

# **Stream Flow, Water Quality, and Low-level Nutrient Monitoring in the Englishman River Watershed, 2002**

*as part of the*

## **Englishman River Watershed Recovery Plan**

*Prepared for*

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## **ABSTRACT**

Following initial habitat assessments and literature reviews, the Pacific Salmon Foundation identified further flow and water quality monitoring as a priority under the Englishman River Watershed Recovery Plan. In 2002, Lough and Morley determined reduced summer flow was limiting to fish production and northwest hydraulic consultants identified potential loss of Englishman River surface water through groundwater seepage.

Discharge was monitored in the mainstem and Morison Creek with semi-permanent stage recorders and flow metering. Fish habitat suitability was measured as discharge decreased through the low water period by conducting depth/velocity transects, measuring wetted width, and photographing habitat.

Results confirmed mainstem discharge dropped below the minimum threshold of the current Provisional Operation Rule for Arrowsmith Dam fisheries flow releases. Loss of flow by groundwater seepage appeared insignificant, but results were inconsistent. Habitat suitability monitoring reconfirmed ideal base summer flow would be near 20% of mean annual discharge, or 2.76 m<sup>3</sup>/s. The current minimum base flow is 1.6 m<sup>3</sup>/s, or approximately 10% of mean annual discharge. Hydrometric data for Morison Creek identified a rapid decrease in flow in early August, possibly a result of rural or agricultural withdrawals.

Water samples collected from the mainstem indicated lack of inorganic nutrients may be limiting to fish production. Harmful bacteria and metals were present only in very low concentrations and were not considered a risk to salmonid fish species.

Recommendations resulting from this study are as follows:

1. Reassess mainstem discharge to confirm potential loss of flow by groundwater seepage.
2. Determine the cause of water loss in Morison Creek.
3. Maintain summer flow near 20% of mean annual discharge (2.76 m<sup>3</sup>/s), with a short term minimum base flow of 10% (1.38 m<sup>3</sup>/s).
4. Initiate stream enrichment in the mainstem to increase primary autotrophic productivity.

## **ACKNOWLEDGEMENTS**

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James Craig and Brad Smith, BC Conservation Foundation, provided key support preparing the proposal and completing the fieldwork. Laura Cassin edited the first draft report.

Craig Wightman, Senior Fisheries Biologist, MWLAP, Vancouver Island Region, supported the study and edited the final draft.

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## 1.0 Introduction

The Englishman River Watershed Recovery Plan, developed by the Pacific Salmon Endowment Fund Society (PSEFS), is an initiative aimed at rebuilding wild salmon and steelhead stocks in the Englishman River. The Englishman River was selected for recovery by regional biologists from Department of Fisheries and Oceans (DFO) and Ministry of Water, Land and Air Protection (MWLAP) because it is a suitable size for habitat restoration activities and has a wide range of mostly wild anadromous fish species (Bocking and Gaboury 2001).

Following initial development of the plan, M. Lough and C. Morley conducted a study funded by PSEFS to identify limiting factors to salmonid production and “identify opportunities to alleviate these constraints to fish production”. Their study found “reduced summer rearing habitat caused by low summer flows” to be a major limiting factor. A channel assessment by northwest hydraulic consultants (nhc Ltd.) identified potential loss of surface flow through groundwater seepage, compounding the effects of low flows.

The BC Conservation Foundation (BCCF) monitored flow in the mainstem from late June through early November. Monitoring results will assist development of a *Rule Curve*<sup>1</sup> for Arrowsmith Dam fisheries flow releases and confirm possible groundwater seepage. Habitat suitability and wetted widths were measured at predetermined stages based on percent of mean annual discharge (MAD). Discharge was measured in Morison Creek to assess impacts of rural and agricultural water withdrawals. The South Englishman and Centre Creek flows were also measured to determine loss of fish habitat.

Further to the flow monitoring objectives of the contract, water sampling and temperature recording were completed in the mainstem and tributaries to determine if other factors were negatively impacting fish production.

## 2.0 Study Area

The Englishman River enters the Strait of Georgia on the central east coast of Vancouver Island near the town of Parksville (Figure 1). It supplies water to residents of Parksville and the Parksville East Water District. The watershed originates on Mount Arrowsmith and has a total area of approximately 325 km<sup>2</sup> (Bocking and Gaboury 2001). Mean annual discharge, based on 23 years of data from 1915 to 2000, is 13.8 m<sup>3</sup>/s (Water Survey of Canada).

A dam on the outlet of Arrowsmith Lake, in the headwaters of the Englishman River, has been augmenting low summer flows for fisheries and domestic purposes since 1999. The dam has a live storage volume of 9,000,000 m<sup>3</sup> of water. Approximately 50% of the storage is allocated for fisheries' purposes (Regional District of Nanaimo website). The current water license requires that 1.6 m<sup>3</sup>/s, approximately 10% of MAD<sup>2</sup>, be maintained

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<sup>1</sup> A *Rule Curve* is an operating protocol for dam and reservoir operations.

<sup>2</sup> Assuming MAD is 13.8 m<sup>3</sup>/s, 10% of MAD is 1.4 m<sup>3</sup>/s.

