APPENDIX 69-1 ELBOW RIVER AQUATIC HABITAT ASSESSMENT: REDWOOD MEADOWS TO DISCOVERY RIDGE (FALL 2019) TECHNICAL DATA REPORT

ALBERTA TRANSPORTATION SPRINGBANK OFF-STREAM RESERVOIR PROJECT
RESPONSE TO NRCB AND AEP SUPPLEMENTAL INFORMATION REQUEST 2,
DATED NOVEMBER 18, 2019

Appendix 69-1 Elbow River Aquatic Habitat Assessment: Redwood Meadows to Discovery Ridge (Fall 2019)
Technical Data Report
June 2020

SPRINGBANK OFF-STREAM RESERVOIR PROJECT
Elbow River Aquatic Habitat Assessment: Redwood Meadows to Discovery Ridge (Fall 2019) Technical Data Report

Prepared for:
Alberta Transportation

Prepared by:
Stantec Consulting Ltd.

June 2020

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Abbreviations

BIM	beaver impoundment
BL	boulders
BPA	armoured bank backwater pool
BPBk	bedrock-formed backwater pool
BPBo	boulder-formed backwater pool
BPL	log-formed backwater pool
BPR	root-wad formed backwater pool
BR	bedrock
BWC	backwatered channel confluence
CB	cobble
CCP	channel confluence pool
EAU	electronic aquatic utility
EDW	edgewater
FGL	fast glide
FI	fines
FLT	flat
FWMIS	Fisheries and Wildlife Management Information System
GEOTIFF	georeferenced .tif image
GF	grasses/forbes
GNSS	global navigation satellite system
HPN	high precision network
HSI	habitat suitability index
IVG	instream vegetation

IWD	instream woody debris
LB	large boulder
LG	large gravel
LHV	limiting habitat variable
LSA	armoured bank lateral scour pool
LSBk	bedrock-formed lateral scour pool
LSBo	boulder-formed lateral scour pool
LSL	log-enhanced lateral scour pool
LSP	lateral scour pool (undifferentiated)
LSR	root-wad enhanced lateral scour pool
LWD	large woody debris
MCD	mid-channel debris pool
MCP	mid-channel pool (undifferentiated)
OR	organics
OWD	overhead woody debris
PLP	plunge pool
POW	pocket water
QAES	qualified aquatic environment specialist
RIF	riffle
RMS	root mean square
RTK	real-time kinetic
RUN	run
SA	sand
SB	small boulder
SG	small gravel

SGL	slow glide
TIN	triangular irregular network
TS	trees/shrubs
UC	undercut banks
VIS	water visibility
WE	wetted edge

1.0 INTRODUCTION

Elbow River supports a traditional and recreational fishery that is part of known local and national fishing culture, with the Glenmore Reservoir being a popular fishing location for northern pike, trout, and perch. Salmonids are the most abundant fish species caught in Elbow River, with brown trout being the most abundant salmonid in the lower sections of Elbow River to Elbow Falls (FMWIS 2020) and bull trout being the most abundant in the lower sections from Elbow Falls to the headwaters of Elbow River (FMWIS 2020). Brook trout and rainbow trout are found consistently throughout the length of Elbow River.

The Project (i.e., during flood and post-flood operation) is designed to alter stream flows to mitigate the effects of floods in Elbow River downstream of the Project area. The construction of the diversion inlet and spillway, and the flood operations and post-flood operations will result in changes to physical habitat, flow regime, and water quality in Elbow River. It is anticipated that these changes will result in permanent alteration and destruction of fish habitat, which will be mitigated and offset to maintain the productivity and sustainability of fish habitat.

This technical data report has been completed for Alberta Transportation by Stantec Consulting Ltd. to support ongoing Elbow River pre-construction monitoring for the Project. The results of this report may also be used for responding to ongoing information requests as part of the Environmental Impact Assessment process and serve as baseline information for post-construction compliance monitoring.

This report presents the results of three major components of pre-construction monitoring activities completed in the fall of 2019:

1. Habitat mapping was conducted within the main stem of Elbow River in fall 2019 between Redwood Meadows and Discovery Ridge to document pre-construction baseline habitat information and inform Project related monitoring during construction and operation (e.g., identify temporal changes to habitat with the Project in place).
2. The known fish distribution within the study area was updated for 2019 by presenting current Fisheries and Wildlife Management Information System (FWMIS) fish records for the main stem of Elbow River between Elbow Falls and Glenmore Reservoir as well as presenting the results of incidental and underwater camera fish observations made during the habitat assessment.
3. Fish habitat within Elbow River was characterized using a habitat suitability index (HSI) model for the following key indicator species: bull trout, brown trout, rainbow trout, and mountain whitefish. HSI rankings serve to provide contextual interpretation of the habitat mapping results, as they relate to key indicator species. HSI rankings were overlaid on the habitat mapping results to provide a visual interpretation of habitat potential for each indicator species and life stage.

Spawning surveys and spawning habitat suitability assessments were concurrently completed during the fall 2019 habitat survey to supplement the results presented in this report. The findings of these studies are available in the following documents:

- Appendix 69-2: Elbow River Spawning Habitat Suitability Assessment: Elbow Falls to Gooseberry Campground (Fall 2019) Technical Data Report.
- Appendix 69-3: Elbow River Spawning Survey and Spawning Habitat Suitability Assessment: Redwood Meadows to Discovery Ridge (Fall 2019) Technical Data Report.

2.0 METHODS

2.1 HABITAT ASSESSMENT

The habitat assessment documented here was completed for all main-stem surface waters (i.e., main and side channels) of Elbow River between the Tsuut'ina Nation Reserve boundary near Redwood Meadows and the Reserve boundary near Discover Ridge; an approximate 24 km stretch of river (Figure 2-1). The field survey was completed by a single crew of three over a 27-day period between October 30th and November 26, 2019. All field survey data was collected and recorded using Stantec's Electronic Aquatic Utility tool (EAU). The field survey was conducted as follows:

- Two aquatic specialists traversed the main stem of Elbow River on-foot and documented each macrohabitat unit (see Section 2.1.2) as follows:
  - a waypoint was taken within the spatial boundaries of the macrohabitat unit
  - substrate, cover, and large woody debris was visually characterized for the entire surface area of each macrohabitat unit
  - georeferenced photographs were collected at regular intervals along a channel, so all surveyed areas were photo documented
- One surveyor accompanied the aquatic specialists on-foot and collected transect-based elevation measurements within the wetted area of each channel to support the development of detailed river bathymetry. More detailed methods relating to field survey of channel morphology are described in Section 2.1.5.

Evidence of fish spawning activities (e.g., redds) were documented throughout the habitat assessment.

Field data was used to support the creation of georeferenced habitat maps and detailed river bathymetry as follows:

- High resolution aerial orthoimagery (georeferenced) was used in ArcMap to delineate the 2-dimensional boundaries of each macrohabitat unit documented during the field survey. The imagery was collected for the study area by Z-Air near the start of the survey (October 17, 2019). Therefore, the surface area of mapped habitat indicates channel form and the discharge rate encountered on October 17, 2019 at the time of the flyover.
- River elevations were used to create 3-dimensional (3D) bathymetry of the study area as described in detail in Section 2.1.5.

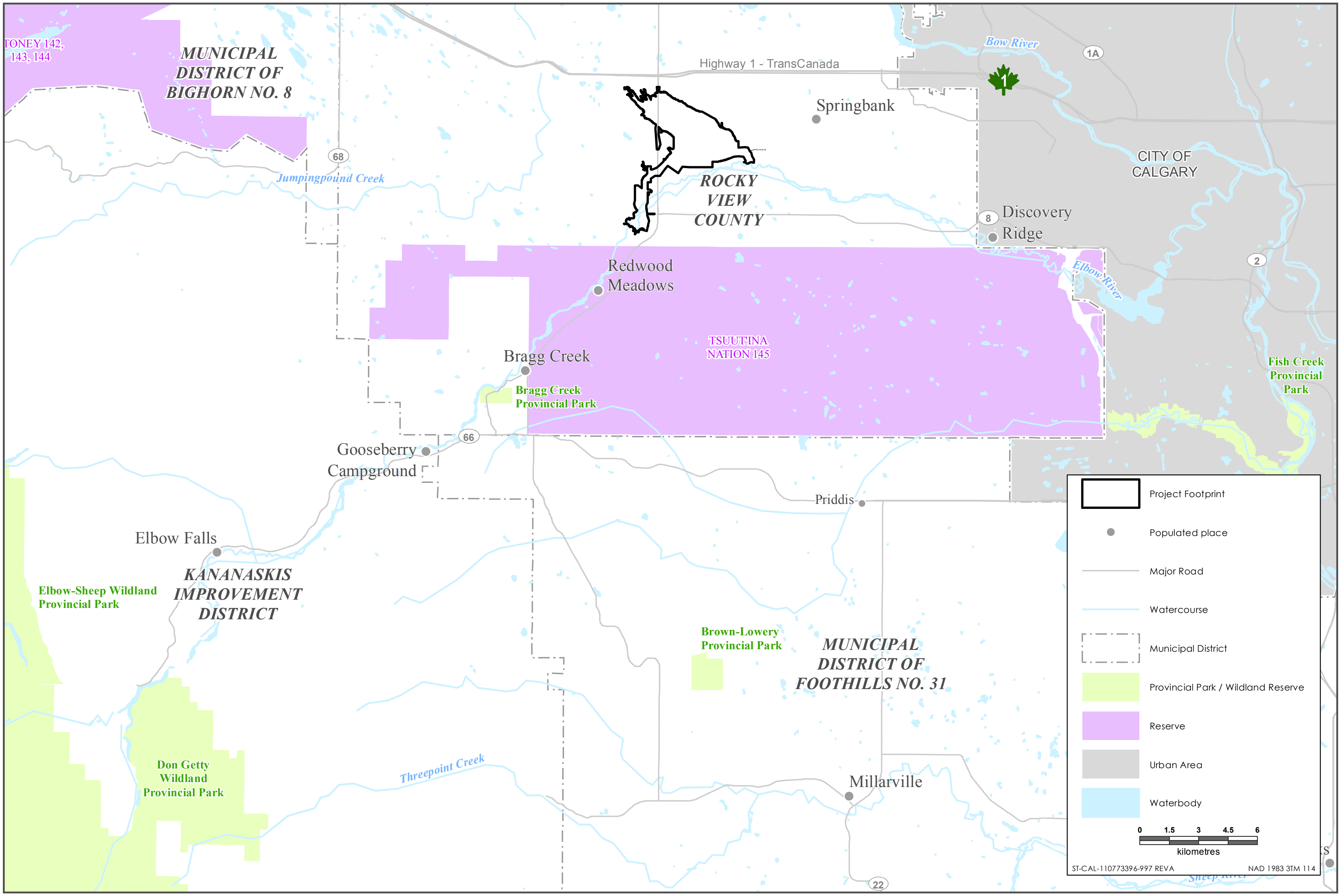
The following major habitat attributes were examined as part of the habitat assessment and used to describe/summarize habitat for the surveyed area:

- channel types (Section 2.1.1)
- macrohabitat composition and distribution (Section 2.1.2)
- substrate composition (Section 2.1.3)
- functional fish cover (Section 2.1.4)
- river bathymetry (Section 2.1.5)

2.1.1 Channel Types

Aquatic habitat in the Elbow River study area is primarily distinguished by the hydrologic processes driving channelization and maintenance of the main stem of the river, within the terraces of the larger river valley. Furthermore, channel habitat can be discussed in term of seasonal conditions vary such as stage and fluctuations in flow. Some channels may be considered active (i.e., receiving surface waters directly from Elbow River mainstem) or inactive (i.e., surface waters maintained by hyporheic flow or groundwater), depending on the overall rate of discharge at a specific time of year. In contrast, some channels always remain disconnected from Elbow River at the upstream end and are only maintained in certain years by receiving flood waters from the surrounding flood plain. Seasonal variations in flow for specific channels are accompanied by seasonal variations in water quality (e.g., temperature, dissolved oxygen), habitat structure (e.g., substrate embeddedness), or water velocity.

Four main types of channels and channel conditions were distinguished to support interpretation of fish habitat collected in the fall of 2019 (Table 2-1). Following completion of the field survey, each assessed channel was categorized as belonging to a specific channel type based on field observations and review of aerial orthoimagery.



Sources: Base Data - Government of Canada, Thematic Data - Government of Alberta

General Overview of Elbow River Survey Area

Stantec

ALBERTA TRANSPORTATION SPRINGBANK OFF-STREAM RESEVOIR PROJECT ENVIRONMENTAL IMPACT ASSESSMENT

Figure 2-1

Table 2-1 Elbow River Habitat Assessment Channel Types

Channel Type	Description
Active Channels	Channel segment conveying surface water flows for the main stem of Elbow River.
Main Channel	Channel segment conveying more than 50% of the surface water volume for Elbow River at the time of survey.
Side Channel	Channel segment conveying less than 50% of the surface water volume for Elbow River at the time of survey.
Inactive Channels	Channel receiving little to no surface water flows directly from Elbow River at the time of survey. Surface water at the time of survey is primarily maintained by the hyporheic flow or groundwater.
Connected	Channel segment that receives surface water directly from Elbow River at high discharges up to and including bankfull discharge.
Disconnected	Channel segment that <u>does not</u> receive surface water directly from Elbow River at bankfull discharge or lower. Disconnected channels are created and maintained by flows greater than bankfull discharge (i.e., or may be abandoned.

2.1.2 Macrohabitat Composition and Distribution

Macrohabitat units were characterized based on the Fourth Edition of the California Salmonid Stream Habitat Restoration Manual (Flosi et al. 2010) which was published in 1991 with updates to 2010 (Table 2-2). This method was chosen to accurately reflect the channel-forming processes of a river as they relate to fish habitat structure and the resulting combinations of depth and velocity that account for macrohabitat differences throughout the mapped channels. Additional macrohabitat units (e.g., armoured bank lateral scour pool and bedrock-formed backwater pool) were added during the survey to create a more complete picture of macrohabitat in Elbow River (Table 2-2). A guide describing of each type of macrohabitat including photos and aerial imagery is provided in Attachment A.

Table 2-2 Elbow River Mainstem Macrohabitat Mapping Units

Level 1	Level 2	Level 3	Level 4 (Actual Unit Classification)	Code	Source
High flow	Turbulent		Riffle	RIF	Flosi et al. 2010
	Non-turbulent		Run	RUN	Flosi et al. 2010
			Pocket water	POW	Flosi et al. 2010
			Fast glide	FGL	Adapted from Flosi et al. 2010*
Medium flow	Pool	Mid-channel scouring	Mid-channel pool (undifferentiated)	MCP	Flosi et al. 2010
			Mid-channel debris pool	MCD	Added for survey
			Channel confluence pool	CCP	Flosi et al. 2010
			Plunge pool	PLP	Flosi et al. 2010
		Lateral scouring	Lateral scour pool (undifferentiated)	LSP	Flosi et al. 2010
			Log-enhanced lateral scour pool	LSL	Flosi et al. 2010
			Root-wad enhanced lateral scour pool	LSR	Flosi et al. 2010
			Bedrock-formed lateral scour pool	LSBk	Flosi et al. 2010
			Boulder-formed lateral scour pool	LSBo	Flosi et al. 2010
			Armoured bank lateral scour pool	LSA	Added for survey
		Backwater	Bedrock-formed backwater pool	BPBk	Added for survey
			Boulder-formed backwater pool	BPBo	Flosi et al. 2010
			Root-wad formed backwater pool	BPR	Flosi et al. 2010
			Log-formed backwater pool	BPL	Flosi et al. 2010
			Armoured bank backwater pool	BPA	Added for survey
	Slow glide			SGL	Adapted from Flosi et al. 2010*
Low flow	Beaver impoundment			BIM	Added for survey
	Edgewater			EDW	Flosi et al. 2010
	Backwatered channel confluence			BWC	Added for survey
	Flat			FLT	Added for survey

NOTE:
*Glide habitat (Flossi et al. 2010) is further subdivided into fast glide and slow glide by Stantec (see Attachment A).

2.1.3 Substrate Composition

Substrate for each macrohabitat unit was characterized visually, in order of dominance for each macrohabitat unit. Up to five substrates were listed for a macrohabitat unit in decreasing order depending on composition. A summary of substrate types used to characterize stream substrate during the survey is provided in Table 2-3.

Table 2-3 Fish Habitat Assessment Substrate Categories

Substrate Category	Size Class	Code
Organics	n/a	OR
Fines	<0.06 mm (particle not discernable)	FI
Sand	0.06 mm to 2 mm	SA
Small Gravel	2 mm to 16 mm	SG
Large Gravel	17 mm to 64 mm	LG
Cobble	64 mm to 25.6 cm	CB
Small Boulder	25.7 cm to 1 m	SB
Large Boulder	>1 m	LB
Bedrock	n/a	BR

In addition to substrate composition, substrate embeddedness (i.e., the degree to which coarse substrate materials are covered by fines) was rated for each macrohabitat unit according to the categories described below. A summary of the embeddedness categories used to describe substrate embeddedness during the survey is provided in Table 2-4.

Table 2-4 Fish Habitat Assessment Substrate Embeddedness Categories

Embeddedness Category	Description
Non-Embedded	Lacking fines
Low	<25% Embeddedness
Medium	25% to 50% Embeddedness
High	50% to 75% Embeddedness
Very High	>75% Embeddedness

2.1.4 Functional Fish Cover

The percentage of the total surface area providing functional fish cover was visually estimated for each macrohabitat unit (total % cover). The types of functional fish cover in order of dominance was further documented for each macrohabitat unit. Up to four types of cover were listed for a macrohabitat unit in decreasing order (based on area), depending on cover composition. The types of cover and associated codes used to characterize functional fish cover is provided in Table 2-5.

Table 2-5 Types of Functional Fish Cover Documented for each Macrohabitat Unit During the Habitat Assessment

Cover Type	Code
Undercut banks	UC
Grasses and forbes	GF
Trees and shrubs	TS
Overhead woody debris	OWD
Instream woody debris	IWD
Boulders	BL
Water visibility	VIS
Instream vegetation	IVG

For each macrohabitat unit, large woody debris was enumerated. Debris was considered large woody debris and counted where it was greater than 10 cm in diameter, greater than 1 m in length, intersected the stream channel, and provided functional fish cover at the time of the assessment.

2.1.5 River Bathymetry

Bathymetric data was collected within the wetted area at the time of the assessment. Elevations were measured by a surveyor on-foot using a Trimble R10 GNSS real-time-kinematic (RTK) positioning system which has a horizontal accuracy of 8 mm + 1 ppm root mean square (RMS), and a vertical accuracy of 15 mm + 1 ppm RMS. Elevation data was derived from provincial high precision network (HPN) 40301 with ties to several Alberta Survey Control Monuments throughout the survey.

Generally, cross-channel transects of RTK measurements were established within major macrohabitat units identified during the survey (i.e., riffles, runs, pools). Where there was a marked change in gradient across a transect, measurements were concentrated in that area to capture the grade-change. Additional measurements were made in the deepest areas of identified habitat (e.g., pools) to characterize maximum depths available to fish. Where areas were too deep or fast-flowing to wade by the surveyor, an estimate of the maximum depth was made in the field and denoted in association with the nearest measurement. Each measurement was categorized as being taken at the wetted edge (WE), in water, or in dry-channel (up-grade) areas for post-survey processing. Survey measurements were primarily collected in active main and side-channel areas during the fish habitat survey.

The 3D surface bathymetry was created using AutoCAD Civil 3D 2019 Version. Where depths were estimated in the field, associated elevations for these areas was added to the 3D surface using the orthoimagery to approximate the horizontal location of the deepest point of the assessed macrohabitat feature. Where WE measurements were only taken at one side of a wetted channel, a bathymetry estimate was made for the opposing bank WE coordinate with the same elevation value was added to the bathymetry dataset using the orthoimagery to verify horizontal positioning. Within the AutoCAD Civil 3D 2019, a second 3D surface was created to denote the water level; this water level surface was created with the WE measurements and created for the 3D bathymetry surface. To capture water depths, a triangular irregular network (TIN) volume surface was generated using the water level surface as the base and the 3D bathymetry surface as the comparison. The TIN volume surface was then exported as a GEOTIFF with a grid spacing of 0.5 m.

Depth statistics (e.g., average depth, maximum depth) were calculated for the bathymetric dataset using ArcGIS zonal statistics tool, including statistics for each channel type and macrohabitat unit type. Statistics were only calculated for macrohabitat units in which greater than 20% of the total surface area contained bathymetry data.

