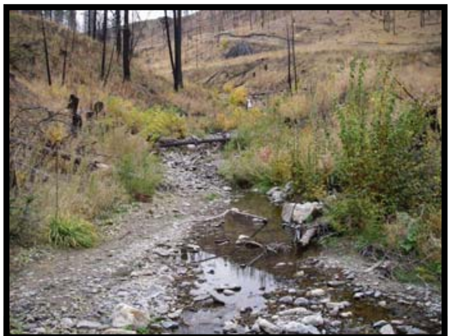
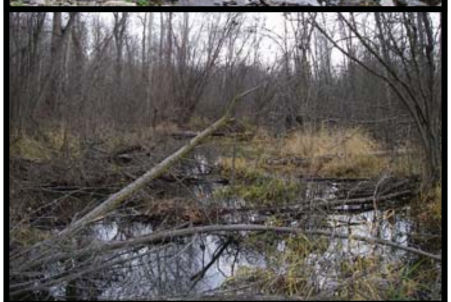
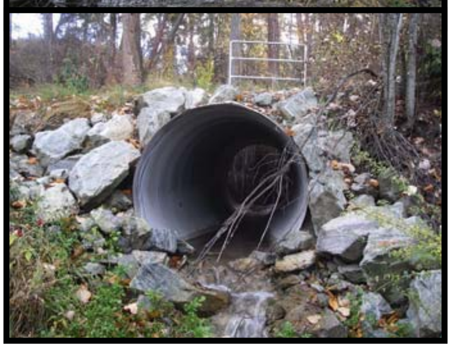
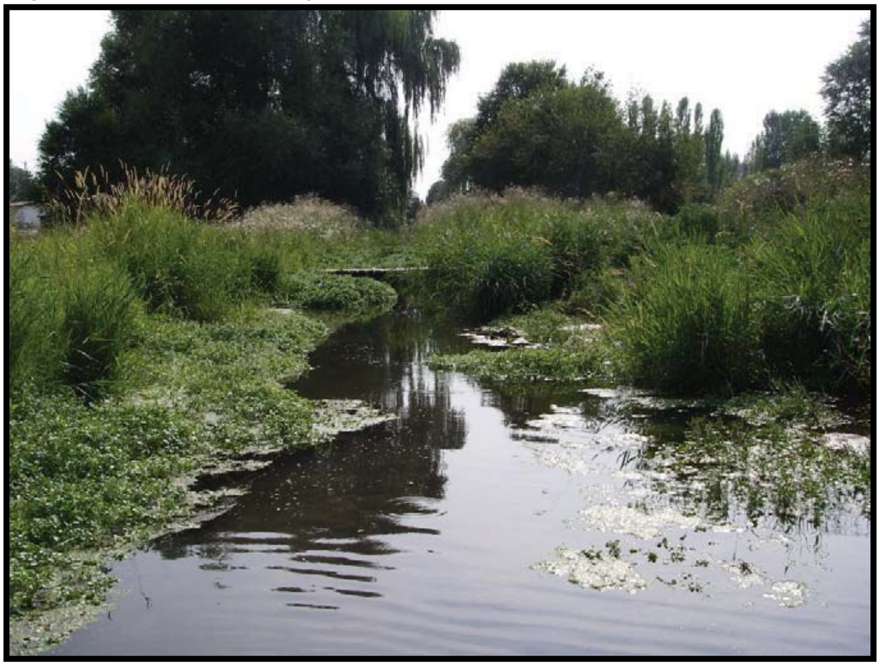
SENSITIVE HABITAT INVENTORY AND MAPPING (SHIM)

Inventory Summary Report – Volume 2









Prepared For:
THE CITY OF KELOWNA

Prepared By:
ECOSCAPE
Environmental Consultants Ltd.

April, 2007

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SENSITIVE HABITAT INVENTORY AND MAPPING (SHIM)

Fascieux Creek (both arms), Brandt's Creek, Wilson Creek, Priest Creek, Mill Creek tributaries (Scotty Creek, Whelan Creek , Francis Brook), Bellevue Creek tributaries, Rembler Creek, Lebanon Creek, Cedar Creek, Leon / Thompson Creek

Inventory Summary Report – Volume 2

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1.0 INTRODUCTION

Ecoscape Environmental Consultants (Ecoscape) was retained by the City of Kelowna (CoK) to complete Sensitive Habitat Inventory and Mapping (SHIM) on Mill Creek and Bellevue Creek occurring within the city limits. The following report summarizes the inventory findings, which have been provided to the CoK and the Community Mapping Network (www.shim.bc.ca) in digital GIS format.

1.1 Project Background

As resource development and human populations increase in British Columbia, pressures for all resources and services have accelerated. Rapid growth has often overwhelmed the ability of local planners to manage land and preserve sensitive habitats (Mason and Knight, 2001). This has resulted in the loss or degradation of aquatic and riparian habitats that are critical for fish and a diverse wildlife assemblage. Thus, there is an urgent need to develop better methods to conserve and protect and reclaim these habitats.

Sensitive Habitat Inventory and Mapping (SHIM) is a standard for fish and aquatic habitat mapping in urban and rural watersheds in British Columbia. SHIM attempts to ensure the collection and mapping of reliable, high quality, current, and spatially accurate information about local freshwater habitats, watercourses, and associated riparian communities.

SHIM is designed as a land-planning, computer-generated interactive GIS tool that identifies sensitive aquatic and terrestrial habitats. It is intended to provide community, stewardship groups, individuals, regional districts and municipalities with an effective low cost delivery system for information on these local habitats and associated land uses.

SHIM has numerous applications and can:

- Provide current information not previously available to urban planners, to allow more informed planning decisions and provide inventory information for Official Community Plans;
- Assist in the design of stormwater/runoff management plans;
- Monitor for changes in habitat resulting from known disturbance;
- Identify and map potential point sources of pollution;
- Help guide management decisions and priorities with respect to habitat restoration and enhancement projects;
- Assist in determining setbacks and fish/wildlife-sensitive zones;
- Identify sensitive habitats for fish and wildlife along watercourses;

- Provide a means of highlighting areas that may have problems with channel stability or water quality, and require more detailed study;

- Provide baseline mapping data for future monitoring activities; and,

- Map and identify the extent of riparian vegetation available and used by wildlife and fisheries resources.

1.2 Project Objectives

The objectives of the project were to:

- Inventory and map 12 prevalent creeks within the Kelowna city limit, their associated riparian habitats, and watercourse and important fisheries habitat features;

- Provide the basis for accurately mapped baseline data that can be integrated into local mapping and planning initiatives; and,

- Augment and potentially enhance local land use planning maps and/or specific site or detailed planning surveys.

The primary functions of SHIM are to:

- Identify sensitive habitats and resources within local communities;

- Integrate property boundaries, land parcels, and road networks with locations of sensitive resources to facilitate Official Community Plans and Development Permit applications;

- Work within an interactive Geographical Information System (GIS) to provide useful map products for analysis and effective communication;

- Facilitate updating and exchange of information; and,

- Establish partnerships with provincial and municipal governments, stakeholders, and the public to protect and manage aquatic habitats and associated functions (i.e. riparian communities and linear corridors etc.).

By combining resource information from a variety of sources the goal is that SHIM will provide a robust baseline inventory (cataloguing the stream and all natural and anthropogenic features occurring within and long it) for improving integrated resource management and planning within the City of Kelowna.

2.0 SCOPE OF WORK

The project work scope was based on the Request for Proposal (CAS06-66, July 25, 2006). The fundamental objective was to complete Sensitive Habitat Inventory and Mapping (SHIM) surveys on all creeks (*both first priority and second priority*) identified in Section 2.1 (B) of the Request for Proposal, which included:

- Fascieux Creek (both arms);
- Brand Creek;
- Wilson Creek;
- Priest Creek;
- Mill Creek tributaries including Scotty Creek, Whelan Creek , and Francis Brook;
- Bellevue Creek tributaries;
- Rembler Creek;
- Lebanon Creek;
- Cedar Creek; and,
- Leon / Thompson Creek

Existing Terrestrial Resource Inventory Mapping (TRIM) and other supplemental mapping by the City of Kelowna suggested that the combined stream length of the above noted watercourses (within the Kelowna city limit) is estimated at about 42 km, on which the RFP was premised. The actual combined stream length inventoried during the 2006 SHIM project totalled 52.2km. All Creeks surveyed by SHIM are illustrated in the figure that follows. Mill Creek and Bellevue Creek were surveyed in 2005 and are summarized under a separate cover in the City of Kelowna Volume 1 SHIM Inventory Summary Report (Ecoscape, 2006).

3.0 METHODOLOGY

Field inventory, data processing and data deliverables conformed to the SHIM Standards (Mason and Knight, 2001), which can be reviewed in full at:

http://www.shim.bc.ca/methods/SHIM_Methods.html .

3.1 Centerline Survey

Kyle Hawes, R.P.Bio. was the principle surveyor and completed all field survey elements with the assistance of a field technician (Jason Schleppe, R.P.Bio and Robert Wagner).

The stream centerline was mapped along the center of the bankfull (not floodplain) width. The creeks were stratified into a series of successive sections (segments), each possessing and being characterized by different attributes or biophysical characteristics (i.e., hydraulic class, channel characteristics, substrates composition, and riparian class etc.). The stream segmentation and associated attributes was the fundamental unit of the centerline survey with point features providing a more quantitative measure of relative disturbance/modification, and aquatic habitat quality/complexity (i.e. area abundance of deep pools/spawning substrates/coarse woody debris measure etc.).

