ASH RIVER NUTRIENT ENRICHMENT
FOR FISH HABITAT RESTORATION
2005

prepared by
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EXECUTIVE SUMMARY

Pollock fertilizer additions and salmon carcass plants in the Ash River in 2005 provided remediation for reduced biological productivity stemming from Elsie Lake Dam and the Ash Hydro Project. Acting as a nutrient sink, the reservoir has reduced low level nutrients such as orthophosphate and nitrogen in the Ash River downstream decreased primary production. With the addition of fertilizer to affected reaches, increased biological productivity resulted in larger steelhead fry which should increase over-winter survival and smolt production. Carcass additions provided both nutrients and a direct source of food to juveniles before winter when food becomes scarce.

On June 8 and 9, 2005, 1,680 kg of Alaskan pollock bone meal packed in burlap bags was anchored to the stream bottom at two sites between Elsie and Dickson lakes. Between October 18 and November 19, 2005, 699 chinook and 1,091 coho were transported from Robertson Creek hatchery and distributed at three sites in the same reach.

Staff conducted water quality and flow/temperature monitoring throughout the pollock treatment period. Water chemistry data was collected on a monthly basis from four sampling locations in the treatment reach. No adverse changes in water chemistry were documented as a result of the project.

Monitoring of algal growth using periphyton collectors indicated increased growth at the full mix site, and moderate growth downstream. Periphyton accrual was quantified by analyzing chlorophyll *a* concentrations on foam core samples taken from collectors. The effective distance of the treatment was estimated to be 3.5 km.

Juvenile fish sampling occurred between September 23 and 26, 2005 to evaluate the effectiveness of pollock treatments. Although results were not statistically significant (95% confidence level), steelhead fry in the treated reach were 42% heavier on average than those in the control reach, located 1 km downstream of Elsie Dam.

Fisheries staff from the BC Conservation Foundation (BCCF), BC Conservation Corps (BCCC), Ecofish Research Ltd. and Hupacasath First Nation (HFN) conducted project activities, overseen by Ministry of Environment (MoE) staff.

The total project cost for the 2005 Ash River Nutrient Enrichment Program was $24,258. BC Hydro contributed $17,925 through their Bridge Coastal Fish and Wildlife Restoration Program (BCRP) while $6,333 of in-kind support came from the Hupacasath First Nation (HFN), and the Ministry of Environment (MoE).

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1.0 INTRODUCTION

Primary nutrients essential for growth of aquatic organisms (algae, aquatic invertebrates, fish) include carbon (C), nitrogen (N), and phosphorus (P). Typically occurring in a ratio of 40:7:1 by mass (Vallentyne 1974), C and N are relatively common in most ecosystems, but P lacks a gaseous phase and is often limiting biotic production in aquatic habitats (Schindler 1980, Stockner 1987). Gresh *et al.* (2000) found that as a result of anthropogenic factors, as little as 6-7% of the historical input of marine-derived nutrients (particularly P) from spawning salmon is currently available in Pacific Northwest streams.

Studies have shown that dams cause nutrient imbalances that affect ecosystem productivity. By increasing water retention, biogenic reduction of organic matter and sedimentation rates increase, leading to effective P-sinks and reduced habitat productivity (Stockner *et al.* 2000). In the Arrow Lakes system (Columbia watershed), river-borne nutrients that would normally contribute to productivity are now utilized in upstream impoundments (Mica and Revelstoke dams), with most settling in impoundment sediments (Pieters *et al.* 2003).

On the upper Ash River on Vancouver Island, the Elsie Reservoir Hydro project was completed in 1958 with dam construction at the outlet of Elsie Lake. The dam flooded 401 ha of land, thereby expanding the original 271 ha lake to a 672 ha reservoir (BCRP 2000). Reservoir storage is diverted by penstock to a generating station on Great Central Lake. Similar to other impoundments, nutrient uptake in the reservoir has likely reduced the transfer of phosphorus and nitrogen downstream (Dr. K. Ashley, Vancouver, BC. pers. comm.).

Ash River water samples collected in 2000 and 2001 showed nutrient concentrations were limiting to primary productivity, confirming the stream as an enrichment candidate (McKusker *et al*. 2002, Hansen 2003). Three 2001 samples taken between August 8 and October 10 had soluble reactive phosphate concentrations below the test detection limit (i.e., <1 µg/L ortho-phosphorus) and dissolved nitrogen (nitrate+nitrite) concentrations ranging from 4 to 24 µg/L.

Lill (2002) described stream enrichment as an effective technique to help recover depressed steelhead populations in Vancouver Island streams. The addition of organic nutrients and/or salmon carcass redistribution[1] are recommended as short term strategies to replace losses in marine-derived nutrients during periods of poor salmon returns or where cultural oligotrophication has occurred (impoundment-related nutrient sinks).

In the 1990s, development of slow-release fertilizers was undertaken by Fisheries Research and Development Section, MoE, Vancouver, BC and supervised by Dr. Ken Ashley (Mouldey and Ashley 1996, Mouldey *et al.* 1998, 1998a). In 2001, the Ash River was treated with slow release inorganic fertilizer briquettes called "Nutri-Stones™", manufactured by Lesco, Inc. of Ohio. The product was applied late due to shipment delays and effectiveness monitoring was confounded by high water in August (Hansen 2003).

[1] Carcass redistribution involves taking post spawn hatchery broodstock and/or carcasses dead-pitched from spawning channels (high abundance) and redistributing them into the upper reaches of the watershed (typically low abundance).

Early in 2003, an organic, heat-pasteurized fertilizer product, Alaskan pollock bone meal[2], was tested at the MoE Fish Health Lab in Nanaimo and confirmed pathogen free. Testing for other contaminants and metals was also completed and confirmed the product's suitability (Pacific Environmental Science Centre, North Vancouver). In 2003 and 2004, the efficacy of bone meal as a stream fertilizer was documented at the Centennial Research Channels on the Chilliwack River and on select Vancouver Island streams. The logs proved to be good sources of nutrients resulting in improved periphyton biomass and juvenile fish growth. Although effective, pollock logs tended to break down to piles of loose fish meal soon after being placed instream, and the product is now applied loose in burlap bags.

In 2005, members of the Ash River Restoration Working Group[3] (ARRWG) met to discuss potential restoration projects on the Ash River. The group decided that organic fertilizer, ideally salmon carcasses, would be preferred over inorganic fertilizers for use in the Ash River. Following recommendations from ARRWG, a stream enrichment proposal utilizing pollock bone meal and salmon carcasses was prepared by BCCF and submitted by HFN to BCRP.

