KELOWNA FILE:
CAS08-42

SENSITIVE HABITAT INVENTORY
AND MAPPING (SHIM) – 2008 Survey Period

Inventory Summary Report - Volume 3

A Comprehensive Watercourse Catalogue



ECOSCAPE
Environmental Consultants Ltd.

City of Kelowna

Okanagan Basin
WATER BOARD

Prepared For:
City of Kelowna

Prepared By:
Ecoscape Environmental Consultants Ltd.

File No.:08-293
February, 2009

SENSITIVE HABITAT INVENTORY AND MAPPING (SHIM) - 2008

Bauer Brook, Campbell Brook, Industry Brook, Vernon Creek (Upper), Gopher Creek, Bellevue Creek (North Arm), Thomson Creek (Upper reaches), Hachey Creek, Michaelbrook Creek, Rumohr Creek, KLO Creek, Hydraulic Creek, Mission Creek (top of Ravine only), Dewdney Creek

Inventory Summary Report – Volume 3

Prepared For:

THE CITY OF KELOWNA
1435 Water Street
Kelowna, BC.
V1Y 1J4

Prepared By:

ECOSCAPE ENVIRONMENTAL CONSULTANTS LTD.
102 - 450 Neave Court
Kelowna, BC
V1V 2M2

February, 2009

ECOSCAPE
Environmental Consultants Ltd.

File No. 08-293
City of Kelowna File: CAS08-42

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1.0 INTRODUCTION

Ecoscape Environmental Consultants Ltd. (Ecoscape) was retained by the City of Kelowna to complete Sensitive Habitat Inventory and Mapping (SHIM) of streams occurring within the City of Kelowna. The following report summarizes the inventory findings, which have been provided to the City of Kelowna 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. Accordingly, there is an urgent need to develop stronger tools and better methods to conserve, 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 current 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 integration into 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 that 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 the extents of the identified watercourses within the City of Kelowna and associated riparian habitats, and important watercourse and 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 along 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 (CAS08-42, June 2, 2008). The fundamental objective was to complete Sensitive Habitat Inventory and Mapping (SHIM) surveys on all creeks identified in the Request for Proposal including:

- ✓Bauer Brook
- ✓Bellevue Creek (North Arm)
- ✓Dewdney Creek
- ✓Campbell Brook
- ✓Gopher Creek
- ✓Hachey Creek
- ✓Hydraulic Creek
- ✓ Industry Brook
- ✓KLO Creek
- ✓Michaelbrook Creek
- ✓Mission Creek (top of Ravine only)
- ✓Rumohr Creek
- ✓Thomson Creek (Upper reaches)
- ✓Vernon Creek East – above Duck (Ellison) Lake

Field inventory methods and data processing and management were to conform to SHIM Standards and Methodology. At the completion of the project, standard SHIM deliverables were to be provided to the City of Kelowna and subsequently to the Community Mapping Network (CMN) for publication in the SHIM atlas.

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 principal surveyor and completed all field survey elements with the assistance of biologist, Tyra Zeman, B.Sc., BIT.

The stream centerline was mapped along the center of the bankfull (not floodplain) width. The creek was 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, large woody debris, bank erosion, etc.).

During previous SHIM surveys within the Okanagan, Ecoscape developed and appended a Level of Impact rating to the data dictionary, which is included in Appendix A in the Volume 1 SHIM report. This simple rating system was designed with the intent of providing a more measurable parameter in evaluating stream condition and monitoring and evaluating habitat restoration and future conservation efforts on local watercourses and associated riparian and floodplain communities. The raw data and rationale for respective stream segment scores can be found in Appendix A 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 to yield the stream condition score.

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
	Level of Impairment	Score 0 (Severely impaired) – 6 (Natural); Rationale
	Enhancement Opportunity Rating	0 (Nil) – 4 (Very High); Rationale
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.

[1] A combined weighted score of 6 would be attained if all segments were natural with no discernable human disturbance on either the right or left bank. Note this evaluation does not factor in impacts upstream of the Kelowna City limit, which could still impact on water quality and habitat values.

3.2 Top of Bank Survey

Watercourse (lake, pond, stream and wetland) location and extent are critical for providing information to help determine the degree of protection to which a watercourse 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, UTM Zone 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. Final mapping deliverables were produced in ArcGIS 9.2.

3.4 Quality Assurance and 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 of the surveyed watercourses. Summary results and discussions for individual watercourses are commensurate with their overall magnitude, habitat rating, and level of impact. Refer to the attached summary pages and corresponding figures (maps) for segment attributes and representative photos. The processed data from the centreline survey (Stream_line) and feature data has been included in Appendix A. In addition, this data can be found in digital format accompanying the complete inventory catalogue, which includes all point features, attributes, and representative photos (intended for use in a GIS platform). Furthermore, the reader is encouraged to refer to the Community Mapping Network, SHIM atlas (www.shim.bc.ca).

Additional field information was collected for Thompson Brook during the 2008 field survey to update the spatial extents of this watercourse recognizing the changes that have occurred since the 2006 survey period. Watercourse information for Thompson Brook is presented in Volume 2 (Ecoscape, 2007a).

4.1 Bauer Brook – Campbell/Industry System

Campbell Brook (through Tower Ranch golf course) and Industry Brook merge at the eastern limit of Tower Ranch in a large golf course pond along McCurdy Road. From here, Bauer Brook commences as a ditched watercourse along McCurdy Road then diverges to the north through a steep-banked, densely vegetated pacific willow – Manitoba maple gully. Downstream of the gully, Bauer Brook is again confined by ditching as it flows through fields and rural lots and then follows Moyer Road (westward) before turning northward into agricultural fields used by livestock. Through this bottom reach (Segment 1), constructed ponds and ditching continue until the flows infiltrate the level fields and enter the city storm system, connecting to the Chichester wetland and Francis Brook.

During the SHIM survey, flows were observed to increase progressively downward through the watercourse with lower segments likely being permanently wetted throughout the year.

Combined, the stream length of Bauer Brook and its two tributaries within the Kelowna city limit equals about 5.4 km. Of this length, only about 8% is natural or at least has not been recently disturbed (Table 2). Although only one segment was defined primarily as culvert (Table 2) numerous road crossings and intermittently piped sections through other modified and channelized segments result in a total culverted length of 834 m over the SHIM surveyed stream length.

Table 2. Bauer-Campbell-Industry Creeks summary of Primary Stream Character. Values shown below are based on SHIM field inventory and analysis of 5.4 linear km of creek within the City of Kelowna.

Primary Character	Length (m)	Percentage of stream length
Modified	2405	44%
Ditch	1708	31%
Channelized	644	12%
Natural	451	8%
Culvert	233	4%

There were few concerns with respect to bank stability with the exception of the Morrison Road culvert, which is too short. Because of the inadequate culvert length, severe bank and headwall erosion from the over-steepened road slope is occurring. Part of the road slope has collapsed around outlet and flows were documented discharging through soil that had collapsed over the outlet.

