EA3330

FISH PASSAGE DESIGN FOR UNNAMED CREEK

***Prepared by*:**

M.N. Gaboury
LGL Limited environmental research associates
9768 Second Street
Sidney, BC V8L 3Y8

***Prepared for*:**

BC Hydro
Fish and Wildlife Compensation Program – Peace Region
1011 - 4th Ave (3rd floor),
Prince George, BC V2L 3H9

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1 INTRODUCTION

Fish passage in Unnamed Creek is obstructed by the culvert crossing on 12 Mile Road (Road 190) (A. Langston, BC Hydro Fish and Wildlife Compensation Program - Peace Region pers. comm.). Fish species of interest in Unnamed Creek include rainbow trout (*Oncorhynchus mykiss*) and kokanee (*Oncorhynchus nerka*). The goal of this project was to develop a detailed treatment prescription that provided fish passage for the species and life stages of interest at Unnamed Creek. The design has been prepared for implementation by a construction contractor experienced in working instream, constructing full-spanning rock weirs and installing culvert baffles. This report describes a fish passage design for this priority culvert, including construction drawings, material specifications and quantities and an itemized breakdown of estimated construction costs.

2 STUDY AREA

Unnamed Creek is located within Butler Ridge Provincial Park, ~37 km northwest of Hudson's Hope, BC. Unnamed is a 4^{th} order (at 1:20,000 scale) stream with a drainage area of 23.22 km^2 (Figure 1). The creek enters Dunlevy Inlet of Williston Reservoir ~20 km northwest of the W.A.C. Bennett Dam.

3 METHODS

3.1 Hydrology

Mean annual, mean monthly and 2, 10, 25, 50 and 100 year return period maximum discharges were estimated for the project stream based on hydrometric data from Water Survey of Canada (WSC) stations within the Peace River area. Estimated flood frequency values for this smaller stream were based on an analysis of average unit values for the regional stations at Dawson Creek (07FD015), Flatbed Creek (07FB009), Dickebusch Creek (07FB004), Quality Creek (07FB005), Sukunka River (07FB007) and Windrem Creek (07FB011).

The estimates of maximum daily peak discharges for the various flood frequencies were determined using HydroTech analysis system, developed by Science Technology Associates (Anonymous 1997). The drainage area of Unnamed Creek was determined using ArcView GIS.

3.2 Fish Passage Design Methodology

Detailed site surveys, and the preparation of rehabilitation design drawings adhered to the BC Ministry of Environment's Activity Standards Document that describes: Strategic Resource Planning for the Development of Watershed Enhancement Plans, and Enhancement and Rehabilitation procedures for instream structures and treatments: http://www.env.gov.bc.ca/wld/documents/fia_docs/aquatic_rest_standard_s.pdf.

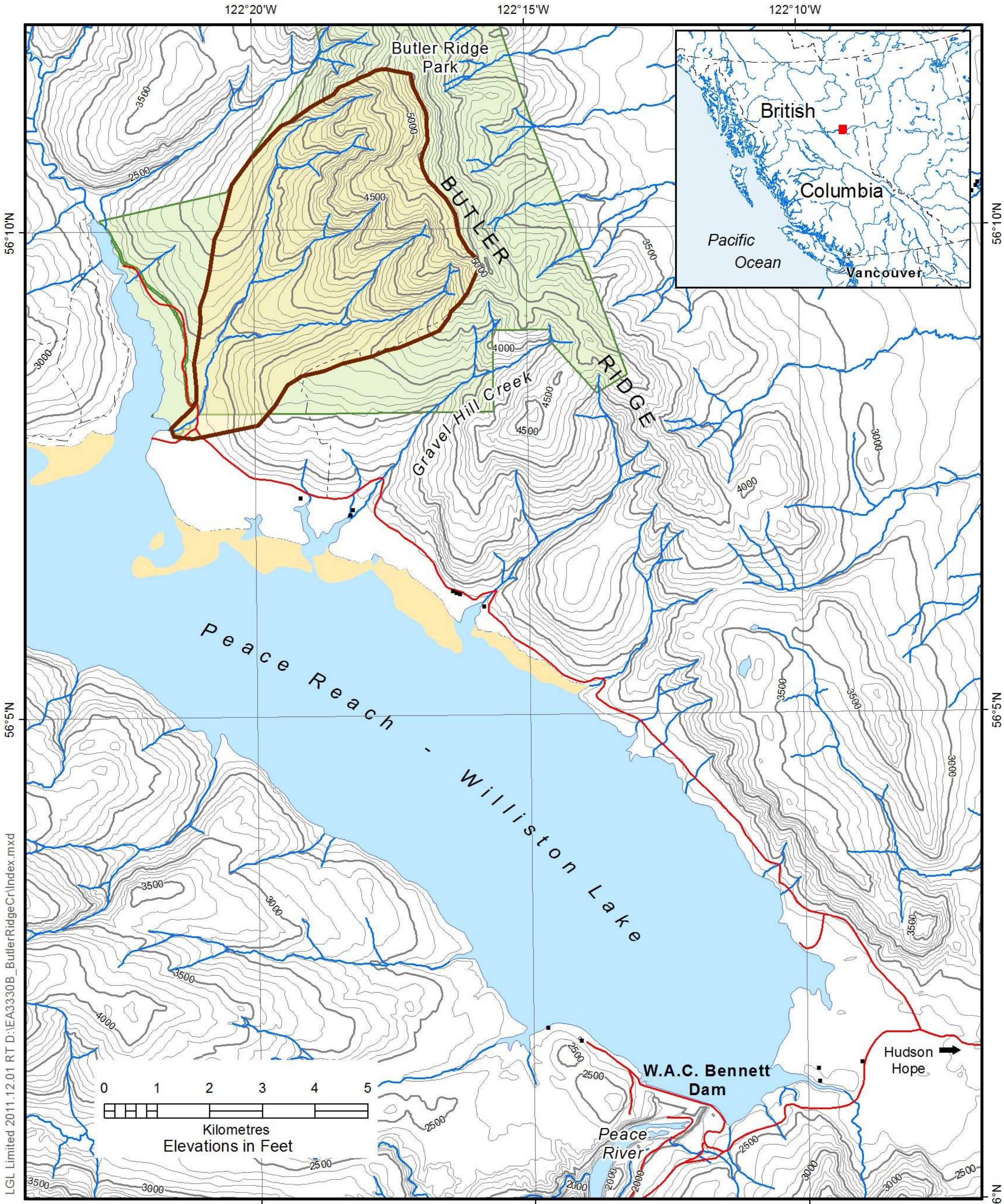


Figure 1. Index map of Unnamed Creek.

The rehabilitation design methodology involved the following steps:

1. *Conducting a field survey of the fish passage obstruction area.*

A field survey to assess the fish passage obstruction was conducted 9 August 2011. Field information collected at the Unnamed Creek culvert crossing area included:

- Topographic (engineer's level) surveys of the stream channel and floodplain near the culvert to provide plan, profile and cross section elevation drawings for the section of channel and culvert to be modified to provide fish passage, and
- Photographs of the project site, labeled with D/M/Y, Geographic Position System (GPS) location in Lat/Long or UTM coordinates, and point of view.

2. *Preparing a site-specific fish passage design.*

The Unnamed Creek fish passage design drawings included:

- Existing and proposed rehabilitation profiles of the channel, floodplain and culvert,
- Cross section plots of specific project site locations with rehabilitation project details overlain on the cross sectional plot (Note: left and right banks as viewed looking downstream),
- Methods for design, including design criteria, assumptions and calculations,
- Methods, specifications and scheduling for construction, and
- Estimated construction costs for the rehabilitation project.

Manning's equation was used to estimate culvert capacity with and without baffles at 50 and 100 yr return period maximum daily discharges. Roughness values used in Manning's equation calculations included: 0.026 for calculating capacity discharges in a round, corrugated culvert; 0.035 for calculating capacity discharges in a round, corrugated culvert with baffles; and 0.050 for baffled culvert at discharges $\leq$10 yr return period flows. Slope and culvert diameter values in the equation were based on field measurements obtained during this project.

4 REHABILITATION DESIGN

4.1 Hydrology

Discharges in the Unnamed Creek have not been monitored on a continual basis by Water Survey of Canada (WSC). Typically, mean monthly flows in these Peace watersheds begin to rise in March-April in response to snow melt, peak in mid-May, and steadily decline to baseflow conditions in July through February.

