British Columbia within portions of both the Purcell and Rocky Mountain ranges (Figure 1). These watersheds cover approximately 2,750 km², encompassing a large portion of the southern Rocky Mountain Trench and are all direct or indirect tributaries to the upper Kootenay River, which flows into the United States near Libby, Montana. The five stream systems included in this study are Bighorn Creek (tributary of the Wigwam River), Blackfoot Creek (tributary of the White River), the White River (tributary of the upper Kootenay River), Wigwam River (tributary of the Elk River) and Skookumchuck Creek (tributary of the upper Kootenay River). All of these streams have been identified as containing reaches significantly important for bull trout spawning (Westover, Heidt, 2003).
Figure 1. Overview map of the study area.
3.0 METHODS

3.1 Site location and timing
Permanent sampling sites were established for each system at several locations. These sites were chosen based on annual observations of natural bull trout spawning occurrences (Tepper, 2002). Each sampling location was marked with flagging tape on both the upstream and downstream margins of the site for visual identification between study years. In addition, each site was recorded using a GPS device for future identification of each site location. The size of sample sites varied significantly in lengths and widths between systems.

Timing of sample extraction at each site varied slightly between study years; however, samples were generally taken within a 3 week period between the last week of February and first 2 weeks of March. Timing was dependent on ice conditions at each site, as sampling required ice-off conditions, and was determined through prior visual inspection.

3.2 Transportation to sampling sites
Because sampling was conducted during winter months and study locations are located in remote, high elevation areas, significant portions of the forest service roads were not accessible by truck. MOE staff transported equipment with 4wd vehicles on maintained FSRs to a point nearest location sites. From these points, snowmobiles were used to access the sites (up to 70 km one way at each site). The snowmobiles used for this project were a 2003 Bombardier Summit Skidoo and a 1995 Bombardier Skandic Skidoo. A trailer pulled by the Summit Skidoo was used to transport the McNeil sampler and additional equipment to and from the sites, as well as hauling the bagged substrate materials back to the vehicles.

3.3 Substrate sampling and processing
Substrate sampling was conducted utilizing a standard 15.2 cm hollow core sampler (McNeil and Ahnell, 1964) as well as the equipment and material listed in Appendix B. Sampling procedures generally followed the methodology outlined in Weaver and Fraley (1991). At each sampling location, four core samples were taken across two to four transects. Whenever possible, coring sites on each transect were located at the tail (“mound”) of a bull trout redd. Sampling involved working the corer into the streambed to a depth of approximately 15 cm. All materials were removed from inside the core cylinder and placed in the inside tray of the sampler. Using a cup,
1000 ml of water and fine sediment was removed from the sampler and placed in an Imhoff settling cone (Shepard and Graham 1982) for 20 minutes and then the amount of sediment per litre of water was recorded. After taking the Imhoff cone sample, the total volume of turbid water inside the corer was determined by measuring the depth of water from the substrate at the bottom of the core cylinder to the water surface. After slowly removing the water from the sampler, the remaining substrate materials were placed in a heavy duty plastic bag and placed into a sand bag for transport. Each bag was labelled on the outside and inside (on waterproof paper) and then transported to a laboratory for gravimetric analysis (Tepper, 2002). The samples were processed during all years of this study (2003-2008) by Artech Consulting Ltd. in Cranbrook, British Columbia.

The product of the Imhoff cone reading (mg of sediment per litre) and the total volume of turbid water inside the McNeil corer produced an approximation of the dry weight (g) for the suspended material. The bagged substrate samples were oven dried and sieve separated into 17 size classes ranging from 101.5 mm to 0.075 mm in diameter (Table 1). Materials retained on each sieve were weighed and a calculation of the percent dry weight was produced for each size class. The estimated dry weight of the suspended fine material (Imhoff cone results) was added to the weight observed in the pan, yielding the percent of material <0.075 mm. Percentages were summed and a cumulative particle size distribution was obtained for each sample (Tappel and Bjornn 1983; Tepper, 2002).
Table 1. Mesh size of sieves used to gravimetrically analyse hollow core (McNeil and Ahnell 1964) stream substrate samples collected from the Wigwam River mainstem from 2003-2008.

