Appendix J
Aquatic Effects Assessment

Fisheries Component of Aquatic Effects Assessment of Proposed Bulk Water Supply Intake in Englishman River

***Prepared by*:**

LGL Limited environmental research associates
9768 Second Street
Sidney, BC V8L 3Y8

***Prepared for*:**

Englishman River Water Service
1116 Herring Gull Way
Parksville, BC V9P 1R2

April 2014

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF PHOTOS

1.0 Introduction

Englishman River Water Service (ERWS) is a joint venture of the City of Parksville, the Regional District of Nanaimo and Nanoose formed to secure, treat and distribute water originating from the Englishman River. The bulk water supply from the river is intended to supplement existing supply sources owned and operated by the individual jurisdictions. An existing City of Parksville river intake downstream of Highway 19A currently extracts river water from the mainstem to supplement its well water supply during the peak demand period between June and October.

The current project being proposed by ERWS is the construction of a new river intake, with construction of a water treatment plant (WTP) and associated water distribution system to follow. The current population in the service area is 17,500 full time residents with an additional 10,400 part-time residents in the summer. The proposed intake would supply 55% of the current population with the balance coming from existing groundwater wells. It is estimated that by 2050 there will be 35,800 full time residents and 13,900 part-time summer residents. The proposed river intake would support 71% of the demand.

It is believed that the Department of Fisheries and Oceans (DFO) considers the proposed municipal water supply intake to be a new project in accordance with the Fisheries Act. Therefore, ERWS will have to apply for DFO Authorization under Section 35 of the Fisheries Act for the works. Part of the submission requirements for the Authorization is the preparation of this Aquatic Effects Assessment which provides a summary of the fish habitat at the site and the impacts that the project is likely to have on that habitat. The assessment includes both the impacts of construction of the intake as well as downstream impacts relative to changes in flow as a result of water withdrawal during the operational stage. The assessment on the effects of flow changes on fish habitat is based on the estimated demand in 2050.

The purpose of this report is to:

- Document the existing distribution and status of the fish populations;
- Document the distribution of the various channel types (i.e., riffle, pool and glide) downstream of the proposed intake site;
- Identify the types and relative quality of the existing fish habitats;
- Assess the potential effects of water withdrawal on Englishman River flows and fish habitats downstream of the bulk water supply intake by modeling riffle and glide habitats for native salmon and trout rearing and spawning;
- Estimate the change in weighted useable area as a result of water withdrawals at the intake relative to timing of habitat use and frequency of flows;

- Identify and quantify permanent or temporary aquatic resource impacts, and
- Recommend mitigation measures.

2.0 Background

Construction of the Arrowsmith Dam and Arrowsmith Lake storage reservoir resulted from direction from the Province of British Columbia to the Town of Qualicum Beach, City of Parksville and the Regional District of Nanaimo to consider three key principles during planning:

1) Investigate the Englishman River as a single source of future surface water supply for the region;
2) Create water storage in a reservoir to reduce impacts to local aquifers from water withdrawals; and
3) Provide sufficient water storage to help augment and stabilize summer base flows that support aquatic life.

In March 1997, a Conditional Water Licence was issued authorizing the construction of the Arrowsmith Dam. The dam impounded a water storage volume of 9,000,000 m^3, with half of this volume reserved for enhancing instream flows for aquatic life. A Conditional Water Licence and corresponding Provisional Operating Rule (specifying a flow of 1.60 m^3/s at the Highway 19A Bridge) were issued based on the premise of utilizing the existing City of Parksville intake in the interim until such time the future proposed water intake was constructed upstream of the Englishman River Water Survey Canada hydrometric gauge (Station 08HB002).

The Englishman River now serves as a natural waterway that conveys water from Arrowsmith Lake to the point of extraction from the river. However, not all water released from Arrowsmith Lake reaches the extraction point. Depending on the time of year, some of this water is lost to evaporation or passes through the river substrates to recharge the Englishman River aquifer. Without the dam and reservoir, the flows in the Englishman River would at times return to historically low levels and reduce the benefit to groundwater recharge that is now occurring during the summer and fall low flow period.

Additional water management strategies and technologies are being explored to further reduce water extraction rates during peak water demands that coincide with low summer flows in the Englishman River. For example, ERWS is examining additional municipal water conservation measures to further reduce water demand during >5 year droughts. Also, ERWS and the fisheries agencies are improving the management of Arrowsmith Dam releases by revising the “rule band” to maintain, where feasible, Englishman River flows during July to October at even higher minimum flows than have occurred recently (i.e., 2000-2013).

Improvements in the timing and volume of flow releases could mitigate potential impacts to fish rearing habitats during low flow periods caused by droughts. ERWS has also begun field trials on Aquifer Storage and Recovery (ASR). If feasible, ASR could potentially further reduce peak surface water demands during critical low flow summer periods in the Englishman River by up to 40%.

As a consequence of Arrowsmith Dam releases improving summer base flows in the Englishman River, the following fisheries enhancement improvements have been realized:

- Mean annual discharge in the Englishman River has increased from 13.11 m^3/s prior to 1999 to 13.54 m^3/s since 2000;
- Minimum daily discharge has increased from a median value of 0.29 m^3/s prior to 1999 to 1.12 m^3/s since 2000;
- In collaboration with DFO and MoE staff, summer flows have been augmented in the Englishman River during periods when potable water demand is reduced; and
- Significant summer base flow improvement has allowed for additional instream and off-channel fish habitat enhancements to be created.

3.0 Physical Description of New Water Intake and Weir

The new ERWS intake will replace the existing intake which uses a buried well screen infiltration gallery. The new water intake site will be located on the right (north) bank immediately upstream of the Highway 19 bridge crossing of the Englishman River (Figure 1). The north bank consists of glacial till and bedrock that extends to just downstream of the railway crossing. It appears that the channel position and banks at this site have remained relatively stable since at least 1949 (Gaboury 2005).

The proposed design is a side bank intake structure with inclined wedge wire screen panels designed to meet DFO fish protection criteria with 2.54 mm slots and to prevent debris from entering the pumps. The width of the intake structure is approximately 10.5 m with a 15 m^2 flat maintenance deck above the screens.

The intake structure will also have two 3.5 m wide by 0.8 m high pneumatic crest gates connected to a concrete sill which lies across the river. The concrete sill extends from the river bank (to the north) to a large rock (to the south), and is approximately 7.5 m long by 2 m wide. A natural channel will be provided to enable fish passage around the weir. The two purposes of the weir are: 1) to raise the minimum water level upstream of the weir by 0.4 to 0.5 m, such that the full water withdrawal rate can be extracted up to the water licence amount, and 2) to provide a structure that will allow for more accurate river discharge measurements. The right (looking downstream) crest gate will be automated to maintain a constant upstream water level and will also be calibrated to accurately measure low flows.

Figure 1. Map of lower Englishman River showing the proposed water intake site and boundaries of Reaches 1 and 2.

4.0 Assessment Methods

The assessment of effects of water withdrawals at the proposed intake on fish populations and habitats downstream in the lower Englishman River involved the following field and office activities:

1. Review and summarize relevant fish population and habitat information for the Englishman River;
2. Complete a meso-habitat survey to identify, map and quantify the length of the habitat types downstream of the intake (pools, riffles and glides);
3. Establish up to ten channel cross sections at representative locations for riffles and glides;
4. Complete topographic surveys using a level and rod at each of the channel cross sections;
5. Classify channel substrate at each of the channel cross sections;
6. Use Habitat Suitability Indices for Steelhead (*Oncorhynchus mykiss)*, Chinook (*O. tshawytscha)*, Coho (*O. kisutch*) and Chum (*O. keta*) to establish weighted useable area versus discharge relationships along the section of the Englishman River downstream of the proposed intake location to the river mouth across the range of expected summer flow levels (less than 5 m^3/s) using RHYHABSIM (River Hydraulics and Habitat Simulation) software;

4.1 Assessment of Existing Fish Values

Existing information on fish populations and habitat within the lower Englishman River mainstem was obtained from published reports and unpublished assessment data. Existing data and reports on the Englishman River environment that were pertinent to potential environmental concerns / impacts associated with the siting and construction of the water intake and backwater weir were reviewed.

4.2 Meso-habitat Survey

The classification and distribution of meso-habitats in the lower Englishman River was completed during a field survey conducted on 22 August 2013 at ~1.6 m^3/s (Water Survey of Canada, Station 08HB002). Two fisheries biologists waded the river from the proposed intake site to tidal waters. Habitats were classified as pool, riffle or glide and the upstream and downstream limits of the channel section for each habitat type were located using a handheld GPS. Using the GPS waypoint data, meso-habitats were mapped and their length measured using ArcView.

4.3 Habitat-Flow Modeling

Bed profile, water surface elevation, velocity, depth, substrate and discharge measurements were collected at a total of 10 cross sections representing riffle (five cross sections) and glide (five cross sections) habitats within Reach 2 of the lower Englishman River mainstem. Cross section surveys occurred on 24 July and 5 September 2013 in accordance with data requirements for completing hydraulic modelling with the RHYHABSIM model using a single velocity calibration data set (Jowett 2006; Jowett et al. 2008). This calibration method entailed measuring water surface elevations (WSELs) at a series of calibration flows, mean-column-velocity calibration data at one flow, and stream discharge at each WSEL calibration flow. Transects were located in representative riffle and glide habitats that encompassed typical spawning and rearing habitats for salmon and trout. Water surface elevations at these riffle and glide transects were surveyed over a range of at least three calibration flows.

A permanent benchmark for each survey transect was defined by a head pin established on the top of the right bank (looking downstream). Each pin was flagged and semi-permanently fixed with rebar. The location of each transect was marked with a Garmin model 76CSx GPS unit.

Hydraulic-habitat modeling provided a mechanism to examine the suitability of the existing habitat for Steelhead and salmon as well as the potential suitability of the habitat for species-specific life stages at river discharges under the proposed water withdrawal scenario. Habitat suitability indices (HSI) for native salmon and Steelhead fry, parr and spawners were used with the modeling program RHYHABSIM, Vers. 5.1 (River Hydraulics and Habitat Simulation; Jowett 1999) to predict weighted usable area (WUA) for species-specific life stages of salmon and trout inhabiting riffle and glide habitats. The HSIs had been prepared previously for BC Hydro Water Use Plans and were provided by BC Forests, Lands and Natural Resource Operations for this project (Appendix A to Appendix I). These published HSIs are based on preferences of embryo, fry, parr and adult life stages to velocity, depth, and substrate in characteristic spawning and rearing habitats of salmon and trout. A suitability of 1.0 represents the optimum amount of usable habitat, 0 represents unsuitable habitat conditions, and values in-between represent varying degrees of suitability (Thorn and Conallin 2006).

RHYHABSIM is a habitat-hydraulic model and is designed to measure the amount of microhabitat available in a stream or river for fish or macroinvertebrates at different lifestages and at different flows (Jowett 1989). Habitat-hydraulic models combine biological data of the indicator species (i.e., habitat suitability indices) with the hydrologic and morphological characteristics of the stream to produce a quantitative relationship between flow and usable habitat areas (Thorn and Conallin 2006). In the model, hydraulic variables are combined with the species and life stage specific biological habitat suitability values to produce life stage specific curves representing the usable habitat area (i.e., weighted useable area) versus stream discharge (Thorn and Conallin 2006). In our application of the RHYHABSIM model, riffle and glide habitats were included in the assessment for trout and salmon fry, parr and adults.

A benefit to using RHYHABSIM is its ability to analyze multiple species and life stages and derive information on how they will respond to changes in flow rates. It should be noted that RHYHABSIM only provides information regarding potential habitat available for the indicator species and how habitat area changes for different flows. If the model indicates optimal habitat for a particular species at a given flow, it does not mean that species will be able to survive in the stream because other abiotic factors such as water quality and biotic factors such as competition also play a role (Thorn and Conallin 2006).

4.4 Potential Effects on Fish

The potential harmful effects of withdrawing water at the proposed intake site on fish species or their habitats at and downstream of the intake site were assessed based on the expected construction and operational schemes for the water intake (CH2M Hill and KWL 2013). The context for the evaluation of these effects on fish and fish habitat is relative to the type, quality and quantity of fish habitat within the lower Englishman River under existing conditions. Where it was determined that there may be negative short or long term potential impacts, recommendations were made to mitigate these impacts.

5.0 Results and Discussion

5.1 Fish Populations and Habitats

The Englishman River supports significant populations of salmon. Chum is the dominant anadromous species followed by Coho. Steelhead, Cutthroat Trout (*Oncorhynchus clarkii*), Chinook, Pink (*O. gorbuscha*) and Sockeye (*O. nerka*) are also present (Bocking and Gaboury 2001). The anadromous section extends up to Englishman River falls, a distance of about 16 km from the mouth. Resident game species include Dolly Varden (*Salvelinus malma*) and Rainbow Trout (*O. mykiss*).

Table 1 shows when the various life stages for each anadromous salmonid species are present within the Englishman River and estuary. The mainstem reach that extends from downstream of Highway 19A to Morison Creek is an important spawning area for all species of anadromous fish within the Englishman River, including Chum, Coho, Chinook and Pink salmon, Steelhead and Rainbow Trout (Figure 2). Some salmon and Steelhead spawning has also been observed as far upstream as the anadromous barrier (Lough and Morley 2002; J. Craig, BCCF pers. comm.).

Table 1. Life history timing for anadromous salmonids within the Englishman River and estuary.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Coho	Eggs	Eggs	Eggs								Eggs	Eggs
			Fry	Fry	Fry							
	Parr	Parr	Parr			Parr	Parr	Parr	Parr	Parr	Parr	Parr
				Smolts	Smolts	Smolts						
	Adults								Adults	Adults	Adults	Adults
Chinook	Eggs	Eggs	Eggs								Eggs	Eggs
			Fry	Fry	Fry							
						Parr	Parr	Parr	Parr	Parr		
				Smolts	Smolts	Smolts	Smolts	Smolts				
								Adults	Adults	Adults		
Pink	Eggs	Eggs	Eggs								Eggs	Eggs
			Fry	Fry								
									Adults	Adults		
Chum	Eggs	Eggs	Eggs								Eggs	Eggs
			Fry	Fry	Fry	Fry						
									Adults	Adults	Adults	Adults
Sockeye	Eggs	Eggs	Eggs								Eggs	Eggs
			Fry	Fry	Fry	Fry						
					Smolts	Smolts						
							Adults	Adults	Adults	Adults		
Steelhead		Eggs	Eggs	Eggs	Eggs	Eggs						
						Fry	Fry	Fry				
	Parr	Parr	Parr	Parr	Parr	Parr	Parr	Parr	Parr	Parr	Parr	Parr
				Smolts	Smolts	Smolts						
	Adults	Adults	Adults	Adults	Adults	Adults	Adults				Adults	Adults

Eggs | Fry | Parr | Smolts | Adults

J. Craig (BCCF) indicated that the most critical fish habitat in the mainstem is located in Reach 3 (from the confluence of the South Englishman River downstream to Top Ridge Park (Allsbrook Canyon)) and Reach 4 (from below the confluence of Morison Creek downstream to the South Englishman River confluence) (Figure 2). As identified above, the habitats in these reaches are most important for salmon, Steelhead and Rainbow Trout spawning, and Coho, Chinook, Steelhead and Rainbow Trout rearing and overwintering.