Based on HydroTech software analyses, average two-year and 100-year maximum daily unit discharges for gauged watersheds of <120 km^2 were estimated at 63 and 1400 l/sec/km^2, respectively (Table 1). The average unit flood discharge (daily max) with a return period of 50 yr was calculated at 885 l/s/km^2 for those hydrometric stations with less than 120 km^2 but averaged 632 l/s/km^2 with a range between 286 and 1516 l/s/km^2 for all the hydrometric stations. The 50 yr flood in Unnamed Creek was an estimated at 20.5 m^3/s using a value of 885 l/s/km^2.

Mean monthly discharges for May and June were estimated at 0.32 and 0.27 m^3/s, respectively, and for September the mean flow was estimated at 0.05 m^3/s (Table 1).

4.2 Fish Passage Design Criteria

For the goal of providing consistent access during the open water period into Unnamed Creek, the species of interest was primarily rainbow trout and secondarily kokanee. Swimming speeds for rainbow trout and sockeye (kokanee is a land-locked form of anadromous sockeye) that would allow fish passage through culverts over 24 m in length range from 0.1-0.4 m/s for juveniles up to 0.4-0.9 m/s for adults (Table 2; Whyte et al. 1997). A preferred method of determining fish swimming speeds for specific culverts, where distance between resting pools is known, is based on fish length and swimming distance (Figure 2; Katapodis 1993). For culverts without baffles, water velocities would need to be less than the prolonged swimming speed of the target fish species. For culverts with baffles, fish should be able to burst over the notch in the baffle and rest in the backwater and velocity shadow created by the baffles. For example, swimming speeds of 1.5 m/s could be maintained by trout of 25 cm length over a swimming distance of about 1 m, while prolonged swimming speeds of 1 m/s could be maintained by trout of 25 cm length over a swimming distance of about 2 m (Figure 2). Smaller trout of about 200 mm could burst at 1.2 m/s for 1 m and at a prolonged speed of 0.9 m/s over a swimming distance of about 2 m.

Minimum water depths in the baffled culverts should be based on the fish being completely submerged in the flow to maximize thrust from body and tail movements. Consequently, minimum depths for migration through the culvert should be ~0.23 m (Whyte et al. 1997).

The fish passage criteria that guided the preparation of this design were:

1. Upstream fish passage for juvenile trout required primarily during spring and early summer when access to rearing habitat is desirable;
2. Upstream fish passage to access spawning habitat required by adult kokanee primarily in September and for adult rainbow trout in May-June;
3. Average culvert velocities in the baffled culverts at the time of fish migration should not exceed the burst swimming speed of the target fish species;
4. Near boundary water velocities in the baffled culvert should allow for fish to migrate upstream between baffles at a prolonged swimming speed; and
5. Minimum flow depth of ~0.20 m between baffles in the culvert during fish migration periods.

Table 1. Summary of annual maximum daily peak and mean monthly discharges for Peace River area streams and discharge estimates for Unnamed Creek.

Gauge	Station Name	Years	No. of Years	Area (km^2)	Unit Discharge ($l/s/km^2$) Mean Annual	2 yr	10 yr	25 yr	50 yr	100 yr	Max	Average Monthly Discharge ($l/s/km^2$) January	February	March	April	May	June	July	August	September	October	November	December
07FD015	Dawson Ck. above S. Dawson Ck.*	1981-1995	15	116	9	32	219	380	521	674	309	5.2	4.3	76.7	11.2	1.7	3.4	2.6	0.9	0.0	0.0	0.0	6.9
07FB009	Flatbed Ck. at KM 110 Heritage Highway	1982-2005	24	486	9	84	223	349	479	649	494	1.2	1.0	1.4	10.1	29.8	24.1	15.4	7.4	6.4	4.5	3.1	1.6
07FB004	Dickebusch Ck. near the mouth*	1978-2005	28	82	7	88	429	897	1516	2511	1390	0.0	0.0	1.2	7.3	23.2	20.7	17.1	7.3	4.9	3.7	1.2	1.2
07FB005	Quality Ck. near the mouth*	1978-2001	24	30	6	82	217	295	355	417	307	0.0	0.0	0.0	10.0	16.7	13.3	13.3	6.7	3.3	3.3	3.3	0.0
07FB007	Sukunka R. above Chamberlain Ck.	1977-1985	9	927	37	212	282	286	286	287	287	4.0	3.2	3.6	14.2	80.4	82.8	39.2	14.2	23.4	22.7	16.1	5.7
07FB011	Windrem Creek near Chetwynd*	1986-1998	12	23	7	51	287	644	1146	1996	935	26.1	21.7	4.3	8.7	13.0	8.7	4.3	8.7	0.0	0.0	4.3	34.8
	Mean of All Gauges				14	100	274	442	632	908	557	1.6	1.3	19.8	9.7	17.8	15.4	12.1	5.6	3.6	2.9	1.9	2.4
	Mean of * Stations Above			<120	7	63	288	554	885	1400	735	7.8	6.5	20.6	9.3	13.7	11.6	9.3	5.9	2.1	1.7	2.2	10.7
Gauge	Station Name	Years	No. of Years	Area (km^2)	Discharge (m^3/s) Mean Annual	2 yr	10 yr	25 yr	50 yr	100 yr	Max	Average Monthly Discharge (m^3/s) January	February	March	April	May	June	July	August	September	October	November	December
07FD015	Dawson Ck. above S. Dawson Ck.*	1981-1995	15	116	1.1	3.7	25.4	44.1	60.5	78.2	35.8	0.6	0.5	8.9	1.3	0.2	0.4	0.3	0.1	0.0	0.0	0.0	0.8
07FB009	Flatbed Ck. at KM 110 Heritage Highway	1982-2005	24	486	4.3	40.9	108.5	169.8	233.0	315.6	240.0	0.6	0.5	0.7	4.9	14.5	11.7	7.5	3.6	3.1	2.2	1.5	0.8
07FB004	Dickebusch Ck. near the mouth*	1978-2005	28	82	0.6	7.2	35.2	73.6	124.3	205.9	114.0	0.0	0.0	0.1	0.6	1.9	1.7	1.4	0.6	0.4	0.3	0.1	0.1
07FB005	Quality Ck. near the mouth*	1978-2001	24	30	0.2	2.5	6.5	8.9	10.7	12.5	9.2	0.0	0.0	0.0	0.3	0.5	0.4	0.4	0.2	0.1	0.1	0.1	0.0
07FB007	Sukunka R. above Chamberlain Ck.	1977-1985	9	927	34.1	196.5	261.4	264.9	265.6	265.7	266.0	3.7	3.0	3.3	13.2	74.5	76.8	36.3	13.2	21.7	21.0	14.9	5.3
07FB011	Windrem Creek near Chetwynd*	1986-1998	12	23	0.2	1.2	6.6	14.8	26.4	45.9	21.5	0.6	0.5	0.1	0.2	0.3	0.2	0.1	0.2	0.0	0.0	0.1	0.8
Estimate for Unnamed Creek (based on * stations)				23.22	0.20	1.5	6.7	12.9	20.5	32.5		0.18	0.15	0.48	0.22	0.32	0.27	0.22	0.14	0.05	0.04	0.05	0.25

Table 2. Swimming speeds for rainbow trout and sockeye (Whyte et al. 1997).

Species and Life Stage		Sustained Speed* (m/s)	Prolonged Speed* (m/s)	Burst Speed* (m/s)
Rainbow Trout	Adults	0.9	1.8	4.3
	Juveniles (125 mm)	0.4	0.7	1.1
	Juveniles (50 mm)	0.1	0.3	0.4
Sockeye	Adults	1.0	3.1	6.3
	Juveniles (130 mm)	0.5	0.7	-
	Juveniles (50 mm)	0.2	0.4	0.6

* Sustained speed - can be maintained indefinitely
Prolonged speed - can be maintained for up to 200 minutes
Burst speed - can be maintained for up to 165 seconds