<table>
<thead>
<tr>
<th>Mesh Size (mm)</th>
<th>Mesh Size (Inches/Sieve #)</th>
</tr>
</thead>
<tbody>
<tr>
<td>101.50</td>
<td>4.0”</td>
</tr>
<tr>
<td>76.10</td>
<td>3.0”</td>
</tr>
<tr>
<td>50.80</td>
<td>2.0”</td>
</tr>
<tr>
<td>38.10</td>
<td>1.5”</td>
</tr>
<tr>
<td>25.40</td>
<td>1.0”</td>
</tr>
<tr>
<td>19.05</td>
<td>0.75”</td>
</tr>
<tr>
<td>12.70</td>
<td>0.5”</td>
</tr>
<tr>
<td>9.52</td>
<td>0.375”</td>
</tr>
<tr>
<td>6.35</td>
<td>0.25”</td>
</tr>
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<tr>
<td>2.00</td>
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</tr>
<tr>
<td>1.18</td>
<td>#16</td>
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<tr>
<td>0.841</td>
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</tr>
<tr>
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</tr>
<tr>
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<td>#50</td>
</tr>
<tr>
<td>0.15</td>
<td>#100</td>
</tr>
<tr>
<td>0.075</td>
<td>#200</td>
</tr>
<tr>
<td>PAN + Imhoff</td>
<td>(&lt; 0.075)</td>
</tr>
</tbody>
</table>

3.4 Data analysis

The overall composition of the stream-bed substrate samples was expressed as percent finer than the indicated sieve size. Substrate statistics were then calculated from the data on the overall composition of substrate samples for each site over the five year study period. Specifically, percent materials less than 6.35 mm were calculated directly from the sieving results (Tepper, 2002). This median size class was used by Weaver and Fraley (1991) to describe bull trout spawning gravel quality in numerous watersheds within the Flathead River drainage in Montana, United States. JMP 7.0 statistical software was utilized to compare mean 6.35 mm variance between years at each site and determine variance between samples and sites through the use of the “Tukey-Kramer” analysis (p=0.05). This analysis was then graphed for each location and comparatively for all sites. In the graph, a means diamond illustrates a sample mean and 95%
confidence intervals. The line across each diamond represents the group mean. The vertical span of each diamond represents the 95% confidence interval for each group. Overlap marks are drawn \((\sqrt{2}/2)(CI)\) above and below the group mean. For groups with equal sizes overlapping marks indicate that the two groups are not significantly different at the 95% confidence level. The confidence interval computation assumes that variances are equal across observations. Therefore, the height of the confidence interval (diamond) is proportional to the reciprocal of the square root of the number of observations in the group (Figure 2) (JMP Statistics and Graphics Guide). Additional analysis and graphs in this report were carried out using Microsoft Excel.

Figure 2. Example of JMP analysis graph used in report.
4.0 RESULTS SUMMARY

4.1 Bighorn Creek

4.1.1 Study area

Bighorn Creek originates from the Macdonald Range of the Rocky Mountains, in the southeast corner of the Rocky Mountain Trench, approximately 35 km southeast of Fernie, BC. This system has a mainstem length of approximately 25 km, flowing in an easterly direction to its confluence with the Wigwam River. Bighorn Creek has a total watershed area of approximately 139 km² and has a flow regime comparable to other interior streams, with peak flow occurrence in June/July and low flows in late fall and winter. Specific discharge statistics are not available for this system.

The Bighorn Creek watershed is located within the Engleman Spruce Sub-Alpine Fir Dry Cool biogeoclimatic sub-zone (Summit Environmental Consultants Ltd., 2001). The upper reaches of the watershed were extensively logged throughout the 1960’s and 1970’s. In addition, natural disturbance events occurring in this watershed include a wildfire in the 1930’s which devastated the lower reaches, and a 1995 flood event which is thought to occur every 100 to 200 years (Cope, 2000). Research from restoration projects suggest that recent changes in land use and forest cover may have significantly affected the hydrology and sediment structure of the watershed (Oliver, 1996; Columbia Environmental Services Ltd., 1996a, 1996b). In addition, research information also suggests that watershed geology contributes to a naturally dynamic and unstable environment, which are specifically impacted by changes in land use and forest cover (Cope, 2000). A combination of these factors has resulted in increased flows and sediment contribution, leading to both vertical and horizontal channel changes and subsurface flows in certain reaches during low flow conditions.

