Kingfisher Creek Watershed Restoration: A Case History

J.P. den Dulk
EcoTec Environmental Consultants Inc.
2621 Golf Course Drive, Blind Bay, BC, V0E 1H1, Canada
ecotec-west@bc.sympatico.ca

ABSTRACT

The Kingfisher Creek watershed was chosen as a demonstration watershed by the British Columbia Ministry of Environment, Lands and Parks (MELP) and Forest Renewal British Columbia (FRBC) in order to advance the techniques utilized within the Watershed Restoration Program (WRP). It is located in the Interior Cedar–Hemlock biogeoclimatic zone east of Enderby, B.C., approximately midway between Calgary, Alberta and Vancouver, B.C. The impacts throughout this area include the removal of riparian vegetation, input of sediment, exaggeration of the hydrologic regime, loss of in-stream large woody debris (LWD), and disconnection of the main channel from its floodplain. Fish species affected include anadromous coho, chinook, and sockeye salmon; resident rainbow and bull trout; and adfluvial rainbow trout populations from both Mara and Mabel lakes. The restoration works completed include: the development of a side channel near the confluence with the Shuswap River to restore spawning and rearing habitat; up-grading of trails and fish access to the Cougar groundwater channel (Hunter's Creek) at 10.5 km, Forest Service Road (FSR); bioengineering of eroding banks and addition of LWD-boulder structures to Danforth Creek under the B.C. Hydro utility corridor at 12 km, FSR; addition of in-stream LWD and riffle structures to Danforth Creek adjacent to the access road and bridge at 16 km, FSR; and addition of LWD to Danforth Creek throughout the B.C. Hydro utility corridor at 18.5 km, FSR. Altogether, approximately 12,250 m^2 of over-wintering pond habitat and 2,670 m of rearing and spawning channel habitat were treated with restoration prescriptions. This project created 356 person-days of employment, and final expenditures amounted to $155,774.33.

Key words: fish, habitat restoration, large woody debris, *Oncorhynchus* spp., riparian, salmon, *Salvelinus confluentus*, trout, watersheds.

PROJECT BACKGROUND

In 1997, Forest Renewal British Columbia (FRBC) endeavoured to establish demonstration watersheds throughout British Columbia in order to provide opportunities for the training of restoration specialists in the various techniques already established by the Watershed Restoration Program (WRP). Through a roundtable established for this task, Kingfisher Creek was chosen as a representative watershed for the southern Interior region.

Restoration prescriptions were investigated, formulated, and implemented for 1 groundwater development project within the Kingfisher Creek watershed during the 1997 work season to address (primarily) lost rearing habitat features for coho salmon. This channel is located on Hunter's Creek at 10.5 km on the Three Valley–Mabel Forest Service Road (FSR). A side-channel diversion project was also initiated "in the dry" with the anticipation of completion during the 1998 fisheries-work window. At the completion of the 1997–98 fiscal year it was anticipated that future works would continue to focus on the habitat requirements of coho salmon while addressing other physical and biological issues within the watershed.

The process to determine specific prescriptions included the involvement of various staff from the British Columbia Ministry of Environment, Lands and Parks (MELP), FRBC, Department of Fisheries and Oceans (DFO), United States Forest Service, British Columbia Ministry of Forests (MOF), and B.C. Hydro, as well as members of the Spallumcheen Indian Band (SIB) and the Kingfisher Environmental Interpretative Centre Society (KEICS), several consulting firms, numerous sub-contractors, and 2 local landowners.

As a result of the work conducted in 1997, EcoTec Environmental Consultants Inc. was retained to design and implement the prescriptions for 1998. Jan den Dulk was assigned as project manager based upon his extensive experience conducting numerous fish habitat and channel condition restoration projects throughout British Columbia since 1996.