Ecoscape developed and appended a Level of Impact rating to the data dictionary (Shown in Volume 1, Appendix A (Ecoscape, 2006). This simple rating system was designed with the intent on providing a more measurable parameter in monitoring and evaluating habitat restoration and future conservation efforts on City watercourses and associated riparian and floodplain communities. The raw data and rationale for respective stream segment scores can be found in Appendix B within the Stream line data. Weighted scores for respective SHIM impact ratings were obtained by dividing the cumulative length of segments receiving the same SHIM impact rating by the total SHIM stream length to obtain a fractional abundance (% of SHIM stream length). This value was then multiplied by the respective SHIM Score (0-6) equaling the weighted score. A zero (0) to six (6) rating system was developed to evaluate respective stream segments in terms of their degree of disturbance, where a stream segment not being recently modified (natural) received a score of 6 (nil), and a stream segment being highly modified on both banks/channelized/ditched, etc. received a score of 0 (both_banks_high). The sum of weighted scores was then divided by the maximum attainable score (6)[1] and transformed into a percentage value.

Table 1 provides a complete list of features and corresponding attributes that were recorded using the Trimble Geo Explorer (GPS) and SHIM Data Dictionary.

Table 1. Overview of watercourse and habitat attributes to be collected using the SHIM Data Dictionary (Module 3, Mason and Knight, 2001). The complete data dictionary can be found in Appendix A.

Survey Component	Main Attribute	Detailed Feature Collected
Stream Centre Line	Stream Reference Information	Name; Watershed Code; Date; Time; Survey Conditions; Surveyors
	Stream Segment Points	Start; Stop; Reach Break; Elevation; Representative Photographs
	Stream Segment Class	Stream Section; State of Section (i.e. natural/modified/channelized); Dominant Hydraulic Type
	Segment Characteristics	Section Gradient; Fish Spawning; Canopy; Access; Gravel
	Segment Substrate Attributes	Dominant Substrate Type; Compaction
	Segment Channel Attributes	Widths (wetted, bankfull), Depths (wetted, bankfull)
	Segment Instream Cover	% Total Cover; % by Feature/Cover Type (large woody debris/deep pool/over stream vegetation etc.)
	Segment Riparian Attributes	Left and Right Bank Riparian Class (vegetation association; structural stage; bank slope; material etc.)
		Segment Summary Description
Watercourse and Habitat Features	Culvert Attributes	Type-Material; Condition; Barrier; Size; Baffles
	Obstruction Attributes	Type-Material; Barrier; Size; Photo
	Stream Discharge Attributes	Point of Discharge; Type-material; Size
	Erosion Feature	Type of Erosion; severity; exposure; material
	Fish Habitat Attributes	Type of Habitat (Spawning/rearing/cover); Size; Slope; Photo
	Enhancement Areas	Type of Enhancement; Potential or existing enhancement
	Wildlife Observations	Type of Observation; Wildlife species; Photo
	Wildlife Tree Attributes	Type of Tree; Size; Location
	Near Waterbody Attributes	Type of Waterbody (spring/side channel/pond etc.); Size
	Wetland Attributes (Polygon feature)	Wetland Type-Class; Photo
	Photograph Location	Location; Direction.
	Level of Impairment	Score 0 (natural) – 6 (severely impaired); Rationale
	Enhancement Opportunity Rating	0 (Nil) – 4 (Very High); Rationale

[1] A combined weighted score of 6 would be attained if all segments were natural with no measurable human disturbance on either the right or left bank.

3.2 Top of Bank Survey

Watercourse (lake, pond, stream and wetland) location and extent are critical for providing information to help determine the extent of protection to which a water course should be entitled. Determining the correct location of a stream, functionally (hydrologically) connected watercourses and wetlands, and their associated top of banks (TOB) is a necessary prerequisite for delineating Fisheries Sensitive Zones (FSZ). FSZs are an essential planning component in defining the Streamside Protection and Enhancement Area for development adjacent to a stream.

The top of bank was defined using the following criteria as recognized by the Ministry of Environment and Department of Fisheries and Oceans Canada:

i) The point closest to the boundary of the active floodplain of a stream where a break in the slope of the land occurs such that the grade beyond the break is flatter than 3:1 at any point for a minimum distance of 15 metres measured perpendicularly from the break;

ii) For a floodplain area not contained within a ravine, the edge of the active floodplain of a stream where the slope of the land beyond the edge is flatter than 3:1 at any point for a minimum distance of 15 metres measured perpendicularly from the edge; or,

iii) The first significant break in a ravine slope where the break occurs such that the grade beyond the break is flatter than 3:1 for a minimum distance of 15 metres measured perpendicularly from the break, and the break does not include a bench within the ravine that could be developed.

3.3 Data Logging and Processing

GPS settings were in accordance with Resource Inventory Committee Standards to ensure the collection of spatially accurate data. The coordinate system used was North American Datum 83, 11 north.

Field (GPS) data were post processed (differentially corrected) in the office using base stations situated both in Penticton (SOPAC, Dominion Radio Astrophysical Observatory), and Kettle Falls, Washington (USFS, Colville National Forest).

Data dictionary tools designed for ARC View 3.x were employed to process the data and to export the data into ESRI shapefiles.

3.4 Quality Assurance Quality Control

The Resource Inventory Committee and SHIM methodology (Mason and Knight, 2001) provide specific requirements for quality assurance and quality control. These standards such as GPS settings/precision, logging intervals, and data management and deliverables were followed throughout the project.

4.0 RESULTS

The following section summarizes the morphological and biophysical character of each surveyed stream. All creeks are discussed separately in respective subsections. Refer to the attached summary pages for segment attributes and representative photos and overview figures (maps) that follow. All data and summary information presented herein has been uploaded to the City of Kelowna intranet, which includes all point features, attributes, and representative photos (intended for use in a GIS platform). In addition, the reader is encouraged to refer to the Community Mapping Network, SHIM atlas (www.shim.bc.ca).

4.1 Brandt Creek

Within the City of Kelowna, Brandt Creek extends about 13.6 km from its terminus at Okanagan Lake upstream to the headwaters in north Glenmore near Robert Lake. The creek was divided into 29 segments. Segments 1 to 16 have been ditched and channelized through intense industrial, commercial, and urban landscapes. The creek splits into an east and west channel at Segment 16. From here Segments 17-26 represent the western channel, ending in agricultural fields with discontinuous surface flows and ditching west of Glenmore Road to the north of Union Road. Segments 1-4 of the Eastern Channel follow ditching and modified riparian gully associations to the headwaters on Curtis Rd. near Robert Lake.

4.1.1 Stream Primary Character

Brandt Creek has been modified over its entire length (Table 2). Over 70% (nearly 10km) of the creek has been channelized and ditched, 1.5 km of segments are defined as culvert, and about 2.4 km of stream is less confined but still modified by discontinuous urban activities. Entire stream segments occurring within culverts have a combined length of about 1.5 km. However, the cumulative length of culverts over the entire Brandt Creek stream length (including road and driveway crossings) totals over 3.1 km, double that of exclusively culverted segments. The majority of modifications recorded were related to channelization, ditching, and armouring. Over 63% of Brandt Creek is devoid of riparian shrub cover and tree canopy with a 0% crown closure.

Table 2. Brandt Creek summary of primary stream character. Values shown below are based on SHIM field inventory and analysis of 13.6 linear km of creek within the Kelowna city limits.

Segments	Primary Character	Length (m)	Percentage of stream
2,3,5,6,7,8,9,10,11,12,13,16,18,19,21,23,24	Channelized	6306	46%
4,15,22,25	Culvert	1506	11%
1 (East Channel), 4	Ditch	3392	25%
1,2,3,14,17,20,26,	Modified	2373	17%

4.1.2 Instream Habitat Cover/Complexity

Total and relative instream cover is a field estimate of the type and amount of in-channel cover available to fish. Total cover represents the total percentage of the wetted area of respective segments occupied by cover. The relative abundance (%) of cover types (e.g., deep pool, large woody debris etc.) is an estimate of the distribution (of respective cover types) within the total cover estimate.

Approximately 70% of Brandt Creek has little cover habitat (0-10% total cover) for fish. Over much of the stream length there is dense instream vegetation and northern water cress (*Nasturtium microphyllum*) predominates. This weedy mustard introduced from Europe often forms a very dense mat due to minimal canopy closure and high instream light intensity. Due to its intolerance of shade, riparian restoration/enhancement, resulting in improved canopy closure will help to control the spread of this species

Table 3. Brant Creek summary of instream habitat/cover. Values shown below are based on SHIM field inventory and analysis of 13.6 linear km of creek within the Kelowna city limits.