4.1.2 Site Description

One permanent sample site was established on Bighorn Creek, approximately 700 metres upstream of its confluence with the Wigwam River at approximately km 44 on the Wigwam River Road (Figure 3, Appendix I). This site was established based on annual observations of natural bull trout spawning occurrences (B.C. Ministry of Environment). A total of 12 gravel samples were taken at this site. Specific site measurements varied slightly between study years;
however, averages (2003-2008) at this site were: wetted width = 5.1 m, total length = 23.9 m, and water depth of samples = 252 mm.
Figure 3. Bighorn Creek McNeil sampling site.
4.1.3 Results

Although there is a degree of variability between years at the Bighorn Creek site, there is not an obvious trend which indicates significant change in material composition (Figure 4). It should be noted that one of the 2008 Bighorn site results contained a sample percentage which was extremely low and may reflect an error in lab analysis. The mean percentage for the Bighorn site including and excluding this 2008 sample data for the 6 year study is 23.4% and 23.7%, respectively (±4%, ±3%; 95% confidence interval), a relatively insignificant percentage difference. However, if this specific sample was remotely comparable to the sample mean from previous years, the overall mean from the Bighorn site would likely reflect the previous 5 years. As such, caution should be used when comparing 2008 site results with the rest of the data set.

Figure 4. Percent of materials less than 6.35 mm at Bighorn Creek.

Detailed analysis of variability between study years at this site indicates that only the 2007 and 2008 data reflect statistically significant differences across study years (Figure 5). Given the possibility of lab error in summary analysis for 2008, it could be concluded that trend data indicates relative consistency in substrate materials. With a 6 year mean of 23.4% (±4%; 95% confidence interval) the percentage of measured fines appears well within levels calculated for successful fry emergence. It is interesting to note that this location was the most active spawning area among all sites in this study and many healthy alevin were observed in samples taken from redd mounds. Analysis of both the average percent of materials less than 6.35 mm over six years...
and the redd count data over the same period indicates both consistent use and a relatively stable trend in substrate composition, especially compared to other sites in this study. It should be noted that this stable trend indicator is a reflection of only the study period and contradicts information from previous studies (see 4.1.1), which indicate significant instability and changes in sediment within this system over time. Long term data sets from substrate sampling at this location may present a more conclusive trend.

Figure 5. Statistical variability of samples at Bighorn site.
4.2 Blackfoot Creek

4.2.1 Study area

Blackfoot Creek originates in the Quinn Range of the Rocky Mountains in southeastern British Columbia, approximately 60 km from the town of Canal Flats, BC. This system has a length of approximately 50 kms, flowing in a north/northwest direction to its confluence with the mainstem White River. Blackfoot Creek has a total watershed area of approximately 152 km$^2$ and has a flow regime comparable to other interior streams, with peak flow occurrence in June/July and low flows in late fall and winter (Masse, 2000). Specific discharge statistics are not available for this system.

This system is characterized by a long, narrow valley running through steep and rugged mountain terrain and falls within the Dry Cool Englemann Spruce-Subalpine Fir and Dry Cool Parkland Englemann Spruce-Subalpine Fir biogeoeclimatic sub zones and the Alpine Tundra biogeoeclimatic zone at higher elevations (Masse, 2000). The headwaters of Blackfoot Creek were devastated by wildfire in 1985 and significant salvage logging has occurred, leaving portions of riparian areas severely degraded (Cope, 2003). Logging is currently occurring in several areas adjacent to the mainstem and significant portions of tributary basins from mid to upper portions of the watershed. Most tributary streams entering the system are characterized by short, steep ravines and seasonal debris torrents. A historic flood event occurred in 1995 which is thought to occur every 100 to 200 years.

4.2.2 Site Description

One permanent sample site was established on Blackfoot Creek, just downstream of a Forest Service Road bridge crossing at approximately 48 km on the Blackfoot FSR (Figure 6, Appendix I). This site was established based on annual observations of natural bull trout spawning occurrences (B.C. Ministry of Environment). A total of 12 gravel samples were taken at this site. Specific site measurements varied slightly between study years; however, averages (2003-2008) at this site were: wetted width = 7.8 m, total length = 12 m, and water depth of samples = 210 mm. It should be noted that the Blackfoot site was established in 2004, enabling a five year analysis as compared to six years of data from the other systems in this report.
Figure 6. Blackfoot Creek McNeil sampling site.
4.2.3 Results
Sample analysis from the Blackfoot Creek site indicates a significant degree of variability over five years. Although there is not enough data to confirm a consistent change in substrate material composition, sample data from 2007 and 2008 does indicate a shift to higher concentrations of fines over the previous 3 years (Figure 7). It should be noted that the number of bull trout redds counted at this site over the past 5 years has steadily decreased and may be a direct reflection of a change in substrate composition resulting from extensive bedload movement and channel aggradation and degradation.