Extensive channelization, ditching, and hydrologic alterations to Bauer Brook and tributaries through Tower Ranch, along McCurdy Road, and through agricultural fields below have had a considerable negative impact on the integrity of this small ephemeral drainage and associated riparian communities. The result of the various alterations and disturbance results in a low stream grade (condition score) of 19% (Table 3).

Table 3. Bauer-Campbell-Industry Creeks level of impact summary. Features and values shown below are based on SHIM field inventory (2008) and analysis of 5.4 linear km of creek within the City of Kelowna and . jurisdictional boundaries.

Segments	SHIM Score	Length (m)	Percentage of Stream	Weighted Score
1,1Cl,2,2Cl,3,3Cl,4Cl,6,8,9,10,12	0.0	3545	65%	0.000
5,7,7Cl	1.0	594	11%	0.109
11.0	2.0	130	2%	0.048
4.0	4.0	549	10%	0.403
5Cl,6Cl	5.0	625	11%	0.574
			Weighted Score	1.134
			Condition Score	19%

Although not contributing to fish habitat values, provisions for increased buffers / setbacks along this ephemeral watercourse will allow for riparian community regeneration. These expanded thickets / riparian corridors will provide increased habitat heterogeneity and cover for a diversity of wildlife present within the rural and wildland interface; encouraging greater wildlife dispersal and potentially supporting increased local species richness and diversity.

4.2 North Arm Bellevue Creek

North Arm Bellevue Creek receives water primarily from a diversion pipe situated on the right bank of Bellevue Creek at the downstream end of Crawford Canyon. Over the majority of the 3.8 km length, North Arm Bellevue is better described as a dry armoured diversion channel and ditch than a stream. From a small 200mm PVC outlet (Segment 12) the channel follows the right bank of Bellevue Creek diverging gradually to the north over remnant irrigation/diversion weirs through interior Douglas-fir and cedar forest. The channel is often poorly defined and evidence of scour is intermittent; with soil and leaf litter accumulation documented in sections where the channel is more poorly defined. Downstream of Woodhaven Regional Park, the channel becomes more confined as a ditch, being regularly culverted beneath urban subdivisions (Table 4). Although clearly defined by human alteration (e.g., ditching and channelized by retaining walls), channel scour is discontinuous and upland grasses and herbs were often observed growing through the channel.

Table 4. North Arm Bellevue summary of Primary Stream Character. Values shown below are based on SHIM field inventory and analysis of 3.8 linear km of creek within the City of Kelowna.

Primary Character	Length (m)	Percentage of stream length
Modified	2092	55%
Culvert	1244	33%
Ditch	270	7%
Natural	196	5%

Where defined, the average channel width was about 1.3 m with a gradient averaging about 1.5%. Because of the intermittent character, substrates through the defined channel segments are primarily fines consisting of sand and soil, unless armoured through channelized sections, with gravel and cobbles being more prevalent in upper reaches – likely scoured during events when the diversion gate is open.

Segment 4 is a well defined gully but lacks a defined channel or evidence of scour. The prominence of this gully suggests that Segment 4, although not a creek, may be a relic or former flood channel of Bellevue Creek before it was confined and channelized to the south. Below Segment 4 however, a natural spring occurs at the upstream end of Segment three (3), about 1200m upstream of Okanagan Lake. Downstream of this feature, North Arm Bellevue Creek has a wetted and defined channel. However, streamflows are intercepted by the city storm system through Segment 2 before again day-lighting through Segment 1 just above the confluence with Okanagan Lake.

Table 4 indicates that a mere 5% of North Arm Bellevue is natural, represented through Woodhaven Regional Park. The remainder is intensely modified. The intense urban character of North Arm Bellevue results in a very low condition score of 13% (Table 5). Recognizing that the majority of North Arm Bellevue is constructed and extensively piped (under recent subdivisions) or confined to rear lot boundaries and, furthermore has a hydrology largely supported by a diversion pipe, there is limited capability to restore aquatic or riparian values. Any emphasis on preservation or enhancement of North Arm

Bellevue should focus on the spring (Segment 3) from which natural streamflows originate about 1200 up upstream from Okanagan Lake.

Table 5. North Arm Bellevue level of impact summary. Features and values shown below are based on SHIM field inventory (2008) and analysis of 3.8 linear km of creek within the City of Kelowna.

Segments	SHIM Score	Length (m)	Percentage of Stream	Weighted Score
1,2,5,6,7,8,12	0.0	2323	61%	0.000
3	1.0	687	18%	0.181
4,10,11	2.0	596	16%	0.313
9	5.0	196	5%	0.258
			Weighted Score	0.752
			Condition Score	13%

4.3 Dewdney Creek

4.3.1 Stream Primary Character

Dewdney Creek is a small tributary to Mission Creek originating from groundwater discharges in the Hall Road area. This short (1.1km) watercourse is connected by surface flows to Mission Creek and although not sampled, upstream fish passage is possible and the lower segments of Dewdney are likely capable of supporting small populations of fish. Over 70% of the watercourse is natural (Table 6), flowing through mature cottonwood riparian communities. Numerous springs and wet seepage areas were documented along this first order watercourse. Wet red-osier dogwood – mountain alder – skunk cabbage swamp associations (WS00) were characteristic of these wet groundwater discharge zones, from which drainageway channels commence over sandy substrates flowing to the mainstem of Dewdney Creek.

Table 6. Dewdney Creek summary of Primary Stream Character. Values shown below are based on SHIM field inventory and analysis of 1.1 linear km of creek within the City of Kelowna.

Primary Character	Length (m)	Percentage of stream length
Modified	773	72%
Natural	304	28%

4.3.2 Stream Channel and Hydraulic Character

Flows were observed to progressively increase moving downstream, a factor relating to the intimate connection of Dewdney Creek with the groundwater table. The hydraulic character of Dewdney Creek is predominantly (64% of stream length) a low-gradient riffle-pool. With the exception of Segment 4, where the creek is diverted through a series of rural ponds, the average channel width was recorded to be 2.7 m. Sandy substrates predominate over segments 1-3 with organic aquatic substrates and detritus accumulation in wider slow-moving sections. The channel gradient increases through Segment 5, resulting in increased scour from higher stream velocities exposing coarser glacial tills (cobble/gravel).

4.3.3 Instream Habitat Cover/Complexity

Overstream vegetation and instream vegetation provides the greatest proportion of cover through Dewdney Creek; estimated to each be contributing about 30% of the total instream cover. The ponds occurring within Segment 4 may provide may provide refuge and general resident habitat for rainbow trout and species of coarse fish (e.g., red-side shiner), if they are able to access Segment 4 from below.

It is unlikely that if present in lower reaches of Dewdney Creek that fish would be able to ascend through segment 5 to the upper two ponds, where low base flows and higher gradients would obstruct upstream migration.