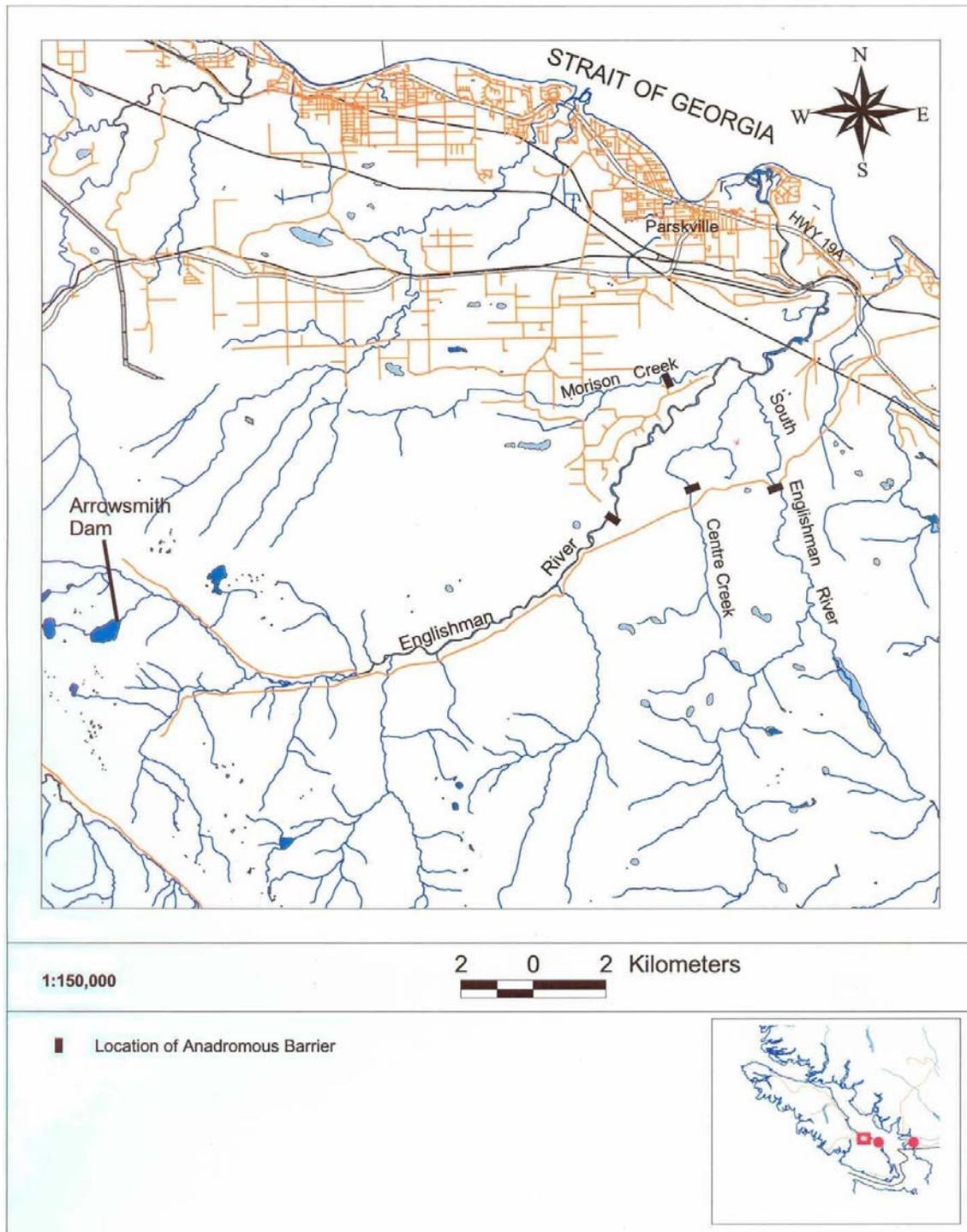


Figure 1. Englishman River Watershed

in the lower river (Provisional Operation Rule), as measured at the Water Survey of Canada gauge below the Highway 19A bridge.

Weyerhaeuser owns 69% of the watershed as private forest land, and only 10% of the remaining area is non-forest land (DRAFT report<sup>3</sup>). Much of the watershed was logged in the early 1900's. A significant second cut rotation occurred in the 1950's and 1960's. In the last 30 years, timber harvest levels have been reduced and focused on headwater areas of the watershed (Bocking and Gaboury 2001).

All five species of Pacific Salmon and steelhead trout return annually to the Englishman River. In 2001, estimated salmon escapement to the Englishman River was: 11 sockeye, 8,000 coho, 13,500 pink, 10,400 chum, and 1,200 chinook (Baillie and Young 2002). Steelhead returns to the Englishman River began to decline in 1985. Record lows in the mid 1990's resulted in angling closures during the winter steelhead season. In 2002, PSEFS funded an intensive snorkel survey program to assess winter steelhead abundance. Results suggest escapement in 2002 ranged from 99-232, with a most probable estimate of 145 fish (Smith 2002).

## 3.0 Methods

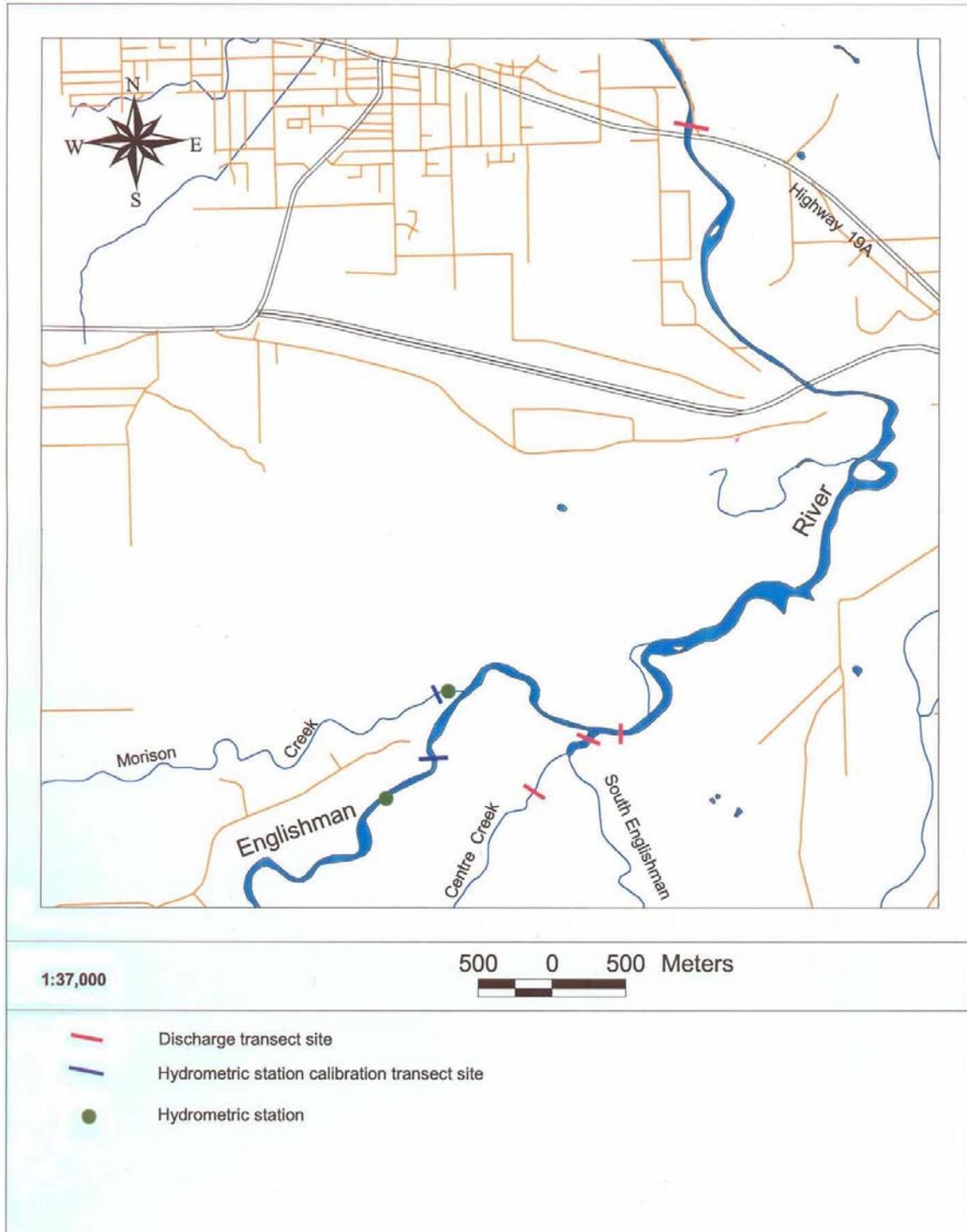
### 3.1 Discharge Monitoring

Discharge was measured in the Englishman River mainstem, South Englishman, Morison Creek and Centre Creek using Swiffer current velocity meters (Figure 2). Site selection and discharge measuring methodology was consistent with Resources Information Committee standards (RIC). Depth and velocity measurements were taken at a minimum of 20 stations equally spaced across the wetted width. The number of stations was slightly reduced in the smaller tributaries during low flow periods.

For continuous monitoring, semi-permanent pressure/transducer instruments were installed on Morison Creek and the mainstem by Edutech Technologies Corp. (Gibsons, B.C.). The pressure/transducers recorded hourly stage measurements. Discharge was manually measured bi-weekly, adjacent to the stream stage recorders to develop rating curves for the water level data (Appendix A). Staff gauges with references to benchmarks were set at both locations to allow for correction and confirm the pressure/transducers did not shift (Ferguson pers. comm.).

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<sup>3</sup> DRAFT Englishman River Watershed Assessment completed by Ostapowich Engineering Ltd. and Bill Pollard and Associates for Weyerhaeuser Company Ltd., September 2002.



