

**ASH RIVER INSTREAM FERTILIZATION
2001**

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administered by
B.C. Conservation Foundation
Langley, B.C.

funded by
BC Hydro
Bridge-Coastal Restoration Program
Burnaby, B.C.
Project #01.VI.03

March, 2003

ABSTRACT

Slow release fertilizer briquettes were distributed instream at two sites in the Ash River on July 19, 2001. Each application was 132 kg (total-264 kg) of "Nutri-Stones™", an "aquatic restoration fertilizer briquette" produced by Lesco Inc., Ohio. The loading rate of 2.5 µg/L of phosphorus (P) and 3 µg/L of nitrogen (N) was calculated based on an estimated average summer flow (July, August, September), adjusted for 75% snow-pack (2001) to 1.88 m³/s. Water chemistry was monitored for low level nitrogen and phosphorus and periphyton samples were collected and analyzed for chlorophyll *a* and phaeophytin *a*. Analysis was completed at the Pacific Environmental Science Centre (PESC). In late August, a series of flood events resulted in the displacement of the majority of the briquettes downstream from the original treatment sites. In combination with the late fertilizer application (due to manufacturer shipment delays), this likely had a major effect on the efficacy of the fertilizer treatment in 2001.

ACKNOWLEDGEMENTS

Funding for this project was provided by BC Hydro, Bridge-Coastal Restoration Program supervised by Carol Lamont. The project was administered by the B.C. Conservation Foundation under the supervision of Pat Stephenson. The project supervisor was Craig Wightman, Fisheries Section, Ministry of Water, Land and Air Protection (MWLAP), Nanaimo. Expert consultation was provided by Ken Ashley, Fisheries Research and Development Section (MWLAP), Vancouver. Megan McCusker researched the background information and calculated the fertilizer loading rates. Brad Smith, Corey Hryhorczuk, Scott Sylvestri, and Loreta Hansen applied the fertilizer briquettes to the stream and placed the periphyton blocks. Water and periphyton sampling was conducted by Loreta Hansen. Water chemistry analysis was undertaken at the Pacific Environmental Science Centre in North Vancouver. The map and photographs were supplied by Brad Smith. Craig Wightman and James Craig edited this report.

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1.0 INTRODUCTION

2001 was the inaugural year of nutrient addition for the enhancement of juvenile steelhead in the treatment reach below the Elsie Lake reservoir to Dickson Lake (the Middle Ash River). The objective of slow-release inorganic fertilizer application is to temporarily replace the source of organic nutrients lost due to human influences (mainly depleted Pacific salmon spawning populations in streams). Nutrient addition should increase primary productivity leading to increased invertebrate populations; thereby, improving the growth and survival of juvenile fish (Mouldey Ewing, et al. 1998). Slow-release fertilizer briquettes have been developed over the last decade by Fisheries Research, Ministry of Water, Land and Air Protection (MWLAP), in Vancouver. In 2001, the first shipment of fertilizer briquettes called "Nutri-Stones™" was received from Lesco Inc. of Ohio for use as an "aquatic restoration fertilizer." Details of the scientific rationale and case study examples of inorganic stream enrichment are presented in the Fish Habitat Rehabilitation Procedures, Watershed Restoration Technical Circular No. 9, 1997 (Slaney and Zaldokas, editors).

The Ash River up to Elsie Lake is one of the main spawning areas for summer-run steelhead (*Oncorhynchus mykiss*) in the Somass River watershed (Burt & Horchik 1999). Steelhead adults move into the Ash River from July to October. The spawning period is January to the end of April. The incubation period is January to mid-June. Juvenile fish rear until the end of October and over-winter into April. The life history periods were provided by Ron Ptolemy (Consultative Committee for the Ash River Water Use Plan 2002).

The historic or naturalized mean annual discharge of the Ash River at the Elsie Dam equivalent to the Elsie Lake inflow is 21.1 cms. During the critical low flow period (CSFP) August and September the mean daily flow is 4.7 cms. The CSFP mean daily flow downstream of the Elsie Lake spillway (the treatment reach) is 3.3 cms (Consultative Committee for the Ash River Water Use Plan 2002).