2.0 GOALS AND OBJECTIVES

The Ash River Nutrient Enrichment Project was designed to improve the growth and survival of juvenile salmonids, primarily steelhead (*Oncorhynchus mykiss*), through the addition of bone meal and carcasses downstream of Elsie Dam. The objective is to increase the ratio of steelhead smolts per spawner, as demonstrated on the Keogh River in North Vancouver Island. Pollock bone meal was applied in the spring as a slow release fertilizer to increase periphyton accrual and invertebrate food supply. Salmon carcasses were applied in the fall to provide a direct food source for juvenile steelhead prior to the onset of winter and to provide additional P in the upper mainstem below Elsie Dam. Limiting factors addressed include reduced biological productivity resulting from dam construction and operations. Salmon carcasses and/or pollock bone meal were loaded at a rate intended to increase ortho-phosphate concentrations from <1ug/L to 1-5 ug/L downstream of the treatment sites. Stream flow, water chemistry, periphyton accrual and fish growth monitoring was intended to ensure pollock bone meal loading rates are not excessive and to assess the effectiveness of fertilizer additions. Background details, scientific rationale, and case study examples of stream enrichment are compiled by Ashley & Slaney (1997) and by Kiffney, Bilby, and Sanderson (2005).

3.0 STUDY AREA

The Ash River is one of the main tributaries to the Stamp-Somass River, located near the municipality of Port Alberni. The section of river targeted for nutrient enrichment is the 11 km of mainstem extending from Elsie Lake Dam to Dickson Lake. Though not accessible to most anadromous salmonids due to selective barriers below Dickson Lake, this reach does suport summer steelhead and resident/adfluvial populations of trout and char. Kokanee (*O.*

[2] Imported and supplied by Welcome Harvest Farms, Texada Island, BC.
[3] Includes representatives of Hupacasath First Nation, Nuu-chah-nulth Tribal Council, Fisheries and Oceans Canada, Ministry of Environment, BC Conservation Foundation, Alberni Valley Enhancement Association, and the West Coast Aquatic Management Board.

nerka) are present in Elsie Lake, and small numbers may also occur in Dickson Lake (C. Wightman, MoE, Nanaimo, pers. comm.). Elsie Lake is a BC Hydro storage reservoir with a penstock diversion to a powerhouse on Great Central Lake. Dickson Lake empties into the lower Ash River which eventually joins the Stamp River 6 km downstream of Great Central Lake.

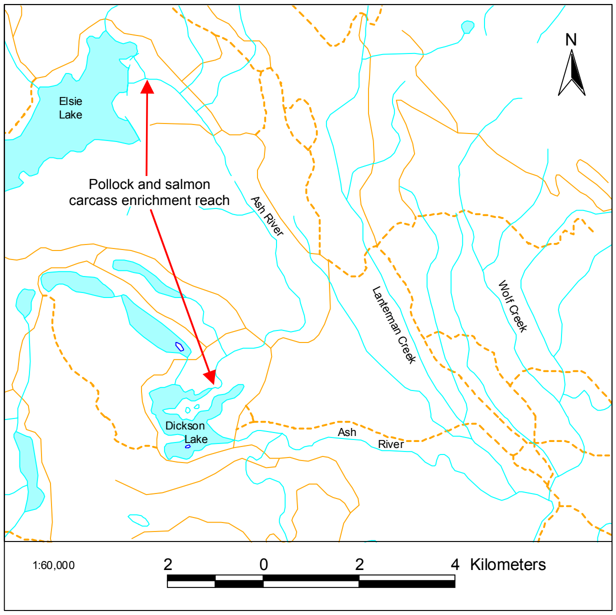


Figure 1. Nutrient enrichment and salmon carcass distribution reach on the Ash River, 2005.

Burt and Horchik (1999) state that the Ash River is one of the main spawning areas for summer run steelhead in the Somass River watershed. Adult migration occurs between July and October, and the spawning period is January to the end of April. For juvenile steelhead, the growth period extends from May to October, and over-wintering occurs between November and March. The majority of steelhead smolts are two years old when they leave the system in April and May (Hansen 2003). Recent monitoring by BCCF staff has documented a significant presence of summer run steelhead in the reach between Elsie and Dickson lakes. On February 1, 2001, 54 adult steelhead were observed in a 1.2 km reach downstream of Elsie Lake. On January 24, 2002, 18 were observed in the same reach. Numerous fresh redds were noted as well (MoE files). Adult steelhead are known to migrate to the base of Elsie Lake Dam (C. Wightman, Biologist, MoE, Nanaimo, pers. comm.).

3.1 Site Locations

Fertilizer application sites were chosen based on the estimated effective distance of the product and ease of access. Sites were also selected based on known rearing areas to provide the maximum benefit for juvenile salmonids. Two pollock sites were spaced 4 km apart to allow most of the nutrients to be bound up in primary production between treatment locations (Figure 2). Carcass distribution locations followed similar rationale, though access was a greater consideration. Three carcass plant sites were used to allow for a more uniform distribution through the treatment reach.

4.0 MATERIALS AND METHODS

4.1 Fertilizer Application

Loading rates for pollock application were calculated to achieve a target concentration of 2.5 µg/L orthophosphate (PO_4). Pollock bone meal is 7.69% P (17.6% P_2O_5) and estimated to release most of the nutrients over a 90 day period. Equation 1 describes how these parameters were used to calculate the amount of pollock loaded at each site. All calculations made before the treatment period were based on a forecasted discharge of 3.5 m^3/s obtained from BC Hydro.

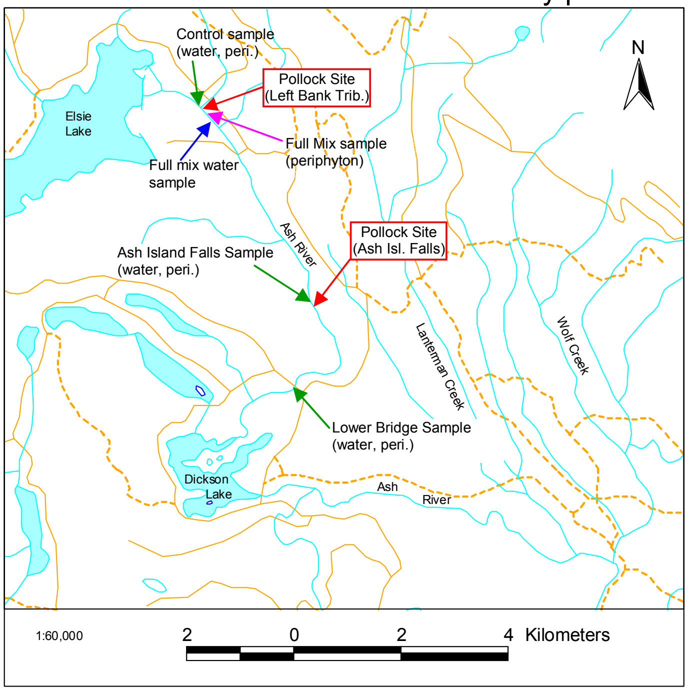


Figure 2. Pollock fertilizer locations on the Ash River including water and periphyton sampling sites.