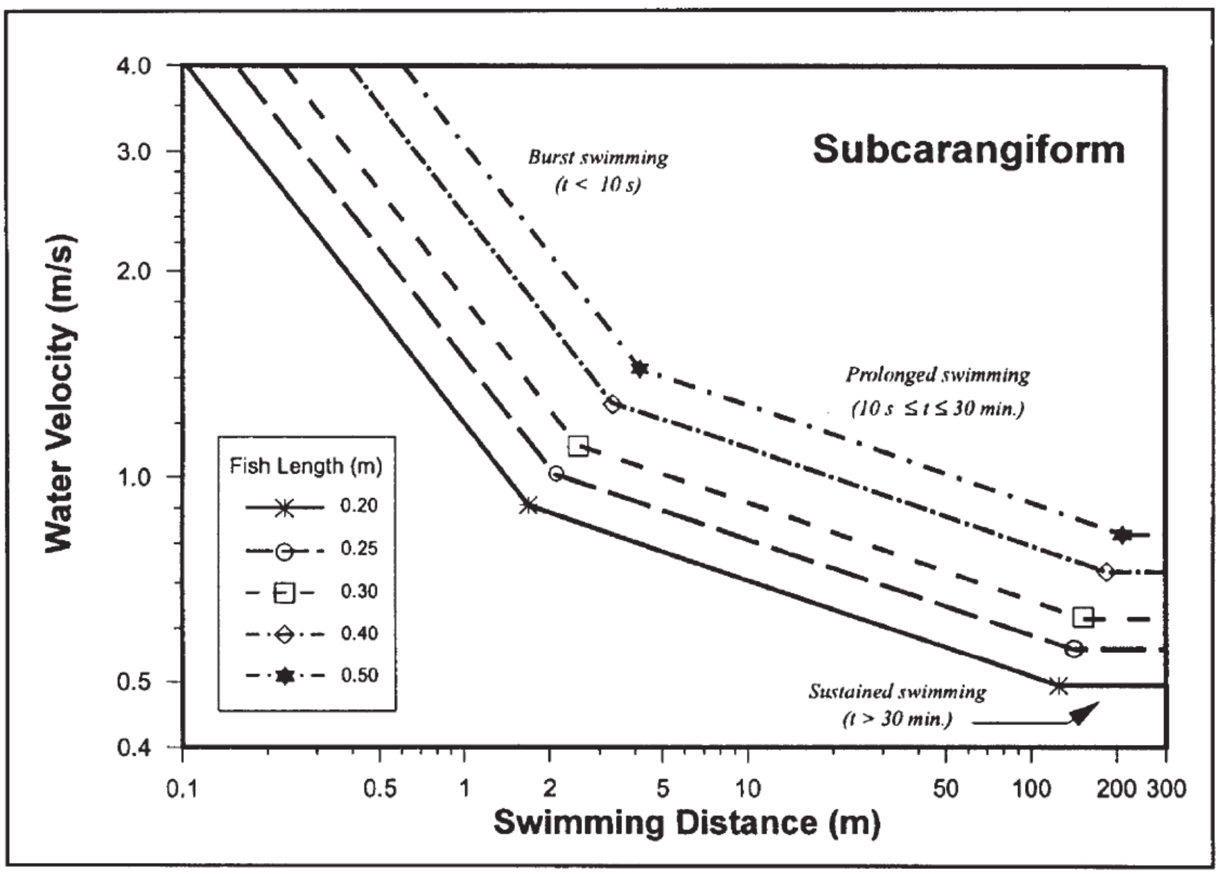


Figure 2. Swimming distance and velocity relationships applicable to salmon and trout (Katapodis 1993).

4.3 Instream Backwater Riffles

To re-establish fish access through the Unnamed Creek culvert, a series of riffles are proposed to backwater the culvert and create several fish accessible steps in water surface along the existing channel (Figure 3 and Figure 4; Photo 1 to Photo 7). A total of five riffle structures are proposed for Unnamed Creek. Because the riffle section will have a localized channel slope that is lower than the existing slope, the slope from the most downstream riffle to the existing streambed must provide a gradual transition to prevent excessive bed erosion and headcutting. Design sketches that show profile and cross section views of the proposed riffle structures in each section of channel are provided in Figure 5 and Figure 6.

The riffle structures will have downstream face slopes of 5-25% and should be constructed following the guidelines in the schematic riffle construction drawing (Table 3; Figure 7). The riffles should be built with a range of rock sizes. The largest rocks are selected to be stable at the 50 yr return period flood stage, but smaller boulders may tumble as initial adjustments in the riffle occur. The larger rocks placed on the surface of the riffle create chutes and small drops that provide diverse rearing habitat for parr and assist fish passage at low flows. These rocks are the most vulnerable to movement and represent the upper range of rock size required for the riffle.

Table 3. Dimensions for backwater riffle structures in Unnamed Creek.

Backwater Riffle Structures									
Structure Number	Chainage (m)	Bed Elevation (m)	Riffle Crest Elevation (m)	Riffle Height above Existing Bed (m)	Crest to Crest Difference	D/S Face Slope (%)	D/S Face Length (m)	Channel Width (m)	Volume of Rock Required (m^3)
1	0+031	96.3	97.1	0.8	-	5	16.2	6	49
2	0+044	97.2	97.9	0.7	0.8	10	6.9	13	62
3	0+060	97.7	98.7	1.0	0.8	10	10.0	15.8	158
4	0+069	98.1	99.4	1.3	0.7	20	6.5	17.5	148
5	0+077	98.1	100.1	2.0	0.7	25	8.0	18.7	299
								Total	**716**

An approximation of the size of rock that would be stable on the constructed riffle structures in Unnamed Creek may be obtained by analyzing the tractive force on the downstream face of the riffle and applying guidelines for selecting riprap materials (Newbury and Gaboury 1994). This analysis requires an estimate of the 50 yr return period discharge, channel slope and probable channel width. As Unnamed Creek is an ungauged stream with no hydrological records, unit area flood flows were calculated from gauged watersheds in the Peace region and used to estimate the 50 yr flood for the creek (Table 1). Based on this analysis, a conservative 1 in 50 yr discharge of 20.5 m^3/s was applied as the design flow in calculations to size the boulders for the riffle structures.

Tractive force, T (kg/m^2) for the riffle structures may be estimated as T = 1000 x Flow Depth (D in meters) x Slope of the Downstream Face of the Riffle (S in m/m) or:

$$T = 1000 \times D \times S \qquad \text{(Chow 1959)}$$

Although the gradient in this section of Unnamed Creek is ~4.8%, the stability of the riffle materials under the design flow condition can be tested where critical flow is assumed to occur on the downstream riffle faces which have 5-25% slopes. The design discharge for Gravel Hill Creek is 20.5 m^3/s. In this case, the critical depth in the channel at the design discharge would be solved using the continuity equation and mean channel width. Using a conservative mean channel width of ~18 m for Unnamed Creek after rehabilitation and a 20% slope on the downstream face of the riffle, the calculations are:

Discharge (Q) = velocity x depth (d) x width

with $v_c = (g \times d)^{1/2}$ substituted for velocity

$$20.5 = (9.8 \times d)^{1/2} \times d \times 18$$

$$d = 0.50 \text{ m}$$

Tractive Force (T) = 1000 x depth (m) x slope (m/m)

$$T = 1000 \times 0.50 \times 0.20$$

$$T = 100.0 \text{ kg/m}^2$$

Studies of stable channels, summarized by Lane (1955), indicate that the relationship between the tractive force and bed material diameter at incipient motion for pebble-size and larger materials is T (kg/m^2) = diameter (θ cm). Suitable rock size for a riffle with a 20% slope on the downstream face is therefore ~1.0 m. Larger rock sizes of ~1.2 m would be required for the 25% sloped riffle and ~0.5 m rock for the 5 and 10% sloped riffles.

Rock diameter of 0.5-1.2 m should be used for construction of the riffle crest and downstream surface of the riffles. Smaller diameter rocks (0.2-0.8 m diameter) can be used in the core of the structure. Larger diameter boulders (0.5-1.1 m) should be randomly spaced on the downstream face of the riffles approximately 30-50 cm apart to provide greater hydraulic roughness and habitat diversity. The volume of rock required for the five riffles is about 716 m^3. Design specifications for the riffle structures, including riffle crest location, design elevation and volume of rock for each structure are provided in Table 3.