In Reach 3 above Allsbrook Canyon, the C.W. Young Side Channel on the left bank of the river, downstream of Morison Creek, is used for spawning by the same species as found in the mainstem as well as Cutthroat Trout. Coho and Chum salmon and Cutthroat Trout spawn in the MacMillan Bloedel side channel, on the right bank of the river just downstream of the BC Hydro transmission corridor. Both channels extract water from the Englishman River mainstem at two separate locations and then discharge flow back to the mainstem at two separate locations. Both side channel outlets are upstream of Allsbrook Canyon.

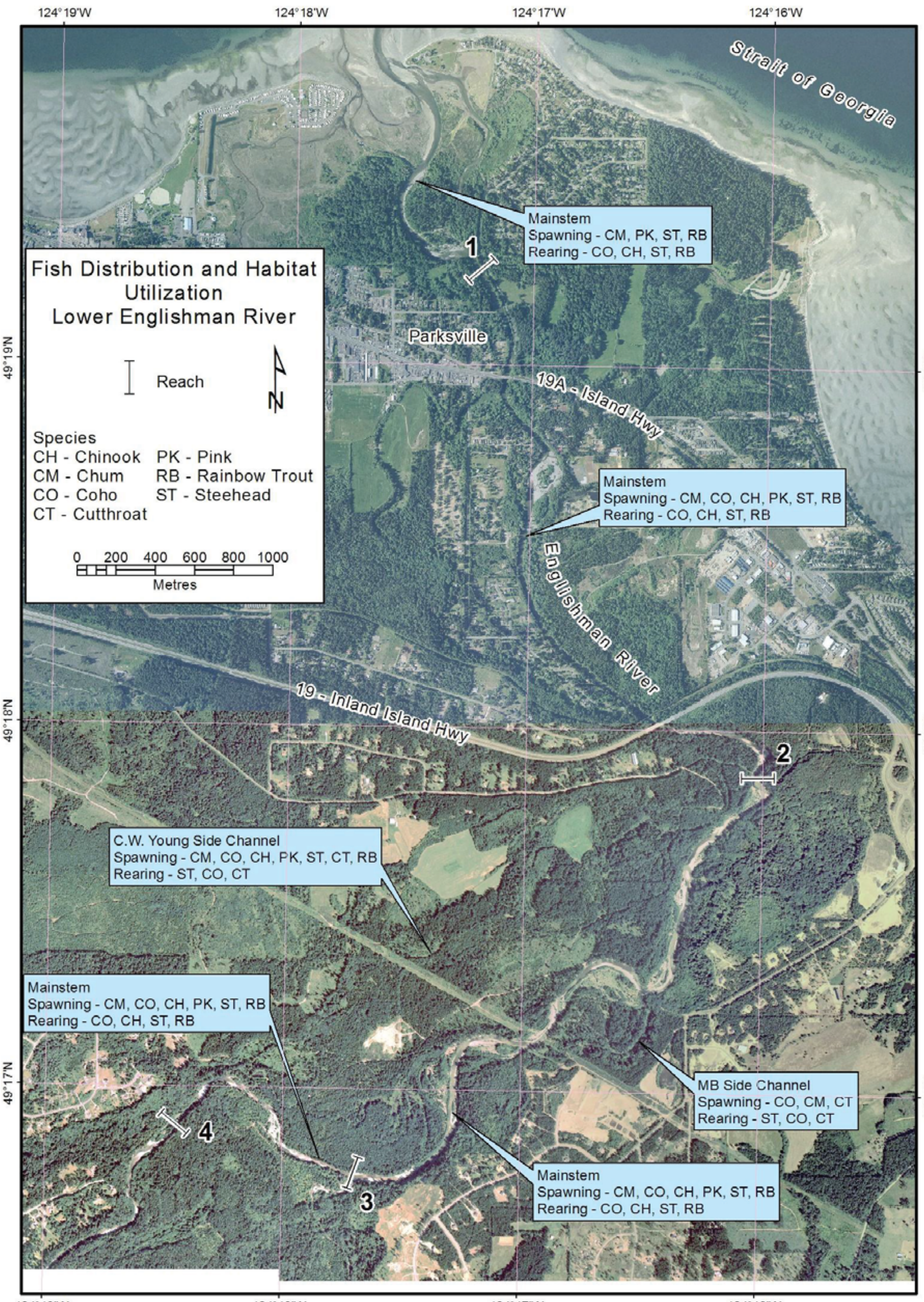


Figure 2. Map of lower Englishman River showing distribution of salmon and trout species that use mainstem and side channel habitats for spawning and rearing.

Under existing conditions, summer rearing habitat in the Englishman River is considered one of the primary limiting factors of Coho, Steelhead, Chinook and Rainbow Trout production within the watershed (Bocking and Gaboury 2001; Lough and Morley 2002). Rearing habitat is limited by low summer flows that typically occur between July and October (Table 2). In Reaches 1 and 2 (i.e., the river section downstream of the proposed water intake), production of rearing salmonids is limited by the lack of winter refuge and lack of pools with adequate cover in summer and winter (Lough and Morley 2002).

In the mainstem of the Englishman River, the impacts of low summer flows have been alleviated to some degree by the relatively recent (since 2000) ability to augment low summer flows with the release of storage water from the headwater reservoir at Arrowsmith Lake. A Provisional Operation Rule for Arrowsmith Lake Reservoir was issued by Order under s. 18, *Water Act* which requires a minimum flow release to maintain a discharge of 1.20-1.60 m^3/s at the Water Survey of Canada (WSC) gauge located at the Highway 19A bridge crossing. However, due to the relatively small storage volume of Arrowsmith Reservoir coupled with years of low precipitation and the naturally low summer discharges in the Englishman River, annual minimum discharges have been below 1.20 m^3/s eight times between 2000 and 2012, albeit for short durations. Nevertheless, the release of water from Arrowsmith Dam has greatly improved summer discharges. For example, the median annual minimum flow prior to the Arrowsmith Dam was recorded as 0.29 m^3/s but with the dam releases since 2000 has improved to 1.12 m^3/s (Table 2).

5.1.1 Fish Habitat at Intake Site

The proposed water intake would be located on the right bank (facing downstream) at a shallow curve meander bend of the river near the upstream end of Reach 2 (Figure 1). Boulders and cobbles are the predominant channel substrates present near the water intake site. Water depth during the summer is ~0.5 m in the thalweg of the right bank channel. The habitat immediately adjacent to the site is characterized as shallow glide. At low discharges the site is adjacent to a large mid-channel outcropping of bedrock, with short riffle and glide sections immediately downstream.

The glide habitat at the intake site would be suitable as rearing habitat for salmonids, particularly Steelhead, Rainbow Trout, Cutthroat Trout, Chinook and Coho fry at low and moderate flows. The glide habitat would also be suitable as rearing habitat for Steelhead and Rainbow trout parr and adults at moderate and high flows. The large cobble and boulder substrate in the glide and riffle immediately downstream of the intake site would limit its utilization by salmonids for spawning.

Although the bank vegetation near the Highway 19 and railway crossings has been disturbed, large mature Douglas fir and red cedar are the dominant tree species found on the right bank at the proposed intake site.

Table 2. Annual minimum discharges in Englishman River, WSC gauge 08HB002, over period of record, 1913-2012.

Year	Minumum Daily Discharge (cms)	Date (Month--Day)	Period Summaries	
1913	0.28	9--1		
1914	0.09	9--4		
1915	0.65	9--20		
1916	0.43	10--17		
1917	1.10	8--11		
1970	0.17	9--1		
1971	1.16	8--29		
1980	0.63	9--19		
1981	0.46	8--23		
1982	0.49	9--3		
1983	0.48	10--12		
1984	0.42	8--31		
1985	0.27	8--28		
1986	0.29	9--19		
1987	0.27	10--19		
1988	0.27	9--14		
1989	0.31	10--3		
1990	0.22	8--29		
1991	0.29	8--5		
1992	0.25	8--16		
1993	0.14	9--30		
1994	0.34	9--2		
1995	0.25	9--25		
1996	0.21	8--28		
1997	0.83	8--19		Minimum
1998	0.17	9--7	1913~1999	Discharge
1999	0.89	10--12	Minimum	0.09
2000	0.67	9--28	Median	0.29
2001	1.12	7--24		
2002	0.97	11--5		
2003	1.02	7--21		
2004	1.15	9--7		
2005	1.22	9--28		
2006	0.74	10--13		
2007	1.56	9--14		
2008	0.94	8--17		
2009	0.76	10--12		Minimum
2010	1.29	8--11	2000-2012	Discharge
2011	1.21	8--18	Minimum	0.67
2012	1.52	9--3	Median	1.12

5.1.2 Fish Habitat Downstream of Intake Site

The proposed intake site is located ~2.7 km upstream of the existing water intake and ~4.5 km upstream of the river mouth. Fish habitat downstream of the proposed intake site is situated within Reaches 1 and 2 of the Englishman River (Figure 1). Fish habitat within this ~4.5 km section of channel is characterized as predominantly glide with current utilization by salmon and Steelhead for spawning, and by Coho, Chinook, Steelhead and Rainbow and Cutthroat Trout for rearing (Figure 2). Timing of use of this habitat by these species would be as described in Table 1.

The lower river is characterized as a riffle-pool-glide morphology with an overall gradient of ~0.4%. Overall composition of habitat types in the lower Englishman River downstream of the proposed water intake was ~53% glides, ~26% riffles and ~20% pools (Table 3; Figure 3; Photo 1 to Photo 12). The preponderance of glide habitat with an average composition of ~20% sand, ~61% gravel and ~8% cobble and boulder provides a large quantity of moderate quality spawning habitat and moderate to high quality fry rearing habitat (Table 4). Riffles were comprised predominantly of gravel and cobbles with only a few riffles in primarily the upper river section having emergent boulders. The relatively low composition of boulders on the riffles suggests moderate quality rearing habitat for Steelhead parr. Pools had primarily gravel and sand substrates. Exposed lateral gravel / cobble bars adjacent to the right and/or left banks were observed in some riffle, pool and glide habitats at a survey flow of 1.6 m^3/s.

Table 3. Channel length and proportion by length of glide, riffle and pool habitats downstream of the proposed water intake on the Englishman River. Refer to Figure 3 for meso-habitat distribution on river.

Habitat Type	Channel Length (m)	Proportion
Glide	1762	53.4%
Riffle	860	26.1%
Pool	676	20.5%
Total	3298	100.0%

Table 4. Substrate composition (%) of glide and riffle habitats surveyed at river cross sections.

Habitat Type	Sand	Fine Gravel	Coarse Gravel	Cobble	Boulder
Glide	20	20	41	6	2
Riffle	8	7	53	16	5

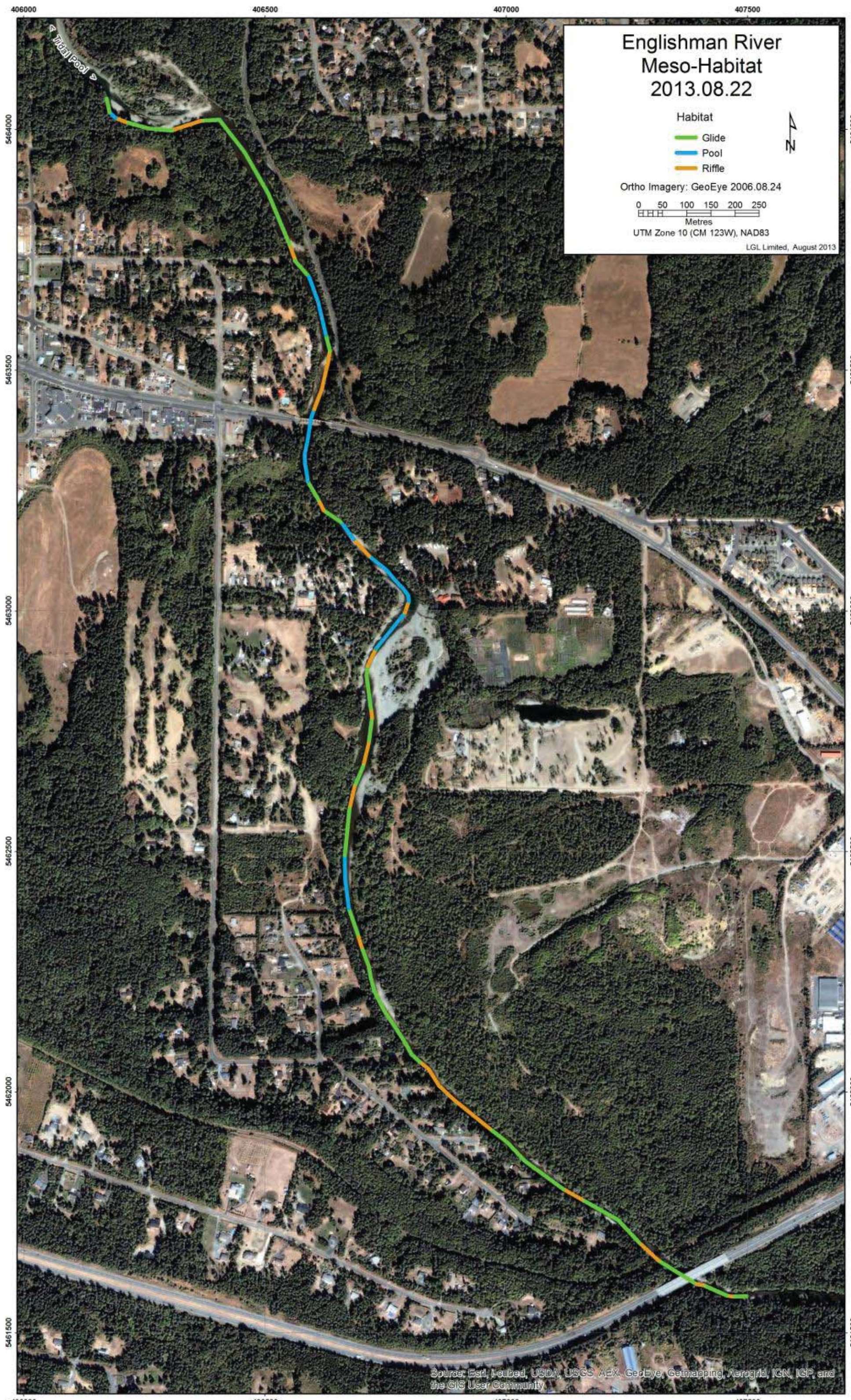


Figure 3. Distribution of meso-habitats between the zone of tidal influence and the proposed water intake site on Englishman River.

5.2 Habitat-Flow Relationships

5.2.1 Fry

Area of Coho and Chinook (spring period) and Steelhead fry habitat in glides increases rapidly to peak WUA values as flows increase, and then suitability decreases gradually with increasing discharge (Figure 4). Area of Steelhead parr and Chinook (summer period) fry habitat in glides increases gradually as flows increase to peak WUA values, then taper off very gradually with increasing discharge. Discharges at peak WUA values for fry inhabiting glides ranged from 0.10 m^3/s for Chinook spring fry to 5.80 m^3/s for Chinook summer fry (Table 5). Peak WUA values for Steelhead and Coho fry were 0.60 and 1.40 m^3/s, respectively.

Area of salmon and Steelhead fry habitat in riffles increases quite rapidly to peak WUA values as flows increase, and then suitability decreases gradually with increasing discharge (Figure 5). Discharges at peak WUA values for fry inhabiting riffles ranged from 1.30 m^3/s for Chinook spring fry to 3.90 m^3/s for Chinook summer fry (Table 5). Peak WUA values for Steelhead and Coho fry were 1.90 and 2.40 m^3/s, respectively.