% Total Cover	Combined Segment Length	% of SHIM Stream length	% of Total Cover by Cover Type [a]						
			B	DP	IV	LWD	OV	SWD	UC
0-10	9494	70%	17%	0%	74%	0%	9%	0%	0%
11-20	1832	13%	36%	8%	32%	0%	23%	0%	0%
31-40	1049	8%	5%	0%	65%	0%	30%	0%	0%
41-50	806	6%	1%	56%	41%	2%	0%	0%	0%
61-70	396	3%	0%	0%	99%	0%	1%	0%	0%

a. Cover codes: B=boulder; DP=deep pool; IV=instream vegetation; LWD=large woody debris; OV=overstream vegetation; SWD=small woody debris; UC=undercut bank

4.1.3 Obstructions/ barriers

Two upstream fish migration barriers were documented along Brant Creek. The first significant barrier is the culvert outfall of Segment 15, which occurs about 3.8 km upstream of Okanagan Lake. The 0.5 m outfall plunge combined with the culvert length, totalling about 1.1 km, presents a considerable barrier to upstream migration by fish. The second obstruction is a flood control gate and rip rap apron at the bottom of Segment 17 that occurs about 6 km upstream of Okanagan Lake.

4.1.4 Bank Stability and Erosion

Bank stability has been modulated extensively by channelization involving rip rap and retaining walls. However, ditching and channelization without the use of rock has created areas of considerable instability resulting in about 4.5 km of stream susceptible to erosion. In particular, Segments 5, 6, and 8 contained the greatest bank instability and these three segments alone accounted for over 83% (about 0.5 km) of active erosion documented over the entire stream.

4.1.5 Discharges

Considering the length of creek that has been culverted, the number of recorded stream discharges is considered an underestimate. Ecoscape expects that a large number of discharges occur underground where Brandt Creek is piped through culvert. A total of 43 discharges were documented in daylighted stream channels – nearly all were storm drains. An effluent discharge documented in Segment 5, about 1.5 km upstream from Okanagan Lake, was discharging effluent directly into the creek with a very strong, noxious chlorine odour.

4.1.6 Stream Impact Summary

The sum of the weighted scores (Table 4) for Brandt Creek was 0.50, resulting in a stream impact rating equalling just 8%. Severe impairments along the majority of Brant Creek are clearly reflected in the stream impact rating. Recognizing the severe stream channel degradation and fragmentation, opportunities to realize a net improvement of proper functioning stream and riparian habitats will be challenging. However, remnant riparian gully communities and wetlands should be preserved and restored /enhanced recognizing the disproportionately high ecological values these small areas have along Brandt Creek for fish and wildlife values.

Table 4. Brandt Creek impact summary. Values shown below are based on SHIM field inventory and analysis of 13.6 linear km of creek within the Kelowna city limits.

SHIM Impact Rating	SHIM Score	Combined Segment Length (m)	Percentage of Stream	Weighted Score
Both_banks_high	0	8720	64%	0.00
Both_banks_mod	1	3191	24%	0.24
Both_banks_low	2	1476	11%	0.22
1_bank_high	3	86	1%	0.02
1_bank_mod	4	103	1%	0.03
			Weighted Score	**0.50**
			Stream Grade	**8%**

4.2 Cedar Creek

Cedar Creek is a tributary to Lebanon Creek (discussed below). Within the City of Kelowna, Cedar Creek extends about 1.1 km from its confluence with Lebanon Creek upstream to the Kelowna city limit. The creek was divided into four (4) segments. An unnamed tributary was also mapped. Within the city limit, this watercourse is just over 0.7 km in length. It continues southward beyond the city limit and converges on Chute Lake Road. The tributary enters Cedar Creek in Segment 2 and has a stream channel character similar to Cedar Creek.

4.2.1 Stream Primary Character

Nearly all of the Cedar Creek watershed was burned during the 2003 wildfires. Subsequently, salvage logging was carried out over the majority of the watershed within Kelowna to the edge of the stream channel. Although the fire affected the entire creek, Segments 1 and 4 were not subject to salvage logging and as such were classified as natural, despite the fact that most of the riparian community was largely lost to fire. Nevertheless, natural regeneration of riparian shrubs, including red-osier dogwood, common snowberry, and elderberry, was observed to be moderately vigorous.

4.2.2 Stream Channel and Hydraulic Character and Bank Stability

Cedar Creek is an ephemeral watercourse. Surface flows were intermittent during the autumn field inventory and were generally observed over steep gradient sections of the stream. Subsurface flows were likely present in lower gradient areas during the survey, but during higher flow events would contain surface flows as indicated by scour and well defined channel. The creek cascades over its length within the City limit to Lebanon Creek. The fire and salvage logging coupled with increased overland flows has resulted in channel down-cutting and erosion along most of Cedar Creek and the tributary. In some areas, the channel has down-cut over 1 m. Boulders and coarse woody debris have begun to stabilize the stream channel in isolated areas where these features have now become embedded in the stream channel and substrates are beginning to accrete upstream forming a cascade pool morphology.

The stream gradient averages about 15%. The average channel width is about 1.8 m. Coarse substrates (cobble and boulder) predominate throughout segments 1-3. Segment 4 occurs through a riparian gully with a low gradient (3%) with broadleaf flood associations (e.g. Cottonwood – water birch – red-osier dogwood) and wetland thickets. Substrates in this segment are a mix of organic and fines and small gravel (where a riffle-pool stream morphology develops).

4.2.3 Obstructions/ barriers

Lebanon Creek is a fish bearing water course and contains resident rainbow trout (confirmed by Ecoscape). Cedar Creek may be frequented by trout intermittently when the stream contains surface flows. However, the steep gradient of Segment 1 (20%) is likely an obstruction to upstream migration much beyond the confluence with Lebanon Creek.

Segment 2 has a lower gradient (12%) but there are insufficient sustained surface flows and a lack of residual pools to provide viable ephemeral habitats for small resident trout. Moreover, Segment 3 ascends a steep grade (25%) and would be an upstream migration barrier beyond Segment 2.

4.2.4 Discharges

Urban encroachment has not yet resulted in development of stormwater or other discharges to Cedar Creek within the Kelowna city limit.

4.2.5 Stream Impact Summary

The sum of the weighted scores (Table 5) for Cedar Creek was 2.6, resulting in a stream grade equalling 43%. The fire and associated salvage logging have had the greatest impact along Cedar Creek. The encroachment from logging has resulted in the degraded condition/function of the stream corridor. Nevertheless, regeneration along the stream is moderately vigorous.

The existing level of impact/disturbance along Cedar Creek with respect to salvage logging and bank instability provides low to moderate opportunities for instream and riparian enhancement/restoration. The 2003 wildfire and subsequent salvage logging and removal of riparian vegetation has resulted in considerable bank instability on both the right and left banks along the stream resulting in severe erosion and channel down cutting. Coarse woody debris and cobble/bolder substrates have begun to naturally stabilize the stream channel since the fire. Channel stabilization works had previously occurred in the tributary – involving the instream placement of coarse woody debris bundles, which are mitigating channel instability and promoting accretion of substrates upstream of these structures – reducing channel down-cutting.

Table 5. Cedar Creek and unnamed tributary impact summary. Values shown below are based on SHIM field inventory and analysis of 1.86 linear km of creek within the Kelowna city limits.

SHIM Impact Rating	SHIM Score	Combined Segment Length (m)	Percentage of Stream	Weighted Score
Both_banks_low	2	1446	78%	1.56
1_bank_mod	4	115	6%	0.24
1_bank_low	5	300	16%	0.8
			Weighted Score	**2.6**
			Stream Grade	**43%**

4.3 Fascieux Creek

Fascieux Creek has a total stream length of 6.8 km. The stream splits into two (2) channels at Casorso Road, about 1 km upstream from Okanagan Lake. The north arm is just under 3.5 km in length, originating from ditching and tile drains just west of Benvoulin Road and north of Munson Road. The south arm is about 3.3 km in length originating from ditching and groundwater discharges from tile drains near the intersection of KLO Road and Benvoulin Road.

4.3.1 Stream Primary Character

The Creek originates from ditching and tile drains and has been modified over its entire length (Table 6). Channelization and ditching, generally coupled with riparian community impairments occur over about 60% of the creek (both arms combined). About 0.73 km (11%) of the creek represents stream segments confined entirely by culvert. Throughout the creek, just over 1 km is actually within culvert (including culverted segments in addition to road and driveway crossings. Non-channelized, modified stream segments make up the balance (29%) of the creek, which are less confined wetlands and sloughs with persistent riparian disturbance and modifications associated with urban and rural (at upstream ends of the creek) landuse use.

Table 6. Fascieux Creek summary of Primary stream character. Values shown below are based on SHIM field inventory and analysis of 6.8 linear km of creek.

Primary Character	Length (m)	Percentage of stream
Channelized/Ditched	4070	60%
Culvert	733	11%
Modified/non-channelized	1962	29%

The predominant hydraulic character is slough as the creek moves slowly with an average gradient of less than 0.4%. Canopy closure over the stream is poor with over 50% of the creek having 0% canopy closure and another 25% of the creek having less than 20% closure. Fine substrates, including organic matter and detritus are the predominate substrates throughout the stream. The stream channel width averages about 3.4 m but reaches a width of over 80 m in the Fascieux Creek Wetland between Richter and Casorso Road. Due to the low gradient and shallow groundwater regime, many segments are in succession to wetland ditches/channels and are ingrown - or – are in the process of becoming ingrown with cattail, bulrush, and other associated marsh vegetation.

4.3.2 Instream Habitat Cover/Complexity

Similar to other highly modified urban watercourses, the low gradient of Fascieux Creek, coupled with the lack of riparian cover has resulted in the establishment and channel ingrowth of northern watercress and cattails in ditched areas. The instream habitat is poor to moderate quality for small resident fish to the often very dense instream vegetation.