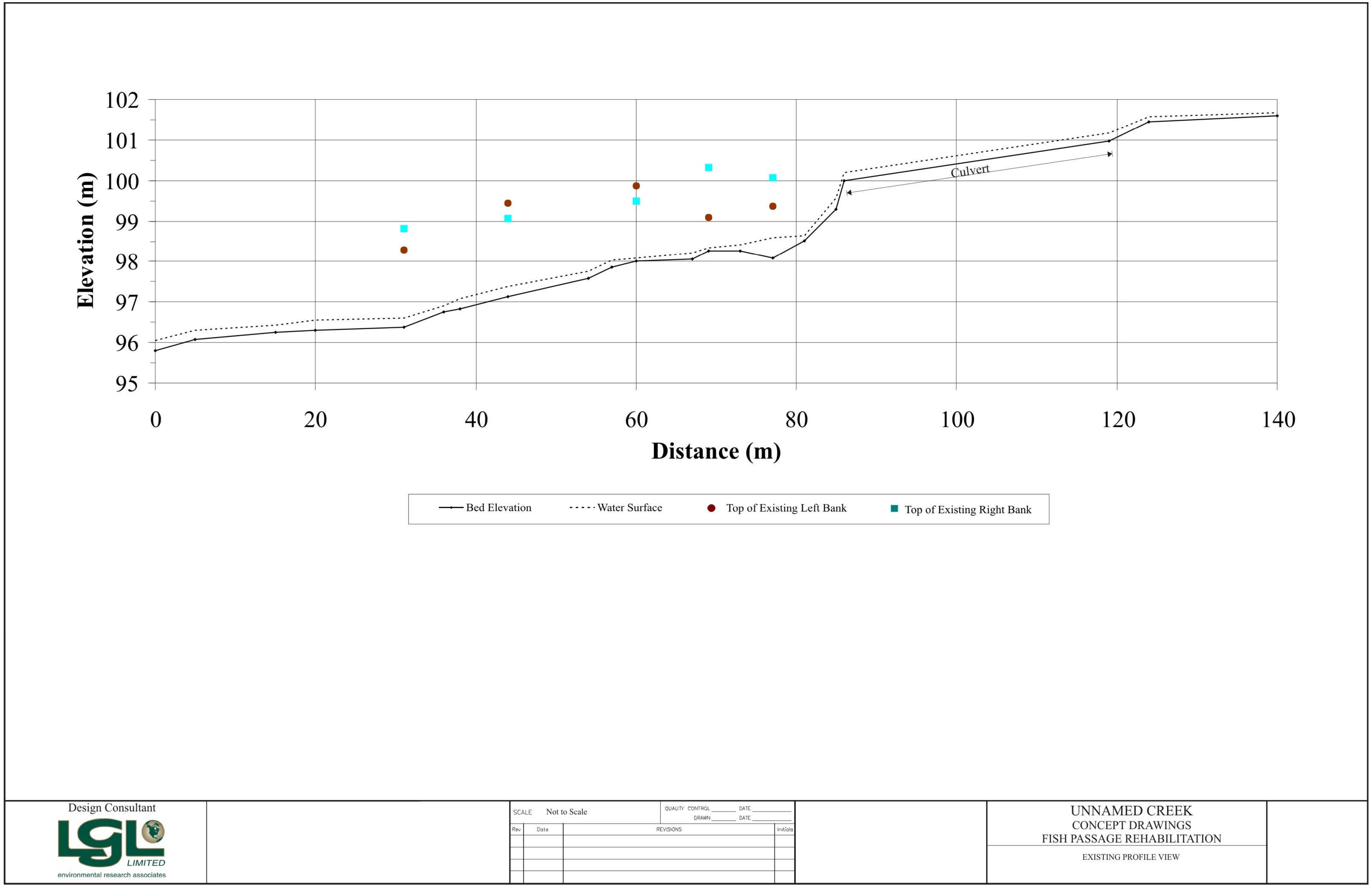


Figure 3. Existing profile of Unnamed Creek adjacent to the culvert crossing on Road 190.

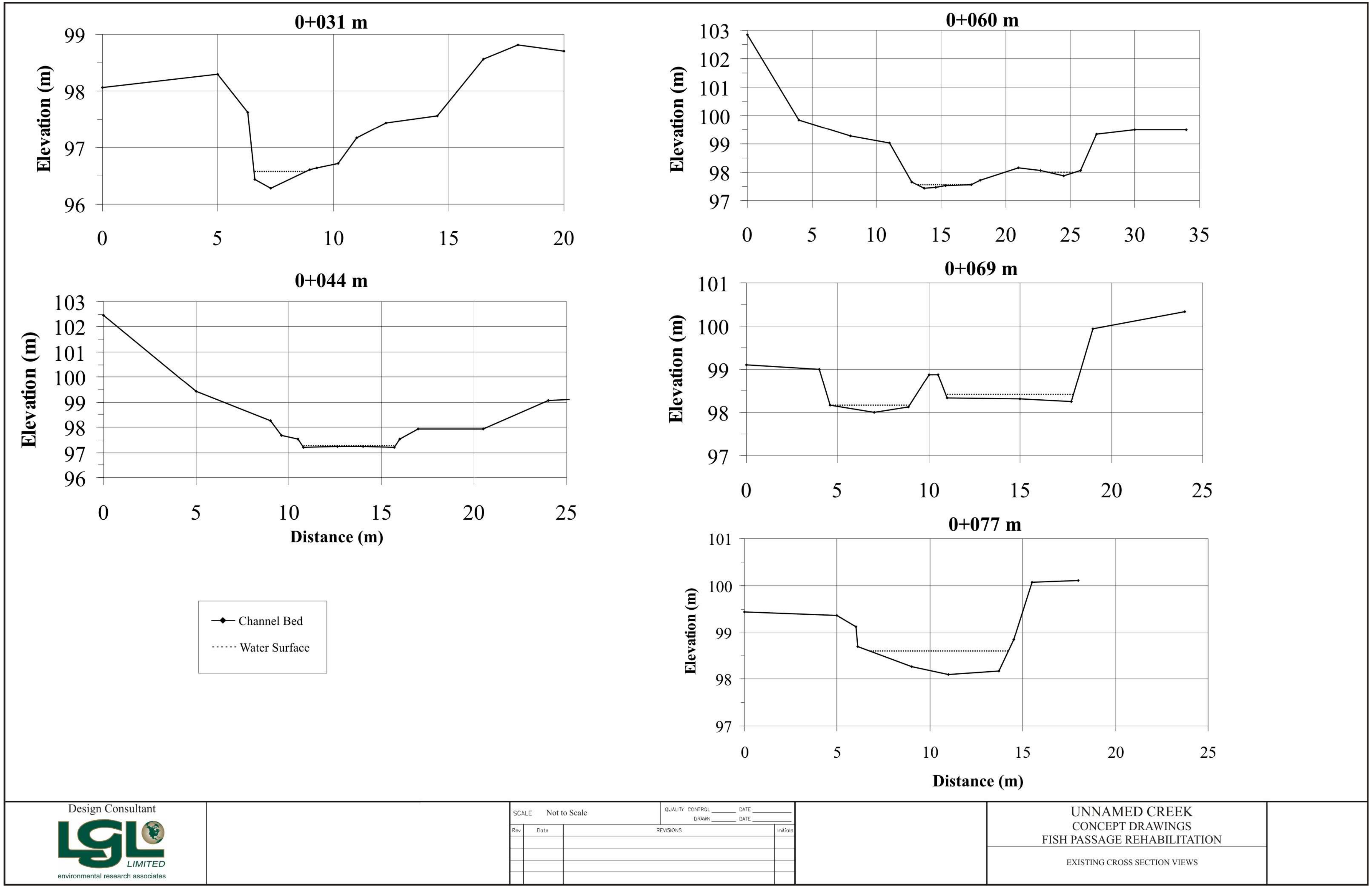


Figure 4. Existing cross sections of Unnamed Creek adjacent to the culvert crossing on Road 190.