![Blackfoot Creek McNeil Sampling](image)

**Figure 7. Percent of materials less than 6.35 mm at Blackfoot Creek.**

Specific analysis of variability between study years at this site indicates that sample data from 2004, 2006 and 2007 reflect statistically significant differences across study years (Figure 8). With a 5 year mean of 28.3% (± 8%; 95% confidence interval) the percentage of measured fines from the Blackfoot site appears within the upper threshold for successful fry emergence. However, if the percentage of fines continues to increase as in 2007 and 2008 samples, it may indicate a potential for decreasing egg to fry survival at this site, and may explain the decrease in bull trout spawning use at this site.
Figure 8. Statistical variability of samples at Blackfoot site.
4.3 White River

4.3.1 Study area

The White River originates from glacier-fed lakes in the Height of the Rockies Wilderness Area (HOTR), between the Park and Front Ranges of the southern Rocky Mountains in southeastern British Columbia. The upper basin of the White River is divided into three large forks. The North Fork White River and the Middle Fork White River flow south approximately 40 km until they join the East Fork of the White River, which flows directly west from its headwaters. From the East Fork confluence, the White River flows west/southwest for approximately 10 km. At Whiteswan Provincial Park the river turns north/northwest for its final 34 km until it empties into the upper Kootenay River, approximately 30 km northeast of the village of Canal Flats (Cope, 2003) (Figure 40). The White River has a total watershed area of 987 km² with a mean annual discharge of 23.3 m³/s (Water Survey of Canada). The flow regime is comparable to most interior streams with peak flows occurring in June or July and expected low flows in late fall and winter. Significant tributaries to the North and Middle Forks include Schofield Creek, Nilksuka Creek, Nipakoo Creek, Colin Creek, Maiyuk Creek, Kotsats Creek, Klookuh Creek and Rock Canyon Creek. Significant tributaries to the White River below the East Fork confluence include Grave Creek, Thunder Creek, Blackfoot Creek, Outlet Creek, Ptarmigan Creek, Elk Creek and Moscow Creek.

The White River is characterized by long, narrow and forested valleys running through the rugged Rocky Mountains. Elevated layers of limestone dominate the geology. Three biogeoclimatic zones dominated the valleys. Montane Spruce at lower elevations, Engelmann Spruce and Sub alpine fir at middle elevations are the most common and alpine tundra at higher elevations (above approximately 2300 m) (Cope, 2003). In 1936, a forest fire burned much of the HOTR and the upper Middle Fork White River watershed. Historic forest fire salvage logging was extensive in these reaches. In 2003, a wildfire again burned the upper Middle Fork White River and the HOTR (Cope, 2003). Aggressive salvage logging was undertaken within the entire upper basin of the Middle Fork White River, below the HOTR, resulting in severe impacts to riparian areas throughout the upper reaches (Tepper, pers. comm.).
4.3.2 Site Description

Two permanent sample sites were established on the Middle Fork White River, at approximately 63 km and 65 km on the Middle Fork FSR (Figure 9, Appendix I). A total of 12 gravel samples were taken at each of these sites (n=24). Specific site measurements at each site varied slightly between study years; however, averages (2003-2008) at site 1 (km 63) were: wetted width = 9.8 m, total length = 11.6 m, and water depth of samples = 370 mm. Averages at site 2 (km 65) were: wetted width = 6.1 m, total length = 16.5 m, and water depth of samples = 340 mm.
Figure 9. White River McNeil sampling sites.
4.3.3 Results

4.3.3.1 Kilometer 63 site

Sample analysis from the White River km 63 site indicates both a stable trend consistency with high percentages in measured fines over five years (Figure 10). It is important to note that bull trout redd counts conducted over the same 5 year period have not documented any evidence of bull trout spawning activity at this site. Substrate materials at this site are composed almost entirely of fines and small gravels, with few cobbles and larger substrate material present. As such, the percentage of materials less than 6.35mm found in the sample analysis are not unexpected.

![White River (km 63) McNeil Sampling](image)

Figure 10. Percent of materials less than 6.35 mm at White km 63.

