Middle Shuswap Sensitive Ecosystem Inventory and Sensitive Habitat Inventory Mapping Project:

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Executive Summary

Human population growth and development of rural areas in the Okanagan has increased the need for conservation of high value and sensitive habitat in the area. The first step in conserving sensitive areas is to identifying these areas and providing the data to the agencies and groups concerned with their preservation. Whitevalley Community Resource Centre in partnership with B.C. Ministry of Environment, Fisheries and Oceans Canada, the Okanagan Nations Alliance, the Okanagan Indian Band and the Allen Brooks Nature Centre conducted a preliminary Sensitive Ecosystem Inventory (SEI) and Sensitive Habitat Inventory Mapping (SHIM) of the Middle Shuswap River between Wilsey Dam at Shuswap Falls and Peers Dam at Brenda Falls at the outlet of Sugar Lake in the North Okanagan Regional District.

SEI inventories rare and fragile ecosystems using aerial photography supported by selective ground truthing of the data. The SEI is used as a flagging tool that provides information and support to local governments and others who are working to maintain biodiversity. It provides a basis for land use planning and private land stewardship. The SHIM is an aquatic inventory, which identifies, inventories, and maps all watercourses, their associated riparian habitats and important fisheries habitat features. It is used as a reference in reviewing development applications.

The SEI covered an area of approximately 64 km^2 covering a 1 km band on either side of the Shuswap River from the Wilsey Dam at Shuswap Falls to Peers Dam at the outlet of Sugar Lake. The study area is a transition zone between biogeoclimatic zones with a variety of habitat types ranging from dry open ponderosa pine/ bunchgrass and Douglas fir forests to moist cedar/hemlock forests. Much of the riparian area along the river is old cottonwood forest that provide habitat for a variety of wildlife species including the endangered screech-owl. The preliminary SEI map was given to the local Ministry of Environment office and the North Okanagan Regional District.

A total of 82,846 m of streams were mapped for the SHIM portion of the project. This included 32,931m of main stem and 27,667 m of side channels on the Shuswap River and 22,248 m of tributary streams. The side channels contained a greater variety of habitat than the main river channel. They had a greater variety of hydraulic types, substrates, temperature, types and relative abundance of in-stream and above-stream cover The SHIM data was given to provincial and regional governments and uploaded to the Community Mapping Network website.

The SHIM data was analyzed to determine the potential spawning and rearing areas between the two dams on the Shuswap River. Seventy-three ha of spawning-sized gravel/cobble substrate covered by at least 0.3 m of water at low flows in the study area. This compares to 49.2 ha of spawning gravel between Wilsey Dam and Mabel Lake (Summit 2002). There are 26.5 kms of side channels in the study area, 25.1 kms were flowing during moderate to low flows. The wetted side channel area was 27.59 ha. All these side channels offer potential rearing or refuge habitat for fish during different life

stages. The side channel habitat has a greater diversity of hydraulic types as well as a greater diversity and relative abundance of cover and lower velocities than the main river.

Rainbow trout was the most common fish species captured while sampling the Shuswap River side channels and tributaries. Fish densities, determined by a two-pass removal method of electro-shocking at selected sites, were low in Shuswap River side channels compared to some the tributaries. These findings were consistent with more intensive fish stock assessments done previously.

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Introduction

Population growth in the North Okanagan is projected to increase from approximately 17% to over 25% in the next 25 years (www.bcstats). Farmland in BC has increased in value by 20.3% between July 2005 and July 2006 (Figure1). Landcor Data Corporation reports that the average sale price across the Okanagan rose 13.9% between 2004 and 2005, 22.5% from 2005 to 2006, and jumped 11% in just the first three months of 2007. With the increase in rural property values, there has been an accompanying increased the number of listings and sales. The expanding population and development of rural areas increases the urgency of protecting sensitive and high-value habitats in these areas.

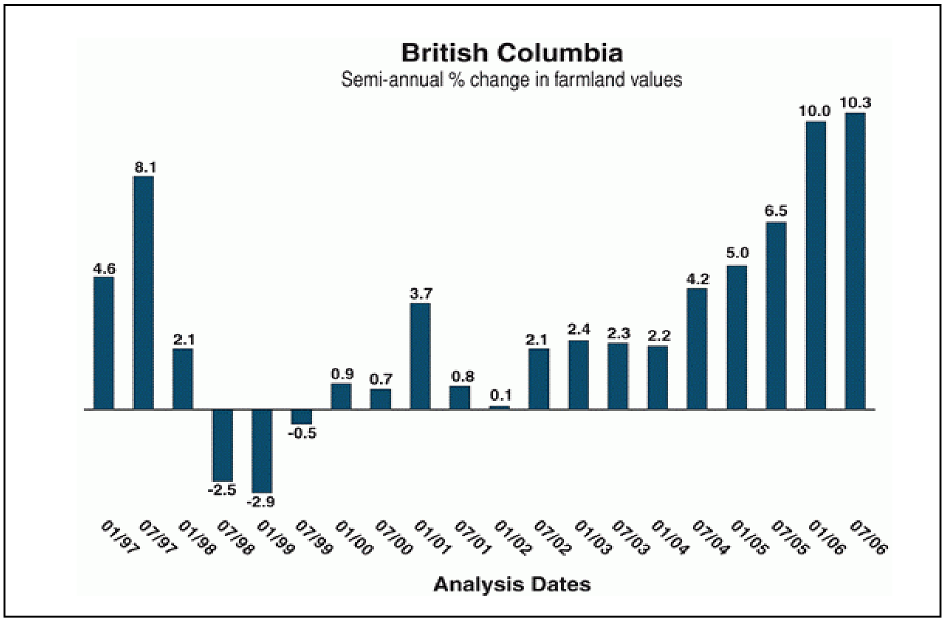

Figure 1: Rural property value has been increasing substantially in the past three years in British Columbia as the demand for land increases. Source: Farm Credit Canada,
http://www.fcc-fac.ca/en/Products/Property/FLV/Fall2006/index.asp#bc

In a recent survey conducted by the Okanagan Collaborative Conservation Program (OCCP), conservation/preservation of sensitive habitat especially riparian and valley bottom habitat was the most commonly cited concern for the area (OCCP is composed of 20 federal, provincial, regional and municipal governments and various conservation groups that co-ordinate and facilitate conservation efforts in the Okanagan Valley).

The first step in conserving valuable habitat is identifying it. Section 6.2 of provincial Ministry of Environment's (MOE) Environmental Best Management Practices for Urban and Rural Land Development in British Columbia states that local governments and developers are responsible for protecting sensitive habitats. The results based approach of the provincial government puts the identification and conservation of sensitive habitat on the developer, local governments and community groups. Good data is necessary for local and regional governments to develop policies and community development plans and for MOE to approve proposals for development.

Whitevalley Community Resource Centre (WCRC) was asked to lead a project that would identify sensitive habitat along the Shuswap River valley between Wilsey and Peers dam by Ministry of Environment staff. WCRC would work with MOE, Fisheries and Oceans Canada (DFO), the Okanagan Nations Alliance (ONA), and the Okanagan Indian Band (OKIB) to conduct a Sensitive Ecosystems Inventory (SEI) and Sensitive Habitat Inventory Mapping (SHIM) project.

A SEI uses aerial photography supported by selective field checking to identify and map rare and fragile ecosystems in a specified area. SEI mapping methodology is based on interpretation of air photos to define SEI polygons or by imposing a SEI theme on existing Terrestrial Ecosystem Mapping (TEM) polygons.

SHIM identifies, inventories, and maps all watercourses, their associated riparian habitats and important fisheries habitat features. SHIM projects inventory and map watercourses not currently identified or acknowledged in local/regional plans and maps that can be integrated into local mapping and planning initiatives. These are usually smaller streams and wetland areas that haven’t been recorded on the 1:20,000 provincial TRIM maps. For the Middle Shuswap Rive project, it would primarily be identifying the smaller side channels, wetlands and tributaries. This information can then be integrated into local mapping and planning initiatives.

Goals and Objectives

The goal of this project is to identify sensitive habitats in the Middle Shuswap River Valley between Wilsey and Peers Dams as the first step in the conserving these high-value habitats.

The objectives of this project are:

1. Conduct a preliminary SEI of the area that includes a one kilometer band on either side of Middle Shuswap River from Wilsey Dam to Peers Dam.
2. Conduct a SHIM of the Middle Shuswap River, its side channels and tributaries in approximately the same area as the SEI.
3. Present the preliminary SEI and SHIM data to MOE and the NORD to assist in making decisions regarding land development.
4. Present the SHIM data to the Community Mapping Network and the SHIM website for public use.
5. Quantify potential spawning and rearing areas for salmonids in the study area.

Study Area

Figure 2: The Middle Shuswap River between Wilsey and Peers Dams. Wilsey Dam is located approximately 13 km east of Lumby on Mabel Lake Road. Peers Dam is located approximately 13 km north of Cherryville.

The study area for this project covered an area extending approximately 68 km^2 along the Middle Shuswap River in the South Thompson watershed. Specifically, the area includes the Shuswap River valley from Wilsey Dam at Shuswap Falls (118^o 48"40.7' W, 50^{o}17"42.1' N) to Peers Dam (Sugar Lake Dam) at Brenda Falls (118^o 32"33' W, 50^{o}21"4' N) (Figures 2- 4). Wilsey Dam is located approximately 13 km northeast of Lumby on the Mabel Lake Road. Peers Dam is located at the outlet of Sugar Lake approximately 13 kms north of Cherryville and 39 kms north east of Lumby.

Peers dam regulates the water level in Sugar Lake, storing water for the hydroelectric plant at Wilsey Dam at Shuswap Falls. From the Peers Dam, the river flows southwest for roughly 15 km to Cherryville then flows to the northwest for 13 km to Wilsey Dam. The SEI included a band approximately 1 km on either side of the river. The SHIM surveyed the Shuswap River and its tributaries for roughly the same geographic area.

Figure 3: This Google Earth image shows the U-shaped Middle Shuswap River valley and the surrounding mountains. The Upper Shuswap River drains the Monashee Mountains to Sugar Lake. Peers Dam at the Sugar Lake outlet marks the upstream boundary of the Middle Shuswap River that flows through the Wilsey Dam at Shuswap Falls and into Mabel Lake. Both Sugar and Mabel Lake lie in valleys that run in a north/south direction. The two valleys are connected by the east-west Lumby (Whitevalley) Valley. The Silver Hills form the highland that fills the interior portion of the U. The Columbia River separates the Monashee from the Selkirk Mountains to the north and east. The study area includes the valley area beginning at Wilsey Dam at Shuswap Falls to Sugar Lake.

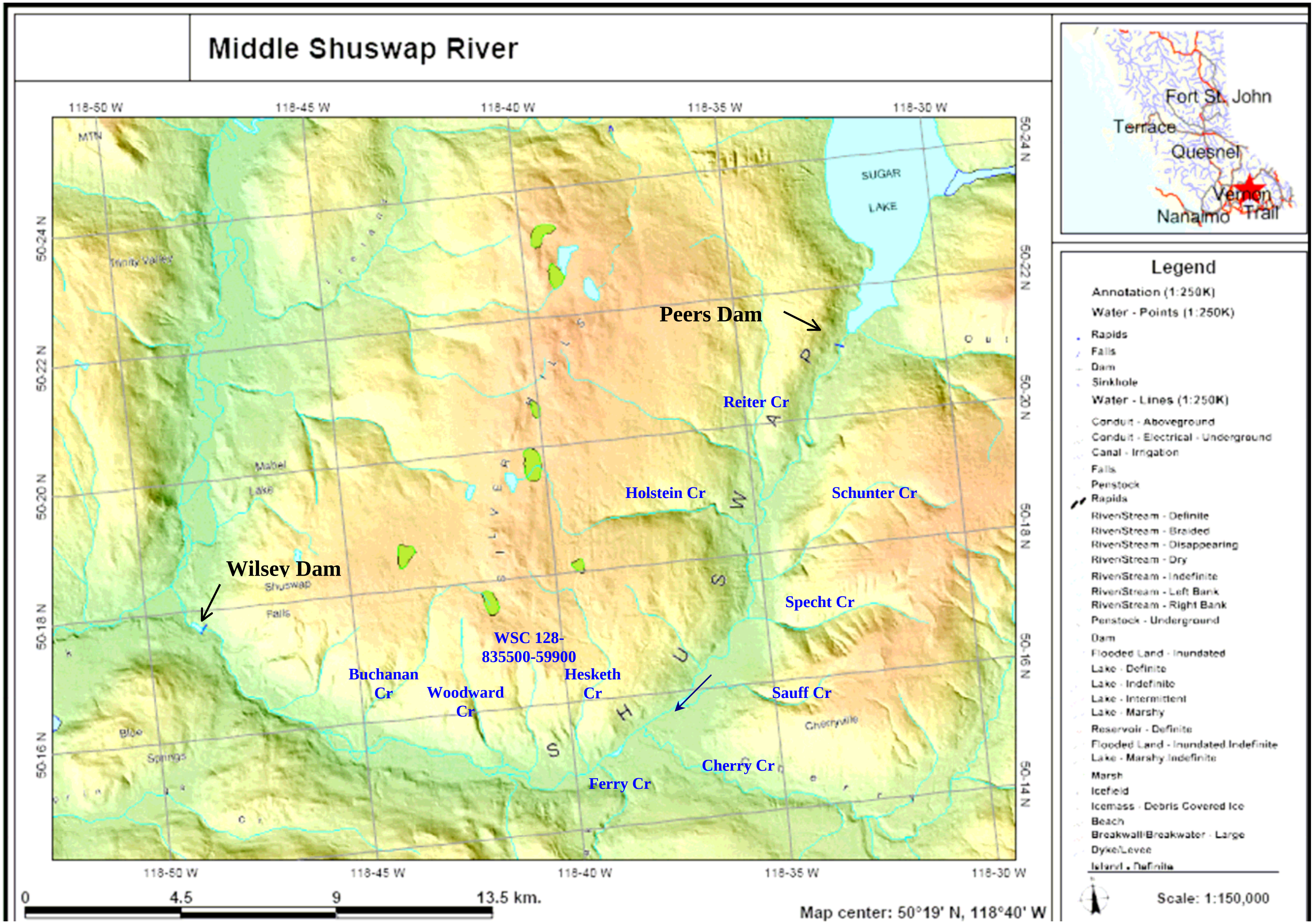

Figure 4: This hillside-shaded image shows the study area located between the dams at Sugar Lake and Shuswap Falls with the tributary streams labeled. Source: BC Water Resources Atlas Web Mapping Application, http:srmapps.gov.bc/apps/wrbc/

The middle Shuswap River between the two dams has a drainage area of 2000 km^2 with an average (1990 to 2005) mean daily flow of 52.15 m^3/s and an average total annual discharge of 30,961.5 m^3 (Environment Canada). The drainage area upstream of the Sugar Lake Dam is 1113 km^2 and the tributary area between Sugar Lake Dam and Wilsey Dam is 856 km^2 (BC Hydro, 2005). Sugar Lake is considered to be oligotrophic with low levels of macronutrients, phytoplankton and zooplankton (Bryan and Jensen, 1999). The elevation of land in the study area ranges from 450 m to 2680 m (BC Hydro, 2005). The biogeoclimatic subzone in the study area changes from the warm moist Interior Cedar-Hemlock on the southwest leg to moist-warm Interior Douglas fir on the northwest leg (Ministry of Forests 2003). The precipitation in the cedar hemlock zone around Sugar Lake is substantially greater than that of the Douglas fir zone in Vernon/Cherryville valley (Figures 3 - 5).

The primary land-uses in the study area are agricultural and residential at lower elevations and logging in the upper portions of the watershed. Agriculture is predominantly livestock and hay production. Livestock range on Crown land at mid and upper elevations. Logging has been taking place in the study area for more than 40 years and is still occurring to some degree on both Crown and private lands. The section of the Shuswap River from Cherryville to the Wilsey Dam is a locally popular tube and canoe run during the summer months.

The Shuswap River above Wilsey Dam is more incised with a narrow flood plane compared to the area below the dam where most the farmland lies within the flood plain. As a result, riparian area upstream of Wilsey Dam is relatively undeveloped compared to the area downstream of the dam. While much of the old growth conifers have been removed from the riparian area, land-clearing activities has only encroached into the riparian area in a few areas. There are still old cottonwood riparian forests with dense undergrowth and beaver ponds of up to1.5 ha along much of the river. This riparian area provides habitat for numerous species of wildlife including the endangered western screech-owl (Davis and Weir 2004).

Fish species identified in earlier studies in this section of the river are: bull trout (*Salvelinus confluentus*), rainbow trout (*Oncorhynchus mykiss*), mountain whitefish (*Prosopium williamsonii*), longnose dace (*Rhinichthys cataractae*), redside shiner (*Rhichardsonius balteatus*), prickly sculpin (*Cottus asper*), slimy sculpin *(Cottus cognatus)*, *longnose* sucker (*Catostomus catostomus*) and northern pikeminnow *(Ptycheilus oregonensis)* (Triton 1995). Whitefish are the most abundant species in the Shuswap River between the dams (Griffith 1979; Fee and Jong 1984). Rainbow trout are the dominant species in the tributary streams. Standing stock assessments carried out in 1979, 1984 and 1995 indicate that the river system was performing below theoretical capacity (Arc 2001).

Adult Chinook salmon were transplanted above Wilsey dam in 1993 and 1995. Chinook fry were transplanted above Wilsey Dam in 2007.