The decline at a constant rate in habitat suitability at higher flows is indicative of increasing velocities and depths in riffle and glide areas. For all sites, there is generally more available habitat area at a given discharge for Coho, Chinook summer and Steelhead fry than for Chinook spring fry.

5.2.2 Parr

Area of Steelhead parr habitat in glides and riffles increases gradually to peak WUA values as flows increase, and then suitability tapers off very gradually with increasing discharge (Figure 4 and Figure 5). Discharges at peak WUA values for Steelhead parr were 8.30 m^3/s for glides and 5.50 m^3/s for riffles (Table 5).

5.2.3 Spawning

Spawning area for salmon and Steelhead increases quite gradually in glides with maximum WUA values for all species at >10 m^3/s (Table 5; Figure 6). Spawning area of salmon and Steelhead increases rapidly in riffles with maximum WUA values at >6 m^3/s (Figure 7). Flows at maximum WUA for Chinook spawning were the highest with estimates of ~32 m^3/s in glides and ~35 m^3/s in riffles.

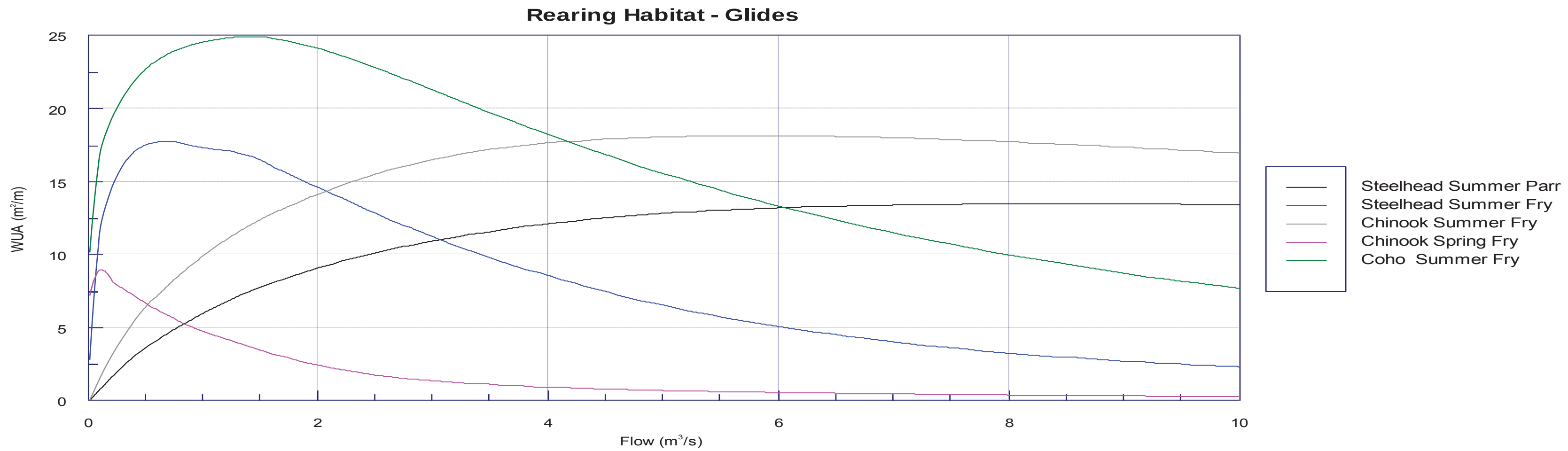


Figure 4. Weighted usable area plots for lower Englishman River glides based on rearing habitat suitability indices for Steelhead, Chinook and Coho.

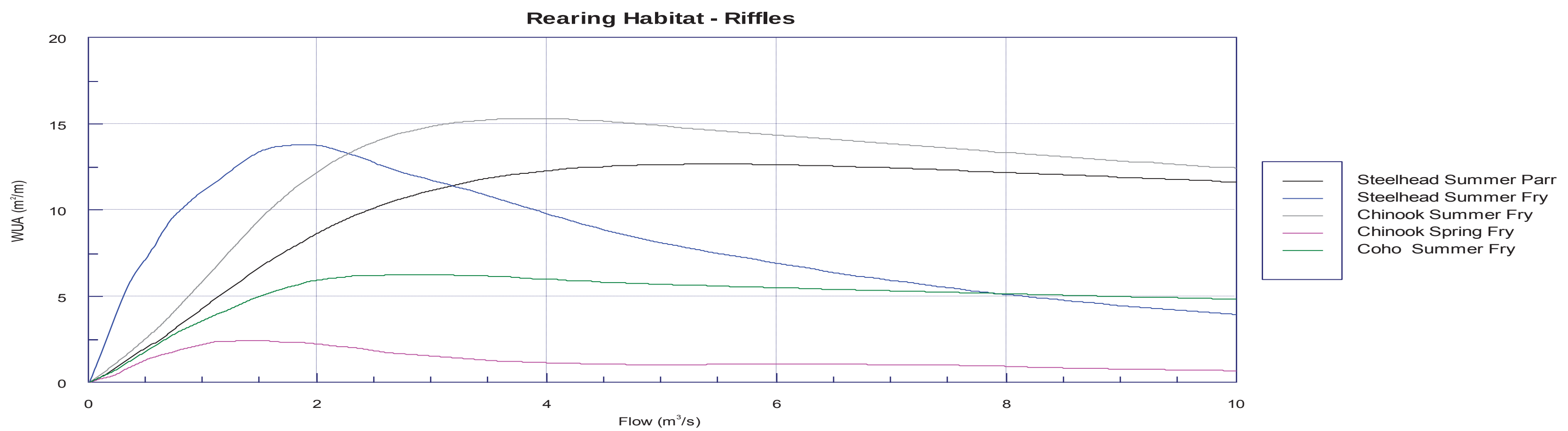


Figure 5. Weighted usable area plots for lower Englishman River riffles based on rearing habitat suitability indices for Steelhead, Chinook and Coho.

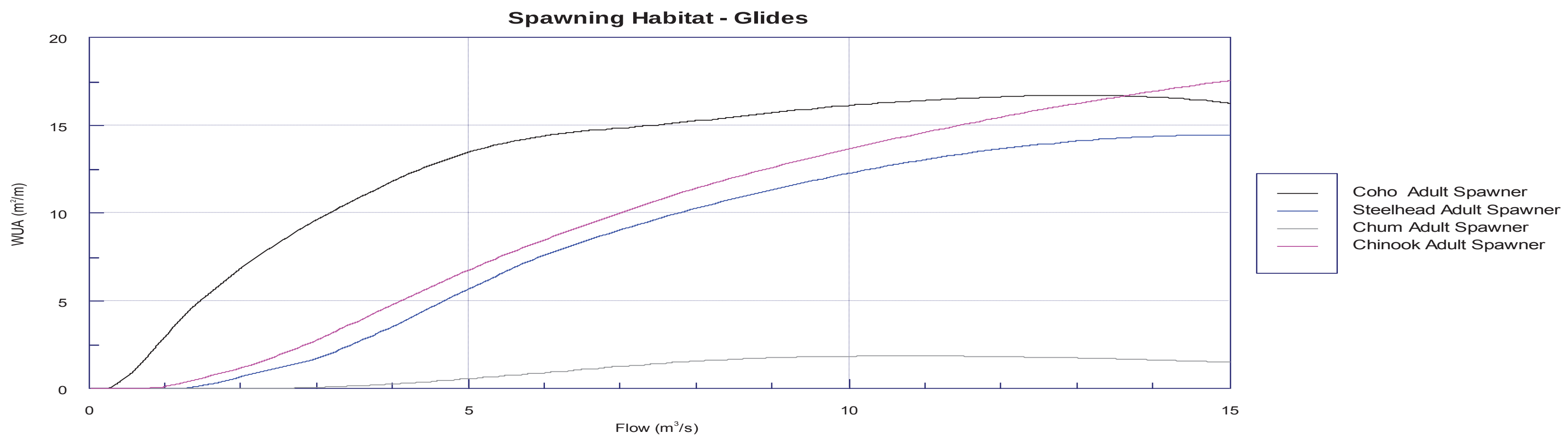


Figure 6. Weighted usable area plots for lower Englishman River glides based on spawning habitat suitability indices for Steelhead, Chinook, Coho and Chum.

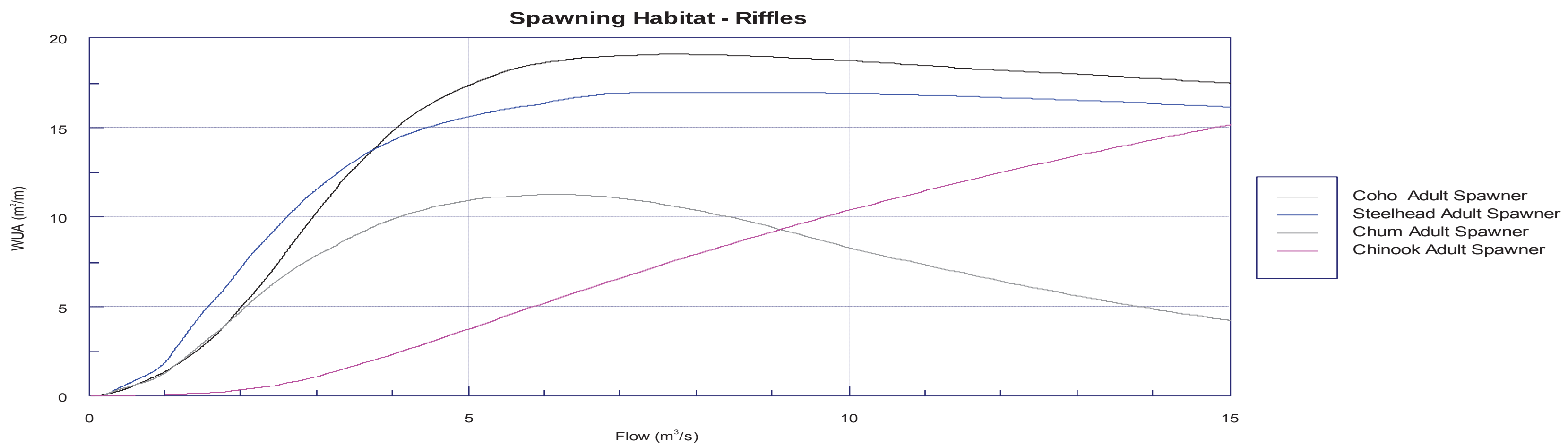


Figure 7. Weighted usable area plots for lower Englishman River riffles based on spawning habitat suitability indices for Steelhead, Chinook, Coho and Chum.

Table 5. Channel and flow characteristics at maximum weighted usable area for salmon and Steelhead in lower Englishman River.

				At Maximum WUA				
Species	Lifestage	Habitat	Maximum WUA	Discharge (cms)	Mean Depth (m)	Mean Velocity (m/s)	Wetted Width (m)	Wetted Perimeter (m)
Steelhead	Summer Fry	R	14.35	1.90	0.18	0.35	29.36	29.49
	Summer Fry	G	17.70	0.60	0.30	0.07	29.42	29.50
	Summer Fry	R+G	15.51	1.30	0.29	0.18	30.32	30.43
	Summer Parr	R	13.18	5.50	0.35	0.48	32.45	32.70
	Summer Parr	G	13.44	8.30	0.73	0.33	33.27	33.69
	Summer Parr	R+G	13.05	7.10	0.59	0.38	33.17	33.52
	Spawner	R	16.94	7.70	0.43	0.54	33.41	33.70
	Spawner	G	14.44	14.90	0.91	0.48	33.82	34.40
Coho	Summer Fry	R	6.15	2.40	0.21	0.37	29.75	29.90
	Summer Fry	G	24.90	1.40	0.38	0.11	31.92	32.05
	Summer Fry	R+G	18.37	1.50	0.31	0.19	30.76	30.89
	Spawner	R	19.08	7.60	0.43	0.54	33.39	33.67
	Spawner	G	16.70	12.90	0.86	0.44	33.67	34.21
Chinook	Spring Fry	R	2.16	1.30	0.13	0.33	27.14	27.25
	Spring Fry	G	8.92	0.10	0.20	0.02	24.33	24.38
	Spring Fry	R+G	6.06	0.10	0.16	0.12	18.29	18.34
	Summer Fry	R	15.96	3.90	0.29	0.43	31.19	31.39
	Summer Fry	G	18.12	5.80	0.63	0.27	32.99	33.33
	Summer Fry	R+G	16.99	4.80	0.50	0.31	32.56	32.84
	Spawner*	R	15.16	15.00	0.61	0.72	34.89	35.30
	Spawner*	G	17.56	15.00	0.91	0.48	33.82	34.41
Chum	Spawner	R	11.26	6.10	0.38	0.50	32.82	33.13
	Spawner	G	1.85	10.70	0.80	0.39	33.49	33.98

Note: * Chinook spawner WUA is greater than 15 cms, estimated at ~32 cms in glides and ~ 35 cms in riffles

5.3 **Potential Effects on Fish**

5.3.1 **Footprint of Intake Infrastructure**

Installation of the intake and weir structures will permanently replace natural channel bottom below the high water mark with concrete. The areas of natural channel affected will include ~39 m^2 for the footprint of the water intake, ~16 m^2 for the sill of the pneumatic weir, and ~8 m^2 for the concrete abutment that ties the weir into the mid-channel bedrock outcropping. Installation of the intake and access stairway will also result in a permanent loss of ~40 m^2 of riparian habitat. In total, ~63 m^2 of channel and ~40 m^2 of riparian habitat will be lost as a result of the installation of the intake, weir and stairway.

5.3.2 Construction Phase

Potential harmful effects on fish and fish habitats during construction in the specified fisheries work window would primarily result from short term disturbance to juvenile Coho, Chinook, Steelhead and resident trout that rear in the glides and riffles proximal to the proposed water intake. Impacts could result from activities such as bedrock blasting or hydraulic hammering, construction of cofferdams, fish salvaging, bank or bed disturbance by equipment or labourers, and sediment inputs to the Englishman River.

5.3.3 Operation and Maintenance Phase

During intake operation, entrainment or impingement of particularly juvenile fish may occur with inappropriate or inadequate screening of the water intake or if the screen is not regularly maintained. Approach velocities (i.e., the water velocity into or perpendicular to the face of an intake screen) that exceed 0.11 m/s may be too great for salmon or trout juveniles to avoid, causing impingement and potential fish losses.

Upstream migration by juvenile and adult salmon and trout may be impeded at low river discharges when the pneumatic weir is inflated. The weir will be raised under three conditions: 1) when water withdrawals exceed 24 ML/day, which is scheduled to occur after 2035, 2) if gravel and other bedload accumulates at the intake screen which reduces screen capacity, and 3) when river flows are to be measured downstream of the weir. In general, the weir will function at low river discharges which typically occur between July and October. Although the incidence of upstream migration by juvenile salmon and trout at low flow conditions in summer is expected to be relatively low, installation of a fish passage structure would mitigate potential impacts of the proposed pneumatic weir on smaller juvenile salmon and trout migrating upstream. Also, several adult salmon species found in the Englishman River commence their spawning migrations in August and September (Table 1) when very low discharges have been recorded (Table 2).