2.2 FISH DISTRIBUTION

2.2.1 Field Observations (Fall 2019)

While conducting the habitat surveys and coinciding redd surveys, incidental fish observations made by the field crew were recorded. Species was determined and fish size was estimated where possible. In addition, a high-resolution underwater camera was deployed at select locations to collect video clips to further document fish presence and distribution in the survey area. Although video was recorded in a variety of habitat types, selected locations were typically wadable areas (i.e., smaller pools) with relatively low velocity and abundant instream cover. A camera was mounted on an extendable monopod, allowing video to be acquired in harder to reach places (i.e. undercut banks, deep pools). A total of 2 hours, 33 minutes and 22 seconds of underwater video footage was recorded at a total of 107 locations. Individual recording lengths averaged 1 minute and 22 seconds and ranged between 22 seconds to 05 minutes and 11 seconds. Longer videos were taken where fish were visually observed to assist with species identification. Footage was reviewed following completion of the field program at half speed to identify fish and estimate species, maturity, or fish size, where possible.

Where a school of Age 0 mountain whitefish was observed and could not be enumerated, the observation was recorded in the field as "dozens" of individuals observed. To report the relative of abundance of individual fish observed, "dozens" of fish was reported as three dozen fish.

2.2.2 FWMIS Records Review

Elbow River watershed records for fish were extracted on March 2, 2020 from FWMIS (FWMIS 2020). All fish sampling and fish observation events in Elbow River between Elbow Falls and Glenmore Reservoir were included. Sport fish records were then categorized by date into the biologically significant periods (BSP), defined as follows:

- BSP-1: April 2 to June 15
- BSP-2: June 16 to September 25
- BSP-3: September 26 to December 1
- BSP-4: December 2 to April 1

In addition to fish capture and observation records, a search for FWMIS records of salmonid redds was also made for the search area.

2.3 FISH HABITAT SUITABILITY

To characterize macrohabitat quality for the life stages of select sport fish species that maintain populations in the surveyed area, an HSI approach was used.

Key indicator species were selected based on their known distribution in the assessment area (see Section 3.2, Fish Observations). Habitat suitability was evaluated for adult, juvenile, fry and spawning life stages of the following species:

- brown trout
- bull trout
- mountain whitefish
- rainbow trout

For each species and life stage, an HSI formula was developed, as described in Sections 2.3.1 through 2.3.4. HSI index values range from 0 to 1, with 0 being the least suitable habitat and 1 being the most suitable habitat. Habitat variable indices (i.e., water depth, water velocity, substrate size, and cover) for each macrohabitat (2,238 macrohabitat units in total) were used to calculate habitat suitability for each key indicator species by life stage. This resulted in the calculation of over 35,000 HSI values for macrohabitats throughout the study area.

The results of HSI values are presented in two ways. Summary tables are created that group HSI values in a series of ranges and report the area of each range, along with the percent of total area. The ranges selected and a general description of how to interpret the HSI value range is included in Table 2-6. HSI values are presented on a series of detailed maps, one series for each species life stage, that show the distribution of habitat suitability throughout the surveyed area.

Table 2-6 Categories of HSI Index Results and General Description of Suitability

HSI Value Range	General Description
0.00	unsuitable habitat for given life stages
0.01-0.09	nearly unsuitable habitat for given life stages
0.10-0.24	low habitat suitability for given life stages
0.25-0.49	moderate habitat suitability for given life stages
0.5-1.00	high habitat suitability for given life stages

The resulting HSI value for each macrohabitat unit is calculated as the minimum value the suitability indices calculated for all applicable environmental variables. For example, if habitat parameters of depth, velocity and substrate were highly suitable for a given fish species and life stage (e.g., index value = 1 for all), but low cover was available and associated with a low cover index value (index value = 0.2), the resulting HSI value for that specific macrohabitat unit would be 0.2 and the limiting environmental variable resulting in that value would be cover.

To describe the relative limiting nature of each environmental variable, the limiting habitat variable (LHV), or the environmental variable with the lowest index value, was identified for each macrohabitat unit. No LHV was identified where there were no limiting habitat variables for a macrohabitat unit (i.e., HSI=1). Because two environmental variable indices may equally limit the overall HSI of a macrohabitat unit (e.g., depth and velocity index values are equally less than 1), many macrohabitat units had multiple LHVs associated with them. The LHV area was calculated by summing the total surface area of macrohabitat units for which a specific LHV was identified (e.g., total surface area of macrohabitat units for which cover is an LHV).

A variety of habitat variables were used in the development of the HSI indices for each species and life stage, including variables collected during the survey or those estimated using desktop or field-collected information. Substrate (dominant and subdominant) as well as cover composition was characterized for each individually mapped macrohabitat unit. Detailed bathymetry was also created for most main and side channel areas surveyed. However, velocity was not collected in the field for characterization of individual each macrohabitat units and, therefore, velocities associated with each type of macrohabitat unit is estimated based on professional judgement of the field crew lead who conducted the assessment. Velocities were collected in the field in support of identifying potential spawning habitat for brown trout and characterizing the velocity at identified redds and this information is used to estimate velocities.

In addition, detailed bathymetry and macrohabitat unit specific depths were not developed for the entire survey area and had to be estimated based on a combination of channel type and macrohabitat unit. Generally, low velocities (less than 0.5 m/s) and shallow depths (less than 0.8 m) were encountered in inactive channels which were primarily supported by hyporheic and (or) groundwater flows. Velocities and depths in active channels had a much greater range depending on macrohabitat type. Estimates of macrohabitat-associated velocities and depths by channel type is presented in Table 2-7.

The velocities listed in Table 2-7 are used for the velocity variable in HSI development for all species and life stages. The depths listed in Table 2-7 are only used where bathymetry-derived average depths were not available for a specific macrohabitat unit. In addition, where bathymetry-derived average depths are less than 5 mm, they are considered inaccurate due to the nature of macrohabitat identified in the field (i.e., all macrohabitat units had average depths of greater than 5 mm) and the depths in Table 2-7 are used.

Table 2-7 Macrohabitat-Associated Depths and Velocities for each Observed Combination of Channel Type and Macrohabitat Unit

Channel Type	Macrohabitat Type	Velocity Range (m/s)	Velocity for HSI (m/s)	Depth Range (m)	Depth for HSI (m)*
Active main and side channel – high flow	Riffle	0.3-2.0	1.2	0.0-0.4	0.2
	Run (including pocket water)	0.7-2.0	1.35	0.4-1.5	0.95
	Fast glide	0.4-0.8	0.6	0.4-0.8	0.6
	Pools (combined)	0.0-0.7	0.35	1.0-2.5	1.75
	Slow glide	0.1-0.4	0.25	0.0-0.8	0.4
	Edgewater	0.0-0.1	0.05	0.0-0.2	0.1
	Backwatered channel confluence	0.0-0.1	0.05	0.3-0.8	0.5
	Flat	0.0-0.1	0.05	0.1-0.4	0.25
Inactive connected channels – medium flow	Riffle	0.1-0.4	0.25	0.0-0.1	0.05
	Run	0.1-0.5	0.3	0.3-0.5	0.4
	Pools (combined)	0.0-0.2	0.1	0.4-0.8	0.6
	Slow glide	0.1-0.2	0.15	0.0-0.4	0.2
	Beaver impoundment*	0.0-0.1	0.05	0.0-0.8	0.4
	Edgewater	0.0-0.1	0.05	0.0-0.1	0.05
	Backwatered channel confluence	0.0-0.1	0.05	0.3-0.6	0.45
	Flat	0.0-0.1	0.05	0.0-0.3	0.15
Inactive disconnected channels – low flow	Riffle	0.1-0.4	0.25	0.0-0.1	0.05
	Pools (combined)	0.0-0.2	0.1	0.4-0.6	0.5
	Slow glide	0.0-0.2	0.1	0.0-0.3	0.15
	Backwatered channel confluence	0.0-0.1	0.05	0.2-0.4	0.3
	Flat	0.0-0.1	0.05	0.0-0.4	0.2

NOTE:
*Depth used for HSI where unit-specific bathymetry data (i.e., average depth) was not calculated.

Substrate suitability was assessed based on preferred substrate characteristics identified by Fernet et al. (1990) and indices from that study are used for each fish species. However, the substrate suitability index and classification system used in that study included different categories of substrate size. To account for differences between data sources, substrate codes for collected data were transformed in accordance with Table 2-8.

Table 2-8 Transformed Substrate Values for Alignment with Suitability Index

Suitability Index Class Name	Suitability Index Size Range (mm)	Suitability Index Substrate Code	2019 Field Data Class Name	2019 Field Data Size Range	2019 Field Data Transformed Substrate Code for Suitability Index
Detritus	n/a	0	Organics	n/a	0
Clay and silt	<0.062	1	Fines	<0.06	1
Sand	0.062-2.0	2	Sand	0.06-2.0	2
Small gravel	2-8	3	Small gravel	2-16	3.5
Medium gravel	8-32	4			
Large gravel	32-64	5	Large gravel	16-64	4.5
Small cobble	64-128	6	Cobble	64-256	6.5
Large cobble	128-256	7			
Small boulder	256-762	8	Small boulder	257-1,000	8.5
Large boulder	>762	9	Large boulder	>1,000	9
Bedrock	n/a	10	Bedrock	n/a	10

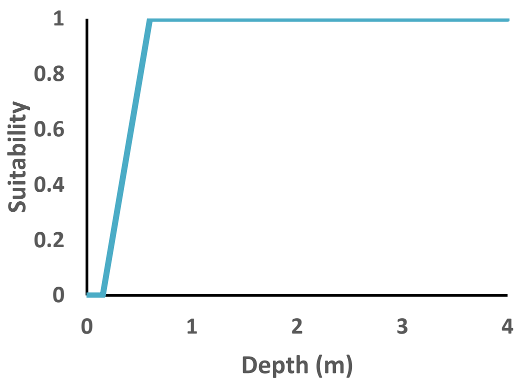
Source:
(Fernet et al. 1990)

2.3.1 Brown Trout

The brown trout HSI was based on the depth and velocity indices developed in Addley et al. (2003) for the South Saskatchewan River basin, the substrate indices developed by Fernet et al. (1990), and the % cover indices developed by the U.S. Fish and Wildlife Service (Raleigh et al. 1986).

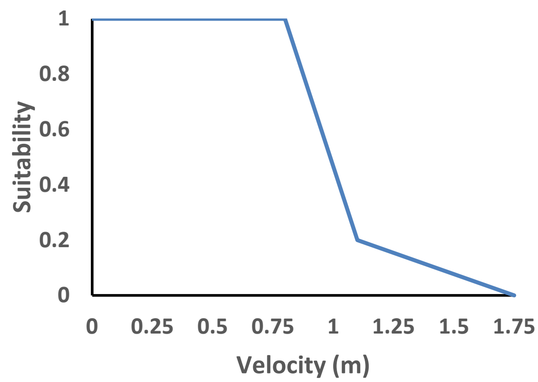
2.3.1.1 Adult

Suitability indices used to develop the HSI for adult brown trout are presented in Figure 2-2 to Figure 2-5.



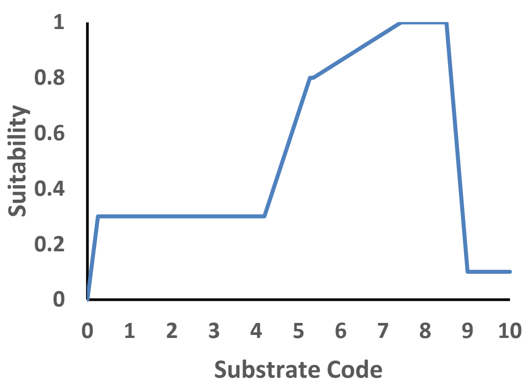
SOURCE: Addley et al. 2003

Figure 2-2 Brown Trout Adult Depth Suitability Index



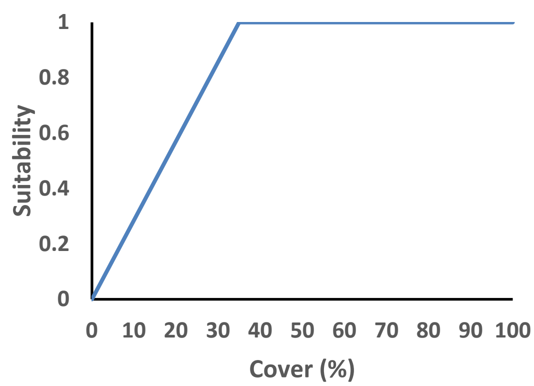
SOURCE: Addley et al. 2003

Figure 2-3 Brown Trout Adult Velocity Suitability Index



SOURCE: Fernet et al. 1990

Figure 2-4 Brown Trout Adult Substrate Suitability Index



SOURCE: Raleigh et al. 1986

Figure 2-5 Brown Trout Adult Cover Suitability Index

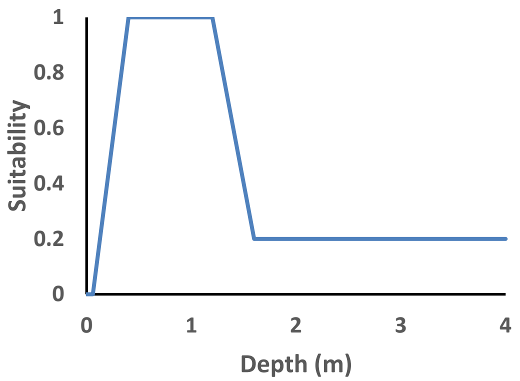
The overall HSI for adult brown trout was calculated using the following formula for each individually mapped macrohabitat unit in the surveyed area:

$HSI_{ADULT\ BNTR} = \min\{SI_{DEPTH}, SI_{VELOCITY}, Max(SI_{DOMINANT\_SUBSTRATE}, SI_{SUBDOMOMINANT\_SUBSTRATE}), SI_{COVER}\}$

The suitability index (SI) value for substrate is the highest value ("Max") associated with the dominant or subdominant substrate type noted for a mapped macrohabitat unit.

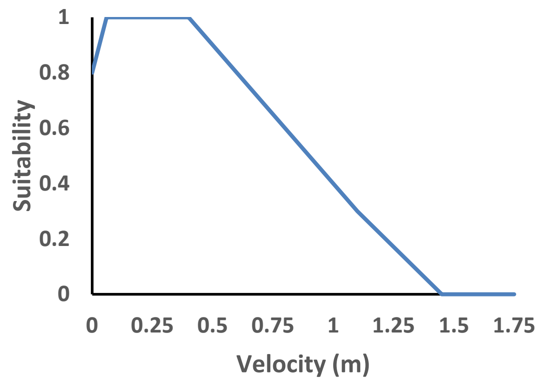
2.3.1.2 Juvenile

Suitability indices used to develop the HSI for juvenile brown trout are presented in Figure 2-6 to Figure 2-9.



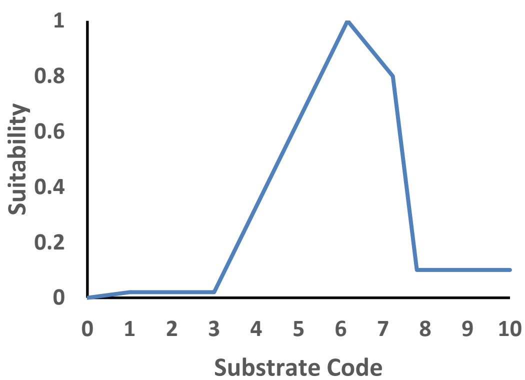
SOURCE: Addley et al. 2003

Figure 2-6 Brown Trout Juvenile Depth Suitability Index



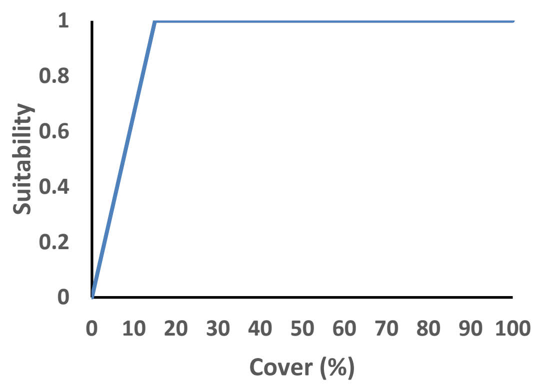
SOURCE: Addley et al. 2003

Figure 2-7 Brown Trout Juvenile Velocity Suitability Index



SOURCE: Fernet et al. 1990

Figure 2-8 Brown Trout Juvenile Substrate Suitability Index



SOURCE: Raleigh et al. 1986

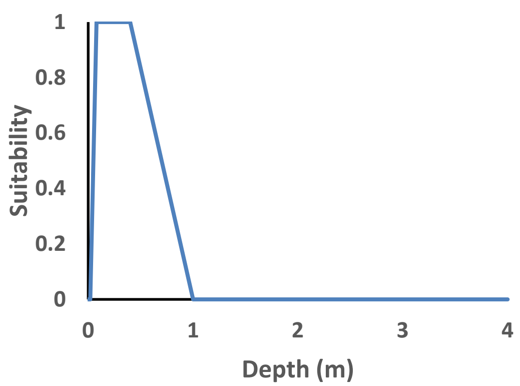
Figure 2-9 Brown Trout Juvenile Cover Suitability Index

The overall HSI for juvenile brown trout was calculated using the following formula for each individually mapped macrohabitat unit in the surveyed area:

$HSI_{JUVENILE\ BNTR} = \min \{SI_{DEPTH}, SI_{VELOCITY}, Max(SI_{DOMINANT\_SUBSTRATE}, SI_{SUBDOMOMINANT\_SUBSTRATE}), SI_{COVER}\}$

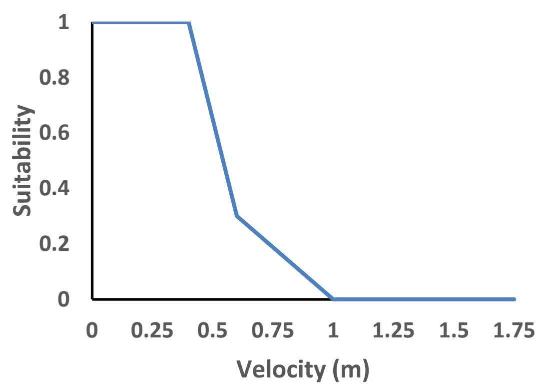
2.3.1.3 Fry

Suitability indices used to develop the HSI for brown trout fry are presented in Figure 2-10 to Figure 2-13. The brown trout index for fry (Raleigh et al. 1986) was adapted such that areas lacking cover as defined by the field survey (e.g., boulders, woody debris) were still considered somewhat suitable to brown trout fry (HSI=0.5) because fry commonly use cobble as cover which was not included in the total % cover characterization of macrohabitat features. As such, only a combination of low total % cover and small substrate materials would be considered unsuitable to brown trout fry.