2.0 METHODS and MATERIALS

2.1 Pre-fertilization Data Collection

i) Water licences were reviewed from the MWLAP website in March 2001, and are listed in Table 1. Potential drinking water licenses included domestic, enterprise, waterworks (municipality), and water users' community licenses (group of domestic licenses). Associated maps were located at the MWLAP offices although not included in this report.

Table 1. Water licenses on the Ash and Stamp rivers, from MWLAP website. The address of the site is http://wlapwww.gov.bc.ca:8000/pls/wtrwhse/water/water_licences.input.

*** Some small quantity domestic licenses apparently exist on Dickson Lake (Craig Wightman, MWLAP, pers. comm.).

Ash River

Power-General	BC HYDRO & POWER AUTHORITY	PWR SUPPLY RESOURCE MGMT 6911 SOUTHPOINT DR (EO8) BURNABY BC V3N4X8
Storage-Power	BC HYDRO & POWER AUTHORITY	PWR SUPPLY RESOURCE MGMT 6911 SOUTHPOINT DR (EO8) BURNABY BC V3N4X8

Stamp River

Waterworks	BEAVER CREEK	B-6083 BEAVER CREEK RD PORT ALBERNI
Local Auth	IMPROVEMENT DISTRICT	BC V9Y8H9
Waterworks	BEAVER CREEK	B-6083 BEAVER CREEK RD PORT ALBERNI
Local Auth	IMPROVEMENT DISTRICT	BC V9Y8H9
Domestic	RAGE IVAR A & PATRICIA G	BOX 1359 PORT ALBERNI B C V9Y7M2
Irrigation	RAGE IVAR A & PATRICIA G	BOX 1359 PORT ALBERNI B C V9Y7M2
Irrigation	RAGE IVAR A & PATRICIA G	BOX 1359 PORT ALBERNI B C V9Y7M2
Irrigation	JONES MELVIN J & LEA S	SITE 128 COMP 15 RR 1 PORT ALBERNI BC V9Y7L5

ii) Previously collected water chemistry was requested from the Water Survey of Canada (WSC) and Ministry of Water, Land, and Air Protection offices (Table 2). Minimum detectable limits (MDL) were not supplied with this information. Low level testing is essential for accurate readings of dissolved orthophosphorus (SRP) from freshwater samples of Island streams, which are generally phosphorus (P)-limited i.e. $<1 \text{ ug L}^{-1}$. For this reason, the dissolved orthophosphorus (SRP) values shown in Table 2 are suspected to be measured at an MDL of $<3 \text{ ug L}^{-1}$. Available phosphorus is generally taken up very rapidly by algal growth (Ashley & Slaney 1997), therefore the measurable low level dissolved orthophosphorus (SRP) would be expected to decrease during the summer growing period. The results shown do not reflect this and are therefore suspect.

Table 2. Water chemistry data for the EMS station E218227, Ash River just above Stamp River.

	Dissolved Ammonia	Nitrite plus Nitrate (NO ₂₊₃ -N)	ortho-phosphate (PO ₄ ³⁻ -P)	Total Dissolved Phosphorus	pH	Alkalinity Total 4.5	Dissolved Oxygen	Temperature
	µg L ⁻¹	µg L ⁻¹	µg L ⁻¹	µg L ⁻¹		mg L ⁻¹	mg L ⁻¹	Celsius
25-Jan-93	7	170	3	4	6.9	16		
1-Feb-93	13	140	3	3	6.8	11.5		
8-Feb-93	8	110	3	3	7	14.2		
16-Feb-93	14	70	4	3	7	17.9		
7-Apr-93	5	60	3		6.8	23.1	4.7	
5-May-93	5	60	3			20.4	5.2	12
2-Jun-93	5	20	3			17.8		
7-Jul-93	5	20	3			24.8	6.1	18.5
28-Jul-93	15	20	3		7.7	22.1	11.5	20.4
4-Aug-93								25
11-Aug-93							10.5	19
16-Aug-93							9.1	19.2
14-Sep-93	5	30	3		7.5	21.8		
6-Oct-93	10	20		3 (total P)	7.4	20.2		
9-Nov-93	48	20	4			15.8		
24-Nov-93	16	60	6		6.9	26.6		
8-Dec-93	14	40	3		6.8	13.7		
12-Apr-94	101	130	10		7	31.6		
3-May-94	6	50	7		7.9	38.9	10.8	
31-May-94						20		