Works Completed in 1997–98

The project located at 10.5 km on the FSR is supplied by a groundwater infiltration gallery and utilizes an abandoned

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overflow channel on the Hunter's Creek floodplain approximately 0.5 km upstream from the confluence with Kingfisher Creek. The habitat produced includes approximately 650 m of flowing (channel) and 6,000 m^2 of still (pond) water. Large woody debris (LWD), riparian plantings, and the addition of spawning gravels all enhanced the habitat quality.

The project located near the confluence with the Shuswap River is supplied by a combination of natural hillside springs and an intake diversion from Kingfisher Creek, and utilizes an abandoned side-channel gazetted as Gonzales Creek. The habitat produced includes approximately 1.2 km of flowing and 6,000 m^2 of still-water habitat. Riparian plantings, the addition of LWD, and the establishment of gravel beds have augmented the over-wintering habitat and spawning features in this project.

WATERSHED CHARACTERISTICS

Kingfisher Creek is located 30 km east of Enderby, B.C. and encompasses 75,000 ha, which drain south into the Shuswap River downstream of Mabel Lake. The watershed includes both Danforth and Hunter's creeks, in addition to the mainstem river, and lies within the Interior Cedar–Hemlock biogeoclimatic zone. It has been modified through agriculture and livestock free-ranging, utility-corridor construction and maintenance, forest fires, and timber harvesting activities. This area is also heavily used for recreation and tourism.

Fish species that utilize the watershed include: anadromous coho salmon (*Oncorhynchus kisutch*), chinook salmon (*O. tshawytscha*), and sockeye salmon (*O. nerka*); resident rainbow trout (*O. mykis*) and bull trout (*Salvelinus confluentus*); and Mabel Lake and Mara Lake adfluvial rainbow trout populations. (Note that other species may be identified in the Overview Fish Habitat Rehabilitation Procedure [FHRP] yet to be published.) The current run of mid-Shuswap coho is believed to be only a fraction of historical escapement numbers and has been designated as threatened (P. Slaney, B.C. Ministry of Environment, Lands and Parks, 1999, pers. comm.).

Adverse impacts on fish habitat throughout the watershed include the removal of riparian vegetation (floodplain timber harvesting); input of sediment to the creek (lateral channel avulsions and livestock trampling); exaggeration of the hydrologic regime (up-slope timber harvesting); loss of in-stream LWD (active removal and disintegration); and disconnection of the main channel from its floodplain (road/bridge construction and channel degradation). These are largely the result of past timber harvesting practices and utility corridor construction and maintenance.

PROJECT DESIGN

The restoration works proposed for 1998 focused on side-channel development and "in-stream" techniques aimed at the placement of LWD, bank bioengineering, and spawning and rearing habitat creation.

Works Proposed for the 1998 Fisheries-Work Window

Specifically, the 1998 prescriptions and work plan included:

1. Continued development of the side channel to restore spawning and rearing habitat near the confluence of Kingfisher Creek and the Shuswap River.
2. Upgrading the access trail system through the groundwater channel site at 10.5 km on the FSR and adding additional LWD to the rearing ponds.
3. Stabilization of the mainstem channel through a combination of hard and soft engineering techniques, from the confluence of Danforth and Kingfisher creeks (approximately 12 km on the FSR under the B.C. Hydro right-of-way) and extending upstream approximately 120 m on Danforth Creek.
4. Placement of in-stream LWD and boulder structures to provide channel stability and rearing habitat for coho salmon where the spur road at 16 km on the FSR crosses Danforth Creek.
5. Development of off-channel alcoves and placement of in-stream LWD to provide channel/floodplain stability and rearing habitat for coho salmon under the B.C. Hydro right-of-way at 18.5 km on the FSR.

