

# Survey of barriers to anadromous fish migration in the Canadian Okanagan sub basin



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# 1.0 INTRODUCTION

## 1.1 Project Background

The Okanagan Basin is a transboundary tributary of the Columbia River. The Okanagan Nation Alliance (ONA) in British Columbia and the Colville Confederated Tribes (CCT) in Washington are working collaboratively to monitor and evaluate this transboundary sub basin. Termed the Okanagan Basin Monitoring and Evaluation Program (OBMEP), its goal is to monitor over 20 years the status and trends of components such as physical habitat condition, water quality and quantity, and juvenile and adult fish production in the Okanagan sub basin as it relates to anadromous salmon (CCTFWD 2005).

The monitoring of status and trends of fish and their habitat in OBMEP requires temporal and spatial replication, and probabilistic sampling of stream reaches (Hillman 2004). The CCT initiated the OBMEP program in 2004 with the ONA implementing the Canadian portion in 2005. The Canadian OBMEP program requires selection of 48 stream reaches, or sites, selected from a list of possible sites randomly generated from the Environmental Protection Agency's (EPA) Environmental Monitoring and Assessment Program (EMAP) design, as adapted from Hillman (2004). EMAP is a statistically based and spatially explicit site-selection process developed for aquatic systems. The 48 sites are then divided into 6 panels representative of the basin consisting of 8 sites each. One panel is sampled annually with the other five panels rotating to be sampled yearly.

The 48 Canadian Okanagan EMAP sites are selected based on accessibility with preference toward sites accessible to anadromous salmon.

The Vaseux Lake Outlet Dam, herein referred to as McIntyre Dam, is considered the upper fish migration barrier for chinook (*O. tshawytscha*), steelhead (*O. mykiss*), and sockeye (*O. nerka*) salmon in the Okanagan sub basin (Figure 1)<sup>1</sup>. Two other dams - the Skaha Lake Outlet Dam and the Okanagan Lake Outlet Dam - exist further upstream on the Okanagan River. With the experimental re-introduction of sockeye salmon into Skaha Lake<sup>2</sup> in 2003 the range of sockeye salmon has been extended to the Okanagan Lake Outlet Dam. Thus for OBMEP, the study area is confined to the Okanagan sub basin from the Okanagan Lake Outlet Dam in Penticton, BC to the U.S border.

Since it is preferred that EMAP sites be accessible to anadromous salmon, site selection within this study area requires the verification of barriers to anadromous salmon. The purpose of the study is to locate and document fish migration barriers in the Canadian Okanagan OBMEP study area.

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<sup>1</sup> Although fish passage above McIntyre Dam did occur in 2000 (Wright, H. Pers. Comm. 2006).

<sup>2</sup> Re-introduction of sockeye salmon into Skaha Lake commenced with the release of 352,000 fry.

## 2.0 METHODS

### 2.1 Study Area

The barrier survey study area was from the Okanogan Lake Outlet Dam in Penticton, BC to the U.S border and was based on the OBMEP study area in Canada (Figure 1). Preference for the barrier survey went towards streams having EMAP sites (Figure 2).

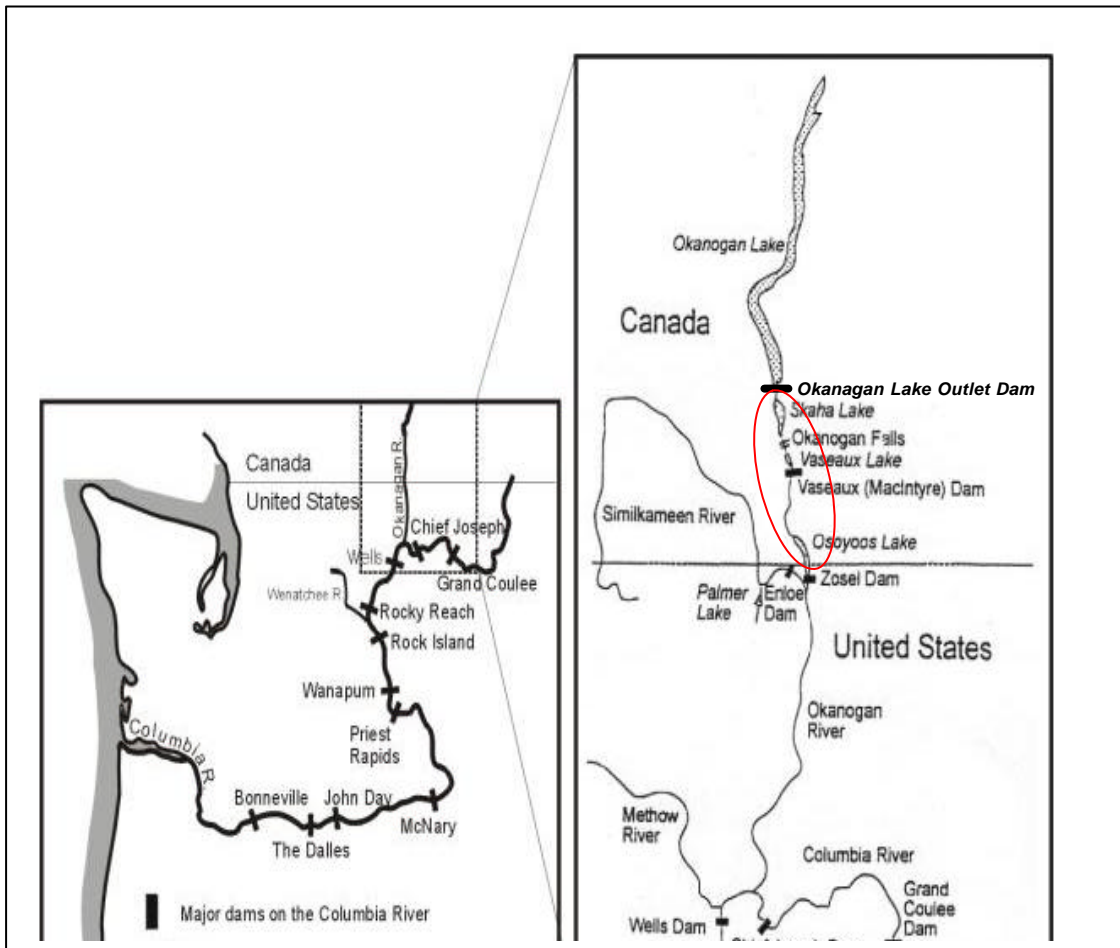


Figure 1. OBMEP study area in the Canadian Okanogan sub basin.

