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FISH HABITAT RESTORATION DESIGNS FOR ENGLISHMAN RIVER

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Submitted to:

BC Conservation Foundation
3-1200 Princess Royal Ave.
Nanaimo, BC V9S 3Z7

***For*:**

Pacific Salmon Foundation
Suite 300, 1682 West 7th Ave.
Vancouver, BC V6J 4S6

***Prepared by*:**

Marc Gaboury

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

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Craig Wightman (Ministry of Water, Land and Air Protection) defined the scope and selected the priority watersheds for the project. Steve Lorimer (TimberWest) and Tom Holmes (Weyerhaeuser) were instrumental in facilitating access for the field team to private company lands within the watershed. Pat Stephenson (BC Conservation Foundation) provided contract management and project support. Mike McCulloch (BCCF) identified highly utilized steelhead rearing and holding habitats on site and assisted with the field work. James Craig, Harlan Wright and Brad Smith (BCCF) provided information from their current streamflow gauging and habitat assessment study. Bruce Murray (LGL Limited) assisted with the level surveys and Robin Tamasi (LGL Limited) prepared the maps. Craig Wightman and Bob Bocking (LGL Limited) reviewed the report and provided valuable comments. The assistance of all of these individuals is greatly appreciated.

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1.0 INTRODUCTION

The Englishman River has been selected by the Pacific Salmon Endowment Fund Society as the first watershed to receive attention in the Georgia Basin salmon recovery planning process for coho and steelhead (PSEF Technical Committee 2001). The Englishman River is an important salmon-producing stream on the mid-east coast of Vancouver Island. The watershed has all species of salmon, including steelhead and is designated a sensitive stream by the BC government under the Fish Protection Act. Forestry, agriculture, and urban development are the primary land uses in the watershed.

The Englishman River recovery plan (Bocking and Gaboury 2001) indicated that instream rearing habitat with the mainstem and tributaries should be assessed and, if needed, restoration designs prepared. Recent assessments of channel condition (nhc 2002) and fish habitat (Lough and Morley 2002) identified enhancing pool and cover habitat in the Englishman River mainstem as a priority. In particular, construction of large woody debris (LWD) structures in Reach E3 was recommended by nhc (2002). In addition, the Greater Georgia Basin Steelhad Recovery Action Plan indicated a medium potential for habitat restoration and suggested that anchored LWD structures be constructed on the mainstem (Lill 2002). The PSEFS, in cooperation with BC Ministry of Water, Land and Air Protection (MWLAP) and Fisheries and Oceans Canada (DFO), Habitat Restoration Unit, South Coast Division, have proposed that fish habitat restoration designs be prepared for reaches E2 and E3 of Englishman River (Figure 1). The BC Conservation Foundation and LGL Limited were contracted to identify potential restoration sites and prepare site-specific designs.

To date there has been relatively few instream mainstem projects. The Englishman River Enhancement Group have opportunistically cabled deadfall that have entered the river to live trees on the bank. In 2002, DFO constructed two LWD structures to protect the right bank and deflect flows away from a constructed side channel at about chainage 6+700 m upstream of the river mouth (M. Sheng, DFO pers. comm.).

This project is a fundamental step in habitat restoration as it establishes biological rationale and feasibility, and provides site-specific fish habitat restoration designs and construction procedures that will be implemented in an upcoming instream work window. A total of about 5.7 km of stream was assessed and 16 sites were prescribed for instream restoration. The restoration designs target all life stages of salmonids found within the proposed restoration section, but in particular the holding and rearing habitats for those species that spend an extended period of time as juveniles in fresh water. Therefore, the target species in this project include coho salmon, steelhead (rainbow), cutthroat and Dolly Varden. Included are the maps, construction drawings, materials summary, work plan, schedule and estimated costs of construction.

2.0 ASSESSMENT METHODS

Field reconnaissance for the siting and design of restoration treatments was conducted on 29 May, 2002. Field information was collected for all sites and included:

- locating each proposed restoration site by thalweg chainage from the Englishman River mouth;
- estimating right and left bank heights above present water level;
- determining the availability of ballast rock on site;
- determining the type of bed and bank substrates; and
- identification of specific factors to restore local fish habitat.

In addition, ground photographs at most of the proposed instream restoration sites were taken.

Cross section and channel morphology surveys were completed using an engineer's level on 29 September, 2001 and provided:

- a streambed and water surface profile and typical channel cross sections; and
- a measurement of channel gradient, bankfull width, bankfull height, and bed paving material size.

3.0 DESCRIPTION OF STUDY AREA

Our investigations were limited to reaches E2 and E3 (reaches identified by nhc 2002) within the anadromous section of mainstem river. These reaches were identified through discussions with C. Wightman (MWLAP) and M. McCulloch (BCCF). Prioritization for reach selection was based on:

- relative abundance of steelhead adults and juveniles being observed during snorkel surveys;
- high potential or observed utilization by coho juveniles for summer rearing and overwintering;
- potential to benefit other native resident and anadromous salmonids;
- relatively stable channels with a low to moderate likelihood that restoration works would be negatively impacted by current watershed processes and conditions; and
- vehicular access to restoration sites to facilitate equipment and material delivery during construction.

The bulk of the land within the watershed is privately owned. Weyerhaeuser and TimberWest are the largest land holders with 51 and 22%, respectively (Bocking and Gaboury 2001). The study watershed has a drainage area of 324 km^2 and a known accessible length in the mainstem of 15.85 km. Riffle-pool morphology dominated the channel reaches that were assessed. In general, riparian logging has occurred along the mainstem but in most cases this occurred more than 30 years ago (Bocking and Gaboury 2001, nhc 2002). Although the valleys within reaches E2 and E3 are 'stable with no visible sediment sources', the channel in Reach E3 shows evidence of aggradation and irregular lateral activity (nhc 2002). Also, LWD was limited or absent from the channel in both reaches, and when present, was oriented parallel with the banks indicating channel perturbation (Anonymous 1996).

3.1 Hydrology and Channel Characteristics

Discharges have been gauged by Water Survey of Canada for over 23 years at Station 08HB002 - Englishman River near Parksville (drainage area 324 km^2). Mean monthly flows in this coastal watershed begin to rise in October in response to rainfall, peak in December, and steadily decline through Spring with the lowest discharges occurring typically in August or September. Mean annual flow is 13 m^3/s. Based on a recent flood frequency analysis for the watershed (nhc 2002), 2 year and 50 year maximum daily flows were estimated at 204 and 471 m^3/s, respectively. The unit flood discharge with a return period of 50 years is therefore 1454 $l/s/km^2$ and within the range of 758 and 1921 $l/s/km^2$ found for other east Vancouver Island rivers (Gaboury and McCulloch 2002). The two year return period seven day low flow is estimated at 0.353 m^3/s or 1.09 $l/s/km^2$ (nhc 2002).

Cross section surveys determined a mean bankfull width of 37.7 m and depth of 1.34 m for the Englisman River (Table 1, Figures 2 and 3). The average gradient in the mainstem downstream of South Englishman River was about 0.7 %, increasing to about 0.9% upstream of the South Englishman confluence. Median substrate size ranged from 20 to 32 cm from pebble counts undertaken at two riffle sites within the proposed restoration section (Figure 4). The larger median substrate size was due to a higher channel slope (0.09 versus 0.07) and greater channel confinement immediately upstream of the South Englishman River confluence (Figures 2 and 3).

Based on our cross section, pebble count and profile surveys, expected water depths, velocities and tractive forces were approximated at two year and 50 year return period flood discharges, as determined by nhc (2002) (Table 2). At a two year instantaneous discharge, the depth of flow is estimated at 1.9 m with a tractive force of 13.6 kg/m^2. During a 50 year instantaneous flood, water depth is estimated to be 2.8 m and tractive force is 17.1 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 (ϕ cm). Therefore, it is expected that about 14 and 17 cm sized bed material would be dislodged at the two year and 50 year flows, respectively. It is evident from the substrate size distributions that more than 82% of the bed paving material would be stable at the two year flow while more than 60% would be stable at the approximated 50 year flow conditions (Figure 4).

3.2 Fisheries Resources

All species of Pacific salmon have been observed in the Englishman River over the past 40 years with sockeye generally having the lowest abundance (Bocking and Gaboury 2001). Prior to 2000, the historical maximum estimate for coho was 3500 spawners recorded in 1957. Since then, escapements have not exceeded 1500 with a mean of 960. However, approximately 5200 and 8000 coho returned in 2000 and 2001, respectively. These record numbers may be due to increased freshwater survival in two DFO artificial spawning and rearing channels, and to recently improved marine survival.

Winter steelhead are also found in the watershed but stock status is now considered as high risk due to their low numbers since the mid-1990's (Wightman et al. 1998; Lill 2002). Other species such as cutthroat, rainbow and Dolly Varden are numerous in the watershed.

3.3 Habitat Limitations

In pristine watersheds, riparian vegetation, particularly large conifers, provides much of the future supplies of LWD for instream fish habitat. A climax riparian community also contributes to the creation and maintenance of overwintering areas such as overflow channels and off-channel ponds, and stabilizes the streambanks to prevent dramatic changes in channel morphology. Optimum rearing habitat for salmonids requires cover, and historically in these coastal streams LWD provided instream cover for fish rearing in deeper pools. LWD also provides a functional influence on channel morphology in streams with bankfull widths less than 38 m or gradients <8% (Anonymous 1996).

Forest practices and other land uses have accelerated the rate of occurrence of some types of disturbance (i.e., major floods, debris torrents, riparian and channel changes) (Cederholm et al. 2000). Levy et al. (1996) identified the negative impacts of past forest harvesting on fish habitat. He attributed the impacts to channel morphology changes, altered flood hydrographs, increased sediment delivery, and a reduction in LWD recruitment.

Lough and Morley (2002) and nhc (2002) observed evidence of channel morphology changes in the watershed, as indicated by channel widening, extensive gravel bars, pool-infilling, reduced pool frequency, and a lack of functional instream LWD. Historic logging practices often removed most of the conifers from the riparian area of mainstem and tributary channels. The loss of large conifer recruitment from the riparian areas to the stream channels has impacted both instream and off-channel summer and winter rearing habitat. This has particularly impacted juvenile salmon and trout that rear and overwinter in freshwater. In addition, it has affected adult fish that require suitable holding pools for migration and spawning. Similar changes to channel morphology and watershed processes, and consequently fish habitat, can occur as a consequence of poor land use practices associated with agricultural or residential developments.

4.0 RESTORATION OBJECTIVES

The restoration measures described below will mitigate some of the habitat impacts that have occurred historically within the watershed. The biological objectives include:

- improving overwintering and rearing habitat for native salmon, steelhead, trout and char;
- increasing fry densities in LWD complexed sites to 0.9 coho fry/m^2 and 0.3 trout fry/m^2; and
- increasing trout parr densities in LWD and boulder-complexed sites to 0.2 to 0.3 parr/m^2.

The proposed restoration treatment to meet site-level objectives is to construct LWD structures in mainstem sites to provide cover and promote pool scour.

5.0 FISH HABITAT REHABILITATION

5.1 LWD Structures

LWD structures will be built at specific sites in the five watersheds (Figure 5; Tables 3 to 5; Photos 1 to 13). Each proposed LWD structure will be comprised of 1 to 5 logs (Figures 6 to 8). It is anticipated that the logs with rootwads will have an average dbh of 0.4 to 0.7 m and be approximately 8 to15 m long. Although some LWD is available currently at the proposed sites, it is assumed in the materials summary tables that all structure materials will be imported.

LWD cover structures will be positioned preferentially in a triangular manner or with members anchored to bank trees, stumps or deadman anchors to ensure greater stability for the structures. Alternatively, the tops of the LWD will be buried in the streambank (e.g., Figure 9).

Ballast requirements for LWD structures LTR-3 and DJ-5 have been determined using design charts that assume a triangular structure and a safety buoyancy factor of 1.5 or greater (D'Aoust and Millar 1999; Slaney et al. 1997). As an example, for a 0.5 m diameter log with attached rootwad, the total ballast required per metre of effective length would then be 190 kg/m, with safety factors of $\geq$1.5 for buoyancy and sliding (D'Aoust and Millar 1999). Effective length refers to the length of log projecting into the stream.

In situations where the LWD structure is not constructed in a triangular manner, ballast requirements should be determined assuming that each log is a 'single-log lateral jam' (e.g., LO-1 structure) (D'Aoust and Millar 1999; Slaney et al. 1997). In order to determine the ballast requirements for this type of structure, a design velocity estimate using the formula $V=20(HS)^{½}$ is required. Channel gradient (S) is about 0.7% at the locations where these structures are proposed. An average floodplain height (H) of about 2.5 m was assumed in the calculations. The design velocities were calculated as 2.6 m/sec. For a 0.5 m diameter log with 1.5 m diameter rootwad, a minimum ballast per metre of effective length will be about 500 kg/m.