iv). Mean monthly discharge data for the growing season of June to September 1960-1988 provided by WSC is shown in Table 3.

Table 3. Discharge data from WSC (data in cubic metres per second) for the Ash River below Moran Creek (08HB023).

	June	July	August	Sept	Average (Jun-Sep)	Average (75%)
08HB023 1960-1988	15.5	6.47	3.92	4.33	7.6	5.67

Average discharge for July, August and September below Elsie Lake was estimated to be 2-2.5 m³/s (C.Wightman, MWLAP, pers. comm.)

2.2 Fertilizer Site Locations

The upstream slow-release fertilizer application site was situated approximately 300 m below the confluence of the Elsie Lake spillway channel and the low level outflow (LLO) channel (Figure 1) The briquettes were placed by hand in the second riffle zone of the right branch and in the first riffle zone of the left branch. A control reach included the reach upstream to the spillway channel and the LLO. The second site was 5.5 km downstream and accessed from the right bank of the Ash River (Ash Island Falls) shown in Figure 2. The briquettes were placed across the wetted channel in riffle zones.

The water and periphyton sample sites included a control site below Elsie Lake but above the fertilizer application site. Water and periphyton were sampled just upstream of the second fertilizer application site. The downstream sample site was situated in the first riffle zone below the Ash River Road bridge crossing.

Figure 1. Application of the briquettes at the upstream site 300 m below the confluence of the Elsie Lake spillway channel and the LLO.





Figure 2.
Application of
fertilizer
briquettes at
the Ash Island
Falls site.

A map of the treatment sites and the sampling sites is shown in Figure 3.

2.3 Fertilizer Product

The “aquatic restoration fertilizer briquette” or “Nutri-Stone” was supplied by Lesco® Inc. of Ohio.

The guaranteed analysis is:

Total Nitrogen (N) – 16.00% (4.00 % Urea and 12.00% Magnesium Ammonium Phosphate)

Available Phosphoric Acid (P_2O_5) Total - 30.00% (“food grade”)

Magnesium (Mg) Total - 11.00%

Vegetable Oil - 2.00% (Derived from: Corn Oil and Canola Oil)

A copy of the product label is presented in Appendix i. The label includes additional details.

The product was shipped late in the growing season and was applied as soon as possible.

Compaction of the fertilizer into solid briquettes varied in quality. Some of the buckets contained a portion of non-compacted or granular fertilizer. This powdered product would provide an initial pulse of nutrients to the river but would dissolve and wash out of the system very quickly.