Specific analysis of variability between study years at this site indicates no significant statistical differences across study years (Figure 11). With a 5 year mean of 47% (± 2%; 95% confidence interval), the percentage of measured fines is well outside the suggested benchmark for egg to fry survival and, as mentioned, is likely a contributing factor to the absence of bull trout spawning activity.
4.3.3.2 Kilometer 65 site

Sample analysis from the White River km 65 site indicates a slightly variable but stable trend and relatively high percentages in measured fines over five years (Figure 12). It is important to note that bull trout redd counts conducted over the same 5 year period have documented scarce bull trout spawning activity at this site, indicating only a few redds found during this period. Although more suitable than the km 63 site, substrate materials are still largely composed of fines and small gravels, with cobbles and larger substrate material present only in small areas. As such, high percentages of fines found in the sample analysis are not unexpected and are not of significant concern.
Specific analysis of variability between study years at this site indicates no significant statistical differences across study years (Figure 13). With a 5 year mean of 34.6% (±3%; 95% confidence interval), the percentage of measured fines is just outside the benchmark for successful egg to fry survival and, as mentioned, is likely a contributing factor to the absence of major bull trout spawning activity.

Figure 12. Percent of materials less than 6.35 mm at White km 65.

Figure 13. Statistical variability of samples at White km 65 site.
4.4 Wigwam River

4.4.1 Study area

As described in Baxter and Westover (2000) and Cope, Morris and Bisset (2002), the Wigwam River originates in the Rocky Mountains within the state of Montana and flows northwest between the Galton and MacDonald ranges in British Columbia for approximately 47 km until it empties into the Elk River, a tributary to Lake Koocanusa. The headwaters of the Wigwam drainage originate at an elevation of 2135 m and decline to 800 m at its confluence with the Elk River. The Wigwam River has a total watershed area of 835 km² with a mean annual discharge of 9.5 m³/s (Tembec Water Monitoring Station). The flow regime of the Wigwam River is comparable to most interior systems with high annual run-off reaching its peak in May (peak mean daily discharge 74 m³/s on 24 May 2000) and expected low flows in late fall and winter (2.1 m³/s; Prince and Cope 2001). It should be noted that the Wigwam hydrometric data station was positioned just upstream of Bighorn Creek. The inclusion of discharge data from both Bighorn and Lodgepole Creeks, two of the largest tributaries to the Wigwam River, would significantly increase annual discharge statistics. The drainage is comprised of three major east slope tributaries (Lodgepole, Bighorn, and Desolation Creeks) all of which flow out of the MacDonald Range.

The Wigwam River valley is characterized by four biogeoclimatic zone variants; Kootenay dry mild interior Douglas-fir, dry cool montane spruce, Kootenay moist cool interior cedar hemlock, and dry cool Engelman spruce sub-alpine fir (Braumandl and Curran, 1992). A number of natural and anthropogenic disturbance events over time appear to have contributed a substantial volume of coarse sediment to the river including: wildfires in the 1930’s, extensive logging in the headwaters of Bighorn Creek and the headwaters of the Wigwam River from 1950 to 1980, a slide in 1993, and the 1995 flood event thought to occur every 100 to 200 years (Oliver and Cope 1999; Kohn Crippen Consultants Ltd. 1998). Frequent lateral channel migrations over time have resulted in erosion of adjacent terraces, coarse sediment delivery to the river mainstem, and have created numerous sections of braided channel comprised of sorted gravels and cobbles that provide prime spawning habitat for bull trout (Oliver and Cope 1999). The provision of suitably sized bed materials (<70 mm) in a low gradient, low water velocity location with associated
groundwater have been identified as repeating patterns of preferred bull trout spawning habitat (McPhail and Baxter 1996).

The majority of Wigwam River bull trout studies have been conducted over a large portion of its mainstem from the top of a steep canyon reach (km 42) to near its headwaters in Montana, as well as in Bighorn Creek and in Lodgepole Creek upstream to the falls at km 26. This study was conducted on the mainstem Wigwam River just upstream of the Bighorn Creek confluence.

