ASH RIVER NUTRIENT ENRICHMENT
FOR FISH HABITAT RESTORATION
2009

prepared by

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EXECUTIVE SUMMARY

A total of 2,360 kg of pollock bone meal was applied to the Ash River, Wolf Creek, and Lanterman Creek on July 3, 2009. Mainstem loading rates were set at 980 kg per site with application points approximately 1.5 km downstream of Elsie Lake Dam and 500 m downstream of Ash Island Falls. Wolf and Lanterman creeks each received 200 kg of bone meal at accessible bridge crossings. Monitoring of periphyton growth indicated a two to five fold increase in chlorophyll *a* concentration on substrates downstream of enrichment sites. Water chemistry analysis suggested that mainstem reaches downstream of Elsie Lake Dam were co-limited by nitrogen and phosphorous while upstream of the dam nitrogen concentrations were sufficient to support algal growth. Wolf and Lanterman creeks had moderate levels of nitrogen throughout the growing season and benefited though the addition of high phosphorous organic bone meal. It is strongly recommended that future mainstem enrichment projects address nitrogen limitation.

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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 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).

In 1958, a dam was constructed by BC Hydro at the outlet of Elsie Lake in the Ash River sub-basin, part of Vancouver Island's Stamp/Somass watershed. The dam flooded 401 ha of land, thereby expanding the original 271 ha lake to a 672 ha reservoir (BC Hydro 2000). The Ash River watershed is 378 km^2 and has a mean annual discharge of 16.7 m^3/s, measured at WSC station 08HB023 for the period 1961-2005. Naturalized MAD would have likely been higher as BC Hydro has the ability to divert an average of 10.8 m^3/s into Great Central Lake[1]. Reservoir storage is diverted by penstock to a generating station on Great Central Lake which has an operating capacity of 25.2 MW. The water licence allows for a maximum of 76.5 million m^3 of storage and 339 million to be diverted into Great Central Lake per annum (Hirst 1991). 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 phosphorus concentrations below the method 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. Organic nutrient addition and/or salmon carcass redistribution[2] 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, Ministry of Environment (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™",

[1] Based on the existing water license of 339 million m^3 per year which averages to 10.75 m^3/s over 365 days.
[2] Carcass redistribution involves taking post spawn hatchery broodstock and/or carcasses dead-pitched from spawning channels (artificially high abundance) and redistributing them into the upper reaches of the watershed (typically low abundance).

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).

Early in 2003, Alaskan pollock bone meal[3] was tested at the MoE Fish Health Lab in Nanaimo as an organic fertilizer. The bone meal was heat pasteurized before delivery and confirmed to be pathogen free. Testing for other contaminants and metals was also completed and confirmed the product's suitability for potential stream treatments (Pacific Environmental Science Centre, North Vancouver). From 2003 to 2005, 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. The product has since been applied with favourable results as coarse fragmented particles contained in burlap bags.

Following recommendations from the Ash River Restoration Working Group (ARRWG), a stream enrichment proposal utilizing pollock bone meal and salmon carcasses was prepared by BC Conservation Foundation (BCCF) and submitted by Hupacasath First Nation (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 Lake Dam. The objective was to increase the ratio of steelhead smolts generated per spawner, as demonstrated by restoration and monitoring activities on the Keogh River near Port Hardy. The primary limiting factor addressed by stream enrichment is reduced biological productivity resulting from dam construction and water diversions.

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 nutrients to the upper mainstem below Elsie Lake Dam. Salmon carcasses and/or pollock bone meal were loaded at a rate intended to increase orthophosphate concentrations from <1 ug/l (i.e. undetectable) 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 were not excessive and to assess the effectiveness of fertilizer additions. Also, a feasibility study of Lanterman and Wolf creeks (main Ash River tributaries) was conducted to determine baseline water chemistry and potential loading rates/sites. Background details, scientific rationale, and case study examples of stream enrichment are compiled by Ashley and Slaney (1997), Kiffney, Bilby and Sanderson (2005), and Pellett (2009 a-c).

[3] Imported and supplied by Welcome Harvest Farms, Texada Island, BC.