4.3.4 Modifications

Modifications along Dewdney Creek are limited to rural disturbance in Segment 1 including riparian vegetation removal, a bridge, water withdrawal and gas pipeline crossing. Segments 2 and 3 are predominantly natural with light intermittent rural disturbance. For a short distance, the creek deviates westward from the gasline Right of Way and associated riparian management zone before it crosses again at the Segment 3-4 break. It appears that Segment 4 has been diverted from its natural channel, which follows in a more westerly direction, then turning southward to join the lower pond of the Segment, instead culverted through a series of landscaped ponds. Other than tile drains, no discharges were documented along Dewdney Creek.

4.3.5 Bank Stability and Erosion

There were no concerns documented with respect to bank instability and erosion. Provided that the dense shrub and cottonwood riparian communities and associated wet seepage sites are not altered and removed, the integrity of the fine-textured stream banks should be maintained by existing vegetation.

4.3.6 Obstructions / Barriers

There were two primary barriers that may prevent upstream migration of fish from Mission Creek into Dewdney Creek. A perched 900mm culvert outlet, discharging water from Dewdney into Mission Creek, would be a complete barrier to fish. However, a secondary channel connects Dewdney with Mission Creek just downstream of the pipe; where during higher flows (in Mission Creek), fish access into Dewdney Creek is possible – especially to those fish seeking refuge when Mission Creek is in freshet.

A bridge and small gate and dam occur about 660 m upstream from the confluence of Mission Creek. This gated structure and dam may obstruct upstream fish passage into the series of ponds that occur upstream in Segment 4.

4.3.7 Stream Impact Summary

Dewdney Creek receives a moderate condition score of 67% (Table 7). However, the integrity of this watercourse may be at risk recognizing adjacent development pressures and the risks such may have on the groundwater table.

Table 7. Dewdney Creek level of impact summary. Features and values shown below are based on SHIM field inventory (2008) and analysis of 1.1 linear km of creek within the City of Kelowna.

Segments	SHIM Score	Length (m)	Percentage of Stream	Weighted Score
4.0	1	150	14%	0.140
5.0	2	181	17%	0.337
1,2,3	5	653	61%	3.030
1t	6	93	9%	0.517
			Weighted Score	4.023
			Condition Score	67%

4.4 Gopher Creek

4.4.1 Primary Character

Upstream of Springfield Road, Gopher Creek, is approximately 7.7 m in length within the Kelowna city limit. The stream originates from areas below Black Knight Mountain, crosses Highway 33 and meanders through mixed urban and agricultural areas to Springfield Road. From Springfield Road downstream, Gopher Creek is captured by the City drainage system (stormwater) and is piped for approximately 4,100 m. The creek and associated stormwater is discharged to the Chichester wetland complex and from here, now Francis Brook, flows about 2 km to Mill Creek.

The riparian and stream channel character is variable from disturbed grasslands, urban/residential, wetlands (marsh and swamp thicket), and agricultural areas (orchard and old field). During SHIM surveys, several areas of well established riparian vegetation were observed accounting for close to 30% of the watercourse length in the city (Table 8). Channelization and confinement was minimal and the majority of the watercourse and riparian communities have been impacted mostly by rural and agricultural activities.

Table 8. Gopher Creek summary of Primary Stream Character. Values shown below are based on SHIM field inventory and analysis of 7.7 linear km of creek within the City of Kelowna.

Primary Character	Length (m)	Percentage of stream length
Modified	5485	71%
Natural	2221	29%

Fish presence/absence sampling indicated that Gopher Creek is not frequented by fish upstream from where the creek is piped (Naito, 2006) and the most likely fish present, if any, are goldfish, introduced from nearby ponds. Despite being non-fish bearing, Gopher Creek and associated riparian and wetland habitats have moderate to high intrinsic ecological value providing local significant habitat areas for wildlife.

4.4.2 Stream Channel and Hydraulic Character

Gopher Creek was divided into Four (4) sections, adapting working completed previously by Ecoscape (2007b):

1. The area from Belgo Road to Springfield Road (Segments 1-3) has many sections that are still in relatively natural condition. However, rural and agricultural use, extending to the top of bank is common. In some locations, fields or homes are present near the stream and riparian vegetation has been cleared. Flows through Segments 1-3 are more regular and the stream likely flows throughout most months of the year. The stream gradients in this general area are higher and in many areas this would be considered a ravine due to the width between the left and right top of bank. The grades between the high water level and top of bank are quite steep in many areas, which has resulted in the more natural condition of segments below the top of bank.

2. The area from Belgo Road to Garner Road (Segments 4-5) is used primarily for agriculture. In most areas, fields or homes are present near the stream and riparian vegetation has largely been cleared. However, more natural sections occur through Segment 5 approaching Garner Road with mature forest present through the gully. However, trees have been cleared to a greater extent in downstream areas. Surface flows through Segments 4 and 5 appear to be permanent to semi-permanent in natural.

3. The area from Garner Road to Highway 33 (Segments 6-10) is within a moderately urbanized area, although some segments are still in relatively natural condition (e.g. some communities below Kirschner Mountain Estates). Disturbed and constructed wetlands occur in Segments 8 and 10. The stream likely maintains surface flows throughout most months of the year through these segments, with the wetted channel becoming more discontinuous moving upstream. Surface flows emerge from a disturbed cattail marsh adjacent Segment 10. Segment 10 itself, however is channelized and isolated from the wetland and was dry during the field survey. Upstream of Segment 10 (north of Highway 33), Gopher Creek becomes an ephemeral watercourse.

4. Upstream of Highway 33 (Segments 11-15) Gopher Creek flows through shallow grassland gullies and more densely vegetated riparian gullies. Disturbance through the upper section of Gopher Creek is attributed primarily to historic and current cattle grazing, which has resulted in degraded range and transitional wetland (saline meadows) condition along the ephemeral watercourse. Substrates through this section are predominantly fines over wetted reaches with more ephemeral sections having a prevalence of soils and leaf/needle litter, where the duration of flow is insufficient to scour the channel.

4.4.3 Modifications

While over 70% of Gopher Creek has been disturbed or modified, anthropogenic features (e.g. bridge, bank stabilization, discharges, etc.) occur relatively infrequently recognizing the suburban and rural character of this watercourse. The majority of alterations include general rural encroachment and riparian disturbance/alteration and vegetation removal. Channelization and retaining structures were uncommon.

As urban development has expanded to include areas around Loseth Road, stormwater management has resulted in an increase in the development and expansion of wetland and pond features intended for increased attenuation during precipitation events. However, only two (2) stowmwater discharges were documented, as the majority of the watercourse continues to be rural, with the absence of drainage infrastructure.

4.4.4 Bank Stability and Erosion

Over most of its length there were no issues of bank instability documented along Gopher Creek, which is likely a function of the ephemeral character of the upper reaches and well

vegetated riparian gully in the bottom segments below the stormwater discharges and detention ponds. However, intense and persistent cattle use in Segment 14, which is a very moist to wet water birch – red-osier dogwood riparian gully, has resulted in severe channel down-cutting and erosion of silts. Although any surface connection to downstream segments is very ephemeral, persistent livestock use and resultant erosion is severely degrading the condition of this sensitive plant community.