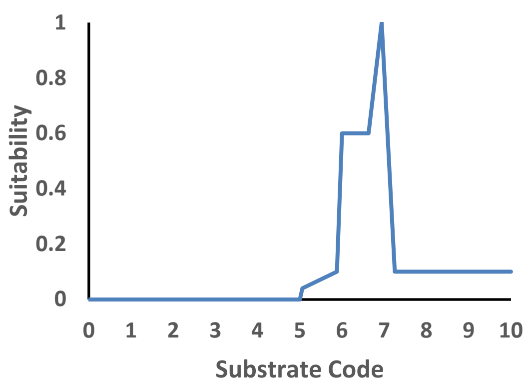
SOURCE: Addley et al. 2003

Figure 2-10 Brown Trout Fry Depth Suitability Index



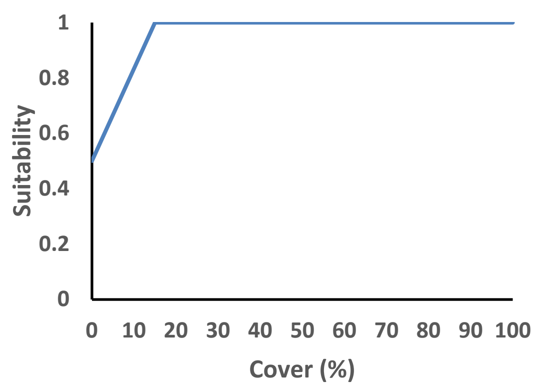
SOURCE: Addley et al. 2003

Figure 2-11 Brown Trout Fry Velocity Suitability Index



SOURCE: Fernet et al. 1990

Figure 2-12 Brown Trout Fry Substrate Suitability Index



SOURCE: adapted from Raleigh et al. 1986

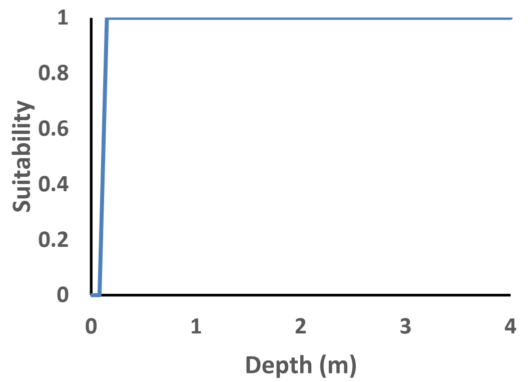
Figure 2-13 Brown Trout Fry Cover Suitability Index

The overall HSI for brown trout fry was calculated using the following formula for each individually mapped macrohabitat unit in the surveyed area:

$HSI_{FRY\ BNTR} = \min\{SI_{DEPTH}, SI_{VELOCITY}, Max(SI_{DOMINANT\_SUBSTRATE}, SI_{SUBDOMOMINANT\_SUBSTRATE}), SI_{COVER}\}$

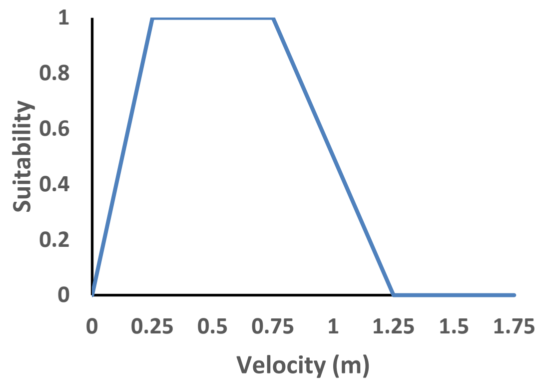
2.3.1.4 Spawning

Suitability indices used to develop the HSI for spawning brown trout are presented in Figure 2-14 to Figure 2-16. Cover (%) was not considered an important variable in determining the suitability of spawning habitat (Raleigh et al. 1986), and a suitability index was not included for cover as a result.



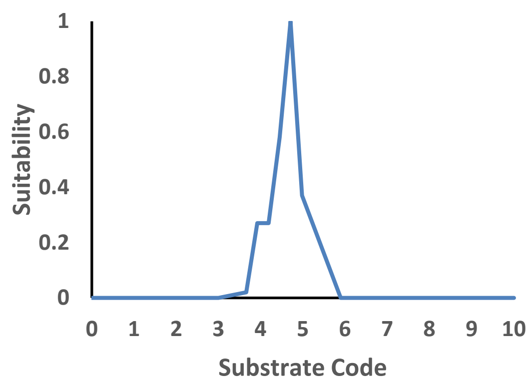
SOURCE: Addley et al. 2003

Figure 2-14 Brown Trout Spawning Depth Suitability Index



SOURCE: Addley et al. 2003

Figure 2-15 Brown Trout Spawning Velocity Suitability Index



SOURCE: Fernet et al. 1990

Figure 2-16 Brown trout spawning substrate suitability index

The overall HSI for spawning brown trout was calculated using the following formula for each individually mapped macrohabitat unit in the surveyed area:

$$HSI_{SPAWNING\ BNTR} = \min\{SI_{DEPTH}, SI_{VELOCITY}, Max(SI_{DOMINANT\_SUBSTRATE}, SI_{SUBDOMOMINANT\_SUBSTRATE})\}$$

2.3.2 Bull Trout

The bull trout HSI for each life stage was based on the depth and velocity indices developed in Addley et al. (2003) for the South Saskatchewan River basin. Substrate and cover indices were developed based on literature review of habitat preferences for each life stage or indices developed for other species (e.g., brown trout) were used as appropriate.

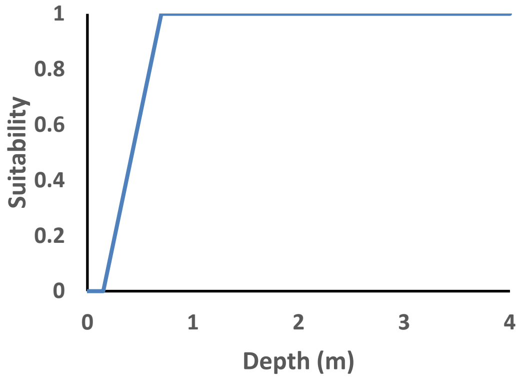
Spawning typically occurs in areas influenced by groundwater, which stabilizes temperatures throughout the egg incubation period (Baxter 1997; Baxter and McPhail 1999; Baxter and Hauer 2000; Ripley et al. 2005). However, habitat information relating to groundwater inputs was not collected during the field survey. As a result, a suitability index for groundwater influence was not included.

2.3.2.1 Adult

Adult bull trout exhibit high associations with cover and, while foraging, rarely stray from overhead cover (Nakano et al. 1992). This association is consistent with the adult brown trout suitability index developed by Raleigh et al. (1986) which was adopted for the adult bull trout suitability index for cover.

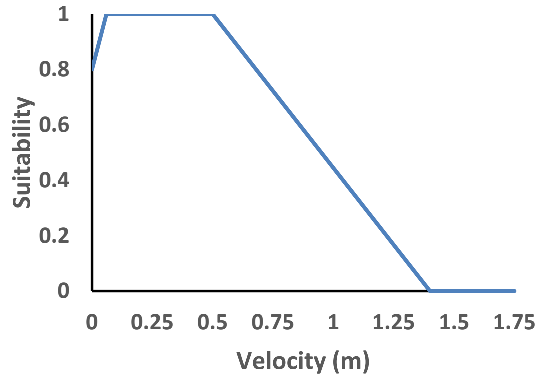
Adult bull trout are most commonly found in pools and, during the day, associate mostly with large cover in the form of undercut banks, depth or visibility, or boulders (Stewart et al. 2007). These forms of cover are included within measures of % total cover for the survey. As a result, a substrate index was not included for the bull trout HSI, with the exception of boulders, because it does not appear to be a determining component of adult habitat suitability.

Suitability indices used to develop the HSI for adult bull trout are presented in Figure 2-17 to Figure 2-19.



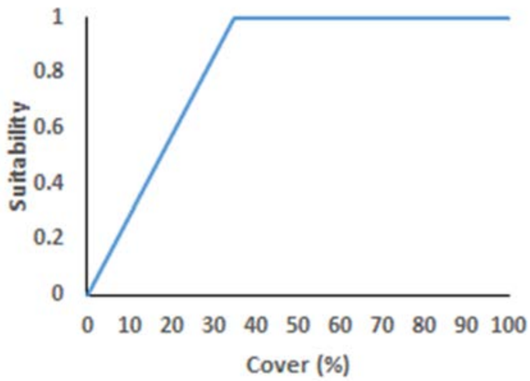
SOURCE: Addley et al. 2003

Figure 2-17 Bull Trout Adult Depth Suitability Index



SOURCE: Addley et al. 2003

Figure 2-18 Bull Trout Adult Velocity Suitability Index



SOURCE: Raleigh et al. 1986 index for adult brown trout

Figure 2-19 Bull Trout Adult Cover Suitability Index

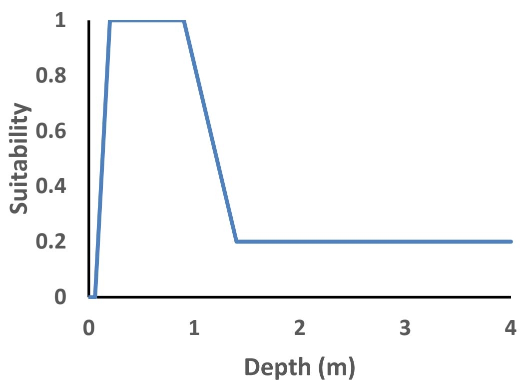
The overall HSI for adult bull trout was calculated using the following formula for each individually mapped macrohabitat unit in the surveyed area:

$HSI_{ADULT\ BLTR} = \min \{SI_{DEPTH}, SI_{VELOCITY,}, SI_{COVER}\}$

2.3.2.2 Juvenile

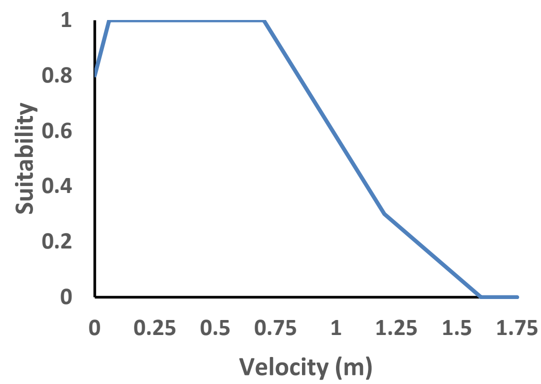
Juvenile bull trout and fry are known to extensively use cobble and boulders as cover and associate with the streambed until they grow larger than 100 mm in total length (Stewart et al. 2007). Therefore, a substrate index was developed based on the brown trout fry index (Fernet et al. 1990), which rated cobble substrates as most suitable. However, the index was modified to rate increased suitability for boulders which are still suitable for providing cover to juvenile bull trout. Juvenile bull trout also use non-substrate forms of function fish cover as they increase in age and size (Stewart et al. 2007). Therefore, a suitability index for total % cover was developed based on the juvenile brown trout index (Raleigh et al. 1986). The index was modified such that areas devoid of cover (0%) still presented some suitability (0.5) so that the juvenile HSI in those areas devoid of measured cover are governed by the substrate index.

Suitability indices used to develop the HSI for juvenile bull trout are presented in Figure 2-20 to Figure 2-23.



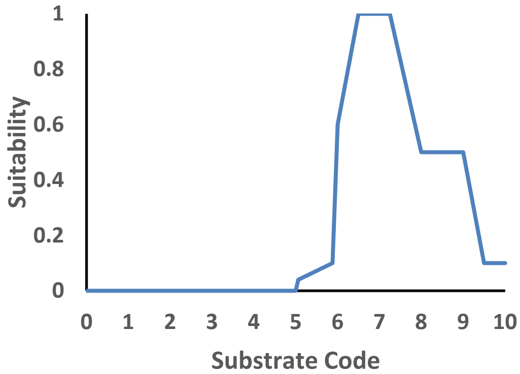
SOURCE: Addley et al. 2003

Figure 2-20 Bull trout Juvenile Depth Suitability Index



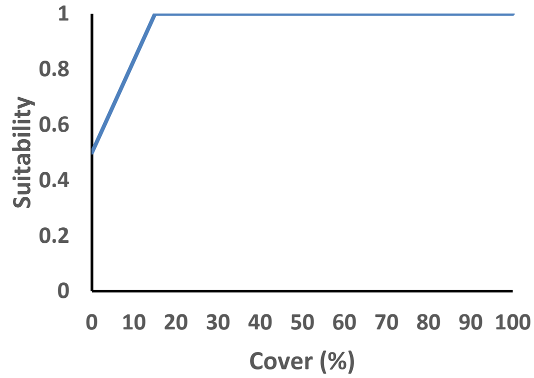
SOURCE: Addley et al. 2003

Figure 2-21 Bull Trout Juvenile Velocity Suitability Index



SOURCE: adapted from Fernet et al. 1990

Figure 2-22 Bull Trout Juvenile Substrate Suitability Index



SOURCE: adapted from Raleigh et al. 1986

Figure 2-23 Bull Trout Juvenile Cover Suitability Index

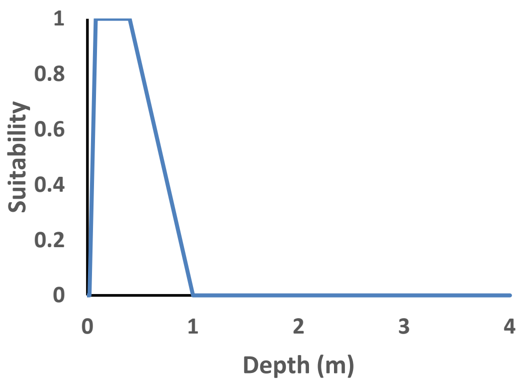
The overall HSI for juvenile bull trout was calculated using the following formula for each individually mapped macrohabitat unit in the surveyed area:

$HSI_{JUVENILE\ BLTR} = \min\{SI_{DEPTH}, SI_{VELOCITY}, Max(SI_{DOMINANT\_SUBSTRATE}, SI_{SUBDOMOMINANT\_SUBSTRATE}), SI_{COVER}\}$

2.3.2.3 Fry

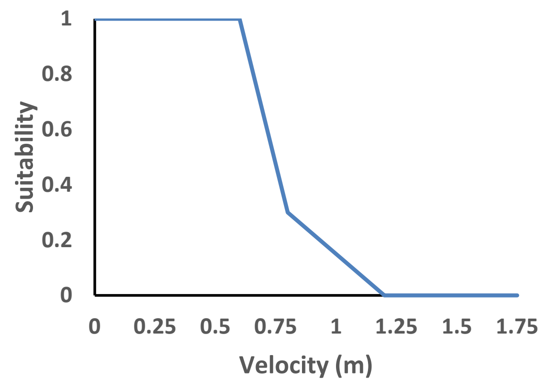
Bull trout fry are heavily associated with large cobble substrate (Addley et al. 2003, Stewart et al. 2007), which they use as cover. This is consistent with the substrate suitability index for brown trout fry (Fernet et al. 1990) for which suitability peaked in associated with large cobble. Therefore, the brown trout substrate suitability index for fry was adopted. Because cover is predominately provided in the form of cobble and represented in the substrate index, a total % cover index was not included for the fry life stage.

Suitability indices used to develop the HSI for bull trout fry are presented in Figure 2-24 to Figure 2-26.



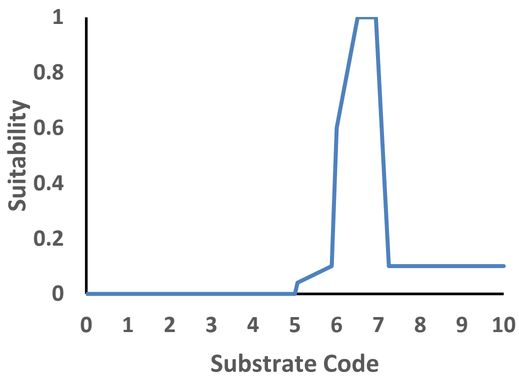
SOURCE: Addley et al. 2003

Figure 2-24 Bull Trout Fry Depth Suitability Index



SOURCE: Addley et al. 2003

Figure 2-25 Bull Trout Fry Velocity Suitability Index



SOURCE: adapted from Fernet et al. 1990

Figure 2-26 Bull Trout Fry Substrate Suitability Index

The overall HSI for bull trout fry was calculated using the following formula for each individually mapped macrohabitat unit in the surveyed area:

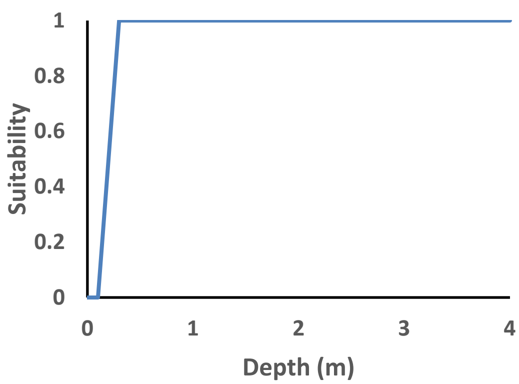
$HSI_{FRY\ BLTR} = \min \{SI_{DEPTH}, SI_{VELOCITY}, \mathrm{Max}(SI_{DOMINANT\_SUBSTRATE}, SI_{SUBDOMOMINANT\_SUBSTRATE})\}$

2.3.2.4 Spawning

A spawning substrate index with small gravel to small cobble associated with an index value of 1 was used as recommended in the South Saskatchewan River basin workshop (Addley et al. 2003).

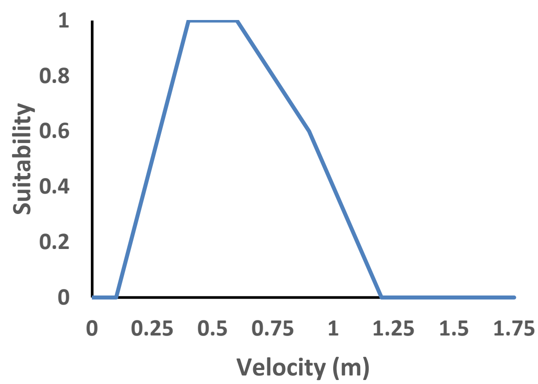
In contrast with brown trout, cover is believed to be an important component of spawning site selection by bull trout (Baxter and McPhail 1996). Therefore, a spawning suitability index for cover was included in the HSI which considered areas devoid cover (0%) as providing a low suitability index value (0.2) for spawning and areas with greater than 10% cover providing an index value of 1.

Suitability indices used to develop the HSI for spawning bull trout are presented in Figure 2-27 to Figure 2-30.



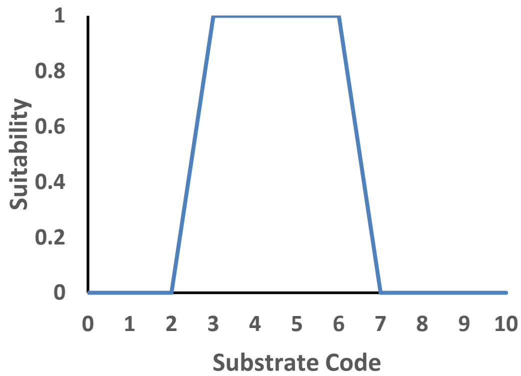
SOURCE: Addley et al. 2003

Figure 2-27 Bull Trout Spawning Depth Suitability Index



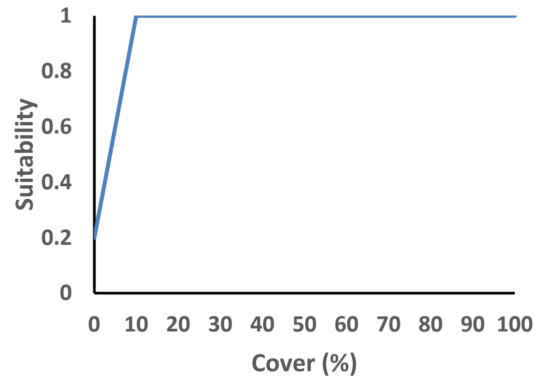
SOURCE: Addley et al. 2003

Figure 2-28 Bull Trout Spawning Velocity Suitability Index



SOURCE: derived from Addley et al. 2003 notes

Figure 2-29 Bull Trout Spawning Substrate Suitability Index



SOURCE: derived from Addley et al. 2003 notes

Figure 2-30 Bull Trout Spawning Cover Suitability Index

The overall HSI for spawning bull trout was calculated using the following formula for each individually mapped macrohabitat unit in the surveyed area:

$HSI_{SPAWNING\ BLTR} = \min\{SI_{DEPTH}, SI_{VELOCITY}, \text{Max}(SI_{DOMINANT\_SUBSTRATE}, SI_{SUBDOMOMINANT\_SUBSTRATE})\}$

2.3.3 Mountain Whitefish

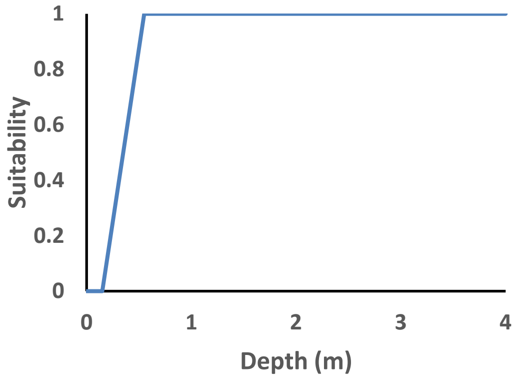
The mountain whitefish HSI was based on the depth and velocity indices developed in Addley et al. (2003) for the South Saskatchewan River basin, and the substrate indices, where applicable, developed by Environmental Management Associates (EMA) for the Bow River (EMA 1994).

Substrate as cover is important to fry and juvenile life stages and their association with this type of cover is reflected in the substrate indices for mountain whitefish (EMA 1994). Otherwise, cover is not considered an important component driving the suitability of habitat to mountain whitefish (EMA 1994). As a result, no indices of cover are included in HSIs for mountain whitefish.