3.0 STUDY AREA

The Ash River is the largest tributary to the Stamp River, located near the municipality of Port Alberni. The section of river targeted for nutrient enrichment includes 11 km of mainstem extending from Elsie Lake Dam to Dickson Lake (Figure 1). Though not accessible to most anadromous salmonids due to selective barriers below Dickson Lake, this reach does support summer run steelhead and resident/adfluvial populations of trout and char. In addition, coho fry have been sampled above Dickson Falls by electrofishing crews on occasion (M. McCulloch, MoE, Nanaimo, pers. comm.). Kokanee (*O. nerka*) are present in Elsie Lake, and small numbers may also occur in Dickson Lake (C. Wightman, BCCF, 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. Wolf and Lanterman creeks are tributaries to the Ash River. Both creeks join the Ash mainstem below anadromous barriers and are therefore accessible to all species of salmon and summer and winter run steelhead.

Figure 1. Location of Ash River watershed relative to Vancouver Island

Burt and Horchik (1999) identified the Ash River as 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 extends from January through the end of April. For juvenile steelhead, the growth period is from April to October, and over-wintering occurs between November and March.

3.1 Site Locations

Fertilizer application sites were chosen by considering 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 were determined following similar rationale, though access was given greater consideration.

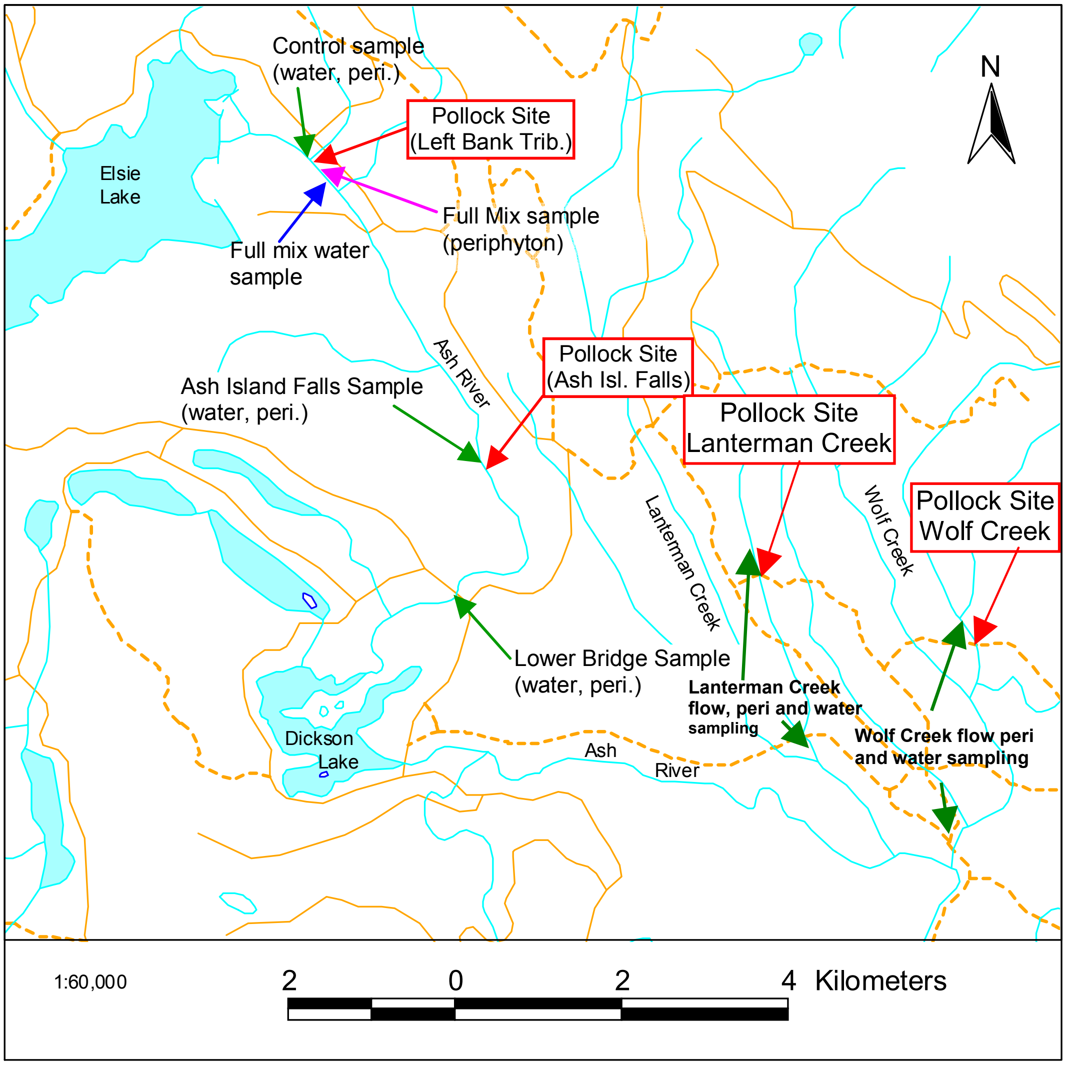


Figure 2. Fertilizer treatment, flow monitoring, and water and periphyton sampling sites in the Ash River watershed, 2009.

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 its nutrients over a 90 day period. Equation 1 describes how these parameters were used to calculate the amount of pollock loaded at each site. Calculations assumed a discharge of 3.5 m^3/s below Elsie Lake for the treatment period (licensed minimum fish flow release).

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 for the treatment reach by site.

Location	Discharge (m^3/s)	Product	Target (kg)
First left bank tributary downstream of Elsie Lake Dam	3.5	Pollock	980
500 m downstream of Ash Island Falls	3.5	Pollock	980
Wolf Creek at the Mainline Bridge	0.8	Pollock	200
Lanterman Creek at the Mainline Bridge	0.8	Pollock	200
Total			**2,360**