4.4.5 Stream Impact Summary

Persistent rural and agricultural disturbance and encroaching urban development has resulted in a condition score of 28%. While having a negligible effect on downstream fisheries resource values (being culverted for over 4000m), opportunities to restore or enhance riparian and wetland community condition and function along Gopher Creek should be realized.

Table 9. Gopher Creek level of impact summary. Features and values shown below are based on SHIM field inventory (2008) and analysis of 7.7 linear km of creek within the City of Kelowna.

Segments	SHIM Score	Length (m)	Percentage of Stream	Weighted Score
3t,7t	0	322	4%	0.00
1,3,4,5,6,7,8,9,10,11,14	1	4861	63%	0.63
1t,2t,2,5,6t,13	2	1117	14%	0.29
4t	3	139	2%	0.05
8t,15	4	842	11%	0.44
9t,10t,11t	5	424	6%	0.26
			Weighted Score	1.69
			Condition Score	28%

4.5 Hachey Creek

Hachey Creek is an ephemeral watercourse and tributary to Priest Creek. The total stream length within the Kelowna city limit is 3.6 km. Although ephemeral, channel scour and areas of significant bank erosion indicated seasonal high flows during run-off, which have likely been exacerbated by the loss of forest cover further up the watershed as a result of the 2003 wildfires and subsequent salvage logging. Road confinement and agricultural use (e.g. fields and livestock) of the area are the primary factor influencing the alteration of this watercourse. A summary of the primary character of Hachey Creek is presented in Table 10.

Table 10. Hachey Creek summary of Primary Stream Character. Values shown below are based on SHIM field inventory and analysis of 3.6 linear km of creek within the City of Kelowna.

Primary Character	Length (m)	Percentage of stream length
Natural	1473	41%
Ditch	942	26%
Modified	1155	32%

Within Kelowna this ephemeral watercourse has three distinct sections. The lower section (Segments 1-2) begins at the confluence with Priest Creek and follows a disturbed forested ravine with a channel gradient of about 6% and mean channel width of about 1.2 m. Erosion occurs along both banks in Segment 2 in the upper portion of the ravine due to encroachment and lack of riparian vegetation.

Above the ravine, Hachey Creek is ditched and intensely modified from Segments 3 to 8. The average channel gradient ranges from 1% - 2% with a mean channel width of about 1.4 m. Erosion and bank instability is prevalent along this section, attributed largely to the ditching and absence of riparian vegetation through fields and livestock access areas.

Upstream of Segment 8, the channel gradient increases to over 10% and agricultural activities end as the stream channel begins to climb through a natural forested ravine. Intermittent wetted channel sections were documented in Segment 11. The average channel width is about 1.2 m. The increased channel gradient through this section results in increased scour during flow events, exposing coarser materials (cobble/gravel).

With greater than 40% of the watercourse length within the city still being natural or not recently disturbed, Hachey Creek, despite extensive disturbance through the middle section received a condition score of 35%.

Table 11. Hachey Creek level of impact summary. Features and values shown below are based on SHIM field inventory (2008) and analysis of 3.6 linear km of creek within the City of Kelowna.

Segments	SHIM Score	Length (m)	Percentage of Stream	Weighted Score
1,2,5	4	925	26%	1.036
9,11,12	2	1473	41%	0.825
3,4,6,7,8,10	1	1172	33%	0.328
			Weighted Score	2.190
			Condition Score	36%

Although ephemeral in character adapting Best Management Practices along agricultural segments, such as exclusion fencing, may allow for some natural regeneration. In addition, greater control or partial exclusion of livestock from Hachey Creek may help to reduce the risk (e.g. sediment loading) on downstream environments in Priest Creek, which supports a healthy resident rainbow trout population and is also frequented by adfluvial rainbow during spring spawning migrations from Okanagan Lake.

4.6 Hydraulic Creek

Only the bottom 720 m of Hydraulic Creek occurs within the Kelowna city limit before its confluence with Mission Creek. Over this length, the stream drops rapidly from McCulloch Road through a steep-walled canyon down to the floodplain and natural cottonwood riparian communities along Mission Creek. From the confluence (with Mission Creek) Segment 1 is just under 290 m in length. The hydraulic character is riffle pool with an average gradient of about 7% and mean channel width of about 4.5 m. Segment 1 may provide suitable spawning substrates for rainbow trout however, the higher gradient and predominance of coarser cobble and boulder substrates likely limit the availability of spawning habitat through this segment. Instream cover through segment 1 is relatively low with only about 10% total cover, of which small boulders account for up to 90% with small pools making up the balance.

Within Segment 2, steep cascades and a series of waterfalls would prevent upstream fish passage from Mission Creek and Segment 1. The average gradient exceeds 25% over the segment with waterfalls and steep chutes occurring through the bedrock-controlled canyon. The channel width as defined by the often sheer bedrock face averages about 5m. Although unable to pass upstream through this steep segment, fish migrating or flushed downstream from fish bearing headwater lakes (Hydraulic Lake) may find temporary refuge and cover in deep pools, which are common and associated with boulders and bedrock.

The entire length (720 m) of Hydraulic Creek within the Kelowna city limit is natural. Just upstream beyond the city limit and above the high gradient and waterfall canyon, more intense activities occur including recreational pursuits and South East Kelowna Irrigation District infrastructure.

4.7 KLO Creek

4.7.1 Stream Primary Character

KLO Creek is a tributary to Mission Creek with about a 2.8 km section occurring within the Kelowna city limit. This watercourse has a high habitat rating and despite waterfall barriers in Segments 4 and 6, rainbow trout were observed throughout the 2.8 km survey length. Over 90% of the watercourse remains natural within Kelowna. Disturbance or alteration occurred primarily along the right bank in Segment 8, associated with the quarry (Table 12).

Table 12. KLO Creek summary of Primary Stream Character. Values shown below are based on SHIM field inventory and analysis of 2.8 linear km of creek within the City of Kelowna.

Primary Character	Length (m)	Percentage of stream length
Natural	2599	94%
Modified	152	6%

The majority of modifications along KLO Creek, within Kelowna, relates to historic irrigation and diversion works including relic concrete weirs/dams and armoured road fill slopes. Much of the armoured road fill slopes and channelization occurring along over 170 lineal meters of KLO Creek have naturalized to some degree. Three (3) bridges span over the creek. Of these, two are deteriorated wooden structures which should either be completely removed or replaced with smaller pedestrian-sized structures to still accommodate low impact recreational use. Due to the natural character and absence of urban development, no discharges occur along KLO creek.

4.7.2 Stream Channel Character and Habitat

Tables 13 and 14 summarize the stream channel and hydraulic character of KLO Creek.