Maintenance activities that could occur within the wetted perimeter of the channel could include: 1) removing gravel, cobble and boulders from the intake pool to improve water withdrawal efficiency, 2) removal, cleaning or replacement of the intake screens, 3) repair or cleaning of the inflatable weir, 4) repair or cleaning of the fish passage structure, and 5) repair of other components of the water intake structure. Depending on the maintenance activities involved and the timing of these activities at the water intake site, there could be some short term disturbance to either spawning or rearing fishes that are proximal to the intake.

5.3.3.1 Flow Changes

Water withdrawals from the proposed water intake will have a maximum licenced withdrawal rate of 48 ML/day (0.55 m^3/s) and a maximum average daily demand

(ADD) in July of 24 ML/day (0.27 m^3/s). Average monthly withdrawal rates will vary as a percentage of the July ADD (Table 6).

Table 6. Maximum daily average design pumping rates by month as a percentage of July average daily demand (ADD), equal to 24 ML/d or 0.27 m^3/s.

Month	% of July ADD	Water Withdrawal Rate (m^3/s)
November	43%	0.12
December	46%	0.12
January	41%	0.11
February	41%	0.11
March	44%	0.12
April	44%	0.12
May	61%	0.16
June	80%	0.22
July	100%	0.27
August	93%	0.25
September	75%	0.20
October	57%	0.15

Based on predicted increases in the population within the service area, a maximum ADD of 24 ML/day is forecasted for 2016 to 2035, with higher water demand (and potentially higher withdrawal rates) after 2035. However, it is quite conceivable that future water withdrawals after 2035 may be much less than the licenced maximum instantaneous withdrawal rate of 48 ML/day because of more widespread acceptance of water conservation programs, successful implementation of Aquifer Storage and Retrieval, and a less than anticipated population growth rate for the service area. Therefore, flow exceedances were calculated based on average monthly withdrawal rates as a percentage of July ADD equal to 24 ML/day (Appendix J to Appendix M; Table 7). In this analysis, flow exceedances 'after withdrawal' were based on existing recorded flows (1999-2011) minus the projected monthly withdrawals for each month shown in Table 6.

From the flow comparison in Table 7, water withdrawals are not expected to significantly affect flows for salmon or Steelhead spawning, egg incubation, emergence and smolt migration between the months of November and June. However, low flows in August-October may delay the start of spawning and reduce the wetted area suitable for spawning by Chinook, Pink, Chum and Coho (Table 1). Low flow conditions of $<1.46\ m^3/s$ currently occur in August-October but flows will be further reduced with water withdrawal to $<1.25\ m^3/s$ at >80% flow exceedances (Table 7).

As is common with most east Vancouver Island streams, low summer flows in the lower Englishman River generally limit the potential quantity of rearing habitat available to native salmon and trout populations. Under existing conditions, the lowest flows occur from July to October (Table 7).

The key concern of water withdrawals at the proposed intake site relates primarily to the potential loss of flow downstream of the new intake during the low flow summer period that could affect the amount and quality of functional fish habitat in the mainstem. Reduced water flows in the summer downstream of the water intake could also contribute to higher water temperatures that exceed optimal conditions for salmonid growth and survival. However, water is typically being extracted from the siphon deep in Arrowsmith Lake during the summer low flow period. The water being withdrawn is therefore colder than the river which helps to decrease the maximum temperatures in the lower reach during low flow conditions.

A reduction in flow with proposed water withdrawals could potentially reduce the quantity of suitable rearing habitat for Steelhead fry and parr, Chinook summer fry and Coho summer fry. An analysis was completed to assess the effect of water withdrawals on rearing habitat area. In the analysis, species and life stage specific WUA area for riffles and glides combined (Table 5) was determined for flow exceedance discharges of 20% to 90% under 'existing' and 'after water withdrawal' conditions. Each species and life stage specific WUA was then calculated as a percent of maximum WUA at each flow condition. The change in the 'percent of maximum WUA' was used as a measure of the expected change in the quantity of suitable rearing habitat for that species and life stage with water withdrawal. Overall, proposed water withdrawals in August caused the greatest decrease in the quantity of suitable rearing habitat followed by July, September and October (Table 8). In August, changes in the quantity of suitable rearing habitat with water withdrawals of up to 24 ML/day were:

- a reduction of 8% for Steelhead parr and Chinook summer fry, no change for Coho fry and an increase of 3% for Steelhead fry at 50% exceedance flows;
- a reduction of 10% for Chinook summer fry, 9% for Steelhead parr, 3% for Coho fry and 2% for Steelhead fry at 80% exceedance flows; and
- a reduction of 11% for Chinook summer fry, 10% for Steelhead parr, 3% for Coho fry and 2% for Steelhead fry at 90% exceedance flows.

Steelhead parr and Chinook summer fry are the species and life stages most affected by low summer flows (i.e., $\geq$80% exceedance flows). Further reductions in the quantity of suitable rearing habitat for these species will occur as a result of proposed water withdrawals, with the smallest percent of maximum WUA occurring in October and August at $\geq$80% exceedance flows.

Table 7. Mean daily flow exceedances in Englishman River at WSC gauging station under existing conditions and proposed water withdrawal rates based on Table 6.

	Flow Exceedance (%)							
	50		80		90		99	
	Existing	After Withdrawal	Existing	After Withdrawal	Existing	After Withdrawal	Existing	After Withdrawal
January	14.50	14.39	8.27	8.16	6.10	5.99	3.98	3.87
February	10.20	10.09	5.47	5.36	3.96	3.85	3.00	2.88
March	11.60	11.48	6.82	6.70	5.14	5.02	2.56	2.44
April	11.60	11.48	8.09	7.97	6.52	6.40	4.54	4.42
May	10.30	10.13	6.69	6.53	5.81	5.65	3.79	3.62
June	5.55	5.33	3.22	3.00	2.43	2.21	1.41	1.19
July	2.09	1.82	1.38	1.11	1.26	0.99	1.08	0.81
August	1.72	1.47	1.32	1.07	1.23	0.98	1.09	0.84
September	1.75	1.55	1.46	1.25	1.23	1.03	0.95	0.75
October	3.90	3.75	1.08	0.93	0.96	0.81	0.75	0.59
November	12.20	12.08	6.12	6.00	3.92	3.81	1.04	0.92
December	12.50	12.38	5.57	5.45	4.02	3.90	2.46	2.34

Table 8. Change in the quantity of suitable rearing habitat for salmon and Steelhead relative to the change in river flows with water withdrawal rates between July and October based on Table 6.

			Percent of Maximum Weighted Usable Area (Max WUA)											
			July			August			September			October		
Flow Exceedance	Discharge / Species & Life Stage	Max WUA	Existing	After Water Withdrawal	Change with Water Withdrawal	Existing	After Water Withdrawal	Change with Water Withdrawal	Existing	After Water Withdrawal	Change with Water Withdrawal	Existing	After Water Withdrawal	Change with Water Withdrawal
20%	Discharge (m^3/s)		3.89	3.62	0.27	2.37	2.12	0.25	2.13	1.93	0.20	9.89	9.73	0.15
	Steelhead Summer Parr	13.05	92%	90%	-2%	74%	71%	-4%	71%	67%	-4%	98%	98%	0%
	Steelhead Summer Fry	15.512	60%	63%	3%	86%	90%	4%	90%	93%	3%	19%	19%	0%
	Chinook Summer Fry	16.992	99%	98%	-1%	85%	82%	-4%	82%	78%	-4%	91%	92%	0%
	Coho Summer Fry	18.37	79%	82%	2%	96%	98%	2%	98%	99%	1%	37%	38%	0%
50%	Discharge (m^3/s)		2.09	1.82	0.27	1.72	1.47	0.25	1.75	1.55	0.20	3.90	3.75	0.15
	Steelhead Summer Parr		69%	64%	-4%	62%	54%	-8%	62%	57%	-5%	92%	91%	-1%
	Steelhead Summer Fry		92%	95%	3%	97%	100%	3%	97%	99%	3%	59%	62%	3%
	Chinook Summer Fry		80%	75%	-4%	73%	65%	-8%	73%	68%	-5%	99%	98%	-1%
	Coho Summer Fry		99%	100%	1%	100%	100%	0%	100%	100%	0%	78%	80%	2%
80%	Discharge (m^3/s)		1.38	1.11	0.27	1.32	1.07	0.25	1.46	1.26	0.20	1.08	0.93	0.15
	Steelhead Summer Parr		51%	45%	-6%	51%	42%	-9%	54%	48%	-6%	42%	39%	-3%
	Steelhead Summer Fry		100%	99%	-1%	100%	98%	-2%	100%	100%	0%	98%	98%	0%
	Chinook Summer Fry		61%	55%	-7%	61%	51%	-10%	65%	58%	-6%	51%	47%	-4%
	Coho Summer Fry		99%	97%	-2%	99%	96%	-3%	100%	98%	-1%	96%	95%	-1%
90%	Discharge (m^3/s)		1.26	0.99	0.27	1.23	0.98	0.25	1.23	1.03	0.20	0.96	0.81	0.15
	Steelhead Summer Parr		48%	39%	-10%	48%	39%	-10%	48%	42%	-6%	39%	35%	-4%
	Steelhead Summer Fry		100%	98%	-2%	100%	98%	-2%	100%	98%	-1%	98%	97%	-1%
	Chinook Summer Fry		58%	47%	-11%	58%	47%	-11%	58%	51%	-7%	47%	43%	-4%
	Coho Summer Fry		98%	95%	-3%	98%	95%	-3%	98%	96%	-2%	95%	94%	-2%

5.4 Mitigation Recommendations

5.4.1 Footprint of Intake Infrastructure

Mitigation for the permanent loss of ~63 m^2 of natural channel habitat and ~40 m^2 of riparian habitat as a result of the installation of the intake, weir and stairway could be mitigated by enhancing or creating rearing and overwintering habitats in the lower Englishman River. Rearing and overwintering habitats are often considered critical limiting factors for freshwater life stages of Pacific salmonids. Creation or enhancement of rearing and overwintering habitats in the Englishman River is considered biologically relevant and an appropriate approach to mitigate some of the potential impacts associated with construction of the new water intake structure (M. McCulloch FLNRO pers. comm.). Habitat enhancement / creation options could include strategic placement of large woody debris (LWD) structures in Reach 3, and boulder placements in Reaches 2 and 3. Each option above would have benefits that target different fish species groups and life stages but all options would provide benefits to native salmonid rearing and overwintering habitats in the Englishman River.

5.4.2 Construction Phase

Short term disturbance to fish populations and potential impacts on river water quality (i.e., riparian clearing, bank erosion, sediment mobilization, etc.) as a result of intake construction can be effectively mitigated through established environmental protection procedures that have been endorsed by the regulatory agencies and by site-specific environmental management and erosion and sediment control plans to be developed by ERWS for construction operations. Construction of the intake and weir should occur during the DFO instream work window in the summer months when the river levels are at their lowest and when spawning, egg incubation and fry emergence are not occurring. The work site should be isolated by upstream and downstream cofferdams, and fish should be salvaged from within the isolated work area. The upstream cofferdam should divert the flow around the south side of the large mid-channel bedrock outcropping. The downstream cofferdam should prevent river water from entering the weir and intake construction area. A sump should be dug on the dry side of the cofferdam to allow pumping of subsurface flow and any sediment-laden water to an appropriate settling area, pond or apparatus outside of the wetted perimeter of the river. These plans and procedures will prevent sediment laden waters from the worksite from entering Englishman River.

The disturbance to riparian vegetation should be kept to the absolute minimum required to conduct the works. Riparian vegetation which is damaged or lost as a result of this construction project should be replaced, where appropriate.

5.4.3 Operation and Maintenance Phase

During the operational phase, potential impacts on spawning, incubation and rearing habitat downstream of the intake as a result of a decrease in river discharge after raw river water is extracted can be mitigated by ensuring that releases from Arrowsmith Dam meet, where conditions permit, a minimum maintenance flow in the mainstem immediately downstream of the intake. This minimum maintenance flow target should be high enough to ensure that serious harm to fish that are part of or support a commercial, recreational or Aboriginal fishery, as specified under Section 35 of the Fisheries Act (2012), does not occur.

There is an opportunity to improve the management of Arrowsmith Dam releases to meet water extraction and fish habitat considerations by placing a greater emphasis on the predominant low flow period of August 15 to October 15 (80% occurrence of annual minimum flow in period of record; Table 2). Improvements in the timing and volume of flow releases could mitigate potential impacts to rearing habitats during low flow periods caused by droughts. Kerr Wood Leidal Associates Ltd. (KWL) modeled Englishman River flows based on available water storage at the Arrowsmith Lake reservoir and on proposed water withdrawal rates of 24 and 48 ML/day (as per Table 6) to determine achievable minimum maintenance flow targets downstream of the proposed water intake (Appendix N). Under various drought flow scenarios, KWL determined that minimum maintenance flows of 0.9-1.6 m^3/s can be maintained downstream of the intake with average monthly withdrawals based on a July maximum instantaneous withdrawal of 24 ML/day (Table 9). Minimum flows would be <0.9-1.6 m^3/s for each flow condition with average monthly withdrawals based on a July maximum ADD of 48 ML/day.

Table 9. Minimum maintenance flows downstream of the proposed water intake under various flow conditions in the Englishman River.

Flow Conditions	Target Flow at Hwy 19 (m^3/s)	
	24 ML/day	48 ML/day
1 in 2 yr Drought	1.6	1.6
1 in 5 yr Drought	1.2	0.9
1 in 10 yr Drought	0.9	<0.9
1 in 20 yr Drought	0.9	<0.9

A water extraction regime based on 24 ML/day and management of Arrowsmith Lake reservoir within a revised “rule band” that meets target minimum maintenance flows would maintain lower Englishman River flows during July to October at higher minimum flows than have occurred under existing conditions (Table 2). These minimum maintenance flow provisions would mitigate potential impacts as a result of water withdrawal at 24 ML/day and ensure that all important spawning and rearing sections of the river downstream of the intake remain productive and viable for salmon and trout.

A water extraction regime based on 48 ML/day and management of Arrowsmith Lake reservoir within a revised “rule band” that meets target minimum maintenance flows would maintain lower Englishman River flows during July to October at minimum flows that are similar to existing conditions (Table 9). Minimum average daily flows of 0.67, 0.74, and 0.76 m^3/s have occurred during drought years between 2000 and 2012 (Table 2), and similar flows would be expected at a 48 ML/day extraction regime.

Under these minimum flow scenarios, Coho summer fry, Chinook spring fry and Steelhead fry would be at or near maximum WUA at flows between 0.9 and 1.6 m^3/s (Figure 8). Chinook summer fry and Steelhead parr are the most affected by low summer flows but effects on these two species would be similar to or better than existing conditions if proposed rates of water extraction at the new intake included a revised rule curve for Arrowsmith Reservoir management, as described above. Management of Arrowsmith Reservoir storage and releases is therefore fundamental to ensuring the highest possible maintenance flows occur during the July-October period so that the largest area of suitable salmonid rearing habitats are maintained during this critical fish production period.

The hydrologic modelling completed by KWL indicates that provided storage management operations at Arrowsmith Lake are optimized, the dam has sufficient storage capacity to maintain minimum flows of 0.9 m^3/s for up to the 20-year drought condition downstream of the intake plus provide sufficient flow to meet the 24 ML/day withdrawal rate. However, as withdrawal rates increase over the long term up to 48 ML/day, Arrowsmith Lake does not have sufficient storage to meet both the increased demand as well as a minimum instream flow of 0.9 m^3/s in >5 year droughts. Therefore, in the future, consideration must be given to reducing maximum withdrawal rates through municipal water demand conservation measures and/or through supply from other sources such as groundwater or the proposed aquifer storage and recovery system. Water conservation measures should be considered for drought periods as part of the current water system development as well as to plan for future increased uncertainty in natural inflow to Arrowsmith Lake and Englishman River as a result of climate change and other hydrologic impacts such as land use changes.