4.4.2 Site Description

One permanent sample site was utilized on the Wigwam River mainstem, just upstream of the Bighorn Creek confluence (Figure 14, Appendix I). This site was previously established based on annual observations of natural bull trout spawning occurrences (Tepper, 2002). It should be noted that although identified as one site, gravel samples were taken from two locations approximately 500 metres apart. These two separate locations are actually two sections of the same site, with the total site gravel samples (12) taken from both the lower location (4 samples) and the upper location (8 samples). For the purpose of location description, these locations will be referred to as Site 1(a) and Site 1(b) (Figure 2). Site size varied slightly between study years; however, averages (2003-2008) at the 2 locations were: wetted width at 1(a) = 7.1 m and 1(b) = 5.1 m, total length at 1(a) = 10.1 m and 1(b) = 21.7 m, and water depth of samples at 1(a) = 382 mm and 1(b) = 254 mm.
Figure 14. Wigwam River McNeil sampling site.
4.4.3 Results
Sample analysis from the Wigwam River site indicates both a relative degree of variability and fairly high percentages in measured fines over six years (Figure 15). It should be noted that there has been a noticeable change in streambed composition at this site over the past several years, with a shift from smaller gravels and cobbles to larger cobble and boulder materials. It is also of interest that bull trout redd counts conducted over the same 6 year period have documented a decrease in bull trout spawning activity at this site. While bull trout do utilize this site in a limited capacity for spawning, large substrate material and high percentages of fines in the gravels likely are limiting factors to spawner use.

![Wigwam River McNeil Sampling](image)

**Figure 15. Percent of materials less than 6.35 mm at the Wigwam River.**

Specific analysis of variability between study years at this site indicates that only 2004 data represents a significant statistical difference across study years (Figure 16). With a 6 year mean of 33.5% (± 4%; 95% confidence interval), the percentage of measured fines is at the benchmark upper limits for successful egg to fry survival and, as mentioned, may be a contributing factor to the absence of major bull trout spawning activity.
Figure 16. Statistical variability of samples at the Wigwam site.
4.5 Skookumchuck Creek

4.5.1 Study area

Skookumchuck Creek originates in the South Purcell Mountains within the Purcell Wilderness Conservancy. From its headwaters, the stream flows east/northeast for approximately 62 km to its confluence with the upper Kootenay River, near the town of Skookumchuck, BC. The headwaters of the Skookumchuck drainage originate at an elevation of approximately 2,250 m and declines to 750 m. Skookumchuck Creek has a drainage area of approximately 637 km², with a mean annual discharge of 10.3 m³/s (Water Survey of Canada). The flow regime is comparable to most interior streams with peak flows occurring in June and expected low flows in late fall and winter (Cope, 2003). Significant tributaries to Skookumchuck Creek include Buhl Creek, Bradford Creek and Sandown Creek.

The Skookumchuck Creek valley is characterized by five biogeoclimatic zone variants: Kootenay dry mild ponderosa pine, Kootenay dry mild interior Douglas-fir, dry cool montane spruce, fry cool Engelmann spruce sub-alpine fir and alpine tundra (Braumandl and Curran, 1992; Cope, 2003). The upper reaches of Skookumchuck Creek flow through a narrow alluvial floodplain, characterized by channel-confining bedrock outcrops, bordered by steep mountain slopes. The lower reaches are almost entirely confined to a long, narrow bedrock canyon, surrounded by steep, densely forested terrain. The watershed has a long timber harvesting history, with records of harvest activities dating back to 1916 (Cope, 2003). Currently, logging is continuing throughout most of the upper watershed.

4.5.2 Site Description

Two permanent sample sites were established on Skookumchuck Creek, at approximately 38 km and 42 km on the Skookumchuck FSR (Figure 17, Appendix I). These sites were established based on annual observations of natural bull trout spawning occurrences (B.C. Ministry of Environment). A total of 12 gravel samples were taken at each of these sites (n=24). Site sizes varied slightly between study years; however, averages (2003-2008) at site 1 (km 38) were: wetted width = 6 m, total length = 287.9 m, and water depth of samples = 288 mm. Averages at site 2 (km 42) were: wetted width = 7.3 m, total length = 26.8 m, and water depth of samples = 323 mm.
Figure 17. Skookumchuck Creek McNeil sampling sites.
4.5.3 Results

4.5.3.1 Kilometer 38 site

Sample analysis from the Skookumchuck Creek km 38 site indicates both a stable trend consistency and relatively high percentages in measured fines over six years (Figure 18). It is important to note that bull trout redd counts conducted over the same 6 year period have documented very little bull trout spawning activity at this site. However, this may also be due to a lack of groundwater evident at the site and not directly attributable to material composition.