The ballast requirement for logs with rootwads attached would require conversion of the dimensions of the rootwad into an equivalent diameter and length of a log of equal mass. The total ballast requirement for the log with rootwad would be the sum of the individual ballast requirements determined for the bole and rootwad.

For typical triangular log structures, we recommend anchors of 0.8 m in diameter, based on a typical log diameter of 0.5 m. Except where noted, sufficient quantities of rock required to ballast the LWD structures are not available on site and would need to be brought to the proposed locations. The size or number of boulders can be reduced where a long stem lies on the stream bank, as its weight will prevent movement of the rootwad end that is in the stream. Similarly, fewer boulders would be required if the tops of the LWD are buried into the streambank about 2 to 3 m horizontally and 1 m vertically (Figure 9). We recommend that boulder ballasting be concentrated away from the channel thalweg and preferably on the streambanks. Cedar log piles should be considered as another alternative to boulder ballasting. The piles should be 0.5 m in diameter and buried 2.5 to 3 m below the existing thalweg elevation.

LWD that are ballasted with boulders will be anchored by drilling 9/16-5/8" holes in the rock and using Epcon Ceramic 6 epoxy or equivalent and ½ inch galvanized cable (Figure 10). Two options for cabling of LWD to boulders are provided. The second option in Figure 10 provides a more natural appearance by minimizing exposure of the cable.

When fastening cable around live trees, the cable will be as close to the ground as possible or buried approximately 10 cm into the ground and wrapped around the base of a tree. Also, the cable will be wrapped in natural looking nylon or rubber material to protect the living tree. As an alternative to cabling to live trees, duckbill anchors or deadman anchors may be placed in the ground on the bank.

At the time of construction, determining the best location for the LWD structures will require a visual examination of the thalweg profile and plan view of the channel. Typically, the LWD structure will be located at the deepest point in the thalweg profile and upstream of a riffle or shallowest point on the thalweg profile (Figure 11). At all sites, LWD structures will:

- be situated in the thalweg and as close to the bank as possible;
- have a projection width above bankfull depth of less than 30% of the design bankfull width; or conversely
- have at least 70% of the design bankfull width unobstructed by LWD.

5.2 Boulder Placements

Boulder placements or clusters to increase hydraulic diversity on the downstream face and scour pools of riffles are proposed (Tables 3 and 4). Construction of boulder clusters follows a typical design template (Figure 12). Larger diameter boulders should be randomly spaced on the downstream face of the riffles approximately 50 to 70 cm apart to provide greater hydraulic and habitat diversity.

The boulders are selected to be stable at flood stage. An approximation of the maximum size required may be obtained by analyzing the tractive force on the face of the riffle or for the run habitat, and applying guidelines for selecting riprap materials (Newbury and Gaboury 1994). The tractive force T (kg/m^2) may be estimated as T = 1000 x Flow Depth (D in meters) x Slope of the Downstream Face of the Riffle or Run (S in m/m) or:

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

The relationship between tractive force and bed material diameter at incipient motion for pebble-size and larger materials is T (kg/m^2) = diameter (ϕ cm) (Lane 1955). A safety factor of 1.5 x ϕ cm is recommended for selecting stable rock diameters (U.S. Federal Highway Administration 1988).

A conservative depth of flow of 2.5 m and a riffle slope of 2.5% was selected in the tractive force calculations where boulders are placed on the downstream face of the riffle. Stable rock sizes based on the tractive force equation were 0.9 m. The recommended boulder diameter for boulder clusters or riffle enhancement is 0.9 to 1.2 m. The recommended rock sizes will maximize hydraulic diversity and provide optimal habitat conditions for steelhead and rainbow parr.

6.0 PROJECT IMPLEMENTATION

6.1 Access, Logistics, Materials and Labour

Access for delivery of materials to the proposed restoration sites is fair. Permanent and deactivated logging roads in Block 602, currently owned by TimberWest, provide access to Sites 5+600 to 9+380 m. A temporary crossing over the TimberWest side channel would need to be built to provide access to sites downstream of the South Englishman River. Sites downstream of 5+600 m and upstream of the inland Island Highway Bridge would be accessed from Allsbrook Road while the sites downstream of the bridge would be accessed off Martindale and Levirs roads. Some minimal improvements may need to be made to abandoned roads and trails to allow truck access. Short trails off the roads would need to be created to access individual LWD sites. It is recommended that a self-loading logging truck move the LWD to suitable staging areas near the project sites. Similarly, a dump truck should bring boulders to these locations. An excavator or forwarder should then move materials from these drop-off locations to each restoration site.

An excavator should be used to construct the LWD and boulder structures. Drilling, cabling and gluing of the boulders to the LWD should be done by the labour crew. The required crew and machinery will be a crew supervisor, an excavator operator, several swampers, and an environmental monitor. Continued professional input from a biologist/hydrologist that is familiar with LWD and riffle structure construction is recommended.

The materials required to construct the prescriptions as outlined include:

- Large logs, preferably with branches and rootwads attached: 8-15 m long by 0.4-0.7 m average diameter;
- Boulders (0.8 m diameter) for ballasting the LWD;
- Galvanized cable, ½” or larger; and
- Galvanized wood staples and cable clamps.

Special equipment required:

- Excavator (e.g., Hitachi 200 or Cat E70B) for instream complexing;
- Dump and self-loading logging trucks;
- Forwarder;
- Rock and wood drill equipment, and epoxy for fastening cable in rock; and
- Chainsaw winches to pull LWD into place (optional).

Labour required:

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

The estimated cost for implementing the proposed works is $57,170 (Table 6).

6.2 Fish Habitat Construction Timing Windows

The following table summarizes recommended timing windows for instream construction in Region 1 from the Department of Fisheries and Oceans Land Development Guidelines (Chilibeck 1992).

Species	Construction Window
Chinook salmon	15 Jul - 15 Sep
Coho salmon	15 Jun - 15 Sep
Pink salmon	1 May - 15 Aug

Species	Construction Window
Chum salmon	15 May - 15 Sep
Sockeye salmon	1 Jun - 15 Sep
Kokanee	15 Jun - 31 Jul
Steelhead	1 Aug - 15 Nov
Rainbow trout (resident)	15 Aug - 15 Nov
Cutthroat trout (resident)	1 Aug - 30 Sep
Dolly Varden (resident)	1 Jun - 15 Sep
Available Window (pinks present)	15 Aug - 15 Aug
Available Window (no pinks)	15 Aug - 15 Sep

These dates refer to the period when there are no fish eggs or alevins present in the substrates of the river or creek. Please note that specific species timings will change from year to year with variations in spawner run timings and other environmental conditions. Actual permissible windows will be determined by both federal and provincial fisheries staff. In cases where construction activities will be conducted entirely "in-the-dry", extensions to these construction windows may be granted by agency staff.

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 specific sites have been confirmed for implementation (Appendix 1). It is anticipated that construction of the proposed restoration works would proceed during the fisheries work window in one season. Depending on the emergence of trout fry and the presence of pink salmon in the target watershed, construction is recommended during August.

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 the DFO Land Development Guidelines (Chilibeck 1992) and that fish salvage operations are conducted, as necessary. Appendices 2-4 contain 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).

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TABLES

Table 1. Summary of wetted (Sept. 30, 2002) and bankfull channel measurements for each surveyed cross section.

Site (m)	Wetted		Bankfull			Bank Height (m)	Bank Height to Bankfull Depth
	Width (m)	Depth (m)	Width (m)	Depth (m)	Width to Depth Ratio		
7+045	30.7	0.31	37.0	1.24	29.9	1.4	1.1
7+280	13.3	0.60	35.4	1.38	25.7	2.1	1.5
7+450	23.8	0.61	38.7	1.61	24.0	1.7	1.1
8+210	25.1	0.30	49.5	1.51	32.7	3.0	2.0
8+400	21.4	0.32	28.0	0.97	29.0	3.1	3.3
Mean	22.9	0.43	37.72	1.34	28.3	2.3	1.8

Table 2. Estimates of Englishman River channel hydrology and morphology at two flood discharges. Velocity and depth estimated using Manning's equation.

Flood Event	Discharge (cms)	Channel Width (m)	Velocity (m/s)	Estimated n	Depth (m)	Slope (m/m)	Tractive Force (kg/m^2)
2 yr maximum daily	204	38.8	3.52	0.031	1.49	0.007	10.43
2 yr instantaneous	320	38.8	4.21	0.031	1.95	0.007	13.65
50 yr maximum daily	471	50	4.33	0.030	2.17	0.006	13.02
50 yr instantaneous	740	50	5.19	0.030	2.85	0.006	17.10

Note: 1) instantaneous discharge estimated at 1.57 x maximum daily flow (nhc 2002).
2) channel width, slope and roughness for 50 yr floods are approximate.

Table 3. Construction notes for specific restoration sites in Englishman River. Chainage starting at 0+000 m at the river mouth.

Chainage to Structure (m)	Structure Type	Right or Left Bank		Restoration Objectives and Construction Notes
3+760	LTR-3	Left	Rest. Obj.	To provide deep pool and LWD cover along left bank.
			1	Locate at existing shallow pool (0.3-0.4 m deep), approximately 270 m downstream of railway crossing; pre-excavate streambed to create a long narrow pool (2 m wide x 10 m long) with residual water depth of 0.7 m prior to constructing LWD structure.
			2	Construct two LTR-3 structures immediately downstream of live big leaf maple; bank height about 5 m.
3+910	DJ-5	Right	Rest. Obj.	To provide deep pool with LWD cover near right bank.
			1	Locate at existing pool (0.5 m deep); pre-excavate streambed to create a long narrow pool (2 m wide x 10 m long) with residual water depth of 0.7 m prior to constructing LWD structure; bank height about 6 m.
4+030	Railway Bridge Crossing			
4+080	Inland Island Highway Bridge Crossing			
4+460	LTR-3	Right	Rest. Obj.	To provide pool with LWD cover near right bank.
			1	Locate two structures with upstream structure at head of pool and downstream structure sited 20 m below end of upstream
5+600	DJ-5	Left	Rest. Obj.	To provide deep pool with LWD cover near left bank.
			1	Locate two structures with upstream structure at base of riffle and downstream structure sited 20 m below end of upstream
			2	Pre-excavate streambed to create a long narrow pool (2 m wide x 10 m long) with residual water depth of 0.7 m prior to constructing each LWD structure; bank height about 1.5 m rising to about 3 m downstream.
5+700	LO-1	Right	Rest. Obj.	To provide pool with LWD cover near right bank.
			1	Anchor cedar log with rootwad and branches to existing 2.5 m boulder; pre-excavate streambed to create a long narrow pool at head of boulder and where rootwad will be located.
5+900	LTR-3	Left	Rest. Obj.	To provide pool with LWD cover near left bank.
			1	Locate two structures with upstream structure at base of riffle and downstream structure sited 20 m below end of upstream
6+430	Boulder Placement	Mid-channel	Rest. Obj.	To diversify hydraulic habitat on the downstream face and toe of an existing riffle; to improve steelhead parr rearing habitat.
			1	Arrange 8 - 1 to 1.2 m diameter boulders in clusters of four at downstream toe of riffle; create 0.4-0.5 m deep backwater pool downstream of largest boulder by grouping three other boulders in a semi-circle about 1 m downstream of largest boulder; largest boulder placed with longest axis perpendicular to flow.
			2	Diversify the downstream face of the riffle using seven boulders with 0.9-1.0 m diameters.
7+120	LTR-3	Left	Rest. Obj.	To provide pool with LWD cover near left bank.
			1	Locate two structures with upstream structure at base of riffle and downstream structure sited 20 m below end of upstream
7+260	LTR-3	Left	Rest. Obj.	To provide pool with LWD cover near left bank; to increase the area of high quality steelhead parr summer rearing habitat.
			1	Locate two LTR-3 LWD structures with upstream structure at base of riffle and downstream structure sited 20 m below end of upstream structure.