**Figure 2. Discharge transect and semi-permanent flow monitoring station locations.**

### **3.2 Mainstem Habitat Suitability**

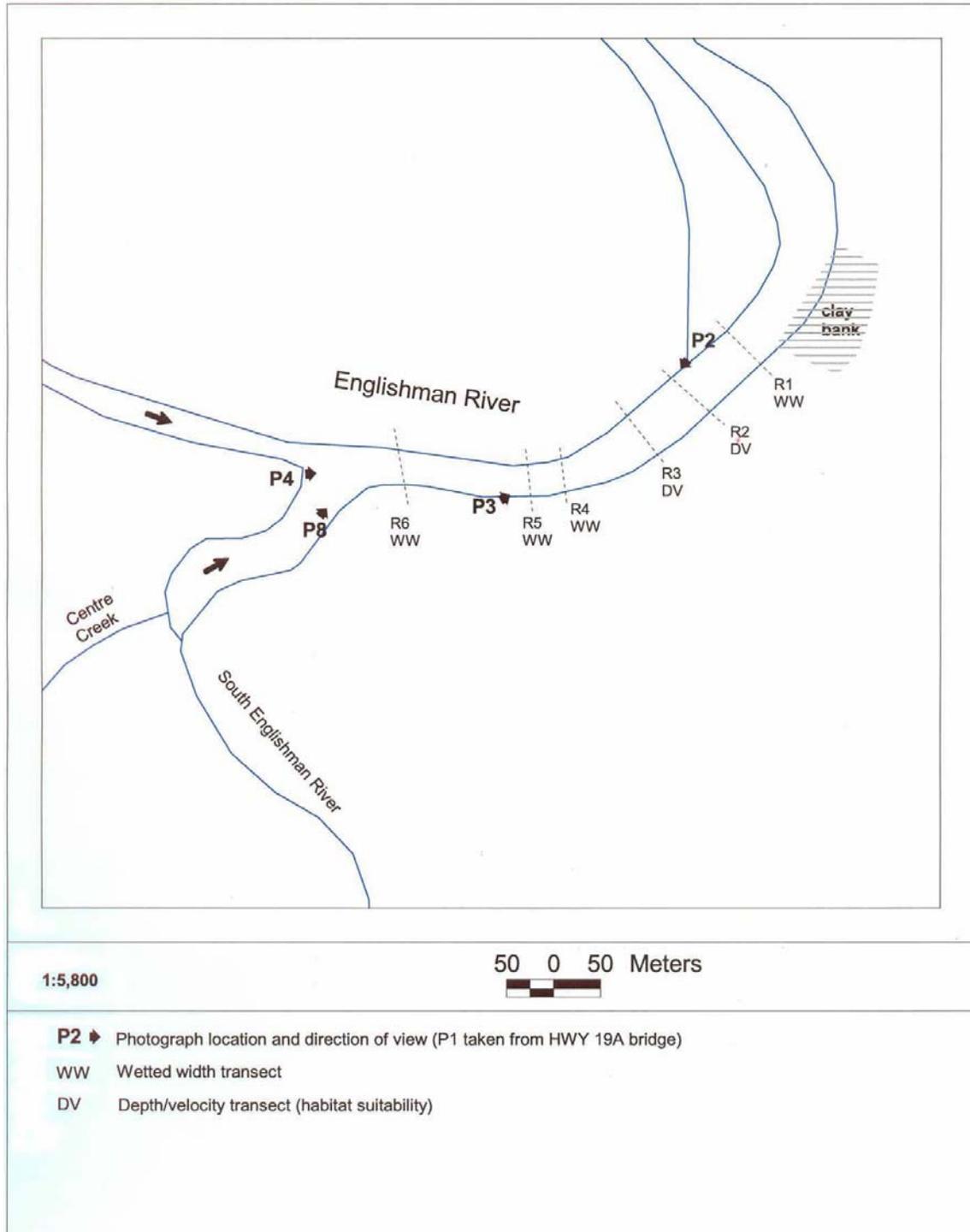
Habitat suitability for juvenile steelhead rearing and fast water invertebrates was measured by performing full stream depth/velocity transects as flows dropped through the seasonal low flow period. Four sites were selected in representative riffles that were relatively suitable for steelhead parr rearing (Figures 3 and 4). Riffle habitat was the preferred mesohabitat type for habitat suitability monitoring for the following reasons:

1. Riffles show greater rates of change in wetted width, depth, and velocity than other habitat types (Ptolemy and Lewis DRAFT, 2002).
2. In medium-large streams, the majority of steelhead parr rear in riffle/rapid habitat (BCCF snorkel survey results).
3. Aquatic insect production, beneficial to all fish species, occurs mainly in riffle habitat (Ptolemy pers. comm.).
4. In pool and run habitat, optimum velocities for steelhead parr and insect production are achieved at high discharges (Ptolemy pers. comm.).

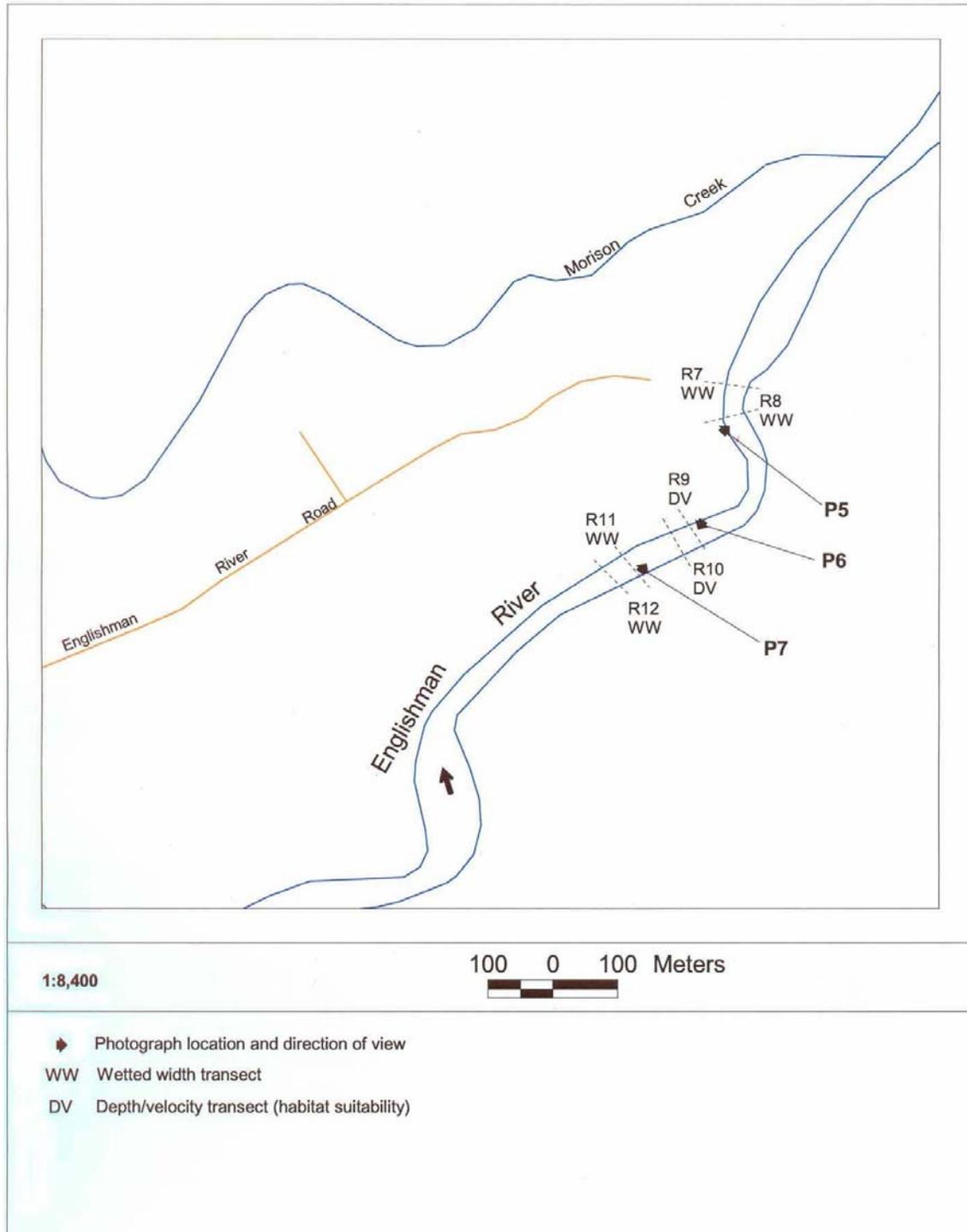
The intention of the study was to conduct transects at 40%, 20%, 10%, 5%, and 2.5% of MAD. The same methodology used to measure discharge was applied to the habitat suitability transects. Riffle transect data were rated using a spreadsheet that incorporates habitat suitability curves provided by R. Ptolemy in February 2001 (Appendix B). Because transects were done only in riffle habitat, coho fry habitat suitability estimates were not applicable.