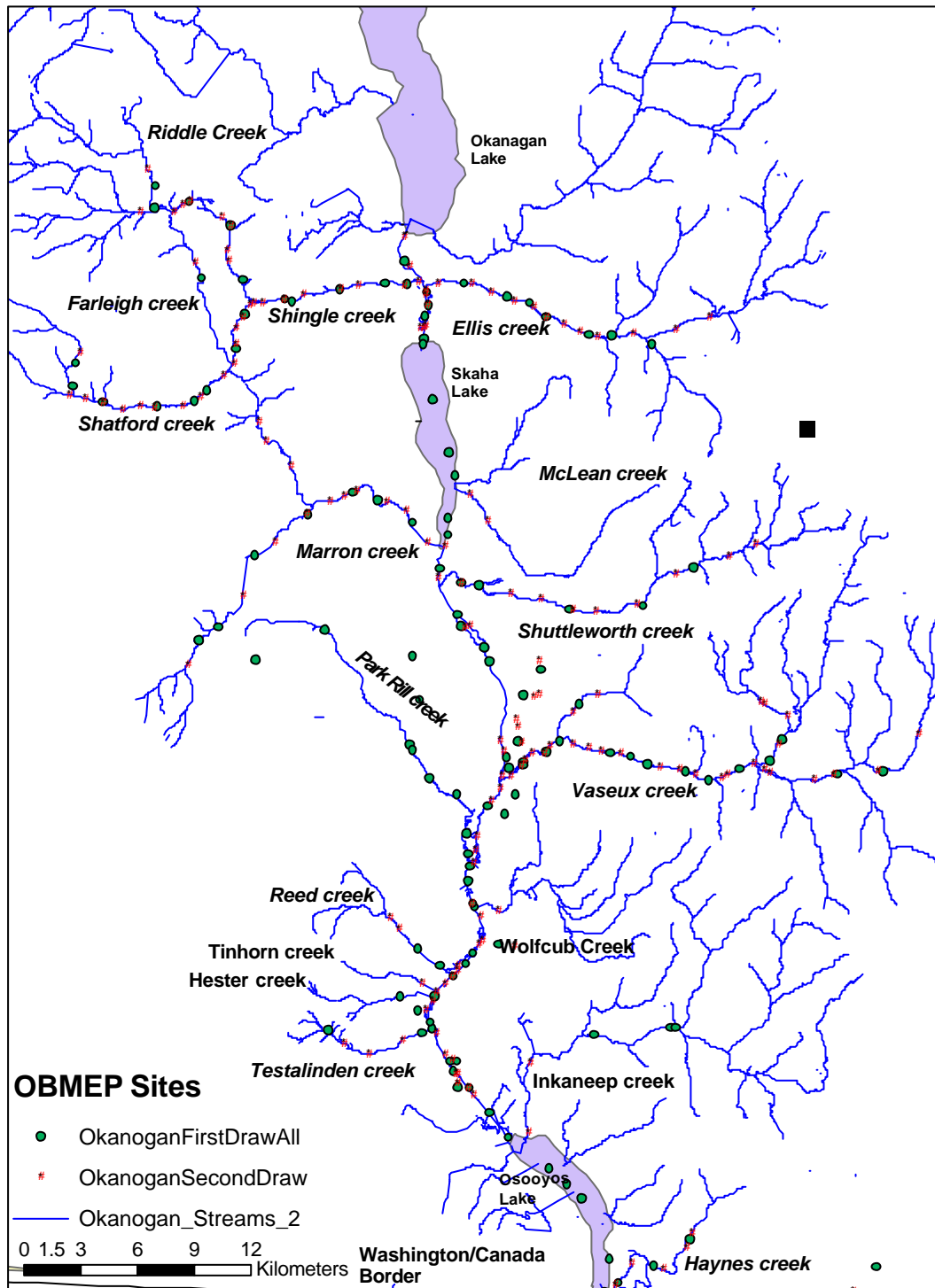


Figure 2. The OBMEP study area in Canada. EMAP sites are designated by the red and green dots (Source: CCT).

## 2.2 Barrier Survey Protocol

Barriers were identified as a cascade, dam or weir (including beaver dam), culvert, falls, jam, or gradient barrier (Table 1). The barriers were documented and examined under

low summer flow conditions however, if the potential barrier was surmountable by salmon during higher flows experienced in the fall or spring, the barrier status was described as a partial barrier. If the impending barrier was impossible for anadromous salmon to pass during all flow conditions, the barrier was designated as a permanent barrier.

Table 1. Definitions of fish migration barrier types.

| Barrier Type        | Definition   | Reference         |
|---------------------|--|-------------------|
| Cascade             | Barrier if gradient exceeds 20% for 160 m or more (16% in streams with bank full widths less than 0.9 m)   | (WDFW 2000)       |
|                     | Highly turbulent series of short falls and small scour basins, with very rapid water movement as it passes over a steep channel bottom with gradients exceeding 8% | (Armantrout 1998) |
| Dam/Beaver Dam/Weir | A barrier obstructing the flow of water that increases the water surface elevation upstream of the barrier   |                   |
| Culvert             | A passage, usually a pipe, constructed beneath a road, railroad, or canal to transport water   |                   |
| Falls               | Free-falling water with vertical or nearly vertical drops as it falls over an obstruction  |                   |
|                     | Barrier if vertical drop exceeds 3.7 m   | (WDFW 2000)       |
| Jam                 | Wholly or partially submerged accumulation of woody debris from water currents that partially or completely blocks a stream channel and obstructs streamflow       | (Armantrout 1998) |
| Gradient Barrier    | Barrier if gradient exceeds 20% for 160 m or more (16% in streams with bank full widths less than 0.9 m)   | (WDFW 2000)       |

Fifteen tributaries were documented for barriers from July 5<sup>th</sup> to July 14<sup>th</sup>, 2005 including, Shingle, Shatford, Riddle, Ellis, McLean, Vaseux, Tinhorn, Hester, Testalinden, Wolfcub, Reed, Shuttleworth, Haynes, Park Rill, and Inkaneep creeks. Tributaries were physically surveyed with the exception of Inkaneep Creek, which has barriers documented from previous years. Marron and Farleigh creeks were not surveyed due to time constraints. Although tributaries upstream of McIntyre Dam are considered inaccessible to anadromous salmon, they were analyzed in terms of anadromous salmon passage. These tributaries include Shingle (including Shatford and Riddle creeks), Ellis, and McLean creeks.

Three of the creeks drain directly into main stem lakes; McLean Creek flows into Skaha Lake, and Inkaneep and Haynes creeks both flow into Osoyoos Lake. Shatford and Riddle creeks are tributaries of Shingle Creek. The remaining 10 streams are tributaries of the Okanagan River.

Barriers were located by a two-person crew walking upstream in the tributary from the confluence. Upon locating a barrier, the GPS coordinates, physical measurements (Table 2), and photos were documented. The types of physical measurements depended on the type of barrier (Table 3).

It was preferred that streams be surveyed until a permanent barrier was located. However, due to accessibility, this was not always possible. In these cases, gradient



barriers were estimated from 1:50,000 scale topographic maps using standard rise over run formula calculations (elevation over reach length).

Table 2. Description of the physical measurements collected for fish migration barriers.

| Physical Measurement | Description  | Units*               |
|----------------------|--|----------------------|
| Drop height          | Measured from the upper water surface of the falls or dam to the lower plunge pool water surface                 | meters               |
| Height               | Measured from the top of the barrier to the lower plunge pool water surface                                      | meters               |
| Span                 | Width of the barrier across the creek i.e. from bank to bank   | meters               |
| Length               | Length of a culvert  | meters               |
| Gradient             | Of channel unit (falls or cascades) over a measured distance   | %                    |
| Outfall drop         | Vertical drop between outlet of a culvert to the surface of the stream or pool at the outflow                    | meters               |
| Plunge pool depth    | Depth of water immediately downstream of the barrier at the deepest point  | meters               |
| Culvert water depth  | Depth of water currently flowing through the culvert at the deepest point  | meters               |
| Distance             | Distance of the barrier from the confluence and/or Distance of the channel unit (i.e. cascade, gradient barrier) | meters or kilometers |

\*Units measured to the nearest 0.1m where applicable.

Table 3. Summary of the physical measurements documented per barrier type.

| Barrier Type           | Physical Measurements                             |
|------------------------|---|
| Cascade                | gradient over a measured distance of channel unit |
| Dam/Beaver<br>Dam/Weir | span  |
|                        | plunge pool depth                                 |
|                        | drop height                                       |
|                        | height<br>length                                  |
| Culvert                | diameter  |
|                        | outfall drop                                      |
|                        | plunge pool depth                                 |
|                        | culvert water depth                               |
| Falls                  | drop height                                       |
|                        | plunge pool depth                                 |
|                        | gradient (if possible)                            |
| Jam                    | height  |
|                        | span  |
| Gradient Barrier       | gradient over a measured distance of channel unit |

### 3.0 RESULTS

A total of 15 streams were included in the barrier assessment (Tables 4a & 4b) and the barriers are mapped in Figure 3. All barriers, whether partial or permanent, were noted, and a full description of these barriers and their history are detailed by stream in sections 3.1 to 3.13. When available, background information (i.e. species presence, description of the watershed, habitat conditions) is provided.