Chainage to Structure (m)	Structure Type	Right or Left Bank		Restoration Objectives and Construction Notes
7+420	LTR-3	Left	Rest. Obj.	To provide pool with LWD cover near left bank; to increase the area of high quality steelhead parr summer rearing habitat.
			1	Locate in 1.5 m deep pool at base of riffle; anchor to deadman log (0.5-0.7 m diameter x 5 m long) buried 2 m deep in left bank.
8+140	LTR-3	Right	Rest. Obj.	To provide pool with LWD cover near right bank; to increase the area of high quality steelhead parr summer rearing habitat.
			1	Locate in deep pool about 50 m upstream of eroding clay banks; one log should have a rootwad and branches; two logs are without rootwad and branches; and one log should have a rootwad.
			2	Place one log without rootwad on a diagonal and upstream of the live cedar to deflect flows away from the bank; log should be sloped down from the bank into the water, and top of log should be less than 0.3 m higher than water surface at water's edge; riprap at base of bank on upstream side of structure to reduce erosion on roots of live cedar.
8+240	LTR-3	Left	Rest. Obj.	To provide pool with LWD cover near left bank; to increase the area of high quality steelhead parr summer rearing habitat.
			1	Locate two LTR-3 LWD structures with upstream structure at base of riffle and downstream structure sited 20 m below end of upstream structure.
			2	Where feasible, embed logs into bank to increase structure stability.
8+300	South Englishman River confluence			
8+600	DJ-5	Right	Rest. Obj.	To provide pool with LWD cover near right bank.
			1	Locate structure immediately downstream of bedrock outcrop and in 0.9 m deep pool adjacent to bank.
8+820	LTR-3	Left	Rest. Obj.	To provide pool with LWD cover near left bank; to increase the area of high quality steelhead parr summer rearing habitat.
			1	Two existing hemlock deadfalls with attached rootwads on site.
			2	Add additional LWD and SWD or short riprap groyne on upstream side of structure to reduce outflanking of structure and potential bank erosion.
			3	Where feasible, embed logs into bank to increase structure stability.
8+960	DJ-5	Left	Rest. Obj.	To provide pool with LWD cover near left bank.
			1	1.5 m deep pool adjacent to left bank.
			2	Additional anchoring of LWD to two live cedars.
9+380	DJ-5	Left	Rest. Obj.	To provide pool with LWD cover near left bank (site immediately upstream of side channel inlet structure).
			1	LWD should extend beyond bedrock shelf along left bank (3-4 m) into 3 m deep pool.
			2	Additional anchoring of LWD to existing bedrock and large live cedar.
9+590	Morison Creek confluence			

Note: Unless stated otherwise, it is assumed that:
1 - A sufficient number and size of rock do not exist on site to ballast LWD structure. Additional ballast rock will need to be brought to the site.
2 - Anchor LWD to live trees or stumps on streambank with diameter >20 cm. Alternatively, embed tops of logs 2-3 m horizontally and 1 m vertically into the bank. Backfill trench with spoil from excavation.

Table 4. Summary of materials required for LWD and boulder structures in Englishman River. Chainage starting at 0+000 m at the river mouth.

Chainage (m)	Structure Type	Right or Left Bank	LWD Required	LWD Size (m)	LWD Ballast		Boulders	Comments
					Boulders Required	Diameter (m)	Diameter (m)	
3+760	LTR-3	Left	6	0.5 x 10/15	26	0.8		Two logs 10 m with rootwads, two logs 15 m with rootwads and two logs 15 m without rootwads
3+910	DJ-5	Right	5	0.5 x 15	15	0.8		Two logs with rootwads, three without
4+460	LTR-3	Right	6	0.5 x 10/15	26	0.8		Two logs 10 m with rootwads, two logs 15 m with rootwads and two logs 15 m without rootwads
5+600	DJ-5	Left	10	0.5 x 15	31	0.8		Four logs with rootwads, six without
5+700	LO-1	Right	1	0.5 x 10				2.5 m boulder on site; use cedar log with rootwad and
5+900	LTR-3	Left	6	0.5 x 10/15	26	0.8		Two logs 10 m with rootwads, two logs 15 m with rootwads and two logs 15 m without rootwads
6+430	Boulder Placement	Mid-channel					1.0-1.2	Add 35 boulders
7+120	LTR-3	Left	6	0.5 x 10/15	26	0.8		Two logs 10 m with rootwads, two logs 15 m with rootwads and two logs 15 m without rootwads
7+260	LTR-3	Left	6	0.5 x 10/15	26	0.8		Two logs 10 m with rootwads, two logs 15 m with rootwads and two logs 15 m without rootwads
7+420	LTR-3	Left	4	0.5 x 5 to 15	14	0.8		One log 10 m with rootwad, one log 15 m with rootwad, and one log 15 m without rootwad; 5 m log deadman
8+140	LTR-3	Right	4	0.5 x 10/15	15	0.8		One log 10 m with rootwad, one log 15 m with rootwad and two logs 15 m without rootwad
8+240	LTR-3	Left	6	0.5 x 10/15	26	0.8		Two logs 10 m with rootwads, two logs 15 m with rootwads and two logs 15 m without rootwads
8+600	DJ-5	Right	5	0.5 x 15	15	0.8		Two logs with rootwads, three without
8+820	LTR-3	Left	3	0.5 x 10/15	14	0.8		One log 10 m with rootwad, one log 15 m with rootwad and one log 15 m without rootwad
8+960	DJ-5	Left	5	0.5 x 15	15	0.8		Two logs with rootwads, three without
9+380	DJ-5	Left	5	0.5 x 15	15	0.8		Two logs with rootwads, three without
Total			78		290			

Table 5. Ballast requirements and boulder size options for the LWD structures in Englishman River. Buoyancy and sliding safety factors ≥ 1.5; ballast factor = 1; and specific gravity of LWD (S_L) = 0.5. Modified after D'Aoust and Millar (1999).

Chainage (m)	Structure Type	No. of Logs	Average Submerged Length of Each Log (m)	Log	Rootwad	Total Mass of Ballast Required (kg)	Alternative Quantities for Each Boulder Diameter (m)							
				0.5 @ 190 or 500 kg/m	660 kg/log (0.5x2x3m)		0.3 @ 35 kg	0.4 @ 90 kg	0.5 @ 190 kg	0.6 @ 300 kg	0.7 @ 480 kg	0.8 @ 700 kg	0.9 @ 1000 kg	1 @ 1400 kg
3+760	LTR-3	6	10	15600	2640	18240	521	203	96	61	38	26	18	13
3+910	DJ-5	5	10	9500	1320	10820	309	120	57	36	23	15	11	8
4+460	LTR-3	6	10	15600	2640	18240	521	203	96	61	38	26	18	13
5+600	DJ-5	10	10	19000	2640	21640	618	240	114	72	45	31	22	15
5+700	LO-1	1	10	5000	660	5660	162	63	30	19	12	8	6	4
5+900	LTR-3	6	10	15600	2640	18240	521	203	96	61	38	26	18	13
6+430	Boulder Placement													
7+120	LTR-3	6	10	15600	2640	18240	521	203	96	61	38	26	18	13
7+260	LTR-3	6	10	15600	2640	18240	521	203	96	61	38	26	18	13
7+420	LTR-3	3	10	7800	1980	9780	279	109	51	33	20	14	10	7
8+140	LTR-3	4	10	7800	2640	10440	298	116	55	35	22	15	10	7
8+240	LTR-3	6	10	15600	2640	18240	521	203	96	61	38	26	18	13
8+600	DJ-5	5	10	9500	1320	10820	309	120	57	36	23	15	11	8
8+820	LTR-3	3	10	7800	1980	9780	279	109	51	33	20	14	10	7
8+960	DJ-5	5	10	9500	1320	10820	309	120	57	36	23	15	11	8
9+380	DJ-5	5	10	9500	1320	10820	309	120	57	36	23	15	11	8

Table 6. Cost estimate (2002) for restoration project in Englishman River.

	Description	Unit	Unit Cost	Approx. Quantity	Cost
Major Equipment:					
1	Excavator, all found	hour	$125	80	$10,000
2	Excavators mob/demob.	km	$1.40	50	$70
3	Forwarder/small excavator	hour	$100	40	$4,000
4	Dump Truck, all found	hour	$70	30	$2,100
5	Self-loading Logging Truck, all found	hour	$80	40	$3,200
Sub-total major equipment					**$19,370**
Manpower:					
1	Project Coordinator (1)	pers-day	$500	20	$10,000
2	Restoration Specialist (1)	pers-day	$730	3	$2,190
3	Semi-skilled Labour (2)	pers-day	$250	15	$3,750
Sub-total manpower					**$15,940**
Light Equipment:					
1	Drilling Equipment Rental	week	$500	2	$1,000
Sub-total light equipment					**$1,000**
Materials:					
1	LWD With and Without Rootwads	log	$200	78	$15,600
*2	Ballast Rock (0.8 m) for LWD Structures	m^3	$20	148	$2,960
3	Boulders for Clusters	m^3	$20	15	$300
4	Miscellaneous (epoxy, clamps, cable, etc)		$1,000	2	$2,000
Sub-total materials					**$20,860**
Total Cost					**$57,170**

Note: *Assume 0.8 m diameter boulder has a volume of 0.51 m^3

FIGURES

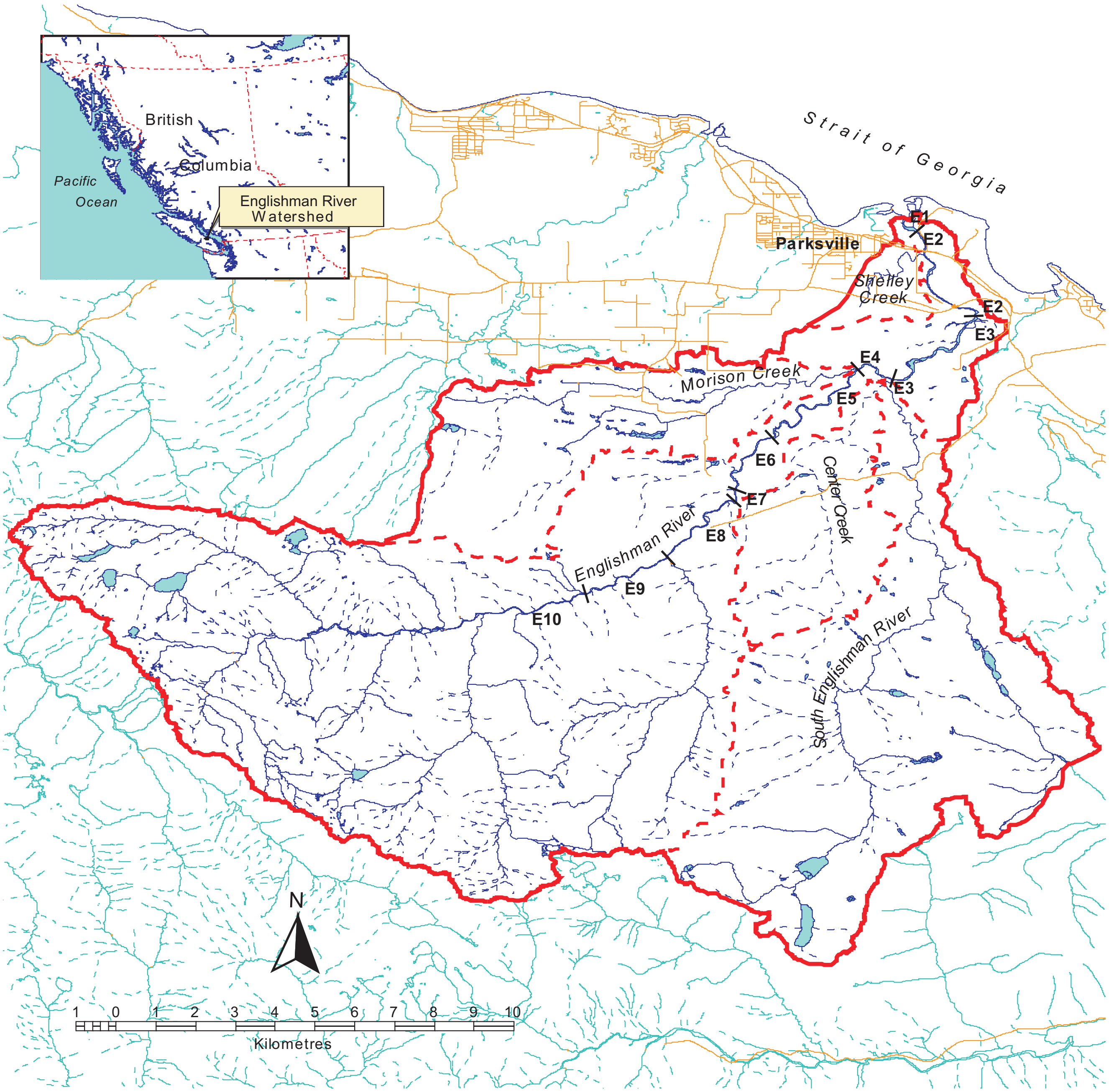


Figure 1. Index map of Englishman River watershed. Reaches for mainstem from nhc (2002).