Upstream fish passage by juvenile and adult fish should be maintained by providing access around the Obermeyer weir when it is inflated under low flow conditions. A pool and weir fishway to accommodate juvenile and adult salmonids should be constructed on the existing bedrock outcrop in the middle of the channel. The fishway would have a channel width of ~1 m, elevation drops of ~0.10 m between successive weirs, and pools with a minimum water depth of ~0.6 m. Velocities in the fishway at the design flows would accommodate the maximum burst swimming speed of 0.4 m/s for juvenile salmonids. Flows in the fishway will be about 10% of Englishman River flows. The upstream invert of the fishway would be set at an elevation to ensure fish passage is maintained when the pneumatic weir is partially or fully inflated. At this preliminary design stage, the dimensions of the rock outcrop in the middle of the channel are sufficient to construct the fishway. Final dimensions and alignment of the fishway will be developed during the final design stage.

Intake screens should be designed so that when the pumps are operating there is a low approach velocity through the screen. This will minimize potential fish entrainment or impingement on the screen, particularly for juvenile life stages. DFO (1995) states in their 'Freshwater Intake End-of-Pipe Fish Screen Guideline' that the surface area of the screen of the water intake be large enough to ensure the maximum approach velocity during water withdrawal for sub-carangiform fish (trout or salmon) is $\leq$0.11 m/s. This guideline covers small water intakes with a withdrawal rate up to 125 L/s but should be acceptable at the higher withdrawal rates for the proposed intake. A regular maintenance schedule that includes screen cleaning would also help to reduce the likelihood of fish impingement.

Maintenance activities that could occur within the wetted perimeter of the channel can be mitigated by working in the least risk work window, and by following established environmental protection procedures, and site-specific environmental management and erosion and sediment control plans developed by ERWS. Where considerable maintenance work is planned, environmental protection procedures should be similar to those described under Section 4.4.2 Construction Phase. In some cases, site isolation and fish salvage may be required.

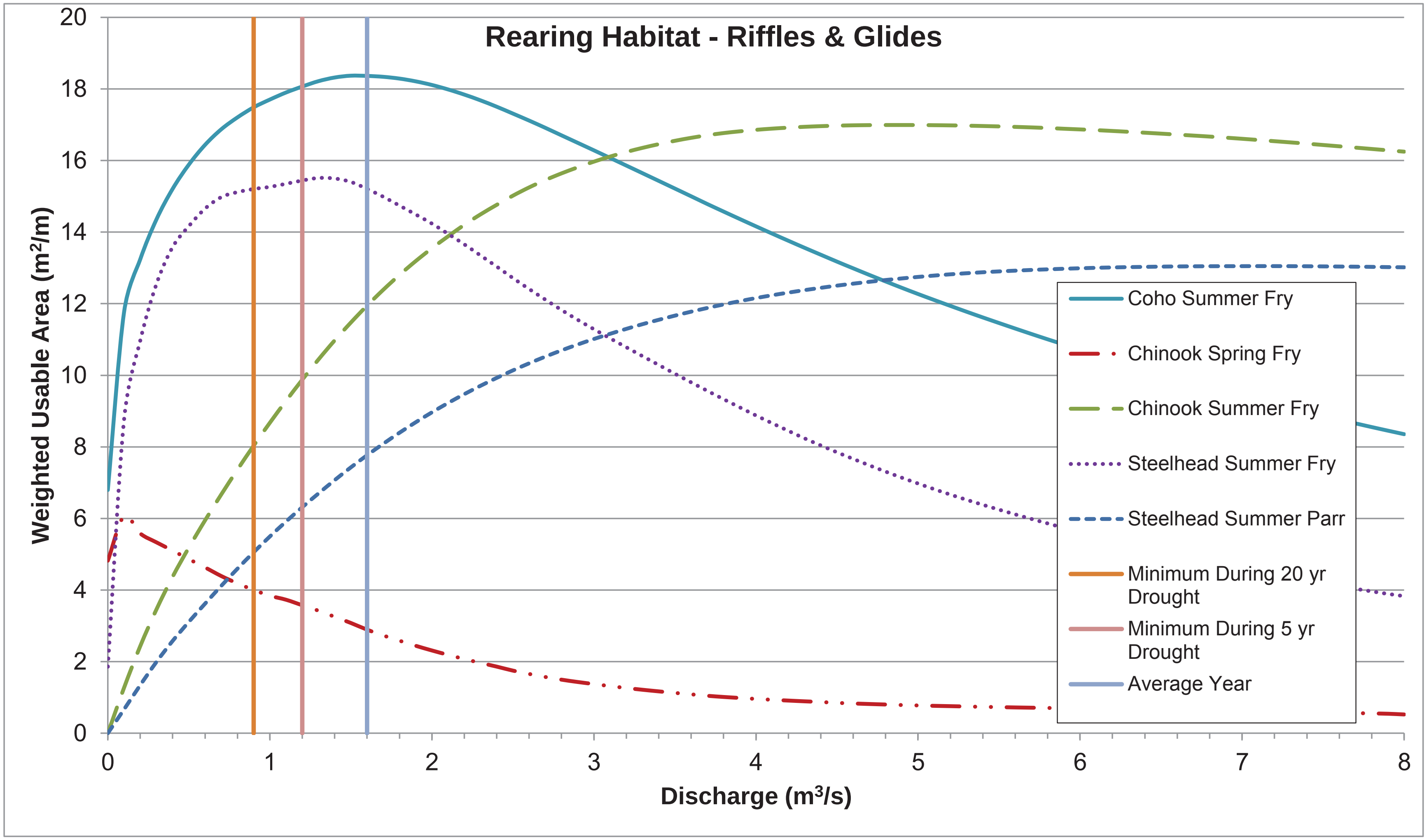


Figure 8. Weighted usable area plots for riffles and glides combined in lower Englishman River based on rearing habitat suitability indices for Steelhead, Chinook and Coho. Minimum maintenance flow targets (0.9-1.6 m^3/s; Table 9) for drought and average flow years are shown.

6.0 Summary and Conclusions

Based on the results of this assessment it is concluded that:

1. The Englishman River supports significant populations of salmon including Chum, Coho, Steelhead, Rainbow Trout, Cutthroat Trout, Chinook, Pink and Sockeye;
2. Summer rearing habitat is considered to be one of the primary limiting factors of Coho, Steelhead, Chinook, Rainbow Trout and Cutthroat Trout production within the watershed due to naturally occurring low summer baseflows;
3. Increased summer baseflows as a result of flow releases from Arrowsmith Lake Dam have greatly improved salmonid rearing habitat, especially in critical habitat identified in Reaches 3 and 4, upstream of the proposed intake structure;
4. River habitat at the intake site is glide habitat that is suitable as rearing habitat for salmonids, but the large cobble and boulder substrate in the glide and riffle immediately downstream of the intake site would limit its utilization by salmonids for spawning;
5. Construction of the intake will result in the loss of about 63 m^2 of river channel habitat and 40 m^2 of riparian habitat;
6. The key concern of water withdrawals at the proposed intake site is the reduction of instream flow in the 2.5 km reach between the proposed intake and the existing intake just downstream of Highway 19a;
7. Upstream migration by juvenile and adult salmon and trout may be impeded at low river discharges when the pneumatic weir is inflated;
8. The water licence for the proposed Englishman River intake allows for up to a maximum average daily flow of 48 ML/day. The initial demand for the new intake and treatment plant is 24 ML/day, which is expected to support municipal demand up to 2035;
9. Compared to current conditions, water withdrawal of 24 ML/day at the proposed intake site would result in a reduction in weighted useable area of up to 8% for Steelhead parr and Chinook summer fry, no change for Coho fry and an increase of up to 3% for Steelhead fry during median summer flow conditions (50% exceeded flow for August);
10. Compared to current conditions, water withdrawal of 24 ML/day at the proposed intake site would result in a reduction of up to 10% for Chinook summer fry, up to 9% for Steelhead parr, up to 3% for Coho fry and up to 2% for Steelhead fry during low summer flow conditions (80% exceeded flow for August or 1 in 5-year drought);
11. Compared to current conditions, water withdrawal of 24 ML/day at the proposed intake site would result in a reduction of up 11% for Chinook summer fry, up to 10% for Steelhead parr, up to 3% for Coho fry and up to

2% for Steelhead fry during very low summer flow conditions (90% exceeded flow for August or 1 in 10-year drought);

12. At water withdrawal rates based on 24 ML/day, the current dam is capable of supporting flows downstream of the intake of 1.6 m^3/s, 1.2 m^3/s and 0.9 m^3/s for the median condition, the low summer flows (up to 5 year drought) and extreme low summer flows (up to 20 year drought), respectively, provided the operating rules for Arrowsmith Lake are adjusted to maximize conservation of storage in the early part of the summer season;
13. At water withdrawal rates based on 48 ML/day, Arrowsmith Lake does not have sufficient storage to meet both the increased demand as well as a minimum instream flow of 0.9 m^3/s in >5 year droughts; and
14. A minimum flow of 0.9 m^3/s downstream of the intake should be considered as the minimum conservation flow to ensure that serious harm to fish does not occur.

Given the potential impacts to fish and fish habitat outlined above, it is recommended that the following mitigation measures be implemented as part of the construction of the proposed ERWS water intake structure:

1. Operating rules for the Arrowsmith Lake dam be adjusted to allow for 1.6 m^3/s in median summer baseflow conditions, 1.2 m^3/s during 5-year drought conditions and 0.9 m^3/s during 10-year drought conditions;
2. A drought management plan be developed by AWS that requires watering restrictions or other water demand reduction measures during periods of drought (5 to 20 year return periods) which will reduce water withdrawals from the river such that a minimum flow of 0.9 m^3/s can be maintained downstream of the intake;
3. Promotion of water conservation measures and implementation of the Aquifer Storage and Recovery system, if proved to be feasible, be carried out to reduce the requirement to increase summer withdrawals from the river beyond the initial maximum daily demand of 24 ML/day;
4. Construction of a bypass fish passage structure to allow upstream migration of juvenile and adult fish when the Obermeyer weir is inflated;
5. Intake screens designed so that when the pumps are operating there is a low approach velocity at the screen, such that velocities are maintained below 0.11 m/s as per DFO guidelines;
6. A regular maintenance schedule should be developed that includes screen cleaning to help to reduce the likelihood of fish impingement on the intake screen;
7. Loss of aquatic and riparian habitat as a result of the construction of the intake should be compensated through habitat enhancement or creation options such as, strategic placement of large woody debris (LWD) structures in Reach 3, boulder placements in Reaches 2 and 3, and replanting of riparian vegetation adjacent to the intake structure; and

8. Best Management Practices for sediment management, water control, spill control and response, and site isolation and fish salvage should be required as part of construction to limit impacts of construction on water quality and habitat.

7.0 References

Bocking, R. and M. Gaboury. 2001. Englishman River Watershed Recovery Plan. Prepared for Pacific Salmon Endowment Fund Society, Vancouver, BC.

CH2M Hill and KWL. 2013. Intake, raw water pump station, and transmission mains, draft technical memorandum 2, 11 December 2013. Prepared for Englishman River Water Service. Prepared by CH2M Hill, Burnaby, BC and Kerr Wood Leidal Associates Ltd., Victoria BC.

DFO. 1995. Freshwater intake end-of-pipe fish screen guideline. Department of Fisheries and Oceans, Ottawa, Ontario.

Gaboury, M. 2005. A strategy for protection and restoration of the Englishman River mainstem. Prepared for the Englishman River Watershed Recovery Plan Community Roundtable and Pacific Salmon Endowment Fund Society.

Jowett, I.G. 1989. River hydraulic and habitat simulation, RHYHABSIM computer manual. New Zealand Fisheries Miscellaneous Report 49, Ministry of Agriculture and Fisheries Management, Christchurch, New Zealand.

Jowett, I.G. 1999. RHYHABSIM software program.

Jowett, I.G. 2006. RHYHABSIM river hydraulics and habitat simulation, software manual, version 4.1.

Jowett, I.G., J.W. Hayes, and M.J. Duncan. 2008. A guide to instream habitat survey methods and analysis. NIWA Science and Technology Series No. 54. 199 p.

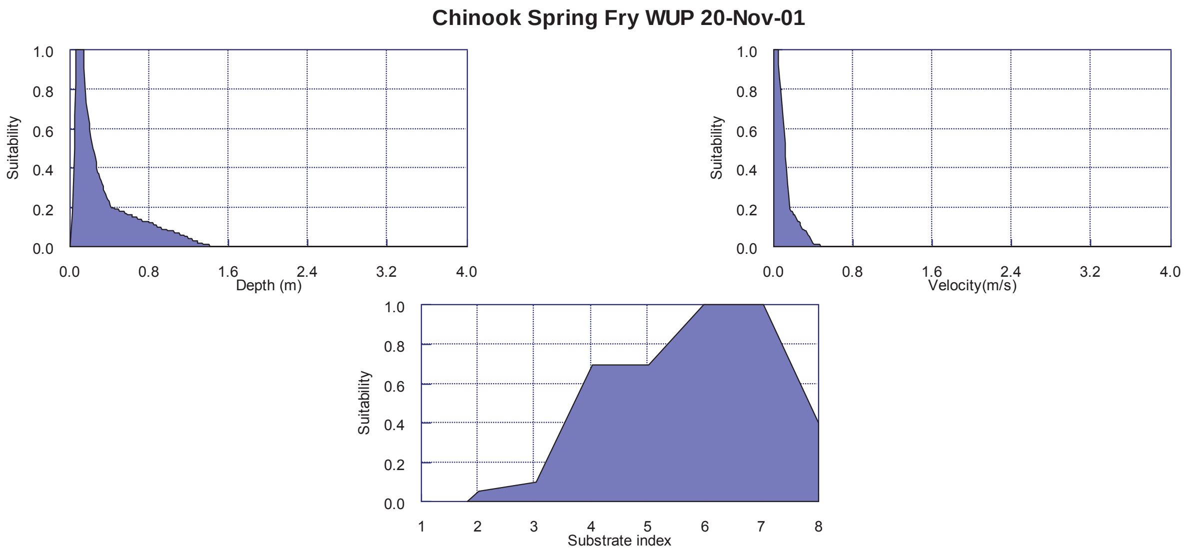
Lough, M.J. and C.F. Morley. 2002. Overview assessment of fish and fish habitat in the Englishman River watershed. Prepared for Pacific Salmon Foundation, funded by Pacific Salmon Endowment Fund Society. pp 28 plus appendices.