Table 4a. Barriers to fish migration in the OBMEP study area in Canada. Where 'n/k' designates unknown data and 'n/a' designates data not collected. GPS coordinates are in decimal degree format.

| Creek    | Barrier Status          | Description   | Photo No <sup>3</sup> | Latitude  | Longitude |
|----------|-------------------------|---|-----------------------|-----------|-----------|
| Shingle  | 4 partial               | 4 beaver dams (within 500 m of mouth)                         | n/a                   | n/a       | n/a       |
|          | partial                 | water intake dam (2.2 km from mouth)                          | 1                     | 49.478056 | 119.63105 |
|          | no                      | falls (~15 km from mouth)                                     | n/a                   | 49.515278 | 119.78056 |
|          | no                      | falls (~15 km from mouth)                                     | n/a                   | 49.514722 | 119.79167 |
| Shatford | partial                 | beaver dam (~2 km from confluence with Shingle Creek)         | n/a                   | n/a       | n/a       |
|          | partial                 | log jam (14.7 km from confluence with Shingle Creek)          | n/a                   | n/a       | n/a       |
| Riddle   | partial                 | hanging culvert (~200 m from confluence with Shingle Creek)   | n/a                   | 49.51137  | 119.78955 |
|          | partial                 | man-made weir (~1615 m from confluence with Shingle Creek)    | n/a                   | 49.51669  | 119.79865 |
|          | 2 partial & 1 permanent | falls (5.3 km from confluence with Shingle Creek)             | n/a                   | n/a       | n/a       |
| Ellis    | permanent               | man-made weir (300 m from mouth)                              | 2                     | 49.481389 | 119.79167 |
|          | permanent               | Ellis Intake Dam (4 km from mouth)                            | n/a                   | 49.473056 | 119.53889 |
| McLean   | partial                 | culvert (103 m from mouth)                                    | n/a                   | 49.380278 | 119.56361 |
|          | partial                 | culvert (286 m from mouth)                                    | n/a                   | 49.379722 | 119.56111 |
|          | 6 partial               | 6 beaver dams within 662 m (between 438m to 1100m from mouth) | n/a                   | n/a       | n/a       |
| Vaseux   | permanent               | falls (~5 km from mouth)                                      | 3                     | n/a       | n/a       |
| Tinhorn  | permanent               | no creek bed (from 764 m to 1146 m from mouth)                | 4                     | n/a       | n/a       |
| Hester   | partial                 | rock weir surrounding culvert (confluence)                    | 5                     | 49.140305 | 119.58333 |

<sup>3</sup> Appendix 1.

Table 4b. Barriers to fish migration in the OBMEP study area in Canada. Where 'n/k' designates unknown data and 'n/a' designates data not collected. GPS coordinates are in decimal degree format.

| Creek        | Barrier Status | Description  | Photo No. | Latitude  | Longitude |
|--------------|----------------|--|-----------|-----------|-----------|
| Testalinden  | partial        | rock weir surrounding culvert (confluence)                           | 6         | 49.12464  | 119.57214 |
|              | partial        | hanging culvert (674 m from mouth)                                   | n/a       | 49.123083 | 119.58033 |
|              | partial        | man-made weir (1360 m from mouth)                                    | 7         | n/a       | n/a       |
|              | permanent      | falls (1510 m from mouth)  | n/a       | n/a       | n/a       |
| Wolfcub      | partial        | 210 m long culvert (confluence)                                      | n/a       | n/a       | 119.54667 |
|              | partial        | 91 m reach of rip-rap boulders (from 230 m to 321 m from confluence) | 8         | n/a       | n/a       |
| Reed         | n/k            | n/k  | n/k       | n/k       | n/k       |
| Shuttleworth | partial        | man-made rock weir (30 from mouth)                                   | 9         | 49.33612  | 119.57778 |
| Haynes       | partial        | hanging culvert (152 m from mouth)                                   | n/a       | n/a       | n/a       |
| Park Rill    | n/k            | n/k  | n/k       | n/k       | n/k       |
| Inkaneep     | 2 permanent    | 2 falls (3.71 km and 3.86 km from the mouth)                         | 10        | n/a       | n/a       |

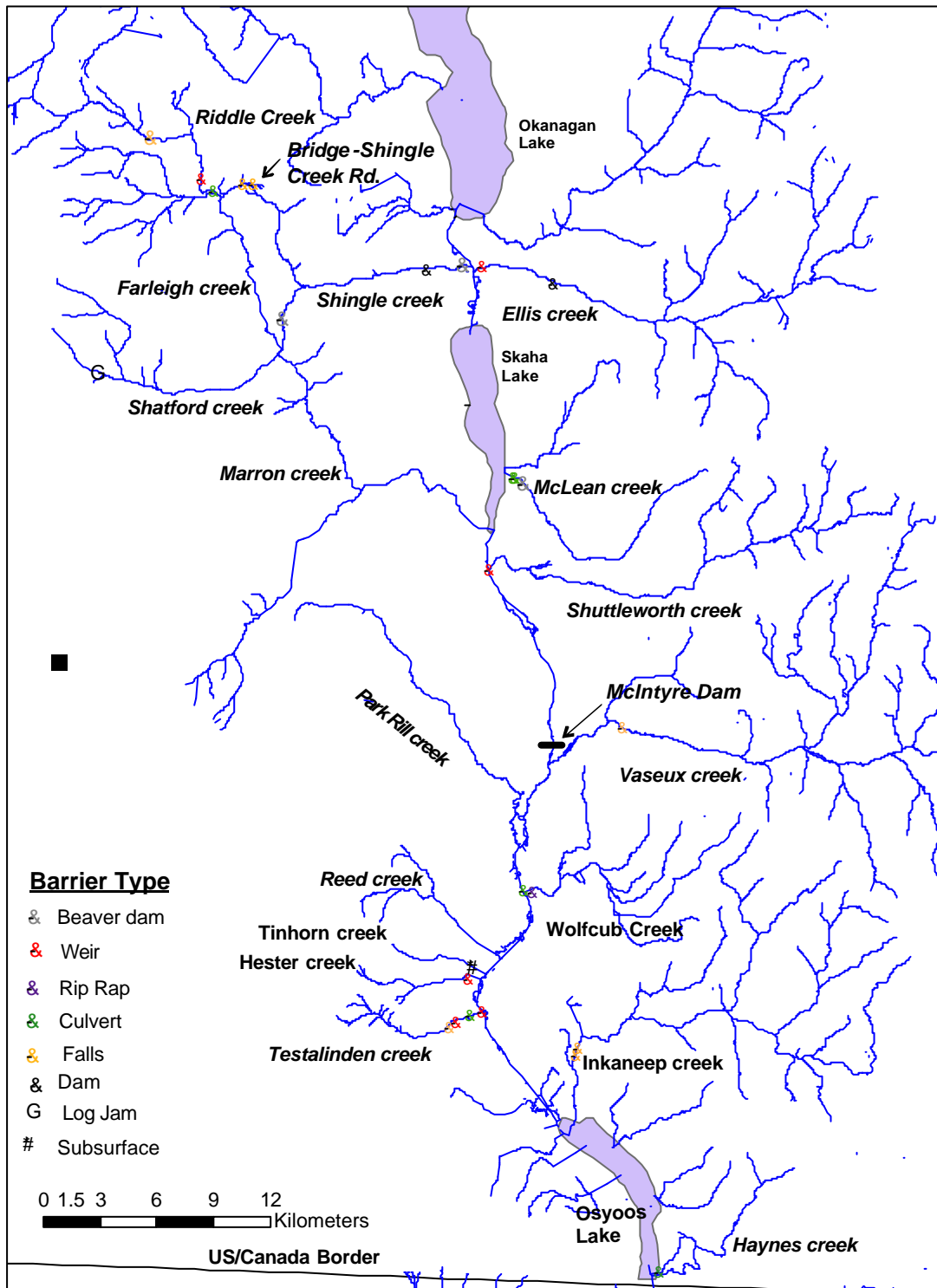


Figure 3. Barriers to fish migration in the OBMEP study area in Canada (Source: CCT).