Table 13. KLO Creek summary of hydraulic character. Features and values shown below are based on SHIM field inventory (2008) and analysis of 2.8 linear km of creek within the City of Kelowna.

Segments	Hydraulic	Length (m)	Percent of Creek	Substrate Composition	
3,5,7,8,9,10	Riffle - Pool	1678	61%	Organic Fines Gravel Cobble Boulder Bedrock	0% 1% 11% 54% 32% 2%
1,2	Riffle	847	31%	Organic Fines Gravel Cobble Boulder Bedrock	0% 1% 4% 65% 30% 0%
4,6	Cascade - Pool	226	8%	Organic Fines Gravel Cobble Boulder Bedrock	0% 1% 3% 27% 30% 39%

Table 14. KLO Creek stream channel summary. Features and values shown below are based on SHIM field inventory (2008) and analysis of 2.8 linear km of creek within the City of Kelowna.

Segments	Gradient (%)			Stream Channel		
	Average	Min	Max	Mean Bankfull Width (m)	Min (m)	Max (m)
3,5,7,8,9,10	6.7	4.5	10.0	8.5	7.0	10.5
1,2	6.5	6.0	7.0	10.0	8.0	12.0
4,6	14.5	12.0	17.0	7.0	6.5	7.5

Suitable spawning substrates were observed throughout the SHIM survey length, including the cascade-pool reaches; where clean, suitably-sized gravels occur on the downward sides of deep pools. In total, 11 deep pools (*with wetted depths approaching 1m*) were recorded during field surveys, with a cumulative length of about 40 m and average width of about 3 m.

Instream cover is predominantly boulder/cobble, with documented use by small resident rainbow trout of all age classes (fry – juvenile – adult). Deep pools and overstream vegetation were infrequent over the surveyed streamlength. Total percent cover in riffle and riffle-pool segments averaged about 12% of which large cobbles and boulders were the primary cover. Associated deep pools accounted for less than 15% of the total cover. Large woody debris was nearly completely absent within riffle and riffle-pool segments and total cover was relatively low.

Instream habitat complexity and cover was greater in the steeper, bedrock controlled cascade – pool segments (Segments 4 and 6). Total cover was estimated between 20-25%, of which deep pools and boulders each accounted for nearly 50%. Often associated with pools, large woody debris was more prevalent in these higher gradient segments and accounted for up to 10% of the total cover.

4.7.3 Bank Stability and Erosion

Low bank stability was documented along nearly 60% of the SHIM-surveyed stream length (Segments 1,2,3,8,9). Marked erosion sites amounted to 80 lineal meters along the left bank and 73 lineal meters along the right bank, with average near-vertical eroding and sloughing wall heights being 2.4 m and 4.8 m respectively. Instability was attributed to the steep naturally unstable till banks. Segments with moderate to high bank and channel stability were those occurring through the bedrock-controlled canyon, along well-vegetated banks, and along Segment 10; where historic channelization and armouring have occurred (water diversion works).

4.7.4 Obstructions / Barriers

Four (4) upstream migration barriers were documented along KLO Creek within the Kelowna city limit. Table 15 presents each of these features, indicating respective distances upstream of the confluence with Mission Creek.

Table 15. KLO Creek documented upstream migration barriers. Features and values shown below are based on SHIM field inventory (2008) and analysis of 2.8 linear km of creek within the City of Kelowna.

Type	Barrier	Length (m)	Width (m)	Residual Depth (m)	Height (m)	Distance U/S (m)	Comment
Persistent Debris	Potential	3.00	9.00	0.10	1.20	1182.00	
Falls	Yes	4.00	3.50	0.80	4.00	1249.00	Pool at top and bottom with RB observed
Falls	Yes	3.00	7.00	0.30	5.50	1573.00	Bedrock falls with associated old dam / diversion gate
Log Jam	Yes	4.00	12.00	0.60	2.00	2404.00	Gravel / fines deposited upstream of feature

4.7.5 Stream Impact Summary

The sum of the weighted scores for KLO Creek was 5.3, resulting in a high quality condition score of 88%. Considering both the high habitat rating and relatively low level of impact, conservation should be a top priority along KLO Creek. By this existing deteriorated bridges should be removed and there should be no further encroachment on riparian communities, which support high biodiversity values.

Table 16. KLO Creek level of impact summary. Features and values shown below are based on SHIM field inventory (2008) and analysis of 2.8 linear km of creek within the City of Kelowna.

Segments	SHIM Score	Length (m)	Percentage of Stream	Weighted Score
1,2,3,9,10	5	1734	63%	3.151
8.	4	152	6%	0.222
4,5,6,7	6	865	31%	1.886
			Weighted Score	5.259
			Condition Score	88%

4.8 Michaelbrook

Michaelbrook originates from a network of ditching and tile drains throughout fields in the vicinity of Swamp Road. The watercourse is largely a result of the ditching network constructed in an effort to draw down the water table to benefit agricultural practices. The constructed wetland that occurs at the downstream end of Segment 1 may be providing critical reproductive habitats for the Great Basin spadefoot, which were documented by Ecoscape within 100m of the Michaelbrook wetland in the summer of 2006. While draining primarily through the wetland into Mission Creek, Michaelbrook is also connected by surface hydrology to the network of ditches comprising Thompson Creek to the south.

The sum of the weighted scores for Michaelbrook was 1, resulting in a condition score of 17%. Despite wetland development and restoration (Michaelbrook Wetland), which now provide high intrinsic ecological value to the area, Michaelbrook is a highly modified watercourse. However, over time, regeneration and establishment of riparian communities should improve the overall condition of this system.

4.9 Rumohr Creek

4.9.1 Stream Primary Character

Rumohr Creek is an ephemeral watercourse. Within the city limit, this intermittent and highly modified drainage has a total length of about 7 km. During the fall 2008 survey, the Rumohr Creek channel was dry on over 70% its length. Wetted stream segments were documented from Segments 13-17, which also include two (2) wetland areas.

Rumohr Creek is ditched, channelized, or culverted over nearly 70% of its length within Kelowna (Table 17). As a result, much of Rumohr Creek has limited habitat value given the extensive ditching, and ephemeral nature.

Table 17. Rumohr Creek summary of Primary Stream Character. Values shown below are based on SHIM field inventory and analysis of 7 linear km of creek within the City of Kelowna.

Primary Character	Length (m)	Percentage of stream length
Ditch	3158	45%
Modified	1388	20%
Channelized	1207	17%
Natural	993	14%
Wetland	158	2%
Culvert	118	2%

4.9.2 Stream Channel and Hydraulic Character

The watercourse can be broken down into three primary areas based on terrain, channel character, and human use interactions:

1. Section one (Segments 1-4) follows a ravine beginning at the downstream end of the survey limit (*note: property access was not granted downstream of Segment 1. Therefore field confirmation of the channel extents and condition leading to the Mission Creek floodplain was not possible*). Extensive bank armouring, using turf stabilizing geogrid, had occurred through Section 1 – subsequent to the 2003 wildfires, which affected the upper catchment area of Rumohr Creek. As a result no concerns were identified relating to bank and channel instability.
2. Section two (Segments 5-12) is ditched and channelized along Gully Road and through rural and agricultural properties.
3. Section three (Segments 13-20) contains more natural segments and was discontinuously wetted. Rumhor Creek splits into two channels at Segment 16. The northern channel is the predominant flow channel and is ditched along Miller Road, before turning south; again connecting with the secondary channel (south western channel) at the slope toe of the mountain from which the creek descends.