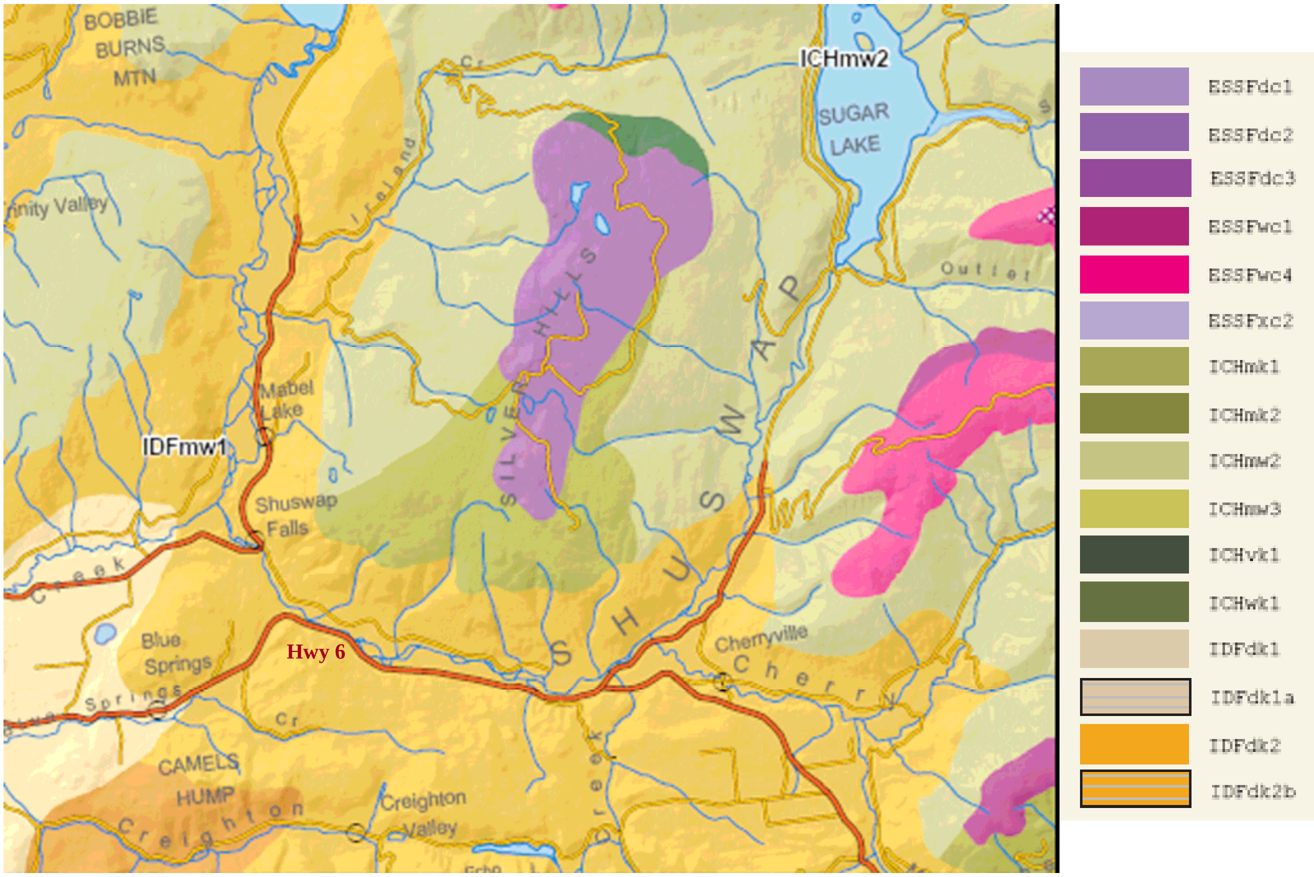

Figure 5: The moist warm interior Douglas fir subzone is extends just past Schunter Creek on the middle Shuswap River. Upstream of there it is the warm moist cedar hemlock subzone. Source: BECWEB

There are five tributaries to the Shuswap River in the study area that have year-round flows: Cherry, Ferry, Reiter, Holstein and Schunter Creeks with Cherry Creek being the most significant. The origin of the discharge measured just below Wilsey Dam on October 12, 1994, (20.1 m^3/s) was 75% Sugar Lake, 10% Cherry Creek, 1.2% Ferry Creek and 13.8% from groundwater and other tributaries (Triton 1995). During the first week of August 2006 the flow measured at Wilsey Dam ranged from 25 to 23 m^3/s (Figures 6). The flow from Sugar Lake for this period was a steady 21 m^3/s (Figure 4) making up 84 % to 91 % of the flow. The flow from Sugar Lake is regulated and relatively constant while the unregulated flows in the tributaries show daily fluxuations and gradually decrease with the dryness of the summer season (Figures 8 & 9).

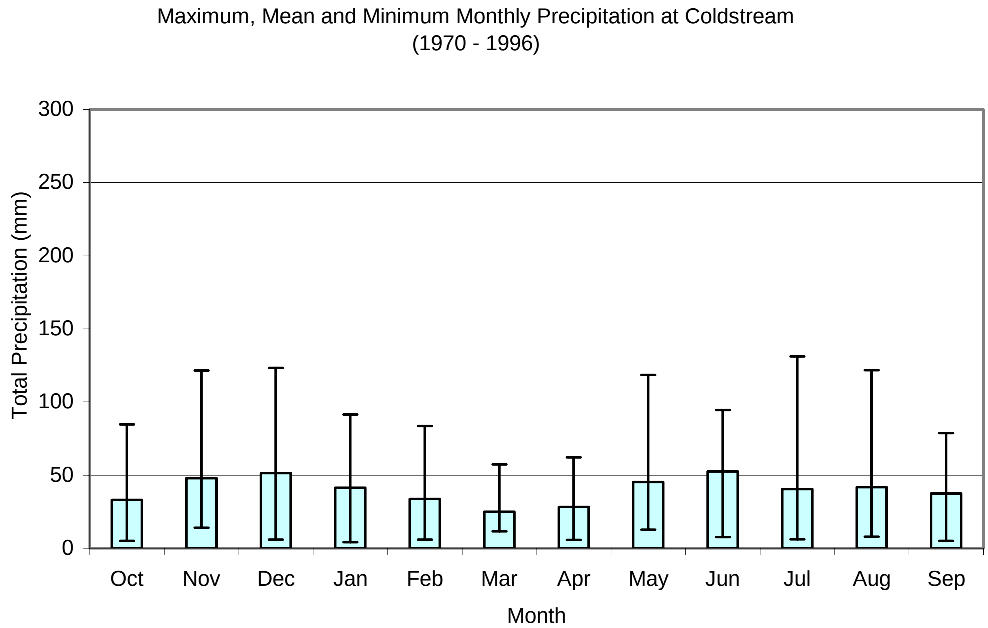

Figure 6: Precipitation between Wilsey Dam and Cherryville is similar to that shown for the Vernon-Lumby valley. (Source: Environment Canada Climate Data, http://www.climate.weatheroffice.ec.gc.ca/climateData)

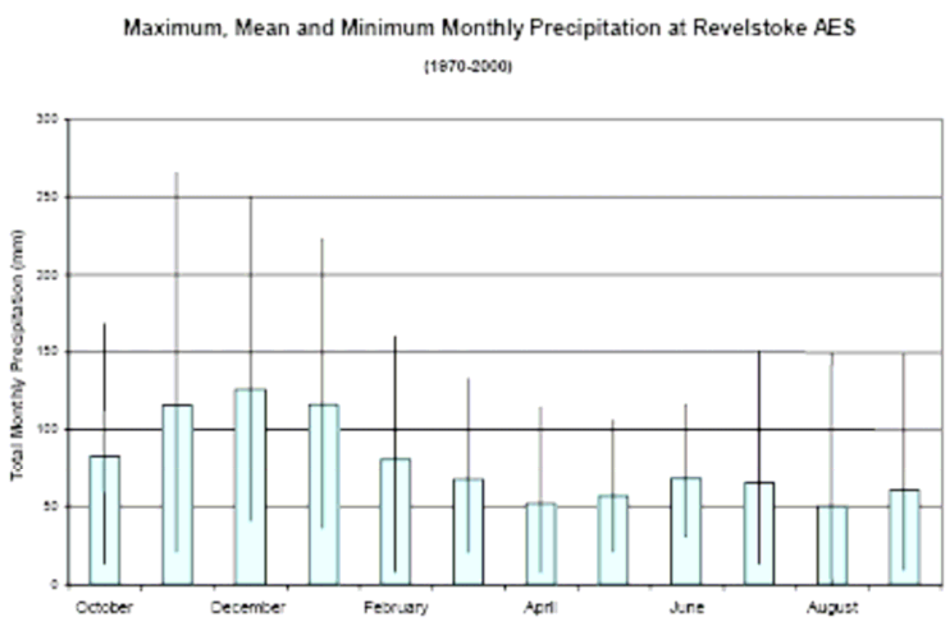

Figure 7: Precipitation at Sugar Lake is similar to that at Revelstoke. (Source: BC Hydro, 2005)

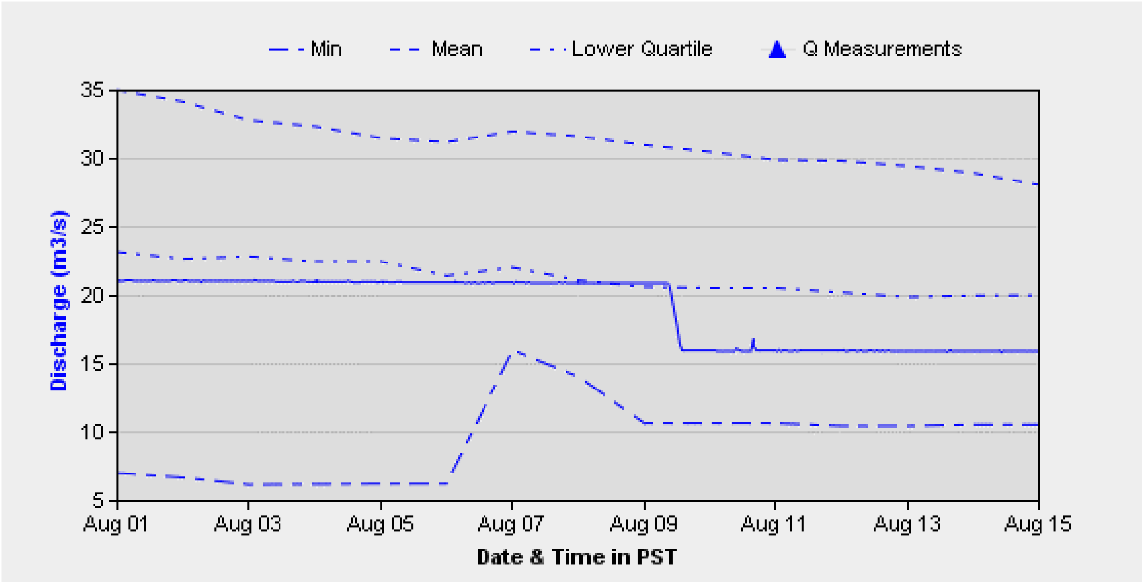

Figure 8: Shuswap River hydrograph measured below Peers Dam at the Sugar Lake outlet (WSC 08LC018) for the first two weeks of August 2006. The reservoir dampens daily fluctuations in discharge. The mid-August discharge was decreased to allow BC Hydro to dredge the fore bay at Wilsey Dam. (Source: Environment Canada's Real-Time Hydrometric Data, www://scitech.pyr.ec.gc.ca/waterweb/fullgraph.asp)

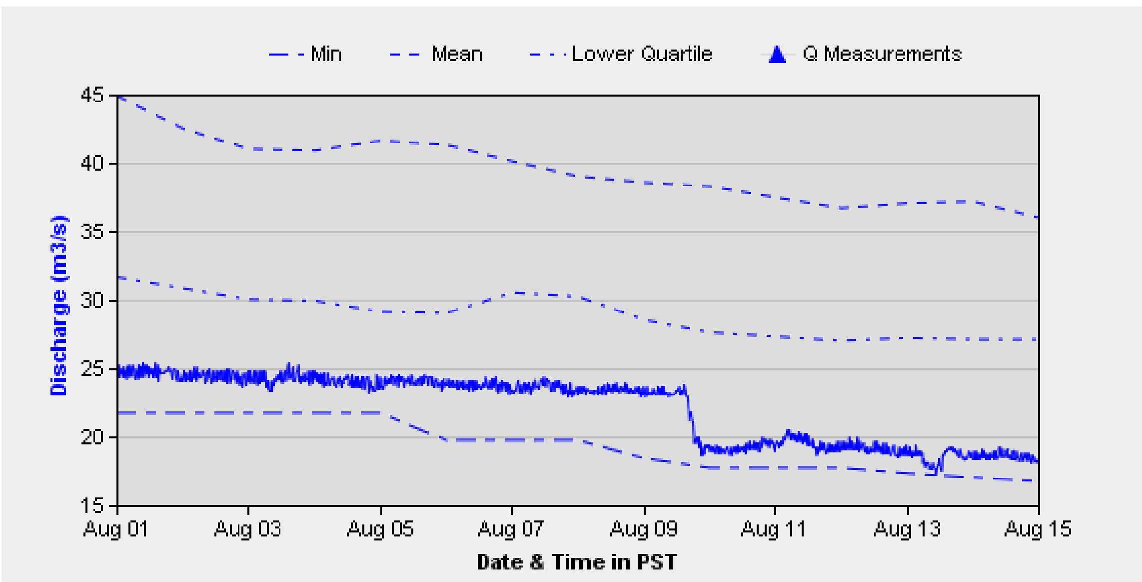

Figure 9: Shuswap River hydrograph measured near Wilsey Dam (WSC 08LC003) showing flows ranging from 25 cms to about 18 cms during the first two weeks of August 2006. The difference in flows at Wilsey and Peers Dams, roughly 4 cms or 16% of the flow at Wilsey, is due to inflows from tributaries and ground water between the two dams. The flow measured near Wilsey Dam reflects daily fluctuations and a gradual decrease from the unregulated tributaries. (Source: Environment Canada's Real-Time Hydrometric Data, www://scitech.pyr.ec.gc.ca/waterweb/fullgraph.asp)

Cherry Creek flows for roughly 41.2 kms with a drainage area of approximately 503 km^2 (Triton 1995). The main tributaries to Cherry Creek are Monashee, Currie and Severide Creeks. Bull trout (*Salvelinus confluentus*), rainbow trout (*Oncorhynchus mykiss*), longnose sucker (*Catostomus catostomus*), slimy sculpin *(Cottus cognatus)* and northern pikeminnow *(Ptycheilus oregonensis)* have been found in the main stem and tributaries (Arc Environmental, 2001, Trumbley Environmental Consulting, 2002).

Ferry Creek has a main stem length of approximately 30 km and drains an area of 145 km^2. Until recently fish passage was blocked at Hwy 6 by a perched culvert. DFO built a riffle downstream of the culvert to remedy this in 2000.

Holstein, Reiter and Schunter Creeks are the other tributaries with year-round flow. They are 9 km, 10.5 km and 7.4 km in length with watershed areas of 25 km^2, 36km^2 and 13 km^2 respectively. Rainbow trout (*Oncorhynchus mykiss*) have been found in all three creeks (Arc 1998, Arc 2002)

There are six creeks that supply intermittent flows to the Shuswap River in the study area: Specht Creek, Woodward Creek, Hesketh Creek (WSC 128-835500-60900), an un-named registered tributary (WSC 128-835500-59900) and two smaller (< 1 km in length) unnamed tributaries. Buchanan and Sauff Creeks have no visible channels connecting the upland creek to the Shuswap River.

Methods

The SEI was contracted out to an experienced firm that has completed other SEI's in the area including Central Okanagan Sensitive Ecosystems Inventory (2001) and the Vernon Commonage Sensitive Ecosystems Inventory (2005).

The SHIM was generally conducted according to the standards set out in the SHIM Manual (Mason 2001). The SHIM method was developed primarily for smaller watercourses than the Shuswap River. Streams are to be mapped by walking the centerline of the creek with a high quality gps unit to record locations every three seconds. The stream centerline is defined as the line midway between the bankfull lines of the left and right banks. This would be the midpoint of the wetted area only during bankfull flows and is often not the midpoint of the wetted area during low flow periods. Where it is not possible to walk the centerline, an offset can be used. While this technique was applied to most of the side channels and tributaries to the Shuswap River, the main channel of the Shuswap River is too fast even in low water to safely transverse the centerline. Instead, for the majority of the river, the bankfull lines on both sides of the river were walked and mapped. The centerline was later drawn as a line midway between these two lines. Surveying both banks of the river was more time consuming, but, in many areas, was the only way to ensure that no small side channels or tributaries were missed. Where the banks were well vegetated, it was difficult to see whether or not there were small watercourses, springs or back channels from the opposite shore. On the canyon section of the Shuswap, immediately upstream of Wilsey Dam, just the top of the right bank (north) was walked and mapped. The steepness of this section prevented both sides of the river from being easily walked. However, the steepness also made the opposite bank clearly visible, so there was less chance of overlooking small tributary watercourses.

Where just one side of the river was walked and an offset used, additional reference points were made at approximately 100 m intervals. At each of these reference points three points at bankfull level on the opposite side were picked and the bearing and distance recorded. These reference points were then used when mapping the centerline.

Another variant from the SHIM method was the estimation of the wetted depth for the main stem segments where the water was too fast to safely conduct measurements. Where it was possible to wade into the river, the estimated depth was confirmed by measurement with the graduated walking staffs. This gave the crew additional confidence in reporting the wetted depth for most riffles and runs. However, pools with depths over 1 m were estimated without confirming measurements.