Following calculations, fertilizer (Figure 3, pre-bagged in burlap, 10 kg each) was loaded on a pickup truck and trailer. BCCF and the HFN staff provided labour during the application (Figure 4a). Bags were anchored with rocks in high flow areas to ensure maximum nutrient leaching and mixing (Figure 4b). Bag placement was clustered to allow for easy removal if necessary. Sites were located away from high traffic areas to reduce the possibility of tampering.

Figure 3. Pollock bone meal contained in pre-packaged burlap bags.

a) 

b) 

Figures 4a and 4b. Pollock filled burlap bags were secured to the bottom of the river using large cobbles.

4.2 Carcass Distribution

A proposal to distribute chinook carcasses was submitted to the DFO Introductions and Transfers Committee prior to carcass plants. Up to 1,500 post-spawn Chinook and coho salmon from First Nation ESSR allocations at Robertson Creek Hatchery were proposed for carcass plants in 2009. 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 the project.

In early fall, Robertson Creek Hatchery and HFN staff were contacted by BCCF to confirm carcass availability and develop tentative logistics. Carcasses were collected and loaded into insulated fish totes by staff at Robertson Creek prior to distribution. 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 to increase retention.

a) 

b) 

Figures 5a and 5b. a) Chinook salmon carcasses to be placed in the Ash River. b) Distributing salmon carcass at the Ash Mainline Bridge.

4.3 Monitoring

Flow Measurements

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. Due to the regulated releases from Elsie Lake Dam, flow monitoring was less intensive on the mainstem than for other enrichment programs on Vancouver Island. Feasibility investigations on Wolf and Lanterman creeks included multiple flow transects over the summer. Data were used in the development of loading rate calculations.

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 (Table 2). Samples were collected in 1.0 l 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 same day by courier to PESC for analysis within 24 hours of specific water quality parameters (Table 3).

Table 2. Summary of water and periphyton sampling locations on the Ash River, 2009.

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	50 m below fertilizer at first left bank tributary
Second LB tributary	X		Approximately 500 m downstream of the first left bank tributary confluence
Ash Island Falls	X	X	750 m downstream of the falls but 150 m above the fertilization site
Ash Mainline(ML)	X	X	Pool below the Ash Mainline bridge
Wolf Creek	X		50 m upstream of the Ash River confluence
Lanterman Creek	X		Old Br 73 bridge crossing

Table 3. Water chemistry parameters tested including associated units and detection limits.