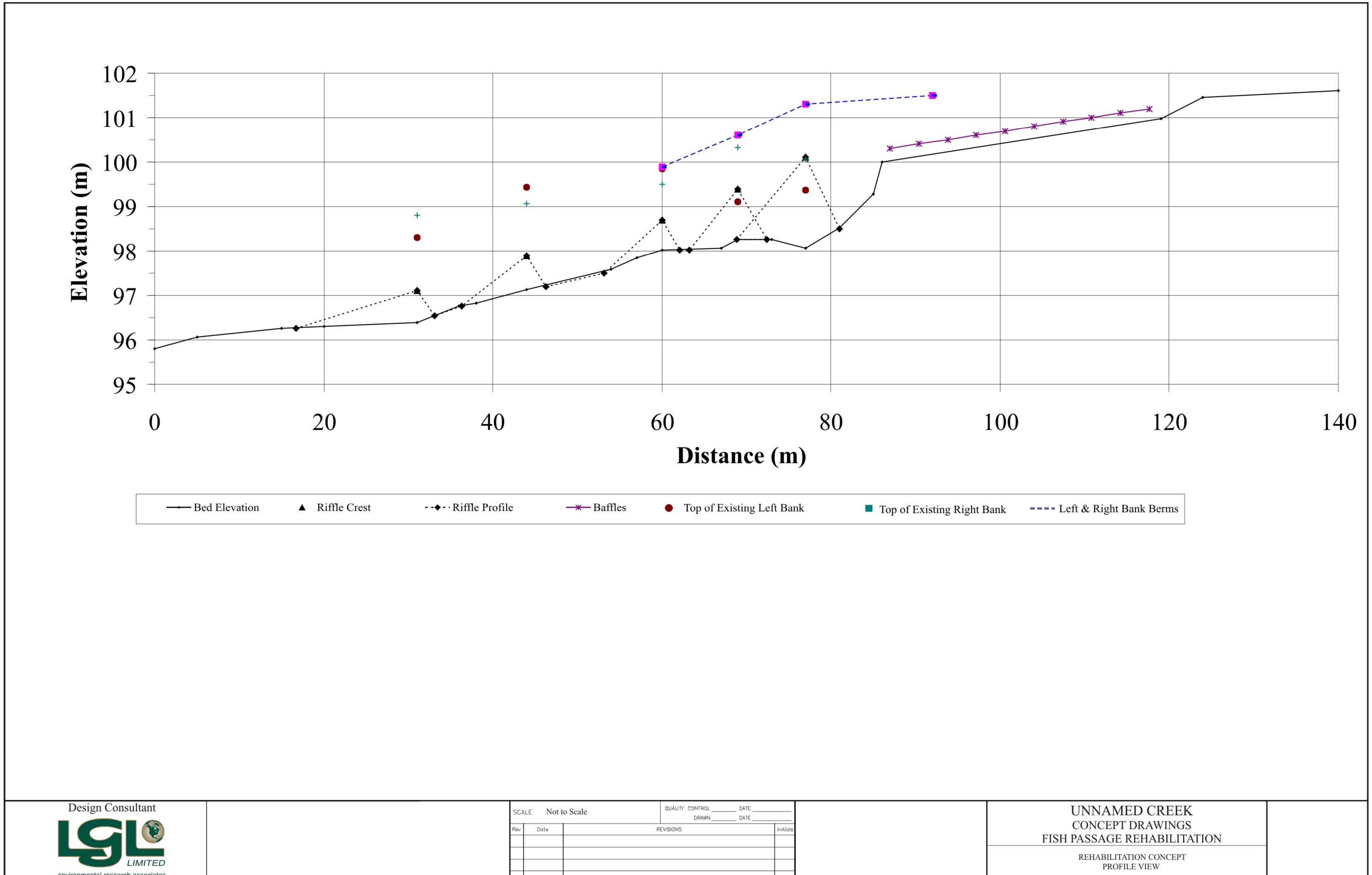


Figure 5. Profile view of Unnamed Creek showing proposed fish passage rehabilitation measures.

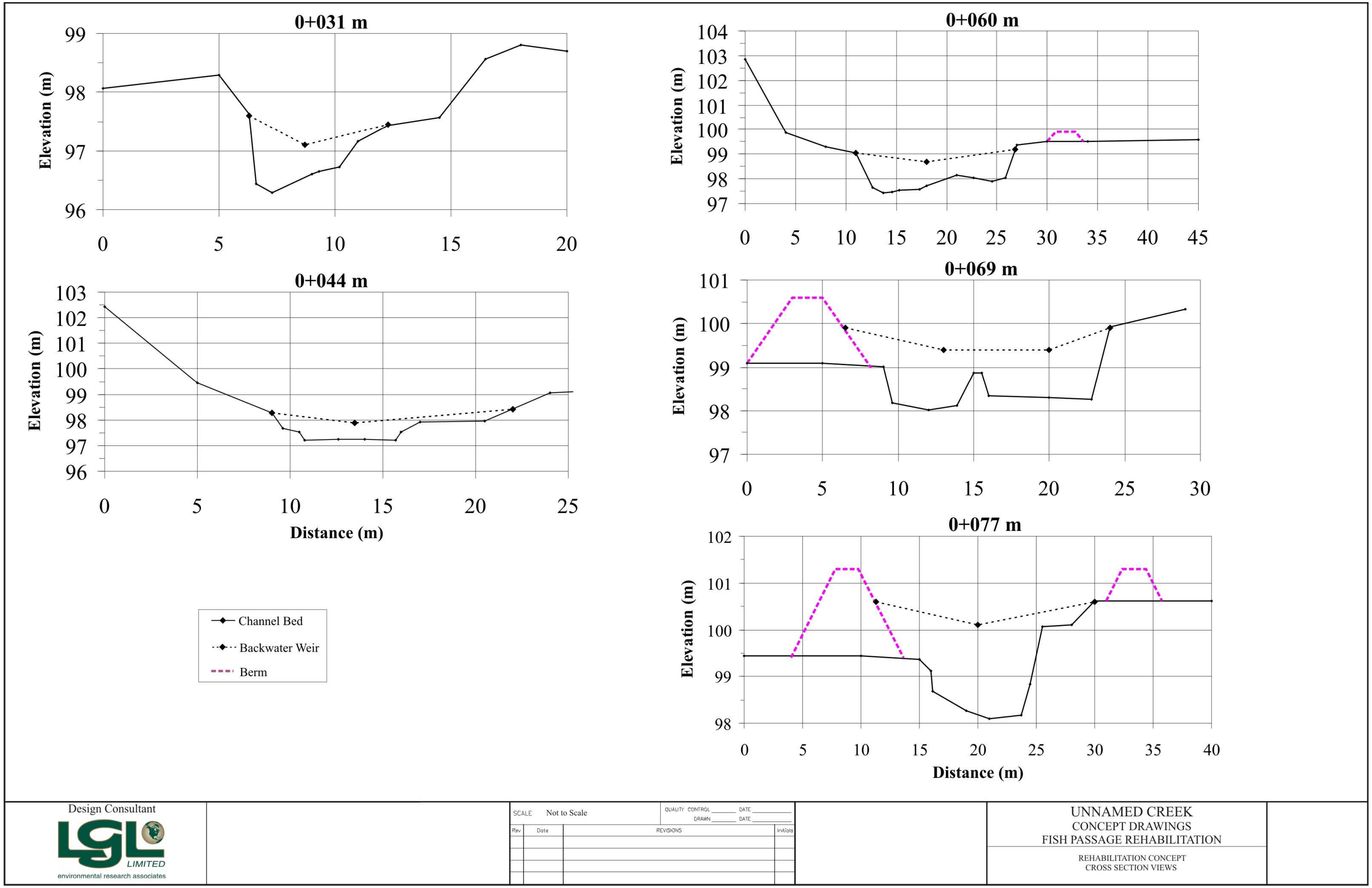
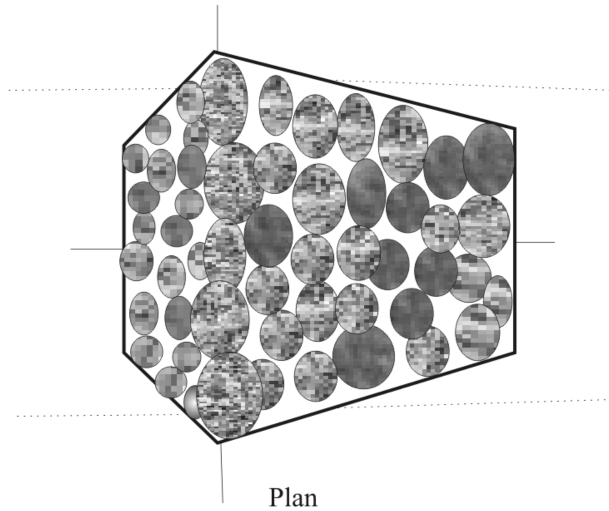


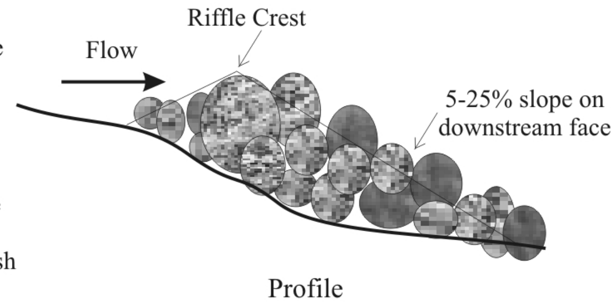
Figure 6. Representative channel cross sections in Unnamed Creek showing proposed riffle crest and berm elevations.

1. PLAN: build riffle crest across the stream with large diameter boulders; back up with next largest stone downstream



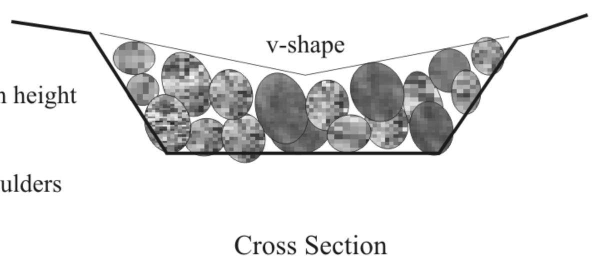
2. PROFILE: construct downstream face of riffle at a shallow re-entry slope that mimics local natural riffles

3. SURFACE: place large rocks randomly on the downstream face, 20 to 30 cm apart to dissipate energy and create low flow fish passage channels and back eddies



4. CROSS SECTION: V-shape the crest and face downwards to the centre of the riffle. Centre should be 0.3 to 0.6 m lower than height at the banks

5. BANKS: rip-rap both banks with embedded boulders and cobbles to the floodplain level



This drawing may be augmented for machine operators or hand labour crews with notes on the placement of construction stakes and photographs of natural and well-constructed riffles (after Newbury et al. 1997).