Although the dense instream vegetation cover has marginal cover value for fish, these areas provide moderate habitat values for benthic invertebrates and potentially amphibian species including Pacific chorus frog, Columbian spotted frog and long-toed salamander. Clean gravel substrates for Kokanee and rainbow spawning are very limited and occur only sparsely in Segments 1 and 2 just upstream of Okanagan Lake.

4.3.3 Obstructions/ barriers

The most significant potential upstream migration barrier (to fish) are the long, culverted stream segments (e.g. Segment 4). However, rainbow trout have been observed in the south arm of the creek upstream almost to Benvoulin Road. Thus, there are no definitive obstructions to fish but culverted segments likely deter upstream movement of some fish species or individuals.

Beaver activity was observed in wetland and slough areas, along more naturalized areas of the stream. During the field inventory, none of the beaver dams observed were recorded as potential upstream migration barriers.

4.3.4 Bank Stability and Erosion

Bank stability is generally moderate to high along the majority of Fascieux Creek. Fifty eight percent of stream length had reasonably high bank stability and about 38% of stream received a moderate bank stability rating. The balance (4%) had a low rating.

4.3.5 Discharges

Considering the length of creek that has been culverted, the number of recorded stream discharges is considered an underestimate. Only 11 discharges were recorded in daylighted stream sections. However, Ecoscape expects a great deal more stormwater discharges occur through the 0.7 km of culverted segments where determination of number and type of discharges was not possible. Many of the discharges documented appeared to contain clean groundwater and are likely fundamentally interconnected with shallow groundwater/tile drains, which help maintain good base flows in the creek.

4.3.6 Stream Impact Summary

The sum of the weighted scores (Table 7) for Fascieux Creek was 0.52, resulting in a stream grade equalling just 9%. Severe impairments including ditching and channelization along the majority of Fascieux Creek are clearly reflected in the stream impact rating. Despite ditching and channelization, the consistent baseflow and a relatively low, moderated flood stage (since majority of flows are derived from groundwater discharge) present opportunities to enhance Fascieux Creek for fish and wildlife values. High opportunity areas for enhancement occur mainly in the upper reaches in Segments 5-9 of the north channel and Segments 13-15 of the south channel. In addition, site redevelopment adjacent Lakeshore Road presents a high enhancement opportunity for Segment 3, which may involve removal of retaining walls and reduced channel confinement.

Table 7. Fascieux Creek impact summary. Values shown below are based on SHIM field inventory and analysis of 6.8 linear km of creek.

SHIM Impact Rating	SHIM Score	Combined Segment Length (m)	Percentage of Stream	Weighted Score
Both_banks_high	0	4588	68%	0
Both_banks_mod	1	1469	22%	.22
Both_banks_low	2	367	5%	.11
1_bank_high	3	188	3%	.08
1_bank_low	5	154	2%	.11
			Weighted Score	**0.52**
			Stream Grade	**9%**

4.4 Francis Brook

Francis Brook is a short tributary to Mill Creek. The total stream length is 1.4 km. Francis Brook originates from the Chichester wetland complex, a constructed wetland system intended for stormwater detention. Chichester receives a significant volume of its water from Gopher Creek. Gopher Creek originates from areas below Black Knight Mountain, crosses Highway 33 and meanders west and then northward through mixed urban and agricultural areas to Springfield Road. Gopher Creek is captured by the City drainage (stormwater) system at Springfield Road and is piped northward for approximately 4.1 km m to the Chichester wetland. Over this distance (underground), there are a total of 23 known stormwater discharges.

4.4.1 Stream Primary Character

A single stream reach was identified occurring from the confluence (of Francis Brook) with Mill Creek to the Chichester wetland complex, which begins about 50 m upstream of Findlay Road. The channel type is riffle pool with an average gradient of about 0.5%. The average wetted width was 2.5 m and the average bankfull (channel) width (to high water level) was 2.8 m. The average wetted depth documented during the survey was 0.14m and the average bankfull depth was about 0.40 m. Riparian vegetation has been highly modified throughout Segment 1 and is predominantly grasses and herbaceous vegetation consequently resulting in low canopy closure of 1-20% over the stream reach. Pacific willow, Siberian elm, as well as red osier dogwood occur infrequently along both banks. Stream bed substrates are predominantly fines (silt/sand) and represent 65% of the substrate composition. Fine organic sediments (i.e., muck) represents about 30% of the substrate composition with gravel and cobble occurring infrequently over small riffles where they are generally embedded in fine substrates.

4.4.2 Instream Habitat/Cover

Total cover in reach 1 was approximately 25% over the 0.6 km reach length. Dense instream vegetation (northern watercress) was the predominant cover type accounting about 60% of total cover. Overstream vegetation accounted about 35% with undercut banks and small residual pools accounting for the remainder of cover.

Francis Brook is hydrologically connected to Mill Creek with no physical barriers (to fish) identified. Fish species observed during the field inventory (no catch records) included redside shiner (*Richardsonius balteatus*) and an unidentified salmonid (rainbow trout (*Oncorhynchus mykiss*) or eastern brook trout (*Salvelinus fontinalis*)). Other fish species include longnose dace (*Rhinichthys cataractae*), prickly sculpin (*Cottus asper*), goldfish (*Carassius auratus*), and northern pike minnow (*Ptychocheilus oregonensis*). However, all fish species documented within Mill Creek may occur in this stream and detailed fish inventories would be required to determine fish species presence and populations.

4.4.3 Bank Stability

Bank stability is moderate to low on both banks and is largely attributed to removal and/or lack of riparian vegetation and intermittent diking.

4.4.4 Chichester Wetland Complex

The Chichester wetland complex was modified/constructed as a catchment for diverted watercourses (i.e., Gopher Creek), groundwater discharge (from tile drains), and to attenuate and filter urban stormwater runoff. Naturalization and succession of this complex has resulted in a functioning wetland ecosystem, albeit at risk from adjacent landuse and disturbance.

A comprehensive community evaluation of Chichester was completed by Ecoscape (2006)[2], which assessed the biodiversity of the wetland complex based on taxonomic and ecosystem variety. Three (3) primary wetland classes (marsh, swamp, shallow open water) occur in the Chichester wetland complex. Nineteen vegetation communities/associations comprising 29 separate polygons were identified in the complex (Table 8).

Structural complexity in respective communities was low to moderate based on the number of vegetation forms that comprise at least 25% total cover within each community. However, the Chichester Wetland complex has high biodiversity value reflected in a moderate to high rating for ecotone abundance (interspersion). Interspersion gives a measure of the presence and length of ecotones (edges) that exist between different vegetation communities. Ecotones are important since many wildlife species depend on more than one habitat type. Thus, as interspersion of wetland vegetation increases, biodiversity of the wetland is enhanced.

[2] Hawes, K., and J. Schleppe. 2006. Francis Brook and Chichester Wetland Complex – Stream Wetland and Riparian Assessment. Ecoscape Environmental Consultants Ltd. File 06-055.

Table 8. Chichester wetland complex classification, vegetation forms and dominant vegetation species (Figure 3).

Wetland Code	Class	Type	Veg^n Form [1]	Dominant Species	Relative Coverage within Complex	Area (m²)
Fl1	Flood Association	broadleaf treed	h;ts	*Salix lucida;Ulmus sp;Acer negundo;Cornus stolonifera*	- [2]	5545
Fl2	Flood Association Disturbed	broadleaf treed	h	*Salix alba*	0.2%	355
G1	Meadow	forb	fo	*Sisymbrium spp,Trifolium sp,Sonchus arvensis*	0.6%	508
M1	Marsh	tall rush	re	*Typha latifolia*	28.3%	8746
M2	Marsh	grass	g;ls;fo	*Phalaris arundinacea;Cornus stolonifera;Urtica dioica*	1.4%	418
M3	Marsh	tall rush	re;fo	*Typha latifolia;Urtica dioica*	1.4%	415
M4	Marsh	tall rush	re;ts	*Typha latifolia;Cornus stolonifera*	4.3%	3244
M5	Marsh	tall rush	re;g	*Typha latifolia;Phalaris arundinacea*	2.2%	655
M6	Marsh	forb	fo;g	*Sonchus arvensis;Phalaris arundinacea*	0.3%	88
M7	Marsh	grass	g;fo;re	*Phalaris arundinacea;Urtica dioica;Typha latifolia*	0.4%	110
M8	Marsh	grass	g;re;ls	*Phalaris arundinacea;Typha latifolia;Cornus stolonifera*	1.4%	413
S1	Swamp	tall shrub	ts;h	*Salix lucida,Cornus stolonifera;Salix lucida;Populus trichocarpa*	3.1%	2942
S2	Swamp	tall shrub	ts;g	*Cornus stolonifera,Salix lucida;Phalaris arundinacea*	0.7%	874
S3	Swamp	tall shrub	ts	*Cornus stolonifera*	0.2%	64
S4	Swamp	tall shrub	ts;re;g	*Cornus stolonifera,Schoenoplectus acutus;Phalaris arundinacea*	0.8%	232
W1	Shallow Open Water	submerged aquatic	su	*Potamogeton sp.*	9.1%	2970
W2	Shallow Open Water	submerged aquatic	su;re	*Potamogeton sp;Schoenoplectus acutus*	17.7%	5204
W3	Shallow Open Water	submerged aquatic	su;re;ff	*Potamogeton sp.;Typha latifolia;Lemna minor*	3.2%	945
W4	Shallow Open Water	submerged aquatic	su;be	*Potamogeton sp;Nasturtium microphyllum*	4.4%	1288

[1] h=broadleaf deciduous; ts=tall shrub; ls=low shrub; fo=forb; g=graminoid; ne=narrow-leaved emergent; be=broad-leaved emergent; re=robust emergent; ff=free-floating; floating plants; su=submerged.