Fertilizer Application and Monitoring Sites in the Ash River Watershed, 2001

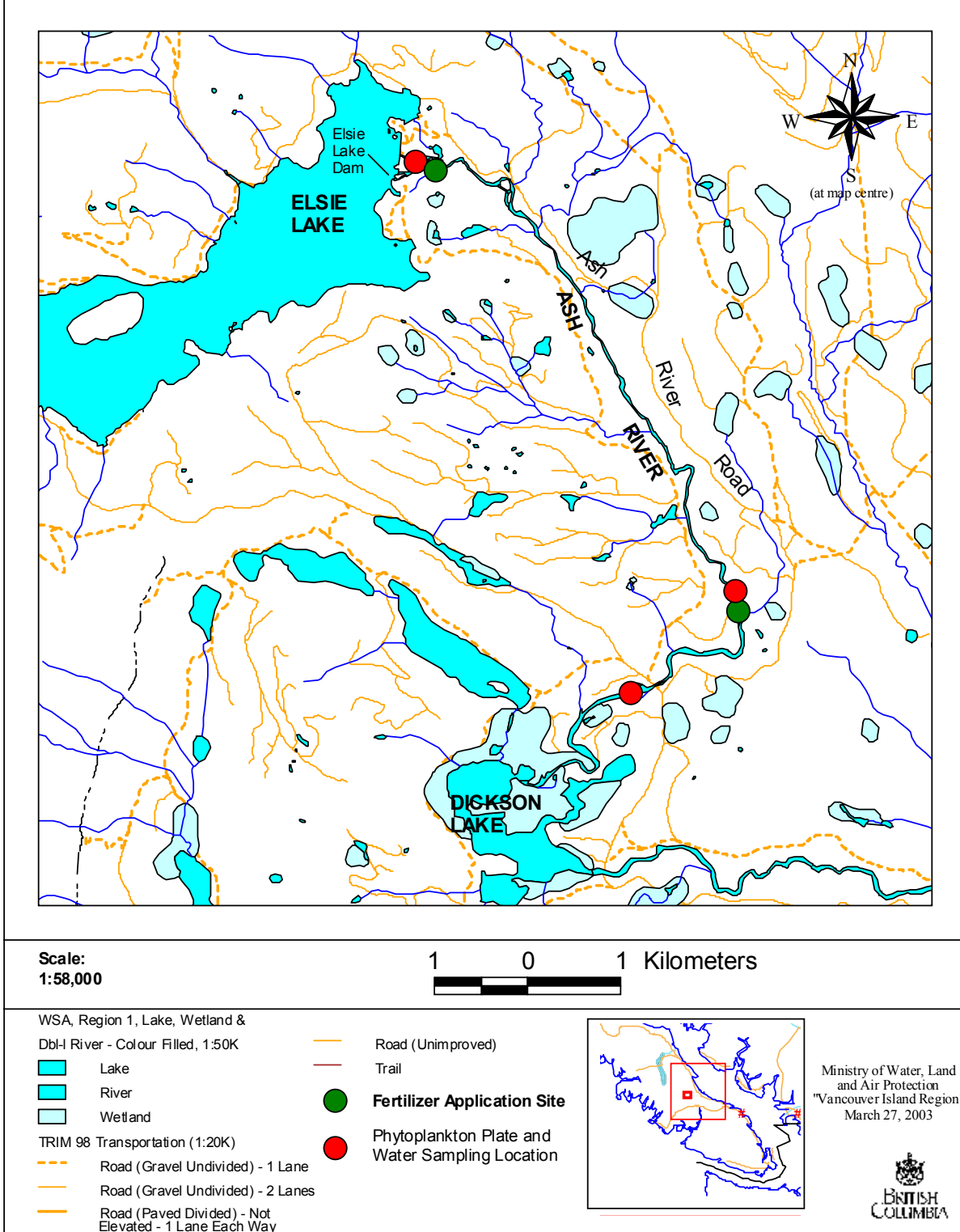


Figure 3. Ash River fertilizer sites and sampling sites in 2001.

2.4 Fertilizer Load Calculations

Loading calculations were derived from the formulation for the slow release product, “Nutri-Stone™,” 16-30-0 (N-P₂O₅-K₂O; % by weight. Fertilizer load was estimated based on a target concentration of 2.5 µg P/L and included 3 µg N/L. The fertilization period of 92 days (3 months) was generally from mid-June to mid-September. The application date may vary depending on the severity of late spring freshets. Fertilizer loads were based on the estimated monthly average for the Ash River below the Elsie Lake Dam or 2.5 m³/s. Loads for 2001 were based on an estimated 75% of average flow, adjusted for a below-normal snow-pack.