In addition to the depth/velocity transects, wetted widths were measured at eight different sites to monitor loss of habitat area (Figures 3 and 4). All transect locations were marked with rebar stakes and representative coloured flagging.

Photos were taken at seven marked locations on the mainstem to provide visual evidence of habitat loss as flows decreased (Figures 3 and 4).



**Figure 3. Transect and photograph locations – downstream of South Englishman confluence.**



**Figure 4. Transect and photograph locations – upstream of Morison Creek confluence.**

### 3.3 Morison Creek Water Quality

Five water samples were collected through two separate 30-day periods. The sample periods corresponded with low flow (August-September) and high flow periods (November). Samples shipped to Philip Analytical Services Corporation<sup>4</sup> (PSC) were analyzed for metal concentrations and non-filterable residue. Samples shipped to Cantest Ltd. were analyzed for fecal coliform and *Escherichia coli* concentrations. Sampling procedures followed RIC standards described in the *Ambient Fresh Water and Effluent Sampling Manual*.

MWLAP Environmental Quality staff also took samples from two locations on the mainstem, and one location on the South Englishman. Results from their analysis were used to complement our low-level nutrient analysis and to confirm contamination is not limiting to fish production elsewhere in the system.

### 3.4 Mainstem Low-level Nutrient Analysis

Water samples were taken downstream of Englishman River Falls at one month intervals throughout the growing season (June to September). Filtered and non-filtered samples were shipped on ice within 24 hours to PSC for analysis. Samples were analyzed for:

- total alkalinity;
- low level ortho-phosphate (soluble reactive phosphorus);
- low level nitrate + nitrite;
- ammonia;
- total dissolved phosphorus; and
- total phosphorus.

## 4.0 Results

### 4.1 Discharge Monitoring

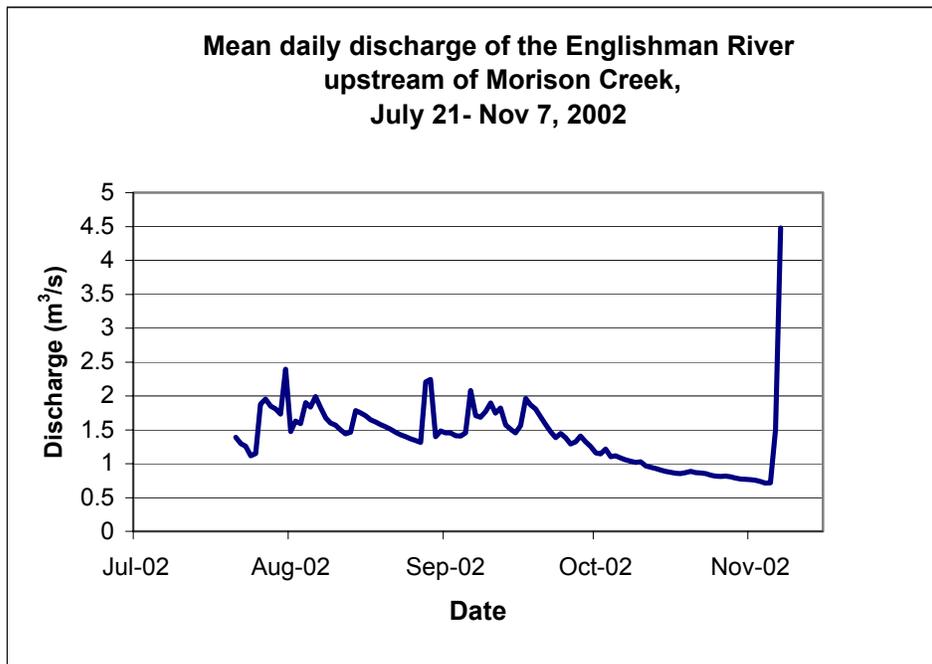
Discharge in the mainstem decreased rapidly from June 19 to July 24 (Table 1). Following July 24, the control structure at Arrowsmith Dam maintained a discharge of approximately 1.6 m<sup>3</sup>/s above Morison Creek until late September (Figure 5). By October, there was insufficient storage and flows dropped below 1.6 m<sup>3</sup>/s. The lowest measurement at the Highway 19A bridge crossing was 0.934 m<sup>3</sup>/s on October 18. Due to an unusually dry fall, flow continued to drop until November 6, when rains increased river levels considerably.

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<sup>4</sup> Philip Analytical Services Corporation (PSC) does the majority of water testing for MWLAP.

**Table 1. Summary of metered discharges on the Englishman River and tributaries, June 19 – October 18, 2002.**

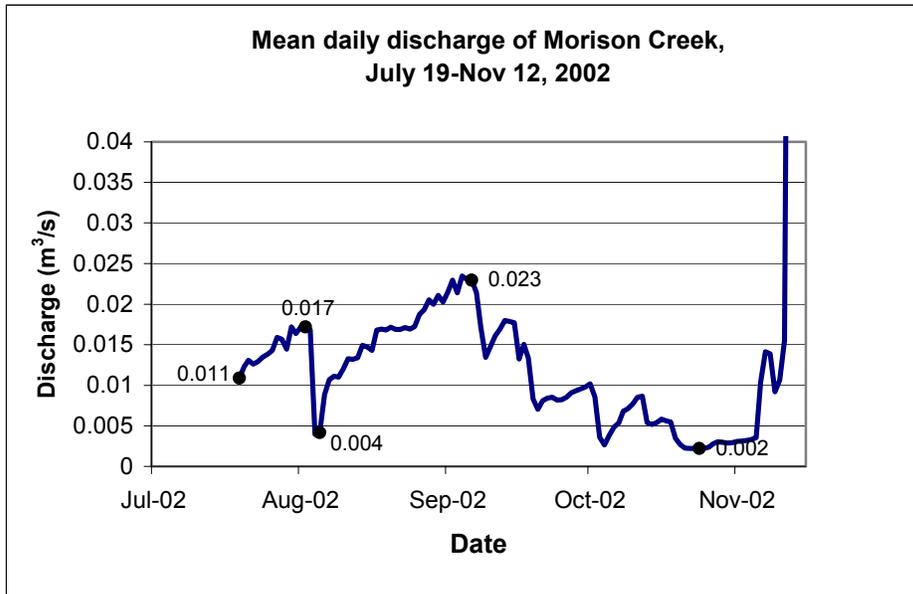
Date (% MAD)	Mainstem sites (m <sup>3</sup> /s)			Tributaries (m <sup>3</sup> /s)		
	HWY 19A	d/s South E.	u/s Morison	South E.	Centre	Morison
June 19 (57%)	7.918	5.310	5.664	0.302		0.048
June 26 (27%)	3.718	3.697	3.926			
July 9 (19%)	2.590	2.086	2.324	0.104		
July 24 (8%)	1.090	1.045	1.311	0.051	0.004	
Oct. 18 (7%)	0.934	0.781	0.802			



**Figure 5. Englishman River hydrometric station data upstream of Morison Creek, July 21 - November 7, 2002. (Note: Stage-discharge relationship does not account for flows greater than 4.4 m<sup>3</sup>/s)**

The major sub-basin, the South Englishman, was last metered on July 24 when there was 0.051 m<sup>3</sup>/s immediately upstream of its confluence with the Englishman River. Centre Creek, the largest tributary of the South Fork, had 0.004 m<sup>3</sup>/s on the same date.