IMPLEMENTATION SUMMARY

Due to extremely low flow conditions in 1998 the majority of in-stream works were, in effect, completed in-the-dry, posing no risk of sediment discharge or disturbance to resident fish populations. As a precaution, cross-stream silt-retention fences were established downstream of all sites for the duration of the construction. All works were initiated on or after 10 August 1998 and completed on or before 10 September 1998. The works completed after the close of the fisheries-work window (31 August) were limited to riparian planting, trail upgrading, and other activities outside of the wetted channel. All restrictions, conditions, and exclusions issued by either MELP or DFO were strictly adhered to and no deviations from the approved work plan were requested.

Table 1. Erosion-control grass seed mixture applied to disturbed sites.

Common name	Species name	Percentage
Perennial ryegrass	*Lolium perenne*	15
Alsike clover	*Trifolium hybridum*	10
White Dutch clover	*Trifolium repense*	10
Red clover	*Trifolium pratense*	5
Timothy	*Phleum pratense*	15
Meadow foxtail	*Alopercurus pratensis*	10
Kentucky bluegrass	*Poa pratensis*	5
Canadian bluegrass	*Poa compressa*	5
Chewings fescue	*Festuca rubra* var. *commutata*	10
Creeping red fescue	*Festuca rubra*	10
Wildflower lupines	*Fabaceae* sp.	5

CHRONOLOGICAL SUMMARY OF ACTIVITIES

Planning meetings to review the proposed prescriptions and work plan for all sites were initiated in June and July. Those in attendance included representatives from MELP, MOF, DFO, Riverside Lumby Ltd, SIB, KEICS, B.C. Hydro, and FRBC. Key technical input was received from P. Slaney, W. Koning, and R. Finnigan (MELP, Fisheries Branch), B. Symonds and D. Gooding (MELP, Water Management Section), and R. Tomich (FRBC).

Davison-Tomich Side Channel

Development of the Davison-Tomich side-channel (gazetted as Gonzales Creek) was initiated on 10 August 1998. This channel is on private property owned by K. Davison and R. Gerry, and letters of agreement for these works are on file with MELP in Kamloops. Prior to construction, this site constituted early second growth (<25 years old) on a poorly sorted, imperfectly drained alluvial fan. Vegetation was primarily birch-alder with evidence of an emerging young cedar-fir understory. Gonzales Creek was an isolated side channel and had been in-filled by periodic flood events (the latest of which occurred on 6 July 1997), to produce a fen with no surface flow or connection to the mainstem channel. Numerous natural springs supplied groundwater from the hillside to the west, and infiltration from Kingfisher Creek supplied seepage from the east.

Using an Hitachi EX 270 excavator, an intake was established to Kingfisher Creek approximately 650 m upstream from the confluence with the Shuswap River. This location presented a relatively stable reach of the mainstem channel on the outside of a naturally maintained meander. The intake flows into a settling pond, which is protected from bankfull-flood-return periods by an existing vegetated berm. An adjustable head gate controls the flow leaving the pond through 220 m of 0.35-m-diameter, ribbed PVC pipe running to the excavated channel. The completed project constitutes 1.2 km of channel (average 1 m wide, 0.5 m deep, and 0.75% slope) lined with 10–15 cm of river rock, and 6,000 m^2 of pond area (average 1 m deep) with approximately 40% LWD surface coverage.

Table 2. Native shrubs planted adjacent to the Mabel Lake Road.

Common name	Family	No. of plants
Blackberry Chester	*Rosaceae*	25
Black raspberry	*Rosaceae*	29
Blueberry northsky	*Ericaceae*	26
Tayberry	*Rosaceae*	7
Honeysuckle emerald	*Caprifoliaceae*	23
Boysenberry	*Rosaceae*	16
Potential goldfinger	*Rosaceae*	25

The 100-m outlet channel discharging into Kingfisher Creek was constructed 10 m upstream of the Mabel Lake Road bridge. Three Newbury riffles were constructed within the outlet channel to provide resting ponds and create turbulent "noise" to attract adult spawning salmon. Large boulders were placed within the alcove at the mouth of the outlet channel to mimic a continuous stream bank and not interfere with the bridge abutment structures downstream. This design is intended to provide suitable access while maintaining the hydraulic conditions that break up back-eddies and retard sediment deposition into the channel outlet.