The slow release fertilizer contains 30% P₂O₅, or 43.7% phosphorus (P) by molecular mass, therefore the percent of (P) in 16-30-0 fertilizer was (0.3) x (0.437) or 13.1%. Fertilizer loading was calculated as follows:

Water discharge during the fertilization period

75% of average flow (m ³ /s)	Sec/day	Days	L/m ³	Litres of water
1.88 x	86,400 x	92 x	1000 =	1.49 x 10 ¹⁰

Kilograms of fertilizer

Target concentration (µgP/L)	µg Fert/ µg P	kg/ µg	Litres	Kg fertilizer
2.5 x	1/0.131 x	1 x 10 ⁻⁹ x	1.49 x 10 ¹⁰ =	284

2.5 Fertilizer Application

The briquettes were introduced into riffle habitat and were hand-applied in an even layer across the streambed (Figure 4). On July 19, 2001, a total of 264 kg of “Nutri-Stones™” was applied at two treatment sites including 132 kg (12 buckets) at the site below Elsie Lake and 132 kg (12 buckets) at Ash Island Falls, 5.5 km below the first treatment. This total amount was based on an average 11 kg of fertilizer per bucket.

Figure 4. Application of briquettes at the upstream site below Elsie Lake.



Generally, a one-time application per growing season is sufficient for good results of algae growth to enhance invertebrate populations. However, heavy rainfall from August 21 to early September, 2001 produced high flow conditions in all central and north Island streams. BC Hydro (BCH)

increased the flows at the Elsie Lake Dam on August 22 in order to keep the reservoir level low during the dam remediation project (D. Wilson, BCH e-mail of August 23, 2001 to Craig Wightman, MWLAP, Nanaimo).

2.6 Water Sampling

Water chemistry samples were collected in 1L plastic bottles and cleaned with distilled water before use. The bottles were rinsed three times with stream water in the field before being filled with water for subsequent lab analysis. For low-level nutrient samples, 100ml sterile brown-glass bottles were used, provided by the Pacific Environmental Science Centre (PESC, North Vancouver). Stream water was field-filtered through a 0.45 μm Sartorius cellulose acetate filter using a 60 ml syringe and field filtration unit. The filtration unit was cleaned with distilled water before use, and the syringe was rinsed with stream water before being filled with sample water. The samples were packed with ice in a cooler and shipped by courier within 24 hours to the lab. The handling and analysis of the water samples were conducted according to the Compendium of Methodologies of Standard Operating Procedures: Organic and Inorganic Analytical Procedures for the Pacific Environmental Science Centre and approved by MWLAP.

Streams are recommended for slow release fertilization if the low-level dissolved ortho-phosphorus measured was less than 1 $\mu\text{g/L}$. Vancouver Island streams are generally considered to be phosphorus-limited.

2.7 Periphyton Sampling

Periphyton blocks were placed at all sample sites (Figure 5). A sheet of white florist's foam, 1.25 cm thick was attached to Plexiglas plates using plastic electrical ties. These plates were bolted to a concrete block. Duplicate blocks were placed in the stream with rocks placed around the upstream edge to protect the plate from increased flows that might flip it or wash it out of place. Each block was placed with at least 20 cm of water flowing overtop of the foam to allow for decreasing water level. Areas that were too shaded or too deep were avoided (Figure 6). The foam was replaced after 6 weeks to avoid the build-up and sloughing off of algae. (Mouldey Ewing et al. 1998). Periphyton samples were collected on August 8, September 5, September 19 and October 10. Using a 7 dram plastic vial, a core of foam (2.7 cm in diameter and 5.73 cm^2 area) was punched out of the foam on each periphyton block. Each sample was drained and placed in the vial. The vial was vented with holes through the cap to allow the sample to dry. The vials were placed in a sealed light-proof container with desiccant and shipped in a cooler with ice to the lab. The samples were measured for chlorophyll *a* and phaeophytin *a* (a breakdown product of chlorophyll *a*) in $\mu\text{g}\cdot\text{m}^{-2}$.



Figure 5. Placing a periphyton block at the downstream sample site below the Ash Rd. bridge crossing.

Figure 6.
Periphyton blocks
placed at the
downstream
sampling site, below
the Ash Rd. bridge
crossing.



2.8 Monitoring in 2001

Water and periphyton samples were collected three times throughout the growing season, on August 8, September 5 and October 10, 2001. Samples were shipped by courier from Courtenay or Port Alberni to the Pacific Environmental Science Centre in North Vancouver.