Mean daily discharge interpreted from the semi-permanent stream stage recording apparatus on Morison Creek is displayed in Figure 6. Following installation on July 19, discharge increased slightly from 0.011 to 0.017 m<sup>3</sup>/s, then dropped sharply to 0.004 m<sup>3</sup>/s on August 4 and 5. Discharge increased through August and then dropped slowly from 0.023 m<sup>3</sup>/s in the first week of September to 0.002 m<sup>3</sup>/s on October 21. As with the mainstem, flows increased dramatically on November 6.



**Figure 6. Morison Creek hydrometric station data, July 19 - November 12, 2002.**

#### **4.2 Mainstem Habitat Suitability Monitoring**

The intention was to conduct transects at 40%, 20%, 10%, 5%, and 2.5% of MAD. However, the actual sampling occurred at 27%, 19%, 8%, and 7% of MAD. The miscalculation was due to an outdated staff/discharge relationship. Sampling was not done below 7% of MAD, because discharge did not fall below approximately 6.5%. Habitat suitability for steelhead parr remained near 50% when metered at 27 and 19% of MAD (Table 2). A significant reduction in habitat suitability was measured when discharge dropped from 19 to 8%. A minor increase in suitability was encountered when discharge dropped to 7% of MAD. Shallow edge habitat that rated poorly at 8% was no longer wetted at 7%, thus the average suitability value increased. Loss of usable habitat for aquatic invertebrates was much more uniform through the low water period.

**Table 2. Habitat suitability (% usable) for steelhead parr and aquatic insects in four riffles sampled in the Englishman River mainstem, June – October, 2002.**

Site	Habitat Suitability (%)							
	27% MAD		19% MAD		8% MAD		7% MAD	
	Rb parr	Insect	Rb parr	Insect	Rb parr	Insect	Rb parr	Insect
R2	53	63	48	42	34	28	33	22
R3	54	39	53	35	39	13	41	16
R9	46	55	46	42	28	29	30	36
R10	56	64	55	55	37	35	48	9
<b>mean</b>	<b>52</b>	<b>55</b>	<b>51</b>	<b>44</b>	<b>35</b>	<b>26</b>	<b>38</b>	<b>21</b>

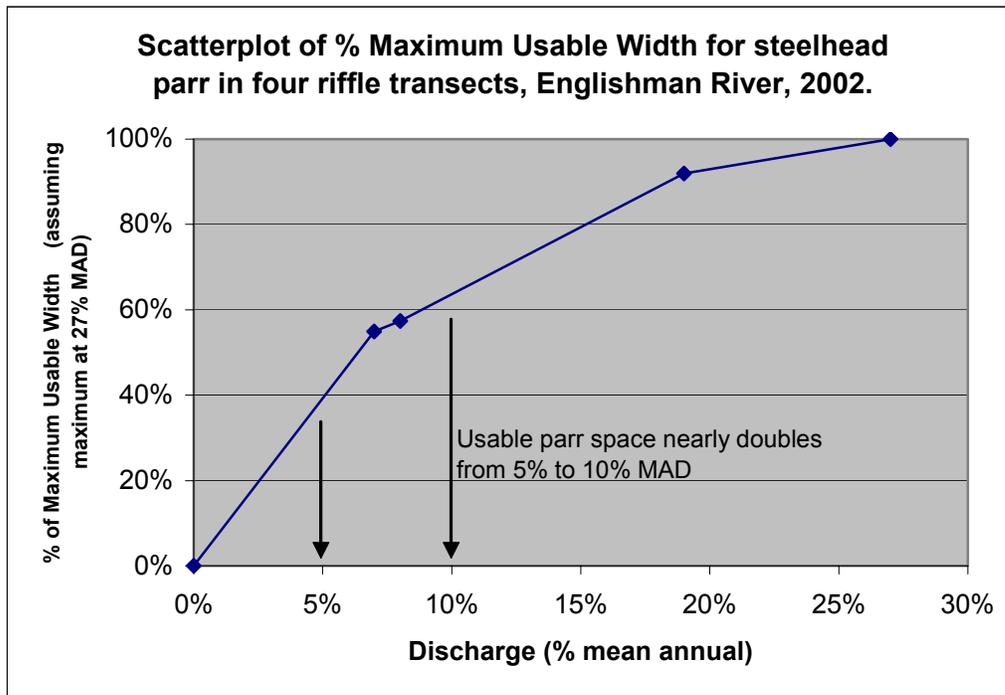
When wetted widths are rated with the respective habitat suitability percentages, the resulting weighted usable widths also showed a significant loss of habitat for insects and steelhead parr below 19% of MAD. Although there was a minor increase in hydraulic

suitability for steelhead parr when flows dropped to 7% (Table 2), there was a net loss of suitable habitat due to significant reduction in wetted width (Table 3).

**Table 3. Weighted usable width for steelhead parr and aquatic insects in four riffles sampled in the Englishman River mainstem, June – October, 2002.**

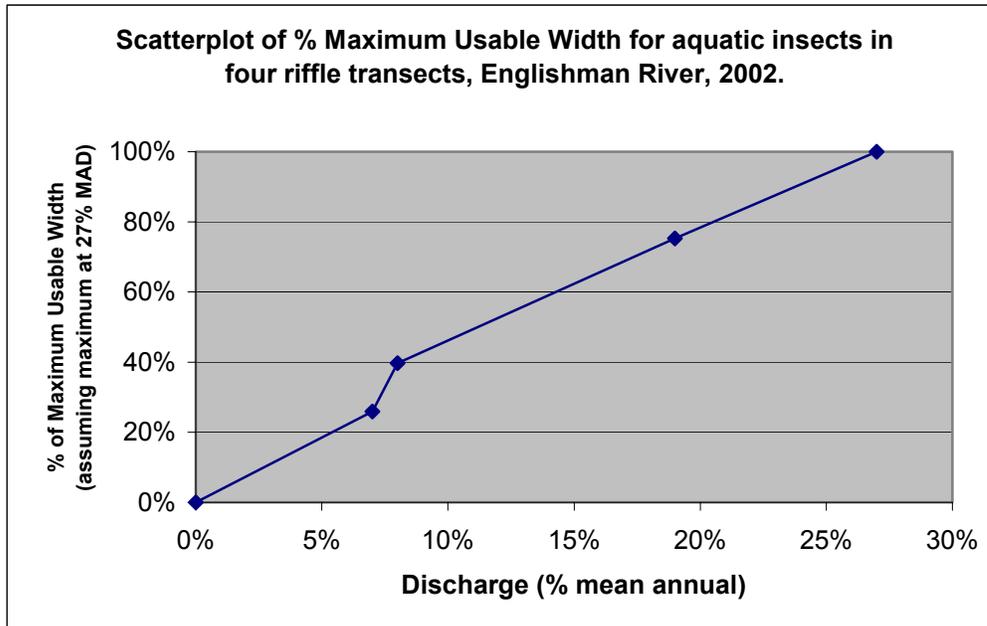
Site	Weighted Usable Width (m)							
	27% MAD		19% MAD		8% MAD		7% MAD	
	Rb parr	Insect	Rb parr	Insect	Rb parr	Insect	Rb parr	Insect
R2	21.3	25.3	19.7	17.3	13.3	10.9	12.4	8.3
R3	21.5	15.6	20.2	13.3	12.8	4.3	13.2	5.1
R9	13.2	15.7	12.2	11.2	6.6	6.8	6.6	7.9
R10	11.8	13.5	10.5	10.5	6.9	6.5	6.0	1.1
<b>mean</b>	<b>16.3</b>	<b>17.0</b>	<b>15.0</b>	<b>12.8</b>	<b>9.4</b>	<b>6.8</b>	<b>9.0</b>	<b>4.4</b>