Note: Dominant species for each form are separated by a semi-colon. The dominant form is listed first, followed by sub-dominant forms. Species separated by a"," are codominant species within the same form.

[2] The riparian association Fl1 does not occur within the high water level of the wetland. However these broadleaf associations have high intrinsic ecological value relative to the overall function of the wetland complex; where they contribute increased habitat structural heterogeneity.

4.4.5 Stream Impact Summary

The sum of the weighted scores (Table 9) for Francis Brook was 1.5, resulting in a stream grade equalling 25%. The relatively low grade is based on the level of impact recorded for Francis Brook and Chichester – relating to excavation, construction, channelization and removal of riparian vegetation. Nevertheless, being a wetland, this area remains a complex of high environmental sensitivity and despite functional impairments including habitat fragmentation and degradation, the wetland complex provides wildlife and biodiversity values that are disproportionate to the small relative area it occupies.

Table 9. Francis Brook impact summary. Values shown below are based on SHIM field inventory and analysis of 1.4 linear km of creek.

SHIM Impact Rating	SHIM Score	Combined Segment Length (m)	Percentage of Stream	Weighted Score
Both_banks_mod	1	741	52%	.52
Both_banks_low	2	677	48%	.96
			Weighted Score	**1.48**
			Stream Grade	**25%**

The existing level of impact/disturbance along Francis Brook and Chichester wetland provide numerous opportunities for instream and riparian enhancement/restoration including controlling the spread of invasive plants and restoring/enhancing riparian community structure and function.

4.5 Lebanon Creek

Within the City of Kelowna, Lebanon Creek extends about 2.2 km from its confluence with Okanagan Lake upstream to the Kelowna city limit. The creek was divided into eight (8) segments. With the exception of Segment 1, downstream of Lakeshore Road, all parts of Lebanon Creek within Kelowna were involved in the 2003 wildfires, which resulted in significant changes to riparian structure and stream channel character.

4.5.1 Stream Primary Character

With the exception of salvage logging over much of the stream length, anthropogenic modifications/structures were uncommon and consisted only of 4 wooden pedestrian bridges and a 6-m long concrete block retaining wall in Segment 1. Regeneration of riparian shrubs, including elderberry and Douglas maple, was moderately vigorous. The riparian community was more intact through Segment 3, likely because the 2003 wildfire appeared to spare this moist riparian community and tall shrub thickets maintain a 67-100% cover adjacent the stream channel.

4.5.2 Stream Channel and Hydraulic Character and

The average channel (bankfull) width was about 4.45 m. The minimum channel width observed was about 3 m in Segment 3 and the maximum average channel width observed was 8 m in Segment 8.

Segments 1 – 3 and 6 have gradients ranging from 3% to 6% with a riffle – pool hydraulic character. Through segments 4 and 5, the stream gradient increased to about 15% and 25% respectively, forming a cascade pool hydraulic character. Bedrock, boulders, and instream woody debris are helping to maintain a stable stream channel, good instream cover for small resident fish, and residual pools. Relic and active stream side channels were recorded in Segment 6 amid a vigorously regenerating riparian/floodplain association. The stream channel (bankfull width) widens in segments 7 and 8 through the ravine bottom. In this area, the floodplain is approximately 15 m wide as the creek meanders through the ravine.

4.5.3 Bank Stability

Segment 2 exhibited a highly unstable stream channel with erosion and downcutting severe, often exceeding 1.4m depth. Such instability is largely attributed to the lack of riparian vegetation due to the 2003 wildfire and flashy high flow events that have since occurred.

Nearly all documented erosion occurred in Segments 2 and 3 where the channel has downcut through deep tills. The combined length of recorded active erosion on the left bank was 93 m, with an average cut bank height equally 1.3 m. The combined length of recorded erosion along the right bank was 153 m, with an average bank height equalling 1.7 m.

4.5.4 Instream/Habitat Cover

Suitable spawning substrates were more prevalent in Segments 4 and 6. The presence of rainbow trout within Segment 4 suggests that Lebanon Creek may support a small viable resident trout population. The greater occurrence of boulders and small bedrock outcrops within the stream channel are likely providing channel stability benefits and maintaining residual pools, helping to support the resident trout population.

Instream cover increases from about 10% in Segments 1-3 to about 20% in Segment 4. Coarse substrates account about 90% of total cover in the lower segments and other than cobble and boulder substrates, there is generally a lack of instream habitat structural heterogeneity. Increasing channel stability in segment 4 maintains residual pools, which accounted for 60% of total cover, followed by boulders and large woody debris, accounting about 30% and 10% of total cover respectively. Although segment 5, itself, is a barrier to upstream fish migration, the cascade pool morphology and associated large woody debris, boulder and deep pool cover may provide temporary habitats for trout moving downstream from a small headwater lake when flows are not too severe. Coarse woody debris is more abundant in segment 7, providing very high cover with 10 span logs / 10 linear metres stream length. Similarly, Segment 8 contains a dense cover of small woody debris and over stream vegetation with a wider stream channel. The dense stocking of spanning logs is likely helping to mitigate channel instability associated with the fire, and loss of riparian vegetation.

4.5.5 Obstructions/ barriers

Segments 1 to 3 have a lower gradient with deeper coarse substrates and appear more ephemeral in character with flows occurring mainly subsurface during low stream stages. More permanent stream flows are evident in Segment 4 corroborated by the presence of rainbow trout in residual pools supported by shallow substrates over bedrock. Segment 5 is a steep bedrock controlled gorge/ravine with an average gradient exceeding 25% and maximum grades exceeding 100%. Therefore, no upstream fish migration is possible beyond about 0.86 km upstream of Okanagan Lake. However, a small headwater lake to Lebanon Creek contains resident rainbow trout. Therefore all of Lebanon Creek may be frequented by fish.

4.5.6 Discharges

No discharges were recorded along Lebanon Creek due to its more rural, relatively undeveloped character.

4.5.7 Stream Impact Summary

The sum of the weighted scores (Table 10) for Lebanon Creek was 2.53, resulting in a stream grade equalling 42%. The fire and associated salvage logging have had the greatest impact along Lebanon Creek. The encroachment from logging has resulted in the degraded condition/function of the stream corridor. In addition, the removal of coarse woody debris from lower stream segments (2 and 3) may be exacerbating channel instability and erosion. Nevertheless, regeneration along the stream is moderately vigorous.

Table 10. Lebanon Creek impact summary. Values shown below are based on SHIM field inventory and analysis of 2.2 linear km of creek within the Kelowna city limits.

SHIM Impact Rating	SHIM Score	Combined Segment Length (m)	Percentage of Stream	Weighted Score
Nil	6	240	11%	0.66
1_bank_low	5	126	6%	0.29
Both_banks_low	2	1667	76%	1.52
Both_banks_lmod	1	167	8%	0.08
			Weighted Score	**2.53**
			Stream Grade	**42%**

The existing level of impact/disturbance along Lebanon Creek with respect to salvage logging and bank instability provides low to moderate opportunities for instream and riparian enhancement/restoration. The 2003 wildfire and subsequent salvage logging and removal of riparian vegetation has resulted in considerable bank instability on both the right and left banks of Segment 2 resulting in severe erosion and channel down cutting. Ecoscape recommends that measures be implemented in Segment 2 to mitigate further channel downcutting and consequential aggradation in segment 1.

4.6 Leon Creek (Brooks Spring / Thompson Brook)

Within the Kelowna city limit, Leon Creek is discontinuous and fragmented by urbanization. The total stream length mapped was 2.7 km. Flows were observed as continuous and regular, from the Kelowna city limit (at the upstream end of the SHIM survey) down to Chute Lake Road where the gradient levels out and the flows infiltrate the deep moderately well drained parent material. A defined channel ceases to exist north of Chute Lake Road and urban development has likely captured a portion of groundwater flows in the City storm sewer. Groundwater flows re-emerge as a spring at the head of a steep ravine (Segment 4) about 0.85 km upstream from Okanagan Lake. Moving downstream through the ravine, wetted flows diminish and become discontinuous, ceasing upstream of Lakeshore Road; where the stream channel is barely distinguishable (Segment 2).

4.6.1 Primary Character

About 88% of Leon Creek has been modified – with just one segment remaining natural through the lower ravine.

Segment 5 has been channelized above Chute Lake Road through existing and developing subdivisions to the western limit of a second ravine. A dam has been constructed at the downstream end of the ravine to attenuate potential high volume runoff flows due to the loss of vegetation throughout the watershed from the 2003 wildfires. Although much of the tree canopy through the ravine (Segment 6) was destroyed by wildfire, the moist to wet gully retained the tall shrub riparian / swamp thickets and vigorous regeneration was evident, including that of cottonwood and water birch. Segment 7 drops from a riparian bench area (Segments 8 and 9) into the ravine (Segment 6).