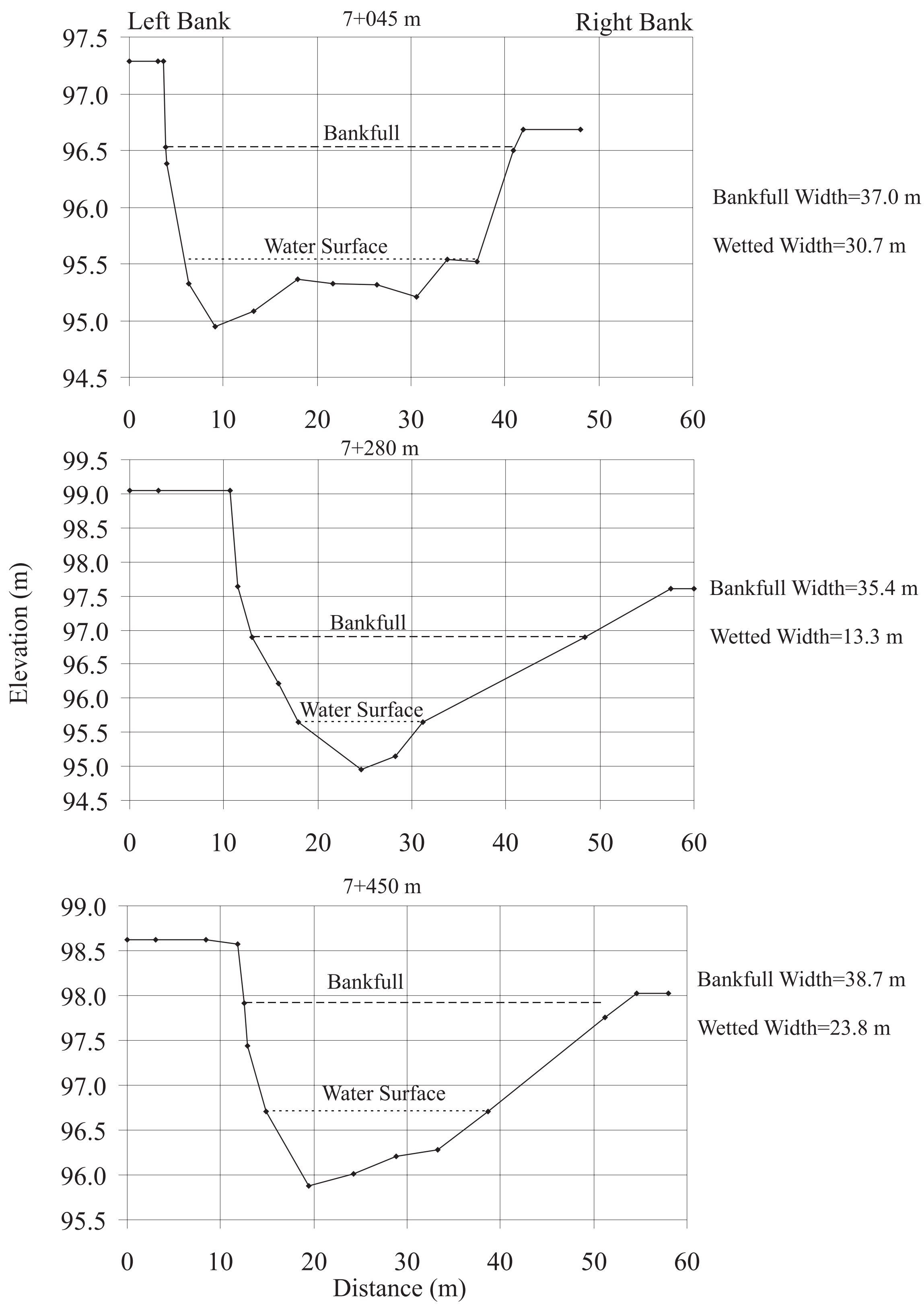


Figure 2. Representative cross sections in Englishman River near restoration Sites 7+120, 7+260 and 7+420 m.	LGL Limited

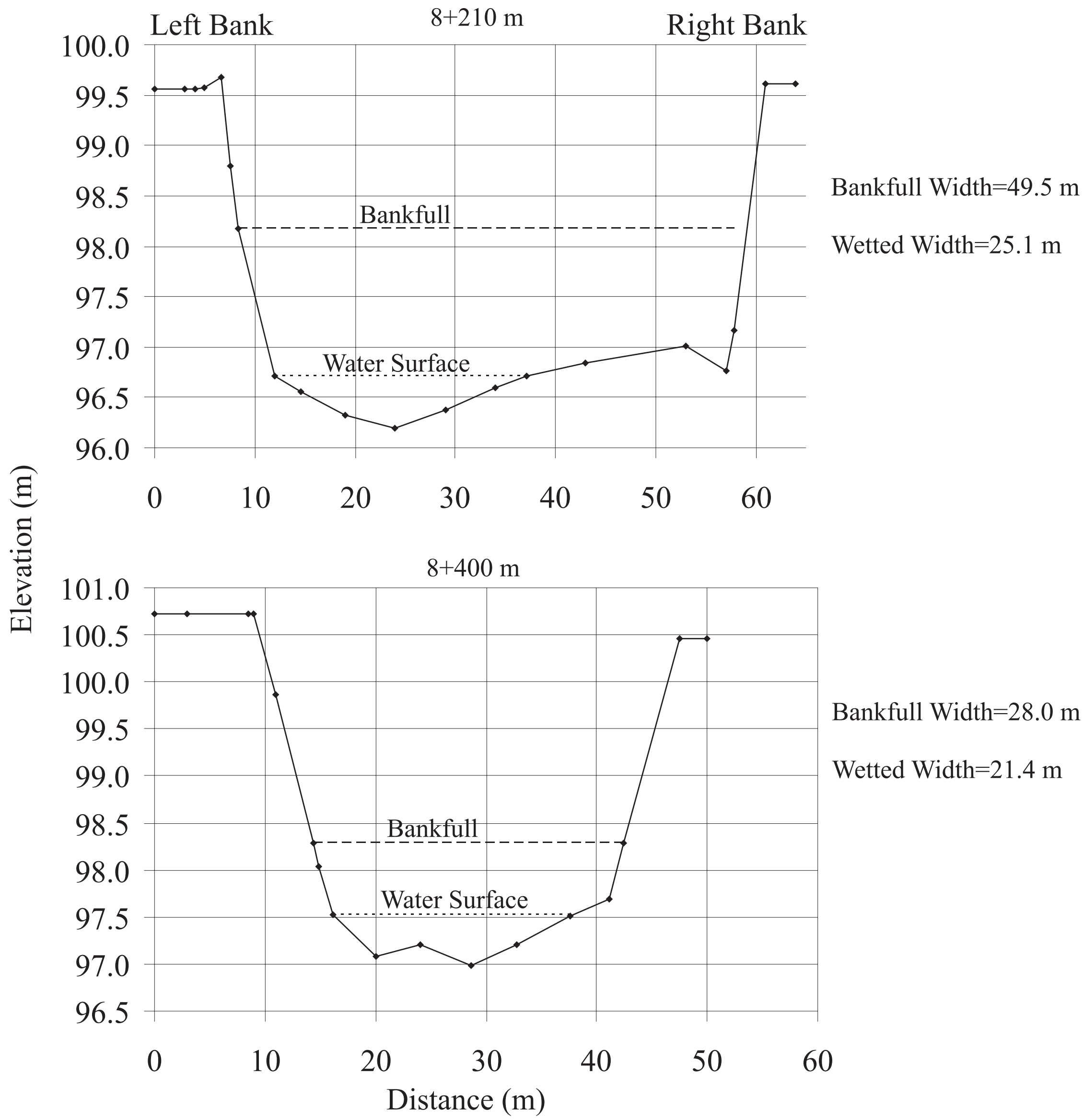


Figure 3. Representative cross sections in Englishman River near restoration Site 8+240 m.	LGL Limited

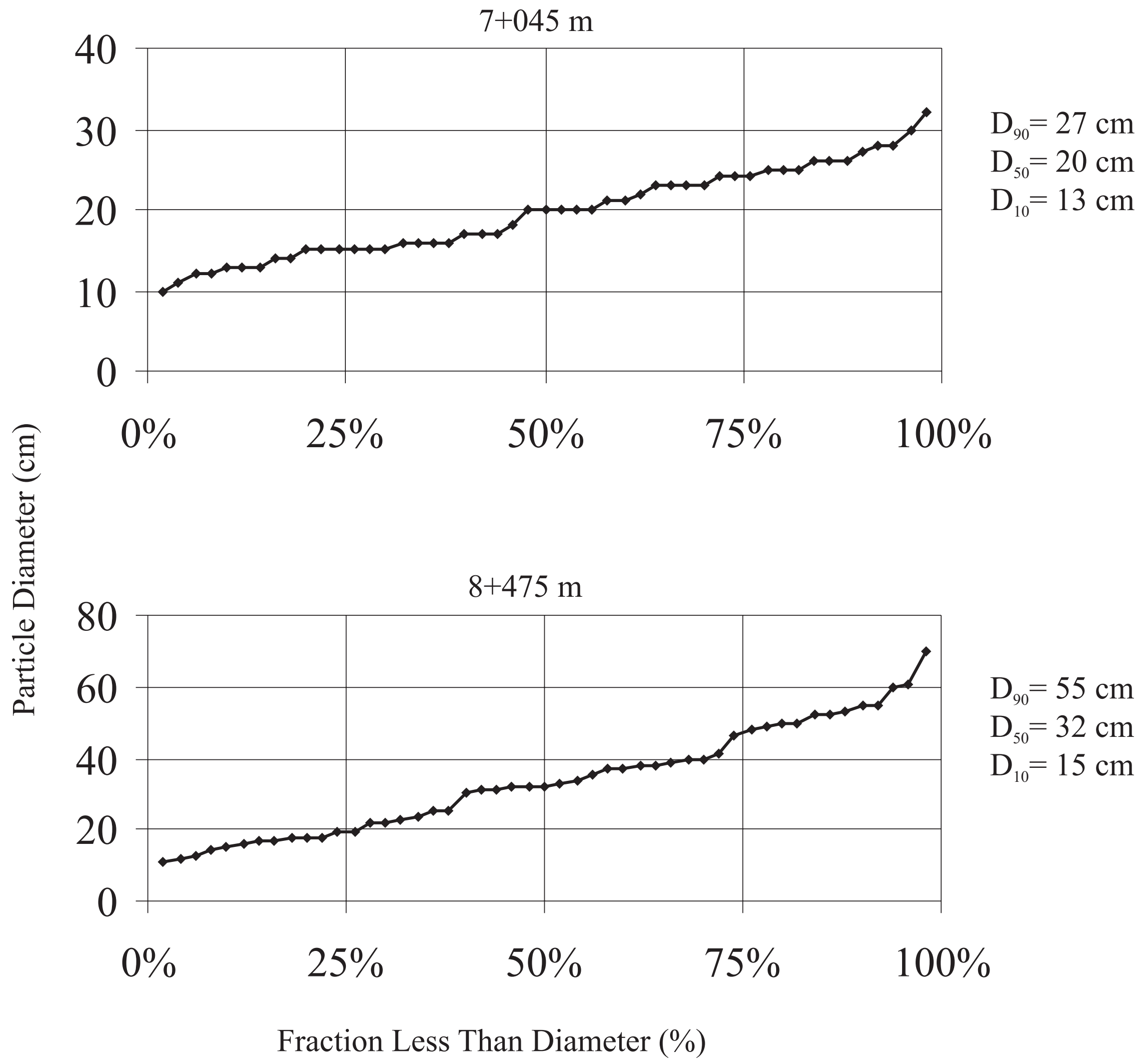


Figure 4. Substrate characteristics from pebble counts in Englishman River.