A further analysis showed that roughly 90% of the maximum rearing space for steelhead parr is maintained at 19% of MAD (Figure 7). Significant habitat losses occur below 10% of MAD. This analysis was based on the assumption that maximum rearing space was obtained when flows are at 27% of MAD, so consequently 19% of MAD still provided relatively significant habitat area.



**Figure 7. Scatterplot of % maximum usable width for steelhead parr in four riffles sampled in the Englishman River mainstem, June - October, 2002 (analysis provided by Ron Ptolemy).**

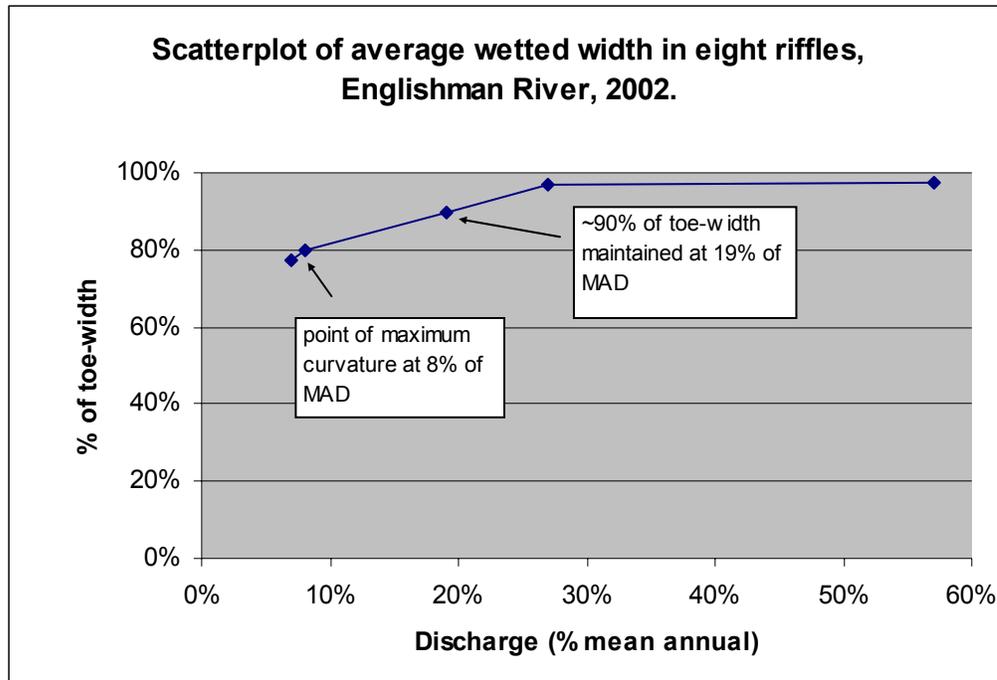
The percent of maximum usable width for aquatic insect production decreases linearly as flows drop from 27 to 8% of MAD (Figure 8). At 19% MAD, 75% of the maximum rearing space is maintained. Below 8%, there is a very sharp reduction in usable width.



**Figure 8. Scatterplot of % maximum usable width for aquatic insects in four riffles in the Englishman River mainstem, June - October, 2002 (using suitability curves from Stalnaker and Arnette 1976).**

Wetted width measured in eight other riffles sites confirmed a gradual loss of habitat area as discharge dropped below 27% of MAD (Appendix C). The percent of wetted width maintained relative to toe-width<sup>5</sup> is expressed in Figure 9. This analysis shows that approximately 90% of toe-width was maintained at 19% of MAD, and approximately 80% of toe-width was still maintained at 8% of MAD. The single data point at 7% of MAD indicates that more rapid loss of wetted area likely occurs at lower flows.

<sup>5</sup> For the purpose of this analysis, toe-width was the maximum width measured at each site (at 27 or 57% of MAD). In wide channel areas the actual distance measured between the toe of opposite stream banks would be greater than the toe-width values used for this analysis.



**Figure 9. Scatterplot of % toe-width at eight riffle sites on the Englishman River, June 18 - October 18, 2002 (analysis provided by Ron Ptolemy).**

Photographs of representative habitat also reflected the loss of habitat area and hydraulic suitability (Appendix D). Visual evidence of habitat loss was most apparent between 19 and 8% of MAD.

### **4.3 Morison Creek Water Quality**

Concentrations of metals in Morison Creek and the mainstem were generally well below maximums allowed in the guidelines for drinking water and aquatic life (Tables 4, 5 and 6). Bacteria densities were generally low, but there was an apparent spike during the fall 'high water' period (Tables 4 and 5). The concentration of chromium was unusually high in the mainstem sample taken on November 12. This result was likely anomalous.

**Table 4. Morison Creek Water Quality results. (Data provided by Environmental Quality staff, MWLAP, Nanaimo)**

Morison Creek									
	Arsenic (ug/L)	Cadmium (ug/L)	Chromium (ug/L)	Copper (ug/L)	Lead (ug/L)	Nickel (ug/L)	Zinc (ug/L)	Fecal Coliforms (Col./100ml)	E.Coli (Col./100 ml)
12-Aug	0.4	<0.01	<0.2	0.72	0.03	0.14	0.1	17	13
20-Aug	0.3	<0.01	<0.2	0.89	0.01	0.23	1.0	8	4
26-Aug	0.4	0.01	<0.2	0.8	0.05	0.34	0.7	36	24
03-Sep	0.4	<0.01	<0.2	0.71	0.05	0.09	0.3	10	5
09-Sep	0.2	0.01	<0.2	0.79	0.13	0.12	0.9	15	11
28-Oct	0.2	<0.01	<0.2	0.79	<0.01	0.17	1.3	18	4
05-Nov	0.2	<0.01	<0.2	0.58	<0.01	0.09	1.9	3	1
12-Nov	0.2	<0.01	<0.2	1.43	0.05	0.37	1.9	39	21
19-Nov	0.2	<0.01	<0.2	1.32	0.03	0.25	4.1	130	42
27-Nov	0.2	<0.01	<0.2	1.18	<0.01	0.25	21.1	4	1

**Table 5. Englishman River Water Quality results - Highway 19A. (Data provided by Environmental Quality staff, MWLAP, Nanaimo)**