Water chemistry analysis included:

Water Chemistry Test	Unit	Minimum Detectable Limit (MDL) in mg/L
Total Alkalinity-pH 4.5	Mg CaCO ₃ /L	0.5
Nitrogen- Ammonia Dissolved	mg/L	0.005
Nitrogen Diss. (NO ₂ +NO ₃) low level	mg/L	0.002
Phosphorus Ortho. Diss. Low level	mg/L	0.001
Phosphorus Total Dissolved	mg/L	0.002
Total Phosphorus	mg/L	0.002

2.9 Juvenile Sampling

In September 2001, four sites consisting of treatment areas and controls, were sampled on the middle Ash River upstream of Dickson Lake. Sampling was conducted by the BCCF Steelhead Crew of Nanaimo.

The following sampling description was provided by the Steelhead Crew.

Sampling was conducted using closed-site electrofishing techniques. At each electrofishing site, about 100 m² 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). Lengths were recorded for all fish captured, and 30+ juveniles per species and age class were weighed using Ohaus top loading scales (model CS 200) accurate to 0.1 g. Habitat parameters were documented consistent with current Fisheries Branch techniques (methodology by R. Ptolemy, Rivers Biologist, MWLAP, 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. Population estimates were later derived and depth/velocity profile adjusted

using Fisheries Branch habitat suitability index curves. Sites on the Salmon River were chosen to monitor stock abundance in general and also to monitor enhancement by fertilizer additions. (Craig, J. et al. 2001)

3.0 RESULTS

3.1 Water Temperatures and Discharge Levels

Water temperatures measured at each water sample site are shown in Table 4. A hand-held thermometer was used.

Table 4. Water temperatures measured in the Ash River in August and September, 2001.

Date	Water Temperature (° C.)		
	Upper Ash	Ash Island Falls	below Ash Rd. bridge
Aug 8	16.0	14.5	16.0
Sept 5		14.0	14.0
Sept 19	15.0	14.5	14.5

Water Survey of Canada maintains a hydrometric station on the Ash River below Moran Creek (#08HB023). Daily discharge data (finalized) is presented in Appendix ii. Heavy rainfall occurred on August 20, 2001. High flow conditions continued into early September. Flows from the Elsie Lake reservoir were increased. The average monthly flow (below Moran Creek) for July, August and September, 2001 was 7.1 m³/s, and the mean minimum daily discharge was 4.17 m³/s (finalized data, WSC).

The mean daily discharge of the Ash River below the Elsie Dam (in the fertilizer treatment reach) for August and September (the critical stream flow period or CSFP) is 3.3 m³/s and for the growing season from April to September is 7.2 m³/s, from the period of record 1984-1998 (Consultative Committee for the Ash River Water Use Plan, 2002).

The previously estimated average summer discharge in the upper river (above Dickson Lake) of 2.5 m³/s was under-estimated.

3.2 Pre-Fertilization Water Chemistry (2001)

Pre-fertilization water samples (Ashley & Slaney 1997) are required to assess stream nutrient deficiency. One pre-fertilization water sample was collected on March 14, 2001 and analyzed at the Pacific Environmental Science Centre for low-level nutrients. The sample site was just downstream of the Ash Road bridge crossing. The mean discharge for that day (measured below Moran Creek) was 4.94 m³/s (WSC- preliminary data). The results were as follows:

units		Ash River 14-Mar-01
$\mu\text{g}\cdot\text{L}^{-1}$	Nitrogen Diss. (NO ₂ +3) LL	33
$\mu\text{g}\cdot\text{L}^{-1}$	Phosphorus Ortho. Diss. LL	<1

The sample indicated a dissolved phosphorus limitation, (<1 $\mu\text{g}\cdot\text{L}^{-1}$).