2.3.3.1 Adult

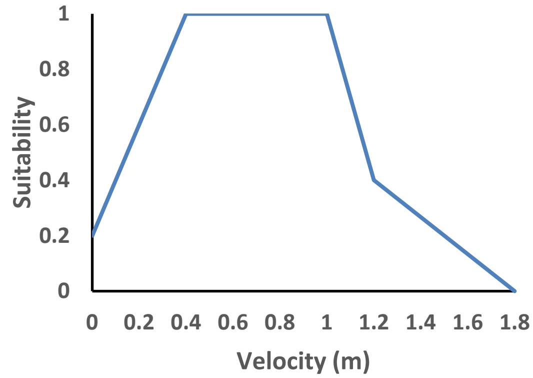
Adult mountain whitefish in Bow River did not appear to display a preference for any substrate type (EMA 1994). Therefore, an index of substrate is not included for the adult mountain whitefish HSI.

Suitability indices used to develop the HSI for adult mountain whitefish are presented in Figure 2-31 and Figure 2-32.



SOURCE: Addley et al. 2003

Figure 2-31 Mountain Whitefish Adult Depth Suitability Index



SOURCE: Addley et al. 2003

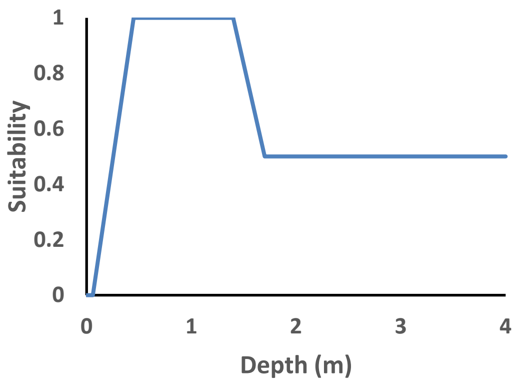
Figure 2-32 Mountain Whitefish Adult Velocity Suitability Index

The overall HSI for adult mountain whitefish is calculated using the following formula for each individually mapped macrohabitat unit in the surveyed area:

$HSI_{ADULT\ MNWH} = \min \{SI_{DEPTH}, SI_{VELOCITY}\}$

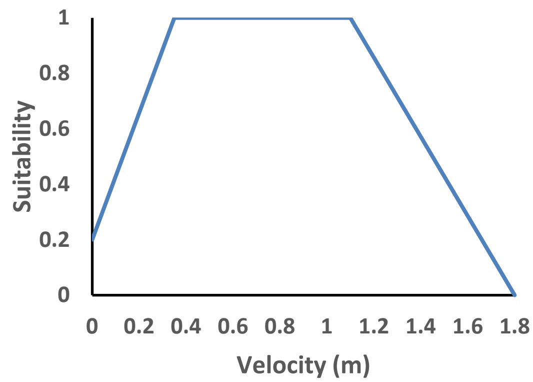
2.3.3.2 Juvenile

Suitability indices used to develop the HSI for juvenile mountain whitefish are presented in Figure 2-33 to Figure 2-35.



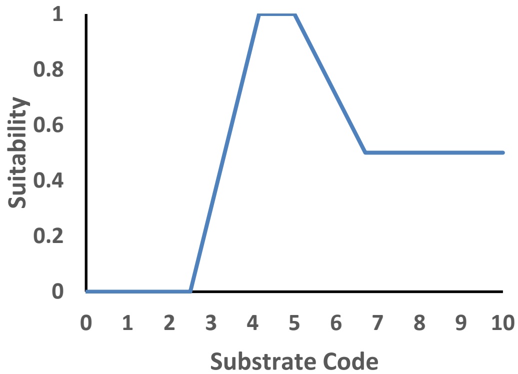
SOURCE: Addley et al. 2003

Figure 2-33 Mountain Whitefish Juvenile Depth Suitability Index



SOURCE: Addley et al. 2003

Figure 2-34 Mountain Whitefish Juvenile Velocity Suitability Index



SOURCE: EMA 1994

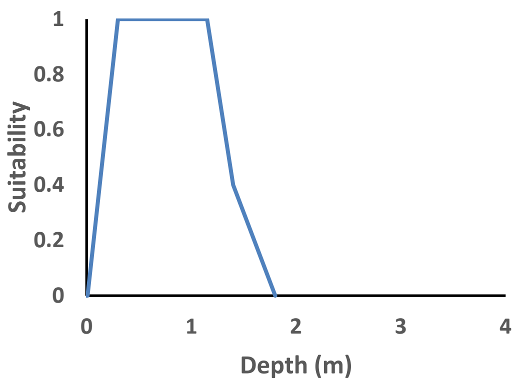
Figure 2-35 Mountain Whitefish Juvenile Substrate Suitability Index

The overall HSI for juvenile mountain whitefish is calculated using the following formula for each individually mapped macrohabitat unit in the surveyed area:

$HSI_{JUVENILE\ MNWH} = \min\{SI_{DEPTH}, SI_{VELOCITY}, \mathrm{Max}(SI_{DOMINANT\_SUBSTRATE}, SI_{SUBDOMOMINANT\_SUBSTRATE})\}$

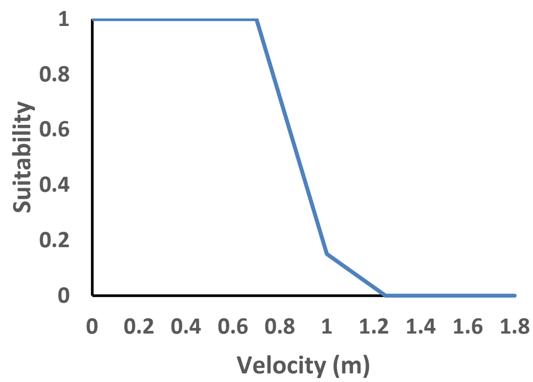
2.3.3.3 Fry

Suitability indices used to develop the HSI for mountain whitefish fry are presented in Figure 2-36 to Figure 2-38.



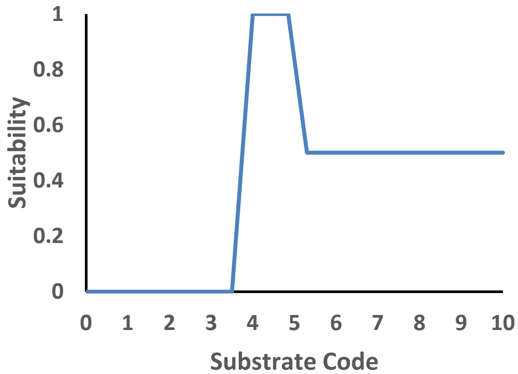
SOURCE: Addley et al. 2003

Figure 2-36 Mountain Whitefish Fry Depth Suitability Index



SOURCE: Addley et al. 2003

Figure 2-37 Mountain Whitefish Fry Velocity Suitability Index



SOURCE: EMA 1994

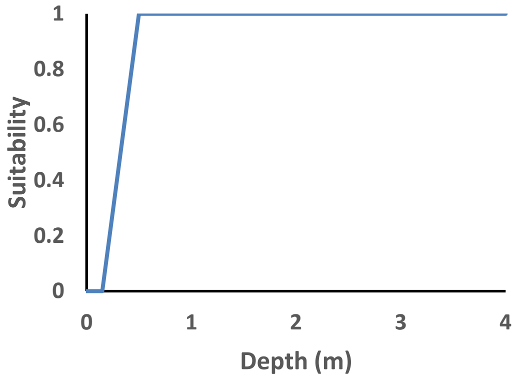
Figure 2-38 Mountain Whitefish Fry Substrate Suitability Index

The overall HSI for mountain whitefish fry is calculated using the following formula for each individually mapped macrohabitat unit in the surveyed area:

$HSI_{FRY\ MNWH} = \min\{SI_{DEPTH}, SI_{VELOCITY}, Max(SI_{DOMINANT\_SUBSTRATE}, SI_{SUBDOMOMINANT\_SUBSTRATE})\}$

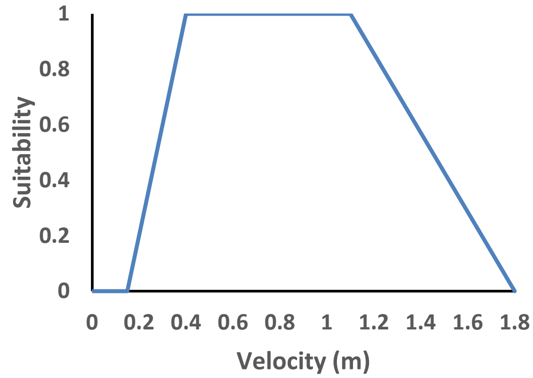
2.3.3.4 Spawning

Suitability indices used to develop the HSI for spawning mountain whitefish are presented in Figure 2-39 to Figure 2-41.



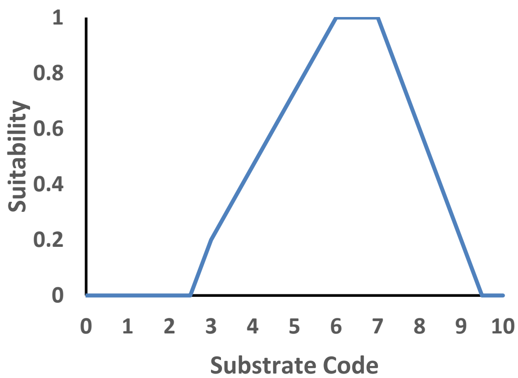
SOURCE: Addley et al. 2003

Figure 2-39 Mountain Whitefish Spawning Depth Suitability Index



SOURCE: Addley et al. 2003

Figure 2-40 Mountain Whitefish Spawning Velocity Suitability Index



SOURCE: EMA 1994

Figure 2-41 Mountain Whitefish Spawning Substrate Suitability Index

The overall HSI for spawning mountain whitefish is calculated using the following formula for each individually mapped macrohabitat unit in the surveyed area:

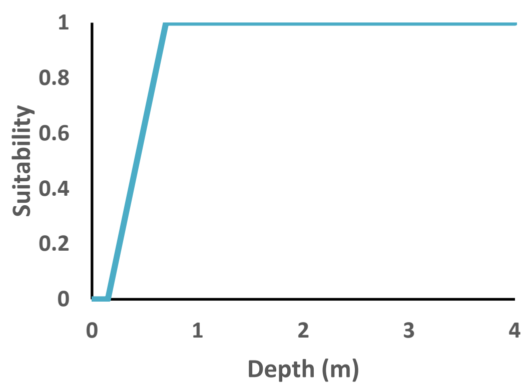
$HSI_{SPAWNING\ MNWH} = \min \{SI_{DEPTH}, SI_{VELOCITY}, Max(SI_{DOMINANT\_SUBSTRATE}, SI_{SUBDOMOMINANT\_SUBSTRATE})\}$

2.3.4 Rainbow Trout

The rainbow trout HSI is based on the depth and velocity indices developed in Addley et al. (2003) for the South Saskatchewan River basin, the substrate indices developed by Fernet et al. (1990), and the % cover indices developed by the U.S. Fish and Wildlife Service (Raleigh et al. 1984).

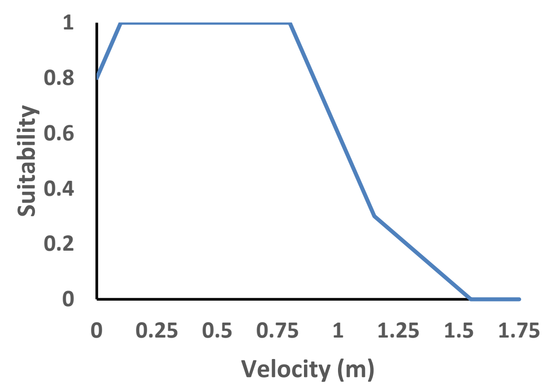
2.3.4.1 Adult

Suitability indices used to develop the HSI for adult rainbow trout are presented in Figure 2-42 to Figure 2-45.



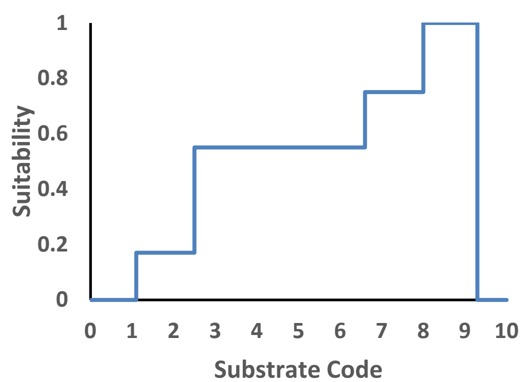
SOURCE: Addley et al. 2003

Figure 2-42 Rainbow Trout Adult Depth Suitability Index



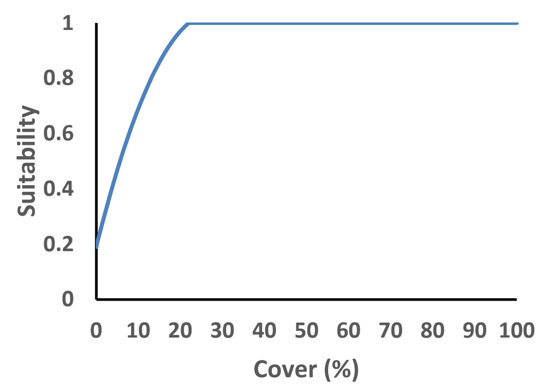
SOURCE: Addley et al. 2003

Figure 2-43 Rainbow Trout Adult Velocity Suitability Index



SOURCE: Fernet et al. 1990

Figure 2-44 Rainbow Trout Adult Substrate Suitability Index



SOURCE: Raleigh et al. 1984

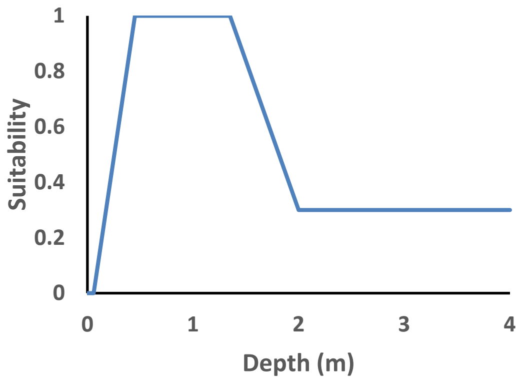
Figure 2-45 Rainbow Trout Adult Cover Suitability Index

The overall HSI for adult rainbow trout is calculated using the following formula for each individually mapped macrohabitat unit in the surveyed area:

$HSI_{ADULT\ RNTR} = \min\{SI_{DEPTH}, SI_{VELOCITY}, Max(SI_{DOMINANT\_SUBSTRATE}, SI_{SUBDOMOMINANT\_SUBSTRATE}), SI_{COVER}\}$

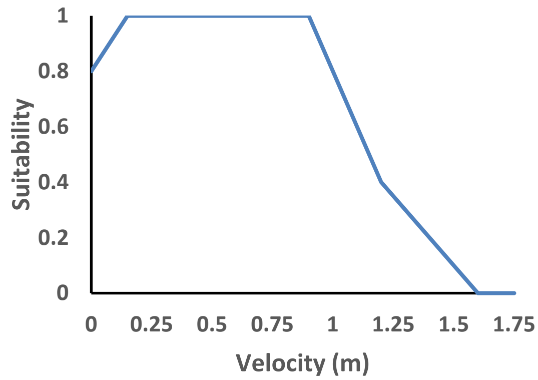
2.3.4.2 Juvenile

Suitability indices used to develop the HSI for juvenile rainbow trout are presented in Figure 2-46 to Figure 2-49.



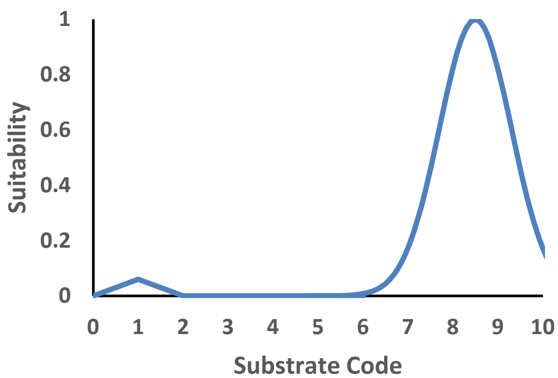
SOURCE: Addley et al. 2003

Figure 2-46 Rainbow Trout Juvenile Depth Suitability Index



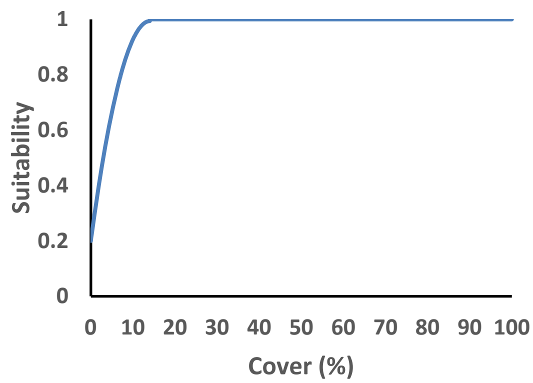
SOURCE: Addley et al. 2003

Figure 2-47 Rainbow Trout Juvenile Velocity Suitability Index



SOURCE: Fernet et al. 1990

Figure 2-48 Rainbow Trout Juvenile Substrate Suitability Index



SOURCE: Raleigh et al. 1984

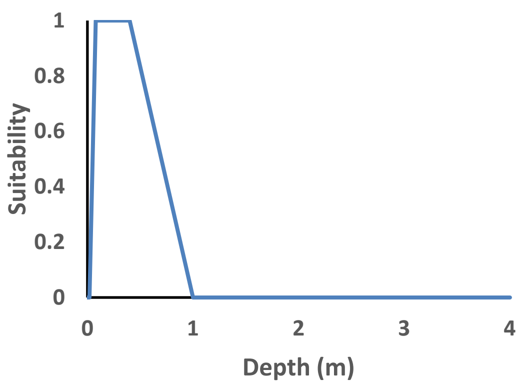
Figure 2-49 Rainbow Trout Juvenile Cover Suitability Index

The overall HSI for juvenile rainbow trout is calculated using the following formula for each individually mapped macrohabitat unit in the surveyed area:

$HSI_{JUVENILE\ RNTR} = \min\{SI_{DEPTH}, SI_{VELOCITY}, \mathrm{Max}(SI_{DOMINANT\_SUBSTRATE}, SI_{SUBDOMOMINANT\_SUBSTRATE}), SI_{COVER}\}$

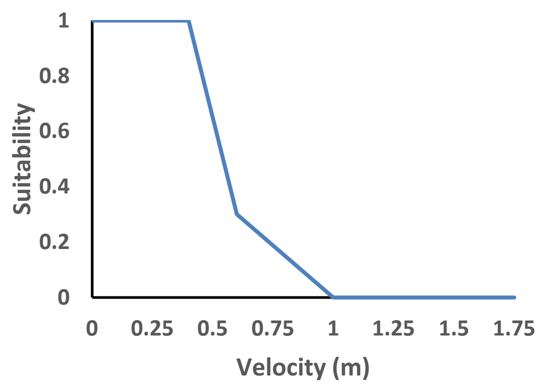
2.3.4.3 Fry

Suitability indices used to develop the HSI for rainbow trout fry are presented in Figure 2-50 to Figure 2-53. A suitability index for % cover was not available when the U.S. Fish and Wildlife Service rainbow trout HSI index was developed (Raleigh et al. 1984). However, fry electrofished in the Crowsnest River were mostly found in shallow littoral areas with good cover (Fernet et al. 1990) suggesting that cover is an important suitability factor to rainbow trout fry. As a result, the cover index for juvenile rainbow trout (Raleigh et al. 1984) is adopted for assessment of fry habitat suitability.