### 3.1 Shingle Creek

This 31.01 km long creek (FISS 2001) drains approximately 220 km<sup>2</sup> (Moore et al. 2004). Shingle Creek is a community watershed (Columbia Environmental Consulting Ltd 2000) that flows through pasture and ranch land in the upper reaches, then through the Penticton Indian Band (PIB) community lands in the lower reaches. The Shingle Creek watershed is characterized by relatively gentle sloping mountains and extensive grassland and bunchgrass areas (Wildstone Resources Ltd 1996). Dominant land uses in the watershed are agriculture, range, and forestry.

No permanent barriers exist on Shingle Creek proper; however four well-established beaver dams exist in the lowest 500 m of the creek are partial barriers to fish passage at low flow levels.

A domestic water intake dam, located 2.2 km from the mouth (Tonasket & Long 2005), serves as a partial barrier to fish migration and is no longer in use (Photo 1). The dam is 1.8 m in height, spans 20.3 m across the width of the creek, and has a plunge pool depth of 0.2 m during low flows. The dam itself is a permanent barrier to fish migration; however it contains a fish ladder that is operational during high flows. Unless the fish ladder is blocked by debris, which has been the case in the past, the dam is passable. In contrast, no kokanee have been observed above the dam during spawning<sup>4</sup>.

Two natural falls exist on upper Shingle Creek and are not barriers to fish migration. The falls are located approximately 15.0 km from the confluence. The first falls was sited 50.0 m upstream from a bridge crossing Shingle Creek Road (Figure 3); the second falls are located 150 m upstream from the bridge. Both falls measure a drop height less than 3.7 meters and are passable to fish under all flow conditions.

The headwaters of Shingle Creek are known to have log jam barriers (FISS 2001).

In both 1999 and 2000, channel restoration projects reduced sediment input into the creek and restored fish habitat for kokanee and rainbow trout stocks (Columbia Environmental Consulting Ltd 2000). Lower sections of Shingle creek have been channelized to control flooding in residential areas and rip rap had been added to line the banks.

Shingle Creek is the main spawning tributary for kokanee in Skaha Lake, with the exception of the main stem Okanagan River (Rebellato 2004). The kokanee spawning habitat is found 2.2 km from the confluence with the Okanagan River to the PIB dam. In 2004, kokanee were first counted in Shingle Creek on September 24<sup>th</sup> and a peak count of live plus dead of 1,784 occurred on October 1<sup>st</sup> (Tonasket & Long 2005). Other species known to inhabit Shingle Creek are rainbow trout (*O. mykiss*), brook trout (*Salvelinus fontinalis*), largescale sucker (*Catostomus macrocheilus*), longnose dace (*Rhinichthys cataractae*), mountain whitefish (*Prosopium williamsoni*), peamouth chub (*Mylocheilus caurinus*), and prickly sculpin (*Cottus asper*) (Fish Wizard 2003). In addition, Shingle Creek was historically a major fishing area for First Nations; the name for this creek translates to “place of the steelhead” (Moore et al. 2004).

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<sup>4</sup> No kokanee were observed above the weir during spawning from 2000 to 2003 (Rebellato 2004). In 2004, no fish were observed above the dam (Tonasket & Long 2004).

### **3.1.1 Shatford Creek**

Shatford Creek is the largest tributary of Shingle Creek and drains approximately 51% of the Shingle catchment basin (112 km<sup>2</sup>; Wildstone Engineering Ltd 2001). This creek has its headwaters near Apex Mountain (Wildstone Engineering Ltd 2001) and measures 21.9 km in length (Fish Wizard 2003). Fish Wizard (2003) lists rainbow trout as present in Shatford Creek. Barrier survey areas include 3 km upstream from the confluence with Shingle Creek, and a 10 m reach of creek commencing 14.7 km from the confluence with Shingle Creek. No permanent barrier to fish migration exists in the survey areas.

A partial barrier in the form of a beaver dam is located in Shatford Creek, approximately 2.0 km from the confluence with Shingle Creek. The height of the dam measures 1.0 m and spans 15.5 m across the width of the creek. The plunge pool is 0.58 m deep at low flows.

A partial barrier in the form of a log jam was identified approximately 14.7 km from the confluence with Shingle Creek (FISS 2001). The log jam has a height of 1.1 m.

Shatford Creek was not surveyed from 2 km to 14.7 km from the confluence with Shingle Creek due to time constraints. Fish migration barriers may be more prevalent in this reach due to the close proximity of these areas to the headwaters, and the steep canyon in which the creek flows.

### **3.1.2. Riddle Creek**

Riddle Creek, a 16.5 km tributary of Shingle Creek (Fish Wizard 2003), has a partial barrier in the form of a hanging culvert 200 m from the confluence with Shingle Creek. The hanging culvert passes under Shingle Creek Road. The drop height measures 1.5 m and the plunge pool was 0.15 m during low flows. The length of the culvert was not recorded. The culvert is potentially passable during flood conditions but otherwise deters fish migration upstream.

Further upstream, approximately 1615 m from the confluence, a second partial barrier exists in the form of a man-made weir with a pump house for irrigation purposes located on private land. The weir has a 2.0 m drop height and spans 5.0 m.

FISS (2001) identifies the presence of a series of three falls located approximately 5.3 km from the confluence with Shingle Creek. The heights of the falls are 2.0 m, 3.0 m, and 4.0 m. FISS (2001) designates the falls as obstructions to fish migration, however for the purpose of this study, the two falls with heights less than 3.7 m will be designated partial barriers; the falls with a height of 4.0 m will thus be classified as a permanent barrier (WDFW 2000).

If the hanging culvert was improved to allow fish passage, migrating fish would be deterred by the man-made weir upstream. Riddle Creek has riffle-pool morphology that is preferred by salmonids however cattle access threatens the integrity of the creek.

## **3.2 Ellis Creek**

Ellis Creek runs through the industrial section east of Penticton, and drains a watershed of 121.8 km<sup>2</sup> (Moore et al. 2004). The 27.3 km long creek (Fish Wizard 2003) flows

through a steep canyon before passing through Penticton where it is channelized with primarily large cobble and boulder substrate added for flood control. Species known to inhabit Ellis Creek include longnose dace (*R. cataractae*) and rainbow trout (*O. mykiss*) (Fish Wizard 2003)<sup>5</sup>. Approximately 4.0 km of the creek was surveyed for barriers from the mouth.

The first fish migration barrier is a large, concrete weir protecting a sewer main (De Leeuw, B. Pers. Comm. 2005; Photo 2) and transects the creek. Located 300 m upstream from the mouth, the barrier has a drop height of 2.0 m, and spans 11.8 m. At the base of the weir lies an outflow toe with a 20% gradient over 6.0 m leading into a plunge pool. The weir itself is not a barrier to fish migration, however the distance of the plunge pool from the weir makes the weir a permanent barrier.

The Ellis Intake Dam is the second permanent barrier to migrating fish on Ellis Creek. The dam is located approximately 4.0 km upstream from the confluence with the Okanagan River. The dam is 30.0 m high, spans 15.0 m and has outflow toe with a 20:1 gradient. The plunge pool is 0.2 m during low flows. A narrow sill exists on top of the outflow toe structure of the weir creating a shallow 0.1 m plunge pool during low flows, but is too narrow to be utilized by fish to breach the weir (Parker 2000). There is currently no fish ladder.