The field data was downloaded daily and emailed to SOPAC, Dominion Radio Astrophysical Observatory, in Penticton (http://sopac.ucsd.edu/sites/) for differential corrections. The corrected files were then exported from the pathfinder software to either .shp or .dwg files and centerline drawn using either ArcMap or AutoCAD. All files were eventually imported into ArcMap to be combined into one map with the attributes and photographs attached to each stream segment with the 2004 color orthophoto as background in a .shp file. The .shp files were then uploaded to the Community Mapping Network by the staff of the Allan Brooks Nature Centre.

TRIM maps and recent (2004) color orthophotos used for the project were obtained through the province's data exchange program from the Base Map Online Store (http://www.basemaps.gov.bc.ca/).

Prior to commencement of fieldwork, permission was sought from landowner to access the river or tributaries through their property. Contact was made by phone or site visits. Information sheets about the project and the SHIM process were prepared and handed out during site visits. Fifty-three landowners were contacted and permission was granted by fifty-two.

Equipment:
A Trimble Pathfinder ProXR gps unit with a Trimble TSC1 data collector was used for mapping.

Distances under 10 m were measured with a 30 m fiberglass measuring tape; distances from 10 to 100 m were measured with a Bushnell Yardage Pro Sport 450; distances over 100 m were measured with a Bushnell Yardage Pro 1000.

Bearings were measured with Suunto MC-2 and Suunto KB14/360R compasses.

Digital photographs were taken with a Panasonic Lumix DMC-FZ50 camera with the zoom set at the 35 mm equivalent. Photographs were taken at 1280 x 960 pixels and later reduce to 600 x 450 pixels for uploading to the Internet. This camera records sound as well as pictures so photos were identified by creek name, segment number, photo number for this segment and direction (upstream, downstream or cross-stream) at the time the picture was taken. This information was used to compile the photo information when they were downloaded. For example, photo # *shuseg7.5p1u* would be photo 1 of segment 7.5 of the Shuswap River taken facing upstream.

A Marsh-McBirney Flo-Mate 2000 was used to measure stream velocity. Discharge measurements in the creek were made according to RIC standards.

Wading staffs were made of 3.18 cm diameter Douglas fir dowelling and marked at 0.1 m intervals. The staffs were slightly longer than 1.5 m and used by surveyors for balance and to measure wetted depth.

Temperature was taken with double metal casing alcohol thermometers.

Provincial (Ka/PE06-23550) and Federal (XHAB 140 2006) fish collection permits were obtained prior to sampling.

Slopes were measured with a Suunto inclinometer, PM-5/360PC graduated to 1^o or 1%. The lower 20 kilometers of the Shuswap River in the study area is under 0.3% so segment gradients were estimations except in the steeper sections.

Stream bank slopes were also measured as part of the segment classification. This is the slope from stream centerline to the top of the bank. This slope measurement is a function of both the bankfull width and the height of bank. This must be taken into account when comparing bank steepness of different size streams. A 5 m vertical bank on a creek with a 50 m bankfull width (25 m to centerline) will have a slope of 11^o. If the bankfull width were 10 m, the same bank slope would be 45^o.

The middle Shuswap River had been defined as 5 reaches in earlier studies (Fee and Jong, 1984, Triton Environmental, 1995, Arc Environmental, 2001). Three of these reaches (3-5) are located in the study area (Figure 10). However, for the SHIM, the river is divided into smaller segments based on 22 stream and riparian categories (Table 1). When there was a change in any of these categories, a new segment was identified and the changes entered into the data collector. SHIM stream segments may be as short as 20 m, especially in smaller streams. The portion of the Shuswap River between the dams was broken into 326 segments including the side channels. In general, the main stem of the river was denoted with whole segment numbers. Side channel segments were denoted with a decimal of the main channel segment. For example, the first segment of a side channel that flowed into segment 65 of the main stem was denoted as segment 65.1. All stream mapping began at the point farthest downstream and worked upstream. The entire survey was begun at the upstream end of the head pond of Wilsey Dam at the Mabel Lake Road Bridge.

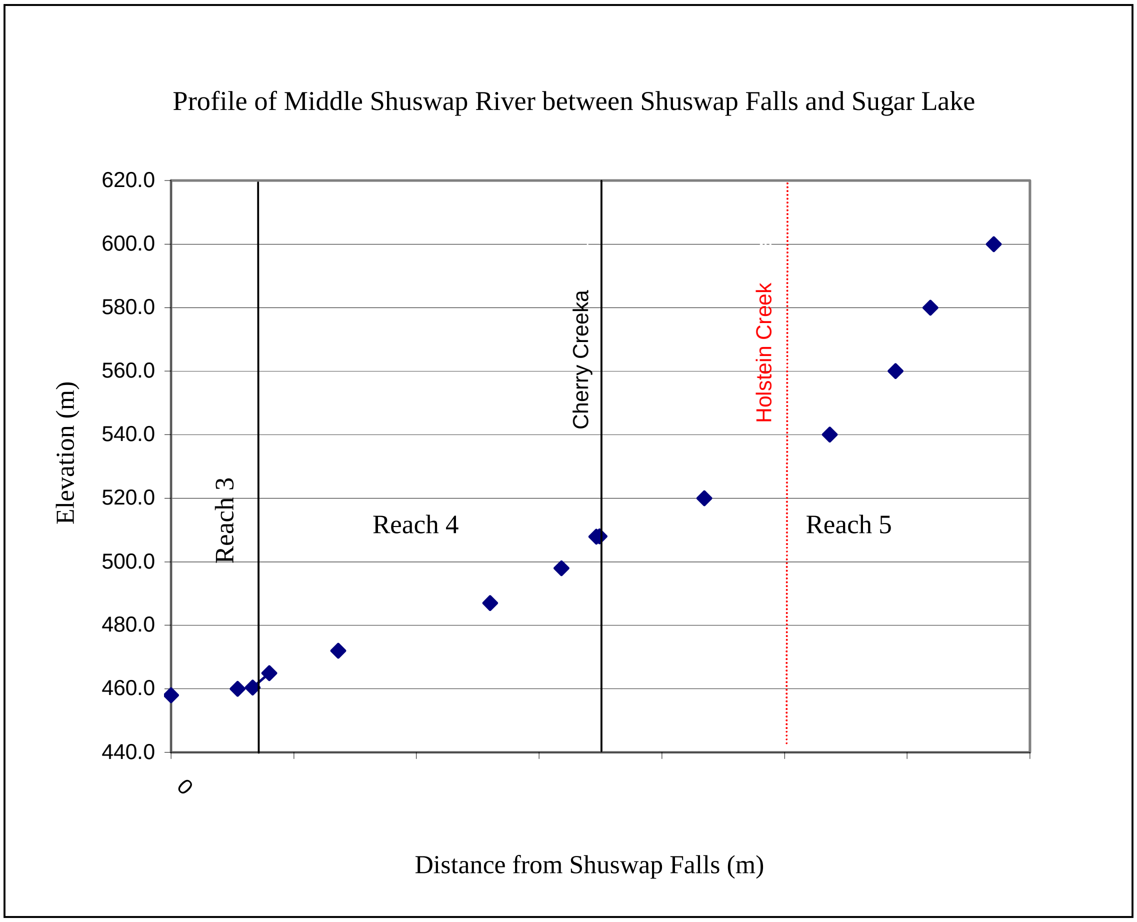

Figure 10: Profile of the Shuswap River between the dams. River distances were taken from the SHIM. Spot elevations for the profile were taken from BC Water Resources Atlas web map, http://srmapps.gov.bc.ca/apps/wrbc/. Cherry Creek was used as boundary between Reach 4 and Reach 5 in the earlier studies. However, the change in gradient, hydraulic type, substrate, cover, confinement and biogeoclimatic zone occurs around Holstein Creek.

Table 1: Stream and riparian characteristics recorded for each segment. These characteristics will be shown as attributes on the online SHIM map. When a stream segment is selected, the stream attributes can be viewed along with a photo of that segment.

Stream Characteristics (Section)	Categories		Riparian Characteristics (Section)	Categories
Primary Stream Class	Natural	Culvert	Riparian Class	Intensive Agriculture
	Channelized	Modified		Non-intensive Agriculture
	Ditch	Discontinued		Broadleaf forest
	Flume	Other		Bryophytes
Secondary Stream Class	Beaver pond	Side Channel		Coniferous forest
	Ephemeral	Wetland		Christmas tree farms
		Other		Disturbed wetland
	Perennial			Dug out pond

Dominant Hydraulic Type	Beaver pond Wetland Slough Pool Riffle	Riffle/pool Cascade Cascade/pool Falls Run		Exposed soil Flood plain Gravel/soil roads Hay field Herbs/grasses Impervious manmade Lawns & Landscaping Logged areas Mixed forest Natural wetland Rock Residential med/high-density Residential low density Residential forested Shrubs
Crown Closure	0 1-20% 21-40% 41-70% 71-90% 1>90%			
Spawning Habitat	Anadromous Resident Unknown	Potential None		
Access for Livestock	Many Few	Potential Unknown	Riparian Band Width	Number of meters
Segment Gradient	Number of Degrees		Bank Slope	Number of Degrees
Bars	Longitudinal or Crescentric (LC) Transverse (TR) Medial (ME)	Diagonal (DI) Point or Lateral (PT) None (NO)	Riparian Structural Stage	Low shrubs (<2m) Tall shrubs (2-10m) Sapling (>10m) Young forest Mature forest Old forest
Substrate Composition	Organic Fines Gravel Cobble Boulder Bedrock		Presence of Snags	None <5 >5
Substrate Compaction	Low Medium High		Presence of Veteran Trees	None <5 >5
Channel Dimensions	Bankfull width (m) Wetted width (m) Active floodplain width (m) Bankfull depth (m) Unstable banks		Density of Shrubs	0-5% 6-33% 34-66% 67-100%
			Bank Stability	High, medium or low
Instream Cover	Total cover % Boulder (B) % Deep Pools DP) % Instream vegetation (IV) % Large woody debris (LWD) % Over-stream vegetation (OV) % Small woody debris (SWD) % Undercut bank (UB)		Dominant Bank Material	Fines Gravel Cobble Boulder Bedrock
			Top of Bank	Riparian band edge represents the estimated top of bank Riparian band edge does not represent the estimated top of bank

Where islands present and one channel was obviously larger that the other, the larger channel was denoted as the main channel and the smaller channel a side channel. Where there was no apparent difference in the two channel capacities, both channels were given whole segment numbers. Islands were distinguished from bars in that at least part of the island was above the bankfull stage. Islands were usually treed with conifers at various developmental stages. Gravel bars may have been treed with deciduous trees up to four meters tall, but there was evidence of recent flooding across the entire bar (i.e. the whole bar was below the bankfull elevation). In the case of bars, only one centerline was mapped halfway between the two bankfull lines. Therefore, the bar would not be indicated on the centerline map and would only be indicated in the attribute information.

When the data was compiled and tabulated, only the side channels that were wetted and connected to the main stem at moderate to low flows were used in calculating the total wetted area for the study area. Dry channels, wetlands and standing water not directly connected to the river were not included.

For comparison to two earlier studies, segments 1-5, 6-49 and 50 – 147 were combined for comparison to reaches 3, 4 and 5 respectively.

A team of at least two persons carried out the fieldwork. One person carried the gps backpack, mapped the center or bankfull line and entered all the data into the required fields of the data collector. The second person carried a backpack with tape measure, camera and first aid kit. A throw bag was also attached to the outside of the second person's pack for easy access. Both team members carried thermometers, inclinometers, compasses, range finders, bear spray and cell phones in their survey vests. The second team member kept hand-written notes with a scaled map to aid with gps line interpretation. The hand notes also included a tally of pools and large woody debris to be entered into the data collector at the end of each segment. The second person walked ahead of the gps person as a safety precaution and to help spot any changes in the stream or riparian characteristics that should be noted or required a segment change. This lead person also helped with the measurements needed for each segment.

Because of the large area, only lower portions of the tributaries could be mapped. Cherry Creek alone, for example, would take a full field season for a two-person team to map with all its tributaries. The tributary mapping was terminated at a point were the survey could easily be resumed such as a bridge or culvert at a road crossing.

Polygons indicating riparian types were defined from the most current color orthophotos (2004) and ground truthed during the SHIM centerline mapping. Where the coniferous forest came to the top of bank, a road or other easily identifiable feature, that boundary was used as the extent of the polygon even if the forest extended beyond the road.

One of the objectives of this mapping project was to quantify the potential spawning and rearing areas for salmonids between the dams. Hydraulic type, substrate and water depth were used as indicators of potential spawning area. Potential spawning areas were limited to areas where the dominate and sub-dominate substrate size were gravel and cobble. The dominant could be either of these sizes as long as the sub-dominate was the other. Main stem spawning areas were limited to water depths between 40 and 100 cm and side channel spawning areas were limited to water depths between 10 and 40 cm. The wetted widths of the segments with the proper substrate size and depth on the main stem were multiplied by their lengths to get the gross areas. The calculated rearing area for the current study is the sum of all side channel wetted areas with water depths greater than 20 cm at the time of survey.

Results

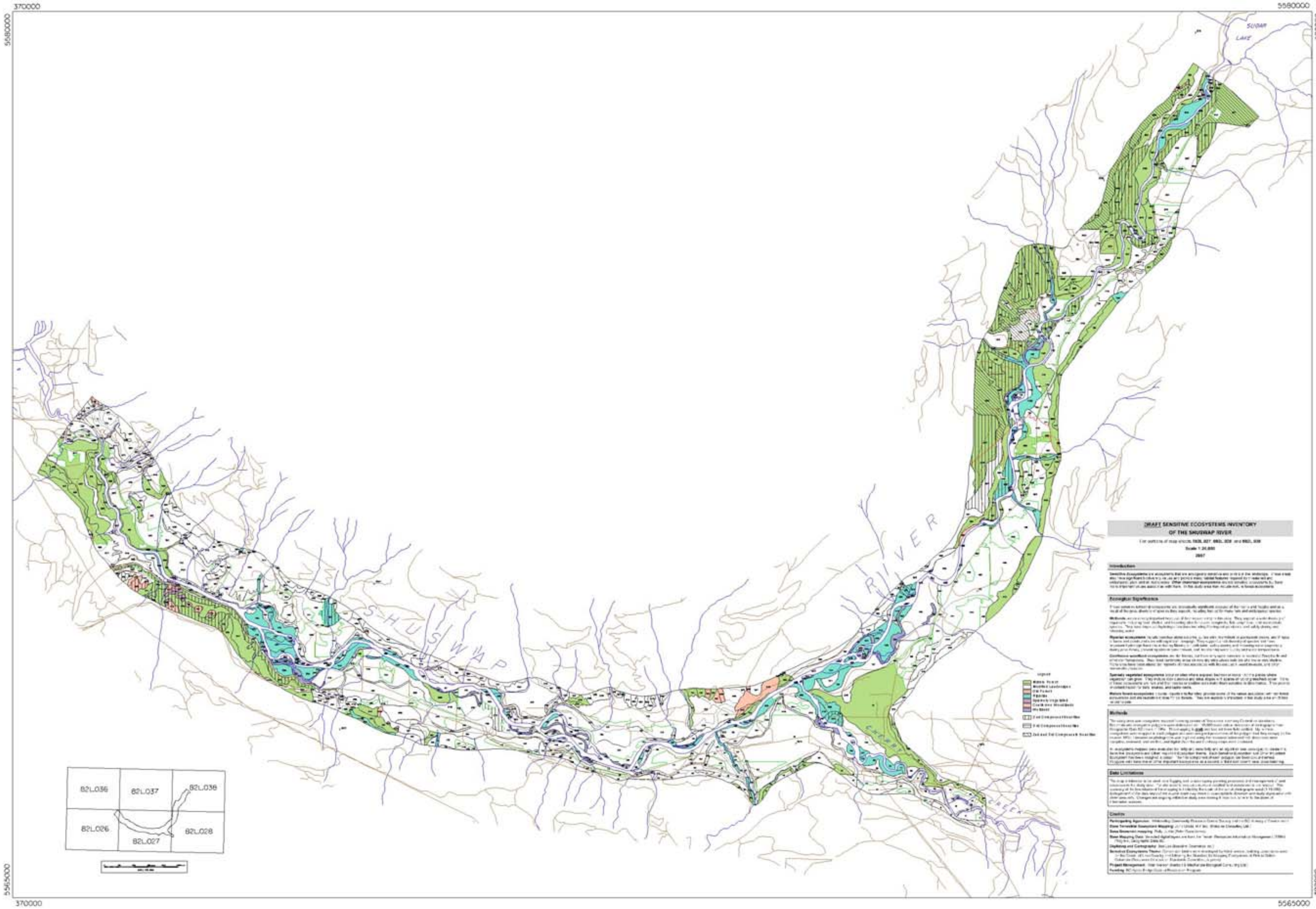

Figure 11: Preliminary SEI of the Middle Shuswap River between dams.