LGL Limited

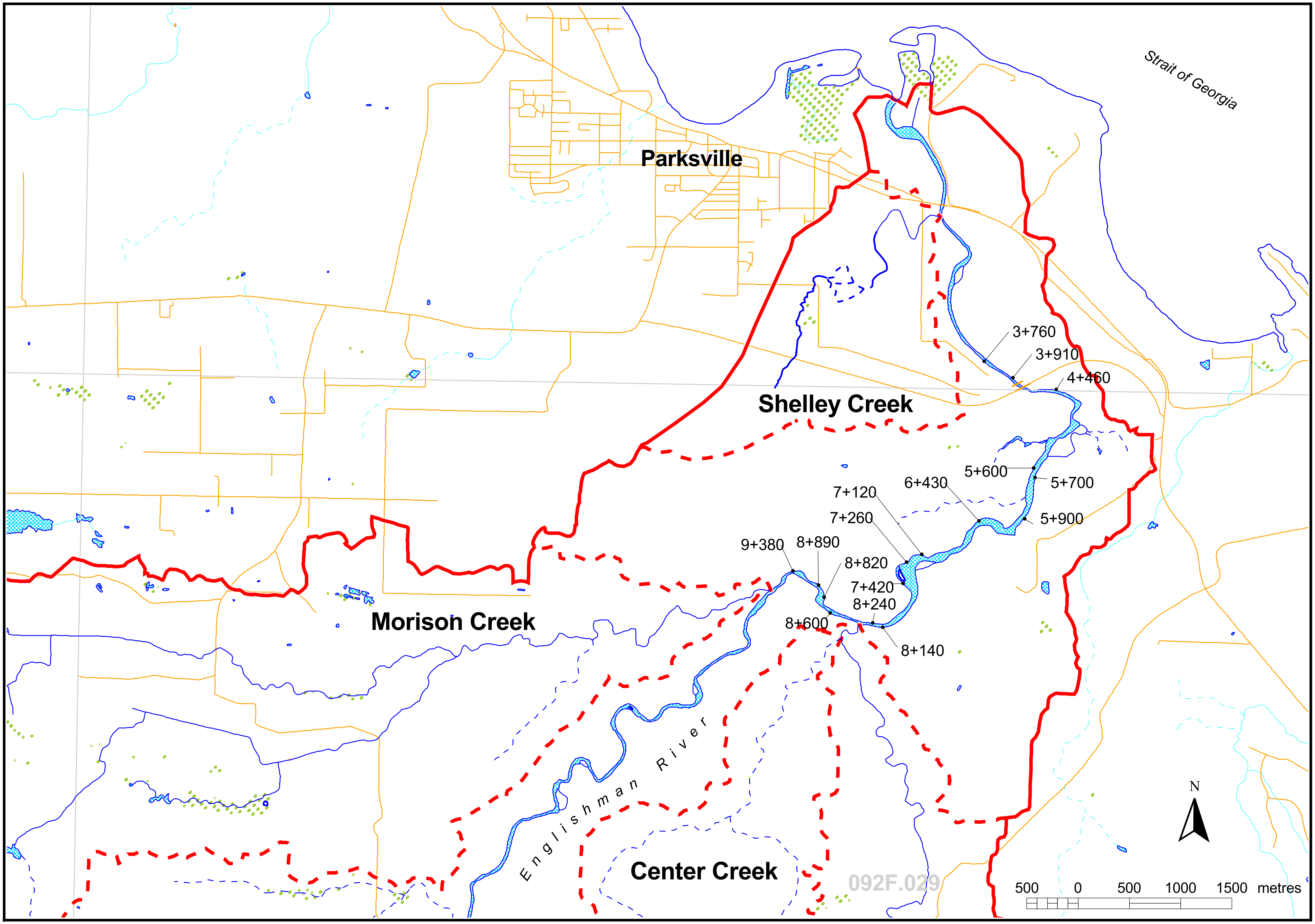
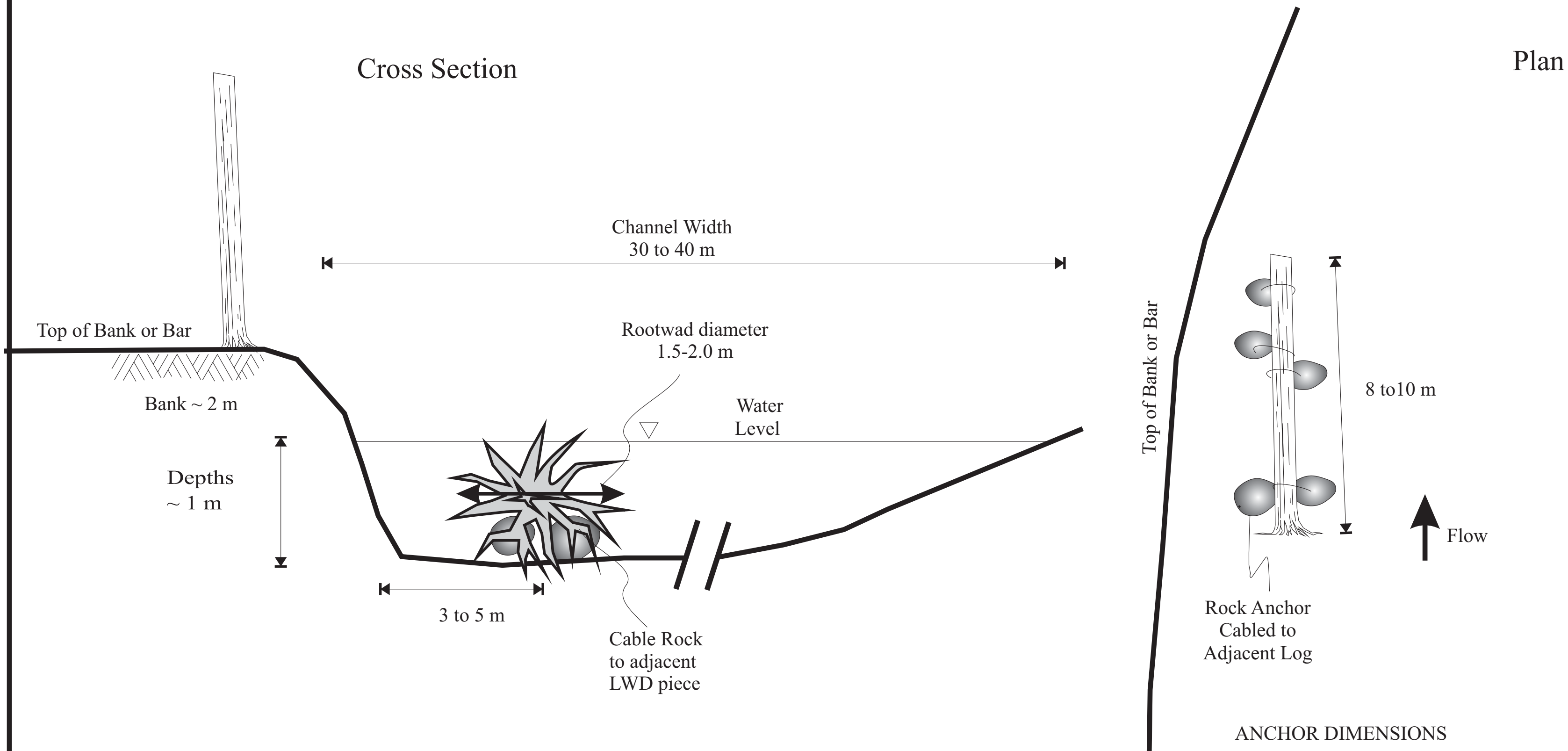


Figure 5. Map showing proposed habitat restoration sites in Englishman River.



ANCHOR DIMENSIONS

Rock Required:

5 - 0.9 m diameter or
7 - 0.8 m diameter boulders

Construction Notes:

1) Use LWD pieces about 8 to 10 m long x 0.5 m bole diameter (dbh).
2) Number and size of rock anchors depends on predicted maximum discharge, maximum flow velocity and number and size of LWD used.
3) Leave cable anchors slack so that rock anchors scour into stream bed.
4) Logs with rootwads attached to be used where available. Care should be given to the positioning of the anchors to not allow the LWD to shift downstream.

LWD Design: LO-1

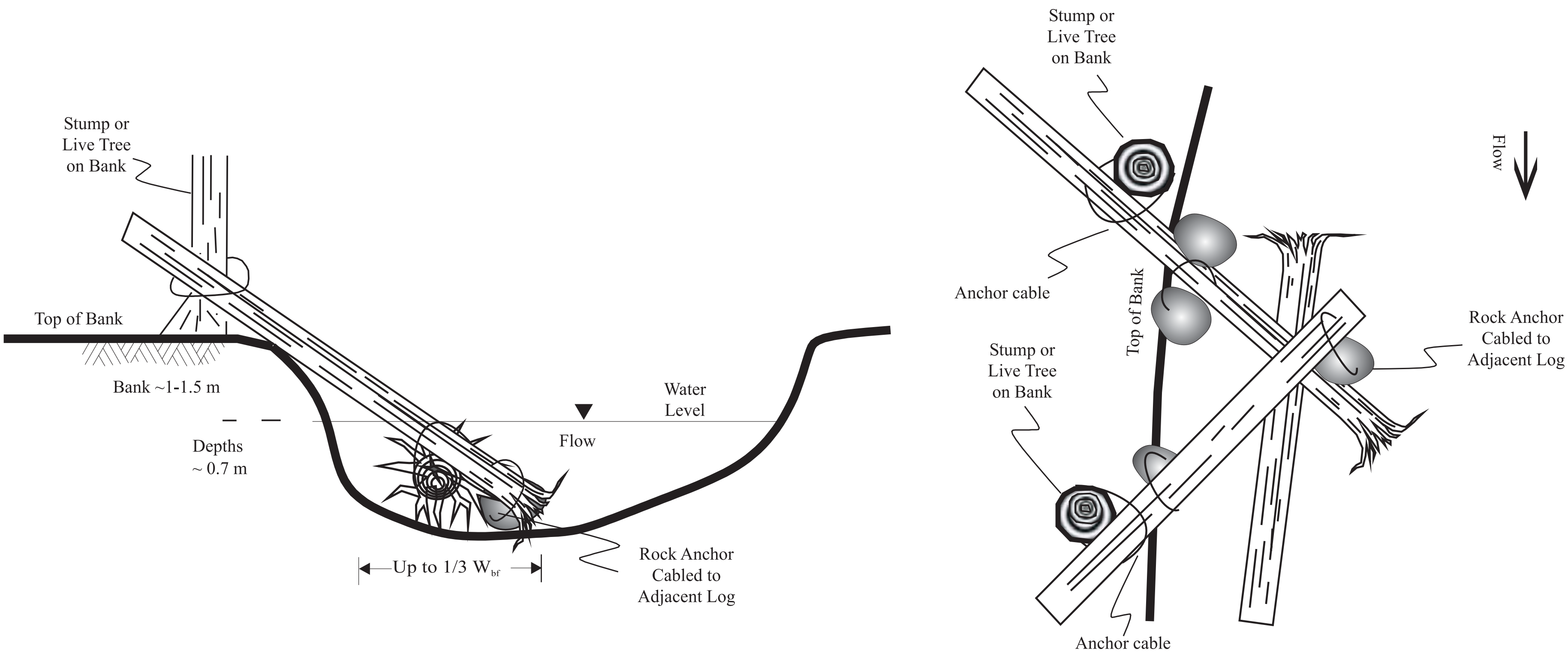
Figure 6. Typical Single LWD Structure - Plan and Cross Section

LGL Limited

Scale: Not to Scale

Cross Section

Plan



Construction Notes:

1) Use LWD pieces 10 to 15 m long x 0.5 m diameter.
2) Number and size of rock anchors depends on predicted maximum flow, maximum flow velocity and number and size of LWD used.
3) Leave cable anchors slack so that rock anchors scour into streambed.
4) If using deadman anchors instead of stumps or live trees on the bank care should be given to the positioning of the anchors to not allow the LWD to shift downstream.
5) Logs with rootwads attached to be used where available.
6) Limit LWD projection width to 1/3 of channel width or based on site conditions.