Equation 1. Pollock loading rate calculation.

Kg pollock needed = (average flow m^3/s) x (90 days) x (2.5 µg/L)/(0.0769 µgP) x (1000L/m^3)/(1x10^9µg/kg) x (86,400 seconds/day)

Simplified:

Kg pollock per site = 252.80 x (average flow m^3/s)

Table 1. Pollock loading rate targets based on the required summer flow of 3.5 m^3/s downstream of Elsie Dam.

Location	Discharge (m^3/s)	Product	Target (kg)
First left bank tributary downstream of Elsie Dam	3.5	Pollock	885
500 m downstream of Ash Island Falls	3.5	Pollock	885
Total			**1,770**

Following calculations, fertilizer was loaded on a pickup truck and trailer. Burlap bags were filled at the river using buckets and scales (Figure 3). BCCF, BCCC, First Nations and MoE all helped during the labour intensive procedure (Figure 4a). Bags were anchored with rocks in high flow areas to allow for maximum nutrient leaching and mixing (Figure 4b). Bag placement was clustered to allow for easy removal if necessary. Where possible, site locations were removed from high traffic areas to prevent tampering.

Figure 3. Pollock bone meal before being loaded into burlap bags.

a) 

b) 

Figure 4a and 4b. First Nations and BCCF crews securing pollock filled burlap bags to the bottom of the river using large cobbles.

4.2 Carcass Distribution

Fall carcass plantings, utilizing chinook and coho from Robertson Creek Hatchery, followed the summer enrichment program. Upwards of 1,500 post spawn chinook salmon from First Nation ESSR allocations at Robertson Creek Hatchery were slated for carcass plants. In 2004, BCCF worked with HFN to distribute 1,046 chinook carcasses.

A proposal to distribute chinook carcasses was submitted to the DFO Introductions and Transfers Committee prior to carcass plants. The proposal was approved and included:

- Proponent/coordinator contact information;
- Brief rationale;
- Carcass source;
- Carcass planting locations – including a map with sites and access points identified;
- Loading rate – number of carcasses of each species; and,
- Letters/emails indicating support for each project.

In early fall, hatchery managers and First Nations were contacted by BCCF staff to confirm carcass availability and develop tentative logistics. Carcasses were collected and loaded into insulated fish totes by staff at Robertson Creek hatchery prior to the distribution days. Totes were trucked to distribution sites where carcasses were pitched into the river by HFN and BCCF staff using peugh sticks (Figure 5a and 5b). Where possible, carcasses were placed in woody debris or in deep pools in order to increase retention.

a) 

b) 

Figure 5a and 5b. a) Chinook salmon carcasses placed in the Ash River. b) Distributing salmon carcass using a peugh stick.

4.3 Water Temperatures and Flow Monitoring

Technicians used hand-held alcohol thermometers to measure water temperature at sampling sites. Stream discharge was measured using a Swoffer® velocity meter (model 2100) and a 50 m fibreglass surveyors tape. Stream transect locations were flagged to ensure data would be consistent. A minimum of 15 stations were measured on each transect. Temperature and flows were monitored periodically during the treatment period. Due to the regulated releases from Elsie Dam, flow monitoring was less intensive than for other enrichment programs on Vancouver Island. Data were used to decide if in season loading rate adjustments were necessary. The data will also be used for adjusting loading rate calculations for future treatments.

4.4 Water Sampling

Water samples were collected four times during the treatment period. Sites were selected upstream (control: 1 site) and downstream (full mix/dilution: 3 sites) of treatments to monitor changes in low level nutrient concentrations. Samples were collected in duplicate using 250 ml plastic bottles provided by the Pacific Environmental Science Center (PESC) in Burnaby, BC. Bottles were rinsed three times with stream water in the field before being filled. Samples were packed with ice in a cooler and shipped that day by courier to a lab for analysis within 24 hours. Maxxam Analytics Inc. received samples until August, at which point water samples were re-directed to PESC. Water quality parameters measured including detection limits are presented below in Table 2.

Table 2. Water chemistry parameters tested including associated units and detection limits.

Water Chemistry Test	Units	Method Detection Limit (MDL)
ALKALINITY		
Total, ($CaCO_3$)	Mg/L or ppm	0.5
NITROGEN		
Ammonia (N)	Mg/L or ppm	0.005
Nitrate + Nitrite (N)	Mg/L or ppm	0.002
PHOSPHORUS		
Orthophosphate (PO_4)	Mg/L or ppm	0.001
Dissolved Phosphorus (P)	Mg/L or ppm	0.002
Total Phosphorus (P)	Mg/L or ppm	0.002

4.5 Periphyton Sampling

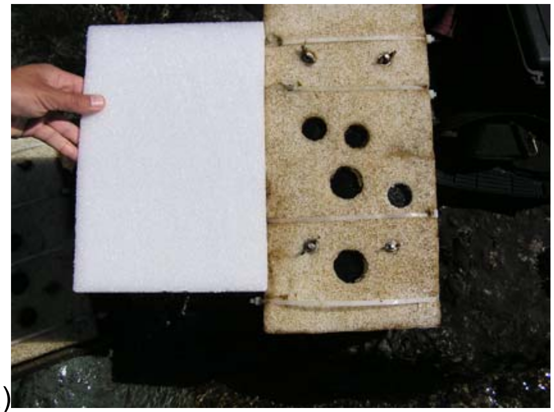
Periphyton growth was quantified by measuring chlorophyll *a* concentrations on core samples taken from collector plates. Blocks consist of a sheet of white florist's foam, 1.25 cm thick, attached to Plexiglas plates with electrical ties. The plates were bolted to concrete blocks and placed in the stream, tipped slightly into the direction of flow. Rocks were placed around the block edges for extra stability. Each block was submerged under at least 12 cm of water to allow for decreasing streamflow. Sites were selected so as to have similar solar exposure, water depth, and water velocity.