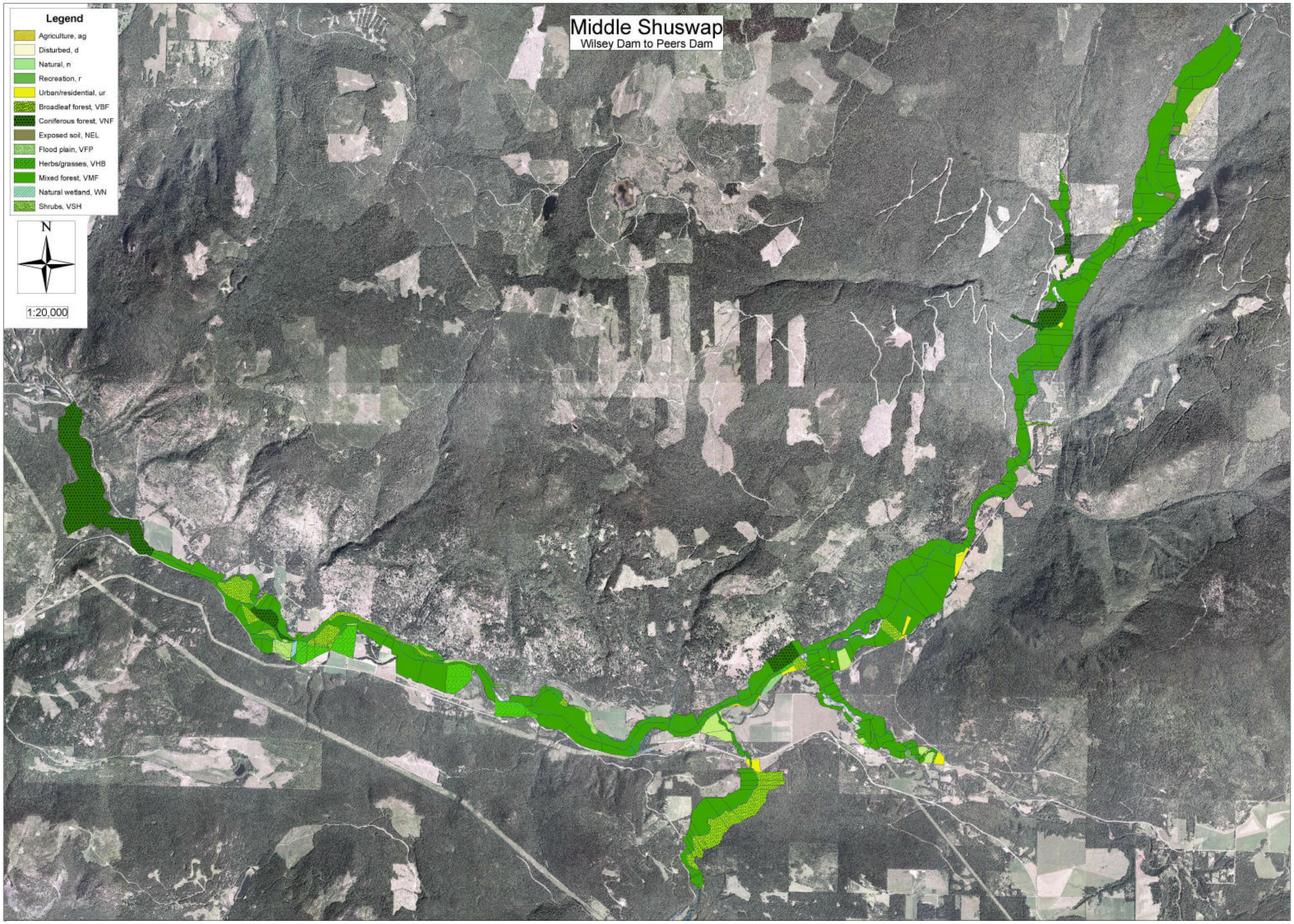

Figure 12: Riparian types

A total of 82,846 m of streams were mapped for the SHIM portion of the project. This included 32,931m of main stem and 27,667 m of side channel on the Shuswap River and 22,248 m of tributaries.

The preliminary SEI map and the SHIM can be viewed online at the Community Mapping Network. The SEI map is also shown in pdf format in Appendix D.

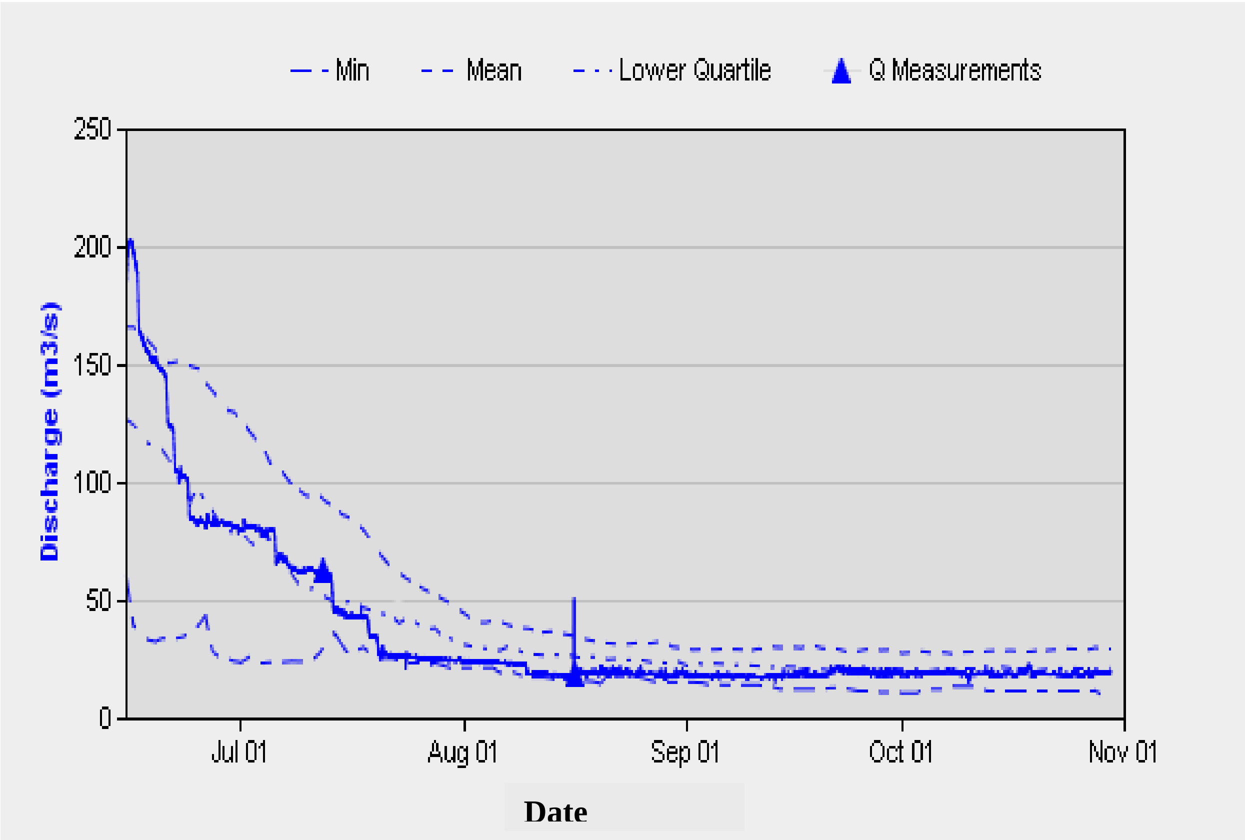

Figure 13: hydrograph of the Shuswap River measured immediately downstream Wilsey Dam at Water Survey Canada station 08LC003 during the time of the survey. The flow in the Shuswap during the mapping period was between the lower quartile and minimum flow. The peak flow for 2006 was 25 % higher than the 71 year average but quickly dropped to close to the minimum recorded flow by mid-July. Mapping of the main stem Shuswap took place between July 14 and October 24, 2006.

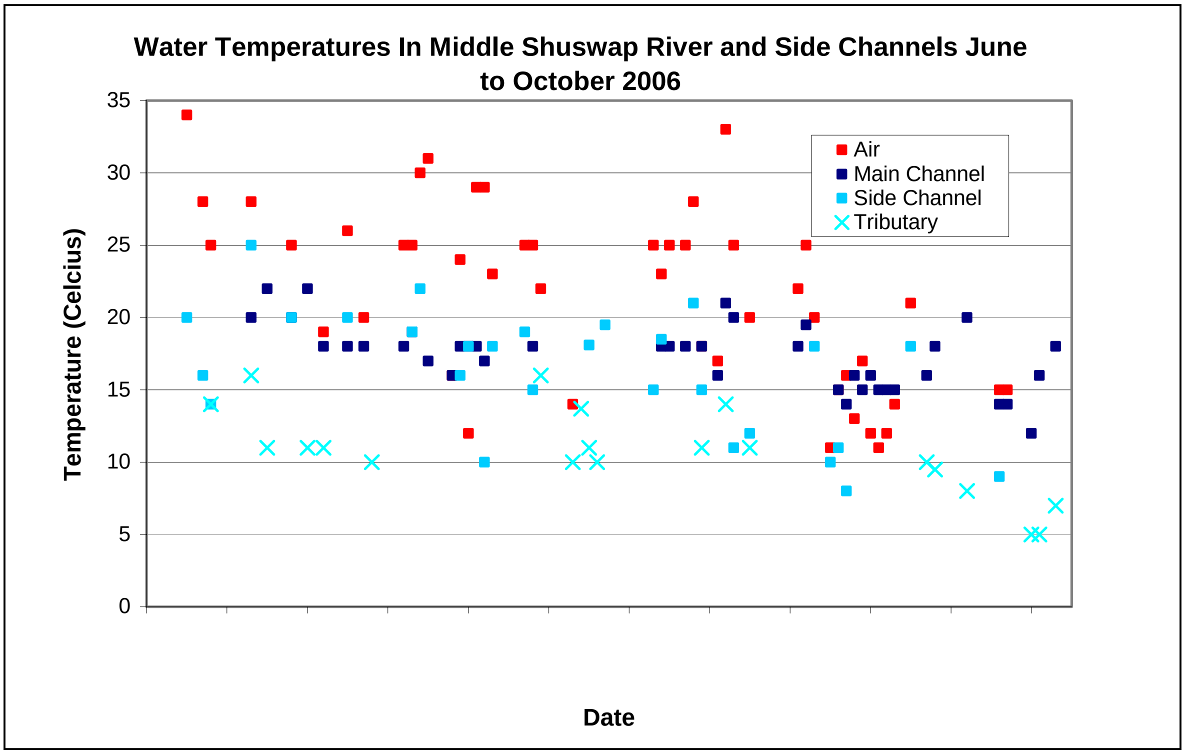

Figure 14: Water and air temperatures measured during the survey from the last week in June until the first week in September 2006 on the Shuswap River and tributary streams. The main channel temperatures were within a narrow range from 12 to 22 ^{0}C. Side channel temperatures had a greater temperature range of 8 to 25^{0}C. The tributary temperatures were generally cooler than the river and ranged from 5 to 16^{0}C. The cooler temperatures in the tributaries may be partially responsible for the greater abundance of rainbow trout found in the some of the tributaries.

Table 2: Potential spawning areas in the Middle Shuswap River between dams characterized by hydraulic conditions, depth of water and substrate. Main channel areas included in this tabulation have a wetted depth of 40 to 100 cm. Side channels have a wetted depth > 30 cm.

Substrate (dom/subdom)	Riffle		Riffle/Pool		Run		Total Area (ha)
	Mean depth (cm)	Area (ha)	Mean depth (cm)	Area (ha)	Mean depth (cm)	Area (ha)	
Main Channel gravel/cobble	35	3.31	47	3.07	90	.95	7.33
Main Channel cobble/gravel	56	38.19	57	2.43	59	17.67	58.29
Side Channels gravel/cobble	40	0.36	40	4.25	50	1.44	6.05
Side Channel cobble/gravel	-	-	50	1.16	-	-	1.16
Area of Combined hydraulic and substrate types							72.83

Table 3: Lengths and areas of channel of the Shuswap River between Wilsey and Peers Dams with predominantly spawning size gravel/cobble substrate. All side and main channels are included that have a wetted depth between 0.2 and 1.5 m.

% Gravel (2–64 mm)	% Cobble (64-256 mm)	Length (m)	Area (ha)
70 - 90	0-25	2,110	1.21
50 – 69	25-45	2,960	7.57
40 – 49	30-60	7,190	22.13
30 - 39	70 - 50	7,940	32.66

Table 4: Area and relative abundance of different cover types in the main stem and side channels in the study area as an area and as a percentage of the total area. The dominant cover types in the main river are boulders and deep pool. The majority of deep pool area in the main channel is found within 3 km above Wilsey Dam. Boulders dominate the 10 kms of the main channel below Peers dam. The side channels have a higher percentage of all types of cover except boulders than the main channel.

Shuswap River between dams	Boulders (B) (ha)	% Total Wetted Area with B	Deep Pools (DP) (ha)	% Total Wetted Area with DP	In-stream Vegetation (IV) (ha)	% Total Wetted Area with IV	Large Woody Debris (LWD) (ha)	% Total Wetted Area with LWD	Over-stream Vegetation (OV) (ha)	% Total Wetted Area with OV	Small Woody Debris (SWD) (ha)	% Total Wetted Area with SWD	Under-cut Bank (UC) (ha)	% Total Wetted Area with U C	Total Wetted Area with Cover (ha)
Main stem	14.54	9.82	10.23	6.91	0.01	0.01	2.50	1.69	1.58	1.07	0.57	0.38	0.12	0.08	29.55
Side Channels	0.97	4.85	2.76	13.75	1.54	7.67	1.00	4.96	0.80	3.98	3.46	0.69	0.23	1.14	7.99
Combined area of all habitat types in both the main channel and side channels															37.54

Table 5: Hydraulic types in main stem and side channels both as areas and as percentage of total wetted area. The main channel is predominately riffles. The side channels have a greater variety of hydraulic types. Beaver activity is largely responsible the relatively high percentage of pond habitat.

Shuswap River between Dams	Total Wetted Area (ha)	Standing Water (ha)	% Standing	Pond (ha)	% Pond	Pool (ha)	% Pool	Run (ha)	% Run	Riffle (ha)	% Riffle	Riffle/ Pool (ha)	% Riffle/ Pool	Cascade (ha)	% Cascade
Main Stem	148.1	0	0	0	0	0.29	0.2	49.26	33.4	84.41	57.0	13.03	8.8	0.88	0.6
Side Channels	20.7	0.37	1.8	3.56	17.2	1.68	8.1	4.51	21.8	5.67	27.4	4.89	23.6	0.02	0.1

Table 6: Comparison of the results of three studies done on the middle Shuswap River between Shuswap Falls and Sugar Lake. Segments of the SHIM were grouped to correspond to the reaches used in the earlier studies for comparison purposes.

Study	Reach	Q[1] (m^3/s)	Wetted Width[2] (m)	Reach Length (m)	Wetted Area (ha)	Riffle Depth (cm)	Gradient (%)	Pool (%)	Run (%)	Riffle (%)	Total Cover (%)	Fines (%)	Gravel (%)	Cobble (%)	Boulder (%)	Bedrock (%)
Fee & Jong (1984)	3	25 - 30	43.0	3,700	15.9	-	0.2	35	55[3]	10	-	20	30	50[4]		
	4		39.1	13,100	51.2	-	0.26	5	80	15	-	5	41	54		
	5		39.0	15,200	59.3	-	0.63	4	42	53	-	4	4	62		
Trident (1995)	3	15.5 - 27	17.3	3,700	10.73	70	-	5.0	80.0	15.0	3.0	8.0	17.0	50.0	22.0	3.0
	4		31.0	13,100	40.61	52	-	3.4	68.3	28.3	2.6	3.0	17.0	60.7	18.6	0.7
	5		29.8	15,200	45.36	69	2.0	0.9	40.1	59.0	2.9	2.7	15.5	55.0	25.0	0.7
SHIM (2006)	3	16 - 30	49.2	3,280	16.13	200	0.07[5]	4.3	18.4	73.8	52	4.8[6]	28.6	33.2	10	23.4
	4		56.74	13,810	74.99	60	0.36	9.7	34.4	56.0	11	10.0	23.3	52.9	13.6	0.1
	5		49.4	16,070	75.43	73	0.58	11.5	33.2	55.3	22	6.0	22.1	51.9	19.8	0.2

[1] Range of flow at the time of survey
[2] Main channel and side channels
[3] Fee and Jong distinguished between run and glide. These two have been combined for comparison purposes.
[4] Fee and Jong categorized substrate >10 cm as "Larges"
[5] Gradients for the reaches was determined using distances from the SHIM and spot elevations from the B.C. Water Resources Atlas web map, http://srmapps.gov.bc.ca/apps/wrbc/
[6] Organics and fines are grouped together for this comparison. Percentages are weighted by fraction of total wetted area. Side channels are included in the total wetted area.

Fish were sampled at 14 sites, 13 sites were above Wilsey Dam and one site was located below the dam. Six sites were side channels on the Shuswap River and eight sites were on tributaries. Most sites were sampled for presence/absence and composition. Additional sampling was done on three side channels of the Shuswap River, Cherry Creek and Ferry Creek using a double pass depletion method for estimating densities and collecting data for calculating mean condition factors. The ONA report on the fish sampling results can be found in Appendix E.