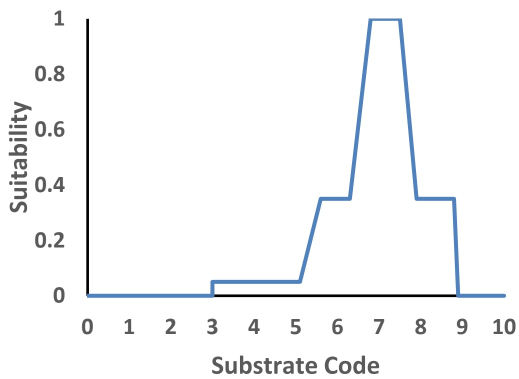
SOURCE: Addley et al. 2003

Figure 2-50 Rainbow Trout Fry Depth Suitability Index



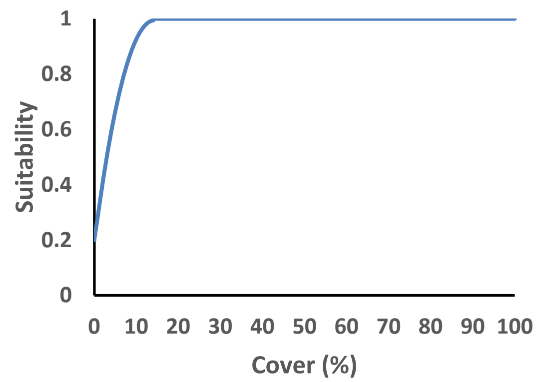
SOURCE: Addley et al. 2003

Figure 2-51 Rainbow Trout Fry Velocity Suitability Index



SOURCE: Fernet et al. 1990

Figure 2-52 Rainbow Trout Fry Substrate Suitability Index



SOURCE: Raleigh et al. 1984

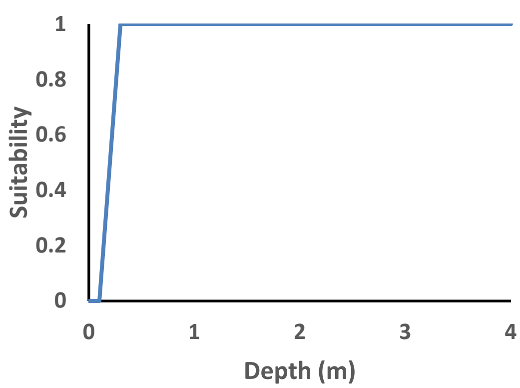
Figure 2-53 Rainbow Trout Fry Cover Suitability Index

The overall HSI for rainbow trout fry is calculated using the following formula for each individually mapped macrohabitat unit in the surveyed area:

$HSI_{FRY\ RNTR} = \min\{SI_{DEPTH}, SI_{VELOCITY}, Max(SI_{DOMINANT\_SUBSTRATE}, SI_{SUBDOMOMINANT\_SUBSTRATE}), SI_{COVER}\}$

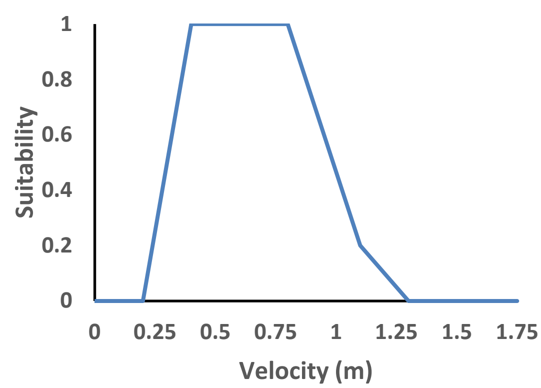
2.3.4.4 Spawning

Suitability indices used to develop the HSI for spawning rainbow trout are presented in Figure 2-54 to Figure 2-56. Cover (%) is not considered an important variable for spawning habitat suitability (Raleigh et al. 1984) and is, therefore, not included.



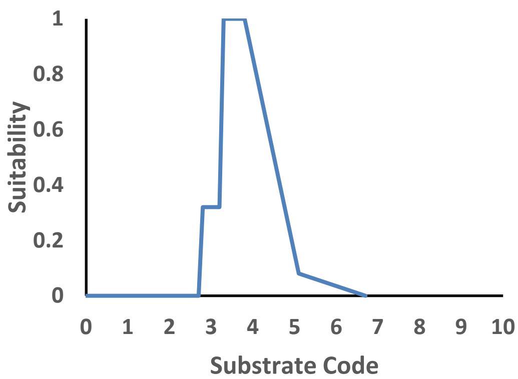
SOURCE: Addley et al. 2003

Figure 2-54 Rainbow Trout Spawning Depth Suitability Index



SOURCE: Addley et al. 2003

Figure 2-55 Rainbow Trout Spawning Velocity Suitability Index



SOURCE: Fernet et al. 1990

Figure 2-56 Rainbow Trout Spawning Substrate Suitability Index

The overall HSI for spawning rainbow trout is calculated using the following formula for each individually mapped macrohabitat unit in the surveyed area:

$HSI_{SPAWNING\ RNTR} = \min\{SI_{DEPTH}, SI_{VELOCITY}, \mathrm{Max}(SI_{DOMINANT\_SUBSTRATE}, SI_{SUBDOMOMINANT\_SUBSTRATE})\}$

3.0 RESULTS

3.1 HABITAT ASSESSMENT

3.1.1 Channel Types

A habitat mapbook displaying georeferenced channel types within the area surveyed in the fall of 2019 is provided in Attachment B. A total of 830 ha of surface water was mapped during the survey (Table 3-1).

Table 3-1 Surface Areas of Mapped Channel Types

Channel Type	Mapped Area (ha)
Main channel	603
Side channel	125
Active channels total	*728*
Connected	81
Disconnected	21
Inactive channels total	*102*
All Channels Total	**830**

3.1.2 Macrohabitat Composition and Distribution

A habitat mapbook displaying georeferenced macrohabitat units within the study area is provided in Attachment B. A total of 2,238 macrohabitat units were mapped during the survey. Summary information for mapped macrohabitat is further presented below for each of the four identified channel types surveyed (Table 3-2 to Table 3-5).

Table 3-2 Summary of Elbow River Macrohabitat Units for Active Main Channel Habitats

Level 1	Level 2	Level 3	Level 4	Total Number	Area (ha)	% of Total Area
High flow	Turbulent		Riffle	337	300.363	49.84
	Non-TURBULENT		Run	179	110.594	18.35
			Pocket WATER	26	15.428	2.56
			Fast glide	122	84.950	14.10
Medium flow	Pool	Mid-channel scouring	Mid-channel pool (undifferentiated)	8	2.944	0.49
			Mid-channel debris pool	8	0.430	0.07
			Channel confluence pool	20	3.092	0.51
			Plunge pool	5	0.649	0.11
		Lateral scouring	Lateral scour pool (undifferentiated)	21	4.937	0.82
			Log-enhanced lateral scour pool	112	15.664	2.60
			Root-wad enhanced lateral scour pool	40	4.055	0.67
			Bedrock-formed lateral scour pool	4	1.176	0.20
			Boulder-formed lateral scour pool	0	0.000	-
			Armoured bank lateral scour pool	13	2.384	0.40
		Backwater	Bedrock-formed backwater pool	2	0.076	0.01
			Boulder-formed backwater pool	3	0.331	0.05
			Root-wad formed backwater pool	11	0.658	0.11
			Log-formed backwater pool	19	1.280	0.21
			Armoured bank backwater pool	4	0.483	0.08
		Pools combined		270	38.159	6.33
	Slow glide			78	16.179	2.68
Low flow	Beaver Impoundment			0	-	-
	Edgewater			183	36.560	6.07
	Backwatered channel confluence			1	0.363	0.06
	Flat			0	-	-

Table 3-3 Summary of Elbow River Macrohabitat Units for Active Side Channel Habitats

Level 1	Level 2	Level 3	Level 4	Total Number	Area (ha)	% of Total Area
High flow	Turbulent		Riffle	200	44.851	35.81
	Non-turbulent		Run	68	14.234	11.36
			Pocket water	1	0.073	0.06
			Fast glide	5	1.253	1.00
Medium flow	Pool	Mid-channel scouring	Mid-channel pool (undifferentiated)	2	0.556	0.44
			Mid-channel debris pool	0	-	-
			Channel confluence pool	9	0.942	0.75
			Plunge pool	6	0.335	0.27
		Lateral scouring	Lateral scour pool (undifferentiated)	16	2.142	1.71
			Log-enhanced lateral scour pool	67	5.827	4.65
			Root-wad enhanced lateral scour pool	14	0.830	0.66
			Bedrock-formed lateral scour pool	0	-	-
			Boulder-formed lateral scour pool	0	-	-
			Armoured-bank lateral scour pool	1	0.178	0.14
		Backwater	Bedrock-formed backwater pool	0	-	-
			Boulder-formed backwater pool	1	0.014	0.01
			Root-wad formed backwater pool	2	0.008	0.01
			Log-formed backwater pool	6	0.188	0.15
			Armoured bank backwater pool	0	-	-
		Pools combined		124	11.020	8.80
	Slow glide			106	24.458	19.53
Low flow	Beaver Impoundment			1	9.307	7.43
	Edgewater			44	5.355	4.28
	Backwatered channel confluence			0	-	-
	Flat			54	14.696	35.81

NOTE:
Dashed lines indicate that the specific macrohabitat type was not identified within the channel type during the survey. This applies to all substrate tables in this TDR

Table 3-4 Summary of Elbow River Macrohabitat Units for Inactive Connected Habitats

Level 1	Level 2	Level 3	Level 4	Total Number	Area (ha)	% of Total Area
High flow	Turbulent		Riffle	47	6.331	7.87
	Non-Turbulent		Run	8	0.881	1.09
			Pocket water	0	-	-
			Fast glide	0	-	-
Medium flow	Pool	Mid-channel scouring	Mid-channel pool (undifferentiated)	3	0.734	0.91
			Mid-channel debris pool	0	-	-
			Channel confluence pool	9	2.666	3.31
			Plunge pool	0	-	-
		Lateral scouring	Lateral scour pool (undifferentiated)	6	1.054	1.31
			Log-enhanced lateral scour pool	18	3.083	3.83
			Root-wad enhanced lateral scour pool	0	-	-
			Bedrock-formed lateral scour pool	4	1.535	1.91
			Boulder-formed lateral scour pool	3	0.289	0.36
			Armoured bank lateral scour pool	4	1.034	1.29
		Backwater	Bedrock-formed backwater pool	0	-	-
			Boulder-formed backwater pool	0	-	-
			Root-wad formed backwater pool	0	-	-
			Log-formed backwater pool	0	-	-
			Armoured bank backwater pool	0	-	-
		Pools combined		47	10.395	12.92
	Slow glide			20	5.249	6.52
Low flow	Beaver Impoundment			3	1.991	2.47
	Edgewater			8	1.251	1.56
	Backwatered channel confluence			85	24.154	30.02
	Flat			115	30.202	37.54

Table 3-5 Summary of Elbow River Macrohabitat Units for Inactive Disconnected Habitats

Level 1	Level 2	Level 3	Level 4	Total Number	Area (ha)	% of Total Area
High flow	Turbulent		Riffle	23	2.224	10.51
	Non-turbulent		Run	0	-	-
			Pocket water	0	-	-
			Fast glide	0	-	-
Medium flow	Pool	Mid-channel scouring	Mid-channel pool (undifferentiated)	0	-	-
			Mid-channel debris pool	0	-	-
			Channel confluence pool	3	3.677	17.37
			Plunge pool	6	0.246	1.16
		Lateral scouring	Lateral scour pool (undifferentiated)	5	1.253	5.92
			Log-enhanced lateral scour pool	4	0.519	2.45
			Root-wad enhanced lateral scour pool	0	-	-
			Bedrock-formed lateral scour pool	0	-	-
			Boulder-formed lateral scour pool	0	-	-
			Armoured bank lateral scour pool	0	-	-
		Backwater	Bedrock-formed backwater pool	0	-	-
			Boulder-formed backwater pool	0	-	-
			Root-wad formed backwater pool	0	-	-
			Log-formed backwater pool	0	-	-
			Armoured bank backwater pool	0	-	-
		Pools combined		18	5.696	26.91
	Slow glide			6	0.478	2.26
Low flow	Beaver impoundment			0	-	-
	Edgewater			0	-	-
	Backwatered channel confluence			9	1.513	7.15
	Flat			50	11.254	53.17

3.1.3 Substrate Composition and Distribution

Substrate summary information for mapped macrohabitat is presented below for each of the four identified channel types surveyed (Table 3-6 to Table 3-9).

Table 3-6 Percentage of Dominant Substrates of Elbow River Macrohabitat Units for the Main Channel

Level 1	Level 2	Level 3	Level 4	OR %	FI %	SA %	SG %	LG %	CB %	SB %	LB %	BR %
High flow	Turbulent		Riffle				0.6	40.4	57.6	1.5		
	Non-turbulent		Run					43.0	55.9	1.1		
			Pocket water					11.5	46.2	23.1	19.2	
			Fast glide					87.7	12.3			
Medium flow	Pool	Mid-channel scouring	Mid-channel pool (undifferentiated)					37.5	62.5			
			Mid-channel debris pool				12.5	25.0	62.5			
			Channel confluence pool		30.0	5.0		30.0	35.0			
			Plunge pool				20.0	40.0	40.0			
		Lateral scouring	Lateral scour pool (undifferentiated)		14.3			61.9	23.8			
			Log-enhanced lateral scour pool		8.0		0.9	63.4	26.8		0.9	
			Root-wad enhanced lateral scour pool		2.5	2.5		72.5	22.5			
			Bedrock-formed lateral scour pool					50.0				50.0
			Boulder-formed lateral scour pool	-	-	-	-	-	-	-	-	-
			Armoured bank lateral scour pool		7.7		7.7	46.2	38.5			
		Backwater	Bedrock-formed backwater pool				50.0	50.0	0.0			
			Boulder-formed backwater pool					66.7	33.3			
			Root-wad formed backwater pool		9.1			63.6	27.3			
			Log-formed backwater pool		26.3		5.3	36.8	31.6			
			Armoured bank backwater pool					50.0	50.0			
	Slow glide				11.5		2.6	79.5	6.4			
Low flow	Beaver impoundment			-	-	-	-	-	-	-	-	-
	Edgewater				9.8		1.6	63.4	25.1			
	Backwatered channel confluence				100							
	Flat			-	-	-	-	-	-	-	-	-

Table 3-7 Percentage of Dominant Substrates of Elbow River Macrohabitat Units for Side Channels

Level 1	Level 2	Level 3	Level 4	OR %	FI %	SA %	SG %	LG %	CB %	SB %	LB %	BR %
High flow	Turbulent		Riffle				1.0	51.0	48.0			
	Non-turbulent		Run		10.3	1.5	1.5	45.6	39.7		1.5	
			Pocket water						100			
			Fast glide					80.0	20.0			
Medium flow	Pool	Mid-channel scouring	Mid-channel pool (undifferentiated)		50.0				50.0			
			Mid-channel debris pool	-	-	-	-	-	-	-	-	-
			Channel confluence pool		66.7			22.2	11.1			
			Plunge pool		33.3		16.7	33.3	16.7			
		Lateral scouring	Lateral scour pool (undifferentiated)		25.0		6.3	62.5	6.3			
			Log-enhanced lateral scour pool		26.9		3.0	44.8	25.4			
			Root-wad enhanced lateral scour pool		42.9			14.3	42.9			
			Bedrock-formed lateral scour pool	-	-	-	-	-	-	-	-	-
			Boulder-formed lateral scour pool	-	-	-	-	-	-	-	-	-
			Armoured bank lateral scour pool						100			
		Backwater	Bedrock-formed backwater pool	-	-	-	-	-	-	-	-	-
			Boulder-formed backwater pool					100				
			Root-wad formed backwater pool			50.0		50.0				
			Log-formed backwater pool		16.7			50.0	33.3			
			Armoured bank backwater pool						0.0			
	Slow glide				5.7		3.8	80.2	10.4			
Low flow	Beaver impoundment				100							
	Edgewater					6.8		2.3	63.6			
	Backwatered channel confluence			-	-	-	-	-	-	-	-	-
	Flat					63.0	1.9		25.9			

Table 3-8 Percentage of Dominant Substrates of Elbow River Macrohabitat Units for Inactive Connected Channels

Level 1	Level 2	Level 3	Level 4	OR %	FI %	SA %	SG %	LG %	CB %	SB %	LB %	BR %
High flow	Turbulent		Riffle				2.1	72.3	25.5			
	Non-turbulent		Run		37.5		12.5	50.0				
			Pocket water	-	-	-	-	-	-	-	-	-
			Fast glide	-	-	-	-	-	-	-	-	-
Medium flow	Pool	Mid-channel scouring	Mid-channel pool (undifferentiated)		33.3				66.7			
			Mid-channel debris pool									
			Channel confluence pool		88.9			11.1				
			Plunge pool	-	-	-	-	-	-	-	-	-
		Lateral scouring	Lateral scour pool (undifferentiated)		33.3			66.7				
			Log-enhanced lateral scour pool		55.6	5.6		33.3	5.6			
			Root-wad enhanced lateral scour pool	-	-	-	-	-	-	-	-	-
			Bedrock-formed lateral scour pool		75.0			25.0				
			Boulder-formed lateral scour pool		33.3			33.3			33.3	
			Armoured bank lateral scour pool		75.0				25.0			
		Backwater	Bedrock-formed backwater pool	-	-	-	-	-	-	-	-	-
			Boulder-formed backwater pool	-	-	-	-	-	-	-	-	-
			Root-wad formed backwater pool	-	-	-	-	-	-	-	-	-
			Log-formed backwater pool	-	-	-	-	-	-	-	-	-
			Armoured bank backwater pool	-	-	-	-	-	-	-	-	-
	Slow glide				5.0		5.0	90.0				
Low flow	Beaver impoundment				100							
	Edgewater							75.0	25.0			
	Backwatered channel confluence			1.2	74.1	2.4		21.2	1.2			
	Flat				47.0	2.6		37.4	13.0			

Table 3-9 Percentage of Dominant Substrates of Elbow River Macrohabitat Units for Inactive Disconnected Channels

Level 1	Level 2	Level 3	Level 4	OR %	FI %	SA %	SG %	LG %	CB %	SB %	LB %	BR %
High flow	Turbulent		Riffle					69.6	30.4			
	Non-turbulent		Run	-	-	-	-	-	-	-	-	-
			Pocket water	-	-	-	-	-	-	-	-	-
			Fast glide	-	-	-	-	-	-	-	-	-
Medium flow	Pool	Mid-channel scouring	Mid-channel pool (undifferentiated)	-	-	-	-	-	-	-	-	
			Mid-channel debris pool	-	-	-	-	-	-	-	-	
			Channel Confluence Pool		66.7		33.3					
			Plunge pool		16.7			66.7	16.7			
		Lateral scouring	Lateral scour pool (undifferentiated)		40.0			40.0	20.0			
			Log-enhanced lateral scour pool		50.0			50.0	0.0			
			Root-wad enhanced lateral scour pool	-	-	-	-	-	-	-	-	-
			Bedrock-formed lateral scour pool	-	-	-	-	-	-	-	-	-
			Boulder-formed lateral scour pool	-	-	-	-	-	-	-	-	-
			Armoured bank lateral scour pool	-	-	-	-	-	-	-	-	-
		Backwater	Bedrock-formed backwater pool	-	-	-	-	-	-	-	-	-
			Boulder-formed backwater pool	-	-	-	-	-	-	-	-	-
			Root-wad formed backwater pool	-	-	-	-	-	-	-	-	-
			Log-formed backwater pool	-	-	-	-	-	-	-	-	-
			Armoured bank backwater pool	-	-	-	-	-	-	-	-	-
	Slow glide							100				
Low flow	Beaver impoundment			-	-	-	-	-	-	-	-	-
	Edgewater			-	-	-	-	-	-	-	-	-
	Backwatered channel confluence				55.6			44.4				
	Flat				42.0			50.0	4.0	2.0		

3.1.4 Functional Fish Cover Composition and Distribution

Fish cover summary information for mapped macrohabitat is presented below for each of the four identified channel types surveyed, including the percentage of total cover associated with each macrohabitat type (Table 3-10 to Table 3-13) and the types of cover associated with each macrohabitat type (Table 3-14 to Table 3-17).