Segments 8 and 9 flow over a level riparian bench area that has been subjected to severe disturbance from 4 wheel drive recreational vehicles (mud bogging), which has had detrimental effects on stream channel morphology (altered flow regimes); with stream flows now following tire ruts. The stream channel is poorly to moderately defined in areas and flows tend to fan out over the riparian bench. The average channel width is about 1.3 m with a bankful (channel) depth of about 0.20 m. The gradient is about 2% as stream flows over fine sands and silts over the bench association accompanied by groundwater seepage and wetland development. The riparian bench association is predominated by young cottonwood, water birch, and aspen canopy with graminoids and invasive forbs occurring in areas of disturbance. The understory is very well developed in the natural fragmented riparian communities comprised of red-osier dogwood, nootka rose, fireweed, alder, and willow sp.

Based on the observed groundwater seepage and stream flows throughout the riparian bench area along segments 8 and 9, the existing broadleaf forest association is likely a remnant of a much larger riparian area that existed previous to the 2003 wildfires.

Segment 10 occurs above the riparian bench. The segment length is about 105 m and the stream grade is about 28% forming a cascade-pool hydrology. Extreme channel instability has resulted in severe erosion and channel down cutting. This instability is likely a result of a combination of factors including loss of riparian vegetation (2003 wildfire) altered hydrology, and increased surface runoff (as a result of the 2003 wildfires and loss of vegetation). Bedrock outcrops are discontinuous along the segment length. In these areas, the stream channel is confined and scoured through a finer overburden to more coarse substrates and bedrock. The channel width is about 2 m with normal bankfull depths (identified in areas of greater channel stability) of about 0.3 m. The existing and potential riparian band is narrow (<5 m) as both stream banks are generally greater than 30% slope and the channel is down-cut in some areas over 1-m below grade. Vegetation communities along Segment 10 are in an early successional stage predominated by herbs and grasses including fireweed, agronomic grasses (used in post fire erosion control measures), and invasive plants such as perennial sow thistle and Canada thistle.

Segment 11 splits into two (2) modified channels and extends upstream to the Kelowna city limit. Riparian communities are a mix of disturbed closed shrub thicket and burned areas predominated by herbs, grasses, and low shrub regeneration. Regeneration of riparian shrubs (red-osier dogwood, willow, alder, and Douglas maple) and trees (cottonwood, water birch) was vigorous. Water birch and cottonwood snags were abundant. However, most were sapling diameter (<150 mm) providing limited suitability for cavity nesting and roosting wildlife such as bats. A more intact mature cottonwood riparian bench association remains upstream of Segment 11 (within the jurisdiction of the Regional District of Central Okanagan) although the wildfire has killed many of the mature cottonwoods. Segment 11 wetted widths were greater, attributed to the shallower stream grade, equalling about 1-m. The average channel width and depth was about 2 m and 0.15 m respectively. Dense instream vegetation (American brooklime – *Veronica americana*) occurs where the channel depth is shallow, stable, and predominated by fine substrates (sand).

4.6.2 Fish and Wildlife

The overall ephemeral character of Leon Creek is not capable of supporting fish populations based on inadequate and discontinuous surface flows and steep gradients. The relatively intact riparian ravine communities and remnant riparian bench communities (Segment 6-9 and 11) and associated thickets provide high wildlife and biodiversity values relative to lower, segments. Despite disturbance and fragmentation, these areas have high habitat suitability for providing food, shelter, and breeding habitat for numerous amphibian, reptile, mammal, bird, and insect species.

4.6.3 Summary of Bank Stability and Erosion

Bank stability is very low to low on both banks almost exclusively through Segment 10 and is largely attributed to removal and/or lack of riparian vegetation and steeper grade. The total recorded length of bank erosion along Leon Creek was about 185m on both the left and right stream banks totalling 370 linear metres. The average height of erosion was about 1-m. Thus the severity of erosion is roughly 370m^2.

4.6.4 Stream Impact Summary

The sum of the weighted scores (Table 11) for Leon Creek was 2.57, resulting in a stream grade equalling 43%. Primary opportunities to restore and protect significant habitat areas along Leon Creek occur from Segments 6-11. Through these segments impacts have been associated with wildfire, salvage logging, excessive human disturbance, and severe channel erosion. Natural regeneration of riparian vegetation is vigorous throughout these segments. Therefore primary goals should focus on preserving adequate setbacks and maintaining intact riparian bench and riparian gully and wetland associations.

Table 11. Leon Creek impact summary. Values shown below are based on SHIM field inventory and analysis of 2.7 linear km of creek within the Kelowna city limits.

SHIM Impact Rating	SHIM Score	Combined Segment Length (m)	Percentage of Stream	Weighted Score
Both_banks_high	0	414	15%	0.00
Both_banks_mod	1	900	33%	0.33
Both_banks_low	2	309	11%	0.23
1_bank_low	5	1087	40%	2.01
			Weighted Score	**2.57**
			Stream Grade	**43%**

4.7 Priest Creek

Priest Creek extends about 7.1 km from its confluence with Mission Creek to the Kelowna city limit. Casorso Creek, flows into Priest Creek about 5.2 km upstream of the Mission Creek confluence. The Casorso Creek length is 1.9 km within the City limit. Both Priest Creek and Casorso Creek were mapped and are summarized below. Priest Creek was divided into 20 segments and Casorso Creek was divided into 8 segments. Within Priest Creek, Segments 1-15 occur below the confluence with Casorso Creek. Segments 1-3 occur over the Mission Creek floodplain area comprising a natural wetland complex that consists of treed cottonwood floodplain and swamp associations, tall shrub swamps, and cattail marsh.

4.7.1 Stream Primary Character

Approximately 50% of Priest Creek within the Kelowna city limit is natural, not being recently disturbed and the other 50% is modified but not channelized. Modifications are more rural in character involving riparian encroachment and agricultural use including live stock access. About 60% of Casorso Creek has been modified by rural activities and about 40% remains natural.

4.7.2 Stream Channel and Hydraulic Character

The primary hydraulic character over 87% (6.2 km) of Priest Creek is riffle pool. The balance of the creek is wetland and flood association. The majority (59%) of Casorso Creek is slough to wetland hydraulic character. Riffle pool morphology accounts for about 34% (0.64 km) and cascade pool accounts for 7% of the mapped stream length. The average stream gradient over Priest Creek is about 2%, with a maximum segment grade of 6% and a minimum grade of 0%. Similarly, Casorso Creek has an average gradient of about 2%, with a maximum grade (through a ravine) equaling 9%. With the exception of Segment 1, which is a shallow open water community within the Mission Creek Swamp/floodplain complex, the average channel (bankfull) width of Priest Creek is about 2.5m.

About 64% of Priest Creek surveyed by SHIM had a crown closure greater than 70%. Six percent of the SHIM stream length has a 0-20% canopy cover. The remaining 30% of the creek has a moderately closed canopy ranging from 21-70%. The well developed and closed tree canopy that predominates over the majority of Priest Creek likely contributes significant instream temperature benefits for fish (maintaining lower water temperatures during summer months).

Substrate compositions in Priest Creek were gradated by three general segment groups. Exclusively organic and fine substrates exist in the lower three segments on the Mission Creek floodplain. From here, stream substrates were a well-graded mix of sand-gravel-cobble through the ravine up to segment 12. Segments 13-15, occurring above the ravine on a more level bench consisted predominantly of fines. The stream grade begins to increase through Segment 16, where substrates again become a well-graded mix of sand-gravel-cobble changing to predominantly cobble with about 25% gravel from Segments 17-20.

4.7.3 Instream Habitat Cover/Complexity

Within Priest Creek, seven (7) segments, with a combined length of 3.1 km, were identified as having spawning habitat potential for resident and adfluvial rainbow, which have been observed in the lower reaches.

The predominantly riffle pool stream morphology maintains good instream cover/habitat for resident rainbow. Over half of Priest Creek within the City limit has good quality total instream cover exceeding 50%. Moderate instream cover (greater than 20%) accounted for about 35% of the 7.1 km SHIM stream length. Areas with low instream cover, accounting about 15% of Priest Creek, had either been subject to anthropogenic disturbance such as channelization, and removal of riparian vegetation or were more ephemeral segments, where aggradation[3] has reduced instream habitat complexity, filling residual pools and covering other instream features such as coarse woody debris. Overstream vegetation and small woody debris were observed to be contributing significantly to instream cover values throughout most reaches of this small creek.

4.7.4 Discharges

There were no stormwater discharges documented flowing into Priest Creek. However, three (3) discharges were documented with sources from the South East Kelowna Irrigation District. Of these, one discharge had a strong chlorine odour.

4.7.5 Bank Stability and Erosion

Segments with high bank stability had a cumulative length of 0.9 km (13% of SHIM stream) and had well developed natural wetland riparian communities and low stream grades. About 43% (3 km) of the SHIM stream length had medium bank stability. About 45% (3.2 km) of Priest Creek had low observed bank stability often occurring due to encroachment of the stream channel, channelization, and removal of riparian vegetation. However, actual recorded erosion totaled about 0.47 km along both the right bank and left bank.

Bank stability along Casorso creek was relatively evenly distributed over the 1.9 km stream length from low to high. Areas with high bank stability were natural wetland and areas containing broadleaf tree and tall shrub thickets and low gradient riparian gully and bench associations. Areas with medium stability have been subject to some disturbance or encroachment and occurred over steeper grades with inherently reduced bank stability. Areas with low stability occurred over segments with more intense modifications and disturbance from rural activities and agriculture.