	Schematic Riffle Construction Drawing
LGL Limited	Scale: Not to scale

Figure 7. Schematic riffle construction drawing.

4.4 Channel Berms

The existing culvert is perched above the channel bed by ~1.5 m. To provide fish access through the culvert, the design necessitates relatively high crest elevations for the riffle immediately downstream of the culvert. As a result, the construction of berms to contain flows within the channel is required on both banks. The berms would be constructed with a suitable core of compacted earth fill consisting of gravelly sandy silt and silty sand. Riprap would be used to face the length and top of the berms. Gradation of the Class 100 kg riprap recommended for the face and top of the berms is specified in Table 4. The berms would have a top width of ~2 m and 2 to 1 side slopes. Berm elevations and dimensions are shown in Table 5, Figure 5 and Figure 6.

Table 4. Gradation of rock sizes in recommended riprap for berms (After Anonymous 2000).

Class of Riprap (kg)	Nominal Thickness of Riprap (mm)	Rock Gradation: Percentage Larger Than Given Rock Mass (kg)		
		85%	50%	15%
100	700	10	100	300

Table 5. Dimensions of berm structures in Unnamed Creek.

Left or Right Bank	Start Chainage (m)	End Chainage (m)	TOB Elevation (m)	Berm Crest Elevation (m)	Berm Height above Existing Bed (m)	Berm Side Slopes	Top Width of Berm (m)	Length of Berm (m)	Volume of Sand / Gravel Required (m^3)	Volume of Riprap Required (m^3)	Total Volume Required (m^3)
Left Bank	0+069	0+073	99.1	100.6	1.5	2:1	2	4.0	21	9	30
	0+073	0+077	99.2	100.9	1.7	2:1	2	4.0	24	10	34
	0+077	0+092	99.4	101.3	1.9	2:1	2	15.0	100	43	142
Right Bank	0+060	0+069	99.5	99.9	0.4	2:1	2	9.0	13	5	18
	0+069	0+073	98.1	99.4	1.3	2:1	2	4.0	18	8	26
	0+073	0+077	100.5	101.2	0.7	2:1	2	4.0	10	4	14
	0+077	0+092	100.6	101.3	0.7	2:1	2	15.0	37	16	53
								Total	**222**	**95**	**317**

4.5 Culvert Baffle Design

The fish passage rehabilitation design will include installation of culvert baffles in the Unnamed Creek culvert. Ten ~30 cm high baffles are recommended (Table 6). The baffles would be of a notched weir design with a semi-circular cut out rather than a v-shaped notch (Figure 8). As shown in the typical baffle drawing, the baffle notch would alternate from the left to right side of the culvert. Also, the baffles should be bolted into the culvert rather than welded because persistent streamflows would make welding of these retrofitted baffles very difficult. Bolt-in baffles should provide a more secure attachment to the culvert as compared to baffles with an expansion ring design, and should also require less maintenance over the long term.

Table 6. Culvert characteristics and baffle specifications at fish passage improvement site.

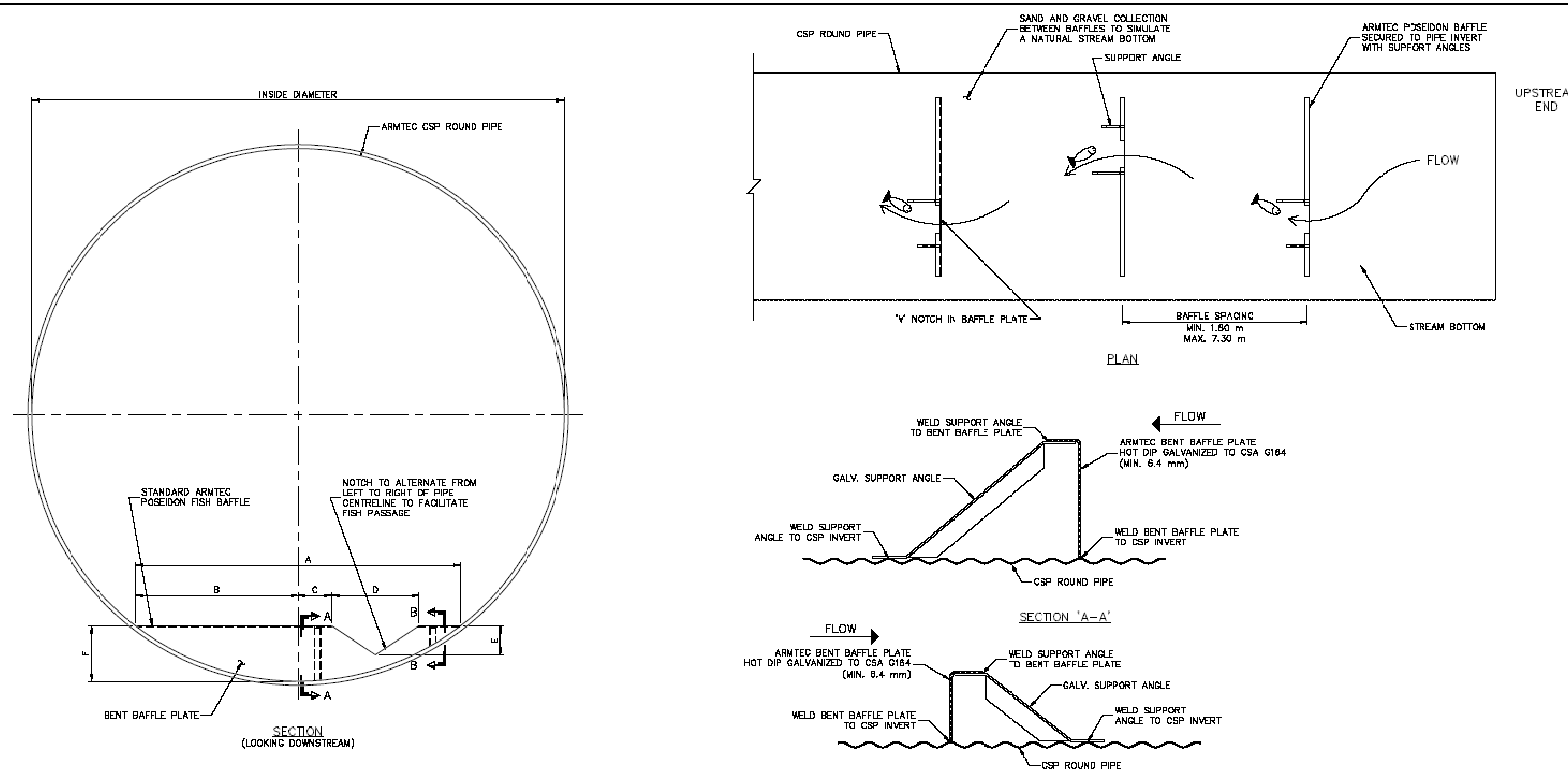
Creek Name	Culvert			Baffles			
	Diameter (m)	Length (m)	Slope (%)	Number	Height (cm)	Spacing (m)	Drop Between Baffle Crests (cm)
Unnamed Creek	2.8	33	3.0	10	30.5	3.4	10

Discharge estimates using Manning's equation found that the existing Unnamed Creek culvert has sufficient capacity for the 100 yr return period maximum daily discharge. The hydraulic efficiency of the culvert is significantly reduced with the installation of baffles. With the proposed 30 cm baffles, discharge capacity was reduced from ~32 to ~18 m^3/s, a decrease of ~45%. Similar levels of reduction have been determined for other baffle installations. Baker and Votapka (1990) reported hydraulic efficiency reductions of 31% for a 30 cm baffle and 43% for a 40 cm high baffle. It was assumed in the calculations of culvert capacity at these large flood discharges that roughness (n) in the culvert was 0.026 without baffles and 0.035 (Baker and Votapka 1990) with baffles. Also, in the calculations the diameter of the culvert with baffles was equal to the culvert diameter minus the height of the baffles.

In turbulent flow in culverts, fish will take advantage of the velocity reduction near the boundary by swimming in the bottom 80 mm of flow. This is particularly important for juveniles which are weaker than adults in swimming performance. The mean velocity in this 80 mm near boundary layer was calculated for various potential fish passage flows (Table 7). The velocity in this bottom layer is usually in the range of 40-80% of the mean culvert velocity (Behlke et al. 1991). It was assumed that fish would burst over the baffle notch and would likely rest in the pool between baffles or swim at a prolonged swimming speed to the next baffle upstream. The mean culvert and near boundary velocities for the proposed baffle site will allow adult fish to migrate successfully upstream through the culvert. Except at flows when mean culvert velocities are >1.1 m/s, juveniles of 125 mm could burst over the culvert baffles and migrate through the pools between the baffles. Juveniles of ≤50 mm could migrate upstream at flows less than about mean annual flow.