Collectors were installed on June 8 and 9, 2005 in pairs at each site. The control site was located 200 m upstream of the first left bank tributary downstream of Elsie Lake. Site two (full mix) was located 100 m below the upper pollock treatment, while site three (dilution) was immediatly above the lower pollock treatment. A fourth site (dilution) was located at the lower bridge pool before the river empties into Dickson Lake (Table 3).

Table 3. Description of water and periphyton sampling locations on the Ash River, 2005.

Site	Water	Periphyton	Description
Control	X	X	0.3 km upstream of the first left bank tributary confluence downstream of Elsie Lake Dam
Full Mix	X		0.5 km downstream of the first left bank tributary confluence, downstream of the small island
		X	50 m downstream of fertilizer at first left bank tributary
Ash Island Falls	X	X	500 m downstream of the falls but 150 m above the fertilization site
Lower Bridge	X	X	Pool below the bridge above Dickson Lake

Using a 7 dram plastic vial, two cores of foam (each 2.7 cm in diameter, 5.73 cm^2 in surface area) were punched as demonstrated in Figure 6a, one from each of the two periphyton blocks (Mouldey Ewing *et al.* 1998). Each sample was drained and placed in the vial (Figure 6b). The vial was vented with holes through the cap to allow the sample to dry. Samples were placed in a sealed, light-proof container, kept cool with ice, and frozen as soon as possible. Periphyton cores were taken every two weeks starting on June 23 and ending on September 14 for a total of seven samples. At the end of the sampling period, all samples were shipped frozen, in a cooler with dry ice, to Maxxam Analytics. Chlorophyll *a* concentrations were measured in units of μg / cm^2 by laboratory staff.

a) 

b) 

Figure 6a and 6b. a) Periphyton collector plate after 54 days vs. a clean sheet of foam. b) Core samples in vials taken from collector plates.

4.6 Juvenile Fish Sampling

Juvenile fish were sampled using an electrofisher (Smith-Root model LR-24) on September 23 and 26, 2005. Two control and two treated sites were chosen to monitor stock abundance in general and to assess effectiveness of fertilizer treatments (Figure 7). Where required, spot shocking was conducted to obtain a minimum of 30 fish. At each electrofishing site, approximately 100 m^2 of suitable steelhead fry habitat (typically cobble/gravel riffles, <30 cm in depth, and <25 cm/sec in velocity) was enclosed with small mesh stopnets, and all fish were removed using the standard, 2-pass removal method (deLeeuw 1981). Fish were briefly anaesthetized using a dilute solution of clove oil and ethanol. Lengths and weights were recorded for all fish captured using measuring boards and an Ohaus top loading scale (model CS 200, accurate to 0.1 g) (Figure 8).

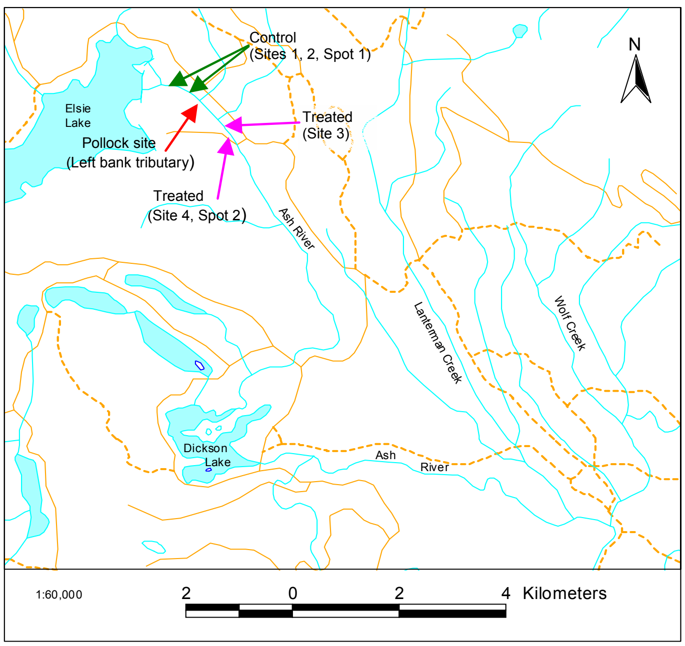


Figure 7. Juvenile electrofishing sites sampled using closed site and spot shocking techniques.

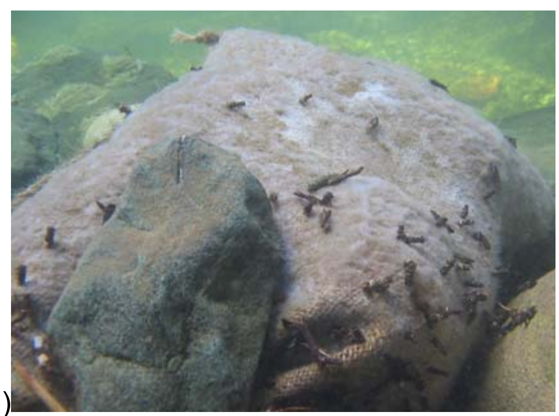
Habitat parameters were documented consistent with current Fisheries Branch techniques (methodology by R. Ptolemy, Rivers Biologist, MoE, Victoria), and each site was photographed. Upon removal of the stopnets, a depth/velocity profile across a representative transect within the site was recorded using a Swoffer current velocity meter, model 2100. Site density estimates were derived and depth / velocity adjusted using Fisheries Branch habitat suitability index curves.

Figure 8. Rainbow trout fry sampled in a treated site on the upper Ash River, 2005.

5.0 RESULTS

5.1 Fertilizer Application

A total of 1,680 kg of pollock bone meal was added to the Ash River on June 8 and 9, 2005. Two sites were fertilized between Elsie and Dickson lakes (Figure 3). The uppermost site received 880 kg of pollock, while 800 kg was introduced at Ash Island Falls. No loading rate adjustments were required as a result of regulated discharge from the Elsie Dam and moderate algal growth through the treatment window.

a) 

b) 

Figure 9a and 9b. a) Pollock bag covered in caddis larvae. b) Contents of burlap bags on b) Contents of burlap bags on August 2, 54 days after application.