[3] Aggradation is the accumulation of sediment in a stream channel on an alluvial fan or on a floodplain

4.7.6 Obstructions/ barriers

Rainbow trout were visually observed in Priest Creek up to Segment 15. All the potential obstructions that were recorded occur downstream of Segment 15. Within Priest Creek upstream of this point, wetted stream sections were more intermittent; however, no permanent obstructions were documented. Therefore fish may occur further upstream and be holding in wetted residual pools. However, Ecoscape expects that fish densities may decrease upstream of the Casorso Creek confluence being limited by reduced stream flows.

4.7.7 Modifications

The cumulative length of modifications within and along Priest Creek and Casorso Creek totals just under 290 m (3%) of the mapped stream length. A breakdown of modifications is shown in the table below.

Table 12. Summary of modifications along Priest Creek.

Type	Number	Cumulative Length (m)	% of Modifications
Bridge	9	17.90	6%
Fence Crossings	14	0.00	0%
Garbage/other	4	28.00	10%
Bank Stabilization/Rip Rap	16	173.50	61%
Dredging	1	67.00	23%
Water Withdrawal	1		0%

4.7.8 Stream Impact Summary

The sum of the weighted scores (Table 13) for Priest Creek was 4.33 resulting in a stream grade equalling 72%. The sum of the weighted scores (Table 14) for Casorso Creek was 4.25 resulting in a stream grade equalling 72%.

Table 13. Priest Creek impact summary. Values shown below are based on SHIM field inventory and analysis of 7.1 linear km of creek within the Kelowna city limits.

SHIM Impact Rating	SHIM Score	Combined Segment Length (m)	Percentage of Stream	Weighted Score
Both_banks_mod	1	678	10%	0.10
Both_banks_low	2	1597	22%	0.45
1_bank_low	5	2108	30%	1.48
Nil	6	2733	38%	2.3
			Weighted Score	**4.33**
			Stream Grade	**72%**

Table 14. Casorso Creek impact summary. Values shown below are based on SHIM field inventory and analysis of 1.9 linear km of creek within the Kelowna city limits.

SHIM Impact Rating	SHIM Score	Combined Segment Length (m)	Percentage of Stream	Weighted Score
Both_banks_high	0	151	8%	0.00
Both_banks_mod	1	409	22%	0.22
1_bank_low	5	358	19%	0.95
Nil	6	970	51%	3.08
			Weighted Score	**4.25**
			Stream Grade	**71%**

Priest Creek is a relatively good functioning watercourse. However it is at risk of urban expansion, encroachment, water withdrawals and habitat degradation. Opportunities to protect and restore Priest Creek should be realized, with priority, recognizing this watercourse is still natural of over much of its length and likely supports a viable resident population of rainbow trout.

4.8 Rembler Creek

Rembler Creek is an ephemeral watercourse. The total stream channel length within the Kelowna city limit is just over 5.6 km. Over this length, about 40 % (2.2 km) of the creek is described as an intermittent vernal watercourse with a discontinuous, often very poorly defined channel (Segments 10-13). There is barely evidence of a stream in Segment 13, which accounts for about 27% of Rembler Creek within the Kelowna city limit. Here the stream channel is only intermittently distinguishable through old field and is likely only wetted during spring run-off accompanied by periods of extended heavy precipitation. However, other areas along the watercourse contain more regular to permanent stream flows and a well defined channel.

4.8.1 Stream Primary Character

Portions of Rembler Creek upslope of Chute Lake Road were burned during the 2003 wildfires. Following the fires and in response to a flash flood event through this corridor, extensive channel armouring and flood mitigation structures were installed in Rembler Creek from Okanagan Lake extending upstream about 2.63 km. Over 5 km (90%) of Rembler Creek has been modified. Of this, almost 1.2 km (21%) has been ditched or channelized and armoured with rip rap (upstream of Lakeshore Road and along Chute Lake Road). Other disturbance regimes along the creek include livestock access, flood mitigation works, and road encroachment. Only about 11% (0.6 km) of the Creek remains natural within the Kelowna City limit.

4.8.2 Stream Channel and Hydraulic Character

Rembler Creek is predominantly a cascade morphology with over 2.6 km (46%) of the creek having a gradient ranging from 7 to 25%. Riffle pool segments account just 5% of the stream length. Segments 6 and 7 are modified riparian gully/tall shrub swamp associations with observed slow-moving and intermittent standing water. Segments 3 and 15 are excavated basins/ponds that occur within the stream line.

The bankfull channel width has been modified considerably in some areas and is barely visible in others and, with the exception of Segments 3 and 15 (ponds), ranges from less than 0.50m to about 4.5 m. Native substrates over much of the creek were a mix of primarily fines and gravels. However, extensive channel armouring with rip rap has altered substrate compositions considerably. Low gradient and poorly defined segments consisted primarily of fine sediments.

4.8.3 Obstructions/ barriers

Rembler Creek provides marginal habitat for fish in segment 1 with a consistent base flow and riffle pool stream morphology. However, recent flood works (catch basins installed within stream channel creating a 2-m vertical drop) have created an absolute fish barrier at the confluence of Rembler Creek and Okanagan Lake. A second flood control structure occurs 300 m upstream of Okanagan Lake at Lakeshore Road, and a third structure occurs just 100 m further upstream. For this reason, instream habitat was not quantified in the field using the SHIM data dictionary.

4.8.4 Bank Stability and Erosion

Bank stability over 91% of the Rembler Creek is generally medium to high, which in many areas has been exaggerated by extensive armouring. Segments with low stability (4, 9, and 14) have a combined length of just over 0.5 km, accounting for about 9% of Rembler Creek. The cumulative length of bank erosion was 426 m (total of erosion on both banks) with an average height of exposure equalling 1.2m. Thus, the approximate severity of erosion is about 510 m^2.

4.8.5 Discharges

Rembler Creek bisects less urbanized and rural areas and a limited number of stormwater drainage infrastructure was observed. Relative to the reduced development intensity the number of stormwater discharges to the creek is low with only six (6) discharges identified.

4.8.6 Stream Impact Summary

The sum of the weighted scores (Table 15) for Rembler Creek was 2.39, resulting in a stream grade totalling 40%. This score reflects intensive flood mitigation works, channelization and ditching (along Chute Lake Road). Opportunities for enhancement and restoration along Rembler Creek are limited due to the intermittent nature of the watercourse.

Table 15. Rembler Creek impact summary. Values shown below are based on SHIM field inventory and analysis of 5.64 linear km of creek within the Kelowna city limits.

SHIM Impact Rating	SHIM Score	Combined Segment Length (m)	Percentage of Stream	Weighted Score
Both_banks_high	0	1196	21%	0.00
Both_banks_mod	1	1910	34%	0.34
Both_banks_low	2	66	1%	0.02
1_bank_high	3	159	3%	0.08
1_bank_mod	4	612	11%	0.43
1_bank_low	5	1697	30%	1.5
			Weighted Score	**2.39**
			Stream Grade	**40%**

4.9 Scotty Creek

Only 0.64 km of Scotty Creek occurs within the Kelowna city limit. Over this length, three (3) segments were identified, all being modified and channelized. Currently, rip rap armouring lines 34 m of the left bank and 53 m along the right bank in the 3 segments combined. A narrow riparian band containing some mature cottonwood provides a discontinuous canopy with a 21-40% crown closure over the surveyed stream length. Segment 3 occurs through the Shadow Ridge golf course and is a modified riffle pool morphology. Riparian communities are disjunct, broken by fairways and consist of a mix of natural young stage cottonwood/tall shrub riparian communities. The average channel (bankfull) width over the three segments is about 4 m.

4.9.1 Instream Habitat Cover and Complexity

Scotty Creek is an ephemeral watercourse, which may be frequented by fish on a seasonal basis depending on flow regimes. Based on observed intermittent and ephemeral flows, Scotty Creek may have limited reproductive capacity for fish. Low flows combined with ditching and removal of instream complexity has reduced instream total cover to between 5 and 10% over the 640 m length of stream within the Kelowna city limit. However, the predominantly gravel and cobble substrates may be utilized by fish for spawning during high flow years when fish (e.g., Rainbow trout and Eastern Brook trout) may ascend Scotty Creek a short distance from Mill Creek. An old concrete control weir/dam situated about 440 m upstream of Mill Creek is a potential upstream migration barrier to fish.

4.9.2 Bank Stability and Erosion

Segment 2 has been ditched along Bulman Road. Bank stability is severely compromised along Segment 2 (103m) and erosion, occurring over the entire Sement 2 length, may begin to partially undermine Bulman Road if mitigative steps are not implemented.

4.9.3 Stream Impact Summary

The sum of the weighted scores (Table 16) for Scotty Creek was 0.78, resulting in a stream grade totalling 13%. The channelization, road encroachments and severe bank instability /erosion results in Scotty Creek receiving a poor grade. The primary opportunity would be either to realign Bulman Road or realign Scotty Creek such that it crosses Bulman Road, at the Segment 2-3 break and meanders through a new channel to Mill Creek. Alternately, instream structures could be installed in combination with bank armouring/bioengineering along Bulman Road to help maintain residual pools.

Table 16. Scotty Creek impact summary. Values shown below are based on SHIM field inventory and analysis of 640 m of creek within the Kelowna city limits.