Thorn, P. and J. Conallin. 2006. RHYHABSIM as a Stream Management Tool: Case Study in the River Kornerup Catchment, Denmark. The Journal of

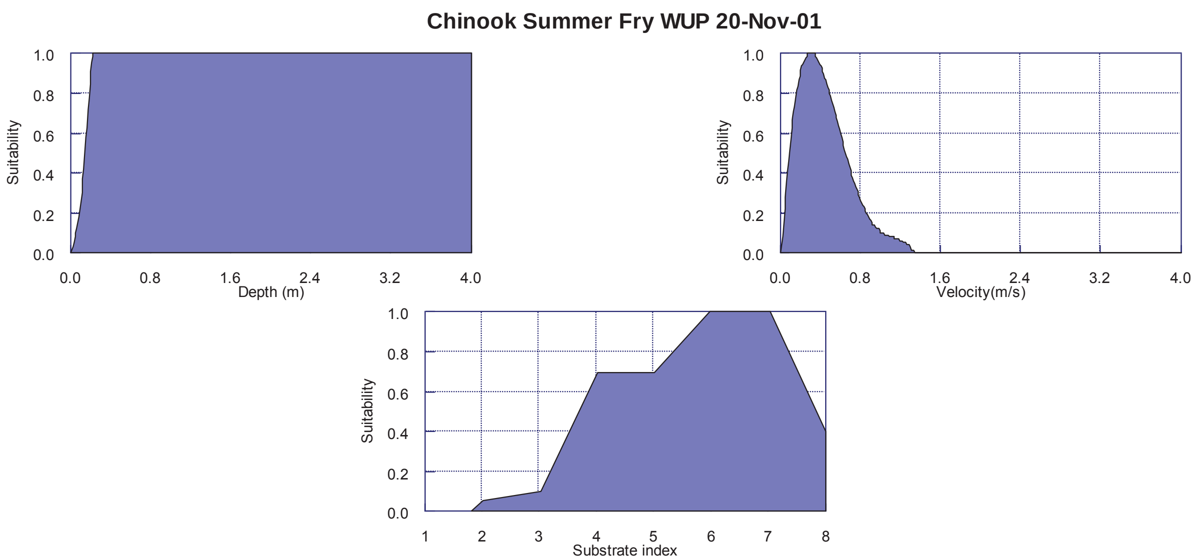
Transdisciplinary Environmental Studies, ISSN vol. 5, no 1-2, 1602 – 2297.

Whyte, I.W., S. Babakaiff, M.A. Adams and P.A. Giroux. 1997. Restoring fish access and rehabilitation of spawning sites. *In* Slaney, P.A. and D. Zaldokas [eds] Fish Habitat Rehabilitation Procedures. British Columbia Ministry of Environment, Lands and Parks, and British Columbia Ministry of Forests, Watershed Restoration Program, Technical Circular No. 9.

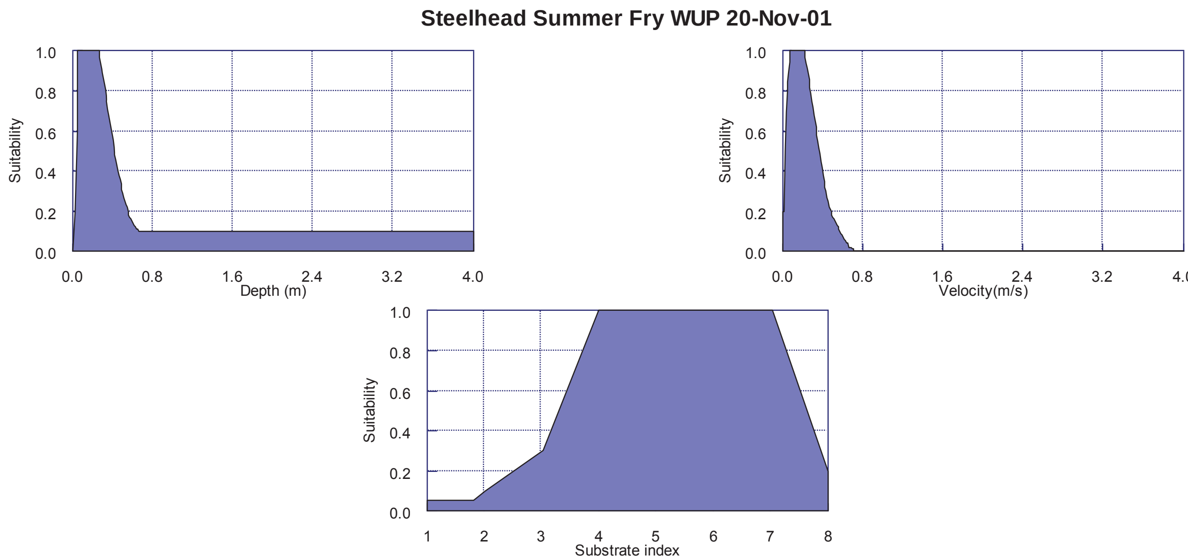
APPENDICES



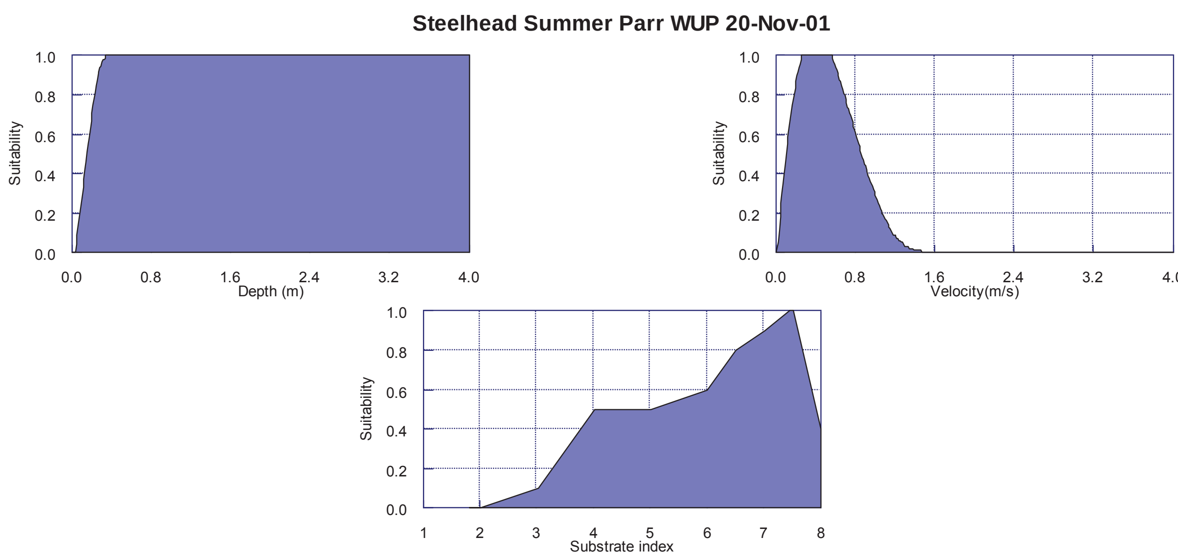
Appendix A. Habitat suitability indices for Chinook – spring fry rearing.



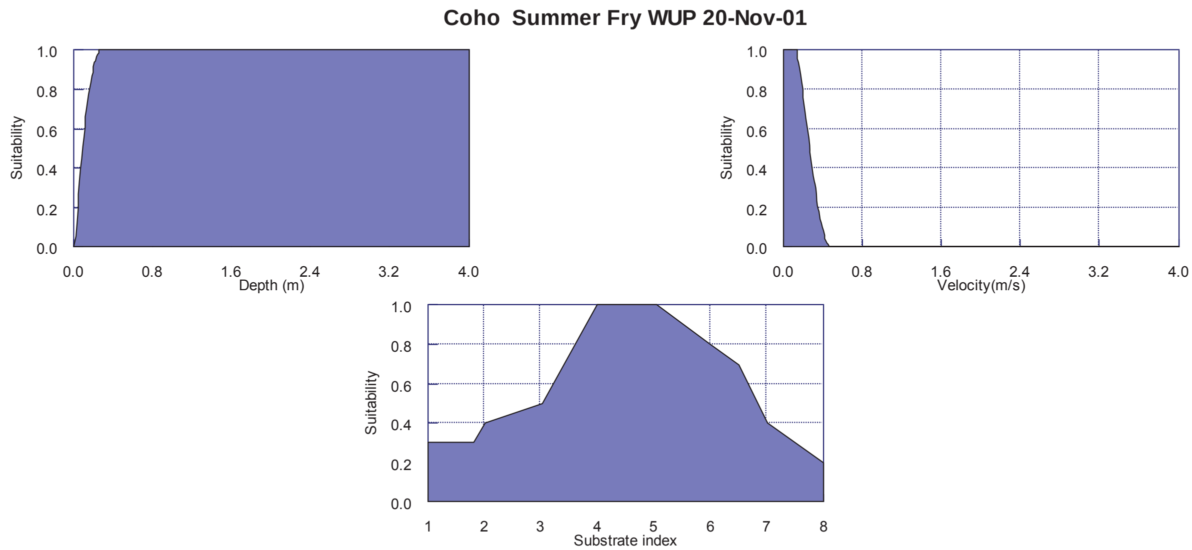
Appendix B. Habitat suitability indices for Chinook – summer fry rearing.



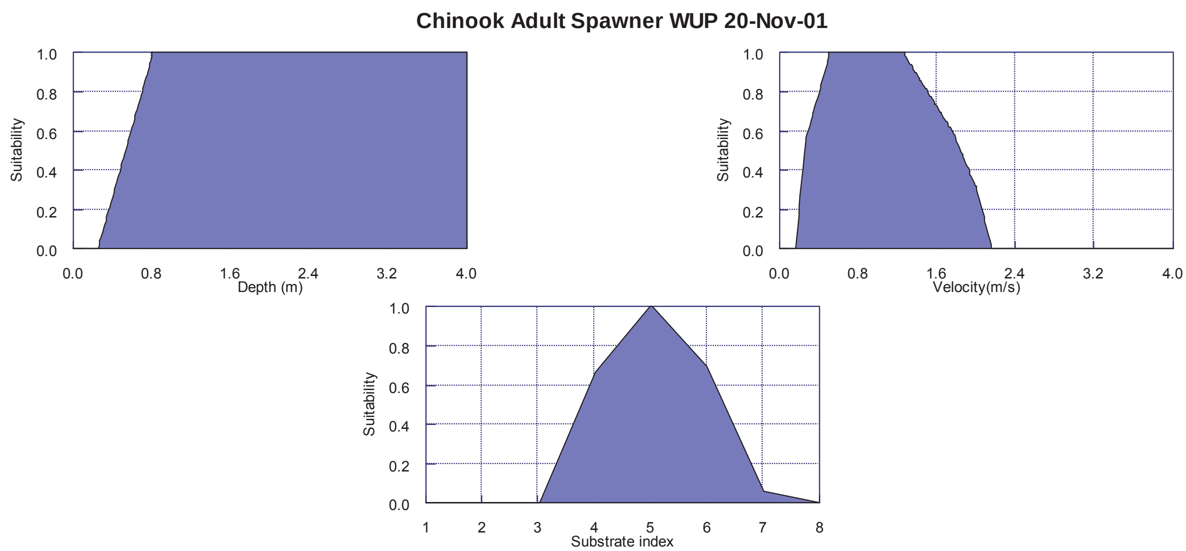
Appendix C. Habitat suitability indices for Steelhead – summer fry rearing.



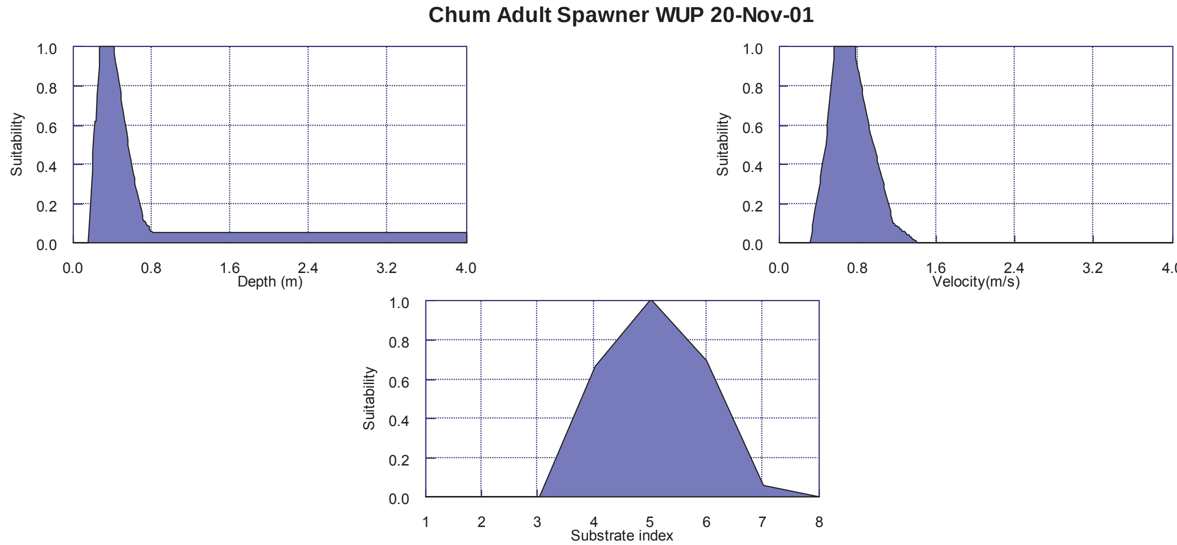
Appendix D. Habitat suitability indices for Steelhead – summer parr rearing.



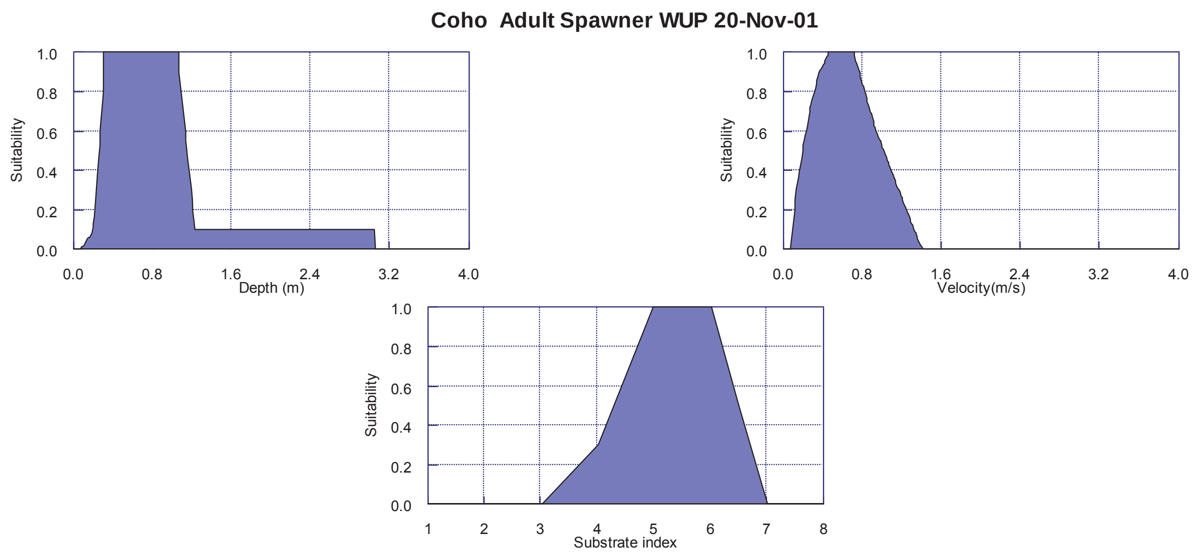
Appendix E. Habitat suitability indices for Coho – summer fry rearing.