4.9.3 Modifications

Forty two culverted crossings with a combined length of 625 m and five (5) bridge crossings were documented. Apart from these features and channelization and ditching, the majority of alterations are rural in character including general fence crossings, water withdrawals, and minor stonework for channel stability. Only four (4) pipe discharges were documented all of which were simply tiles drains.

4.9.4 Stream Impact Summary

The sum of the weighted scores for Rumohr Creek was 2.17, resulting in a condition score of 36% (Table 18). Enhancement opportunities in Section 1 are very limited recognizing the ephemeral nature of the watercourse through this section coupled with the road confinement and armouring works that have occurred. The greatest opportunities occur in Section 3. Existing relatively intact riparian areas in Section three (Segments 13-20) should be preserved for their habitat benefits and biodiversity values. These wetted areas have high capabilities for regeneration and net habitat gains. Efforts should be encouraged to restore or enhance existing wetland and riparian communities that occur in Segments 13-20.

Table 18. Rumohr Creek level of impact summary. Features and values shown below are based on SHIM field inventory (2008) and analysis of 7 linear km of creek within the City of Kelowna.

Segments	SHIM Score	Length (m)	Percentage of Stream	Weighted Score
4,5,8,9,17,18	0	1658	24%	0.000
3,13,16,18,19	2	1871	27%	0.533
1,2,6,710,11,12,14,15,17,29	3	2999	43%	1.281
16.0	4	232	3%	0.132
21.0	6	262	4%	0.224
			Weighted Score	2.170
			Stream Grade	36%

4.10 Upper Vernon Creek - Upstream of Duck (Ellison Lake)

4.10.1 Stream Primary Character

Upper Vernon Creek flows into Duck (Ellison) Lake from Beaver (Swalwell) Lake and its headwaters occurring to the east. Only about 2.4 linear km of Upper Vernon Creek occurs within the Kelowna city limits. Riparian and channel disturbance / alteration has occurred in all segments. The most significant alteration is the concrete Hyram Walker flume, which confines nearly 950 m of the watercourse (Table 19). More natural segments occur just above Duck Lake (Segment 1) and in segments 7 and 8 at the upstream end of the survey limit.

Table 19. Upper Vernon Creek summary of Primary Stream Character. Values shown below are based on SHIM field inventory and analysis of 2.4 linear km of creek within the City of Kelowna.

Primary Character	Length (m)	Percentage of stream length
Channelized	370	16%
Flumed	949	40%
Modified	1043	44%

4.10.2 Stream Channel and Hydraulic Character

Within the Kelowna city limit the hydraulic character of Upper Vernon Creek is 60% riffle-pool and 40% concrete flume (Table 20).

The flume width from the left bank top of structure to right bank top of structure was 7.5 m. The estimated bankfull width through the flume was 3.7 m. The flume was divided into two sections based on a clear gradient change, increasing from 3.5% in Segment 4 to 5% in Segment 5, and the presence of adjacent riparian vegetation along the left bank of Segment 4.

Table 20. Upper Vernon Creek stream channel summary. Features and values shown below are based on SHIM field inventory (2008) and analysis of 2.4 linear km of creek within the City of Kelowna.

Segment	Length (m)	Hydraulic	Gradient (%)	Crown Closure	Bankfull Width (m)	Substrate Composition					
						Organic	Fines	Gravel	Cobble	Boulder	Bedrock
1	238	Riffle/Pool	1.0	41-70%	6.25	0	57	40	2	1	0
2	241	Riffle/Pool	2.0	71-90%	8.50	0	5	25	70	0	0
3	127	Riffle/Pool	3.0	1-20%	9.00	0	2	10	88	0	0
4 and 5	950	Flume	4.0	0	3.70	Concrete					
6	126	Riffle/Pool	4.5	21-40%	7.45	0	2	20	73	5	0
7	302	Riffle/Pool	5.0	21-40%	5.00	0	2	15	43	40	0
8	377	Riffle/Pool	3.5	41-70%	9.20	0	10	20	60	10	0

4.10.3 Instream Habitat Cover/Complexity

The total percent cover by segment and relative distributions of cover types is summarized in Table 21.

With the exception of the 950 m flume, potential opportunities for spawning may occur in all segments, although the suitability in channelized segments 2 and 3 is generally low. Segment 1 just above Duck Lake had the highest spawning suitability with gravels being

most abundant. Through this Segment, four (4) good quality gravel bars, associated with pools, were recorded as potential spawning sites.

Table 21. Upper Vernon Creek summary and distribution of instream cover/habitat complexity. Values shown below are based on SHIM field inventory (2008) and analysis of 2.4 linear km of creek within the City of Kelowna.

Segment	Segment Length (m)	Total % Cover	Percentage of Total cover by Cover Type [a]						
			B	DP	IV	LWD	OV	SWD	UC
1	238	15%	15	10	0	0	25	30	20
2	241	8%	90	0	0	0	0	10	0
3	127	8%	100	0	0	0	0	0	0
4 and 5	950	0%	0	0	0	0	0	0	0
6	126	12%	95	0	0	0	0	0	5
7	302	25%	75	20	0	0	0	0	5
8	377	20%	40	20	0	15	0	0	5

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

4.10.4 Modifications

Apart from the extensive channelization and fluming of this portion of Vernon Creek, other modifications were limited to two bridge crossings, and a large closed bottom structure crossing, a pipeline crossing, and channel armouring/rip rap placement (through the small golf course along Segment 1. Four (4) stormwater discharges were documented along the flume, ranging in diameter from 300mm to 480mm.

4.10.5 Bank Stability and Erosion

Low bank stability was documented along 18% of the SHIM-surveyed stream length (Segments 6 and 7). The stream channel was more confined and down-cut through glacial tills in these segments. Table 22 summarizes the extents of marked erosion sites that occur through Segments 6 and 7.

Table 22. Summary of bank erosion recorded along Upper Vernon Creek . Features and values shown below are based on SHIM field inventory (2008) and analysis of 2.4 linear km of creek within the City of Kelowna.

Left Bank				Right Bank			
Length (m)	Average Height (m)	Area (m^2)	Percent of SHIM stream length	Length (m)	Average Height (m)	Area (m^2)	Percent of SHIM stream length
62	1.3	81	3%	33	1.7	55	2%

4.10.6 Obstructions / Barriers

The 950-m flume presents as almost certain velocity barrier to upstream fish migration. The bottom end of this structure begins just over 600 m upstream from the confluence of Vernon Creek with Duck (Ellison) Lake. Upstream of the flume, no barriers were documented and the stream habitat rating is moderate to high.