Table 3-10 Percent Occurrence of Cover Categories by Macrohabitat Type in the Main Channel of Elbow River

Level 1	Level 2	Level 3	Level 4	Percentage Category of Total Fish Cover							
				0%	1 to 4%	5 to 9%	10 to 19%	20 to 39%	40 to 59%	60 to 79%	80 to 100%
High flow	Turbulent		Riffle	64	19	8	5	3			
	Non-turbulent		Run	19	10	15	20	27	6	2	1
			Pocket water			8	23	46	12	8	4
			Fast glide	66	19	7	7	2			
Medium flow	Pool	Mid-channel scouring	Mid-channel pool (undifferentiated)					13		13	75
			Mid-channel debris pool				13	38	13	13	25
			Channel confluence pool		10	10	15	20	10	20	15
			Plunge pool							40	60
		Lateral scouring	Lateral scour pool (undifferentiated)				10	29	14	24	24
			Log-enhanced lateral scour pool			1		29	23	27	21
			Root-wad enhanced lateral scour pool			5	3	28	35	15	15
			Bedrock-formed lateral scour pool					50			50
			Boulder-formed lateral scour pool	-	-	-	-	-	-	-	-
			Armoured bank lateral scour pool	8		8		15		38	31
		Backwater	Bedrock-formed backwater pool	50				50			
			Boulder-formed backwater pool					67	33		
			Root-wad formed backwater pool					73	9	18	
			Log-formed backwater pool			5	26	21	16	21	11
			Armoured bank backwater pool				25	25			50
	Slow glide			55	3	19	12	9			3
Low flow	Beaver impoundment										
	Edgewater			71	3	9	8	5	2		2
	Backwatered channel confluence					100					
	Flat			-	-	-	-	-	-	-	-

Table 3-11 Percent Occurrence of Cover Categories by Macrohabitat Type in Active Side Channels of Elbow River

Level 1	Level 2	Level 3	Level 4	Percentage Category of Total Fish Cover							
				0%	1 to 4%	5 to 9%	10 to 19%	20 to 39%	40 to 59%	60 to 79%	80 to 100%
High flow	Turbulent		Riffle	64	13	11	8	5			
	Non-turbulent		Run	15	12	16	18	32	4	3	
			Pocket water					100			
			Fast glide	80	20						
Medium flow	Pool	Mid-channel scouring	Mid-channel pool (undifferentiated)		50						50
			Mid-channel debris pool	-	-	-	-	-	-	-	-
			Channel confluence pool	22			11	44		11	11
			Plunge pool					50	33	17	
		Lateral scouring	Lateral scour pool (undifferentiated)	6		13	31	25	13	6	6
			Log-enhanced lateral scour pool			3	6	28	25	19	18
			Root-wad enhanced lateral scour pool				7	36	21	14	21
			Bedrock-formed lateral scour pool	-	-	-	-	-	-	-	-
			Boulder-formed lateral scour pool	-	-	-	-	-	-	-	-
			Armoured bank lateral scour pool								100
		Backwater	Bedrock-formed backwater pool	-	-	-	-	-	-	-	-
			Boulder-formed backwater pool					100			
			Root-wad formed backwater pool	50				50			
			Log-formed backwater pool				17	50	33		
			Armoured bank backwater pool	-	-	-	-	-	-	-	-
	Slow glide			43	11	26	14	5			
Low flow	Beaver impoundment							100			
	Edgewater			77		11	2	7	2		
	Backwatered channel confluence			-	-	-	-	-	-	-	-
	Flat			52	9	13	7	17	2		

Table 3-12 Percent Occurrence of Cover Categories by Macrohabitat Type in Inactive Connected Channels of Elbow River

				Percentage Category of Total Fish Cover							
Level 1	**Level 2**	**Level 3**	**Level 4**	**0%**	**1 to 4%**	**5 to 9%**	**10 to 19%**	**20 to 39%**	**40 to 59%**	**60 to 79%**	**80 to 100%**
High flow	Turbulent		Riffle	79	9	2	6	2		2	
	Non-turbulent		Run	13		13		50	13	13	
			Pocket water	-	-	-	-	-	-	-	-
			Fast glide	-	-	-	-	-	-	-	-
Medium flow	Pool	Mid-channel scouring	Mid-channel pool (undifferentiated)	33			33	33			
			Mid-channel debris pool	-	-	-	-	-	-	-	-
			Channel confluence pool	22	11			22	33		11
			Plunge pool								
		Lateral scouring	Lateral scour pool (undifferentiated)	17		50		17	17		
			Log-enhanced lateral scour pool			6	17	44	11	11	11
			Root-wad enhanced lateral scour pool	-	-	-	-	-	-	-	-
			Bedrock-formed lateral scour pool	25			50	25			
			Boulder-formed lateral scour pool					67	33		
			Armoured bank lateral scour pool				25	50	25		
		Backwater	Bedrock-formed backwater pool	-	-	-	-	-	-	-	-
			Boulder-formed backwater pool	-	-	-	-	-	-	-	-
			Root-wad formed backwater pool	-	-	-	-	-	-	-	-
			Log-formed backwater pool	-	-	-	-	-	-	-	-
			Armoured bank backwater pool	-	-	-	-	-	-	-	-
	Slow glide			70	10	5	5	10			
Low flow	Beaver impoundment						100				
	Edgewater			75				25			
	Backwatered channel confluence			44	5	15	14	19	1	2	
	Flat			40	5	17	19	14	3	1	1

Table 3-13 Percent Occurrence of Cover Categories by Macrohabitat Type in Inactive Disconnected Channels of Elbow River

Level 1	Level 2	Level 3	Level 4	Percentage Category of Total Fish Cover							
				0%	1 to 4%	5 to 9%	10 to 19%	20 to 39%	40 to 59%	60 to 79%	80 to 100%
High flow	Turbulent		Riffle	91	4		4				
	Non-Turbulent		Run	-	-	-	-	-	-	-	-
			Pocket water	-	-	-	-	-	-	-	-
			Fast glide	-	-	-	-	-	-	-	-
Medium flow	Pool	Mid-channel scouring	-	-	-	-	-	-	-	-	
			Mid-channel debris pool	-	-	-	-	-	-	-	-
			Channel confluence pool					33	33		33
			Plunge pool				33	50	17		
		Lateral scouring	Lateral scour pool (undifferentiated)			40	20	40			
			Log-enhanced lateral scour pool					100			
			Root-wad enhanced lateral scour pool	-	-	-	-	-	-	-	-
			Bedrock-formed lateral scour pool	-	-	-	-	-	-	-	-
			Boulder-formed lateral scour pool	-	-	-	-	-	-	-	-
			Armoured bank lateral scour pool	-	-	-	-	-	-	-	-
		Backwater	Bedrock-formed backwater pool	-	-	-	-	-	-	-	-
			Boulder-formed backwater pool	-	-	-	-	-	-	-	-
			Root-wad formed backwater pool	-	-	-	-	-	-	-	-
			Log-formed backwater pool	-	-	-	-	-	-	-	-
			Armoured bank backwater pool	-	-	-	-	-	-	-	-
	Slow glide			50			17	33			
Low flow	Beaver impoundment			-	-	-	-	-	-	-	-
	Edgewater			-	-	-	-	-	-	-	-
	Backwatered channel confluence			56	11	11	11	11			
	Flat			30	10	12	24	16	4	4	

Table 3-14 Percentage of Dominant Cover Types of Elbow River Macrohabitat Units for the Main Channel.

Level 1	Level 2	Level 3	Level 4	Dominant Cover Type							
				BL	GF	IVG	IWD	OWD	TS	UC	VIS
High flow	Turbulent		Riffle	15	2		25	34	16	7	
	Non-turbulent		Run	8	1		25	17	19	21	9
			Pocket water	96							4
			Fast glide	7			17	32	32	12	
Medium flow	Pool	Mid-channel scouring	Mid-channel pool (undifferentiated)								100
			Mid-channel debris pool				25	38	13		25
			Channel confluence pool				5	15	15		65
			Plunge pool					20			80
		Lateral scouring	Lateral scour pool (undifferentiated)				10	5	5	19	62
			Log-enhanced lateral scour pool	2			29	29	5	3	31
			Root-wad enhanced lateral scour pool				28	20	3	13	38
			Bedrock-formed lateral scour pool								100
			Boulder-formed lateral scour pool	-	-	-	-	-	-	-	-
			Armoured bank lateral scour pool	25							75
		Backwater	Bedrock-formed backwater pool								100
			Boulder-formed backwater pool	67							33
			Root-wad formed backwater pool	9			27	18	18		27
			Log-formed backwater pool				47	37			16
			Armoured bank backwater pool	25							75
	Slow glide			3			20	26	43	9	
Low flow	Beaver impoundment			-	-	-	-	-	-	-	-
	Edgewater			2	2		21	68	4	4	
	Backwatered channel confluence						100				
	Flat			-	-	-	-	-	-	-	-

Table 3-15 Percentage of Dominant Cover Types of Elbow River Macrohabitat Units for Active Side Channels

Level 1	Level 2	Level 3	Level 4	Dominant Cover Type BL	GF	IVG	IWD	OWD	TS	UC	VIS
High flow	Turbulent		Riffle	4	11		10	42	1	1	22
	Non-turbulent		Run	3	3		22	22			26
			Pocket water	100							
			Fast glide								100
Medium flow	Pool	Mid-channel scouring	Mid-channel pool (undifferentiated)					50			
			Mid-channel debris pool	-	-	-	-	-	-	-	-
			Channel confluence pool				14	29			
			Plunge pool								33
		Lateral scouring	Lateral scour pool (undifferentiated)				7	7			47
			Log-enhanced lateral scour pool				36	45			9
			Root-wad enhanced lateral scour pool				14	29			14
			Bedrock-formed lateral scour pool	-	-	-	-	-	-	-	-
			Boulder-formed lateral scour pool	-	-	-	-	-	-	-	-
			Armoured bank lateral scour pool	-	-	-	-	-	-	-	-
		Backwater	Bedrock-formed backwater pool	-	-	-	-	-	-	-	-
			Boulder-formed backwater pool				100				
			Roo-wad formed backwater pool		100						
			Log-formed backwater pool				17	17			33
			Armoured bank backwater pool	-	-	-	-	-	-	-	-
	Slow glide			3	5	2	20	28			20
Low flow	Beaver impoundment										100
	Edgewater			20			10	60			10
	Backwatered channel confluence			-	-	-	-	-	-	-	-
	Flat				4	4	15	54			12

Table 3-16 Percentage of Dominant Cover Types of Elbow River Macrohabitat Units for Inactive Connected Channels

Level 1	Level 2	Level 3	Level 4	Dominant Cover Type							
				BL	GF	IVG	IWD	OWD	TS	UC	VIS
High flow	Turbulent		Riffle					50	50		
	Non-turbulent		Run	57			29	14			
			Pocket water	-	-	-	-	-	-	-	-
			Fast glide	-	-	-	-	-	-	-	-
Medium flow	Pool	Mid-channel scouring	Mid-channel pool (undifferentiated)				50	50			
			Mid-channel debris pool	-	-	-	-	-	-	-	-
			Channel confluence pool			43	14	14	14		14
			Plunge pool								
		Lateral scouring	Lateral scour pool (undifferentiated)			25	25		50		
			Log-enhanced lateral scour pool				17	72	11		
			Root-wad enhanced lateral scour pool	-	-	-	-	-	-	-	-
			Bedrock-formed lateral scour pool	67		33					
			Boulder-formed lateral scour pool	100							
			Armoured bank lateral scour pool	100							
		Backwater	Bedrock-formed backwater pool	-	-	-	-	-	-	-	-
			Boulder-formed backwater pool	-	-	-	-	-	-	-	-
			Root-wad formed backwater pool	-	-	-	-	-	-	-	-
			Log-formed backwater pool	-	-	-	-	-	-	-	-
			Armoured bank backwater pool	-	-	-	-	-	-	-	-
	Slow glide								83	17	
Low flow	Beaver impoundment			67		33					
	Edgewater							100			
	Backwatered channel confluence			8		15	8	50	17	2	
	Flat			4	1	9	16	48	20	1	

Table 3-17 Percentage of Dominant Cover Types of Elbow River Macrohabitat Units for Inactive Disconnected Channels

Level 1	Level 2	Level 3	Level 4	Dominant Cover Type							
				BL	GF	IVG	IWD	OWD	TS	UC	VIS
High flow	Turbulent		Riffle				50		50		
	Non-turbulent		Run	-	-	-	-	-	-	-	-
			Pocket water	-	-	-	-	-	-	-	-
			Fast glide	-	-	-	-	-	-	-	-
Medium flow	Pool	Mid-channel scouring	Mid-channel pool (undifferentiated)	-	-	-	-	-	-	-	-
			Mid-channel debris pool	-	-	-	-	-	-	-	-
			Channel confluence pool			67					33
			Plunge pool				17	17	50	17	
		Lateral scouring	Lateral scour pool (undifferentiated)					20	80		
			Log-enhanced lateral scour pool			25	50		25		
			Root-wad enhanced lateral scour pool	-	-	-	-	-	-	-	-
			Bedrock-formed lateral scour pool	-	-	-	-	-	-	-	-
			Boulder-formed lateral scour pool	-	-	-	-	-	-	-	-
			Armoured bank lateral scour pool	-	-	-	-	-	-	-	-
		Backwater	Bedrock-formed backwater pool	-	-	-	-	-	-	-	-
			Boulder-formed backwater pool	-	-	-	-	-	-	-	-
			Root-wad formed backwater pool	-	-	-	-	-	-	-	-
			Log-formed backwater pool	-	-	-	-	-	-	-	-
			Armoured bank backwater pool	-	-	-	-	-	-	-	-
	Slow glide				33			67			
Low flow	Beaver impoundment			-	-	-	-	-	-	-	-
	Edgewater			-	-	-	-	-	-	-	-
	Backwatered channel confluence							25	75		
	Flat			6	9	6		14	66		

A total of 2,537 pieces of large woody debris were counted during the survey. A summary of the amounts of large woody debris associated with each macrohabitat type is presented below for each channel type (Table 3-18 to Table 3-21).

Table 3-18 Summary of Large Woody Debris (LWD) Counts for Elbow River Main Channel

Level 1	Level 2	Level 3	Level 4	Large Woody Debris (LWD) Total (#)	LWD (#/ha)
High flow	Turbulent		Riffle	228	0.8
	Non-turbulent		Run	353	3.2
			Pocket water	18	1.2
			Fast glide	41	0.5
Medium flow	Pool	Mid-channel scouring	Mid-channel pool (undifferentiated)	5	1.7
			Mid-channel debris pool	21	48.8
			Channel confluence pool	25	8.1
			Plunge pool	7	10.8
		Lateral scouring	Lateral scour pool (undifferentiated)	22	4.5
			Log-enhanced lateral scour pool	464	29.6
			Root-wad enhanced lateral scour pool	80	19.7
			Bedrock-formed lateral scour pool	0	0.0
			Boulder-formed lateral scour pool	-	-
			Armoured bank lateral scour pool	21	8.8
		Backwater	Bedrock-formed backwater pool	0	0.0
			Boulder-formed backwater pool	0	0.0
			Root-wad formed backwater pool	9	13.7
			Log-formed backwater pool	53	41.4
			Armoured bank backwater pool	-	-
	Slow glide			28	1.7
Low flow	Beaver impoundment			-	-
	Edgewater			63	1.7
	Backwatered channel confluence			0	0.0
	Flat			-	-
			Total (all habitats combined)	**1438**	**2.4**

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Table 3-19 Summary of Large Woody Debris Counts for Elbow River Active Side Channels

Level 1	Level 2	Level 3	Level 4	LWD Total (#)	LWD (#/ha)
High flow	Turbulent		Riffle	151	3.4
	Non-turbulent		Run	112	7.9
			Pocket water	0	0.0
			Fast glide	2	1.6
Medium flow	Pool	Mid-channel scouring	Mid-channel pool (undifferentiated)	17	30.6
			Mid-channel debris pool	-	-
			Channel confluence pool	17	18.0
			Plunge pool	9	26.9
		Lateral scouring	Lateral scour pool (undifferentiated)	2	0.9
			Log-enhanced lateral scour pool	363	62.3
			Root-wad enhanced lateral scour pool	34	41.0
			Bedrock-formed lateral scour pool	-	-
			Boulder-formed lateral scour pool	-	-
			Armoured bank lateral scour pool	5	28.2
		Backwater	Bedrock-formed backwater pool	-	-
			Boulder-formed backwater pool	0	0.0
			Root-wad formed backwater pool	0	0.0
			Log-formed backwater pool	12	63.8
			Armoured bank backwater pool	-	-
	Slow glide			63	2.6
Low flow	Beaver impoundment			10	1.1
	Edgewater			4	0.7
	Backwatered channel confluence			-	-
	Flat			57	3.9
Total (all habitats combined)				**858**	**6.9**

Table 3-20 Summary of Large Woody Debris Counts for Elbow River Inactive Connected Channels

Level 1	Level 2	Level 3	Level 4	LWD Total (#)	LWD (#/ha)
High flow	Turbulent		Riffle	5	0.8
	Non-turbulent		Run	1	1.1
			Pocket water	-	-
			Fast glide	-	-
Medium flow	Pool	Mid-channel scouring	Mid-channel pool (undifferentiated)	1	1.4
			Mid-channel debris pool	-	-
			Channel confluence pool	2	0.8
			Plunge pool	-	-
		Lateral scouring	Lateral scour pool (undifferentiated)	0	0.0
			Log-enhanced lateral scour pool	47	15.2
			Root-wad enhanced lateral scour pool	-	-
			Bedrock-formed lateral scour pool	0	0.0
			Boulder-formed lateral scour pool	2	6.9
			Armoured-bank lateral scour pool	0	0.0
		Backwater	Bedrock-formed backwater pool	-	-
			Boulder-formed backwater pool	-	-
			Root-wad formed backwater pool	-	-
			Log-formed backwater pool	-	-
			Armoured bank backwater pool	-	-
	Slow glide			2	0.4
Low flow	Beaver impoundment			0	0.0
	Edgewater			3	2.4
	Backwatered channel confluence			50	2.1
	Flat			84	2.8
			Total (all habitats combined)	**197**	**2.4**

Table 3-21 Summary of Large Woody Debris Counts for Elbow River Disconnected Channels

Level 1	Level 2	Level 3	Level 4	LWD Total (#)	LWD (#/ha)
High flow	Turbulent		Riffle	0	0.0
	Non-turbulent		Run	-	-
			Pocket water	-	-
			Fast glide	-	-
Medium flow	Pool	Mid-Channel scouring	-	-	
			Mid-channel debris pool	-	-
			Channel confluence pool	1	0.3
			Plunge POOL	4	16.2
		Lateral scouring	Lateral scour pool (undifferentiated)	0	0.0
			Log-enhanced lateral scour pool	9	17.3
			Root-wad enhanced lateral scour pool	-	-
			Bedrock-formed lateral scour pool	-	-
			Boulder-formed lateral scour pool	-	-
			Armoured bank lateral scour pool	-	-
		Backwater	Bedrock-formed backwater pool	-	-
			Boulder-formed backwater pool	-	-
			Root-wad formed backwater pool	-	-
			Log-formed backwater pool	-	-
			Armoured bank backwater pool	-	-
	Slow glide			1	2.1
Low flow	Beaver impoundment			-	-
	Edgewater			-	-
	Backwatered channel confluence			1	0.7
	Flat			28	2.5
Total (all habitats combined)				**44**	**2.1**

3.1.5 River Bathymetry

A map book displaying the detailed bathymetry collected for the Elbow River main stem and side channels in the fall of 2019 is presented in Attachment C. A summary of bathymetry coverage for the surveyed area is summarized in Table 3-22.

Table 3-22 Surface Areas of Mapped Channel Types

Channel Type	Total Mapped Area (ha)	Total Bathymetry Area (ha)	Percent of Total Area with Bathymetry
Main channel	603	558	92%
Side channel	125	84.3	67%
Active channels total	*728*	*642.3*	*88%*
Connected	81	27.6	34%
Disconnected	21	3.6	17%
Inactive channels total	*102*	*31.2*	*31%*
All channels total	**830**	**673.5**	**81%**

Summary statistics of bathymetry for each channel type is presented in Table 3-23 and Table 3-24.

Table 3-23 Summary Statistics for Bathymetric Data by Channel Type

Channel Type		Average Depth (m)	Maximum Depth (m)
Active	Main channel	0.36	2.3
	Side channel	0.22	2.5
Inactive	Connected	0.17	1.5
	Disconnected	0.14	0.7

Bathymetry data is further summarized in relation to mapped macrohabitat unit types in Table 3-24 to Table 3-28.