Livestock watering access and exclusion fences were established on both the Davison and Gerry properties to protect the riparian zone and channel. In areas with substantial disturbance to the soil by heavy equipment, 1,250 kg of erosion-control grass seed mixture (Table 1) was applied, and approximately 2,000 Pacific willow whips were planted. Along the lower 100 m of channel (adjacent to the Mabel Lake Road), 151 low-growing native shrubs were planted to provide shading while not impairing the sight lines of the property owners (Table 2).

10.5-km Site Upgrade

The works completed at the 10.5-km site on the FSR in 1997 included the creation of approximately 650 m of flowing (channel) and 6,000 m^2 of still (pond) water. This site is supplied by a groundwater infiltration system and utilizes an abandoned overflow channel within the Hunter's Creek floodplain. The habitat produced was augmented with LWD, riparian plantings, and the addition of spawning gravels to enhance the habitat quality. The works in 1998 included upgrading the trail system to restrict disturbance by visitors to the site. Several sections of the channel were also upgraded to improve fish access.

Dissolved oxygen (DO) readings were recorded using a YSI Model 51 meter. Measurements were taken along the channel from the spawning platform (groundwater discharge) and

at stations every 10 m downstream until concentrations had reached equilibrium (i.e., did not deviate by more than 1 mg/L for 3 consecutive stations). The data suggest that DO concentrations are low at the point of groundwater discharge (<5 mg/L at 15°C), but rise rapidly and reach equilibrium by the 25-m station (7–8 mg/L).

In-stream Works at the 12-km Site

The works completed at the 12-km site on the FSR included the stabilization of 2 eroding banks and the restoration of in-stream fish habitat throughout the B.C. Hydro right-of-way utility corridor crossing of Danforth Creek. As a result of the loss of all riparian vegetation and changes in the hydrologic regime from timber harvesting practices throughout the watershed, the (primarily sandy-silt) banks on both sides of the creek at this site exhibited signs of extreme lateral migration, undercutting, slumping, and sediment input. Using a combination of both traditional and bioengineering techniques, the site was stabilized, fish habitat was restored, and a riparian zone was established.

The slopes of undercutting banks were pulled back to approximately 1:3, leaving a trench at the toe of the slope equal to the depth of the thalweg[1]. (Note that the channel is not actively degrading within this reach.) Approximately 250 m^3 of 0.5- to 1.0-m angular rip-rap (sized according to Newbury and Gaboury 1993) was placed within the trench along the toe of the slope up to an elevation equal to that of the floodplain on the opposite bank. Three triangular LWD catchers (Slaney et al. 1997) were constructed to provide over-winter rearing habitat for juveniles and resting ponds for adult spawning coho. Each was constructed from fir or cedar logs with a minimum diameter of 0.5 m and length of 10 m. The apex was attached to a buried boulder (minimum diameter 1.5 m) using 7/16-inch galvanized wire rope and the Hilti epoxy system. The "butt" end was buried into the bank a minimum of 40% of the length. Within the centre of each structure, 1 large rootwad was anchored using wire rope and 2 "U" clamps. Forty-five modified brush layers were constructed above the rip-rap elevation using 8–10 whips, 1 cm in diameter by 1 m long, for each layer. Rebar (1 cm X 1 m) was used to secure the 15 cm X 1.5 m "riser" in place. The whips were buried approximately 80% into the soil, and all leaves and buds were stripped from the whips to prevent desiccation and encourage root growth. Finally, a grass seed mixture was applied to all disturbed soils to prevent surface erosion.

Newbury riffle structures were constructed with approximately 125 m^3 of 0.5- to 1.0-m angular rip-rap (sized according to Newbury and Gaboury 1993) placed across the channel and "keyed" into both banks. The riffle structure provides an upstream pool (approximately 50 m^2 with 1-m depth) and dissipates the flow's energy on the downstream (1:15) grade.