Table 7. Mean and near boundary velocities for culverts with baffles over a range of potential fish passage flows.

Flow Event	Mean Flow (cms)	Depth (cm)	Mean Culvert Velocity (m/s)	Boundary Velocity (m/s)
May	0.32	18.6	1.18	0.99
June	0.27	17.8	1.13	0.97
September	0.05	3.0	0.99	0.78
Mean Annual	0.20	12.0	1.09	1.02
2 yr Flood	1.50	41.5	1.77	1.06



SECTION 'B–B'

SECONDARY SUPPORT ANGLES ONLY REQ'D FOR DIAMETERS GREATER THAN OR EQUAL TO 3000

STANDARD ARMTEC POSEIDON FISH BAFFLES FOR ROUND CSP
DESIGN TABLE

DIA. (mm)	CORRUGATION PROFILE (mm)	BAFFLE WIDTH 'A' (mm)	'B' (mm)	NOTCH OFFSET 'C' (mm)	NOTCH WIDTH 'D' (mm)	NOTCH DEPTH 'E' (mm)	BAFFLE HEIGHT 'F' (mm)	BAFFLE SPACING (m)		EFFECTIVE END AREA OF PIPE (m^2)
								MIN.	MAX.	
1000	68 x 13	784	392	82	285	95	190	1.8	7.30	0.70
1200	68 x 13	894	447	93	300	100	200	1.8	7.30	1.02
1400	68 x 13	1028	514	107	345	115	225	1.8	7.30	1.40
1600	68 x 13 / 125 x 25	1112	556	116	345	115	225	1.8	7.30	1.86
1800	125 x 25	1252	626	130	375	125	254	1.8	7.30	2.35
2000	125 x 25	1330	665	138	375	125	254	1.8	7.30	2.93
2200	125 x 25	1520	760	158	456	152	305	1.8	7.30	3.52
2400	125 x 25	1598	799	166	456	152	305	1.8	7.30	4.22
2700	125 x 25	1708	854	178	456	152	305	1.8	7.30	5.40
3000	125 x 25	1812	906	188	456	152	305	1.8	7.30	6.73
3300	125 x 25	2014	1007	209	540	180	343	1.8	7.30	8.13

* BAFFLE RESTS ON INSIDE CREST STARTING FROM DOWNSTREAM END

NOTES:
1) ALL DIMENSIONS ARE IN MILLIMETERES UNLESS OTHERWISE NOTED
2) TOUCH UP ALL WELDS WITH ZINC RICH PAINT
3) SUPPORT ANGLES AND BAFFLE PLATES MAY BE ZINC RICH PAINTED
4) BAFFLE PLATES MUST BE HOT DIP GALVANIZED TO CSA G164

NO.	DATE	DESCRIPTION OF REVISION	BY	CKD
1	97/09/23	SECONDARY SUPPORT ONLY FOR DIA. >/= 3000 DIA	R.E.	K.A.

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ASSEMBLY DRAWING

ARMTEC POSEIDON FISH BAFFLES FOR CSP ROUND PIPES (1000 TO 3300 DIA)

DATE FEB. 25/97
DRAWN R. EDWARDS
CHECKED
REVIEWED
APPROVED
SCALE N.T.S.
DRAWING NO. CSP-40022 REV. 1

Figure 8. Typical design and installation drawing of fish baffles for a round corrugated culvert (Reproduced from Armtec).

4.6 Project Implementation

4.6.1 Access, Logistics, Materials and Labour

Access for delivery of materials to the proposed rehabilitation site at Unnamed Creek is good. Permanent gravel Road 190 provides access to the site. A short trail off this road should be constructed to access individual riffle sites along the channel. Dump trucks should haul sand/gravel, riprap and boulders to the site.

A track hydraulic excavator should be used to construct the riffle and berm structures. The required crew and machinery will be a crew supervisor, an excavator operator, technicians to install the baffles, and an environmental monitor. Continued professional input from a biologist/hydrologist that is familiar with instream structure construction is recommended.

The materials, equipment and labour required to construct the design as outlined include:

- Sand / gravel for the core of the berms and for the interstitial spaces in the riffle rocks;
- Riprap or boulders and cobble between 0.2 and 1.2 m diameter (b-axis);

Special equipment required:

- Excavator (e.g., Hitachi 200 or Cat E70B) for construction of riffles and berms;
- Dump trucks;
- Sand / gravel compactor;
- Water pump(s); and
- Fish traps (Gee) and fish exclusion netting.

Labour required:

- Ground crew;
- Excavator operator;
- Crew supervisor; and
- Technical support.

Table 8 provides a cost estimate of about $97,000 to implement the rehabilitation works in Unnamed Creek.

Table 8. Cost estimate for rehabilitation works in Unnamed Creek, 2011.

				Fish Passage	
Description		Unit	Unit Cost	Approx. Quantity	Cost
Major Equipment:					
1	Excavator, all found	hour	$175	150	$26,250
2	Excavators mob/demob.	km	$1.40	200	$280
3	Loader/small excavator	hour	$125	100	$12,500
4	Dump Truck, all found	hour	$90	125	$11,250
Sub-total major equipment					**$50,280**
Manpower:					
1	Habitat Restoration Specialist	pers-day	$1,100	15	$16,500
2	Labour	pers-day	$400	20	$8,000
Sub-total manpower					**$24,500**
Light Equipment:					
1	Drilling Equipment Rental	week	$500	1	$500
2	Water Pumps	week	$1,000	1	$1,000
3	Soil Compactors	week	$2,000	1	$2,000
Sub-total light equipment					**$3,500**
Materials:					
1	Riprap for Riffles	m^3	$0	716	$0
2	Riprap for Dykes	m^3	$0	115	$0
3	Sand/Gravel for Riffles & Dykes	m^3	$0	220	$0
4	Steel Fish Baffles	each	$500	10	$5,000
5	Miscellaneous supplies		$1,000	1	$1,000
Sub-total materials					**$6,000**
Sub-Total					**$84,280**
15% Contingency					**$12,642**
Total Cost					**$96,922**

Note: Assumed sand/gravel and riprap to be provided at no cost by BC Hydro. Gravel and riprap loading, transport and placement costs are incorporated in excavator, loader and trucking costs above.

4.6.2 Fish Habitat Construction Timing Windows

The following table summarizes recommended timing windows for instream construction (Table 9). Windows of least risk are designed to protect critical life stages of native fish species known to occur in a stream. The generation and subsequent deposition of sediment in fish streams is of particular concern. Based on the windows of least risk, the timing window during which the instream construction could proceed without causing harm to native fish habitat in the project streams would be from July 15 to August 15.

Table 9. Instream work windows for the Peace Region (Reproduced from BC MOE http://www.env.gov.bc.ca/wsd/regions/nor/wateract/terms_conditions_per.pdf)

FISH PRESENCE	WINDOWS OF LEAST RISK
Both spring and fall spawners* or unknown	July 15 – August 15
Fall spawners* (e.g. bull trout, kokanee and mountain whitefish)	June 15 – August 15
Spring spawners (e.g. Arctic grayling, rainbow trout, minnows, suckers, Stickleback and Walleye)	July 15 – March 31
Anadromous salmon (e.g. chum salmon)	Please contact DFO for site-specific timing

4.6.3 Timing of Works, Priorities and Scheduling

A 'Notification for Proposed Works and Changes In and About a Stream under Water Act Regulation 204/88' for the proposed projects should be prepared for signature once this site has been confirmed for implementation (http://www.env.gov.bc.ca/wsd/water_rights/licence_application/section9/index.html). Also, the site is within Butler Ridge Provincial Park and therefore a Park Use Permit and any other related approvals will be required in advance of physical works (http://www.env.gov.bc.ca/bcparks/permits/). It is anticipated that construction of the proposed rehabilitation works would proceed during the fisheries work window in one season.

4.6.4 Environmental Controls

A qualified environmental monitor must be on site at all times during construction to ensure that all potential impacts to fish habitat are mitigated. This person will be responsible for ensuring that sediment control procedures are followed as per established 'Land Development Guidelines' (Chilibeck el al. 1993) and that fish salvage operations are conducted, as necessary. Appendix A contains excerpts from the DFO Land Development Guidelines on a variety of issues related to work in and around streams. All construction personnel should be familiar with these guidelines prior to commencing work on the site. Four guiding principles are worthy of note here:

- the natural riparian vegetation and stream banks should be protected and/or rehabilitated during and after construction;
- prevent the introduction of pollutants and deleterious substances by controlling construction activities and site conditions;
- prevent the generation of sediment by utilizing proper instream construction controls and supervision; and
- conduct fish salvage as required to remove fish from the area of impact (using minnow traps, beach seines, or lastly, electrofishing).