5.2 Carcass Distribution

A total of 1,790 salmon carcasses were collected from Robertson Creek Hatchery and planted in the Ash River at three locations between Elsie and Dickson lakes (Figure 10). Between October 18 and November 19, 2005, 699 chinook salmon and 1,091 coho were distributed. Plants occurred 1 km downstream of the Elsie Lake Dam (363 chinook, 465 coho), 500 m downstream of Ash Island Falls (195 chinook, 196 coho), and at the Ash mainline bridge above Dickson Lake (141 chinook, 430 coho). The total weight of the carcasses was estimated to be 9,215 kg based on an average of 8.5 kg for chinook and 3.0 kg for coho.

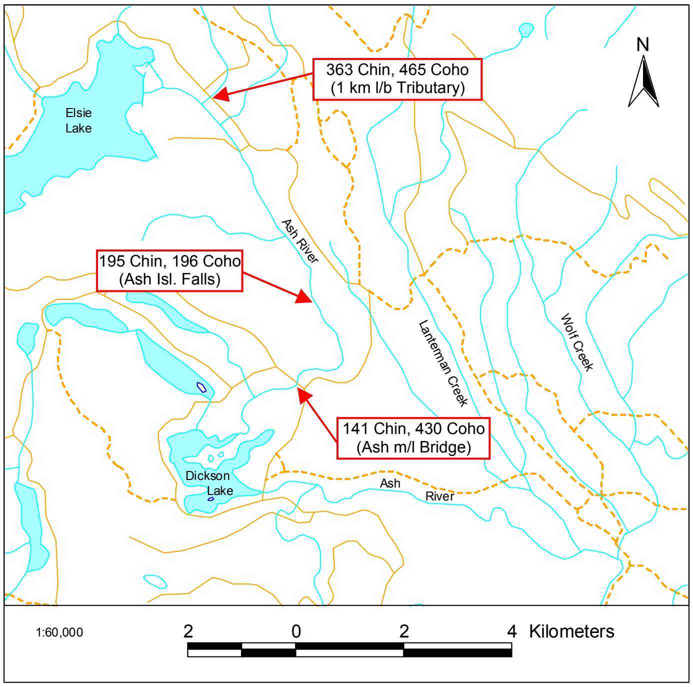


Figure 10. Salmon carcass distribution sites on the upper Ash River, 2005.

5.3 Water Temperatures and Flow Monitoring

Stream measurements taken in June and July confirmed the 3.5 m^3/s minimum operating flow (Table 4). Water temperatures recorded from July to-September varied from between 12 and 16°C. Two scheduled pulse flows occurred later in the season to aid in the upstream migration of adult steelhead and salmon. They occurred on August 30 and on September 20, with peak discharges reaching 10 and 20 m^3/s, respectively (Figure 11).

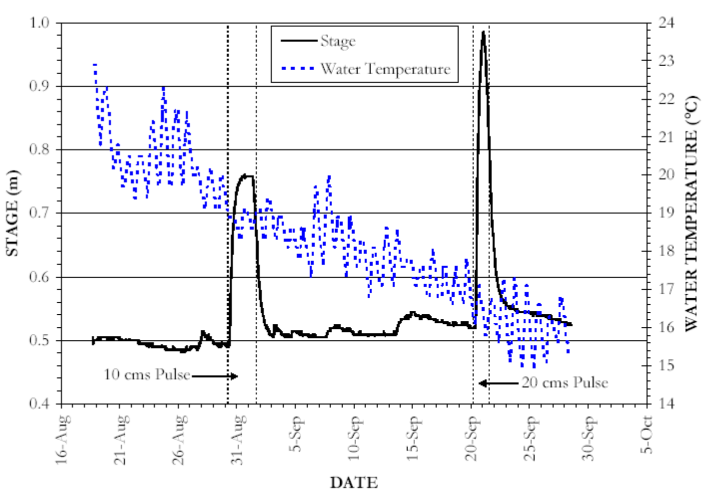


Figure 11. Hydrograph for migration pulse flows recorded at the bridge upstream of Dickson Lake, 2005. (Ecofish 2006).

Table 4. Discharge and water temperature data from the Ash River, 2005.

Location	Date	Discharge (m^3/s)	Temp (°C)
First left bank tributary	08-Jun-05	3.81	N/A
Ash Island Falls	23-Jun-05	3.91	N/A
First left bank tributary	23-Jun-05	3.34	N/A
First left bank tributary	20-Jul-05	3.28	14.0
150 m downstream second left bank tributary	23-Sept-05	N/A	12.0
165 m downstream second left bank tributary	23-Sept-05	N/A	15.5
200 m upstream first left bank tributary	26-Sept-05	N/A	16.0
200 m upstream first left bank tributary	26-Sept-05	N/A	16.0

5.4 Water Sampling

Water chemistry results from Maxxam Analytics showed orthophosphate concentrations that were abnormally high, especially in the control site. Pre-enrichment water chemistry (2001) indicated undetectable concentrations of orthophosphate (<0.001 mg/L). Following discussions with Maxxam Analytics in August regarding detection limits, samples were re-directed to the Pacific Environmental Science Centre (PESC) in Burnaby for analysis. Results obtained from PSEC revealed orthophosphate levels of less than 0.001 mg/L in control sites and at post treatment (dilution) sites, as expected (Table 5).

Other parameters were measured as a precautionary step to ensure treatments did not have a negative effect on water quality. The optimal concentration of 75 ug/L nitrate/nitrite was not observed and the highest measured value was only 13 ug/L. These nitrogen concentrations are sufficient for algal growth, but DIN values less than 20 ug/L may be limiting (Bothwell 1988). Ammonia concentrations remained below the method detection limit of 5 ug/L for most samples. The largest concentrations were measured downstream of treatments at Ash Island Falls and at the Ash Mainline bridge above Dickson Lake (8 and 10 ug/L, respectively). Alkalinity concentrations ranged between 12.4 and 18.5 mg/L $CaCO_3$. In general, water quality parameters in treated areas did not change significantly when compared to control samples.

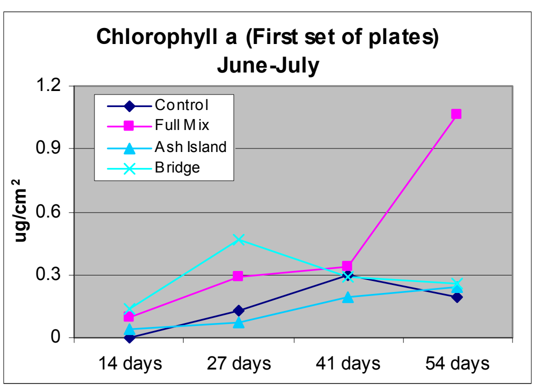
Table 5. Water chemistry data for Ash River, 2005.