ANCHOR DIMENSIONS

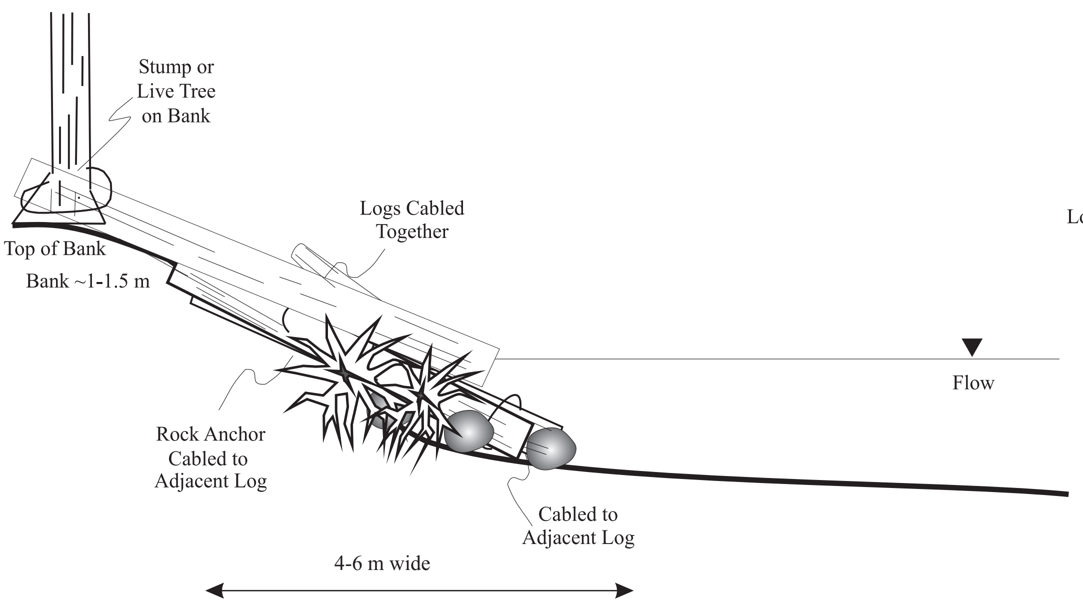
Rock Required (assuming logs with rootwads):
14 - 0.8 m diameter boulders

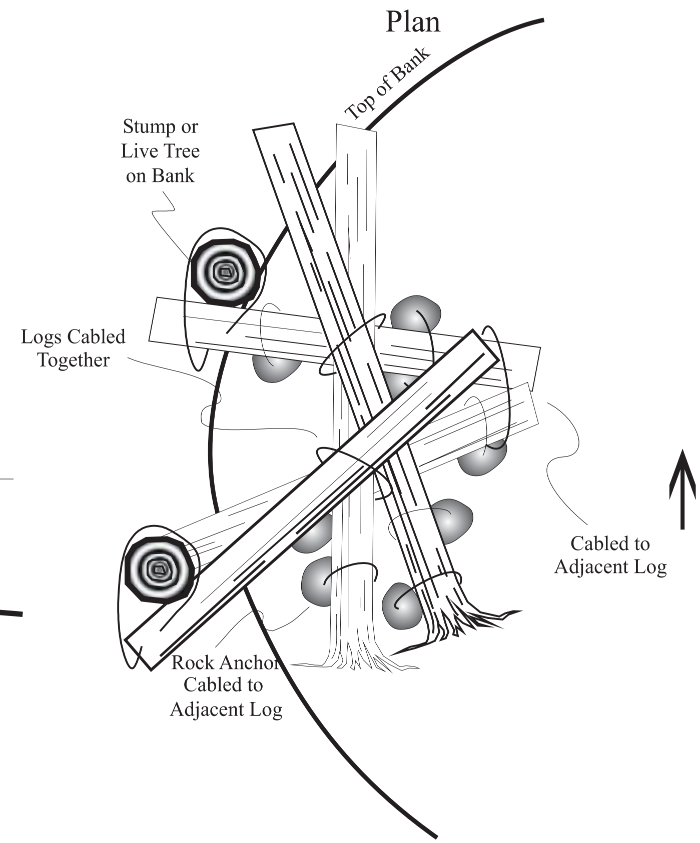
LWD Design: LTR-3

Figure 7. Typical Triangular LWD Structure, Plan and Cross Section

LGL Limited

Scale: Not to Scale





ANCHOR DIMENSIONS

Rock Required:
17 - 0.6 m diameter or
7 - 0.8 m diameter boulders

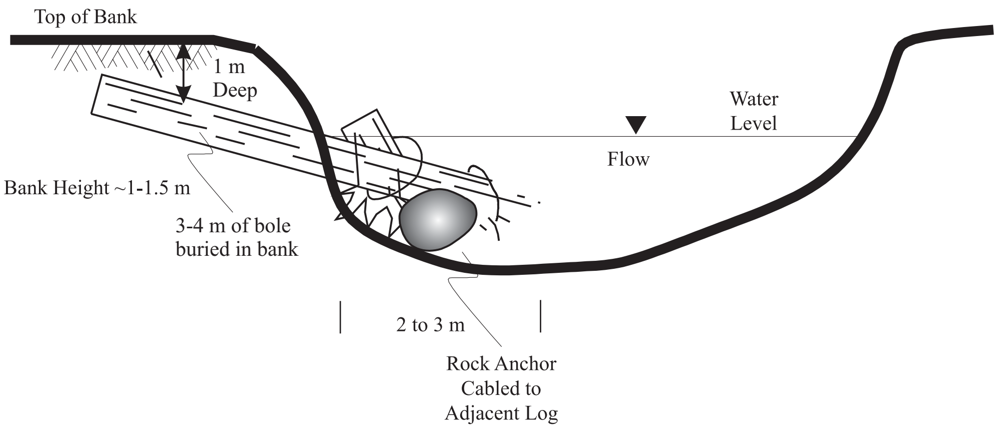
Construction Notes:

1) LWD pieces may be between 10 and 12 m long x 0.5 m diameter.
2) Number and size of rock anchors depends on predicted maximum flow, maximum flow velocity and number and size of LWD used.
3) Leave cable anchors slack so that rock anchors scour into stream bed.
4) If using deadman anchors instead of stumps or live trees on the bank care should be given to the positioning of the anchors to not allow the spur to shift downstream.

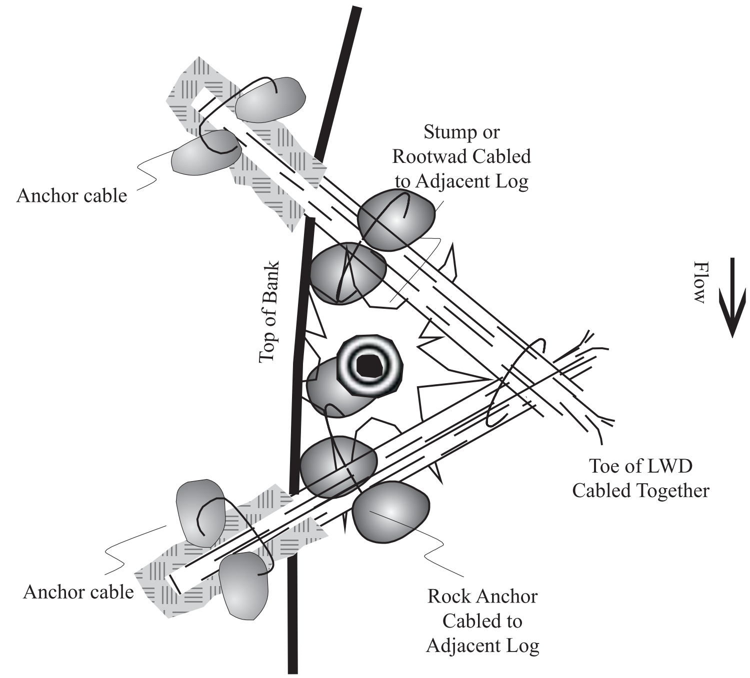
LWD Design: DJ-5
Figure 8. Typical LWD Jam Structure, Plan and Cross Section.

LGL Limited	Scale: Not to scale

Cross Section



Plan



ANCHOR DIMENSIONS
Rock Required (assuming logs with rootwads):
5 - 0.6 m diameter or
2 - 0.8 m diameter boulders

Construction Notes:

1) Use LWD pieces 8 to 10 m long x 0.3 m diameter.
2) Number and size of rock anchors depends on predicted maximum flow, maximum flow velocity and number and size of LWD used.
3) Leave cable anchors slack so that rock anchors scour into stream bed.
4) If using deadman anchors instead of stumps or live trees on the bank care should be given to the positioning of the anchors to not allow the LWD to shift downstream.
5) Logs with rootwads attached to be used where available.
6) Limit LWD projection width to 30% of channel width or based on site conditions.

LWD Design: LT-3

Figure 9. Typical Embedded Triangular LWD Structure Plan and Cross Section

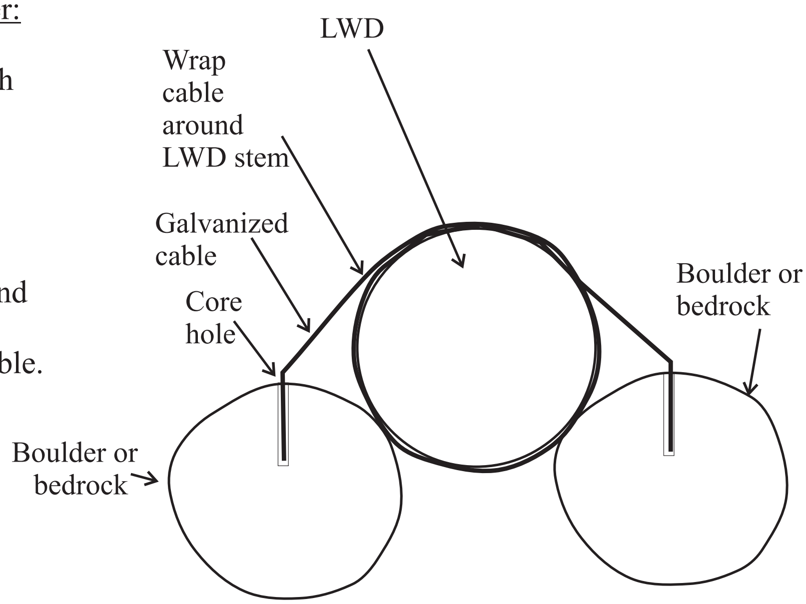
LGL Limited

Scale: Not to Scale

Two Cabling Options

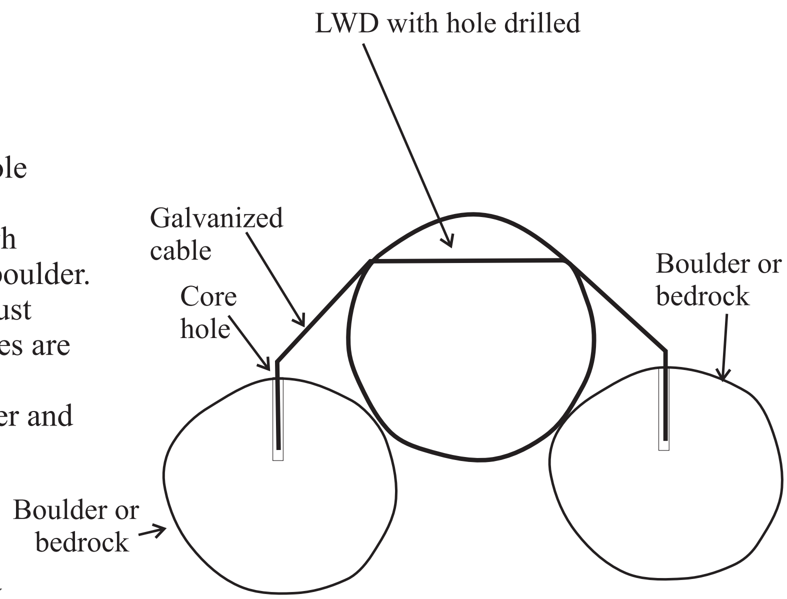
Attach cable to rock in following manner:

1- drill hole in rock 0.2-0.25 m deep with bit 1/16" larger in diameter than cable diameter (9/16" hole recommended).
2- clean holes thoroughly of dust using wire brush and water. Ensure holes are completely clean.
3- wrap cable (1/2" recommended) around LWD, and tighten.
4- squeeze epoxy into hole and insert cable.



Attach cable to rock in following manner:

1- drill a hole through the LWD using a hole diameter slightly larger than cable.
2- Pass the cable from one boulder, through the hole, and back down to the second boulder.
3- clean holes in boulders thoroughly of dust using wire brush and water. Ensure holes are completely clean.
4- squeeze epoxy into holes in each boulder and insert cable.



For additional information, refer to Slaney and Zaldokas (1997) WRP technical circular number 9, chapter 8, page 26.

Use Epcon Ceramic 6 epoxy or equivalent.

Figure 10. Detail for attaching boulders to LWD.