Water Chemistry Test	Units	Method Detection Limit (MDL)
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

Periphyton Sampling

Periphyton growth was quantified by measuring chlorophyll *a* concentrations on core samples taken from collector plates. Plates consist of a sheet of white florist's foam, 1.25 cm thick, attached to a Plexiglas plate with electrical ties (Figure 6a). 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 15 cm of water. There was little risk of plates becoming dewatered as summer base flows are regulated at 3.5 m^3/s (Moran Creek WSC station). Sites were selected to have similar solar exposure and water velocity.

Collectors were installed on July 3, 2009 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 immediately above the lower pollock treatment. A fourth site (dilution) was located at the Ash Mainline bridge pool before the river empties into Dickson Lake (Table 2).

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 (Figure 6b), one from each of the two periphyton blocks (Mouldey Ewing *et al.* 1998). Each sample was drained and placed in the vial. 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 July 14 and ending on September 30. 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 $\mu g/cm^2$ by laboratory staff.

a)  b) 

Figures 6a and 6b. a) Periphyton collector plate prior to installation. b) Lanterman Creek periphyton collector on September 30, 89 days after installation.

5.0 RESULTS

5.1 Fertilizer Application

On July 3, 2009, a total of 1,960 kg of pollock bone meal was distributed evenly between two sites on the Ash River from Elsie to Dickson lakes (Figure 2). No loading rate adjustments were required with the regulated discharge from Elsie Lake Dam. As fungal caps formed on the exterior of pollock bags a portion were sliced open to expose fresh product at each site visit (Figures 7a and 7b). A further 400 kg of nutrients were also applied to key tributaries. 200 kg was loaded at the Ash River Mainline Bridge over Wolf Creek and an additional 200 kg at the old bridge crossing over Lanterman Creek.

a)  b) 

Figures 7a and 7b. a) Pollock bag covered with fungal cap. b) Cutting pollock bags after several weeks to improve nutrient release.

5.2 Carcass Distribution

Between October 1 and 30, 2009, a total of 425 Chinook salmon and 400 coho salmon carcasses were collected from Robertson Creek Hatchery and split amongst three locations between Elsie and Dickson lakes (Figure 9). Plants occurred 1 km downstream of the Elsie Lake Dam, Ash Island Falls, and at the Ash Mainline Bridge above Dickson Lake. Upstream locations received more carcasses to maximize nutrient benefit. The total weight of the carcasses was estimated to be 4,812 kg based on an average of 8.5 kg for Chinook and 3 kg for coho. Carcass availability was limited with only 46% of target quantities available for distribution.

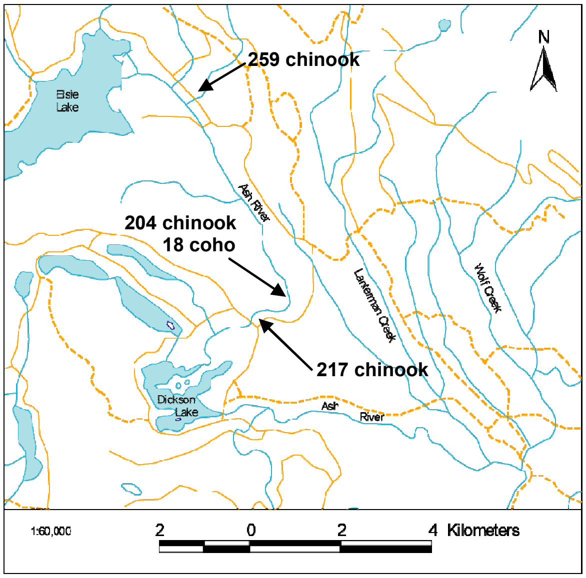


Figure 8. Location of salmon carcass plants in the Ash River, fall 2009.

5.3 Monitoring

Flow Measurements

Summer releases from the Elsie Lake Dam followed the Water Use Plan (WUP) guidelines with a base flow release of 3.5 m^3/s. Two experimental pulse flows occurred later in the season to enhance upstream migration conditions of adult salmon and steelhead. Flows in two major tributaries, Wolf and Lanterman creeks, were measured once at what was assumed to be summer base flow (Table 4).

Table 4. Measured discharge (m^3/s) at Wolf and Lanterman creeks during study period.