Site	Date	Alkalinity	Orthophosphate	Dissloved Phosphorus	Ammonia	Nitrate + Nitrite	Total Phosphorus
		Parameters (mg/l)					
Control	23-Jun-05	13.9	0.003	<0.002	<0.005	0.006	0.003
Full mix	23-Jun-05	12.4	0.006	<0.002	<0.005	0.006	<0.002
Ash Island	23-Jun-05	16.4	0.003	<0.002	0.006	0.009	0.003
Bridge	23-Jun-05	15.9	0.003	<0.002	<0.005	0.008	0.003
Control	20-Jul-05	16.9	0.001	<0.002	<0.005	0.012	<0.002
Full mix	20-Jul-05	17.4	0.002	<0.002	<0.005	0.013	<0.002
Ash Island	20-Jul-05	18.5	0.002	<0.002	0.008	0.013	<0.002
Bridge	20-Jul-05	17.1	0.002	<0.002	0.01	0.007	0.007
Control	16-Aug-05	16.7	<0.001	<0.002	<0.005	0.002	<0.002
Full mix	16-Aug-05	16.3	<0.001	<0.002	<0.005	0.006	0.002
Ash Island	16-Aug-05	16.3	<0.001	<0.002	<0.005	0.004	<0.002
Bridge	16-Aug-05	16.8	<0.001	0.003	<0.005	0.003	0.002
Control	14-Sep-05	16.8	<0.001	<0.002	<0.005	<0.002	<0.002
Full mix	14-Sep-05	16.7	<0.001	<0.002	<0.005	<0.002	0.002
Ash Island	14-Sep-05	17.1	<0.001	<0.002	<0.005	0.002	<0.002
Bridge	14-Sep-05	17.1	<0.001	<0.002	<0.005	0.002	<0.002

* Tan shading indicates PESC lab results

5.5 Periphyton Monitoring

Periphyton core samples were collected seven times over a 97 day period from each of the four sites. After 54 days, the foam was replaced, as the initial algal growth was starting to die off. Chlorophyll *a* concentrations sampled bi-weekly showed strong growth at the full mix site, located approximately 300 m downstream of the upper treatment (Figure 12a and 12b). The Ash Island Falls collector, located approximately 4.7 km downstream of the upper treatment site, had growth that was similar to the control. Substrates at the Ash River mainline bridge, located 1.4 km downstream of the lower treatment site, showed slightly improved growth.



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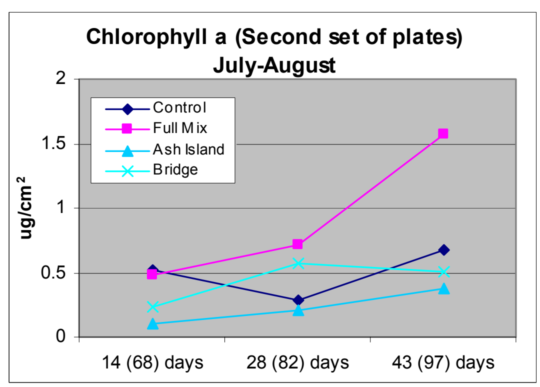

b)

Figure 12a and 12b. Chlorophyll *a* concentrations from periphyton collector plates in the Ash River, 2005.

5.6 Juvenile Fish Sampling

Weights of sampled fish from control and treated areas were pooled and appropriate confidence intervals applied. Treated sites appeared to have larger rainbow trout fry than control sites on average (Figure13), although the difference was not statistically significant

(95% C.I.). Pooled sampling data indicate mean weights of fish in treated reaches were 42% larger than those of the control cohort (0.96 g on average).

Using a mean measured alkalinity of 16.1 mg/L, rainbow fry biomass were below that predicted by Ptolemy's alkalinity model (1993), indicating habitat sampled was under seeded. Densities were highest in the treated reach at 34 fry per 100 m^2 (FPU) and 72% of predicted biomass (Table 6). The control reach (located near Elsie Dam) had an average fry density of 12 FPU, about 13% of the predicted biomass. Spot shocking was required outside electrofishing sites to obtain sufficient sample sizes from treatment and control reaches.

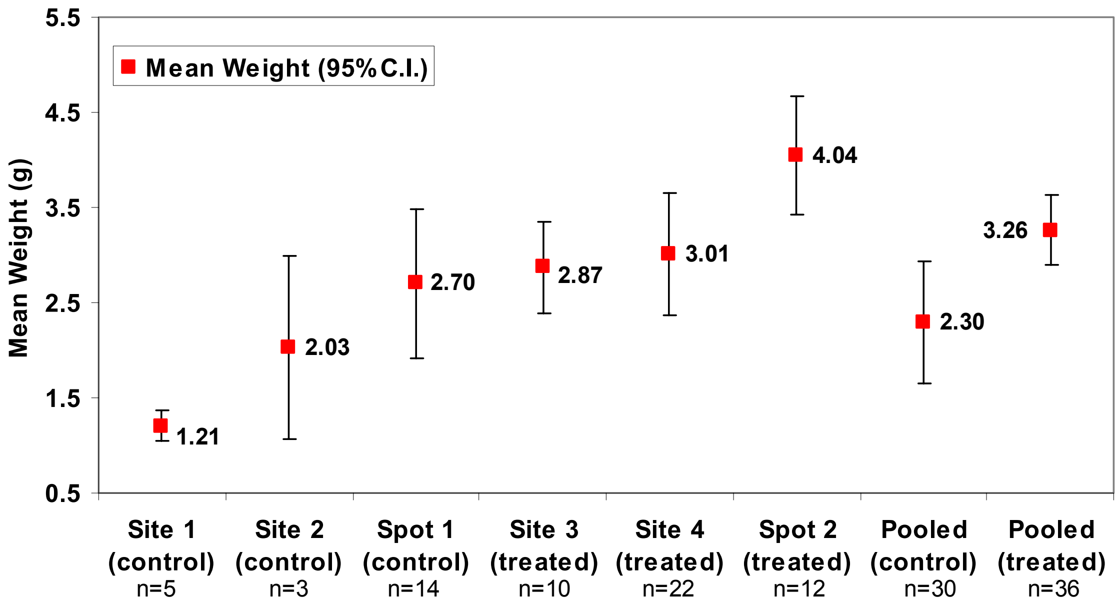

Figure 13. Mean weights of Ash River rainbow trout fry collected from control and treatment reaches, September 23-26, 2005.