Table 3-24 Summary of Depth Ranges and Associated Area Available to Fish Within each Channel Type at the Time of Survey

Depth Range (m)	Channel Type							
	Active				Inactive			
	Main		Side		Connected		Disconnected	
	Area (ha)	% of Total Area	Area (ha)	% of Total Area	Area (ha)	% of Total Area	Area (ha)	% of Total Area
0.00 - 0.25	171.14	30.67	53.60	63.61	20.43	74.12	2.83	79.07
0.25 - 0.50	229.61	41.15	22.84	27.11	5.25	19.06	0.72	20.28
0.50 - 0.75	123.43	22.12	5.50	6.52	1.50	5.46	0.02	0.65
0.75 - 1.00	25.22	4.52	1.55	1.85	0.29	1.06	-	-
1.00 - 1.50	7.87	1.41	0.65	0.77	0.08	0.29	-	-
1.50 - 2.00	0.61	0.11	0.10	0.12	-	-	-	-
2.00 - 2.53	0.06	0.01	0.02	0.02	-	-	-	-
Total	**557.95**	**100**	**84.26**	**100**	**27.56**	**100**	**3.57**	**100**

Table 3-25 Bathymetry Summary Statistics for Macrohabitat Units Mapped in the Elbow River Main Channel

Level 1	Level 2	Level 3	Level 4	Average Depth (m)	Standard Deviation (m)	Maximum Depth (m)
High flow	Turbulent		Riffle	0.32	0.18	1.53
	Non-turbulent		Run	0.47	0.24	1.82
			Pocket water	0.42	0.22	1.32
			Fast glide	0.36	0.19	2.04
Medium flow	Pool	Mid-channel scouring	Mid-channel pool (undifferentiated)	0.85	0.45	2.32
			Mid-channel debris pool	0.43	0.21	0.99
			Channel confluence pool	0.45	0.27	1.32
			Plunge pool	0.60	0.30	1.13
		Lateral scouring	Lateral scour pool (undifferentiated)	0.67	0.41	2.14
			Log-enhanced lateral scour pool	0.55	0.35	1.99
			Root-wad enhanced lateral scour pool	0.55	0.33	1.88
			Bedrock-formed lateral scour pool	0.67	0.36	1.70
			Boulder-formed lateral scour pool	-	-	-
			Armoured bank lateral scour pool	0.67	0.41	1.89
		Backwater	Bedrock-formed backwater pool	1.07	0.67	2.15
			Boulder-formed backwater pool	0.49	0.20	1.04
			Root-wad formed backwater pool	0.47	0.33	1.35
			Log-formed backwater pool	0.43	0.29	1.23
			Armoured bank backwater pool	0.59	0.34	1.17
	Slow glide			0.28	0.21	1.20
Low flow	Beaver impoundment			-	-	-
	Edgewater			0.15	0.14	1.69
	Backwatered channel confluence			0.12	0.11	0.49
	Flat			-	-	-

Table 3-26 Bathymetry Summary Statistics for Macrohabitat Units Mapped in Elbow River Active Side Channels

Level 1	Level 2	Level 3	Level 4	Average Depth (m)	Standard Deviation (m)	Maximum Depth (m)
High flow	Turbulent		Riffle	0.16	0.13	1.20
	Non-turbulent		Run	0.26	0.18	1.25
			Pocket water	0.11	0.09	0.28
			Fast glide	0.21	0.11	0.73
Medium flow	Pool	Mid-channel scouring	Mid-channel pool (undifferentiated)	0.59	0.37	1.40
			Mid-channel debris pool	-	-	-
			Channel confluence pool	0.32	0.28	1.06
			Plunge POOL	0.43	0.23	0.90
		Lateral scouring	Lateral scour pool (undifferentiated)	0.63	0.46	2.53
			Log-enhanced lateral scour pool	0.39	0.29	1.58
			Root-wad enhanced lateral scour pool	0.46	0.29	1.22
			Bedrock-formed lateral scour pool	-	-	-
			Boulder-formed lateral scour pool	-	-	-
			Armoured bank lateral scour pool	0.27	0.12	0.72
		Backwater	Bedrock-formed backwater pool	-	-	-
			Boulder-formed backwater pool	0.24	0.14	0.52
			Root-wad formed backwater pool	0.37	0.15	0.57
			Log-formed backwater pool	0.32	0.25	1.01
			Armoured bank backwater pool	-	-	-
	Slow glide			0.24	0.20	1.62
Low flow	Beaver impoundment			0.28	0.16	0.58
	Edgewater			0.10	0.10	0.79
	Backwatered channel confluence			-	-	-
	Flat			0.18	0.16	0.96

Table 3-27 Bathymetry Summary Statistics for Macrohabitat units Mapped in Elbow River Inactive Connected Channels

Level 1	Level 2	Level 3	Level 4	Average Depth (m)	Standard Deviation (m)	Maximum Depth (m)
High flow	Turbulent		Riffle	0.10	0.11	0.61
	Non-turbulent		Run	0.19	0.12	0.66
			Pocket water	-	-	-
			Fast glide	0.21	0.00	0.21
Medium flow	Pool	Mid-channel scouring	Mid-channel pool (undifferentiated)	0.28	0.16	0.70
			Mid-channel debris pool	-	-	-
			Channel confluence pool	0.21	0.24	1.27
			Plunge pool	-	-	-
		Lateral scouring	Lateral scour pool (undifferentiated)	0.42	0.20	0.81
			Log-enhanced lateral scour pool	0.30	0.27	1.47
			Root-wad enhanced lateral scour pool	-	-	-
			Bedrock-formed lateral scour pool	0.29	0.21	0.93
			Boulder-formed lateral scour pool	0.17	0.12	0.51
			Armoured bank lateral scour pool	0.06	0.08	0.59
		Backwater	Bedrock-formed backwater pool	-	-	-
			Boulder-formed backwater pool	-	-	-
			Root-wad formed backwater pool	-	-	-
			Log-formed backwater pool	-	-	-
			Armoured bank backwater pool	-	-	-
	Slow glide			0.11	0.12	1.07
Low flow	Beaver impoundment			-	-	-
	Edgewater			0.08	0.08	0.43
	Backwatered channel confluence			0.20	0.19	1.16
	Flat			0.17	0.17	0.98

Table 3-28 Bathymetry Summary Statistics for Macrohabitat Units Mapped in Elbow River Inactive Disconnected Channels

Level 1	Level 2	Level 3	Level 4	Average Depth (m)	Standard Deviation (m)	Maximum Depth (m)
High flow	Turbulent		Riffle	0.08	0.08	0.40
	Non-turbulent		Run	-	-	-
			Pocket water	-	-	-
			Fast glide	-	-	-
Medium flow	Pool	Mid-channel scouring	Mid-channel pool (undifferentiated)	-	-	-
			Mid-channel debris pool	-	-	-
			Channel confluence pool	0.11	0.08	0.34
			Plunge pool	0.06	0.09	0.48
		Lateral scouring	Lateral scour pool (undifferentiated)	-	-	-
			Log-enhanced lateral scour pool	0.24	0.14	-0.63
			Root-wad enhanced lateral scour pool	-	-	-
			Bedrock-formed lateral scour pool	-	-	-
			Boulder-formed lateral scour pool	-	-	-
			Armoured bank lateral scour pool	-	-	-
		Backwater	Bedrock-formed backwater pool	-	-	-
			Boulder-formed backwater pool	-	-	-
			Root-wad formed backwater pool	-	-	-
			Log-formed backwater pool	-	-	-
			Armoured bank backwater pool	-	-	-
	Slow glide			0.09	0.07	0.36
Low flow	Beaver impoundment			-	-	-
	Edgewater			-	-	-
	Backwatered channel confluence			0.15	0.12	0.57
	Flat			0.16	0.12	0.66

3.2 FISH DISTRIBUTION

3.2.1 Field Observations (Fall 2019)

A mapbook displaying fish observations made during the aquatic habitat assessment is presented in Attachment D. Observations of brook trout, brown trout, bull trout, and mountain whitefish were made during the survey. Fish observations are presented in groups based on rough visual estimates of fish size. The maximum estimated size of observed bull trout was 450 mm, brown trout was 550 mm, mountain whitefish was 250 mm, and brook trout was 200 mm. A summary of the number and associated size classes of fish encountered during the survey, along with associated macrohabitat units in which they were observed, is presented in Table 3-29 to Table 3-32.

Table 3-29 Summary of Fish Observations and Associated Macrohabitat Units in Main Channel Habitat

Habitat Type	Species and Size Class		
	Brown Trout	Mountain Whitefish	
	(>200 mm)	(>200 mm)	(<100 mm)
Riffle		1	
Run			1
Log-enhanced lateral scour pool	2		
Slow glide	1		1
Edgewater			15
TOTAL	**3**	**1**	**17**

Table 3-30 Summary of Fish Observations and Associated Macrohabitat Units Within Side Channel Habitat

Habitat Type	Species and Size Class						
	Brook Trout	Bull Trout		Brown Trout		Mountain Whitefish	
	(>100 mm)	(>200 mm)	(<200 mm)	(>200 mm)	(<200 mm)	(>200 mm)	(<100 mm)
Riffle						1	1
Run							1
Log-enhanced lateral scour pool		6	1	7	1	1	36
Lateral scour pool					1		
Slow glide	1						40
Edgewater							7
Flat	1						39
TOTAL	**2**	**6**	**1**	**7**	**2**	**2**	**124**

Table 3-31 Summary of Fish Observations and Associated Macrohabitat Units in Inactive Connected Channels

Habitat Type	Species and Size Class		
	Brook Trout	Brown Trout	Mountain Whitefish
	(>100 mm)	(>200 mm)	(<100 mm)
Bedrock-formed lateral scour pool	2		2
Lateral scour pool	1		
Log-enhanced lateral scour pool	1		1
Edgewater			1
Backwatered channel confluence		1	2
Flat	17	1	72
TOTAL	**21**	**2**	**78**

Table 3-32 Summary of Fish Observations and Associated Macrohabitat Units in Inactive Disconnected Channels

Habitat Type	Species and Size Class	
	Brook Trout	Mountain Whitefish
	(>100 mm)	(<100 mm)
Riffle		1
Plunge pool	3	
Flat	4	86
TOTAL	**7**	**87**

Example snapshots from underwater videos displaying fish species from each size class is presented in Photo 1 to Photo 7. Many of the adult brown trout were observed to be infected by *Saprolegnia* (water mould). A large male was identified less than 100 m upstream of an area where brown trout redds were constructed. The fish was lethargic and had extensive infection by *Saprolegnia* (Photo 8).

Photo 1 Photo of Brook Trout of the >100 mm Size Class

Photo 2 Photo of Bull Trout of the >200 mm Size Class

Photo 3 Photo of Bull Trout of the >200 mm Size Class

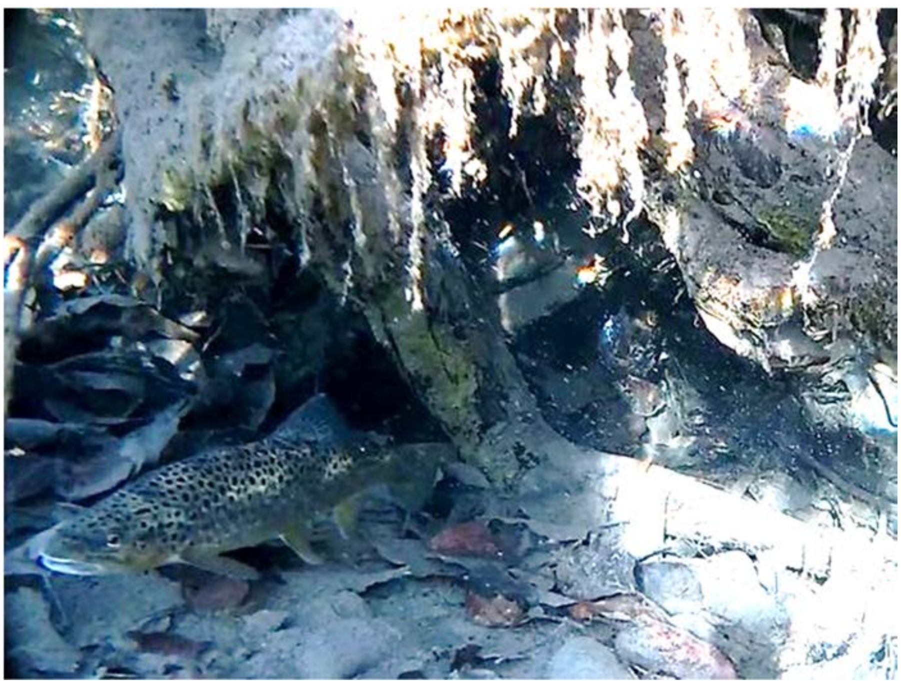

Photo 4 Photo of Brown Trout of the >200 mm Size Class

Photo 5 Photo of Brown Trout of the >200 mm Size Class

Photo 6 Photo of Mountain Whitefish of the >200 mm Size Class

Photo 7 Photo of Mountain Whitefish of the <100 mm (Age 0) Size Class

Photo 8 Large Male Brown Trout Observed in Backwatered Channel Confluence with Extensive *Saprolegnia* Infection (fish was lethargic at time of observation)

3.2.2 FWMIS Records Review

Collection dates for FWMIS records ranged from September 1978 to August 2015 for bull trout, brown trout, cutthroat trout, mountain whitefish, brook trout, rainbow trout, northern pike, and burbot. No records were identified for any other sport fish species within the geographic search area. Records are shown in relation to the Project area. FWMIS records for sampling events varied according to techniques, duration, and macrohabitat. Events were not equally distributed across BSPs (e.g., only a single sampling event was recorded during BSP-4) or geographically along the main stem of Elbow River.

Bull trout redds reported in the FWMIS records are also presented in the following section.

3.2.2.1 Bull Trout

Bull trout were reported during BSP-1, BSP-2 and BSP-3 but not in BSP 4 (Figure 3-1 to Figure 3-3). From April 2 to December 4, individual fish were observed from Elbow Falls to Glenmore Reservoir. In BSP-1 all observations occurred from just downstream of the Project area to Elbow Falls, with none near Glenmore Reservoir. In BSP-2, bull trout were observed from Elbow Falls to Glenmore Reservoir. In BSP-3, all observations occurred further upstream of the Project area.

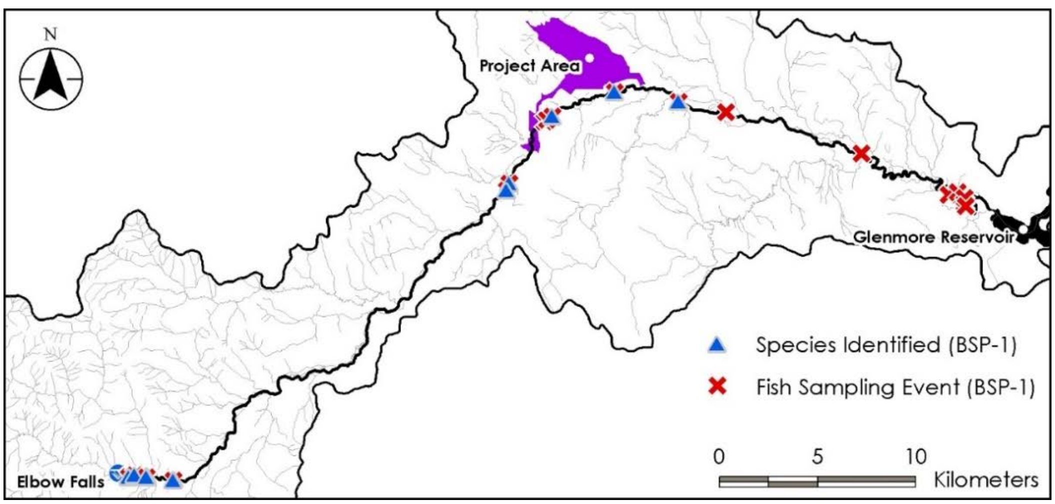

Figure 3-1 FWMIS Bull Trout Records for the BSP-1 Period (April 2 to June 15) in the Main Stem of Elbow River between Elbow Falls and Glenmore Reservoir

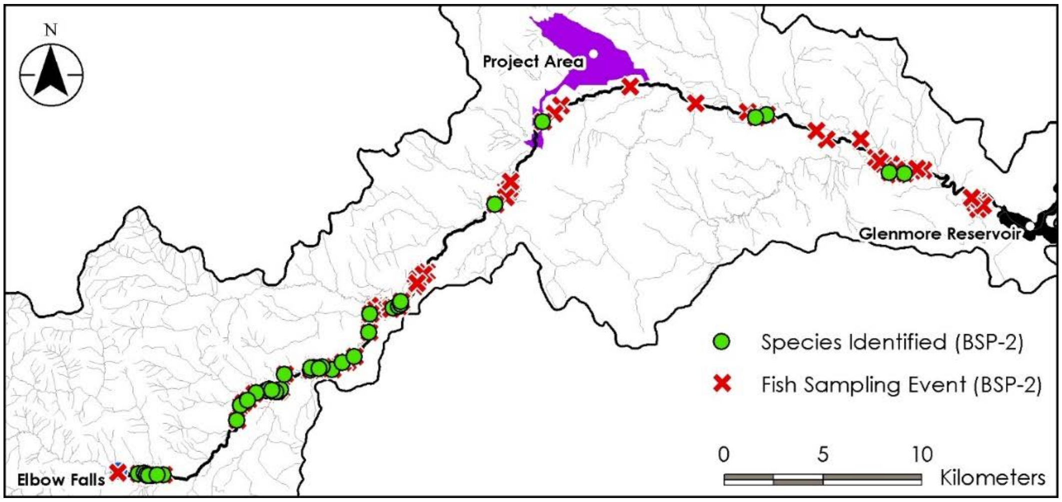

Figure 3-2 FWMIS Bull Trout Records for the BSP-2 Period (June 16 to September 25) in the Mainstem of Elbow River between Elbow Falls and Glenmore Reservoir

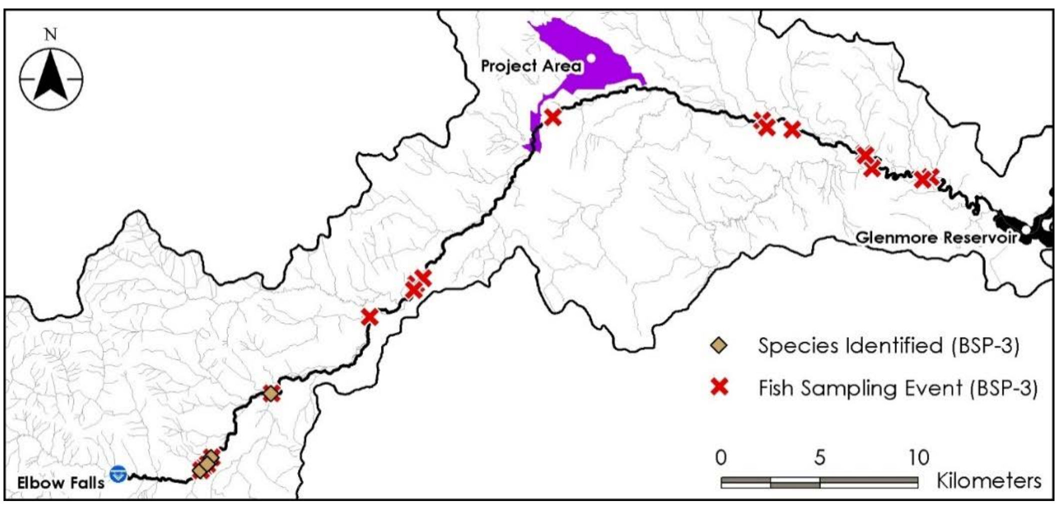

Figure 3-3 FWMIS Bull Trout Records for the BSP-3 Period (September 26 to December 1) in the Mainstem of Elbow River between Elbow Falls and Glenmore Reservoir

Records for a total of 166 bull trout redds were identified for the search area (Figure 3-4). Redds were identified between September of 1978 and August of 2015. Records of bull trout redds near and downstream of the Project area were identified in association with a single survey occurring on October 1, 2007. Records of bull trout redds were concentrated in the upstream extent of the search area, near Elbow Falls.