The Ellis Intake Dam and four other dams above control the water levels of Ellis Creek (DeLeeuw, B. Pers. Comm. 2005). The four other dams are numbered Ellis one to four.

### **3.3 McLean Creek**

McLean Creek is a 14.99 km long tributary (Fish Wizard 2003), and has its headwaters on Mount Christie and drains McLean Clan Lake as well. Kokanee (*O. nerka*) and rainbow trout (*O. mykiss*) are listed as present in McLean Creek (FISS 2003). The lower reaches, up to 1.1 km from the mouth, were surveyed for barriers.

A culvert<sup>6</sup> exists 103.0 m from the mouth. Physical measurements of the culvert include 1.8 m diameter, 21.1 m length, and a plunge pool depth of 0.52 m at low flows. Although the culvert is angled slightly downwards towards the lake and maintains good water drainage, the culvert has been blocked by debris in the past. A second culvert 24 m long<sup>7</sup> exists 286 m from the mouth. Thus these culverts are not permanent barriers to fish migration, but may act to deter fish from migrating upstream and are classified as partial barriers.

The remainder of the survey area, located upstream of the second culvert, contained six partial barriers (beaver dams) within 662 m length of creek only passable during flood conditions (Table 5).

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<sup>5</sup> 10,000 rainbow trout from the Pennask Creek stock were stocked in 1935 (Fish Wizard 2003).

<sup>6</sup> Accessible on Devon Drive.

<sup>7</sup> Accessible on Eastside Road.

Table 5. Summary of beaver dam barriers in McLean Creek

| Type of Barrier | Status of Barrier | Measurements |          |                       | Distance from Mouth (m) |
|-----------------|-------------------|--------------|----------|-----------------------|-------------------------|
|                 |                   | height (m)   | span (m) | plunge pool depth (m) |                         |
| Beaver dam      | partial           | 1.08         | 9.3      | 0.22                  | 438                     |
| Beaver dam      | partial           | 0.4          | 4.7      | 0.22                  | 570                     |
| Beaver dam      | partial           | 0.7          | 7.9      | 0.2                   | 683                     |
| Beaver dam      | partial           | 0.76         | 5.4      | 0.12                  | 800                     |
| Beaver dam      | partial           | 0.65         | 5.1      | 0.2                   | 890                     |
| Beaver dam      | partial           | 0.8          | 7.8      | 0.6                   | 1100                    |

Fish Wizard (2003) reports kokanee (*O. nerka*) and rainbow trout (*O. mykiss*) as present in McLean Creek and that 10,000 rainbow trout from the Swalwell stock were transplanted here in 1948 from the Summerland hatchery.

McLean Creek, although inundated with beaver dams, contains quality spawning substrate for salmon interspersed throughout. Riparian vegetation is well-established and large woody debris is present throughout as well. Culvert maintenance and beaver management would greatly increase salmon access to McLean creek fish use would improve.

### 3.4 Vaseux Creek

Although this 34.82 km long creek (FISS 2001) runs intermittently in the last 3 km before its confluence with Okanagan River, there is continuous flow further upstream (Moore et al. 2004). Vaseux Creek is accessible to anadromous steelhead trout (*O. mykiss*), sockeye (*O. nerka*), and chinook (*O. tshawytscha*) salmon. The majority of the accessible area was fast flowing, turbulent, cool water, consisting mainly of coarse bed materials (medium and large cobble) with the banks and gradient getting increasingly steep as you progress into a canyon.

A permanent falls barrier exists approximately 5 km upstream and is only accessible by foot from the confluence (Photo 3). The waterfall can be divided into two falls, one is the main river channel and the other flows into a large hollowed out rock cavern. Both falls are at least 4.2 m high and are classified as permanent fish passage barriers. This is consistent with another study's findings of a 2.0 m and 3.0 m high rock falls fish migration barrier located 5.5 km upstream from the confluence with the Okanagan River (Dobson Engineering Ltd 2002). A GPS coordinate could not be obtained for the actual falls due to the steep canyon walls.

Until 1998, the Town of Oliver's Irrigation Canal was a barrier to migration after which a fishway was constructed (Long et al. 2006). The fishway is located 650 m from the confluence, and measures 46 m long with an 8% grade. Thus the canal is no longer a barrier.



Rainbow trout (*O. mykiss*), sockeye salmon (*O. nerka*), bridgelip sucker (*Catostomus columbianus*), longnose dace (*R. cataractae*), mountain whitefish (*P. williamsoni*), and prickly sculpin (*C. asper*) are present in Vaseux Creek (Fish Wizard 2003). Only rainbow trout are found in the upper reaches above the falls (Wildstone 2001a). Local residents and Okanagan Elders recall that the creek used to run continuously and supported spawning sockeye, rearing steelhead, and spawning chinook (Moore et al. 2004). Sockeye were reportedly so numerous that they plugged irrigation canals.

Of the many assessments of Vaseux Creek few have focused on fish passage issues in the lower reaches. Many are related to assessments of impacts due to either forestry or from the building Aquila sub-station. The drainage basin of Vaseux Creek is 80% forested and 0.7% agricultural and there is no urban development (Moore et al. 2004).

### **3.5 Tinhorn Creek**

Approximately 1146 m of this 4.55 km creek (FISS 2003) was surveyed for barriers from the mouth. One permanent barrier exists on Tinhorn Creek.

A long culvert exists at the confluence of Tinhorn Creek with the Okanagan River and is not a fish migration barrier during all flows. The culvert is 27.0 m long, and 0.95 m in diameter and contains water during low flows.

A backwater pool exists immediately upstream of the confluence for flood management purposes for the Okanagan River. The pool has unstable banks resulting in sediment deposition and thus limited salmon spawning substrate.

The reach of creek between the confluence and 764 m upstream is a road drainage ditch with no riparian vegetation, and sparse spawning substrate. The ditch flows through residential and agricultural (orchard) lands, and passes through a minimum of 5 culverts.

No creek bed exists between 764 m from the mouth and the upper survey limit. At the upper survey limit, the Town of Oliver Irrigation Canal transects the creek. To prevent flow obstruction by the canal, a concrete overpass is constructed atop the canal to direct creek flows. However, the overpass channels the creek flows into agricultural (orchard) land where no distinct channel or creek bed exists. The overpass only contains water during flash floods (Benzler, A. Pers. Comm. 2006; Photo 4). Creek flows from the overpass drain into agricultural (orchard) property. Thus the permanent barrier is located from 764 m to 1146 m from the mouth.

### **3.6 Hester Creek**

Hester Creek is a short tributary of the Okanagan River, measuring 6.7 km in length (Fish Wizard 2003) and has a flash flood nature. The creek was dry during the survey that was conducted during seasonal low flows.

Approximately 850 m of the creek was surveyed for barriers. At this upper survey limit, the creek and surplus flows from the Town of Oliver Irrigation Canal drain into a 0.9 m

diameter culvert that continues downstream underground<sup>8</sup>. Johnson (1994) confirms that water flow in the creek is from canal supply. The culvert empties into the Okanagan River set back dyke and then empties into the Okanagan River through a second culvert (Hamilton, B. Pers. Comm. 2006). A 1.7 m high rock weir exists immediately between the Okanagan River and the culvert and is a partial barrier to anadromous fish migration (Johnson 1994; Photo 5). The weir is only surmountable during flood conditions.

Upstream of the survey limit<sup>9</sup>, Johnson (1994) documented 6-16 cm deep water adjacent to the canyon and reported that local residents have never seen fish in this section of the creek. Redside shiner (*Richardsonius balteatus*), northern pike minnow (*Ptychocheilus oregonensis*), bridgelip sucker (*C. columbianus*), and prickly sculpin (*C. asper*) were documented immediately above the entrance into Okanagan River (Johnson 1994).