Table 6. Observed and predicted rainbow fry densities from closed electrofishing sites in the Ash River, September 23 - 26, 2005.

Site	Mean Weight (grams)	Unadjusted Density (FPU)	D/V Adjusted Density (FPU)	Predicted Density (FPU)	Percent of Predicted
Control 1	1.22	10.3	16.7	118.2	14%
Control 2	2.17	6.1	7.4	68.7	11%
Mean	**1.58**	**8.2**	**12.0**	**93.5**	**13%**
Treated 1	3.00	12.0	41.6	48.4	86%
Treated 2	3.20	17.4	26.5	45.7	58%
Mean	**3.08**	**14.7**	**34.0**	**47.1**	**72%**

Rainbow fry density in control sites below Elsie Dam may have been affected by pulse flows that occurred on August 30 and September 20 to facilitate adult migration. The earlier pulse had a three day duration peaking at 10 m^3/s while the later pulse reached 20 m^3/s and lasted two days. Sampling occurred on September 23 and 26 when the discharge was approximately 4 m^3/s (Figure 11). The latter pulse may have had the effect of displacing juveniles downstream, leaving habitat immediately below the dam with lower than normal levels of seeding and moving fish from the control reach into the treated section.

Of note were two coho fry sampled at the upper control site. This reach of the Ash River was generally assumed to be accessible only to summer run steelhead due to a number of selective barriers on the system, particularly Dickson Falls. This evidence suggests that coho are occasionally able to navigate the selective barriers.

6.0 DISCUSSION AND RECOMMENDATIONS

Pollock bone meal applied in burlap bags proved to be a better application method than placing meal compressed into logs as done in previously in other watersheds. Bags remained intact for about five weeks and had an effective distance of approximately 3.5 km. The pollock bags developed a “fungal cap” after a few weeks which was thought to slow the release rate of the product. Towards the end of the treatment period, bags were cut open exposing more of the product to the stream flow.

The available phosphate was likely being consumed within a short distance of the application site as good algae growth was consistently observed at the full mix site. Treatments could be further improved with a second application of bone meal in mid-July, or with a greater number of application sites if access permitted. Until development of a slow release pollock product is completed, burlap bags will be used in pollock fertilizer applications.

Orthophosphate concentrations in water samples were suspiciously high. Background concentrations are typically undetectable (<0.001 mg/L), but samples collected from the control sites had concentrations ranging from 0.001 to 0.005 mg/L. There is often error associated with low-level nutrient analysis, particularly when expected results are close to the detection limits. These results were brought to the attention of MoE Environmental Protection staff and will be considered when next year’s terms of reference for laboratory contracting are developed.

Ash River juveniles appeared to show a moderate response to the pollock treatment in 2005. Pulse flows from Elsie Dam may have displaced juvenile fish from the control reach (an excellent spawning area) and mixed them with fish in the treated section. Future sampling should occur prior to scheduled pulse flows, particularly the larger pulse of 20 m^3/s.

7.0 ACKNOWLEDGEMENTS

BC Hydro through Bridge Coastal Fish and Wildlife Restoration Program (BCRP) provided project funding. The ARRWG made recommendations and provided a letter of support which accompanied the proposal to BCRP. Adam Lewis of Ecofish Research Ltd. coordinated the proposal delivery. BCCF administered the funds under the management of Pat Stephenson, Nanaimo. The ESSR program contributed carcasses at Robertson Creek Hatchery. Harlan Wright (BCCF) coordinated the field work with BCCC and HFN staff. Robertson Creek hatchery staff assisted with salmon carcass collection and co-ordinated

distribution days. Loreta Hansen (BCCF) conducted the periphyton and water sampling. James Craig (BCCF) edited this report.

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APPENDIX I

Financial Statement

Project # 05.As.02

Financial Statement Form

INCOME	BUDGET BCRP	BUDGET Other	ACTUAL BCRP	ACTUAL Other
Total Income by Source	17,924.94	8,765.00	17,925.00	6,333.25
Grand Total Income (BCRP + other)				
EXPENSES				
Project Personnel				
Wages (BCCF)	4,500.00		5,568.49	
(HFN)	3,500.00		**4,672.56**	
MoE Biologists		1,265.00		1,265.00
Training/Safety				
Per Diem	165.00		135.00	
Materials and Equipment				
Equipment Rental			10.00	
Materials Purchased			9.62	
Travel Expenses				
Vehicle Lease	975.00		465.16	
Fuel	675.00		468.25	
Permits				
Fertilizer	3,190.40		5,156.90	
Salmon Carcasses		7,500.00		5,068.25
Sign Development	1,200.00			
Communications				
Lab Costs	1,740.00			
Shipping	350.00		330.14	
GST			207.80	
Administration				
Office Supplies				
Photocopies and printing				
Postage				
BCCF admin @ 10%	1,629.54		901.08	
Total Expenses	17,924.94	8,765.00	17,925.00	6,333.25
Grand Total Expenses (BCRP+other)	26,689.94		24,258.25	
BALANCE (Grand Total Income -Grand Total Expenses)	0.00		0.00	

Estimated cost for HFN labour including administration

APPENDIX II

Performance Measures

Performance Measures - Actual Outcomes			**Project # 05.Ash.02**									
			Habitat (m^2)									
Project Type	**Primary Habitat Benefit Targeted of Project (m^2)**	**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 mgmt											
	Functional habitat conserved by other measures (e.g. riprapping)	ST,CT,DV		9.5	*Habitat Restoration by stream enrichment (km habitat enhanced downstream of the Elsie Lake dam)*							
Designated rare/special habitat	Rare/special habitat protected											
Maintain or Restore Habitat forming process												
Artificial gravel recruitment	Area of stream habitat improved by gravel plcmt											
Artificial wood debris recruitment	Area of stream habitat improved by LWD plcmt											
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 III

Confirmation of BCRP Recognition

Cash for Ash River
Alberni Valley Times
Wed 01 Mar 2006
Page: 1 / Front
Section: News
Byline: Shayne Morrow
Source: Alberni Valley Times

A group headed by Hupacasath First Nation has attracted increased funding from BC Hydro for habitat enhancement in the Elsie Lake watershed. Since the late 1990s, the Bridge Coastal Restoration Program (BCRP) has provided funding for restoration work in watersheds affected by hydro development. Hupacasath manager Trevor Jones said it's been a natural fit for the band, but until recently, getting the money was a hit-or-miss proposition.