4.10.7 Stream Impact Summary

Recognizing that 40% of Upper Vernon Creek, through Kelowna is flumed, it is not surprising that this short length of stream receives a low condition score of 29% (Table 23).

Table 23. Upper Vernon Creek level of impact summary. Features and values shown below are based on SHIM field inventory (2008) and analysis of 2.4 linear km of creek within the City of Kelowna.

Segments	SHIM Score	Length (m)	Percentage of Stream	Weighted Score
4,5	0	949	40%	0.00
3,6,7	2	555	23%	0.47
1,2	3	480	20%	0.61
8.0	4	377	16%	0.64
			Weighted Score	1.609
			Condition Score	29%

Upper Vernon Creek received a High Habitat Rating despite the extensive alterations to the stream channel within Kelowna. Although a significant undertaking, removal of the flume would result in a significant benefit to aquatic production. The benefits would be two-fold recognizing that channel restoration would both repatriate 950 m of stream channel (currently flumed) and restore fish passage upstream to Segment 6 and beyond. As the cost associated with such an initiative is likely prohibitive, in the short-term, restoring fish passage to upstream reaches should at a minimum be implemented. Measures to achieve this may include installation of baffles over the 950 m flume length to mitigate the probable velocity barrier this feature presents to fish.

5.0 KELOWNA SHIM AND WATERCOURSE EVALUATION SUMMARY

The following section is a stream condition and habitat rating summary for all streams surveyed during the three-year (2005, 2006, and 2008) Kelowna SHIM project initiative. Table 24 provides an overview of all surveyed streams, which is discussed at greater depth below.

Fish habitat quality scores were assigned to each watercourse within the Kelowna city limit. Respective habitat ratings were assigned based on information compiled during the various field surveys and analysis and data compilation. The following ratings were adapted from the new fish passage protocol (BC MOE, 2008) to consider potential capability based on channel morphology and hydrology - also recognizing that many of the watercourses have been altered by anthropogenic factors:

- **High** Habitat Rating was assigned to watercourses where high-value, critical spawning or rearing habitats were recorded (e.g., locations with abundance of suitably sized gravel, deep pools, undercut banks, stable large woody debris);

- **Moderate** Habitat Rating was assigned to watercourse with suitable spawning habitat and a moderate rearing potential for the fish species present. These systems typically have higher gradients (limiting the availability of higher quality spawning and production capacity) in conjunction with smaller catchment areas; and,

- **Low** Habitat Rating was assigned to ephemeral watercourses and streams without suitable spawning habitat or having low rearing potential (eg. locations without deep pools, undercut banks, or stable debris, and with little or no suitably sized spawning gravels).

The above habitat ratings are based on fish habitat values. However, while some watercourses may receive a low habitat rating, their intrinsic value should not be overlooked. Many of these small riparian gullies support or have the potential to support high biodiversity values in an urban and sub urban context. Recognizing this, efforts should continue to protect and restore associated riparian, transitional, and wetland sites along these watercourses regardless of fish habitat values.

Table 24. Summary of Kelowna streams assessed through SHIM, survey periods, stream lengths, condition, and habitat ratings.

Aquatic Habitat Rating	Stream Name	Survey Period	Stream Length (m)	Condition Score
High	Upper Vernon Creek	2008	2522	27%
	Mill Creek	2005	23300	30%
	Bellevue Creek	2005	6620	50%
	Priest Creek	2006	7100	72%
	KLO Creek	2008	2751	88%
	Hydraulic Creek	2008	721	100%
Moderate	Brandt Creek	20066	13600	8%
	Thompson Brook	2006	4800	11%
	Scotty Creek	2006	640	13%
	Wilson Creek	2006	2630	23%
	Francis Brook	2006	1400	25%
	Lebanon Creek	2006	2200	42%
	Dewdney Creek	2006	1077	67%
Low	Fascieux Creek	2006	6800	9%
	North Arm Bellevue Creek	2008	3802	13%
	Michaelbrook	2008	3369	17%
	Bauer Brook and Campbell - Industry Brook	2008	5442	19%
	Gopher Creek	2008	7706	28%
	Hachey Creek	2008	3571	36%
	Rumohr Creek	2008	7021	36%
	Rembler Creek	2006	5640	40%
	Cedar Creek	2006	1860	43%
	Leon Creek	2006	2700	43%
	Varty Creek	2008	1102	52%
	Whelan Creek	2006	810	63%
	Bertram	2008	1682	68%
	Casorso Creek	2006	1900	71%
	Bruce Creek	2008	173	83%

Streams were assigned into one of three groups based on their condition score (0-33%; 34-66%; 67-100)

Overall, the combined length of streams receiving condition scores of less than 33% accounted for 62% of the total combined length of streams within Kelowna (with the exception of Mission Creek). The combined length of streams receiving condition scores from between 34% - 66% accounted for 26% of the total combined stream length. Only 13% of the total combined streamlength received condition scores better than 66%.

Brandt Creek received the lowest condition score overall at 8% and Hydraulic and KLO Creeks had the highest condition scores, both still being largely natural and undisturbed. Of the high value streams, Mill Creek and Vernon Creek each received condition scores below 30% (Figure 1).