Date	Stream	Site	Discharge (m^3/s)
27-Jul-09	Lanterman Creek	Old Br 73 Road	0.098
27-Jul-09	Wolf Creek	50 m u/s Ash confluence	0.188

Water Sampling

Water chemistry results showed orthophosphate concentrations that were consistently low. Pre-enrichment water chemistry (2001) indicated undetectable concentrations (<0.001 mg/l). All samples in 2009 indicated undetectable levels throughout the treatment period in all sites except Lanterman Creek (Table 5). Total phosphorous (which includes orthophosphate) was detected at low levels in 13 of 38 samples. Nitrate and nitrite levels were very low in the first two samples and dropped to undetectable levels in mainstem sites by September 30. Moderate nitrogen levels were consistently documented in the primary tributaries throughout the treatment period above and below enrichment sites.

Table 5. Water chemistry data (mg/l) for the Ash River and tributaries, 2009.

Stream	Location	Date	Nitrate + Nitrite	Orthophosphate	Total Phosphorus
Ash	Left Bank Trib. Control	14-Jul-09	0.008	<0.001	<0.002
	Left Bank Trib. Below Fert	14-Jul-09	0.006	<0.001	0.002
	U/S Ash Island Falls	14-Jul-09	0.010	<0.001	0.002
	D/S Ash Island Falls	14-Jul-09	0.007	<0.001	0.003
	Lanterman Creek Control	14-Jul-09	0.038	<0.001	<0.002
	Lanterman Creek Treated	14-Jul-09	0.043	0.001	0.002
	Wolf Creek Control	14-Jul-09	0.023	<0.001	0.002
	Wolf Creek Treated	14-Jul-09	0.028	<0.001	0.002
	Elsie Lake U/S Control	16-Jul-09	0.025	<0.001	<0.002
	Left Bank Trib. Control	27-Jul-09	0.003	<0.001	<0.002
	Left Bank Trib.	27-Jul-09	0.002	<0.001	<0.002
	Ash Island Falls U/S	27-Jul-09	0.005	<0.001	<0.002
	Ash Island Falls D/S	27-Jul-09	0.003	<0.001	<0.002
	Lanterman Creek Control	27-Jul-09	0.127	<0.001	<0.002
	Lanterman Creek	27-Jul-09	0.128	0.002	0.004
	Elsie Lake U/S Control	27-Jul-09	0.041	<0.001	<0.002
	Wolf Creek Control	27-Jul-09	0.081	<0.001	<0.002
	Wolf Creek	27-Jul-09	0.072	<0.001	<0.002
	Left Bank Trib. Control	24-Aug-09	0.003	<0.001	<0.002
	Left Bank Trib.	24-Aug-09	0.002	<0.001	<0.002
	Ash Island Falls U/S	24-Aug-09	0.004	<0.001	<0.002
	Ash Island Falls D/S	24-Aug-09	0.005	<0.001	<0.002
	Lanterman Creek Control	24-Aug-09	0.060	<0.001	<0.002
	Lanterman Creek	24-Aug-09	0.059	0.002	0.003
	Elsie Lake U/S Control	24-Aug-09	0.030	<0.001	<0.002
	Wolf Creek Control	24-Aug-09	0.046	0.001	<0.002
	Wolf Creek	24-Aug-09	0.053	<0.001	<0.002
	Elsie Lake U/S Control	10-Sep-09	0.024	<0.001	<0.002
	Left Bank Trib. Control	10-Sep-09	0.003	<0.001	<0.002
	Left Bank Trib. Control	30-Sep-09	<0.002	<0.001	0.002
	Left Bank Trib.	30-Sep-09	<0.002	<0.001	0.003
	Ash Island Falls U/S	30-Sep-09	0.002	<0.001	0.002
	Ash Island Falls D/S	30-Sep-09	0.002	<0.001	0.003
	Lanterman Creek Control	30-Sep-09	0.026	<0.001	<0.002
	Lanterman Creek	30-Sep-09	0.025	<0.001	0.003
	Elsie Lake U/S Control	30-Sep-09	0.027	<0.001	<0.002
	Wolf Creek Control	30-Sep-09	0.020	<0.001	<0.002
	Wolf Creek	30-Sep-09	0.025	<0.001	<0.002