![Skookumchuck Creek (km 38) McNeil Sampling](image)

**Figure 18. Percent of materials less than 6.35 mm at Skookumchuck km 38.**

Specific analysis of variability between study years at this site indicates that only 2008 data represents a significant statistical difference across study years (Figure 19). With a 6 year mean of 37.1% (± 2%; 95% confidence interval) , the percentage of measured fines is just outside the benchmark for successful egg to fry survival and may be a contributing factor to the absence of bull trout spawning activity.
4.5.3.1 Kilometer 42 site

Sample analysis from the Skookumchuck Creek km 42 site indicates a stable trend consistency reflecting significantly high percentages in measured fines over six years (Figure 20). Bull trout redd counts conducted over the same period have documented consistent and significant spawner activity at this site. Although there are suitable cobble/gravel materials for spawning, the large percentage of fines found in the substrate core samples indicate potential for oxygen limitations and reduced chances of egg to fry survival. Given these conditions, documented spawning activity at this site may be more a result of abundant ground water and a lack of suitable spawning areas in the upper watershed, rather than substrate composition.

Figure 19. Statistical variability of samples at Skookumchuck km 38 site.
Specific analysis of variability at this site does not indicate any significant statistical differences across study years (Figure 21). With a 6 year mean of 42.5% (± 5%; 95% confidence interval), the percentage of measured fines is well outside the benchmark for successful egg to fry survival (35%) and exceeds the 40% benchmark for an impaired stream. This factor likely affects egg to fry survival at the site. Despite this hypothesis, it should be noted that several alevin were uncovered from redd mound tailouts and appeared healthy; however, several dead eggs were also observed and appeared to be more common at this site compared to others.
5.0 DISCUSSION

Given the variance pertaining to watershed characteristics, instream habitats, substrate composition and bedload movement between streams and between sites, caution should be used when comparing the sample results directly between sites and stream systems. In addition, predicted emergence success rates are only a relative index of the impacts of measured increases in fine sediment. Actual emergence success rates are also influenced by factors such as extreme flow events, unfavourable temperature regimes and the presence of toxic chemicals and disease organisms (MacDonald and McDonald, 1987). However, Weaver (1996) stated that when the median percent of materials less than 6.35 mm are greater than 35% in any given year, the stream should be considered threatened as a bull trout spawning and/or rearing stream. If materials exceed 40% the stream would be considered impaired (Tepper, 2002). As such, substrate core sample data gives a general indicator of stream health around these benchmark parameters.

When comparing results between the sites in this study (Figure 22), it is important to differentiate between confirmed bull trout spawning areas and those not utilized for spawning. Although the White River (middle fork) is a significant bull trout stream both for spawning and rearing, the sample sites utilized in this study are insignificant from a spawning perspective, with very little documented spawning activity at km 65 and no spawning activity at km 63. The sample site at Blackfoot Creek chosen for this study was based initially on confirmed redds; however, bedload movement and resulting changes in substrate composition have led to fewer redds each year at this location. Bighorn Creek and the Wigwam River are both critical systems for bull trout spawning and rearing. The sites at the Wigwam and especially at Bighorn Creek both are utilized for spawning and, at the Bighorn site, many alevin were uncovered from redd mounds during the sampling process. Skookumchuck Creek km 38 site had limited evidence of spawning over the study, but the kilometre 42 site is heavily used for spawning. The latter site is unique however, given results indicating fines well beyond the benchmark for successful egg to fry survival.
Specific analysis of variability between sites indicate significant statistical differences between sites over the study period (Figure 23). With a 6 year mean of 35% (± 7.4%, 95% confidence interval), the combined percentage of measured fines equals the upper limit benchmark for successful egg to fry survival; however, mean percentages range from 23.5% to 47% (± 4%, ± 2%; 95% confidence interval, respectively). This variability between site locations when combining redd count data documented at the specific sites verifies a clear correlation of fines percentages with preferred spawning habitats. The only clear anomaly to this pattern is the Skookumchuck km 42 site. Additional field research pertaining to egg to fry survival percentages would be beneficial in better understanding the correlation between % fines and fry emergence. The Skookumchuck km 42 site would be an ideal candidate for such a study.
An interesting result from the study is the relative trend consistency from all sites, particularly the lack of statistically significant change in average percent of materials less than 6.35mm at each location. While some individual sites did reflect significant variability over the study period, there were not any conclusive trends indicating increasing fine materials in substrate composition. Given intensive timber harvesting, other land management activities, and other natural and anthropogenic events occurring within these watersheds, it is suspected that this may change over time. Because evolution in channel morphology and stream characteristics are impacted by many characteristics and often require many years to unfold, definitive trend results from these systems may not be seen for several years. As such, it is recommended that the McNeil core sampling program be continued on an annual basis or replicated in 5 to 10 years in order to maintain a long term data set and monitor future impacts.