### **3.7 Testalinden Creek**

This 8.97 km long creek (FISS 2003) flows into the Okanagan River between Osoyoos Lake and McIntyre Dam. The creek's headwaters are in Testalinden Lake and flow through a steep canyon before entering agricultural (orchard) and residential lands.

Approximately 1875 m of the creek was surveyed for barriers. The creek was dry at the time of survey that was conducted during seasonal low flows, and is known to be dry often (Boshard 2001). Three partial barriers and one permanent barrier are located in the survey area.

The first partial barrier is located at the confluence with the Okanagan River. Two culverts exist here and alone are not barriers however; large boulders have been built up around the culvert to serve as a backwater weir for Okanagan River flood control<sup>10</sup> (Photo 6). Unless flooding occurs, the rock weir serves as a barrier. The two culverts at the confluence both measure 0.75 m in diameter. Immediately upstream is a 100 m long backwater pool. Immediately upstream of the pool is a 100 m long reach of spawning habitat containing gravel and small cobble.

The second partial barrier is a hanging culvert passing under Highway 97 and is located 674 m from the confluence. The culvert measures 0.70 m in diameter and has an outfall drop of 0.90 m. During low flows the culvert is not navigable by migrating fish, however would be passable during flood flows.

The next partial barrier is a man-made weir located 1360 m from the confluence (Photo 7). The weir is 2.5 m in height and spans 3.0 m across the width of the creek. The weir is a partial barrier because it would be passable with higher flows. It is believed that the barrier is related to mining activities, which are evident within the canyon. Similarly, gold mine ruins exist in Tinhorn Creek (Mussio et al. 2003).

Falls located 1510 m from the mouth serve as a permanent barrier. The waterfall has a drop height of approximately 4.0 m and is located within a canyon.

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<sup>8</sup> Located at the Oliver Water Works Hester Creek Pumping Station accessible via No. 11 Road.

<sup>9</sup> The location is ambiguous.

<sup>10</sup> By the Ministry of Water, Lands, and Parks Water Branch in the 1950's.

The reach of creek from 674 m to 1510 m has pool-riffle morphology preferred by spawning salmon.

### **3.8 Wolfcub Creek**

Wolfcub creek watershed drains southwest into the Okanagan River east of the community of Oliver and drains an area of approximately 69 km<sup>2</sup> (Wildstone Engineering Ltd 2001b). The creek's headwaters are in Wolfe Lake and the watershed demonstrates consistently low discharge throughout most of the year (Wildstone Engineering Ltd 2001b).

Approximately 3040 m of this creek was surveyed for barriers. The confluence of Wolfcub Creek is via a 210 m long culvert<sup>11</sup> and is a partial barrier to migrating fish. The culvert measures 0.88 m in diameter, and is gated on the upstream side. The gate bars are spaced 0.15 m wide and 0.23 m high. Although the bars are large enough to allow fish passage, the length of the culvert and the bars may inhibit fish migration.

Upstream of the culvert is a 91 m reach with large boulders in the creek bed initiating approximately 230 m from the mouth (Photo 8). Only under flood conditions would this reach of creek be navigable and is therefore designated as a partial barrier.

Sparse riparian vegetation characterize the lowest reaches of Wolfcub Creek (within 674 m from the mouth) as the creek flows through residential areas.

When surplus flows are available, the Town of Oliver Irrigation Canal supports the creek flow (Hamilton, B. Pers. Comm. 2006). The canal is located 1404 m from the mouth.

Atsi Klak Creek joins Wolfcub Creek approximately 3040 m from the mouth of the Okanagan River and was the upper limit of the physical survey. Immediately upstream of this junction, Wolfcub Creek passes under Camp McKinney Road through a set of culverts which are not barriers to fish migration.

A perched culvert with a drop height of 1.45 m is documented upstream of this survey area (Wildstone Engineering Ltd 2001b)<sup>12</sup>. A 2.0 m and 1.0 m high rock falls was immediately upstream and thus there was little incentive to replace the culvert to increase fish distribution. For the purpose of this barrier survey study, we will designate the rock falls as a permanent barrier to fish migration.

Cattle access is evident in the creek between 1404 m and 3040 m of the surveyed area.

Wolfe Lake, where Testalinden Creek originates, was stocked with rainbow trout in 1973 through to 1976 but has since suffered winterkill (Wildstone Engineering Ltd 2001b).

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<sup>11</sup> Approximate length of the culvert.

<sup>12</sup> Author states that the barrier is located upstream of the Camp McKinney road crossing with Wolfcub creek, however distance of this location from the confluence is ambiguous.

### **3.9 Reed Creek**

Due to time constraints, it is not known if barriers exist in Reed Creek. The lower reaches of this creek, up to 1604 m from the mouth, contain little of its original habitat. This section of the creek flows through agricultural areas (orchards) as a narrow ditch with minimal riparian vegetation, unstable banks, and minimal spawning substrate for salmon.

About 3.8 km upstream from the mouth, cattle access has eroded the banks and disturbed the creek bed for approximately 150 m of the creek. Within this same area, a 175 m long diversion channel exists and was dug for flood prevention (MacDougall, G. Pers. Comm. 2005)<sup>13</sup>. The Town of Oliver Irrigation Canal passes over the creek approximately 1146 m from the mouth (FISS 2003) but it does not interrupt the flow of the creek nor does it supply water to the creek (Hamilton, B. Pers. Comm. 2006)<sup>14</sup>.

### **3.10 Shuttleworth Creek**

This 26.7 km creek (FISS 2003) includes longnose dace (*R. cataractae*) and rainbow trout (*O. mykiss*) (Fish Wizard 2003). The creek was surveyed on foot up to 5.0 km from the mouth, the remaining length of the creek is natural, most of which lies within a difficult to access canyon. No permanent barriers to fish migration were identified; however a partial barrier does exist.

A partial barrier in the form of a rock weir, placed 30 m from the mouth, was identified (Photo 9). The weir was constructed to form a sediment-catching basin to solve the creek's mass wasting problem (Moore et al. 2004)<sup>15</sup> and appears to be working. The rock weir has a 9.0 % gradient, 18.2 m long, and is not passable at low flows.

The best observed spawning habitat is a 120 m long reach located approximately 150 m from the mouth. Conversely, very low flow and quickly fluctuating water levels due to irrigation during the summer act as migration barriers, possibly stranding fish. In addition, large cobble substrate exists within these areas.

Gradients for the creek were estimated between the mouth and 16 km upstream. A gradient of 30.48% over a distance of only 100 m was estimated and is located between 9.7 km and 9.8 km from the mouth. This gradient is not a barrier to fish migration but should be verified in the field.

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<sup>13</sup> Located at Old Golfcourse Road and 350<sup>th</sup> Avenue.

<sup>14</sup> The irrigation canal is raised in the air on posts (Hamilton. Pers. Comm. 2006).

<sup>15</sup> As a result of Shuttleworth Creek's unstable banks.