Englishman River @ Highway 19A									
	Arsenic (ug/L)	Cadmium (ug/L)	Chromium (ug/L)	Copper (ug/L)	Lead (ug/L)	Nickel (ug/L)	Zinc (ug/L)	Fecal Coliforms (Col./100ml)	E.Coli (Col./100 ml)
12-Aug	0.1	<0.01	<0.2	0.57	0.03	<0.05	<0.1	9	8
20-Aug	<0.1	<0.01	<0.2	0.44	<0.01	<0.05	<0.1	17	13
26-Aug	0.1	<0.01	<0.2	0.52	0.06	<0.05	0.2	28	13
03-Sep	<0.1	<0.01	<0.2	0.52	0.08	<0.05	<0.1	19	14
09-Sep	<0.1	<0.01	<0.2	0.46	0.12	<0.05	0.4	11	9
28-Oct	0.1	<0.01	<0.2	0.48	<0.01	<0.05	2.0	160	26
05-Nov	<0.1	<0.01	<0.2	0.60	0.06	<0.05	19.7	12	8
12-Nov	0.4	0.17	0.9	4.20	0.40	1.25	4.6	28	19
19-Nov	0.1	<0.01	<0.2	1.08	0.07	0.17	1.8	14	9
27-Nov	<0.1	<0.01	<0.2	0.19	<0.01	<0.05	4.6	3	3

**Table 6. Water quality guidelines (from A Compendium of Working Water Quality Guidelines for British Columbia).**

Maximum Metal Concentrations							
	Arsenic (ug/L)	Cadmium (ug/L)	Chromium (ug/L)	Copper (ug/L)	Lead (ug/L)	Nickel (ug/L)	Zinc (ug/L)
drinking water	25	5	50	500	50	no value	5
aquatic life	5	0.01	1Cr (vi), 9 Cr (iii)	4	4 @ 17 mg CaCO <sub>3</sub> /L	25	33

#### 4.4 Mainstem Low-level Nutrient Analysis

Samples taken downstream of Englishman River Falls contained variable nitrogen and phosphate levels (Table 7). Nitrate+nitrite concentrations ranged from undetectable (<2 ug/L) to 17 ug/L. Two late season samples, taken from the mainstem upstream of Morison Creek, had nitrate+nitrite concentrations that were barely detectable (Table 8). Ortho-phosphate was detectable in early and late season samples, but was undetectable (<1 ug/L) in the mid-season. Sterling and Ashley (2003) classify streams with N:P ratios (based on atomic weight) between 10:1 and 20:1 as co-limited. Consequently, the four samples from the Englishman River at Englishman River Falls indicate a N:P co-limitation.

**Table 7. Water chemistry results from four samples taken from Englishman River downstream of Englishman River Falls.**

Englishman River @ Englishman River Falls						
	Nitrate+Nitrite (ug/L, minimum detection limit = 2)	Ammonia (ug/L, minimum detection limit = 5)	Ortho-phosphate (ug/L, minimum detection limit = 1)	Total dissolved phosphorus (ug/L, minimum detection limit = 2)	Total phosphorus (ug/L, minimum detection limit = 2)	Total Alkalinity (mg CaCO <sub>3</sub> /L, minimum detection limit = 0.5)
13-Jun	4	<5	3	3	<2	17
3-Jul	<2	<5	<1	2	<2	21
6-Aug	17	<5	<1	2	2	20
3-Sep	<2	<5	2	3	2	20

Samples taken upstream of the Morison Creek confluence confirmed N:P co-limitation (Table 8). Limited results provided for the South Englishman had moderate-high concentrations of nitrate+nitrite and ortho-phosphate concentrations at <1ug/L and 4 ug/L (Table 9). Hence, the South Englishman River was P limited in the summer of 2002.

**Table 8. Water chemistry results from Englishman River upstream of Morison Creek confluence. (Data provided by Environmental Quality staff, MWLAP, Nanaimo)**

Englishman River upstream of Morison Creek confluence						
	Nitrate+Nitrite (ug/L, minimum detection limit = 2)	Ammonia (ug/L, minimum detection limit = 5)	Ortho-phosphate (ug/L, minimum detection limit = 1)	Total dissolved phosphorus (ug/L, minimum detection limit = 2)	Total phosphorus (ug/L, minimum detection limit = 2)	Total Alkalinity (mg CaCO <sub>3</sub> /L, minimum detection limit = 0.5)
Jun	Not sampled in June					
9-Jul	-	-	<1	3	<2	-
6-Aug	3	-	<1	3	2	-
3-Sep	<2	-	1	<2	<2	-

**Table 9. Water chemistry results from South Englishman River. (Data provided by Environmental Quality staff, MWLAP, Nanaimo)**

South Englishman ~100m u/s Englishman River						
	Nitrate+Nitrite (ug/L, minimum detection limit = 2)	Ammonia (ug/L, minimum detection limit = 5)	Ortho-phosphate (ug/L, minimum detection limit = 1)	Total dissolved phosphorus (ug/L, minimum detection limit = 2)	Total phosphorus (ug/L, minimum detection limit = 2)	Total Alkalinity (mg CaCO <sub>3</sub> /L, minimum detection limit = 0.5)
Jun	Not sampled in June					
9-Jul	-	-	<1	<2	2	-
6-Aug	129	-	<1	2	<2	-
3-Sep	44	-	4	4	3	-

## 5.0 DISCUSSION/RECOMMENDATIONS

### 5.1 Discharge Monitoring

Due to an unseasonably dry summer and fall, discharge could not be maintained at 1.6 m<sup>3</sup>/s in the mainstem Englishman River between September 20 and November 6. Under normal conditions and perhaps with retained storage in the spring (i.e., June), discharge would have been maintained within the constraints of the current Provisional Operation Rule.

Loss of discharge through groundwater seepage in the lower Englishman was not definitely confirmed by this study. Discharge was greater upstream of Morison Creek than it was at the Highway 19A bridge crossing on two of five sample dates (Table 1). Preliminary results from Water Survey of Canada for the Highway 19A bridge site, 2002, suggest that groundwater seepage was not significant. On average, discharge at the hydrometric station upstream of Morison Creek was 89% of the discharge measured at Highway 19A station. Further monitoring of discharge upstream of Morison Creek and at the Highway 19A bridge is recommended for the low water season of 2003 to confirm potential loss of water through the substrate.

Rural or agricultural water use may have caused discharge in Morison Creek to drop to 0.004 m<sup>3</sup>/s on August 4. It is unlikely the low reading was a result of a stage recording error because there are several points that support the trend. Water use in the headwaters should be examined further to identify the cause.

The hydrometric station installed on Morison Creek should be operated during the low flow season in 2003 to further monitor hydrology responses over time.

## **5.2 Mainstem Habitat Suitability**

MWLAP staff have identified that rearing flows near 20% of MAD would be ideal, but that 10% is an acceptable short-term minimum base flow (R. Ptolemy pers. comm.). Results from habitat suitability, wetted width, and visual observations confirm habitat loss is not significant until flows drop below 19% of MAD (Figures 7, 8, and 9).

Analysis at 7 and 8% of MAD indicate significant loss of habitat below the threshold conservation flow of 1.38 m<sup>3</sup>/s. These results support the Provisional Operation Rule enshrining a minimum base flow of approximately 10% MAD to ensure future fish conservation needs are met.

## **5.3 Morison Creek Water Quality**

Metal concentrations in Morison Creek were generally low in comparison to MWLAP guidelines (Table 6). Arsenic, chromium, copper, lead, nickel and zinc concentrations were well below the maximum levels specified in the guidelines for aquatic life. Cadmium concentrations were detectable on two of ten sample dates. The detectable concentrations of 0.01 ug/L are equal to the maximum acceptable concentration for freshwater aquatic life. For drinking water, all samples were within MWLAP guidelines. Fecal coliform and *E. Coli* were more abundant in the fall samples but were also within the threshold outlined in the MWLAP guidelines.

In the mainstem samples taken at the Highway 19A bridge, results were similar to those in Morison Creek, with the exception of samples taken on November 12, when there was an anomalous spike. The fecal coliform density of 160 / 100 ml was sampled when numerous spawning salmon were observed, and hence additional organics in the water could have added to the coliform load (D. Epps pers. comm.)