Figure 23. Statistical variability of samples between all sites.
6.0 REFERENCES


Masse, Sylvie. 2000. Reconnaissance (1:20,000) Fish and Fish Habitat Inventory of Blackfoot Creek.


Personal Communication. Herb Tepper, Fisheries Biologist, B.C. Ministry of Environment, Cranbrook, B.C.


Summit Environmental Consultants Ltd. 2001. Fish Habitat Assessment and Prescriptions: Bighorn Creek Reaches 1&2.


### Appendix I. UTM (NAD 83) Coordinates of the 8 McNeil Sample Sites

<table>
<thead>
<tr>
<th>Stream System</th>
<th>Site Location</th>
<th>Zone</th>
<th>Easting</th>
<th>Northing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bighorn Cr.</td>
<td>Under Wigwam FSR bridge at Kilometer 44</td>
<td>11</td>
<td>648959</td>
<td>5449674</td>
</tr>
<tr>
<td>Blackfoot Cr.</td>
<td>Downstream of Blackfoot FSR bridge at kilometer</td>
<td>11</td>
<td>618381</td>
<td>5546545</td>
</tr>
<tr>
<td>Skookumchuck Creek</td>
<td>Kilometer 38 on Skookumchuck FSR</td>
<td>11</td>
<td>575628</td>
<td>5536272</td>
</tr>
<tr>
<td></td>
<td>Kilometer 42 on Skookumchuck FSR</td>
<td>11</td>
<td>572329</td>
<td>5535256</td>
</tr>
<tr>
<td>White River</td>
<td>Kilometer 63 on Middle Fork FSR</td>
<td>11</td>
<td>627441</td>
<td>5574447</td>
</tr>
<tr>
<td></td>
<td>Kilometer 65 on Middle Fork FSR</td>
<td>11</td>
<td>627039</td>
<td>5575863</td>
</tr>
<tr>
<td>Wigwam River</td>
<td>(1a) 300 meters upstream of Bighorn Creek confluence</td>
<td>11</td>
<td>648664</td>
<td>5449685</td>
</tr>
<tr>
<td></td>
<td>(1b) 700 meters upstream of Bighorn Creek confluence</td>
<td>11</td>
<td>648602</td>
<td>5449412</td>
</tr>
</tbody>
</table>
Appendix II. Equipment List & Procedure for McNeil Substrate Sampling

**Equipment**
- Large Pack (Hunting Pack) – if samples will be carried any distance
- McNeil Sampler
- 12+ Heavy Duty Garbage Bags (Trash Compactor Bags – 2 Ply)
- 12+ Sand Bags
- Wire or small rope to tie Sand Bags
- Clip Board
- Forms (pre-made) – WATER PROOF
- 12 Labels (pre-made) – for each sample
- Long rubber gloves
- Large Plastic Cup
- 4 Cones – to measure fine sediment
- Wooden Cone holder - fits in a large Bucket (needs to made)
- Black Felt Pen – to mark outside of Sand Bags
- Metal meter stick
- Camera
- Flagging Tape – to mark site for the 1st time
- Rebar, Spray Paint & Hammer - to mark site for the 1st time
- Satellite Phone – safety reason to communicate with other team if needed

**Procedure**
1. Mark location of each transect with rebar (left bank – looking d/s) and flagging tape on trees/shrubs.
2. Take u/s, x/s and d/s photo of each transect site.
3. Locate reds within transect and twist and press the McNeil sampler into the gravel “mound” of the redd, until gravel nears the top of the inside cylinder of the sampler.
4. Remove the gravel from the inside of the cylinder to the inside “tray” section of the sampler, until the “teeth” of the sampler can be felt with your hand at the bottom of the cylinder.
5. Use the cup to remove 1000ml of water and fine sediment from inside the sampler to the sampling/measuring cone – record time to check cone on the form (20 min. from time sample is placed in cone). Ensure this is done immediately after gravel is removed from cylinder.
6. After 20 min. measure the amount of sediment that has accumulated in the bottom of the cone.
7. Use metal meter stick to measure in “mm” the distance from the substrate at the bottom of the cylinder to the water surface – record on the form.
8. Slowly pour water out of the sampler.
9. Pour gravel into garbage bag, “rinse” remaining fine gravel with water, slowly pour off water and dump remaining gravel & fines into a garbage bag. Place pre-made labels into the garbage bag and seal bag with a “knot”. Mark location and sample # on outside of bag.
10. Place garbage bag into a sand bag and seal sand bag with wire or fine rope.