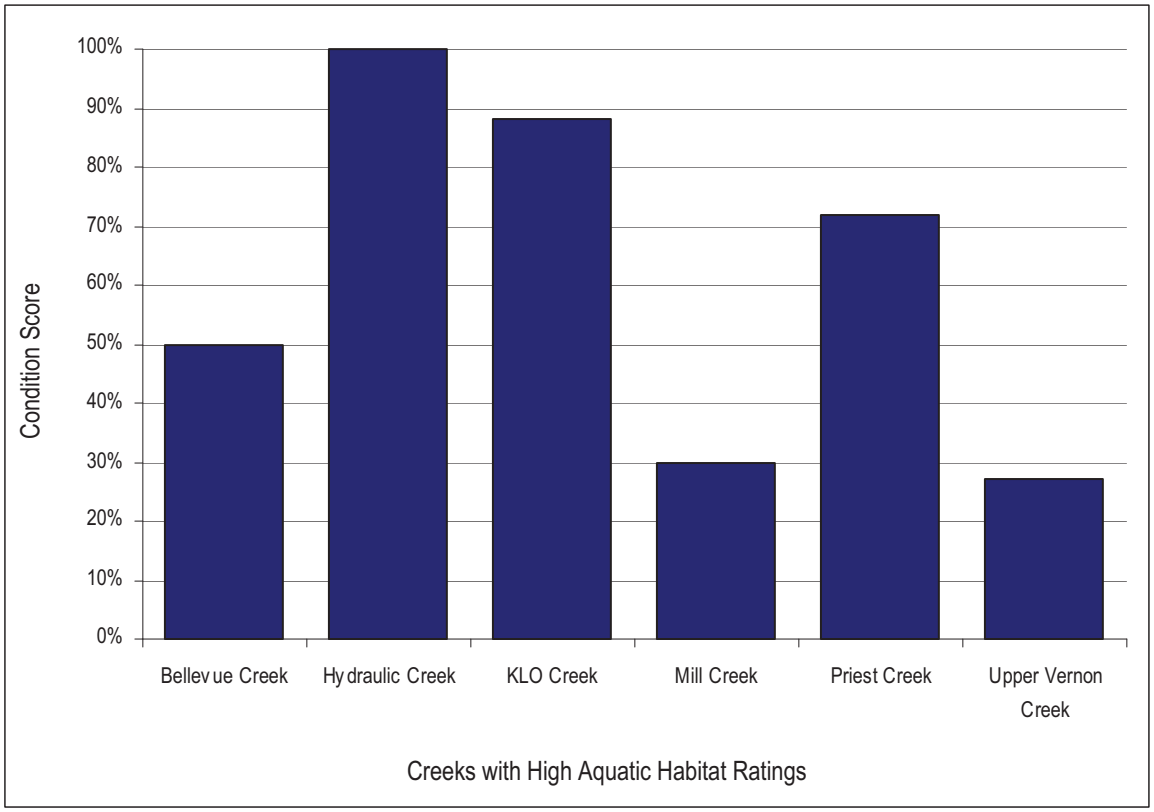


Figure 1. Stream condition scores for Kelowna watercourses (excluding Mission Creek) with High aquatic habitat ratings.

With the exception of Mission Creek, the combined length of streams with high aquatic habitat ratings amounted to about 35% of the total combined streamlength of all watercourses (123 km) within Kelowna. The combined length of moderate and low rated streams account for about 21% and 44% of the total combined streamlength respectively.

High value streams had a total combined length of just over 43 km. Of this length, 60% was represented by the combined length of watercourses receiving low condition scores of less than 33% (Figure 2). Overall, streams with moderate habitat ratings have been impacted the greatest in Kelowna with 88% of the total combined length (26.3 km) receiving condition scores of less that 33%.

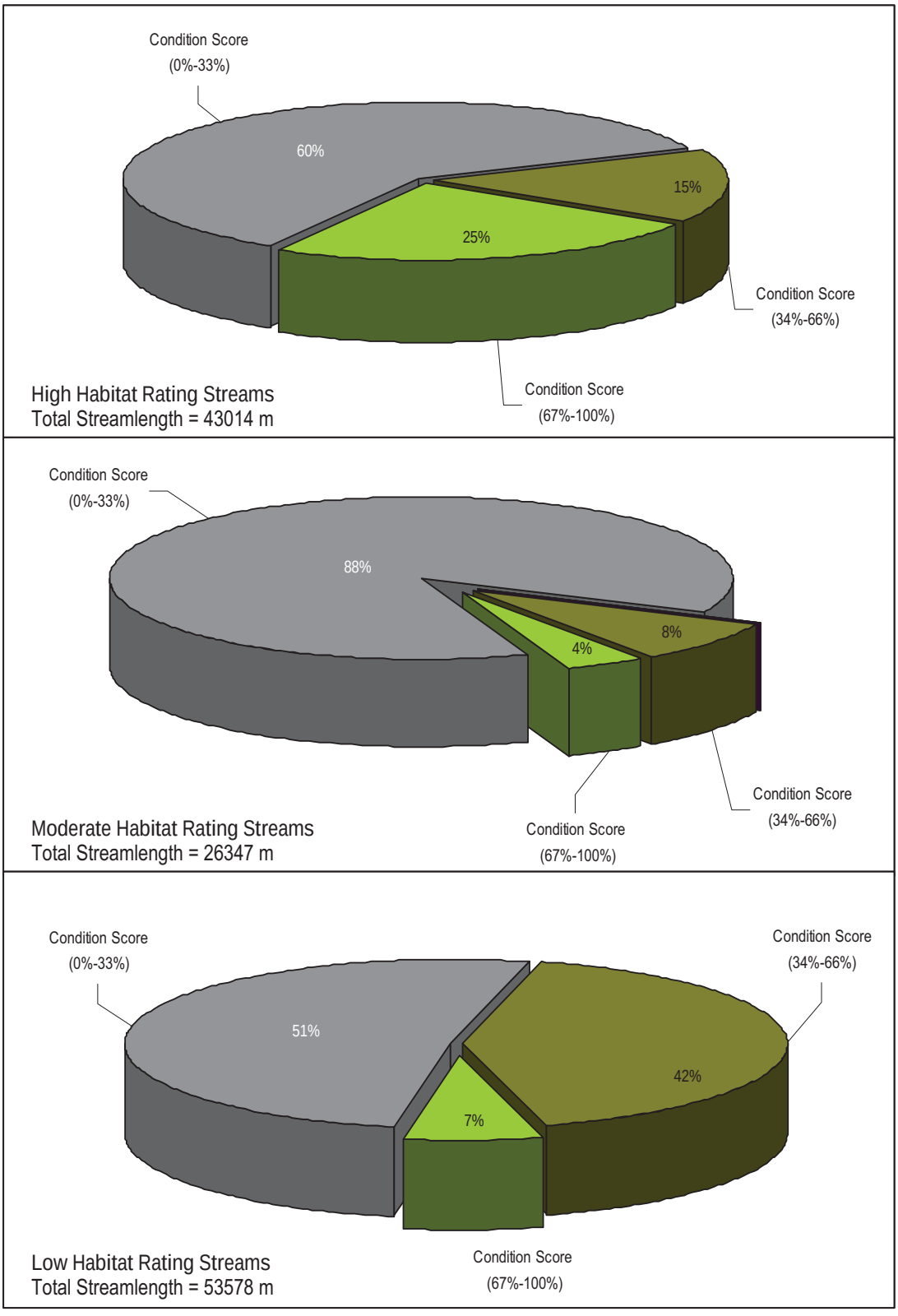


Figure 2. Condition score range distributions for the total combined streamlength in respective stream habitat rating classes (high; moderate; low). Streams within each habitat class (Table 24) were grouped according to their condition scores (0%-33%; 34%-66%; 67%-100%) and the relative condition score range distribution for the sum of stream lengths (in each habitat rating class) was then calculated.

6.0 CLOSURE

This report has summarized detailed field inventory data collected during 2008 SHIM surveys within the City of Kelowna. 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 2008 inventory has resulted in the development of an up-to-date catalogue of watercourse and habitat features occurring within respective watercourses, which has numerous applications and can be used by the community, stewardship groups, individuals, and the City, as well as 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.

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 have 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,
ECOSCAPE Environmental Consultants

Prepared By:

Kyle Hawes, R.P.Bio.
Natural Resource Biologist
Direct Line: (250) 491-7337 ext. 203

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