Water sampling in 2009 included an analysis of nitrogen levels above and below Elsie Lake. Nitrogen concentrations decreased below Elsie Lake throughout the summer growing season while those upstream fluctuated between 25 and 40 µg/l (Figure 9). The final sample in late September indicated undetectable levels (less than 1 ppb or µg/l) when the upper river sample indicated 27 µg/l. Although nitrogen is present in the bone meal, concentrations are too low to provide a significant source. Nitrogen limitation is the most likely reason for reduced success of nutrient enrichment programs on the upper Ash River below Elsie Lake. The addition of a high nitrogen liquid fertilizer in combination with bone meal should provide optimal condition for algal growth and restore productivity to the upper Ash River in 2010.

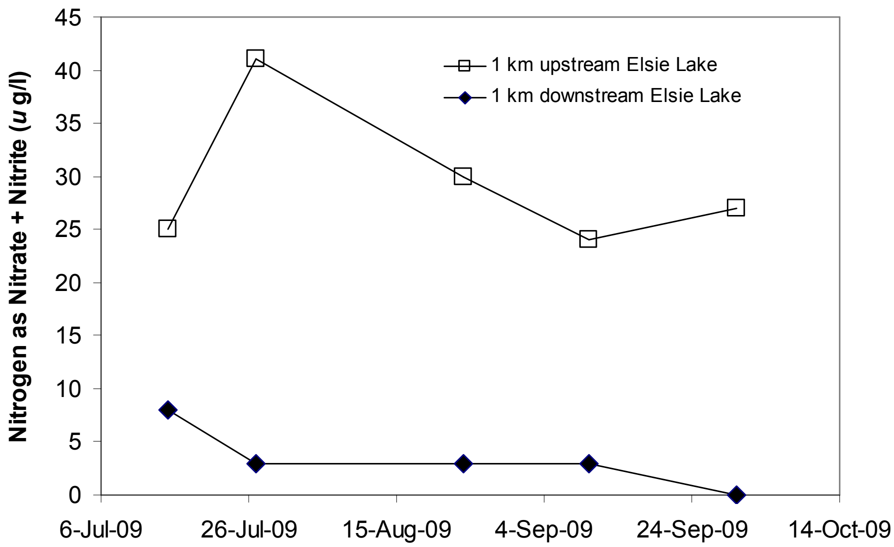
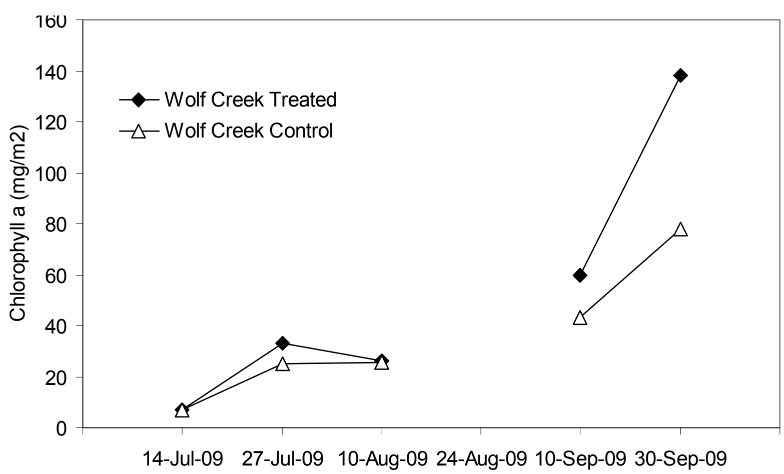