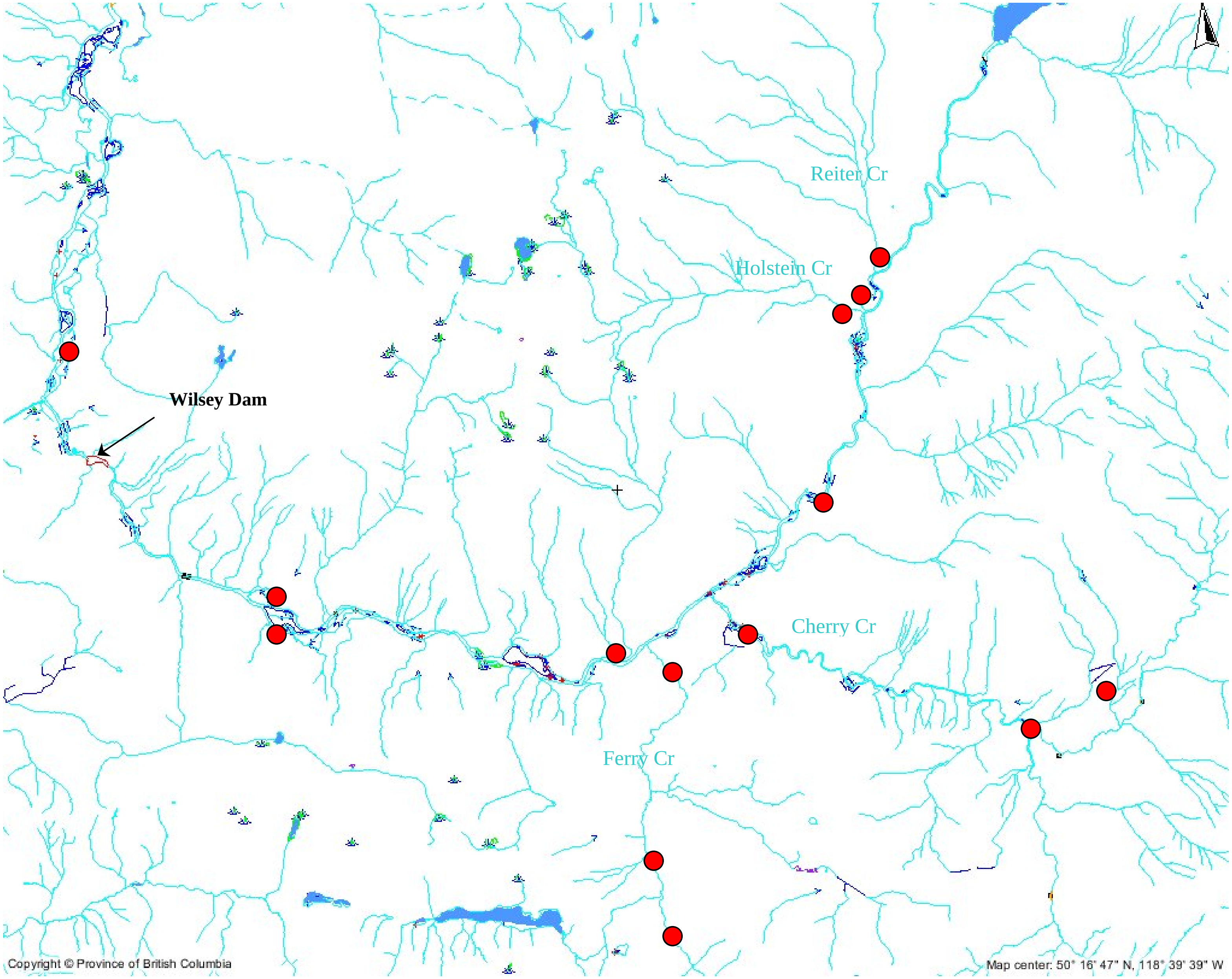

Figure 15: Electrofishing sites are marked by red dots.

Discussion

The preliminary SEI has delineated the study area into polygons of various habitat types. While this data has to be ground-truthed before it will be accepted into the provincial database, it can be used by the local MOE office and NORD when reviewing development proposals. Fieldwork is expensive and may take several years to fund. The preliminary SEI can be used to prioritize the fieldwork need to finalize the SEI.

The primary goal of this project was to map the sensitive habitat between the Shuswap Falls and Sugar Lake. While all riparian areas are considered sensitive habitat the study area is characterized by its variety and its relatively undisturbed nature. As a transition zone between two biogeoclimatic zones, the study area ranges from open, dry ponderosa pine/bunchgrass and Douglas fir forests to moist red cedar/hemlock forest to black cottonwood/ white spruce riparian habitat. As a result of the incised nature of the river in the study area, the riparian area upstream of Wilsey Dam is relatively undeveloped compared to the area downstream of the dam. Only a few houses and a golf course are within the floodplain above the dam. Most of the agricultural land below the dam is within the floodplain and flooding impacts much of it on a yearly basis. Below Wilsey land-clearing and other agricultural activities have impacted the riparian forests. Above the dam, much of the conifers have been removed, there are still old cottonwood riparian forests with dense undergrowth and beaver ponds of up to1.5 ha. These riparian areas shelter numerous side channels and minor tributaries.

The SHIM portion of the project identified the extent and diversity of the side channels in the study area. There are 27. 8 km of side channels with a full spectrum of hydraulic and cover types that provide a greater variety of fish and wildlife habitats than found in the main channel. While the TRIM maps and orthophotos present the main channels of the Shuswap River and its tributaries well, they are sometimes inaccurate or incomplete with respect to the smaller tributaries and side channels. The SHIM data is current, complete and based on field data. For example, Woodward Creek is shown on the TRIM maps to enter the Shuswap River 525 m downstream from where it actually does. Two other examples are given below where the SHIM data is more accurate and/or complete (Figures 16 & 17).

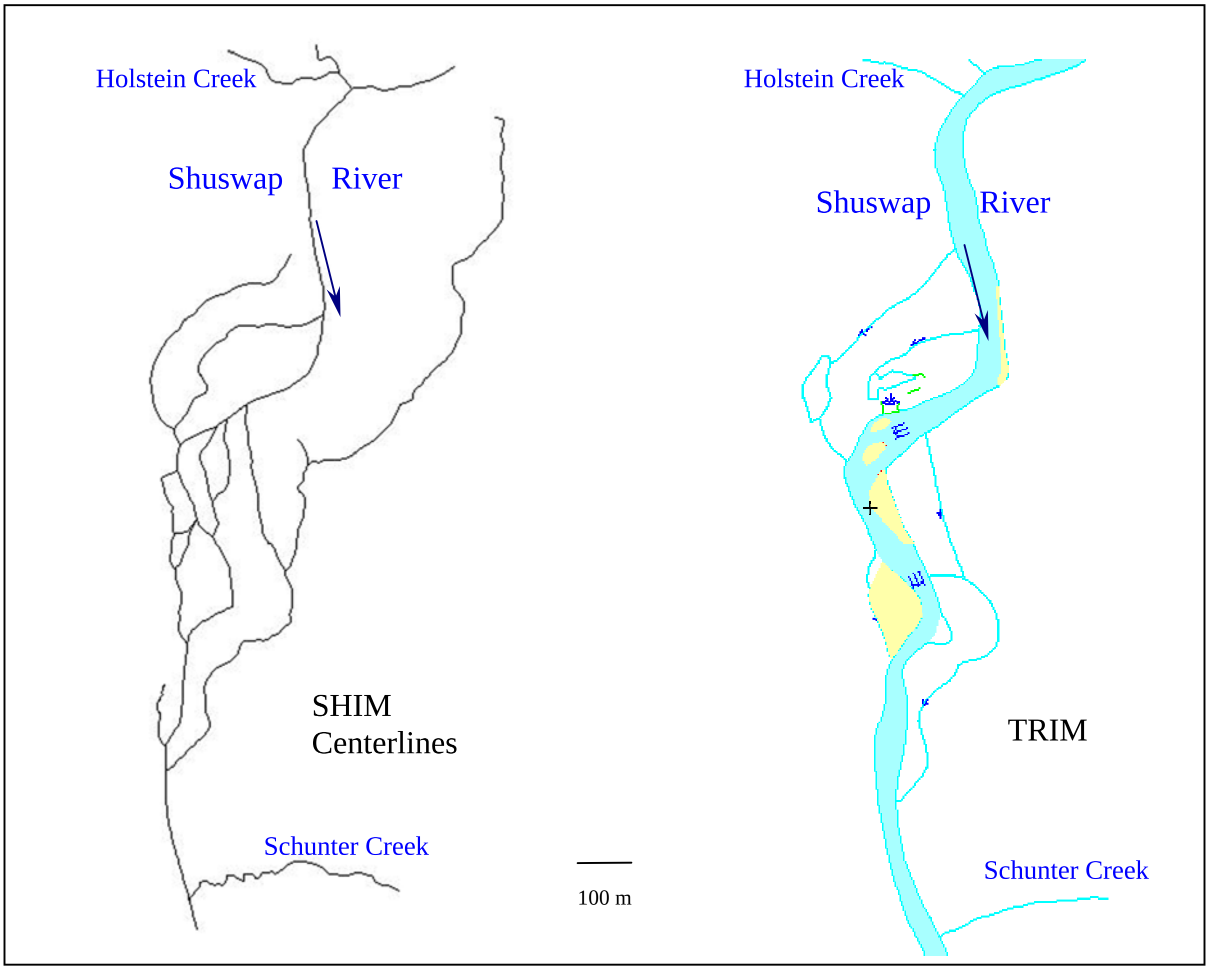

Figure 16: A section the SHIM stream centerline map of the compared to the TRIM map. Both maps show 1800 m of river and side channels between Schunter and Holstein Creeks on the Shuswap River. The TRIM shows the main channel and some of the side channels but does not include several side channels or an 1100 m remnant channel that provides groundwater and rearing habitat. Both the SHIM data and the TRIM data will be available on the Internet: the SHIM data from the community mapping network's North Okanagan Resource/Habitat Atlas (http://www.shim.bc.ca/atlases/nord/main.htm) and the TRIM from MOE's Online Cadastre (http://srmwww.gov.bc.ca/sgb/IMF/index.html) or BC Water Resources Atlas (http://www.env.gov.bc.ca/wsd/data_searches/wrbc/) sites. The advantage of the SHIM site will be both the accuracy of the mapping and the amount of data available. The SHIM is overlaid on the TRIM data so the differences are immediately viewed. When a segment of a stream is selected in the SHIM data, a window opens displaying the stream attributes (Table 1) and a photograph of that segment.

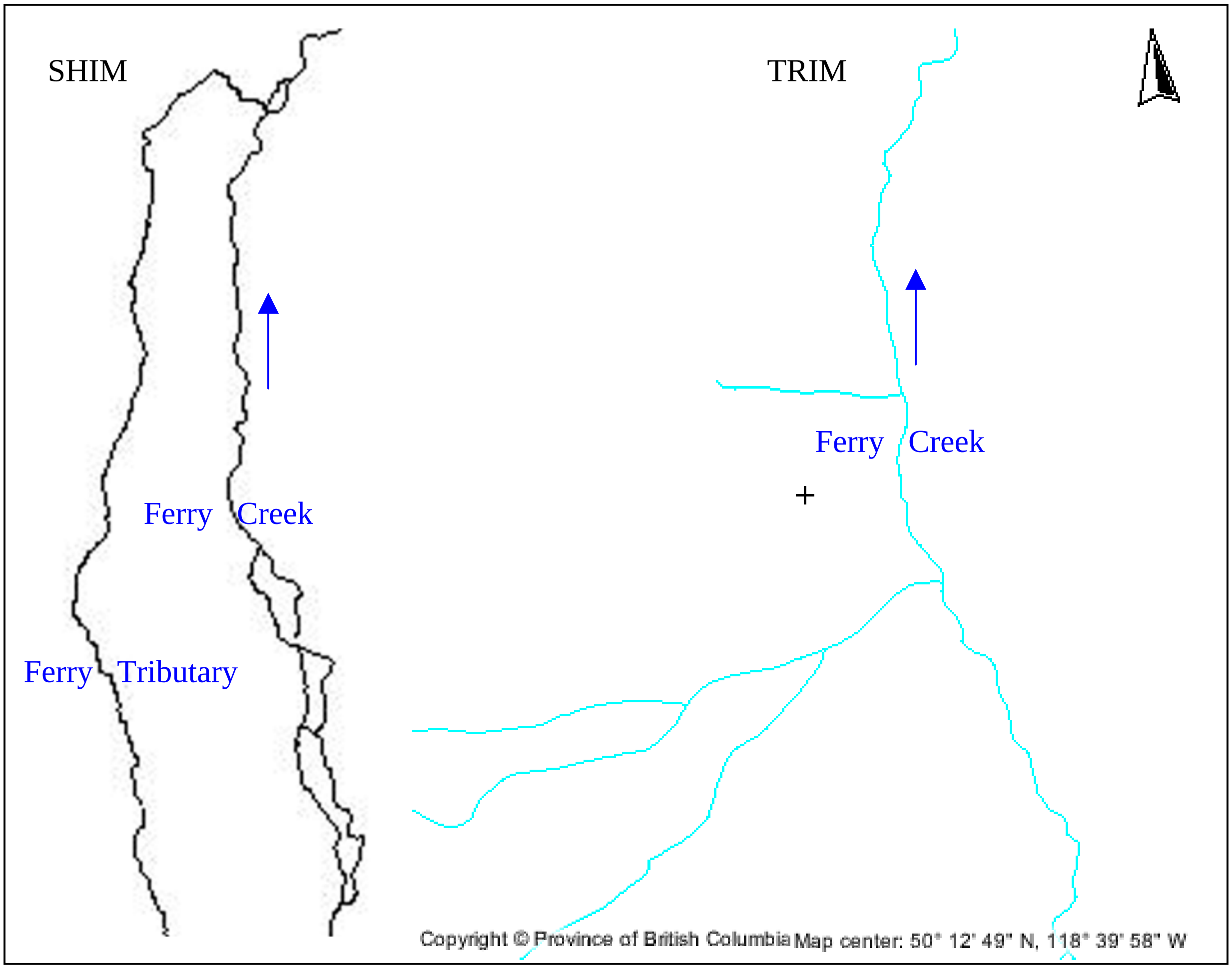

Figure 17: The SHIM centerlines on the left show the actual tributary and side channels of this 2 km section of Ferry Creek compared to the TRIM information on the right. Local residents who have water rights on this un-named tributary inaccurately call it Bonneau Creek. Both the landowners and the provincial Water Management Branch were notified of the error so that their water rights could be amended.

Figure 18: Two different beaver ponds on the Shuswap River. The top pond is 15,000 m^2 while the lower one is roughly 5,000 m^2.

Figure 19: The side channels vary in amount and types of cover. The upper channel is loaded with large woody debris while the lower channel has some small woody debris and undercut banks.

Figure 20: The side channels differ in amount of flow, substrate, temperature and cover. The upper channel is open with boulder substrate and is fast flowing during peak flows. The lower, remnant channel in largely ground water with a fairly constant flow. The temperature of the lower channel was 8^0 C, ten degrees cooler than the river when

surveyed. Groundwater channels such as this one provide cooler summer temperatures and warm winter temperatures than the main channel.

These small channels and seasonally wetted areas tend to be eliminated when development occurs. The beaver ponds are particularly vulnerable to development. What has typically happened in the past on private property was the dams were removed and the area drained. The channel areas were often filled with debris from land clearing. Even today with greater emphasis on environmental sustainability and stewardship and more regulations in place to protect streams and riparian areas, the dams can be removed if they are causing damage to property or interfering with irrigation. A trapper can be hired to remove the beaver. Once drained, the area can be used for pasture, eliminating much of the aquatic and riparian habitat value. With these channels mapped, setback requirements and conditions can be incorporated into any future development approvals.

Spawning Area

One of the objectives of the project was to quantify potential spawning and rearing habitat in the study area. The spawning and rearing preferences of salmonids vary slightly with species. Chinook prefer main stem reaches of moderate to large systems with gradients of 0.25 - 3%, water depth of 35-55 cm and substrate size of 13 - 102mm for spawning (Slaney & Zaldokas, 1997, Keeley & Slaney, 1996). Coho prefer tributaries and main stem with moderate gradient of 0.25% to 4%, depths of 10-40 cms and substrate size of less than 15 cm diameter (Leman, 1989, Grout & Margolis, 1991, Keeley & Slaney, 1996). In a survey done on the middle Shuswap downstream of Wilsey Dam in 2000, the average depth of Chinook redds was 61 cm with a range of 5 to 140 cm. The substrate was largely small cobble (64-128 mm) and large gravel (16-64 mm)(Arc, 2001b).

There are 72.83 ha of gravel/cobble substrate covered by at least 0.3 m of water at low flows (Table 3) in the study area. This is slightly less than an earlier estimate of 76.5 ha of spawning size gravel (Summit 2002). The earlier estimate was based on air photos and site visits and represents the total area with 13 mm to 102 mm gravel substrate without considering water depth.

Table 7: Spawning depths found in the middle Shuswap River downstream of Wilsey Dam (Arc 2001b)

Species	Study	Ave Depth (m)	Range (m)	Substrate
Chinook	Arc 2000	0.61	0.05-1.40[1]	Large gravel and small cobble
	Triton 1994	0.59	0.17-0.98	-
Coho	Arc 2000	0.43	0.22-0.80	Small gravel and large gravel
Sockeye	Arc 2000	0.59	0.20-1.30	Fines, small gravel and large gravel

[1] The low end of the depth range is partially explained by a reduction in flow between the time of spawning and the time the redds were surveyed.

There have been several studies done previously that evaluated the potential for salmon production or the potential impact of restoring passage on rainbow trout upstream of Shuswap Falls (Griffith, 1979, Fee and Jong, 1984, Triton, 1995). The current project mapped habitat locations and types. No attempt was made to calculate production capabilities. However, there are some comparisons that can be made to the section of the river below Wilsey Dam where salmon production has been previously monitored. The lower middle Shuswap River has a lower overall gradient (0.16 %)(Griffith 1979) than the upper (0.41 %) and correspondingly smaller substrate. The river gradient increases with distance upstream from Mabel Lake to Sugar Lake. Downstream of Wilsey Dam, spawning takes place primarily in the 8 km downstream of the dam with the majority of chinook spawning within the area 3.5 km downstream of the dam (Arc 2001c). Summit estimated there were 49.2 ha of spawning gravel between Wilsey Dam and Mabel Lake (Summit 2002). The substrate in the most heavily utilized area (70 – 75 % superimposition) is composed of 1% boulders, 33 % cobbles, 54 % gravels and 12 % fines (Arc 2001c). Upstream of the dam, there are 3 kms of river that have 50 – 60% gravel and 25 – 45% cobble. There are 6 kms of river segments surveyed upstream of Wilsey Dam that have predominately gravel substrate. There are another 8 kms of segments that are predominantly cobble with gravel as the subdominant substrate size. There is also spawning size substrate in Ferry and Cherry Creeks. If spawning gravel is the limiting factor for Chinook, production upstream of the dam could be double what it is in the lower Middle Shuswap.