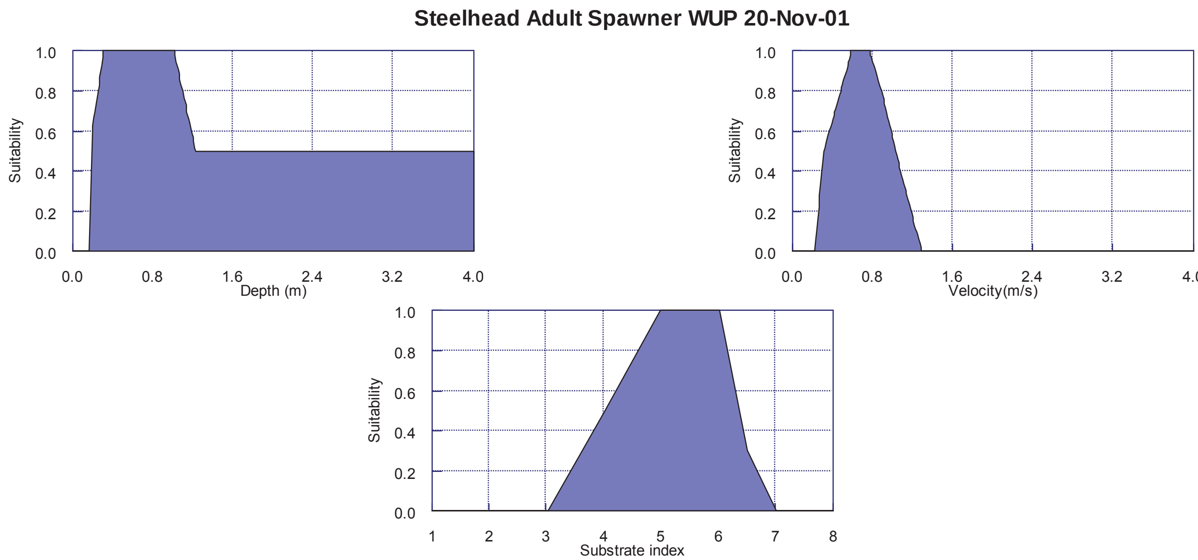
Appendix F. Habitat suitability indices for Chinook – adult spawner.



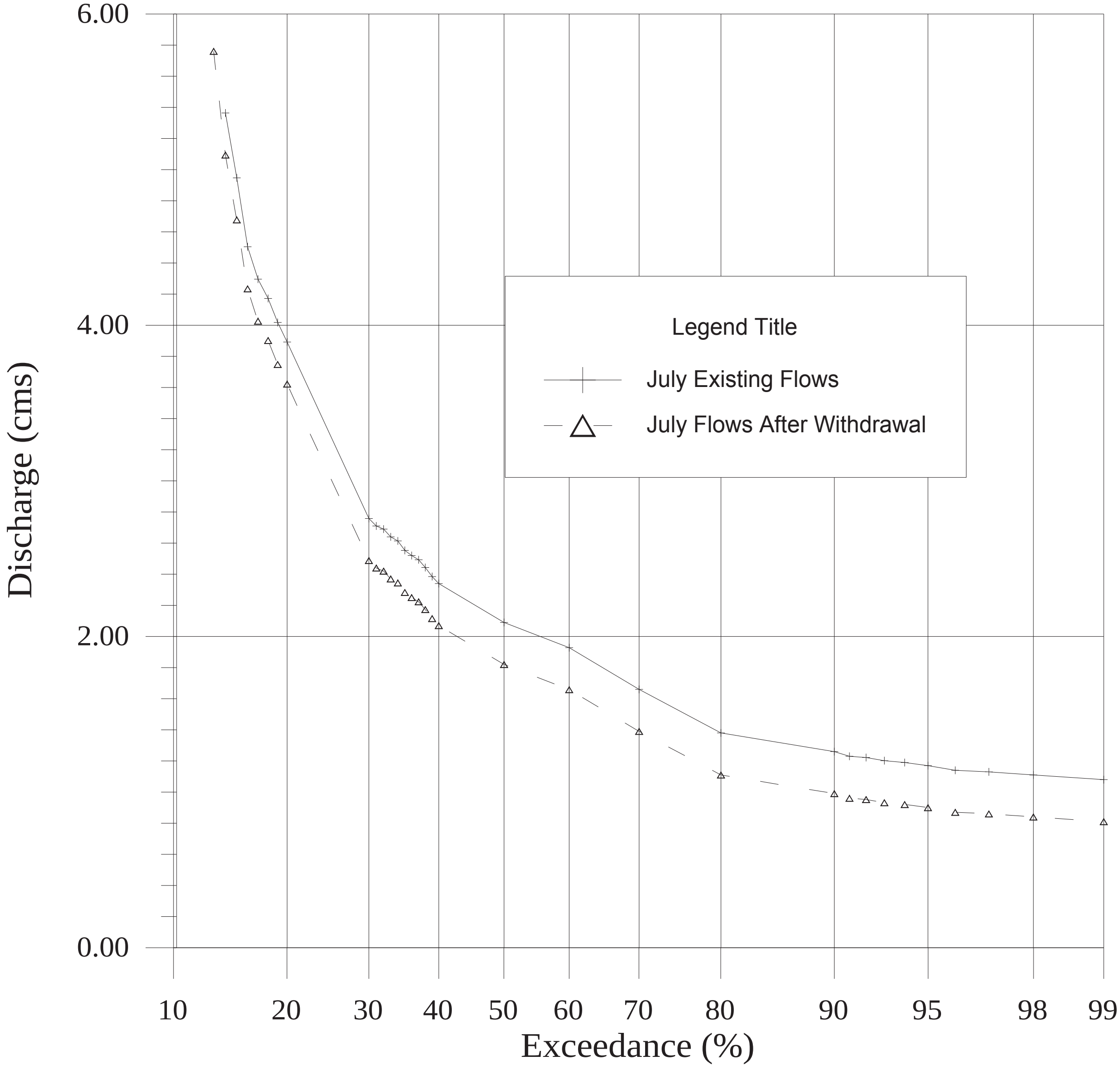
Appendix G. Habitat suitability indices for Chum – adult spawner.



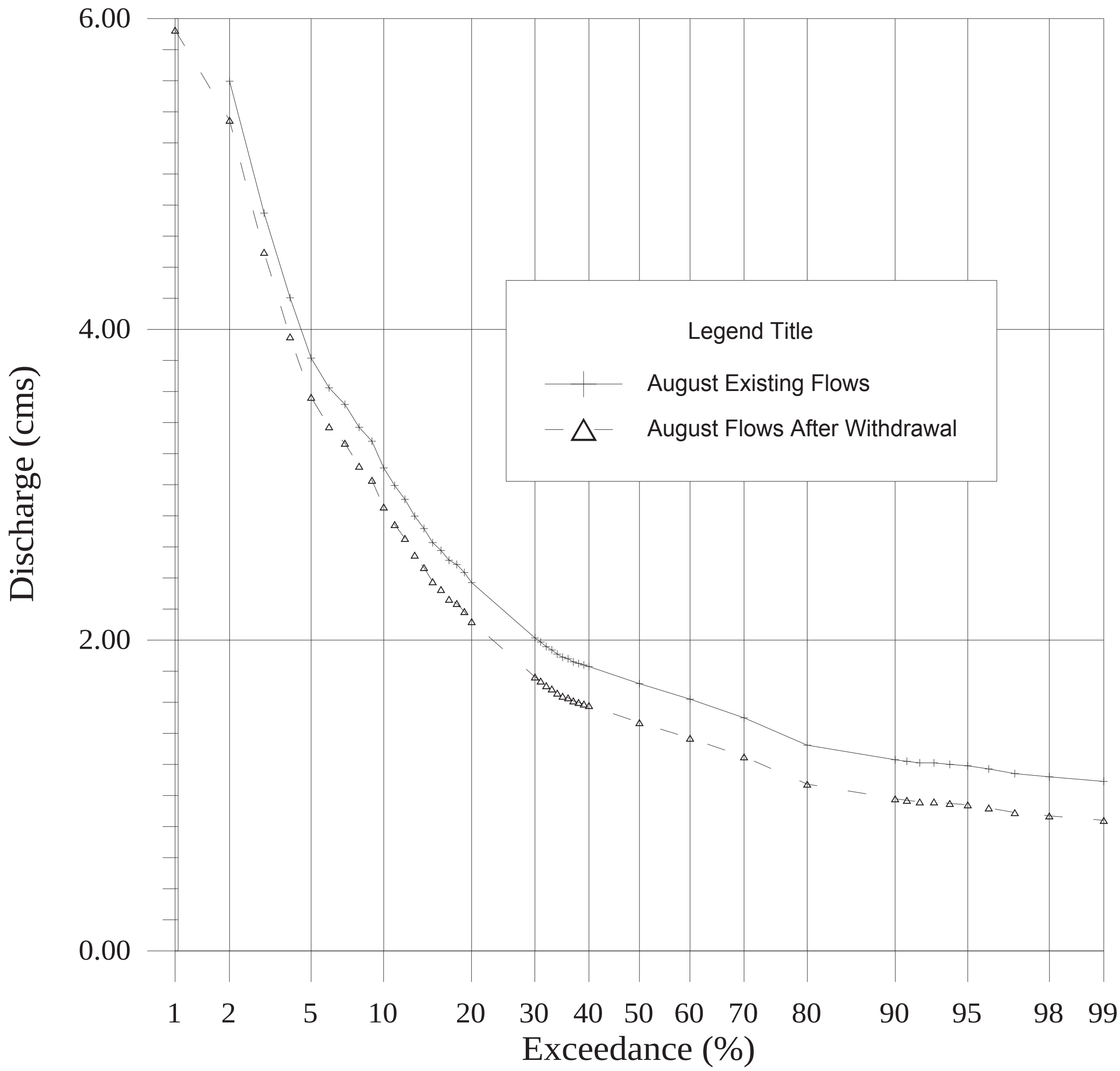
Appendix H. Habitat suitability indices for Coho – adult spawner.



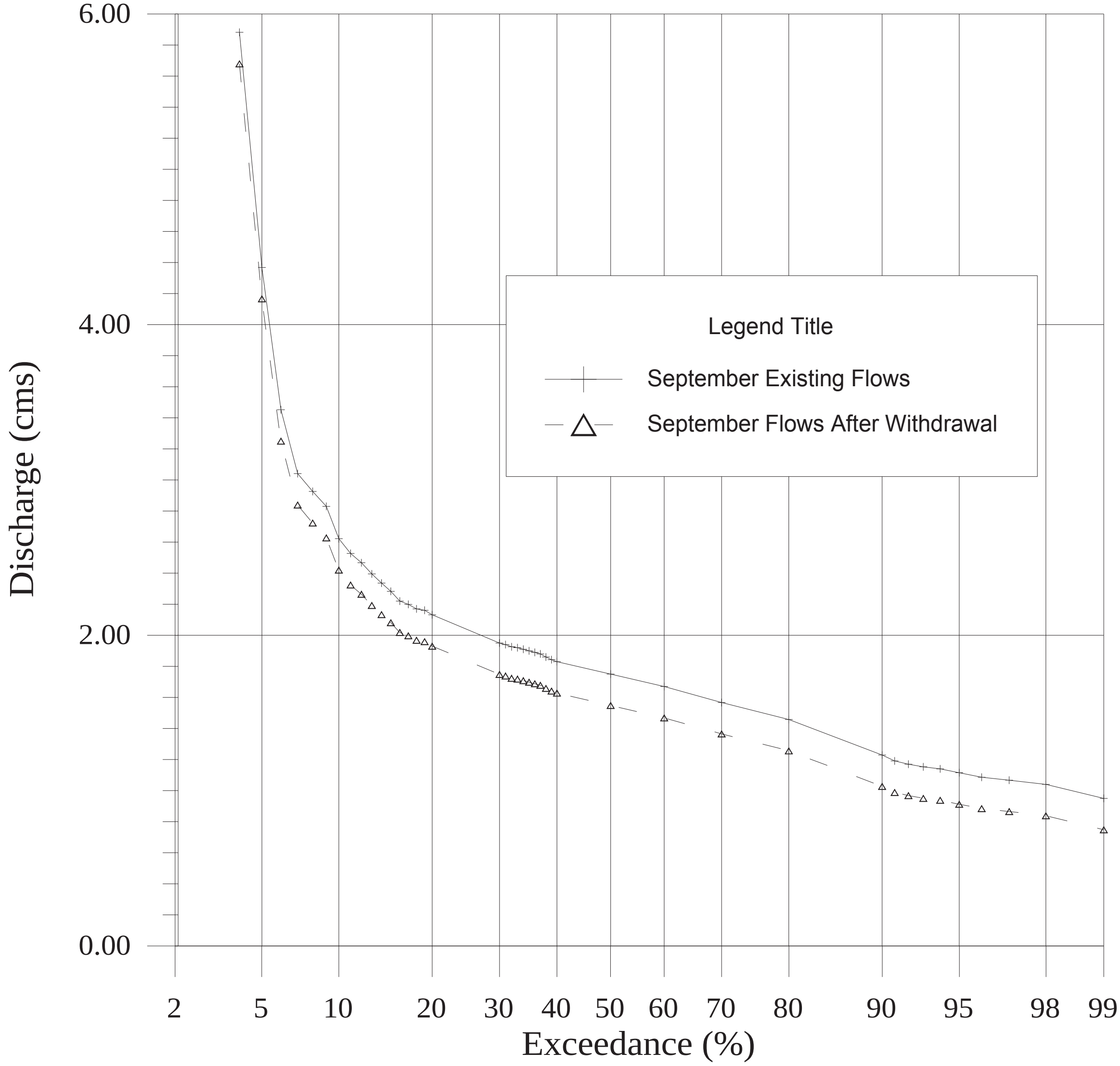
Appendix I. Habitat suitability indices for Steelhead – adult spawner.