3.3 Post-Fertilization Water Chemistry (2001)

Heavy rainfall, which began on August 20, washed out a high percentage of the briquettes and the subsequent water chemistry results were measured near control (or background) levels. The only water sample collected prior to this (August 8, 2001) also resulted in low measurements indicating the loading rate was too low for the estimated stream discharge (Table 5). Measurable increases in P (and N) are often minute as the added nutrients are rapidly taken up by algal growth (Ashley & Slaney 1997), however; visual assessment of algae growth confirmed the remaining fertilizer load was insufficient. The snorkel survey report for January 24, 2002 included the comment “observed growth rates and densities of invertebrate life were only slightly higher in the section “treated” with slow release fertilizer in July, 2001” (Appendix iii).

Table 5. Results of water chemistry analysis for the Ash River sampled in the control reach and the treatment area in 2001.

		Ash River- Control (2001)			
		8-Aug	5-Sep	19-Sep	10-Oct
	Total Alkalinity-pH 4.5	14.8		15	16.8
$\mu\text{g}\cdot\text{L}^{-1}$	Nitrogen- Ammonia Diss.	5	no	6	<5
$\mu\text{g}\cdot\text{L}^{-1}$	Nitrogen Diss. (NO ₂ +3) LL	4	sample	8	24
$\mu\text{g}\cdot\text{L}^{-1}$	Phosphorus Ortho. Diss. LL	<1		<1	<1
$\mu\text{g}\cdot\text{L}^{-1}$	Total Diss. Phosphorus	<2		<2	<2
$\mu\text{g}\cdot\text{L}^{-1}$	Total Phosphorus	<2		4	<2

		Treatment (2001)							
		Ash River- Middle				Ash River- Lower			
		8-Aug	5-Sep	19-Sep	10-Oct	8-Aug	5-Sep	19-Sep	10-Oct
	Total Alkalinity-pH 4.5	16.9	16.2	16.1	17.9	16.9	15.8	15.9	18.2
$\mu\text{g}\cdot\text{L}^{-1}$	Nitrogen- Ammonia Diss.	7	<5	7	6	<5	<5	6	<5
$\mu\text{g}\cdot\text{L}^{-1}$	Nitrogen Diss. (NO ₂ +3) LL	6	15	11	18	6	12	9	20
$\mu\text{g}\cdot\text{L}^{-1}$	Phosphorus Ortho. Diss. LL	<1	<1	<1	<1	<1	<1	<1	<1
$\mu\text{g}\cdot\text{L}^{-1}$	Total Diss. Phosphorus	<2	<2	<2	<2	<2	<2	2	<2
$\mu\text{g}\cdot\text{L}^{-1}$	Total Phosphorus	3	<2	3	<2	3	2	9	<2

3.4 Periphyton Measurements

The periphyton blocks were placed on July 19, 2001. The second sample date was August 21, however, flows were too high to wade safely and visibility was very poor. No samples were collected.

On September 5, the periphyton blocks were found in place and samples were taken at the treatment sites. The foam sheets were replaced with new foam substrate. The road to the control site had been blocked and excavated. Due to unfamiliarity with the road system, an alternate route to the sample site was not found. As a result, the control site was not sampled and the foam was not replaced with new foam. This situation unfortunately, was not corrected due to a very busy summer sampling schedule involving other watersheds in addition to the Ash. The chlorophyll and phaeophytin sample measurements from the control for September 19 and October 10 cannot be compared to the treatment samples. Results of periphyton sampling is shown in Table 6.

Table 6. Chlorophyll *a* and phaeophytin *a* analysis for the Ash River sampled in the control reach and the treatment area in 2001.