"Hupacasath were quick out the door to take advantage of the program in the watershed," Jones said Tuesday. But BCRP money was hard to come by until local interest groups banded together, he said.

"We've now created partnerships in a multi-stakeholder group, known as the Alberni Valley Aquatic Resource Group," Jones said.

AVARG includes parties diverse as the Alberni Valley Enhancement Association, personnel from local Fisheries and Oceans Canada operations and the provincial fisheries ministry. The effect has been an expanded centre of gravity for habitat restoration efforts.

"AVARG has become a model for groups in other Hydro jurisdictions," Jones said. And the results are showing, he added. Prior to AVARG, the band was lucky to get funding for one or two projects per year.

"For 2005-06, we've had four projects funded, and another five for 06-07," Jones said.
FEEDING A RIVER
Three of those projects involve assessment and study. But according to AVARG consulting biologist Adam Lewis, one of the programs is simple, hands-on stuff.

Called the Ash River Nutrient Enrichment program, it's just that -- putting more food into the eco-system.
"There are many ways of fertilizing a stream," Lewis explained. "Last year, we started putting in slow-dissolving, pollock-based blocks of nutrient."

Besides adding food for fish and other aquatic life forms, the supplements also raise critical phosphorous and nitrogen levels in the water. When available, coho and chinook carcasses from Robertson Creek hatchery are also introduced back into the watershed, to replicate the effect of historic spawning patterns

"This program takes place in the Middle Ash River, between Elsie and Dickson Lakes," Lewis said. The river is home to both resident and sea-run trout, as well as coho salmon. Total cost of the program is about $27,000 per year, of which BCRP provides about $18,000. The balance comes from the AVARG stakeholders, Lewis said.

ELSIE ON STEROIDS?
The Elsie Lake Productive Capacity Assessment project was fully funded by BCRP, at a budget of $81,000, with Hupacasath providing the boat and sampling crew.

"We're assessing whether putting fertilizer in Elsie Lake would improve salmon capacity," Lewis said. While lake fertilization to increase nutrients is common (nearby Great Central Lake is one beneficiary), it isn't always a good idea.

"Depending on the food-webs within the eco-system, fertilizing a lake can encourage the growth of species that are actually detrimental to the desired species," he explained. You can wind up boosting the population sticklebacks, which prey on juvenile salmonids, or zooplankton, which benefits no one.

"The lake may be producing more biomass of food, but it may be food that the fish can't eat," Lewis said. The good news is, Elsie Lake appears to be an excellent candidate for fertilization, he added.

The fertilizer comes in the form of a phosphorous-nitrogen drip, which is fed into the lake from barge-based tanks over a period of four or five weeks.

HABITAT AVAILABLE
A third study, budgeted at $63,000, is assessing the productive capacity of the tributaries flowing into Elsie Lake.
"What we know is that the Upper Ash River contains a large quantity of habitat," Lewis said. "Fertilizing Elsie Lake would encourage migration of native rainbow and cutthroat trout up into the tributaries."

According to Hupacasath elders, both coho and sockeye salmon spawned in the upper reaches of the Ash prior to construction of the Elsie Lake Dam in the 1950s.

Now the study has turned up a pair of wild cards, with the discovery of both juvenile coho and land-locked sockeye salmon (known as kokanee) in the system.

"We now know kokanee are present in the lake, but nobody is catching them," Lewis said. That raises some interesting scenarios, he explained.

"It's quite possible that the native cutthroat are preying on juvenile kokanee. On the other hand, fertilization would increase the size of the kokanee," he said.

Whether the kokanee are a historic population similar to those found in other B.C. lakes, or a new race created when the dam blocked passage to the lake is another question the scientists will have to wrestle with.

OPENING THE BARRIERS
The $50,000 Ash River Fish Passage Study will deal with both technical and ethical questions, according to Lewis.
"A great way to increase fish production is to link habitat together," he said. Along the Middle Ash are a number of barriers, including Dickson and Lanterman Falls. Increasing fish passage brings into question the wisdom of tampering with the existing eco-balance --especially when it involves a glamour species.

"Upstream of Dickson Falls, the only fish that can pass (according to current wisdom) are summer steelhead, and the province is reluctant to allow salmon passage," Lewis said. And then there's the dam itself.
"There was no barrier there historically, and it's another place where we could look at fish passage," he said. Technically, it's possible, but there are difficulties, such as screening the Ash River turbine intakes to protect migrating salmon smolts.
But restoring coho salmon above the dam, to take advantage of nearly 20 kilometres of Class A spawning habitat, raises another political issue.

The Upper Ash watershed is private timberland owned by Island Timberlands. Should the property be re-designated as salmon spawning habitat, that puts the owner under a whole new set of federal regulations governing harvesting operations, Jones said.

"Hupacasath would like to see salmon in the headwaters for that reason," Jones said.
"Island Timberlands has supported this work from the beginning," he added.
Lewis noted that AVARG has applied to extend the passage assessment for another year, partly as a result of the discoveries.

"Halfway through the project, we found coho, so that changed everything," he said.
"We've realized there are a lot of holes in our knowledge -- especially in the small tributaries on the Upper Ash."
RETURN OF THE KING
For Al Ross (Kaa-nowsh), hereditary chief of Hupacasath First Nation, the AVARG work has been an opportunity to return to his roots, in more ways than one.

"I worked as a fisheries guardian for Tseshaht First Nation for 15 years.
"This has given me a chance to come back," Ross said.
He now serves as acting fisheries manager for Hupacasath, and has been the go-to guy when it comes to field work.
Ross noted that Hupacasath First Nation is actually a coalition of three inland tribes which lived in the Alberni Valley.

"My own people ruled in the Ash River/Elsie Lake area, right where we're working," he said.
IMMEDIATE BENEFITS
AVEA chair Dave Chitty said AVARG has been a boost for his group.
"Any time we can work together with other groups, it's a win-win," Chitty said. "For example, we had anecdotal knowledge of coho above the barriers, and now we have proof."
One of the biggest benefits has been a change in policy by BC Hydro, Chitty said.
"As a result of the Ash River Water Use Plan, Hydro is now required to increase its fish flows during the early fall," he said.

In past years, during the dry season, the utility allowed flows to drop to minimal levels, Chitty explained.
"Now they've moved the flows back closer to historic levels, which improves the migration of species such as steelhead and coho," he said.

Hupacasath First Nation will be hosting an open house at the House of Gathering, from 4-6 p.m. on March 30. Jones said the public will have a chance to check out the BCRP projects and talk to the biologists.