However, one potentially limiting difference between the main spawning areas downstream of the dam and the areas with suitable substrate upstream of the dam that was pointed out by Stephan Wolski, the biologist in charge of the Shuswap Hatchery, is the number and location of deep pools. Downstream of Wilsey Dam, there are eight deep pool areas (Figure 21) interspersed with the spawning areas. Downstream of each of these pool areas are spawning gravels. The Chinook typically use these pools as holding areas and then drop back to spawn (Wolski, 2007). Above the dam there are fewer pools. There are extensive pool areas in the canyon segment above Wilsey Dam and smaller deep pool areas at segments 26 and 66 located 10.8 kms and 20.7 kms above the dam. There are also a few areas with extensive cover like the large debris jam in segment 16 (7kms upstream of the dam). However, these potential holding areas are not as well spaced as the pools downstream of the dam.

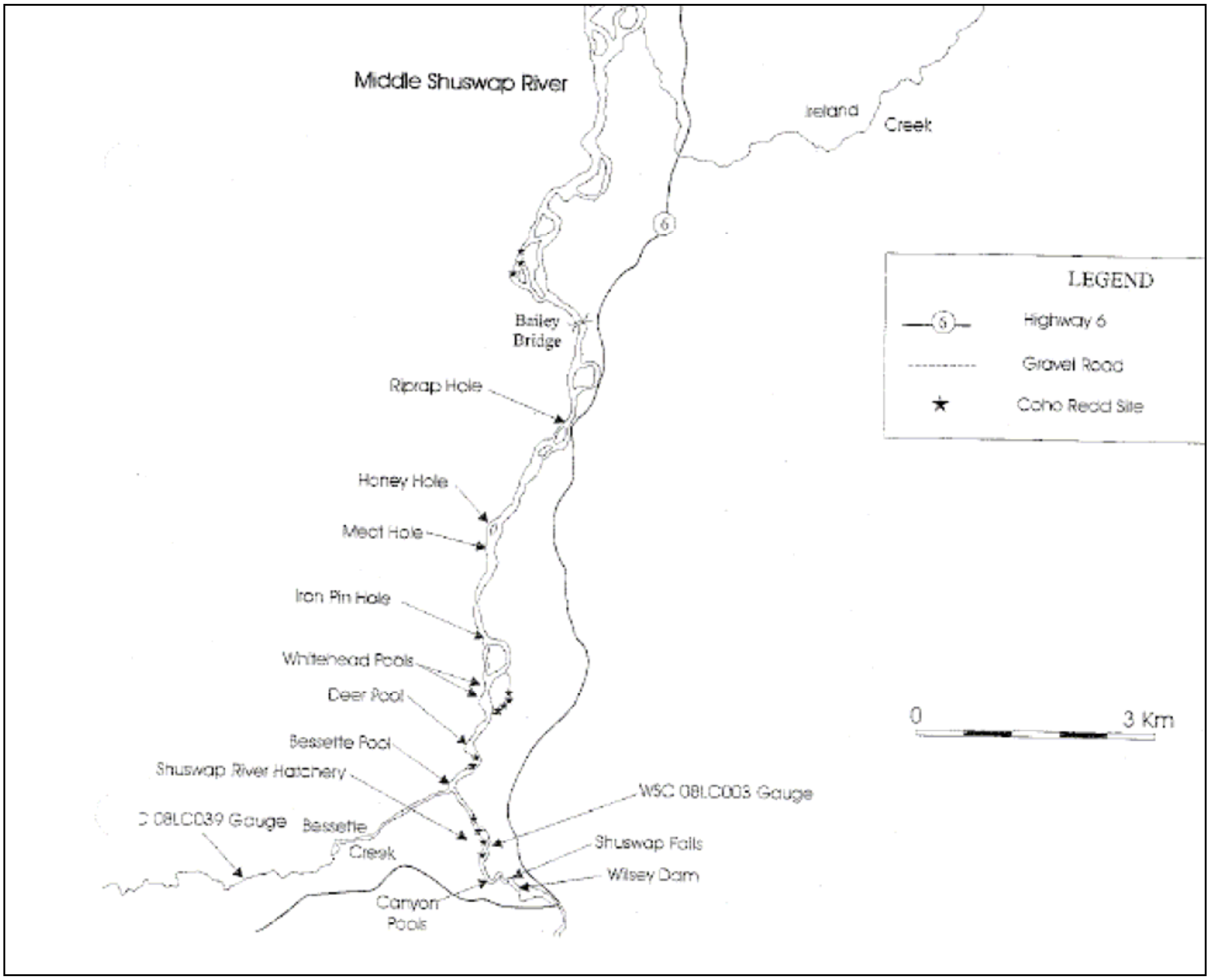

Figure 21: Below Wilsey Dam the spawning areas are interspersed with deep holding pools where Chinook hold until conditions are right for spawning. (Source: Arc, 2001b)

Rearing Area

The majority (95%) of Chinook found in the middle Shuswap River in previous studies are ocean types (Arc, 2001) so rearing habitat is not likely a limiting factor for Chinook. Coho prefer deep, low velocity habitats (pools) in tributaries and main stems for rearing (Hartman, 1965, Fee & Jung, 1984, Bustard, 1975).

There are 26.5 kms of side channels on the Shuswap River in the study area, 25.1 kms were wetted at the time of survey and 1.4 kms were seasonally wet. The wetted side channel area was 27.59 ha. All these offer potential rearing or refuge habitat during different stages. The side channel habitat has a greater diversity of hydraulic types (Table 5) as well as a greater diversity and relative abundance of cover (Table 4) than the main river. The side channels have less flow and generally lower velocity more suitable for salmonid rearing than the main channel.

In comparison, the lower section of the Middle Shuswap River, agricultural development is farther advanced that the area above the dam. Much of the side channel areas had been cut off from the river. A substantial amount of money and effort have gone into restoring some these rearing channels. The five constructed channels have a total area of roughly 16 ha (Table 8).

Table 8: Wetted area of restored/ constructed channels downstream of Wilsey Dam.

Channel	Maltman	Limmer/Lang	Huwer	Procter	Ireland	Total
Area (ha)	2.0	3.9	1.2	8.1	0.4	15.6

Accurately identifying these small side channels and their riparian areas is important aspect of this project. The side channels and small tributaries have a greater diversity in hydraulic types, greater amounts and types of cover, lower velocity, greater range in temperature and greater groundwater influence than the main river. They range from 15,000 m^2 beaver ponds (Figure 18), to debris filled pool areas (Figure 19), to small groundwater–fed streams (Figure 20). The greater diversity of physical conditions provide for a greater diversity of plants, invertebrates and wildlife. These side channels and small tributaries provide rearing areas for salmonids. Beaver dams can convert an oligotrophic stream to a highly productive wetland. Inundation of riverine environments by beaver dams increases deposition of organic-rich sediments that is readily colonized by highly productive aquatic macrophytes and periphyton (Wetzel, 2001). Beaver ponds are a preferred winter habitat of over-wintering coho (Bustard and Narver 1975, Bryant 1984, Swales et al 1989, Nickelson et al 1992). In a 2004 study of a Washington State river system roughly the same size as this study area (1,771 km^2 vs. 2,000 km^2), Pollock et al estimated that the current winter smolt production potential has been reduced by 86% of historic smolt production potential mostly from the loss of beaver ponds.

Conserving the natural channels is likely more cost-effective and maintenance-free than restoring channels in developed areas. Some natural processes are not easily confined to the 5 m to 15 m riparian strip on either side of the stream that are usually given up by the landowner in restoration projects. Damming by beavers, for example, often results in flooding that goes beyond the riparian corridor, damages property and crops and interferes with the operation of the farm or ranch. Road crossings in the restored channels are often targeted by beaver for daming and can result in barriers to fish passage and damage to the road structures.

Fish presence and distribution in the Middle Shuswap River and its tributaries have been established (Arc Environmental Ltd. 1998, Arc Environmental Ltd. 2001a, Arc Environmental Ltd., 2001b, Arc 2001c, Arc 2002, Griffith, R.P. 1886, Fee, J. and J. Jong, 1984, Snowy River Resources 2002, Triton 1995, Trumbley 2002) and was not necessary for the SHIM. However, because of the question of interspecies competition particularly between juvenile rainbow trout and coho if salmon were re-introduced above the falls, some sampling was done to confirm that the study area is generally under utilized by rainbow trout.

In the three earlier studies done on the Middle Shuswap River, the Middle Shuswap was considered under utilized in varying degrees. Griffith (1979) found that there was an abundance of prime under-utilized rainbow trout habitat in the mainstem between Cherry Creek and Brenda Falls and the low numbers of rainbow was due to lack of suitable mainstem spawning substrate in the mainstem. Fee and Jong (1984) observed a higher density of rainbow (12x) largely concentrated in reach 5. The Triton (1995) was more extensive than the earlier two studies (multiple pass electroshocking and three replicate snorkel counts compared to single pass shocking and one snorkel count) and found a lower density of rainbows than either of the two previous studies. A missing 1+ age class in reach 4 partially accounted for the low numbers. The Triton study found the observed 0+ and 1+ age densities of rainbow trout were 10 times lower than the theoretical optimum using Ptolmey's alkalinity model and 1.1 to 4.1 times lower using the Binns HQI model. The observed productivity in Ferry Creek was higher than the optimum predicted by the Binns model while the observed productivity in Cherry Creek fell within the predicted high and low values.

The current sampling indicated that the density of rainbow trout was lower in Cherry Creek that it was in the side channels of the Shuswap River. The rainbow density in Ferry Creek was six times higher than in Cherry Creek and three times higher than in the Shuswap River side channels sampled. The rainbow density was higher in both Cherry and Ferry Creeks than in the Triton study.

Recommendations

The SEI should be finalized. This would include ground truthing, conservation analysis and wildlife work.

BC Hydro owns property along the Shuswap River to about 6 km upstream of the Wilsey dam. Some of this property, notably the picnic site (formally the canoe launch), has considerable habitat value. There are five side channels and a beaver pond at this site that provide a variety of hydraulic conditions, substrate and cover types. The riparian area is less disturbed than the neighboring agricultural land. A covenant placed on this land would prevent the risk of future development.

Acknowledgements

Iverson and MacKenzie Biological Consulting Ltd conducted the preliminary SEI. Kristie Iverson managed this portion of the project and created the SEI from the TEM. The other members of her team were Polly Uunila, P.Geo, who did the draft bioterrain mapping and John Grods, R.P.Bio who did the draft TEM.

Justin Joe of the mapping section of the Okanagan Indian Band's Territorial Stewardship Department conducted the mapping portion of the SHIM.

The biological sampling was carried out by the Okanagan Nations Alliance (ONA) Fisheries Department.

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Appendix I: Performance Measures
NOT APPLICABLE

Performance Measures – Target Outcomes												
Project Type	Primary habitat benefit targeted of project (sq.m.)	Primary Target Species	Estuarine	In-stream Habitat – Mainstream	In-stream Habitat – Tributary	Riparian	Reservoir Shoreline Complexes	Riverine	Lowland Deciduous	Lowland Coniferous	Upland	Wetland
Impact Mitigation												
Fish passage technologies	Area of habitat made available to target species											
Drawdown zone revegetation/stabilization	Area turned into productive habitat											
Wildlife migration improvement	Area of habitat made available to target species											
Prevention of drowning of nests, nestlings	Area of wetland habitat created outside expected flood level (1:10 year)											
Habitat Conservation												
Habitat conserved – general	Functional habitat conserved/replaced through acquisition and management											
	Functional habitat conserved by other measures (e.g. riprapping)											
Designated rare/special habitat (subset)	Rare/special habitat protected											
Maintain or Restore Habitat forming process												
Artificial gravel recruitment	Area of stream habitat improved by gravel placement											
Artificial wood debris recruitment	Area of stream habitat improved by LWD placement											
Small-scale complexing in existing habitats	Area increase in functional habitat through complexing											
Prescribed burns or other upland habitat enhancement for wildlife	Functional area of habitat improved											
Habitat Development												
New habitat created	Functional area created											

Appendix II: Confirmation of BCRP Recognition

Vol. 17 No. 19 **Wednesday, May 17, 2006**

Water Restoration Projects for 2006

Whitevalley Community Resource Centre (WCRC) will be conducting two stream restoration projects during the 2006 season. The first is a riparian planting and protection project. This project is intended to protect the trees planted along the creeks in the Lumby area and along the Shuswap River. Over the past eight years, WCRC has partnered with numerous landowners, fencing the riparian border along the creeks in the Lumby area. Once the creek borders were fenced, planted and naturally generated trees have flourished. Many of these trees, especially deciduous trees such as willow and poplar, have reached a size that makes them susceptible to beaver damage. This summer, WCRC will be hiring a student to assist with the wire wrapping of trees in areas where beaver damage is evident to prevent further damage to the existing trees. In this project, we will also be planting conifer seedlings to replace trees that have already been damaged.

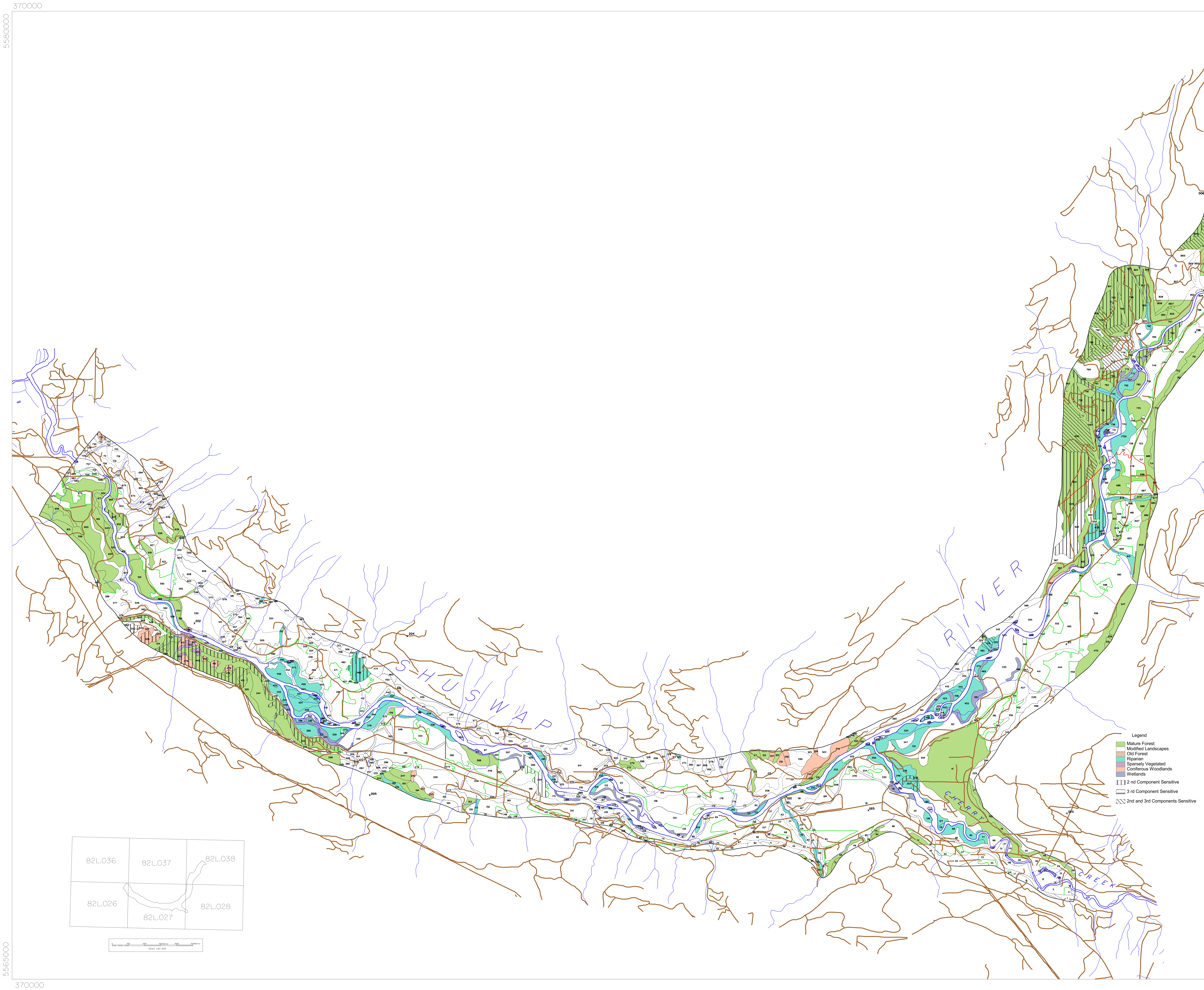
In the second project, WCRC will be working with the Okanagan Indian Band, the Okanagan Nation Alliance Fisheries Department, the Ministry of Environment and Fisheries and Oceans Canada to conduct a sensitive ecosystem inventory (SEI) and sensitive habitat inventory and mapping (SHIM) for the Shuswap River between the Wilsey Dam at Shuswap Falls and Peers Dam below Sugar Lake. A Sensitive Ecosystems Inventory (SEI) systematically identifies and maps rare and fragile ecosystems in a given area. The information is derived from aerial photography, supported by selective field checking of the data. The SHIM will identify, inventory and map all watercourses, their associated riparian habitats and important fisheries habitat features in the study area. The SHIM provides inventories and maps of a detail not currently available. The SHIM field survey and mapping techniques will allow the information to be incorporated into geographical information systems (GIS) using global positioning systems (GPS) for field collection. The electronic data can be integrated into municipal and regional planning maps. It will also be made available to the public via the Community Mapping Network on the Internet. The SHIM will provide up-to-date information on available spawning and rearing habitat that will be available above the Wilsey Dam if a fishway is constructed and provide baseline information to monitor changes after salmon are returned to the Shuswap above the dam. In addition, it will help with regional planning.