		Ash River- Control							
		8-Aug	5-Sep	19-Sep	10-Oct				
$\mu\text{g cm}^{-2}$	Chlorophyll <i>a</i> *	0.93		1.93	2.27				
$\mu\text{g cm}^{-2}$	Chlorophyll <i>a</i> - dup	1.4	No	1.82	3.3				
$\mu\text{g cm}^{-2}$	Phaeophytin <i>a</i> *	0.96	sample	1.41	1.31				
$\mu\text{g cm}^{-2}$	Phaeophytin <i>a</i> -dup	1.87		1.29	1.24				
		Ash River- Middle				Ash River- Lower			
		8-Aug	5-Sep	19-Sep	10-Oct	8-Aug	5-Sep	19-Sep	10-Oct
$\mu\text{g cm}^{-2}$	Chlorophyll <i>a</i>	0.37	0.75	0.34	0.23	0.19	0.68	0.34	0.68
$\mu\text{g cm}^{-2}$	Chlorophyll <i>a</i> - dup	0.28	1.31	0.11	0.11	0.28	0.68	0.34	0.68
$\mu\text{g cm}^{-2}$	Phaeophytin <i>a</i>	0.54	0.43	<.06	<.06	0.21	0.27	0.06	0.27
$\mu\text{g cm}^{-2}$	Phaeophytin <i>a</i> -dup	0.31	2.81	<.06	<.06	0.31	0.51	0.22	0.43

* **MDL** chlorophyll *a* - 0.03 $\mu\text{g cm}^{-2}$
 phaeophytin *a* - 0.03 $\mu\text{g cm}^{-2}$

3.5 Juvenile Sampling

Results of juvenile sampling in the middle Ash River in September 2001 have been provided by the Steelhead Crew, Nanaimo (Appendix iv). Because of the late fertilizer application and the extreme flood event in late August 2001, the results would not reflect a successful season of nutrient addition in the Ash River.

4.0 CONCLUSIONS

The Ash River, like other nutrient-limited streams on Vancouver Island, would benefit from stream fertilization for the enhancement of salmonids. Unfortunately, this inaugural year was challenged with unusually heavy rainfall in late August.

Nutri-Stones™ was a new product and improvement of the briquetting process is needed. The briquettes when adequately compacted were designed to be relatively porous and dissolve slowly, up to 100 days. Approximately 25% of the buckets contained a high percentage of powdered product. Due to the lateness of the fertilizer shipment (July 13, 2001), a portion of the fish growing period in late June and early July, was missed.

Several complications occurred during the Ash River project including:

- late arrival of the fertilizer product due to manufacturing and shipping delays
- lack of compaction of some of the product into solid briquettes
- extreme flood event and subsequent increase in flows at the Elsie Lake Dam in late August

Flood events are unpredictable and will always pose a risk to the expected benefits of inorganic fertilizer additions. Nonetheless, this relatively low cost habitat restoration tool has demonstrated sustained fish production benefits in several Vancouver Island streams over the last decade (eg., Keogh, Adam and Salmon rivers).

5.0 REFERENCES

- Ashley, Ken and Slaney, Pat, 1997.** Fish Habitat Rehabilitation Procedures. Watershed Restoration Technical Circular No. 9. Chapter 13, Accelerating Recovery of Stream, River and Pond Productivity by Low-level Nutrient Replacement.
- Burt, D.W. and J.W. Horchik, 1999.** Production capability of salmonid habitat in selected reaches of the Stamp-Somass River system. Prepared for Ministry of Environment, Lands and Parks, Nanaimo, B.C.
- Consultative Committee for the Ash River Water Use Plan, 2002.** DRAFT. Consultative Committee Report Ash River Water Use Plan. A Project of BC Hydro. Prepared by the BC Hydro Project Team and the Ash River Water Use Plan Consultative Committee, November 28, 2002.
- Craig, J. et al. 2001.** Fish habitat restoration monitoring and assessment projects in the San Juan Watershed (2001). B.C. Conservation Foundation report.
- Larkin, G.A., and P.A. Slaney, 1996.** Trends in marine-derived nutrient sources to south coastal British Columbia streams: Impending implications to salmonid production. Watershed Restoration Management Report No. 3, Ministry of Environment, Lands and Parks and Ministry of Forests, Vancouver, B.C.
- Mouldey Ewing, S.E., Ashley, K.I., and G. Wilson, 1998.** Development and testing of slow release fertilizer for restoring salmonid habitat: 1997 Progress Report. Watershed Restoration Project Report No. 10, Watershed Restoration Program, Ministry of Environment, Lands and Parks and Ministry of Forests, British Columbia.