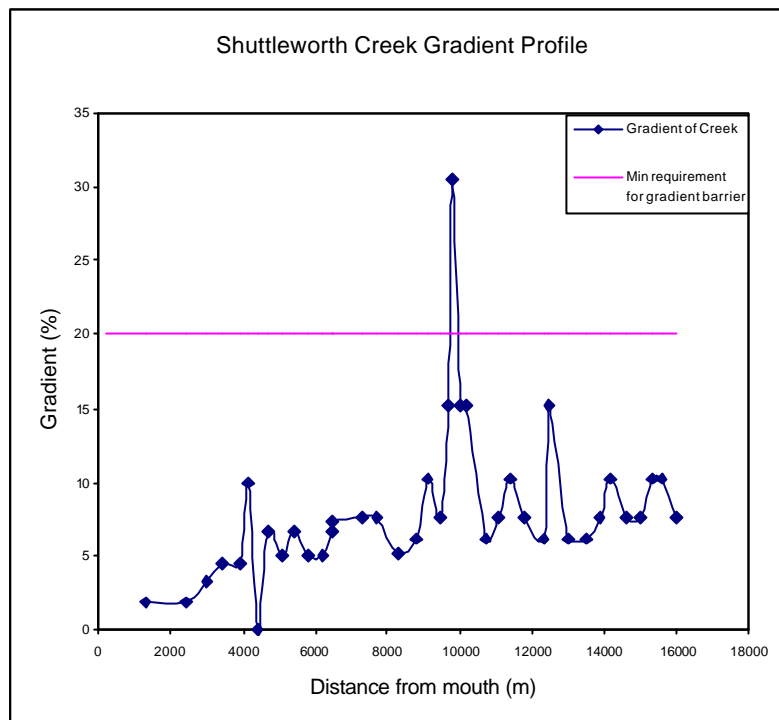


Figure 4. Gradients (%) estimated for Shuttleworth Creek using a 1:50,000 scale topographic map. A 30.48% gradient over 100 m was identified 9.7 km from the mouth and is not a barrier to fish migration. The minimum gradient requirement must be experienced over 160 m to be characterized as a barrier (WDFW (2000)).

### 3.11 Haynes Creek

Haynes Creek is 2.98 km in length (FISS 2001) and primarily flows through agricultural lands (orchards). The creek is most likely fed by irrigation runoff during low flows. No permanent barriers were located, however a partial barrier was identified.

The lowest 152 m of the creek is the most habitable by salmon. Approximately 16 m from the mouth, migrating fish would first encounter a culvert, which is not a barrier to fish migration<sup>16</sup>. Public access may be an issue in this reach, since the creek flows through a campground.

A partial barrier in the form of a hanging culvert exists 152 m from the mouth<sup>17</sup>. The culvert is 1.5 m in diameter, 12.5 m in length, has an outfall drop of 0.2 m, and a plunge pool depth of 0.4 m during low flows. The culvert is a partial barrier since it may discourage fish from migrating further upstream. The section of creek between 20 m and 152 m from the mouth consists of dense riparian vegetation, adequate salmon spawning substrate, and public access does not appear to be an issue.

<sup>16</sup> The culvert passes under Lakeshore Drive at the corner of 16<sup>th</sup> Ave (an unmarked road).

<sup>17</sup> The culvert passes under 16<sup>th</sup> Avenue (an unmarked road).

The reach of creek from 152 m to 500 m from the mouth flows through intense orchards as a narrow ditch and is channelized<sup>18</sup>. This section is bordered by <1 m wide dense riparian vegetation but this vegetation is growing within the channel as well, significantly impeding water flow. The vegetation consists of dense herbs, grasses and woody shrubs and saplings creating periods of anoxic conditions during low flows. In addition, the substrate consists primarily of fines with marginal gravel substrate.

The Haynes Creek canyon begins approximately 3 km from the confluence. The upper reaches sustain mostly flash floods, which is evident by the large cobble and boulder creek bed with vegetation beginning to establish itself.

The long-time resident of the orchard remembers large rainbow/steelhead trout (*O. mykiss*) accessing the lower reaches in the spring (Dawson, W. Pers. Comm. 2005)

### **3.12 Park Rill Creek**

This 31.2 km creek (FISS 2001) is a tributary of the Okanagan River; however during channelization of the Okanagan River in the 1950's (Shulbert 1983) the lowest reaches of Park Rill were significantly altered. Originally, Park Rill Creek flowed into a side channel of the Okanagan River. During the process of channelizing the Okanagan River, this side channel was cut off and now Park Rill Creek drains the side channel into Okanagan River. This lower reach is heavily culverted, and the culverts can be opened or closed to control the water levels.

It is not known if migrating fish can access the lower reaches of Park Rill Creek as not all of the culverts were inspected. However, the habitat is characterized by stagnant and turbid flows, and is pond-like, as the small tributary enters the larger side channel. The creek has abundant in-stream vegetation and most likely suffers from periods of anoxic conditions that choke out most fish. However, carp (*Cyprinus carpio*) were observed in this reach of the creek.

Park Rill creek crosses Highway 97 through a wooden culvert that is not a fish migration barrier. Upstream of this culvert, the creek has been channelized to prevent flooding and flows through pasture and rangeland.

### **3.13 Inkaneep Creek**

Inkaneep Creek measures 23.5 km in length (Fish Wizard 2003) and flows through forested crown land in the upper reaches and the Osoyoos Reserve in the lower reaches. The creek drains the west side of Mount Baldy before emptying into the northern basin of Osoyoos Lake (Moore et al. 2004). The drainage area is 187.6 km<sup>2</sup>, where 80% of the drainage basin is forested, 20% is burned, and agriculture uses comprise 1.8% of the drainage basin (Moore et al. 2004). Inkaneep Creek is the largest watershed of all of the tributary streams south of Penticton (Rae 2005).

Fish resident in Osoyoos Lake are able to access Inkaneep Creek up to two 6 m falls, which constitute a permanent barrier to fish migration, above which only resident

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<sup>18</sup> Permission is required by Dawson Farms (at the junction of Lakeshore Dr. and 16<sup>th</sup> Ave) to access upstream of this area.

rainbow (*O. mykiss*) and eastern brook trout (*S. fontinalis*) reside (Long 2000; Photo 10). The falls are located 3.71 and 3.86 km from the confluence (Long 2005), and “below these barriers ad fluvial rainbow trout (and possibly steelhead) have been documented in the spring and they most likely spawn in Inkaneep Creek” (FISS 1999). In 2000, one kokanee was observed in Inkaneep Creek<sup>19</sup>. In 2001, no kokanee were observed in Inkaneep Creek (Lawrence 2002) and in 2005, 38 steelhead/rainbow trout were observed in Inkaneep Creek (Long 2005). There are [also] accounts of kokanee, sockeye salmon, and rainbow trout being traditionally harvested from Inkaneep Creek (Ernst and Vedan 2000) and historical accounts of steelhead migrating past the falls to access the habitat in the upper reaches according to FISS 1999.

Landslides were documented at 21 km up McKinney Road in 1999, and posed a high risk of sediment delivery and thus adverse impact on fish habitat (Davies 1999). Another major concern documented in 1999 included a lack of channel complexity in the lower reaches of the creek (Davies 1999). However, bank stabilization and riparian planting was performed in 2001 addressed this problem (Alex and Long 2002). Limited amounts of dyking and rip rapping has artificially confined the channel in the lower reaches (Moore et al. 2004). Cattle access is also an issue up to 1024 m from the mouth. Matthews and Bull (2003) rated Inkaneep Creek’s significance for fish protection as very high, high for habitat impact, and very high for significance for habitat restoration.

## 4.0 DISCUSSION AND RECOMMENDATIONS

Overall, the barrier study was a success. The preferred streams in the OBMEP study area were surveyed with the exception of Marron and Farleigh creeks, because of time limitations. The information provided by the barrier study will aid in the selection of the 48 OBMEP study sites in the future. Recommendations to improve fish passage per stream are outlined below.

The majority of the surveyed streams contain culverts. The barrier surveys were conducted during seasonal low flows however it is recommended that culverts be assessed during key spawning periods and include additional physical measurements (i.e. water velocity, culvert water depth, culvert gradient) following protocol outlined by Parker (2000).

At the minimum, beaver control and/or fish ladder maintenance at the Shingle Creek water intake dam should be implemented (in the lowest 2.2 km of the creek) to allow for fish passage. This action alone would significantly increase the connectivity of a diversity of fish habitats upstream such as pool-riffle, off-channels, and sloughs. It is recommended that the annual kokanee enumerations, performed by the ONA fisheries department, be extended above the water intake dam to verify passage.