Several LWD-boulder complexes were constructed to protect eroding banks. Seven boulders (minimum 1.5 m diameter), 6 fir or cedar logs (minimum diameter of 0.5 m and length of 10 m), and 2 rootwads were anchored against the bank to provide direct protection to the flow and refugia habitat for fish during freshet flows. The Hilti system was used to anchor the materials in place.

In-stream Works at the 16-km Site

A B.C. Hydro access road and bridge crosses Danforth Creek at 16 km on the FSR. The riparian vegetation was relatively intact second growth (25–50 yr old), however the channel lacked suitable fish habitat prior to the initiation of this project. In situ gravel distribution indicates that this reach has the potential to constitute a primary spawning and rearing area.

In order to introduce hydraulic variability to this reach, 2 Newbury riffles and 3 triangular LWD catchers were constructed similar to the 12-km site. All works conducted within this site were completed using a Schaeff HS 41 "walking spider" excavator to minimize disturbance to the banks and riparian area.

At the upstream extent of this site, a naturally formed debris jam exists, creating several large pools and providing protection to a vulnerable bank. This structure was used as a template to design the constructed LWD-boulder features.

Midway downstream through this site is an access bridge. This structure was replaced in 1998 by B.C. Hydro to provide greater flood routing (more free-board and channel width). The orientation of the abutments was also modified to conform to the existing stream-flow lines.

At the downstream extent of this site, a debris jam was created during the 6 July 1997 flood event. This jam caused the channel to avulse to the east and create a new route. It is unclear whether the channel configuration will remain as it is or revert to its pre-1997 location. All works constructed in 1998 will function under both circumstances.

18.5-km Side-channel Development and Floodplain Stabilization

Side-channel rearing development and floodplain restoration works were initiated within the B.C. Hydro right-of-way utility corridor crossing of Danforth Creek at 18.5 km on the FSR. As a result of the removal of the majority of riparian vegetation during corridor construction, the 6 July 1997 flood event, beaver dam-building activities, and changes in the hydrologic regime from timber harvesting practices further up in the watershed, the channel has been actively aggrading throughout this site, and the banks on both sides of the creek exhibit signs of instability and lateral migration.

Using the old-growth reach immediately upstream of this site as a template, structures were constructed to provide

[1] Thalweg: the path traced by the flow that follows the deepest part of the channel (Newbury and Gaboury 1993).

stability and protection to the banks and floodplain, and to encourage localized areas of channel-bed degradation. A "walking spider" excavator was employed within this reach due to the inaccessibility of the site by other equipment. Intact cedar LWD was scavenged from under the right-of-way and placed by overlapping and matrix building. Where ever required, wire rope and "deadmen" were used to secure structures in place.

It is anticipated that freshet flows will be concentrated between the LWD-reinforced banks and will encourage floodplain aggradation through sediment deposition. Unanchored LWD will be redistributed and form natural complexes. This reach also constitutes the greatest quality and quantity of gravel throughout the entire watershed and these in-stream structures will help to re-establish lost hydraulic variability and restore spawning areas to their pre-1997 flood productivity.

Three in-stream rearing ponds (each approximately 50 m^2 and 1 m deep) were constructed within the existing side channel and were loaded with LWD. It is anticipated that these ponds will remain ice-free during the winter due to groundwater temperature influences and will provide critical over-wintering coho salmon habitat. They will also act as flood-flow refugia during freshet.

PRODUCTION ESTIMATES

Biostandards for fish habitat enhancement projects were used to estimate smolt/juvenile production for coho salmon, and resident and adfluvial rainbow trout in the Kingfisher Creek watershed (Koning and Keeley 1997). Rainbow trout estimates were derived from coastal steelhead salmon levels (P. Slaney, pers. comm.). These estimates represent potential population target values and are influenced by adult escapement numbers and future changes within the watershed.

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