5 ACKNOWLEDGMENTS

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APPENDICES

Appendix A. Guidelines for instream work (Chilibeck et al. 1993).

SECTION 5 INSTREAM WORK
Objective

It is recognized that at times it may be necessary to perform instream work as part of the process of developing land. The objective of the instream work guidelines is to promote careful planning and construction practices to limit the potential for impacts on the aquatic environment. Instream work is any work performed below the high water mark, either within or above the wetted perimeter, of any feature within the Fisheries Sensitive Zone (FSZ). Prior to commencement of any instream work and with sufficient lead time, proponents should consult with DFO/MWLAP for information regarding FSZ species timing windows and construction methods. Because instream work has the potential to be extremely destructive to fish habitat, methods and procedures to minimize instream activities should be considered during the planning and design stages of a project. The procedures should be specifically designed to achieve the following objectives throughout the project.

$ Protect the natural stream conditions and structure to promote stability of bank and bed structures, and retain riparian vegetation.
$ Provide the instream conditions required for unhindered fish passage upstream and downstream.
$ Prevent introduction of pollutants and deleterious substances by controlling construction activities and site conditions.
$ Prevent generation of sediment, impacting fish and aquatic habitat, by utilizing the proper instream construction technique and supervision.

Guidelines for Instream Work

General guidelines for instream work include:

$ Consult with local DFO/MWLAP staff regarding presence, distribution and timing of migrations of fish species in the stream or watercourse, and FSZ window (Appendices 2 and 3).
$ Plan instream work for periods within the confirmed FSZ window that will minimize disturbance and impact on fish and fish habitat.
$ Plan instream work for periods of suitable stream and environmental conditions, determined in consultation with DFO/MWLAP.
$ Minimize the duration of the instream activities.
$ All material placed within the wetted perimeter must be coarse, non-erodible, and non-toxic to fish. Do not remove gravels, rock or debris from any stream without the approval of DFO/MWLAP.
$ Minimize disturbance to stream banks where equipment enters and leaves the watercourse.
$ Reconstruct and revegetate stream banks to their original condition as soon as activity has finished (see Section 2 in Chilibeck 1992).
$ Use the proper equipment for the proposed construction activity. Avoid damage caused by stuck equipment or delays because of insufficient capacity for proposed work.

$ Ensure that all construction equipment is mechanically sound to avoid leaks of oil, gasoline, hydraulic fluids and grease. Consider steam cleaning and check-up of construction equipment prior to use instream.

$ Require the use of biodegradable hydraulic fluids for machinery used for instream work.

Timing of Instream Work

It must always be assumed that fish are present in a watercourse since the utilization and residency times for different species vary widely in accordance with their spawning and rearing cycle requirements. The windows of allowable times when instream work can be tolerated are often based on the reduced sensitivity of the fish to disturbances rather than the absence of fish during these times. The work should be coordinated and timed so that conflict with the fish populations is minimized. Appendix 2 contains information on the species-specific freshwater FSZ timing windows. The utilization of various habitats (freshwater lakes, rivers, estuarine and marine environments) by both resident and anadromous fish populations place restrictions on instream work. **Timing windows of allowable instream work should always be confirmed with DFO/MWLAP personnel responsible for the local area in which the proposed development is located**. Site specific differences exist and DFO/MWLAP staff should be consulted early as possible in the planning process.

Sediment and Erosion Control during Instream Work

Sediment Control

The temporary containment and removal of sediment-laden water will probably be necessary during instream work, even when isolation techniques are used. Contaminated water within the work site must be pumped onto a land site where it will not re-enter the creek, or will do so only after filtration and settling has taken place.

Instream Machine Crossings

Where no alternate access to the opposite side of a watercourse exists, where it is impossible to do certain instream work from the banks, or where it is not feasible to isolate a worksite during construction, it may be necessary to take machinery and/or equipment into or through a flowing stream. In such situations, the local fisheries agencies must be consulted beforehand. Access should be arranged for the period of flow with the least impact to fish and fish habitat. All vehicles and equipment must be clean and in good repair to avoid leakage of petroleum products. Access by fording should be restricted to one crossing location, and traffic should be limited.
Instream control measures and engineered roads using clean fill materials may be necessary. The access site must be chosen with care, where banks are low, the stream substrate is suitable, and the water shallow. Upon completion, the banks should be restored, restabilized and revegetated to prevent erosion.

Erosion Control and Streambank Rehabilitation

Any time a bank or the channel bottom is disturbed, restorative action should be taken to prevent erosion, siltation and to replace lost fish habitat. If adequate site selection and careful construction techniques are implemented, minimal disturbance and rehabilitation should be required to the riparian zone and the stream. Each site needs to be assessed individually at the planning stage to determine what rehabilitation will be needed. Erosion control materials should not encroach into the stream's cross-sectional width. Encroachment can create backwatering (flooding) and increase stream velocities that may cause scouring and erosion. It may be possible to reuse excavated materials. In some cases, however, they may have to be totally replaced with materials more suitable for fish habitat (i.e. using washed, silt-free gravel as backfill). Acceptable bank erosion control methods include hand seeding, hydroseeding, silt blankets, rock riprap and revegetation using plantings. Scalping existing instream material, like gravel bars or large rocks, will not be permitted. The top of banks and the riparian zone may also need to be stabilized, commonly by planting trees, shrubs, and various bushy types of vegetation. Native species should be used for all revegetation projects.

Maintenance of Instream Structures

Well designed and constructed instream structures should require minimum maintenance. Frequent inspections, particularly during high runoff periods, are very important. Improper functioning of a structure during or after a major storm event may indicate the need for minor repairs or modifications. It is advisable to perform such minor repairs immediately in order to prevent the need for major repairs later, and to ensure safety and reduce the environmental impact. General maintenance should be carried out according to an agreed schedule of works and agency contact procedure. If emergency measures are required, only justifiable essential preventative actions should be taken to protect life and major losses of property. If time allows, contact the fisheries agencies before carrying out emergency repairs.

Guidelines for Construction Practices within the Fisheries Sensitive Zone

The following provisions are steps intended to protect leave strips and maintain a healthy functional riparian zone.

Planning and Minimizing Impacted Area

$ Streambank characteristics and vegetation should be taken into account when planning development activities in and around rivers and streams.
$ During development of the land, there should be no unauthorized work or disturbance into the FSZ.
$ Where encroachment into a leave strip is required, specific plans must be prepared and approved by DFO/MOELP in advance.
$ Requests for permission to encroach will only be considered for major vehicle or footbridge crossings, utility crossings, and stormwater discharge outfalls.
$ The plans for such encroachments should include details including the extent of work areas; plans for the control of water discharged from the work area; the timing of work; and the details for restoration after construction.
$ Carefully select access points to streambank through the riparian zone, minimize the size and duration of disturbance, and preserve streamside vegetation and undergrowth wherever possible.
$ Limit machinery and equipment access and direct disturbance to streambank areas.

Stabilizing Impacted Area

$ Physical stabilization of eroding or eroded banks may be required to promote bank stability and regeneration of riparian vegetation.
$ Design and construction of stabilization works should prevent their subsequent erosion.
$ Remove disturbed, unstable debris from the riparian zone to prevent it from being swept away during high water.
$ Retain stable large woody debris (LWD) which does not impede flows and fish migration, or promote bank erosion.

Revegetating Impacted Area

$ Revegetate disturbed areas immediately following completion of work in riparian zones.
$ Establish ground cover to prevent surface erosion and deeper rooted plants and shrubs to prevent streambank erosion.
$ Cedar, vine maple, alder, cottonwood, willow, salmonberry and red osier dogwood are common native plants used to augment brush and large plant formation.
$ Large tree species will provide long-term sources of LWD.

PHOTOS

Photo 1. Looking upstream in Unnamed Creek from chainage 0+000 m.

Photo 2. Looking upstream at cross section at 0+031 m in Unnamed Creek.

Photo 3. Looking downstream at cross section at chainage 0+044 m.

Photo 4. Looking downstream at cross section at chainage 0+060 m.

Photo 5. Looking upstream at cross section at chainage 0+069 m.

Photo 6. Looking upstream in Unnamed Creek culvert at chainage 0+086 m.

Photo 7. Looking downstream at culvert in Unnamed Creek from chainage 0+130 m.