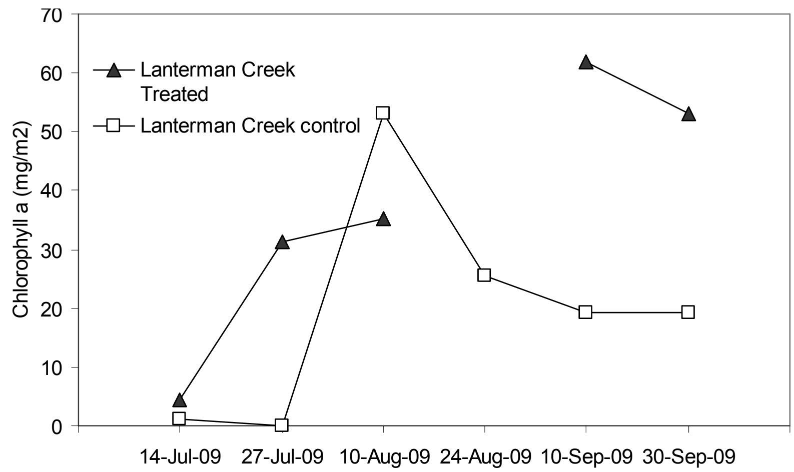
Figure 9. Ash River nitrogen concentrations measured upstream and downstream of Elsie Lake in the summer of 2009.

Periphyton Sampling

Periphyton core samples were collected bi-weekly over a 78 day period in order to capture peak algal growth at each of the four sites. Chlorophyll *a* concentrations indicated algal growth in Wolf Creek was influenced by enrichment but the difference was not as strong as anticipated (Figure 10-a). The pattern of growth in Lanterman Creek showed a decrease in production in the control reach beginning in mid August. At the same time growth in the treated reach increased nearly three-fold compared to the control by the end of the season (Figure 10-b). Mainstem enrichment sites showed a similar pattern of growth throughout the treatment period. Algal concentrations in treated and control reaches were similar until mid August when a significant increase was observed downstream of both enrichment sites (Figures 10 c and d). Consistent with observations in Lanterman Creek, growth increased two fold at the upper site and nearly five fold at the lower site by the last sample period on September 30.



a)



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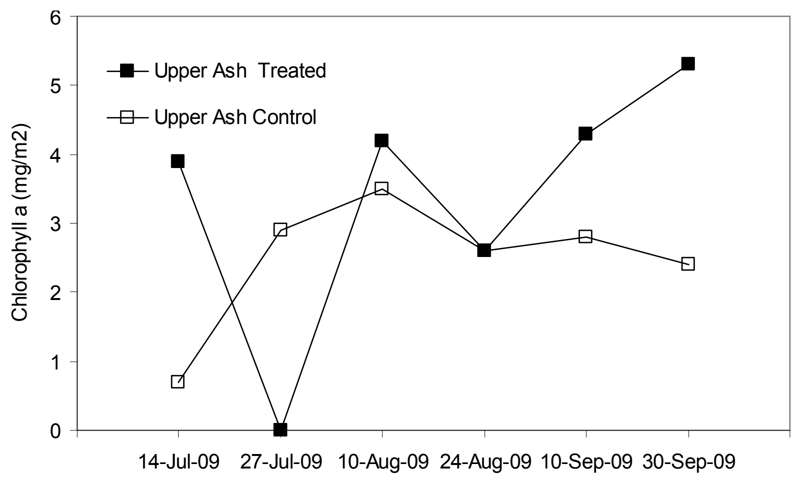

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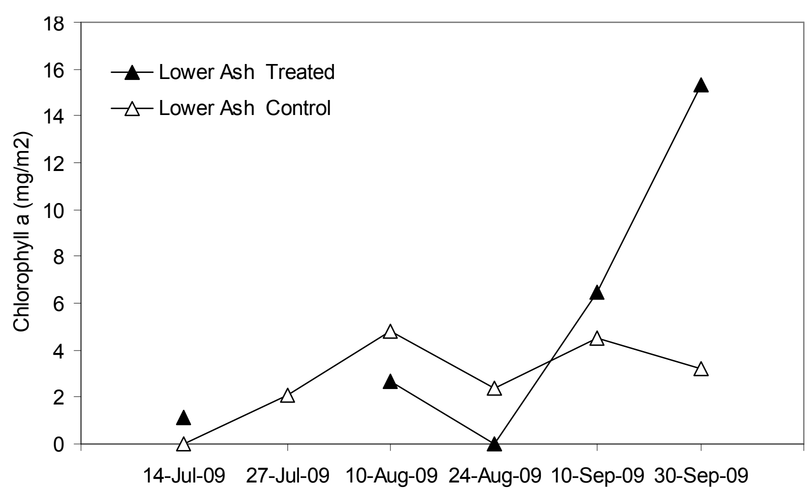

d)

Figures 10 (a-d). Periphyton core analysis from representative control and treated reaches in mainstem and tributary sampling sites, 2009.