Both projects are funded by B.C. Hydro's Bridge Coastal Fish and Wildlife Restoration Program (BCRP). BCRP provides $1.6 million annually to projects that restore fish and wildlife populations and habitat impacted by the construction of hydroelectric generating stations in 15 watersheds located along the coast, the Fraser Valley, Bridge River, Shuswap River and on Vancouver Island. The program is managed by a Board comprised of three public, three First Nation, one federal, one provincial and one B.C. Hydro representatives.

WCRC has received additional funding from Human Resources and Skills Development Canada that will support the wages for a student to assist with these projects.

Anyone with questions about either of these projects can call Wendy at WCRC at 547-8866

Appendix III: Preliminary SEI Map



DRAFT SENSITIVE ECOSYSTEMS INVENTORY OF THE SHUSWAP RIVER

For portions of map sheets **082L.027**, **082L.028**, and **082L.038**

Scale 1:20,000

2007

Introduction

Sensitive Ecosystems are ecosystems that are ecologically sensitive and or rare in the landscape. These areas also have significant biodiversity values and provide many habitat features required by threatened and endangered plant and animal species. ***Other important ecosystems*** are not sensitive ecosystems but have many important values associated with them. In this study area they include mature forest ecosystems.

Ecological Significance

These sensitive terrestrial ecosystems are ecologically significant because of their rarity and fragility and as a result of the great diversity of species they support, including habitat for many rare and endangered species.

Wetlands are extremely important because of their natural rarity in this area. They support a wide diversity of organisms including food, shelter, and breeding sites for ducks, songbirds, fish, amphibian, and invertebrate species. They have important hydrologic functions including filtering out pollutants, and safely storing and releasing water.

Riparian ecosystems include benches along streams, gullies with intermittent or permanent creeks, and fringes of lakes and ponds and sites with significant seepage. They support a rich diversity of species and have important hydrologic functions including filtering out pollutants, safely storing and releasing water (especially during peak flows), preventing stream bank erosion, and maintaining water quality and water temperatures..

Coniferous woodland ecosystems are like forests, but have very open canopies or scattered Douglas-fir and other coniferoustrees. They most commonly occur on very dry sites where soils are shallow or very shallow. Many sites have been altered by ingrowth of trees associated with fire exclusion, weed invasion, and other human disturbances.

Sparsely vegetated ecosystems occur on sites where exposed bedrock or rocks limit the places where vegetation can grow. They include rock outcrops and talus slopes with sparse shrub or grass/herb cover. Many of these ecosystems are rare and their coarse or shallow soils make them sensitive to disturbance. They provide important habitat for bats, snakes, and raptor nests.

Mature forest ecosystems provide important buffer sites, provide some of the values associated with old forest ecosystems and are recruitment sites for old forests. They are especially important in this study area which has no old forests.

Methods

The study area was ecosystem mapped following provincial Resources Inventory Committee standards. Bioterrain and ecosystem polygons were delineated on 1:15,000 scale colour stereo aerial photographs from Geographic Data BC taken in 1994. This mapping is **draft** and has not been field verified. Up to three ecosystems were mapped in each polygon and were assigned proportions of the polygon that they occupy (to the nearest 10%). Linework on photographs was digitized using the monorestitution method, databases were compiled, reviewed, and verified, and digital (ArcInfo) and hardcopy maps were produced.

All ecosystems mapped were evaluated for rarity and sensitivity and an algorithm was developed to create this Sensitive Ecosystem and Other Important Ecosystem theme. Each Sensitive Ecosystem and Other Important Ecosystem has been assigned a colour. The first component of each polygon has been colour-themed. Polygons with Sensitive or Other Important Ecosystems as a second or third component have cross-hatching.

Data Limitations

The map is intended to be used as a flagging tool to accompany planning processes and management of land resources in the study area. For site-specific evaluations, more detailed field assessments are needed. The accuracy of the boundaries of the mapping is limited by the scale of the aerial photographs used (1:15,000). *Enlargement of the data beyond the source scale may result in unacceptable distortion and faulty registration with other data sets.* Changes are ongoing within the study area making it important to refer to the dates of information sources.

Credits

Participating Agencies: Whitevalley Community Resource Centre Society and the BC Ministry of Environment

Base Terrestrial Ecosystem Mapping: John Grods, R.P.Bio. (Makonis Consulting Ltd.)

Base Bioterrain mapping: Polly Uunila (Polar Geoscience)

Base Mapping Data: Selected digital layers are from the Terrain Resources Information Management (TRIM) Program, Geographic Data BC.

Digitizing and Cartography: Bon Lee (Baseline Geomatics Inc.).

Sensitive Ecosystems Theme: Conversion tables were developed by Kristi Iverson, building upon tables used for the District of Lake Country and following the Standard for Mapping Ecosystems at Risk in British Columbia (Resources Information Standards Committee, *in press*)

Project Management: Kristi Iverson (Iverson & MacKenzie Biological Consulting Ltd.)

Funding: BC Hydro Bridge Coastal Restoration Program

Appendix IV: Middle Shuswap River Preliminary Stock Assessment

Middle Shuswap River Preliminary Stock Assessment Based on Sensitive Habitat Inventory Mapping (SHIM) Data, 2006

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ACKNOWLEDGEMENTS

I would like to thank Tom Minor for technical and administrative support for this project. Funding was provided by Whitevalley Community Resources. Karilyn Long developed the sampling design, Natasha Audy supervised and completed all field work and Lynnea Wiens reviewed background literature.

Citation: Benson, R.L. 2006. Middle Shuswap River preliminary stock assessment based on Sensitive Habitat Inventory Mapping (SHIM) data, 2006. Prepared by Okanagan Nation Alliance Fisheries Department. Westbank, BC.

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1.0 Introduction

The Middle Shuswap River once supported anadromous populations of salmonids including Chinook (*Oncorhynchus tshawytscha*), sockeye (*O. nerka*), and coho salmon (*O. kisutch*); (Triton 1995; Global Fisheries Consultants 2001). Construction of Wilsey Dam at Shuswap Falls in 1929 blocked the upstream migration of all fish into the upper Middle Shuswap and Sugar Lake (Triton 1995). Resident salmonids currently present between Wilsey Dam and Sugar Lake include rainbow trout (*O. mykiss*), kokanee, bull trout (*Salvelinus confluentus*), and mountain whitefish (*Prosopium williamsoni*); (ARC Environmental 2001; Chamberlain et al. 2001; Global Fisheries Consultants 2001). Rainbow trout and mountain whitefish are the most prevalent fishes of the Middle Shuswap, and its tributaries, above Wilsey Dam (ARC Environmental 2001). Habitat productivity is low and under capacity, which may be a result of low recruitment, low nutrients, high river temperature, overexploitation, flow effects, or a combination of several of these factors (ARC Environmental 2001).

Chinook salmon are currently unable to reach areas upstream of Wilsey Dam. Triton (1995) conducted a stock assessment and carrying capacity analysis of the system to determine the impacts of re-introducing Chinook salmon on resident fish populations. Their production models indicate fish populations were below carrying capacity for resident rainbow sampled during the study and during previous studies (Griffith 1979; Fee and Jong 1984). Triton (1995) found that it is unlikely that Shuswap River carrying capacity or habitat would limit a spawning population of Chinook.

The purpose of the current study was to calculate abundance estimates, age structures, and condition factors for fish populations in selected tributaries and side channels in order to determine stocking densities and habitat estimates above and below Wilsey Dam, and for input into the Sensitive Habitat Inventory Mapping (SHIM) database. The objective of SHIM is to inventory and map baseline data on watercourses, riparian habitat, and important fisheries habitat for incorporation into local and regional planning initiatives (Mason and Knight 2001). In addition, this information can be used as a baseline prior to providing passage for anadromous salmon and adfluvial rainbow trout and bull trout. Methods used in the current study were similar to previous studies to compare estimates and determine if production has changed over time.

1.1 Study area

The Middle Shuswap River flows from Sugar Lake to Mabel Lake for a total distance of 55 km (Fig. 1). Wilsey Dam is located 23 km from the mouth of Mable Lake and presents a barrier to anadromous fish migration. Major tributaries include Bessette Creek, which enters the Middle Shuswap below the dam, and Cherry, Ferry, and Reiter creeks, which enter above the dam. Flows in the Shuswap River mainstem (WSC station #08LC003 near Lumby) recorded a mean discharge for the month of August (1913-2005) of 35.9 m^3/s and minimum and maximum flows of 20.5 and 80.5 m^3/s respectively.

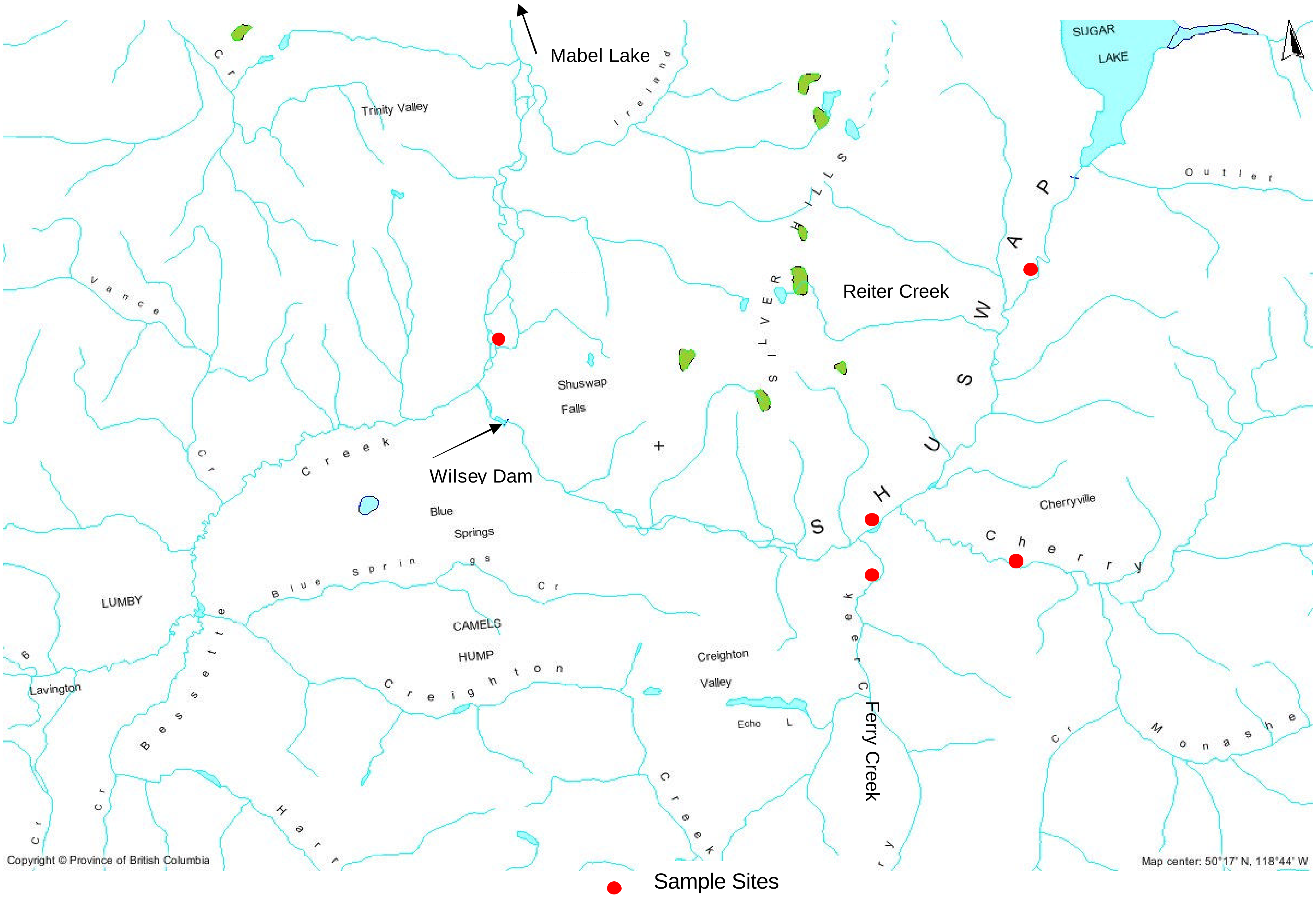

Figure 1. Middle Shuswap River SHIM study area. For Duteau Creek sample sites, refer to Long et al. (2006).

2.0 Methods

In August 2006, the Okanagan Nation Alliance electro-fished two tributaries (Cherry and Ferry creeks) and three side channels (locally called Limmer, Lavolette, and Hesketh side channels) of the Middle Shuswap River between Sugar Lake and Wilsey Dam to determine fish presence/ absence and composition for input into the SHIM database (Figure 2). The methods and sites selected followed previous studies on the system conducted by Fee and Jong (1984) and Triton (1995). One electro-fishing site was sampled at each tributary or side channel.

2.1 Fish capture methods

Fish population estimates were calculated using depletion methods where sites were isolated using stop nets and electro-fished using the two-pass depletion method (Hayes et al. in press; Lockwood and Schneider 2000). The following assumptions were assured during sampling for accurate depletion method estimates (Lockwood and Schneider 2000):

1) Emigration and immigration by fish during the sampling period were negligible;
2) All fish within a specified sample group were equally vulnerable to capture during a pass;
3) Vulnerability to capture of fish in a specified sample group remained constant for each pass;
4) Collection effort and conditions that affect collection efficiency, such as water clarity, remained constant.

Stop nets with 7 mm mesh sizes were placed at the upstream and downstream extents of the sites and secured to the streambed (Peterson et al. 2004). Electro-fishing was completed within the nets (Mitro and Zale 2000). The length of each site ranged from 25.8 m to 55.0 m. Two-pass depletion estimates were made by removing fish within the discrete section, recording the number of fish removed by species and size group then repeating the first two steps. All fish captured during a pass was placed in a large bucket, identified and enumerated.

2.2 Fish biological sampling

All salmonids caught were bio-sampled. Bio-sampled fish were first anesthetized with a 5 mg/L solution of Tricaine Methanesulfonate (MS 222). Small groups were placed in the solution until the first signs of unconsciousness were observed. Fish were sampled and then placed in an aerated recovery container. Water temperature was monitored and replaced periodically. Once fully recovered, fish were released back into the water source. All rainbow trout fry, parr and all coho and Chinook salmon were measured for fork length ($\pm$ 0.5 mm) and wetted weight ($\pm$ 0.01 g) from each site. All species were identified and enumerated (FPC 1995) and life stage was classified in terms of fry, parr, or mature. Selected individuals were photographed.

2.3 Fish habitat measurements

Fish habitat measurements were recorded to characterize area and to determine the wetted and cross-sectional area and discharge. Discharge was measured at each site using standard methods (RIC 1998). Habitat descriptions were based on similar variables (i.e. stream habitat type, substrate, and cover types) categorized by Fee and Jong (1984) and Triton (1995).

Figure 2. Fish sampling methods conducted at Middle Shuswap River study sites.

2.4 Calculations

In order to compare fish stocking densities and condition factors with previous studies, calculation methods were compatible with Fee and Jong (1984) and Triton (1995). In addition, stocking densities and condition factors were compared to estimates below Wilsey Dam in Duteau Creek (Long et al. 2006). The two pass depletion population formulae (Lockwood and Schneider 2000) are the following:

population estimate $$N = \frac{c_1^2}{(c_1 - c_2)}$$

Variance of N $$var = \frac{c_1^2\, c_2^2 (c_1 + c_2)}{(c_1 - c_2)^4}$$

Standard Deviation of N $$SD = \sqrt{var}$$

N = population estimate
C_1 = number of fish caught on the first pass
C_2 = number of fish caught on the second pass

Other calculations used in comparisons include:

1. fish densities (fish/m^2) = N / site area (site length * average wetted width)
2. total salmonid biomass (g) = N * mean fish weight
3. biomass density = total biomass / site area

The condition factor (K factor) of fish is based on work by Fulton (1902) and is an index of the general health of fish populations, based on length and weight. The condition factor is calculated using the formula (Barnham and Baxter 1998):

$$\boldsymbol{K} = \frac{10^{X} W}{L^3}$$

Where K is the Condition factor; W is the weight of the fish in grams (g); L is the length of the fish in millimeters (mm). The value of X is set at (X = 5) to bring the value of K close to unity. For salmonids K values usually fall in the range of 0.8 to 2.0. Table 1 gives the range of expected K values (Barnham and Baxter 1998)

3.0 Results

3.1 Fish population estimates

The predominant species caught in all sites was rainbow trout. Other species present above the dam include the following: prickly / slimy sculpin (*Cottus spp.*), longnose dace (*Rhinichthys cataractae*), redside shiner (*Richardsonius balteatus*), and suckers (*Catastomus spp.*). Below the dam, Chinook, coho, and longnose dace were present.

Rainbow trout was the only species captured in large enough numbers to estimate population, density, and biomass. Pooled population estimates for all age classes and the associated variance are compared to 1994 and 1983 estimates for Cherry and Ferry creeks (Table 1). Variance for 1983 data could not be calculated because Fee and Jong (1984) used a single-pass removal estimate. Density and biomass for rainbow trout in Cherry and Ferry creeks are summarized and compared to 1994 and 1983 estimates (Table 2). Detailed summaries from each creek are presented (Appendix B).

Table 1. Summary and comparison of population estimates (N) and standard deviation (SD (N)) of rainbow trout populations in Cherry and Ferry creeks in 1983, 1994, and 2006. Population (N) has been pooled for all age classes. Results from 1983 and 1994 were adapted from Fee and Jong (1984) and Triton (1995), respectively.