LGL Limited

Scale: Not to scale

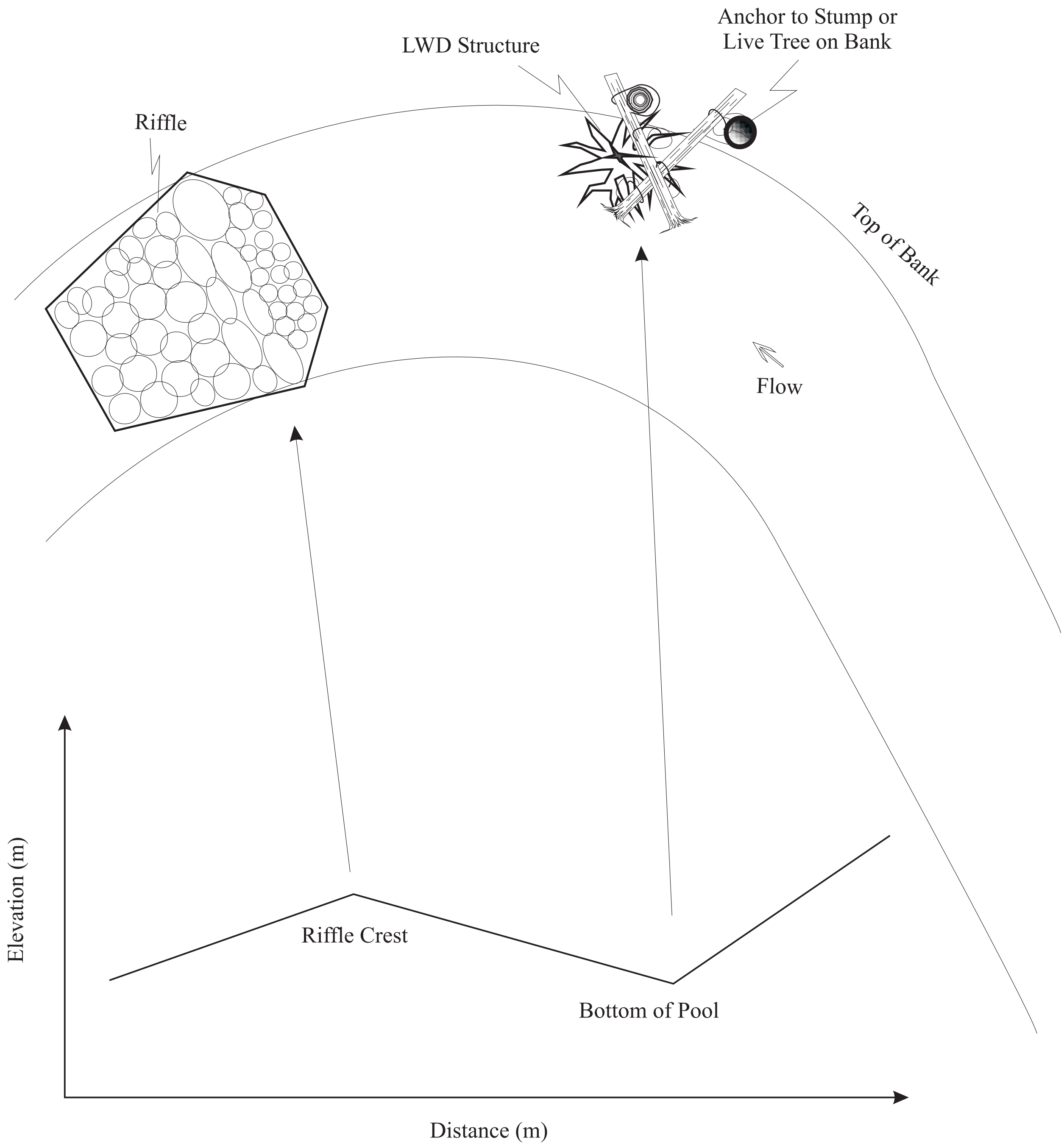
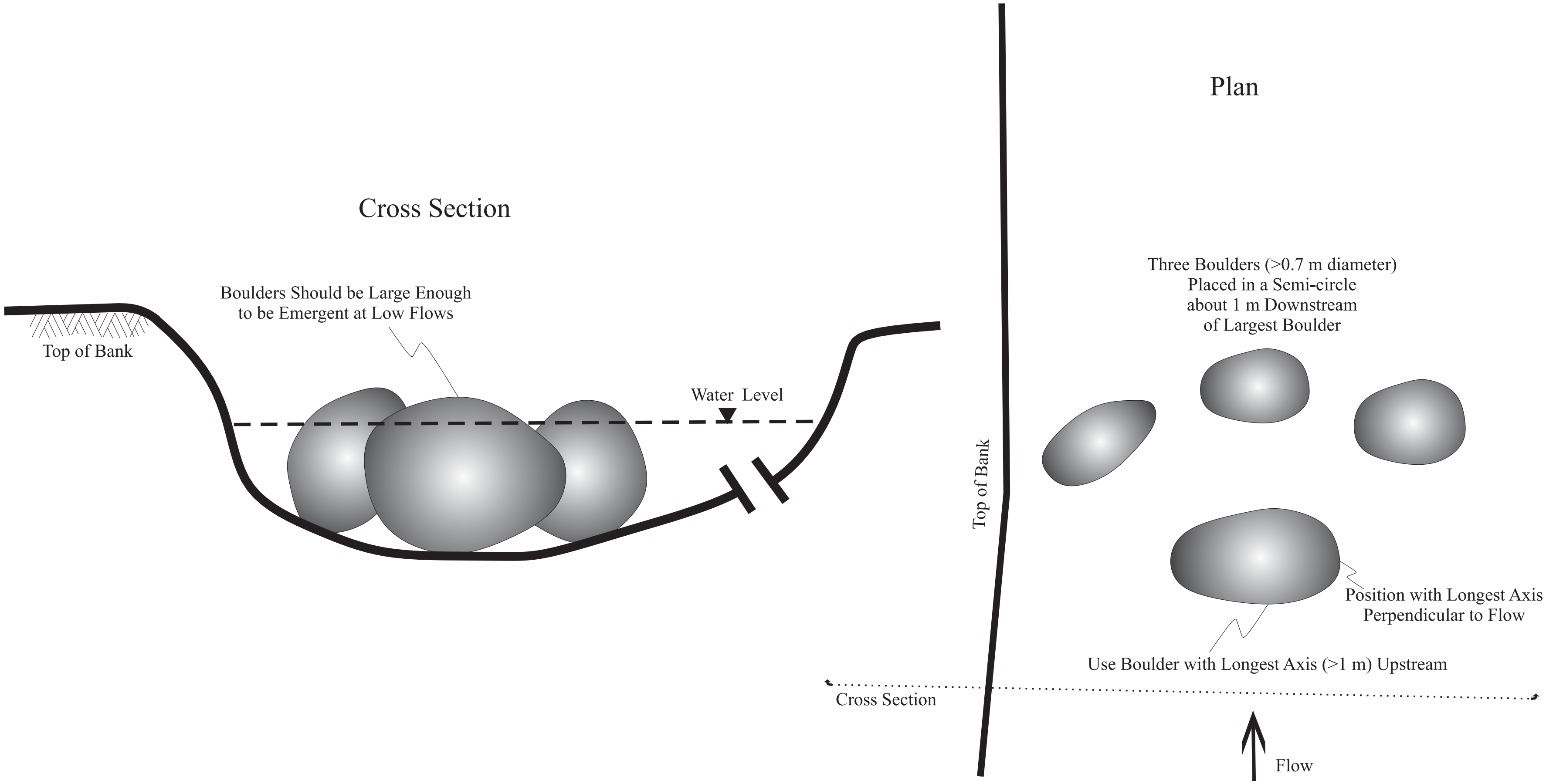


Figure 11. LWD structure placement - the preferred location in plan and profile views.

LGL Limited	Scale: Not to Scale



Construction Notes:

1) Arrange four boulders to create a 0.4-0.5 m deep backwater pool downstream of boulder with longest axis and largest diameter.
2) Three boulders should be placed in a semi-circle downstream of the largest boulder to create a backwatering effect.
3) Largest boulder should be >1 m long on one axis, while the three others should be >0.7 m in diameter.

	LWD Design: Boulder Cluster
	Figure 12. Construction template for a boulder cluster. Plan and Cross Section
LGL Limited	Scale: Not to scale

APPENDICES

Appendix 1

Notification for Proposed Works and Changes In and About a Stream under Water Act Regulation 204/88.

Appendix 1. Notification for Proposed Works and Changes In and About a Stream under Water Act Regulation 204/88

Please refer to the application guidelines (attached), and the Regulation (Users Guide) when completing this Notification Form

1. Applicant Name:

Mailing Address: ____________________

City: ____________________ Postal Code:

Phone: (____) ____-________ Cell Ph: (__) -________ Fax: (___) ______-

2. Location of Works:

Stream Name:

Location on Stream (Property Address):

What stream\river\lake\water body does it flow into?:

Legal description of property where work proposed

3. Drawing, Plan & Site Map: attach an accurate drawing showing lot boundaries, location of proposed works/structures with cross-section, stream direction and flow and location of buildings; photos of existing site. Design drawing of structure. Also include a key map showing location of site.

4. Proposed Timing for work in/ about a stream: Start (day/month/year):__________________Finish (day/month/year):

5. Type of Works. Check appropriate box - - circle whether installation or removal, where applicable:
(Also refer to attached sheet of definitiions)

☐ (a) Road crossing culvert (I) installation (give details of type and dimensions below*) (ii) removal
☐ (b) Clear span bridge (I) installation (ii) removal
☐ (c) Pipeline crossing
☐ (d) Pier or wharf (I) installation (ii) removal
☐ (e) Flow or water level measuring device by Federal or Provincial government (I) installation (ii) removal
☐ (f) Fish fences or screens, fish or game guards by Federal or Prov. Government (I) installation (ii) removal
☐ (g & h) Stream channel restoration or maintenance by a municipality or the Province_
☐ (i) Cutting annual vegetation in a stream channel
☐ (j) Fish habitat restoration or maintenance by Federal or Provincial government_
☐ (k) Repair or maintenance to existing dike or erosion protection works
☐ (l) Construction or maintenance of storm sewer outfalls
☐ (m) Control of Eurasion Watermilfoil or other aquatic vegetation_
☐ (n) Construction or maintenance of ice bridges, winter fords or snowfills
☐ (o) Construction/placement of erosion protection at direction of the Crown during flood emergency
☐ (p) Clearing obstruction from bridge or culvert by the Crown or a municipality during a flood event
☐ (u) Maintenance of a minor and routine nature by a public utility
☐ (v) Beaver dam removal
☐ (w) Construction of a temporary ford

Dimensions: Length ___________ Width ________________ Diameter ______________________________

*Detailed Description of Work to be Performed: (attach appropriate drawings)

_6. Land Ownership: Do you own the land on which the work is to occur? Yes ☐ No ☐

IF NOT, who owns the land?

Private:_____ Crown:__________

Landowner Name:__________________________

Mailing Address:__________________________Phone: (____) _____-

Landowner's Signature: ____________________(Attach tenure document for Crown land)

7. Who is Doing the Work?

Contractor: if different from applicant:

Company Name:

Contact Name:

Address: ____ Postal Code:

Phone: (____) _____-__________Fax: (____) _____-

8. Statement of Intent:

I declare that the information contained on this form is complete and accurate. I have read, understood and will meet the requirements for construction of works and changes in and about a stream in accordance with Section 9 of the Water Act and the Regulation.

Signed: ____ Date:

__Notification for Proposed Works and Changes

In and About a Stream Water Act Regulation 204/88

Application Guidelines

Please fill in all sections of the form. Incomplete forms do not constitute notification and will not be processed. Instead, incomplete forms will be returned to the applicant and this may result in delays for the commencement of the project. Your application must be received by the Designated Habitat Officer a minimum of 45 days prior to commencement of any work, and should accommodate local fish timing windows.

1. Name and mailing address

Enter your name, mailing address, telephone number, and fax number (if applicable).

2. Location of works

Identify the name of the stream on which you intend to carry out the proposed works.

Indicate which stream, river, lake, or body of water the above stream flows into.

Specify where on the stream the works are to take place (eg. distance from road crossing or confluence with another stream).

Indicate property address for location of works, if different from your mailing address.

Provide a complete legal description of the property on which the works are to be carried out.

3. Drawing, Plan and Site Plan

Attach a drawing, to scale, or accurate map which clearly shows:

- the lot boundaries of the property on which the works are to take place
- the location of proposed works
- the stream and direction flow
- a key map to identify the general location of the site

4. Proposed Timing (taking into consideration local fish timing windows)

Indicate proposed start and finish of the work in and about a stream (day/month/year).

5. Type of Works (Refer to attached sheet of definitions)

Identify the type of work by checking one of the boxes.
Describe details of how the work is to be performed, equipment used, method of construction, anticipated duration of time working instream, site preparation and reclamation activities and specifics or details of works installed e.g. size of culvert, bridge span, pipe line size, etc.

6. Ownership of the Land

If you own the land on which the works are to be carried out check 'yes' and go to question 7.

If you do not own the land, indicate whether the land is privately owned or owned by the Crown.

You must have the landowner's approval. The landowner must enter his/her address, telephone number and postal code and sign. If the land is owned by the Crown, please attach the appropriate tenure document.

7. Who is Doing the Work

If you are not carrying out the work yourself, indicate contractor/company's name, mailing address, postal code and telephone numbers.