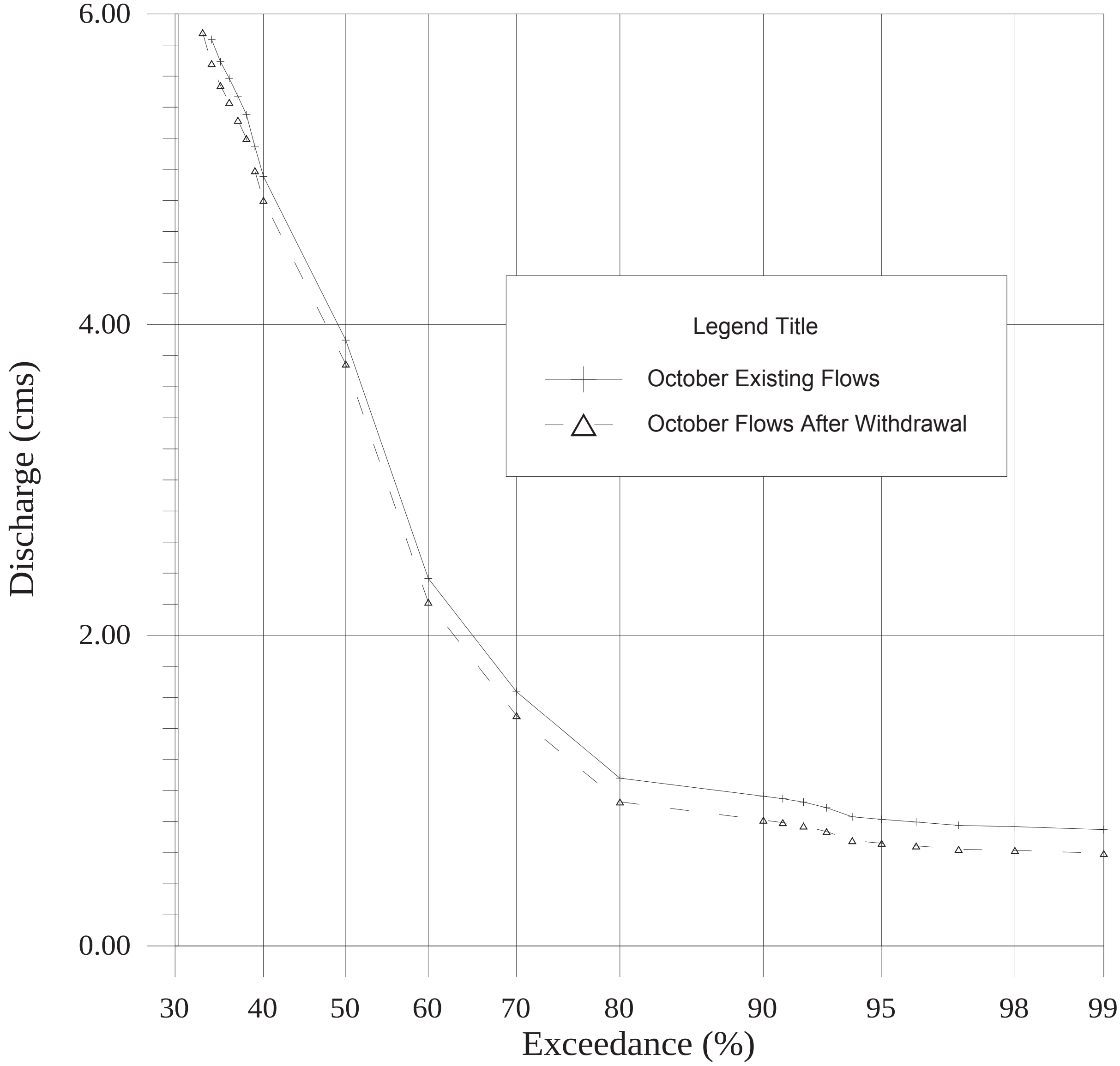
Appendix J. Exceedance curves for July showing flows under existing conditions and after water withdrawal at the WSC gauging station.



Appendix K. Exceedance curves for August showing flows under existing conditions and after water withdrawal at the WSC gauging station.



Appendix L. Exceedance curves for September showing flows under existing conditions and after water withdrawal at the WSC gauging station.



Appendix M. Exceedance curves for October showing flows under existing conditions and after water withdrawal at the WSC gauging station.

Appendix N. Arrowsmith Lake storage assessment to determine feasibility of maintaining conservation flows downstream of the water intake under various drought conditions (KWL January 2014).

Arrowsmith Lake Storage Check - 1:2-Year Return Period Drought Condition

	Required Englishman River Flow, cms						Required Discharge from Arrowsmith Lake - Lake Inflow, cms						Requried Storage m^3	Minimum Lake level to Discharge Desired Flow, m	Available Live Storage, m^3	Storage Shortage, m^3
	Jun	Jul	Aug	Sep	Oct	Nov	Jun	Jul	Aug	Sep	Oct	Nov				
Ph1 + Conservation Flow of 0.9 cms	1.12	1.18	1.16	1.11	1.06	1.02	0.00	0.00	0.23	0.11	0.00	0.00	908,438	802.00	9,000,000	-
Ph1 + Conservation Flow of 1.2 cms	1.42	1.48	1.46	1.41	1.36	1.32	0.00	0.00	0.53	0.41	0.00	0.00	2,489,558	804.11	8,478,333	-
Ph1 + Conservation Flow of 1.4 cms	1.62	1.68	1.66	1.61	1.56	1.52	0.00	0.00	0.73	0.61	0.00	0.00	3,543,638	809.98	7,005,556	-
Ph1 + Conservation Flow of 1.6 cms	1.82	1.88	1.86	1.81	1.76	1.72	0.00	0.00	0.93	0.81	0.00	0.00	4,597,718	810.99	6,704,474	-
Ph2 + Conservation Flow of 0.9 cms	1.34	1.46	1.42	1.32	1.22	1.14	0.00	0.00	0.49	0.32	0.00	0.00	2,140,358	803.15	8,669,333	-
Ph2 + Conservation Flow of 1.2 cms	1.64	1.76	1.72	1.62	1.52	1.44	0.00	0.00	0.79	0.62	0.00	0.00	3,721,478	810.61	6,816,316	-
Ph2 + Conservation Flow of 1.4 cms	1.84	1.96	1.92	1.82	1.72	1.64	0.00	0.00	0.99	0.82	0.00	0.00	4,775,558	811.14	6,658,421	-
Ph2 + Conservation Flow of 1.6 cms	2.04	2.16	2.12	2.02	1.92	1.84	0.00	0.06	1.19	1.02	0.00	0.00	5,978,438	811.72	6,485,172	-

Arrowsmith Lake Storage Check - 1:5-Year Return Period Drought Condition

	Required Englishman River Flow, cms						Required Discharge from Arrowsmith Lake - Lake Inflow, cms						Requried Storage m^3	Minimum Lake level to Discharge Desired Flow, m	Available Live Storage, m^3	Storage Shortage, m^3
	Jun	Jul	Aug	Sep	Oct	Nov	Jun	Jul	Aug	Sep	Oct	Nov				
Ph1 + Conservation Flow of 0.9 cms	1.12	1.18	1.16	1.11	1.06	1.02	0.00	0.00	0.75	0.62	0.00	0.00	3,599,280	810.44	6,866,667	-
Ph1 + Conservation Flow of 1.2 cms	1.42	1.48	1.46	1.41	1.36	1.32	0.00	0.21	1.05	0.92	0.00	0.00	5,736,912	811.29	6,614,474	-
Ph1 + Conservation Flow of 1.4 cms	1.62	1.68	1.66	1.61	1.56	1.52	0.00	0.41	1.25	1.12	0.00	0.00	7,326,672	811.91	6,427,586	899,086
Ph1 + Conservation Flow of 1.6 cms	1.82	1.88	1.86	1.81	1.76	1.72	0.00	0.61	1.45	1.32	0.00	0.00	8,916,432	812.64	6,207,500	2,708,932
Ph2 + Conservation Flow of 0.9 cms	1.34	1.46	1.42	1.32	1.22	1.14	0.00	0.19	1.01	0.82	0.00	0.00	5,328,192	811.18	6,647,368	-
Ph2 + Conservation Flow of 1.2 cms	1.64	1.76	1.72	1.62	1.52	1.44	0.00	0.49	1.31	1.12	0.00	0.00	7,712,832	812.11	6,367,241	1,345,591
Ph2 + Conservation Flow of 1.4 cms	1.84	1.96	1.92	1.82	1.72	1.64	0.00	0.69	1.51	1.32	0.00	0.00	9,302,592	812.93	6,120,000	3,182,592
Ph2 + Conservation Flow of 1.6 cms	2.04	2.16	2.12	2.02	1.92	1.84	0.00	0.89	1.71	1.52	0.00	0.00	10,892,352	814.01	5,796,569	5,095,783

Arrowsmith Lake Storage Check - 1:10-Year Return Period Drought Condition

	Required Englishman River Flow, cms						Required Discharge from Arrowsmith Lake - Lake Inflow, cms						Requried Storage m^3	Minimum Lake level to Discharge Desired Flow, m	Available Live Storage, m^3	Storage Shortage, m^3
	Jun	Jul	Aug	Sep	Oct	Nov	Jun	Jul	Aug	Sep	Oct	Nov				
Ph1 + Conservation Flow of 0.9 cms	1.12	1.18	1.16	1.11	1.06	1.02	0.00	0.18	0.92	0.76	0.00	0.00	4,912,224	810.96	6,713,158	-
Ph1 + Conservation Flow of 1.2 cms	1.42	1.48	1.46	1.41	1.36	1.32	0.00	0.48	1.22	1.06	0.04	0.00	7,399,536	811.82	6,453,448	946,088
Ph1 + Conservation Flow of 1.4 cms	1.62	1.68	1.66	1.61	1.56	1.52	0.00	0.68	1.42	1.26	0.24	0.00	9,524,976	812.52	6,245,000	3,279,976
Ph1 + Conservation Flow of 1.6 cms	1.82	1.88	1.86	1.81	1.76	1.72	0.00	0.88	1.62	1.46	0.44	0.00	11,650,416	813.52	5,944,118	5,706,298
Ph2 + Conservation Flow of 0.9 cms	1.34	1.46	1.42	1.32	1.22	1.14	0.00	0.46	1.18	0.97	0.00	0.00	6,888,144	811.68	6,496,552	391,592
Ph2 + Conservation Flow of 1.2 cms	1.64	1.76	1.72	1.62	1.52	1.44	0.00	0.76	1.48	1.27	0.20	0.00	9,799,536	812.81	6,157,500	3,642,036
Ph2 + Conservation Flow of 1.4 cms	1.84	1.96	1.92	1.82	1.72	1.64	0.00	0.96	1.68	1.47	0.40	0.00	11,924,976	813.86	5,841,176	6,083,800
Ph2 + Conservation Flow of 1.6 cms	2.04	2.16	2.12	2.02	1.92	1.84	0.00	1.16	1.88	1.67	0.60	0.00	14,050,416	815.07	5,424,479	8,625,937

Arrowsmith Lake Storage Check - 1:20-Year Return Period Drought Condition

	Required Englishman River Flow, cms						Required Discharge from Arrowsmith Lake - Lake Inflow, cms						Requried Storage m^3	Minimum Lake level to Discharge Desired Flow, m	Available Live Storage, m^3	Storage Shortage, m^3
	Jun	Jul	Aug	Sep	Oct	Nov	Jun	Jul	Aug	Sep	Oct	Nov				
Ph1 + Conservation Flow of 0.9 cms	1.12	1.18	1.16	1.11	1.06	1.02	0.00	0.34	1.02	0.84	0.30	0.00	6,625,565	811.21	6,637,368	-
Ph1 + Conservation Flow of 1.2 cms	1.42	1.48	1.46	1.41	1.36	1.32	0.00	0.64	1.32	1.14	0.60	0.00	9,813,725	812.15	6,354,138	3,459,587
Ph1 + Conservation Flow of 1.4 cms	1.62	1.68	1.66	1.61	1.56	1.52	0.00	0.84	1.52	1.34	0.80	0.00	11,939,165	813.00	6,101,000	5,838,165
Ph1 + Conservation Flow of 1.6 cms	1.82	1.88	1.86	1.81	1.76	1.72	0.00	1.04	1.72	1.54	1.00	0.00	14,064,605	814.08	5,770,490	8,294,115
Ph2 + Conservation Flow of 0.9 cms	1.34	1.46	1.42	1.32	1.22	1.14	0.00	0.62	1.28	1.05	0.46	0.00	9,025,565	812.01	6,397,241	2,628,323
Ph2 + Conservation Flow of 1.2 cms	1.64	1.76	1.72	1.62	1.52	1.44	0.00	0.92	1.58	1.35	0.76	0.00	12,213,725	813.29	6,013,500	6,200,225
Ph2 + Conservation Flow of 1.4 cms	1.84	1.96	1.92	1.82	1.72	1.64	0.00	1.12	1.78	1.55	0.96	0.00	14,339,165	814.43	5,650,392	8,688,773
Ph2 + Conservation Flow of 1.6 cms	2.04	2.16	2.12	2.02	1.92	1.84	0.00	1.32	1.98	1.75	1.16	0.00	16,464,605	815.70	5,205,833	11,258,771

Note:
Ph1 - Phase 1 Water Withdrawls - 24 ML/day
Ph2 - Phase 2 Water Withdrawls - 48 ML/day
Assessment based on recorded daily flows from 1913 to 1917 and 1970 to 2013 (Recorded flows after construciton of dam in 1999 have been "naturalized" to account for Arrowsmith Lake storage and releases)

PHOTOS

Photo 1. Looking upstream at proposed water intake site on right bank of river.

Photo 2. Looking downstream from proposed water intake site.

Photo 3. Looking downstream at riffle habitat near Inland Island Highway crossing.

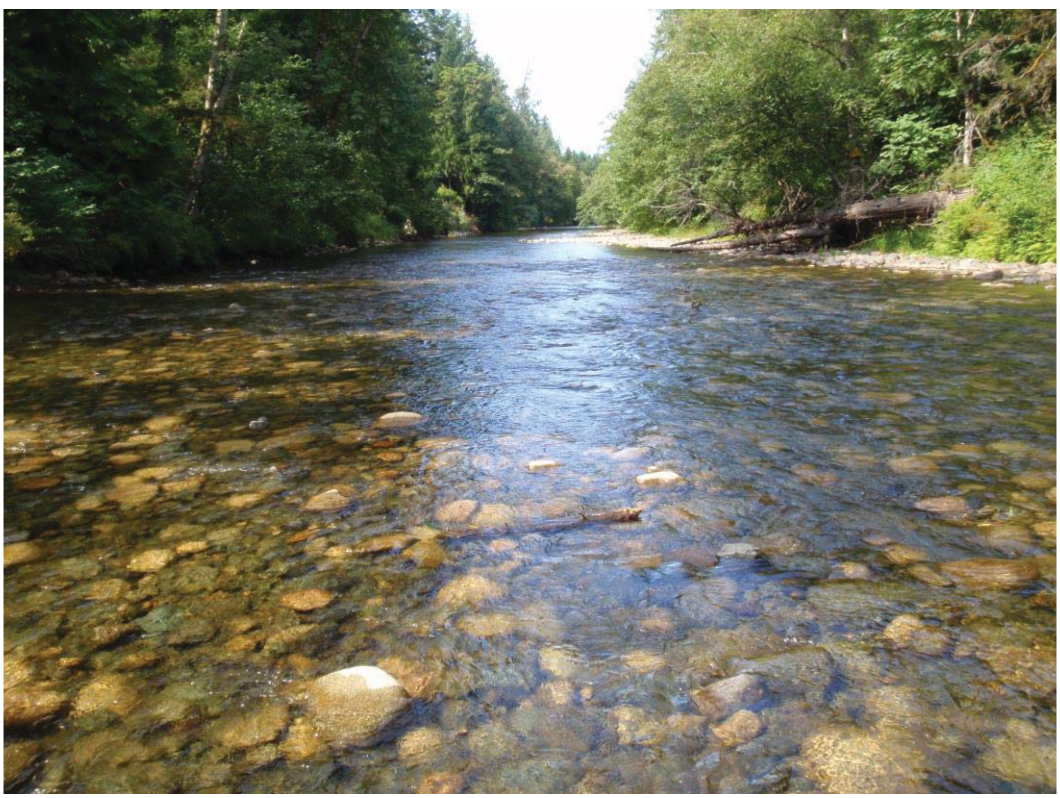


Photo 4. Looking downstream at riffle habitat downstream of Island Corridor Railway crossing.

Photo 5. Looking downstream at glide habitat downstream of Island Corridor Railway crossing.

Photo 6. Looking downstream at glide habitat near middle of survey section.

Photo 7. Looking downstream at pool habitat near middle of survey section.

Photo 8. Looking downstream at riffle habitat near middle of survey section.

Photo 9. Looking downstream at pool habitat immediately upstream of Island Highway 19A crossing.

Photo 10. Looking downstream at riffle habitat downstream of Island Highway 19A crossing.

Photo 11. Looking downstream at glide habitat in section below Island Highway 19A.

Photo 12. Looking upstream at riffle habitat near downstream end of survey section.