Tributary	2006		1994		1983	
Name	N	SD (N)	N	SD (N)	N	SD (N)
Cherry Creek	46	21.76	66	3.42	41	-
Ferry Creek	169	247.68	203	4.49	N/A	N/A

Table 2. Summary and comparison of density and biomass of rainbow trout populations in Cherry and Ferry creeks in 1983, 1994, and 2006. Results from 1983 and 1994 were adapted from Fee and Jong (1984) and Triton (1995), respectively.

Tributary Name	Age Class	2006		1994		1983	
		Density (#/m^2)	Biomass (g/m^2)	Density (#/m^2)	Biomass (g/m^2)	Density (#/m^2)	Biomass (g/m^2)
Cherry Creek	fry	0.12	0.47	0.04	0.07	0.17	0.24
	parr	0.02	0.30	0.03	0.25	0.11	2.40
	mature	0.00	0.13	0.03	1.26	0.01	1.21
	total	**0.14**	**0.90**	**0.10**	**1.59**	**0.29**	**3.85**
Ferry Creek	fry	0.02	0.04	0.17	0.39	N/A	N/A
	parr	0.81	9.14	0.06	0.46	N/A	N/A
	mature	0.07	2.92	0.14	4.46	N/A	N/A
	total	**0.90**	**12.11**	**0.38**	**5.31**	N/A	N/A
Both tributaries	**mean**	**0.52**	**6.51**	**0.24**	**3.45**		

Within sampled side channels, estimates of density and biomass were calculated for rainbow trout. Although Chinook and coho salmon were present below Wilsey Dam (Limmer side channel), density and biomass could not be calculated due to violations of the two pass electro-fishing regression ($C_2 > C_1$) (Hayes et al. in press). Density and biomass for rainbow trout in side channels are summarized (Table 3). A comparison to 1994 and 1983 data was not possible due to different sampling techniques (snorkel surveys, seining) or different site locations. Detailed summaries from each side channel are also presented (Appendix B).

Table 3. Summary of density and biomass of rainbow trout sampled in Hesketh, Lavolette, and Limmer side channels in 2006.

Side Channel	Relation to dam	Age Class	Density (#/m^2)	Biomass (g/m^2)
Hesketh	upstream	parr	0.01	0.18
		mature	0	0
		total	**0.01**	**0.18**
Lavolette	upstream	parr	0.04	0.44
		mature	0.00	0.09
		total	**0.04**	**0.53**
Limmer	downstream	parr	0.00	0.02
		mature	0	0
		total	**0.00**	**0.02**

Mean rainbow trout density and biomass estimates for sites (tributaries and side channels) upstream of Wilsey Dam were compared with estimates below the dam (Table 4). Estimates below the dam included data from Duteau Creek, a tributary of Bessette Creek (Fig. 1). Sampling in Duteau Creek occurred concurrently with the present study (Long et al. 2006).

Table 4. Comparison of mean density and biomass for rainbow trout in the Middle Shuswap River system upstream and downstream of Wilsey Dam.

Relation to dam	Density (#/m^2)	Biomass (g/m^2)
upstream	0.27	3.43
downstream	0.19	1.49

3.2 Fish condition factors

Mean salmonid condition factors at each site ranged from 0.62 to 1.54 (Fig. 2, Table 5), which is typically the condition of extremely poor to good condition fish (Table 6). Salmonid K values are typically within a range of 0.8 to 2.0. Figure 3 and Table 5 also compare condition factors for sites upstream of Wilsey Dam versus those downstream. In order to increase the sample size of downstream sites, data from Duteau Creek was included (Long et al. 2006).

Table 5. Mean condition factors (K) and sample size (n) for salmonids sampled in the Middle Shuswap River system in 2006.

Site	Species	Mean K	n
Cherry Cr	rainbow trout	1.22	29
Ferry Cr	rainbow trout	0.92	35
Hesketh side channel	rainbow trout	0.62	3
Lavolette side channel	rainbow trout	1.54	14
Limmer side channel	rainbow trout	1.11	1
	Chinook	1.40	3
	coho	1.70	2
Sites above dam	rainbow trout	1.12	80
Sites below dam	rainbow trout	1.14	48
	Chinook	1.40	3
	coho	1.14	12

Table 6. Condition factor (K) value and corresponding fish body conditions

K value	Condition
2.00	Exceptional condition
1.60	Excellent condition
1.40	Good well proportioned fish
1.20	Fair condition
1.00	Poor fish, long and thin
0.80	Extremely poor fish typically with a big head and narrow, thin body

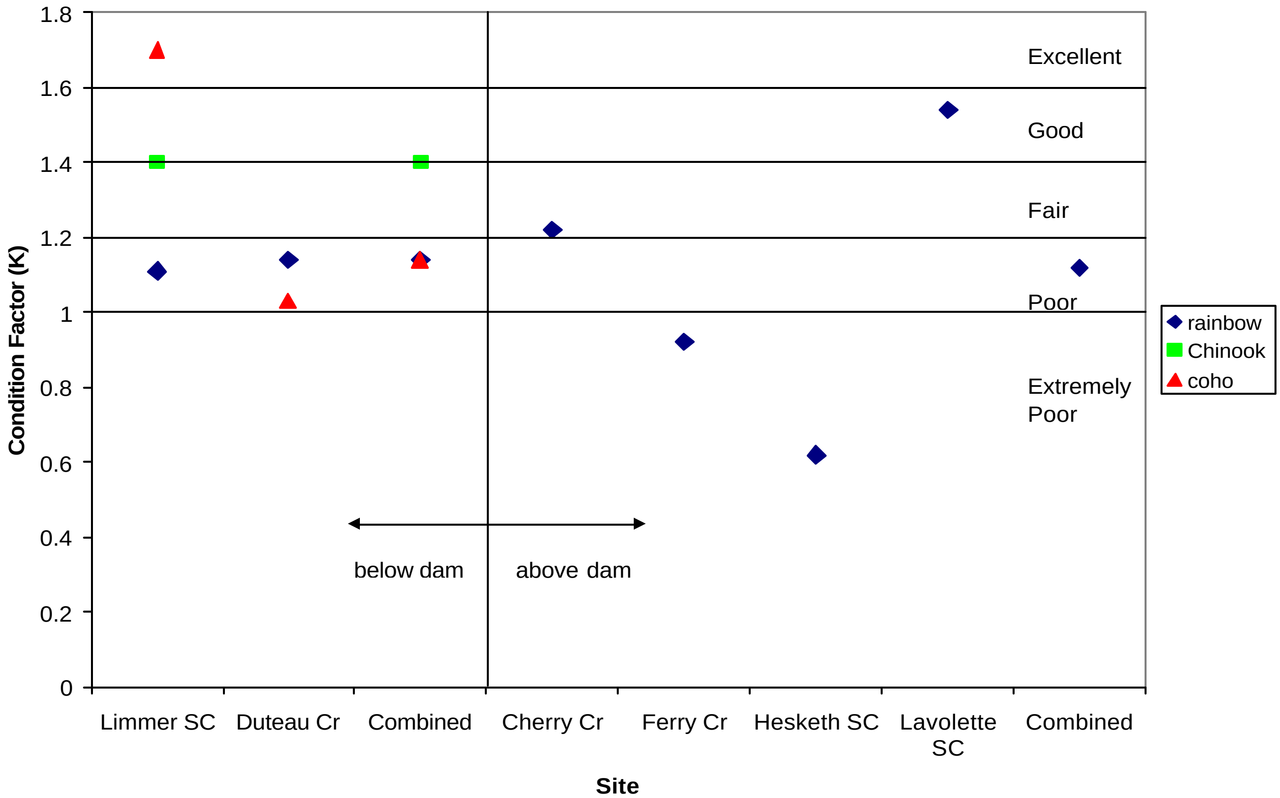

Figure 3. Comparison of mean condition factor (K) for Middle Shuswap River sites sampled above and below Wilsey Dam. Duteau Creek mean K values were adapted from Long et al. (2006).

4.0 Discussion

Information for the SHIM mapping project was achieved and is currently being processed for input into the web program.

Rainbow trout density for each of the five sampled sites, both above and below the dam, ranged from 0.00 to 0.90 fish/m^2. Biomass for all sites ranged from 0.02 to 12.11 g/m^2. Trout density and biomass in the three side channels were significantly lower than in the two tributaries (Tables 2 and 3). Pooled mean density and biomass in Cherry and Ferry creeks were 0.52 fish/m^2 and 6.51 g/m^2, respectively. Pooled mean density and biomass in Hesketh, Lavolette, and Limmer side channels were 0.02 fish/m^2 and 0.24 g/m^2, respectively. The lowest density and biomass estimates were from Limmer side channel, located below Wilsey Dam. Results indicate fish density is 1.4 times greater and biomass is 2.3 times greater above Wilsey Dam compared to below the dam. Average rainbow trout condition at each site was extremely poor to good. Site-specific condition factors may be sensitive to outliers because of small sample size (e.g. Hesketh side channel, n = 3). Therefore, combined condition factors upstream and downstream of Wilsey Dam are a better estimate of general fish condition. There was a slight difference in trout condition downstream versus upstream of the dam (1.14 and 1.12 respectively), however this difference is not likely biologically significant.

A general decline in trout density and biomass was observed in Cherry Creek from 1983, 1994, and 2006. However, methodology employed by Fee and Jong (1984) was not compatible with current methods and their results should be interpreted with caution. Estimates reported by Triton (1995) are more reliable for comparison purposes. Mean population estimates for sampled sites in Cherry and Ferry creeks indicate a decrease in total rainbow trout numbers from 1994 estimates. Methods used by Triton (1995) were more robust and population estimates were more representative of the system than the current study (e.g. estimates of N in 2006 had higher variability and lower precision than 1994 estimates (Table 1)).

Estimated density of rainbow trout in Cherry Creek increased from 0.10 fish/m^2 in 1994 to 0.14 fish/m^2 in 2006. The biomass decreased from 1.58 g/m^2 in 1994 to 0.90 g/m^2 in 2006. The decrease in biomass is likely attributable to an increase in fry density and a decrease in mature trout density (Table 2). Trout density and biomass in Ferry Creek increased significantly between 1994 and 2006. The increase is the result of higher density of parr in the 2006 sampling effort (Table 2). Results corroborate Triton (1995) conclusions that significant resident trout populations are present in Ferry and Cherry creeks, and Ferry Creek supported the highest density per unit area. Comparisons to previous carrying capacity estimates were not possible in the current study, because certain water quality parameters were not measured.

The precision of estimates from the current study is likely poor. An inherent weakness of the two-pass removal method is the dependence on only two data points (Hayes et al. in press). Due to funding limitations, only one site was sampled from each watercourse. The higher variability of 2006 estimates compared with 1994 estimates could be attributable to the lower number of sampling units in 2006. It is difficult to make inferences on an entire creek or side channel based on only one sample. The sampling design of future studies should be modified to increase the inferential strength of population, density, and biomass estimates.

The question of whether Chinook salmon reintroduction above Wilsey Dam would affect resident fish populations could not be fully addressed due to limitations in the sampling design. If required, future sampling design needs to be more robust to adequately address this issue. However, prior studies have shown that spawning, rearing and overwintering habitat and production potential were not limited in the Shuswap River (Triton 1995).

5.0 Recommendations

- Population estimates and stock assessments should be repeated at least one more time. Site selection should be stratified (mainstem, side channel, and tributary) and balanced (sites upstream versus downstream of Wilsey Dam). Electro-fishing sample sites should be replicated 3-5 times per stream or side channel. Multiple sample sites from each water body would provide a better estimate for the entire system and potentially reduce any bias associated with sampling only one site. Three-pass removal electro-fishing methods should be used, which provide more precise, statistically reliable estimates of population size. Sampling should incorporate other methods (seining, snorkeling) to effectively sample habitats that cannot be efficiently sampled with a backpack electro-fisher. Additional methods would provide a more robust and accurate estimate of fish populations and allow better comparisons to 1994 data (because Triton (1995) used electro-fishing, seining, and snorkeling to estimate abundance and biomass). This would allow managers to determine if fish production has increased or decreased since 1994.

- Triton (1995) used production models presented in Binns (1982) and Ptolemy (1993) to assess the theoretical production capability. Attributes for the models include mean weight of fish in each age class, alkalinity of water at critical stream flow, late summer flow, annual stream flow variation, stream temperature, cover, and a food index. Future assessments should collect these data. Theoretical production capability could be calculated to re-confirm that the system is below carrying capacity or to determine if production capability has changed since 1994.

- An invertebrate sampling program could be potentially linked to trout production potential. In addition, invertebrate index sampling is one of the only ways to assess general ecosystem health. Once established, index sites could be a less costly method of monitoring change in trout productivity over time.

- If Chinook salmon are reintroduced above Wilsey Dam, a long term monitoring program should be developed to track changes in fish production, species composition, and potential competitive interactions between Chinook and resident salmonids. Monitoring should occur every five years, along with annual Chinook spawner enumerations.

6.0 References

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Appendix A. Middle Shuswap River habitat summary

Habitat descriptions

Site	***1***	***2***	***3***	***4***	***5***
location	Cherry Cr	Hesketh SC	Limmer SC	Lavolette SC	Ferry Cr
Date	21-Aug-06	22-Aug-06	23-Aug-06	24-Aug-06	25-Aug-06
UTM	118 20 926 55 76 202	118 39 599 50 15 000	118 48 614 50 19 391	118 35 178 50 17 998	118 39 787 50 13 094
Photo	82 - 85	88, 89	96, 97	98, 99	108 - 111
Length (m)	43.4	26	25.8	35	55
Width (m)	9.16	9.9	10.4	17.3	6.5
Area (m^2)	397.5	257.4	268.3	605.5	357.5

Habitat					
%glide	50	90	80	80	33
%riffle	50	10	0	10	33
%pool	0	0	20	10	34
% other	0	0	0	0	0
Substrate					
%f & sand	20	5	90	10	5
%gravel	40	15	5	10	20
%cobble	40	70	0	65	70
%boulder	0	10	5	15	5
%bedrock	0	0	0	0	0
Descrip.					
SC	n/a	stable	manmade	stable	n/a
Cover %	70	?	80	30	60
Cover type	OV, UB	SUB, OV, UB	SUB, IN, OV	SUB, OV, UB	SUB, IN, OV
No. LWD	3	10	5	10	15
SWD	yes	yes	yes	yes	yes
Gradient	1-5%	1-5%	1-5%	1-5%	1-5%

Appendix B. Middle Shuswap River fish data summary and calculations.

Site	Relation to dam	Area	Species	Age	Count	Mean FL (mm)	Mean weight (g)	C_1	C_2	Sum of passes	n	Total biomass	Area (m^2)	Density ($fish/m^2$)	Biomass (g/m^2)
Cherry	upstream	tributary	RBT	fry	21	62	3.92	12	9	21	48	188.16	397.5	0.1208	0.4734
Cherry	upstream	tributary	RBT	parr	7	108	14.31	5	2	7	8	119.25	397.5	0.0210	0.3000
Cherry	upstream	tributary	RBT	mature	1	172	50.30	1	0	1	1	50.3	397.5	0.0025	0.1265
Ferry	upstream	tributary	RBT	fry	6	54	1.97	4	2	6	8	15.76	357.5	0.0224	0.0441
Ferry	upstream	tributary	RBT	parr	35	112	11.31	17	16	33	289	3268.59	357.5	0.8084	9.1429
Ferry	upstream	tributary	RBT	mature	8	161	41.76	5	4	9	25	1044	357.5	0.0699	2.9203
Hesketh	upstream	sc	RBT	fry	0	-	-	0	0	0	0	0	257.4	0.0000	0.0000
Hesketh	upstream	sc	RBT	parr	3	151	15.73	3	0	3	3	47.19	257.4	0.0117	0.1833
Lavolette	upstream	sc	RBT	fry	3	52	2.69	1	2	3	-1	-2.69	605.5	-0.0017	-0.0044
Lavolette	upstream	sc	RBT	parr	9	100	10.61	5	4	9	25	265.25	605.5	0.0413	0.4381
Lavolette	upstream	sc	RBT	mature	1	181	55.63	1	0	1	1	55.63	605.5	0.0017	0.0919
Limmer	d/stream	sc	RBT	parr	1	74	4.49	1	0	1	1	4.49	268.3	0.0037	0.0167
Limmer	d/stream	sc	CH	0+	3	78	6.66	1	2	3	-1	-6.66	268.3	-0.0037	-0.0248
Limmer	d/stream	sc	CO	0+	2	67	4.83	0	2	2	0	0	268.3	0.0000	0.0000
Duteau 1	d/stream	tributary	RBT	fry	2	69	4.09	2	0	2	2	8.18	73.8	0.0271	0.1108
Duteau 1	d/stream	tributary	RBT	parr	2	102	11.53	0	1	1	0	0	73.8	0.0000	0.0000
Duteau 1	d/stream	tributary	CO	0+	2	66	3.39	1	1	2	2	6.78	73.8	0.0271	0.0919
Duteau 2	d/stream	tributary	RBT	fry	29	60	2.72	21	9	30	37	99.96	97.0	0.3789	1.0305
Duteau 2	d/stream	tributary	RBT	parr	3	114	16.45	1	1	2	2	32.9	97.0	0.0206	0.3392
Duteau 3	d/stream	tributary	RBT	fry	7	48	1.05	5	1	6	6	6.5625	34.0	0.1838	0.1930
Duteau 3	d/stream	tributary	RBT	parr	4	117	16.56	3	1	4	5	74.52	34.0	0.1324	2.1918
Duteau 3	d/stream	tributary	CO	0+	8	67	3.13	5	0	5	5	15.65	34.0	0.1471	0.4603