8. Statement of Intent

After you have read and understood the conditions outlined in Part 7, Regulation 204/88, and made sure your project meets all requirements, sign and date the form.

When your form is complete, send it along with the sketch and site plans to the BC Environment office at the addresses below. The form must reach the BC Environment office at least 45 days prior to the start of works to allow for the determination of the applicable site specific requirements.

Attention: Eileen Wright
Vancouver Island Region
Ministry of Environment, Lands & Parks
2080-A Labieux Rd
Nanaimo BC V9T 6J9

Appendix 2

Guidelines for Instream Work
(Chilibeck 1992)

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/MOELP 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/MOELP 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/MOELP.
- 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/MOELP.

- 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/MOELP personnel responsible for the local area in which the proposed development is located**. Site specific differences exist and DFO/MOELP 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.

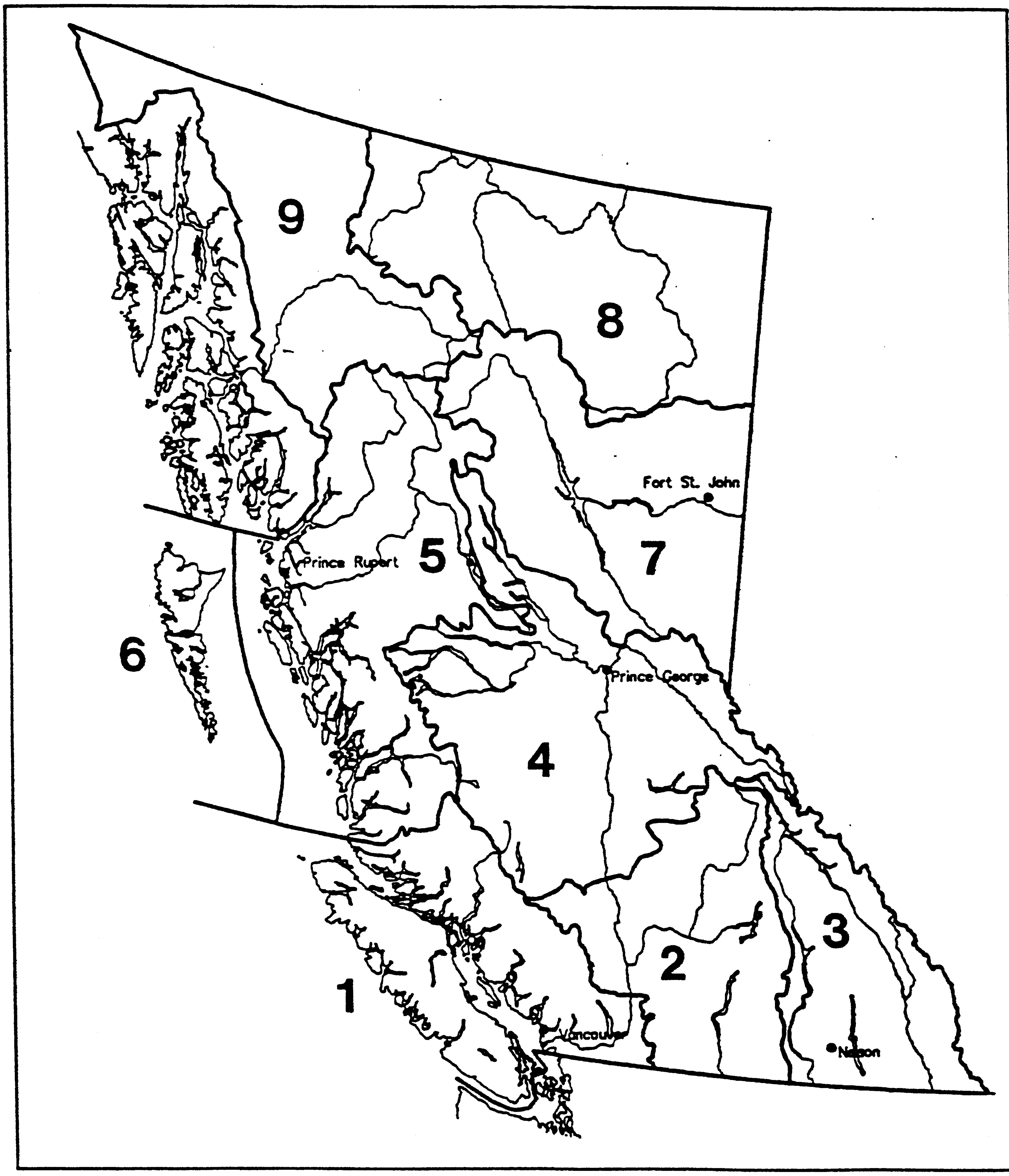
Maintenance of Instream Structures

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.

Appendix 3

Fishery Construction Windows for BC
(Chilibeck 1992)

Figure A3.1 Fisheries Sensitive Zone Areas of British Columbia



BC Fisheries Zones (from Chilibeck, 1992 and FPC 1996)

Species**	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8	Area 9
Chinook salmon	Jul 15-Sep 15	Jun 15-Jul 31	N/A	Jun 15-Jul 15	Jun 15-Jul 31	Jun 01-Jul 31	N/A	N/A	May 01-Jul 31
Coho salmon	Jun 15-Sep 15	Jul 01-Sep 30	N/A	Jun 15-Sep 30	Jul 01-Aug 31	Jun 15-Aug 15	N/A	N/A	Apr 01-Aug 15
Pink salmon	May 01-Aug 15	Jun 01-Aug 31	N/A	Jun 15-Aug 31	May 15-Aug 15	May 15-Aug 15	N/A	N/A	Mar 15-Jul 31
Chum salmon	May 15-Sep 15	N/A	N/A	N/A	May 15-Aug 31	May 15-Aug 31	N/A	Jul 01-Aug 15	Apr 01-Sep 15
Sockeye salmon	Jun 01-Sep 15	Jun 01-Jul 31	N/A	Jun 15-Jul 15	Jun 15-Jul 15	Jun 15-Jul 31	N/A	N/A	Apr 01-May 31
Kokanee	Jun 15-Jul 31	May 15-Aug 31	Jun 15-Aug 15	Jun 01-Aug 31	Jun 15-Jul 15	Jun 15-Jul 31	Jun 01-Aug 31	N/A	N/A
Steelhead	Aug 01-Nov 15	Jul 15-Oct 30	N/A	Aug 01-Apr 30	Aug 15-Dec 31	Aug 15-Nov 15	N/A	N/A	Aug 15-Nov 15
Rainbow trout	Aug 15-Nov 15	Aug 15-Sep 30	Jul 15-Mar 31	Jul 15-Apr 15	Aug 15-Jan 31	Aug 15-Jan 31	Jul 15-Mar 31	Jul 15-Mar 31	Sep 01-Apr 30
Cutthroat trout	Aug 01-Sep 30	Aug 15-Apr 15	Sep 15-Apr 30	N/A	Aug 15-Dec 31	Aug 15-Dec 31	N/A	N/A	Sep 01-Apr 30
Dolly Varden	Jun 01-Sep 15	N/A	Jun 15-Aug 15	Jul 15-Aug 31	Jun 15-Aug 31	May 15-Aug 31	Jun 01-Aug 31	Jun 01-Aug 31	Jun 15-Aug 31
Whitefish	Jun 01-Sep 15	Jun 01-Sep 15	Apr 01-Oct 31	Jun 01-Sep 15	Jun 01-Sep 15	N/A	Jun 15-Aug 31	Jun 15-Aug 31	Jun 01-Aug 31
Artic grayling	N/A	N/A	N/A	N/A	N/A	N/A	Jul 15-Mar 31	Jul 15-Mar 31	Jul 15-Mar 31
Walleye	N/A	Jul 30-Apr 01	N/A	N/A	N/A	N/A	Jul 01-Apr 30	Jul 01-Apr 30	N/A
Pike	N/A	N/A	N/A	N/A	N/A	N/A	Jul 01-Apr 30	Jul 01-Apr 30	N/A
Bull trout	N/A	Jul 01-Jul 31	Jun 15-Aug 15	Jun 15-Aug 15	Jun 15-Aug 31	N/A	Jun 15-Aug 15	Jun 15-Aug 15	Jun 15-Aug 31

* Instream work windows are approximations for a particular species over an entire specified area and should be considered time periods of reduced risk only

** Not a complete list of species of concern. Proponent should consult regional fisheries staff with regard to species not listed here.

Appendix 4

Guidelines for Construction Practices within the Fisheries Sensitive Zone (Chilibeck 1992)

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 organic debris (LOD) 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 LOD.

PHOTO PLATES

Photo 1. Looking upstream at proposed Site 3+760 m along the left bank of Englishman River.

Photo 2. Looking upstream at proposed Site 3+910 m along the right bank of Englishman River.


Photo 3. Looking downstream at proposed Site 4+460 m along the right bank of Englishman River.


Photo 4. Looking upstream at proposed Site 5+900 m along the left bank of Englishman River.


Photo 5. Looking upstream at proposed Site 6+430 m in Englishman River.


Photo 6. Looking downstream at proposed Site 7+120 m along the left bank of Englishman River.

Photo 7. Looking upstream at proposed Site 7+260 m along the left bank of Englishman River.

Photo 8. Looking upstream at proposed Site 7+420 m along the left bank of Englishman River.

Photo 9. Looking upstream at proposed Site 8+240 m along the left bank of Englishman River.

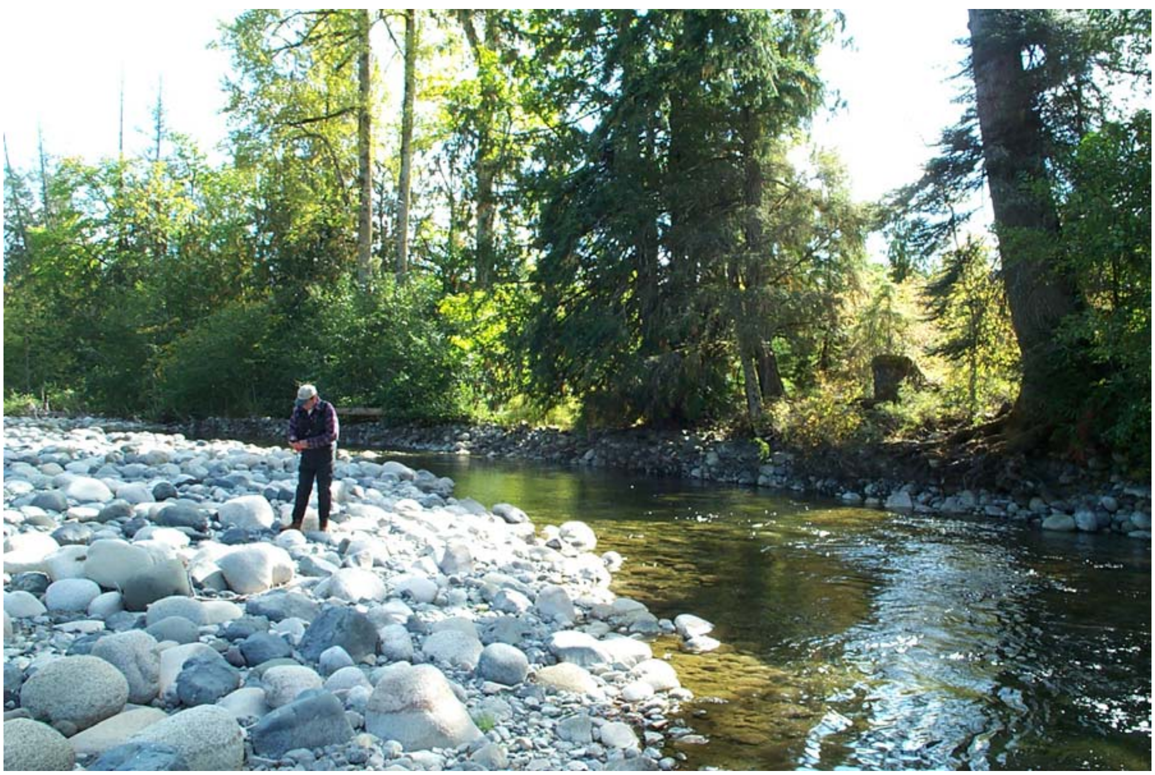


Photo 10. Looking downstream at proposed Site 8+600 m along the right bank of Englishman River.

Photo 11. Looking downstream at proposed Site 8+820 m along the left bank of Englishman River.

Photo 12. Looking upstream at proposed Site 8+960 m along the left bank of Englishman River.

Photo 13. Looking downstream at proposed Site 9+380 m along the left bank of Englishman River.