## **5.4 Mainstem Low level Nutrient Analysis**

Water chemistry results from the mainstem Englishman River confirmed that artificial stream enrichment, aimed at increasing dissolved nitrogen and phosphorus levels, would increase stream productivity. By adding slow release fertilizer, fry and parr have been shown to achieve larger sizes prior to overwintering, ultimately leading to improved smolt production (Scrivener and Brown 1993). In light of the variable ortho-phosphate levels measured in 2002, a conservative application of fertilizer or salmon carcasses is recommended for 2003. Excessive periphyton biomass has been reported when ortho-phosphate levels exceed 10 ug/L (Ashley and Slaney 1997).

A new fertilizer product consisting of 100% compressed pollock bone meal is currently being analyzed for disease and other contaminants. Should the product pass all the tests, it may be a good candidate for use in the Englishman River. Low-level nutrient sampling in the Englishman River should be repeated in 2003 to re-assess ortho-phosphate and dissolved inorganic nitrogen concentrations throughout the growing season.

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### **Personal Communication**

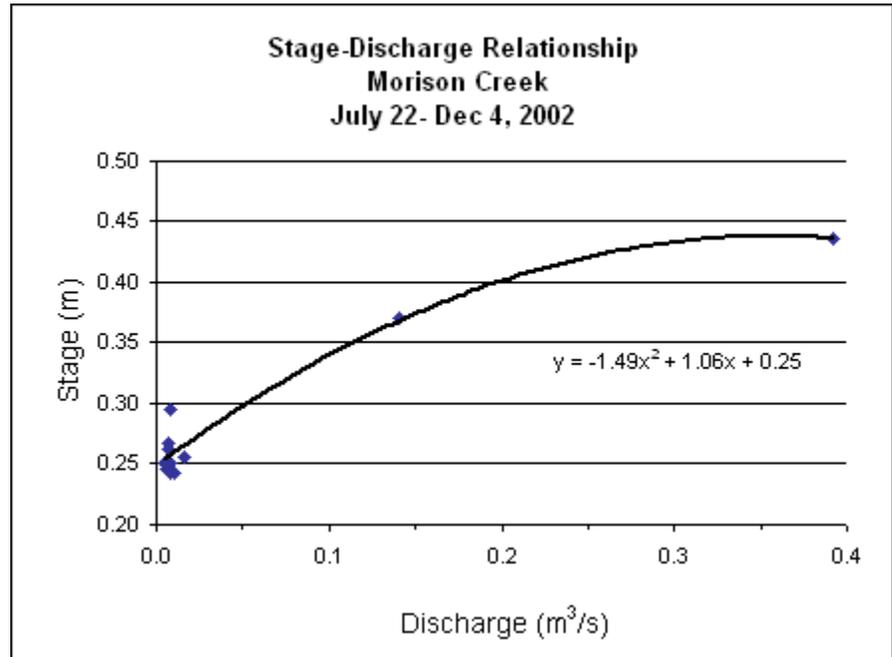
Ferguson, S. Hydrometric Survey Technologist, Water Survey of Canada. Nanaimo, BC.

Ptolemy, R. Fisheries Flow Specialist, Biodiversity Branch, Ministry of Water, Land and Air Protection. Victoria, BC.

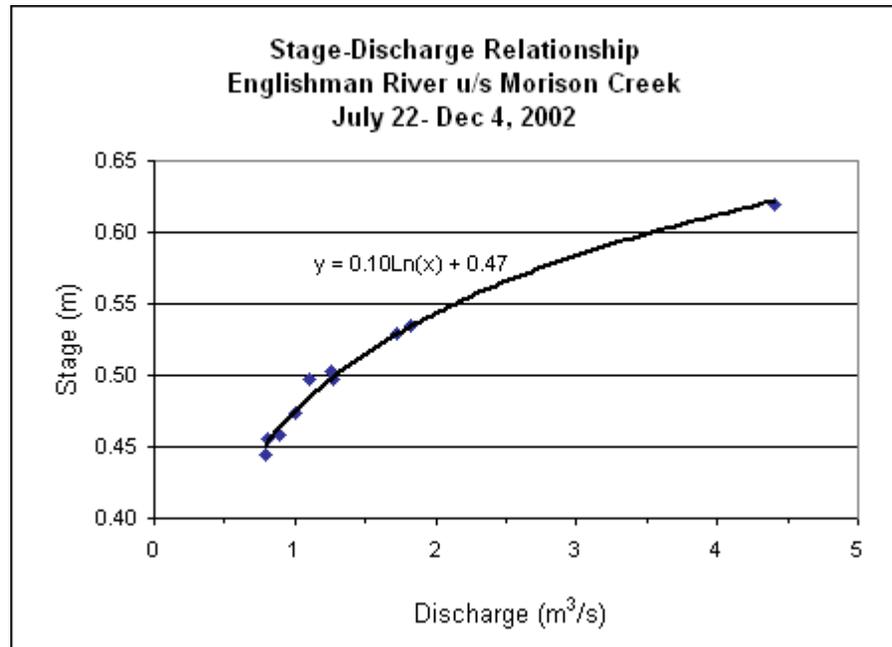
## **Appendix A**

**Stage/discharge relationships for Englishman River and Morison Creek  
semi-permanent stage monitoring stations.**

Stage (m)	Discharge (m <sup>3</sup> /s)
0.242	0.0084
0.243	0.0101
0.251	0.0075
0.251	0.005
0.246	0.0061
0.255	0.0156
0.262	0.0066
0.268	0.0069
0.295	0.0075
0.37	0.1406
0.436	0.3923



Stage (m)	Discharge (m <sup>3</sup> /s)
0.444	0.794
0.455	0.802
0.459	0.895
0.473	1.004
0.497	1.107
0.497	1.276
0.503	1.262
0.529	1.722
0.535	1.816
0.619	4.413



# **Appendix B**

## **Depth/Velocity Data Analysis Spreadsheet**



## **Appendix C**

**Wetted widths measured at eight riffle sites  
on the Englishman River, June 18 – October 18, 2002.**

Transect	Wetted Width (m)				
	57% MAD	27% MAD	19% MAD	8% MAD	7% MAD
R1	30.00	30.95	28.95	28.02	25.40
R4	32.00	33.80	30.98	25.20	26.70
R5	30.00	29.50	26.94	25.10	25.30
R6	29.00	30.30	27.02	22.62	22.80
R7	25.00	27.25	26.28	26.18	25.20
R8	44.00	38.30	36.05	30.60	28.20
R11	19.00	18.55	18.00	17.71	16.70
R12	30.00	29.15	25.79	21.00	19.70
<b>mean</b>	<b>29.88</b>	<b>29.73</b>	<b>27.50</b>	<b>24.55</b>	<b>23.75</b>

## **Appendix D**

**Habitat photographs at 57%, 27%, 19%,  
8%, and 7% of mean annual discharge.**

Photo 1



57 % MAD



27 % MAD



19% MAD



8% MAD



7% MAD

Photo 2



57 % MAD



27 % MAD



19% MAD



8% MAD



7% MAD

Photo 3



57 % MAD



27 % MAD



19% MAD



8% MAD



7% MAD

Photo 4



57 % MAD



27 % MAD



19% MAD



8% MAD



7% MAD

Photo 5



57 % MAD



27 % MAD



19% MAD



8% MAD



7% MAD

Photo 6



57 % MAD



27 % MAD



19% MAD



8% MAD



7% MAD

Photo 7



57 % MAD



27 % MAD



19% MAD



8% MAD



7% MAD

Photo 8



57 % MAD



27 % MAD



19% MAD



8% MAD



7% MAD

# **Appendix E**

## **Temperature Logger Data**