If the Shingle Creek obstructions are addressed, a more thorough investigation into Shatford Creek barriers, in areas from 2.0 km to 14.7 km from the mouth, is recommended.

<sup>19</sup> Indicating that the total population in the reach surveyed is possibly two.

The Ellis Creek weir closest the confluence is a permanent barrier to fish migration and, if outfitted with a fish ladder, it would provide fish access to a 3.7 km reach of creek. Until the weir is addressed, it is not practical to restore access past the Ellis Intake Dam 4 km from the mouth.

Culvert debris removal and beaver management in the lowest 1.1 km section of McLean Creek would greatly improve the connectivity of these areas, and would improve salmon access to the spawning habitat interspersed throughout this reach. A fish survey during critical spawning times would verify if salmon are utilizing the available habitat.

Surveys for anadromous sockeye and chinook in the lowest reaches of Vaseux Creek is highly recommended to bridge the gap in information. Low flows in reaches adjacent to the mouth potentially cause stranding of fish and thus should be investigated further.

Because Tinhorn Creek is a flash flood type creek and the lowest reaches have been modified from their original course into a road drainage ditch (where the gradient is minimal), the flows, substrate, large woody debris, and riparian vegetation are minimal. Fish passage would significantly improve if the creek were restored to its original course, and habitat conditions, below the Town of Oliver Irrigation Canal (1146 m from the mouth).

Because of the modifications to Hester creek below the Town of Oliver Irrigation Canal, very limited habitat for salmon is available. Thus providing access over the rock weir adjacent to the mouth would not significantly improve salmon production in Hester Creek. Instead, restoration of the lower reaches below the canal to its original course (i.e. removal or redesign of the culverted section) would be more beneficial.

It is recommended that flows at the rock weir at the confluence of Testalinden Creek be investigated during salmon spawning periods to verify fish accessibility. If the weir cannot be surmounted during these critical times, salmon lose access to upstream reaches offering riparian vegetation, large woody debris, and marginal spawning substrate.

At a minimum, the removal of in-stream boulders 230 m from to the mouth of Wolfcub Creek would significantly improve fish access. Riparian vegetation planting and restricting public access would also improve conditions in the lowest reaches. Cattle access in the upper reaches of the survey also threatens the integrity of the creek and should be solved.

Without restoration to Reed Creek's original course and habitat characteristics, up to 1604 m from the mouth, this reach is primarily inhospitable to migrating salmon in the lower reaches.

The rock weir at the mouth of Shuttleworth Creek, although effective at providing a sediment-catching basin, is a partial barrier at low flows, however passage should be verified during key spawning periods. If migrating fish are able to surmount the weir, they gain access to a (minimum of) 120 m long channel optimal for spawning salmon. In addition, it is recommended that the gradient barrier, estimated 9.7 km from the mouth, be verified in the field.



Public access restrictions into reaches of Haynes Creek closest to the mouth may encourage fish migration upstream. However, unless in-stream vegetation is controlled from 152 m to 500 m from the mouth, this area is inhospitable to spawning salmon.

A more extensive investigation into the lowest reaches of Park Rill Creek is required to fully understand the potential for anadromous salmon migration into this creek.

It is recommended that cattle access in the lower reaches of Inkaneep Creek be restricted. In addition, kokanee and sockeye surveys during the fall would provide valuable information.

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## APPENDIX 1-Barrier Photo Documentation.

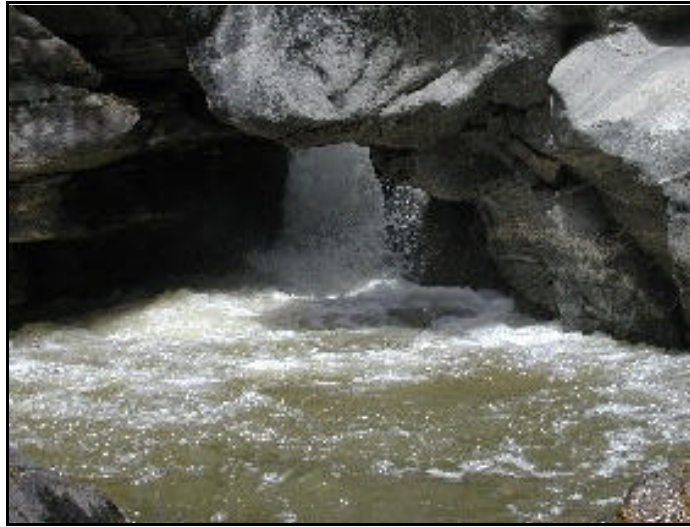
Photo 1. Shingle Creek water intake dam (inoperable) located 2.2 km from the mouth. A partial barrier to fish migration. The fishway is highlighted in red.



Photo 2. Ellis Creek weir, a permanent barrier to fish migration. This barrier is located approximately 300 m from the mouth. The distance between the plunge pool (shown in blue) and the dam is indicated by the arrow.



- Photo 3. Vaseux Creek falls in the main river channel. A permanent barrier to fish migration, located 5 km from the mouth. The view is obstructed by a rock formation in the photo. (The second falls is not shown however it would flow into a cavern immediately to the right).



- Photo 4. An overpass built over the Town of Oliver Irrigation Canal to direct Tinhorn Creek. No distinguishable creek bed exists immediately below the overpass (area shown in red). The creek bed emerges 764 m downstream. Thus the permanent barrier to fish migration is located between 764 m and 1146 m from the confluence with the Okanagan River.

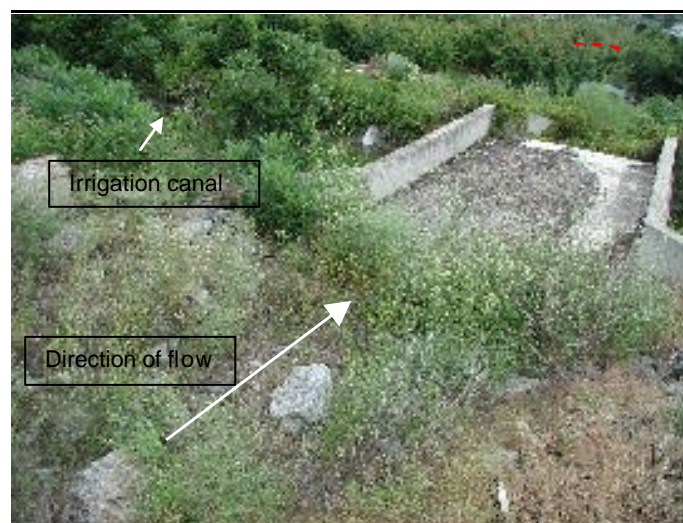


Photo 5. A partial barrier in the form of a weir at the confluence of Hester Creek (Johnson 1994).





Photo 6. Partial barrier at the confluence of Testalinden Creek. A rock weir built up around the culvert obstructs fish migration during low flows. (A 5.7 m long stadia rod is included for scale).



Photo 7. Partial barrier to anadromous fish migration on Testalinden Creek (1360 m from the confluence with the Okanagan River). The barrier is only passable during flood conditions. (A 5.7 m long stadia rod is shown for scale).





Photo 8. A partial barrier to anadromous fish migration located on Wolfcub Creek. The barrier is located between 230 m and 321 m from the confluence of the Okanagan River.



Photo 9. Partial barrier located in Shuttleworth Creek. This rock weir is located approximately 30 m from the confluence with the Okanagan River, and forms a sediment-catching basin upstream.



Photo 10. A permanent barrier in Inkaneep Creek. The falls is located approximately 3.71 km from the confluence with Osoyoos Lake. A second waterfall exists 3.86 km upstream and is a permanent barrier as well. (A person standing to the left of the falls is included for scale).