6.0 DISCUSSION AND RECOMMENDATIONS

Application of nutrients on July 3, 2009, produced a measurable algal growth response in mainstem and tributary target reaches. Monitoring results indicate extremely dilute water chemistry and suggest mainstem reaches are co-limited by nitrogen and phosphorous. Results from sites in Lanterman and Wolf creeks and the upper Ash River above Elsie Lake indicated sufficient nitrogen levels to support a phosphorous enrichment program. It appears that nitrogen limitation in the mainstem is a result of the Elsie Lake impoundment and is a clear footprint impact of the BC Hydro facility. It is recommended that future enrichment projects take this into consideration and incorporate nitrogen enrichment in conjunction with phosphorous additions below the dam. Nitrogen enrichment would have to incorporate a liquid drip station near the outlet of Elsie Lake Dam. Loading rates could be easily set as the discharge throughout the treatment period would not vary significantly from the 3.5 m^3/s outlined in the WUP.

Juvenile steelhead growth response was not measured in 2009. Pulse flows late in the summer have been found to re-distribute juveniles within the control and treated reaches, confounding efforts to demonstrate treatment efficacy. Elevated flows later in the fall inhibited sampling effort (late season electrofishing) and salmon carcass distribution monitoring. It is recommended that carcass distribution monitoring be removed from the list of activities in future projects. The combination of high flows and poor visibility have resulted in poor observer efficiency and an elevated risk to the safety of surveyors during previous projects.

7.0 ACKNOWLEDGEMENTS

BC Hydro through their Bridge Coastal Fish and Wildlife Restoration Program 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. HFN and BCCF co-administered project funding. The ESSR program contributed carcasses from Robertson Creek Hatchery, and hatchery staff assisted with salmon carcass collection and co-ordinated distribution days. The B.C. Conservation Corps provided some funding for two summer employees who were involved in both application and monitoring of this project.

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APPENDIX I
Financial Statement

Project # 09.ASH.01

Financial Statement Form

	BUDGET		ACTUAL	
INCOME	BCRP	Other (In Kind)	BCRP	Other
Total Income by Source	28,118.00	8,125.00	28,118.00	8,125.00
Grand Total Income (BCRP + other)	36,243.00		36,243.00	
EXPENSES				
Project Personnel				
Wages (BCCF)	8,750.00		3,213.68	
(HFN)	5,000.00			
MoE Biologists	0.00	625.00		625.00
Training/Safety	200.00		100.00	
Per Diem (BCCF)	191.25		63.75	
(HFN)	112.75			
Materials and Equipment				
Equipment Rental	380.00		140.00	
Materials Purchased				
Travel Expenses				
Vehicle Lease and Fuel				
(BCCF)	1,600.00		700.00	
(HFN)	1,600.00		700.00	
Permits				
Fertilizer	4,712.00		4,712.00	
Salmon Carcasses		7,500.00		4,125.00
Communications				
Lab Costs - water	1,080.00		1,380.00	
Lab Costs - periphyton	1,440.00		1,482.00	
Shipping (water/peri/fert)	710.00		774.56	
GST			76.99	
Administration				
Office Supplies				
Photocopies and printing				
Postage				
HFN admin @ 10%	2,578.00			
Total Expenses	28,354.00	8,125.00	13,342.98	4,750.00
Grand Total Expenses (BCRP+other)	36,479.00		18,092.98	
BALANCE (Grand Total Income -Grand Total Expenses)	0.00		18,150.02	

*Blue indicates BCCF budget item and green HFN budget item.

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

In the late fall of 2006 an interpretative signboard was installed at the Robertson Creek hatchery. The sign provides background and describes nutrient enrichment activities in the Ash watershed as well as other tools used in river restoration. BC Hydro is acknowledged for their financial support of restoration activities in the watershed through their Bridge Coastal Restoration Program.


ASH RIVER
NUTRIENT ENRICHMENT
how does
work?
toolkit
FISH WILDLIFE