SHIM Impact Rating	SHIM Score	Combined Segment Length (m)	Percentage of Stream	Weighted Score
Both_banks_high	0	340	53%	0
Both_banks_mod	1	103	16%	0.16
Both_banks_low	2	196	31%	0.61
			Weighted Score	**0.78**
			Stream Grade	**13%**

4.10 Thompson Creek

Similar to Fascieux Creek, Thompson Creek originates from a network of ditching and tile drains throughout fields in the vicinity of Swamp Road. The entire watercourse was modified. Over 3.1 km (65%) of Thompson Creek is represented by a network of ditching. Twenty six percent (1.3 km) of Thompson Creek is now represented by a constructed wetland that consists of shallow open water and cattail marsh. Downstream of Gordon Drive, the creek is channelized for about 179 m along a field with a partially naturalized riparian association dominated by a Cottonwood canopy and red-osier dogwood shrub thicket. From here, Thompson creek flows underground beneath a cul de sac and Lakehsore Road for about 149 m and daylights over the final 103 m to Okanagan Lake.

The bottom 100 m of Thompson Creek just above the confluence with Okanagan Lake contains substrates suitable for spawning fish such as Kokanee. Limited salmonid reproductive capacity exists much beyond 100m upstream of Okanagan Lake as stream substrates become exclusively mud and silts. Instream cover is low in segment 1 (4%), which contains suitable spawning substrates. Although channelized, good overstream cover exists through Segment 3 from overstream vegetation and small woody debris. The constructed wetlands comprising Segment 4 have good deep water cover for various fish species. In addition, these wetlands may be providing critical reproductive habitats for the Great Basin spadefoot, which were documented by Ecoscape just 200 m from Thompson Creek in summer 2006.

4.10.1 Stream Impact Summary

The sum of the weighted scores (Table 17) for Thompson Creek was 0.66, resulting in a stream grade equalling 11%. Despite wetland development and restoration, which now provide high intrinsic ecological value to the area, Thompson Creek is a highly modified watercourse. However, over time, establishment of riparian communities and establishment of wetlands should improve the rating of this water course. Due to the very shallow groundwater in this area and wetland tendencies it appears that the majority of surface waters are connected hydrologically to the ditched network that make up the majority of Thompson Creek. Ecoscape recommends that additional wetland mapping fill data gaps in this area that were not within the scope of the 2006 SHIM inventory. Essentially all wetland communities functionally connected to Thompson Creek are also functionally connected, albeit fragmented and at risk, to floodplain associations/wetland complexes of Priest Creek and Mission Creek.

Table 17. Thompson Creek impact summary. Values shown below are based on SHIM field inventory and analysis of 4.8 linear km of creek within the Kelowna city limits.

SHIM Impact Rating	SHIM Score	Combined Segment Length (m)	Percentage of Stream	Weighted Score
Both_banks_high	0	3271	68%	0.00
Both_banks_mod	1	104	2%	0.02
Both_banks_low	2	1272	26%	0.53
1_bank_high	3	180	4%	0.11
			Weighted Score	**0.66**
			Stream Grade	**11%**

4.11 Whelan Creek

Whelan Creek is a small first order tributary to Mill Creek. Only 0.81 km of Whelan Creek, comprising three distinct segments, occurs within the Kelowna city limit. Over this length, 21% is ditched, 32% channelized, and 47% remains a natural wetland complex. Segment 1 is ditched over the 167m length to the confluence with Mill Creek, which parallels the Kelowna International Airport runway. Riparian vegetation along Segment 1 is exclusively graminoids, which are mowed to the top of the ditch bank. A near level grade exists over Segment 1 and the channel (bankfull) is about 1.5m. Substrates are mostly consists of fines and fines and soil.

Segment 2 is associated with a wetland complex that consists of Cottonwood swamp, mixed shrub thicket swamp, cattail marsh, and graminoid marsh. This wetland complex has extremely high biodiversity value and currently supports a viable Great Blue Heron rookery (nest colony). The very high structural diversity, represented by multiple vegetation forms, has a very high habitat suitability rating for feeding, security, and reproduction by a diversity of wildlife. This wetland complex is proper functioning but at serious risk of further fragmentation and degradation from edge effects and urban expansion, which may involve airport upgrades or urban and commercial development.

Segment 3 is partly channelized through a rural property. The riparian character is varied over the segment length and ranges from a channelized clearing predominated by reed canary grass, a disturbed shrub thicket, and a cottonwood grove along the right bank. The channel (bankfull) width is about 1.8 m.

4.11.1 Stream Impact Summary

The sum of the weighted scores (Table 18) for Whelan Creek was 3.8, resulting in a stream grade equalling 63%. Significant emphasis should be placed on preservation of the existing wetland complex (Segment 2) with a goal of securing more of the adjacent habitats to buffer this significant habitat area from further encroachment and degradation.

Table 18. Whelan Creek impact summary. Values shown below are based on SHIM field inventory and analysis of 810 m of creek within the Kelowna city limits.

SHIM Impact Rating	SHIM Score	Combined Segment Length (m)	Percentage of Stream	Weighted Score
Both_banks_high	0	167	21%	0.00
1_bank_high	3	260	32%	0.96
Nil	6	383	47%	2.84
			Weighted Score	**3.8**
			Stream Grade	**63%**

4.12 Wilson Creek

Wilson Creek originates from shallow groundwater, ditching and irrigation water diverted from Mission Creek. Wilson Creek is about 2.6 km in length from its terminus at Okanagan Lake to origins adjacent to the Mission Creek dike system. The origin of Wilson Creek is likely anthropogenic, similar to Francis Brook and Thompson Brook. The creek may have originated as a flood channel of Mission Creek and during diking was likely channelized and ditched as an irrigation supply.

4.12.1 Stream Primary Character

Approximately 37% (974 m) of the creek has been ditched and channelized with riparian impacts ranging from intensive agriculture to commercial/urban landuse. Modified non-confined segments had a cumulative length of 1.2km, accounting about 47% of the creek. Of this length, 920 m represents modified and partially constructed/restored wetland. Segment 8, occurring through a mature cottonwood floodplain/riparian association, was the only reach that has not been recently disturbed and accounts about 16% of the SHIM stream length.

4.12.2 Stream Channel and Hydraulic Character

Wilson Creek has an average gradient of 0.2%. Substrates are exclusively fines and organic sediments (i.e., muck) and instream vegetation (predominantly cattail) is dense throughout much of the channelized and ditched sections (sloughs) providing marginal instream habitat for fish. Nevertheless, no barriers to upstream movement exist and Wilson Creek is likely frequented by various species of fish including redside shiner, longnose dace, carp, and northern pike minnow, and perhaps rainbow trout.

4.12.3 Bank Stability and Erosion

Stream flows are consistent originating from groundwater and irrigation channels and despite much of the creek being channelized and ditched with poor riparian development, bank stability along 68 % Wilson Creek is relatively high with a single segment (accounting for 16%) of the stream length, having low bank stability. Segment 2 had the lowest relative bank stability and the highest incidence and severity of bank erosion occurring mostly along the right bank adjacent a RV park and campground.

4.12.4 Discharges

Stormwater inputs to Wilson Creek were low with just three (3) discharges identified; along Lakeshore Road, a clean-flowing discharge on the right left bank between Gordon Drive and Lakeshore Road (suspected groundwater discharge), and the third discharge from a church parking lot into a wet detention pond, which then flows into a cattail march on the right bank upstream of Benvoulin Road in Segment 7.

4.12.5 Stream Impact Summary

The sum of the weighted scores (Table 19) for Wilson Creek was 1.41 resulting in a stream grade equalling 23%. This relatively low grade represents extensive ditching and channelization and general channel modifications along the majority of the creek length. As opportunities present themselves efforts should be made to enhance instream and riparian habitats taking advantage of consistent base flows and realizing wetland habitat creation and restoration – emulating Segment 3 works.

Table 19. Wilson Creek impact summary. Values shown below are based on SHIM field inventory and analysis of 2.63 linear km of creek within the Kelowna city limits.

SHIM Impact Rating	SHIM Score	Combined Segment Length (m)	Percentage of Stream	Weighted Score
Both_banks_high	0	1153	44%	0.00
Both_banks_mod	1	544	21%	0.21
Both_banks_low	2	501	19%	0.38
1_bank_low	5	432	16%	0.82
			Weighted Score	**1.41**
			Stream Grade	**23%**

5.0 CONCLUSION

The preceding report has summarized detailed field inventory data collected during 2006 SHIM of 12 watercourses within the Kelowna City Limits. The collection and management of data conformed to the SHIM methodology, which is a standard for fish and aquatic habitat mapping in urban and rural watersheds in British Columbia.

The 2006 inventory has resulted in the development of an up-to-date and robust catalogue of watercourse and habitat features occurring in the respective watercourses, which has numerous applications and can be used by community, stewardship groups, individuals, regional districts and municipalities, and senior regulatory agencies. In maintaining the integrity of this SHIM database, periodic field inspections should be carried out to update watercourse and habitat feature mapping.

6.0 CLOSURE

The inventory that has been summarized within this report was commissioned by and prepared for the City of Kelowna. The collection, processing, and management of data has conformed to SHIM standards. No other warranty is made, either expressed or implied.

Questions or inquires pertaining to SHIM methodology, data, and this summary report should be directed to the undersigned.

Respectfully Submitted,
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