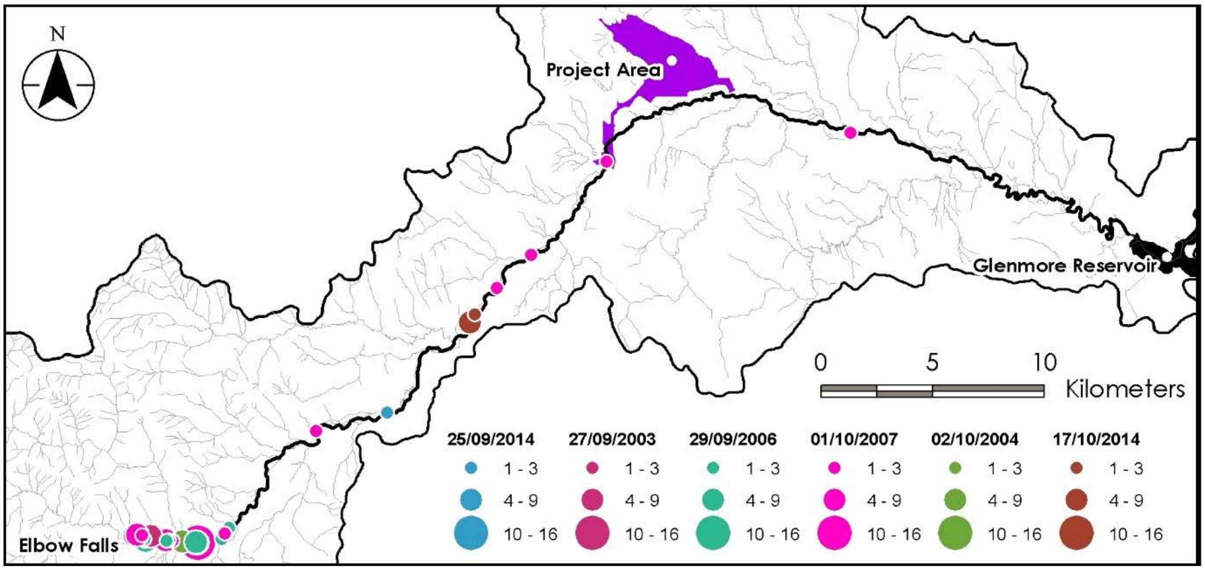

Figure 3-4 FWMIS Bull Trout Redd Records for the Mainstem of Elbow River between Elbow Falls and Glenmore Reservoir

3.2.2.2 Brown Trout

Brown trout were reported during BSP-1, BSP-2, BSP-3, and BSP-4 (Figure 3-5 to Figure 3-8). In BSP-1, brown trout were observed near the Project area and downstream to Glenmore Reservoir. In BSP-2 and BSP-3 they were observed throughout the main stem of Elbow River, from just downstream of Elbow Falls to Glenmore Reservoir. In BSP-4, brown trout were only observed in one location between the Project area and Glenmore Reservoir.

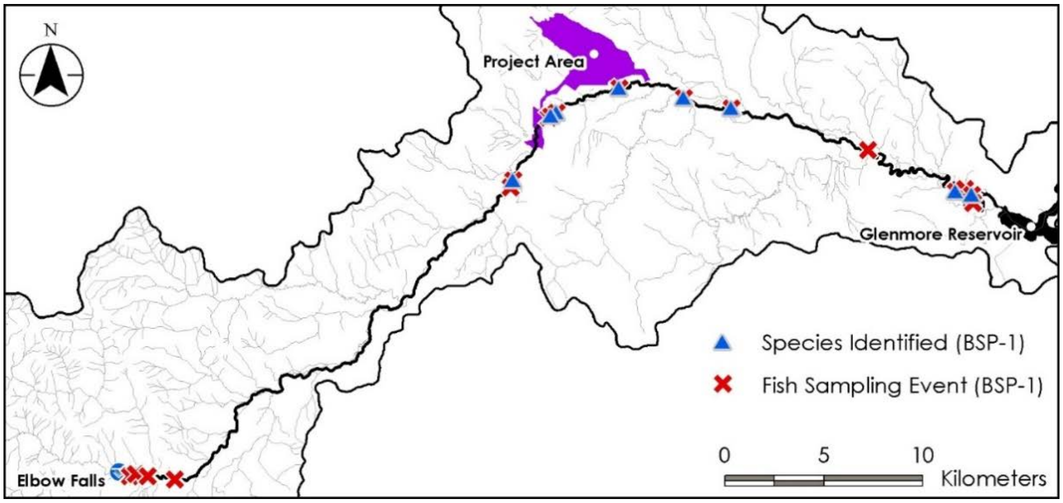

Figure 3-5 FWMIS Brown Trout Records for the BSP-1 Period (April 2 to June 15) in the Main Stem of Elbow River between Elbow Falls and Glenmore Reservoir

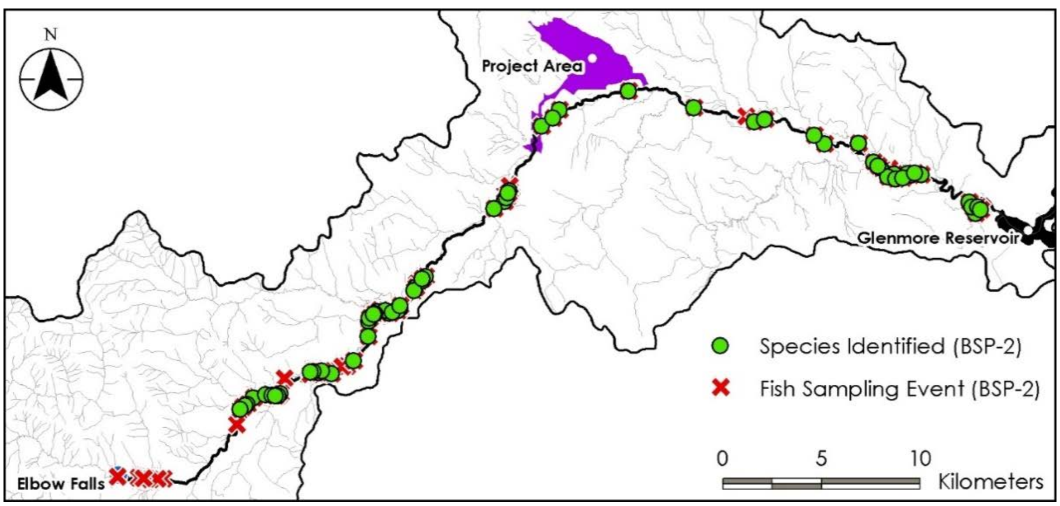

Figure 3-6 FWMIS Brown Trout Records for the BSP-2 Period (June 16 to September 25) in the Main Stem of Elbow River between Elbow Falls and Glenmore Reservoir

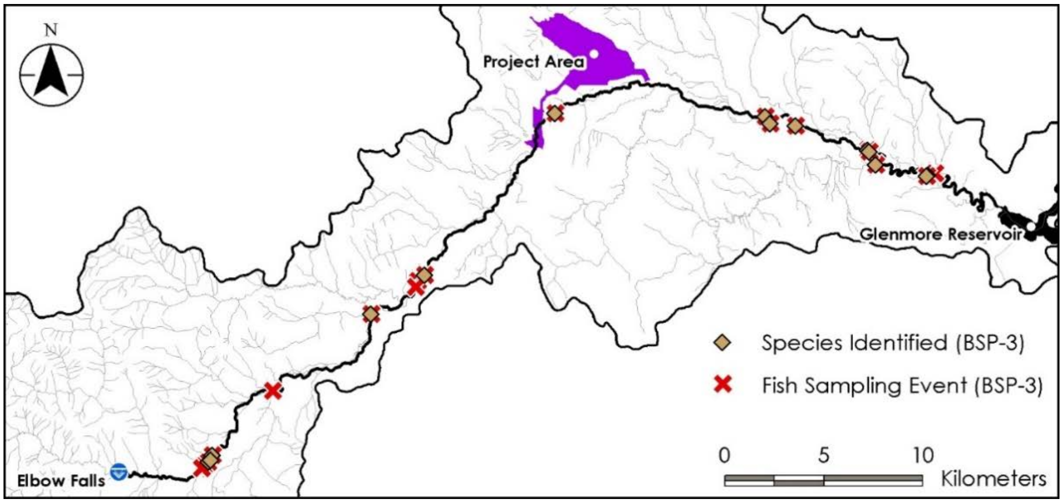

Figure 3-7 FWMIS Brown Trout Records for the BSP-3 Period (September 26 to December 1) in the Main Stem of Elbow River between Elbow Falls and Glenmore Reservoir

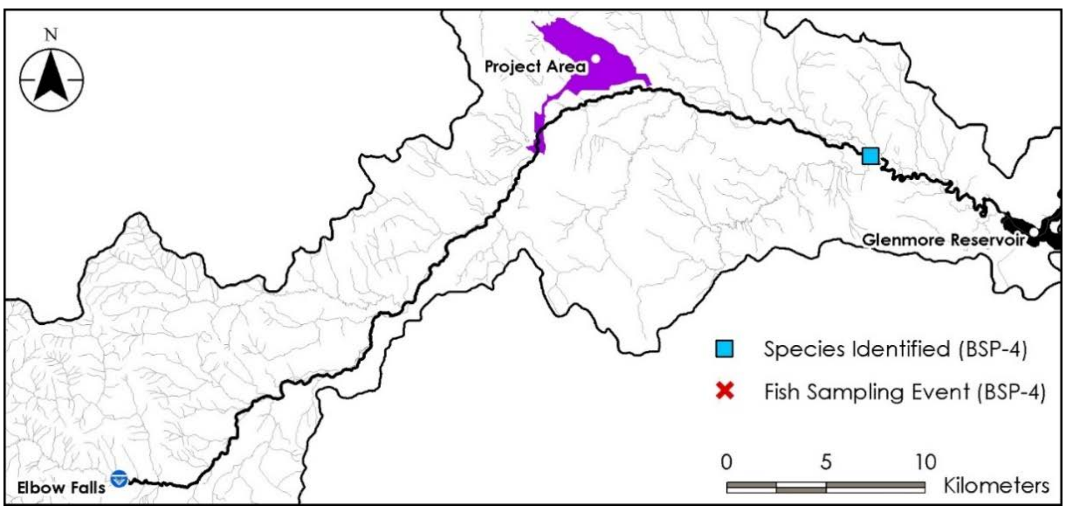

Figure 3-8 FWMIS Brown Trout Records for the BSP-4 Period (December 2 to April 1) in the Main Stem of Elbow River between Elbow Falls and Glenmore Reservoir

3.2.2.3 Cutthroat Trout

A single cutthroat trout record was identified in BSP-1 (Figure 3-9) upstream of the Glenmore Reservoir, and no cutthroat trout records were found in BSP-2, BSP-3 or BSP-4.

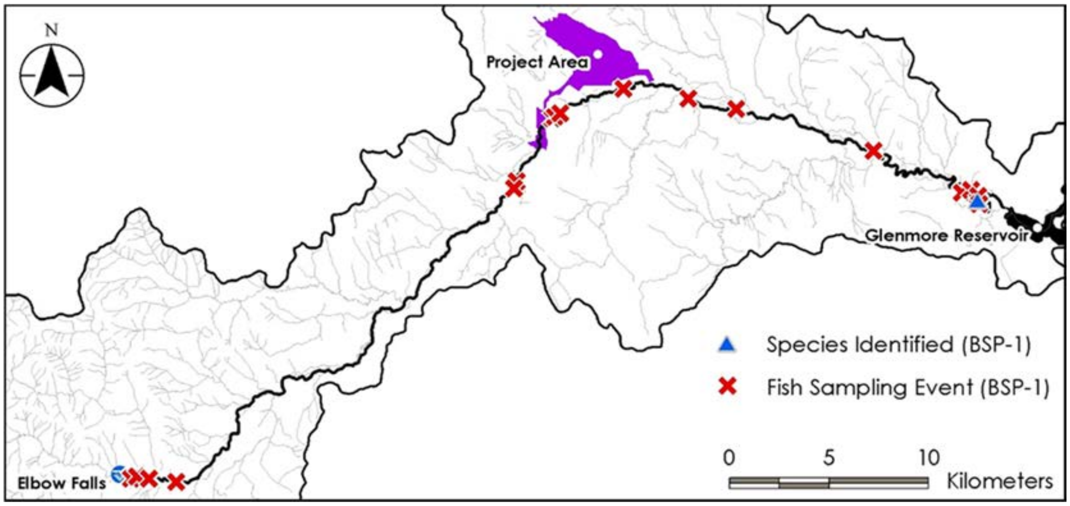

Figure 3-9 FWMIS Cutthroat Trout Records for the BSP-1 Period (April 2 to June 15) in the Main Stem of Elbow River between Elbow Falls and Glenmore Reservoir

3.2.2.4 Mountain Whitefish

Mountain whitefish were reported during BSP-1, BSP-2, and BSP-3 with no records in BSP-4 (Figure 3-10 to Figure 3-12). In BSP-1, mountain whitefish were observed from just upstream of the Project area to Glenmore Reservoir. In both BSP-2 and BSP-3 observations occurred between Elbow Falls and Glenmore Reservoir.

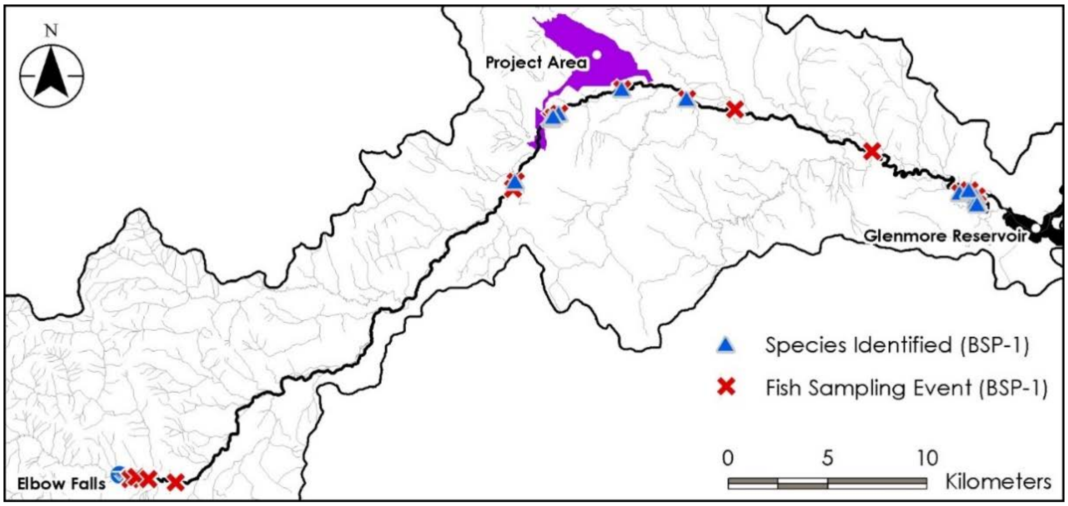

Figure 3-10 FWMIS Mountain Whitefish Records for the BSP-1 Period (April 2 to June 15) in the Main Stem of Elbow River between Elbow Falls and Glenmore Reservoir

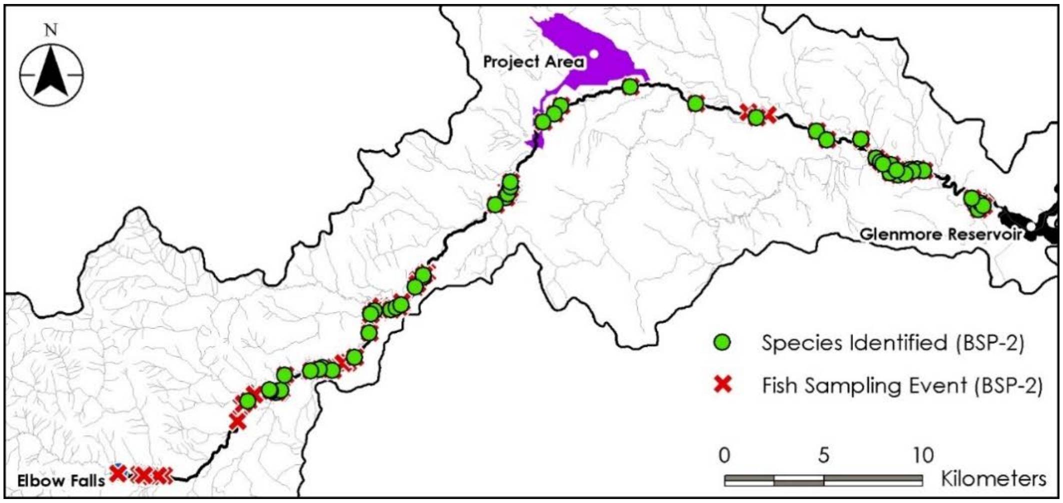

Figure 3-11 FWMIS Mountain Whitefish Records for the BSP-2 Period (June 16 to September 25) in the Main Stem of Elbow River between Elbow Falls and Glenmore Reservoir

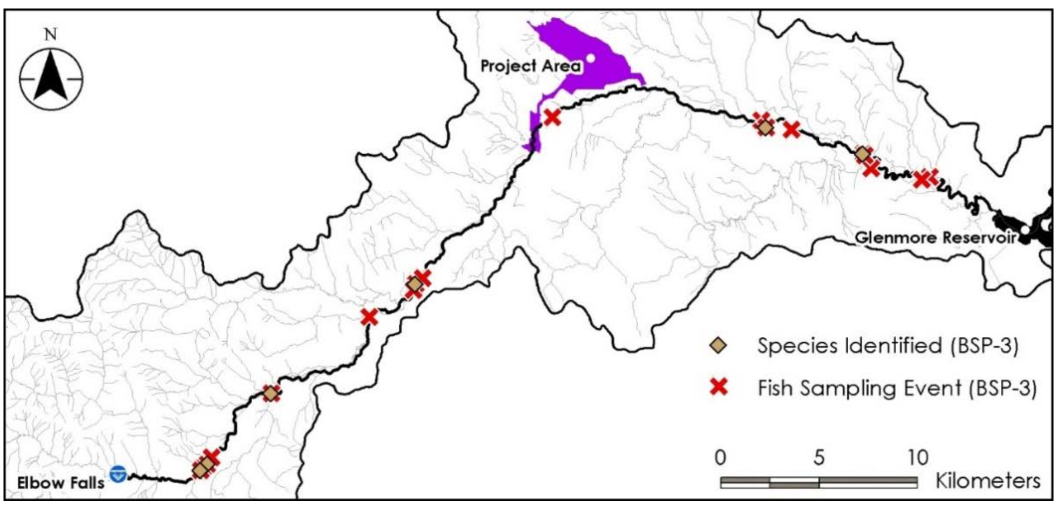

Figure 3-12 FWMIS Mountain Whitefish Records for the BSP-3 Period (September 26 to December 1) in the Main Stem of Elbow River between Elbow Falls and Glenmore Reservoir

3.2.2.5 Brook Trout

Brook trout were reported during BSP-1, BSP-2, BSP-3 but not in BSP-4 (Figure 3-13 to Figure 3-15). In BSP-1, observations occurred just upstream of the Project area down to Glenmore Reservoir. In both BSP-2 and BSP-3, brook trout were observated from Elbow Falls to Glenmore Reservoir.

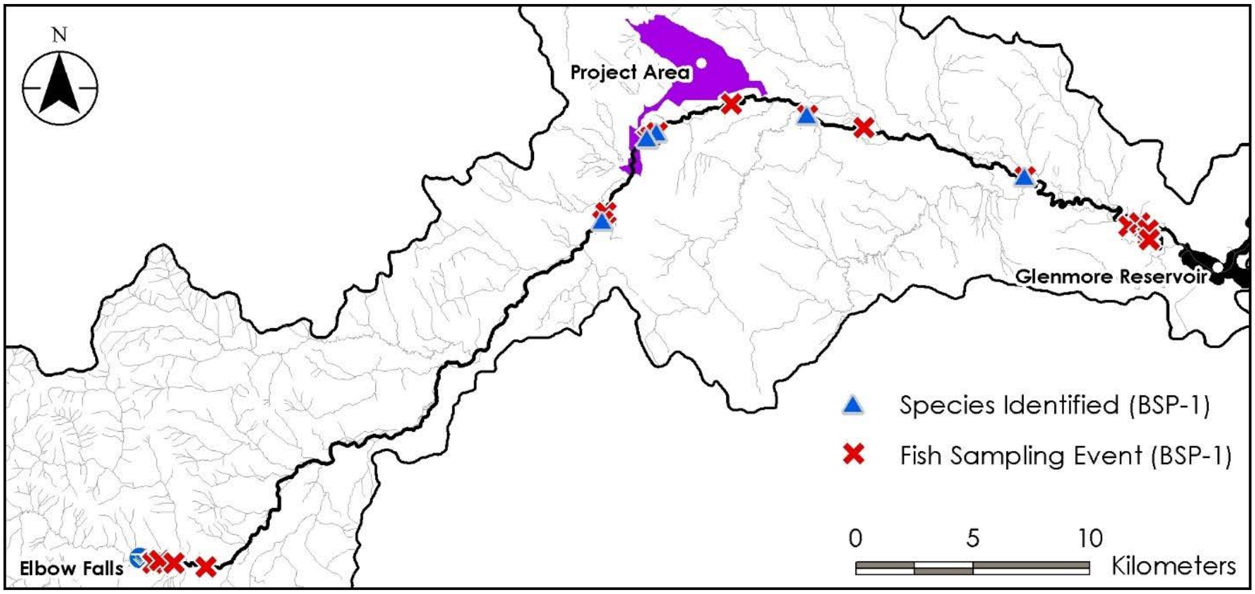

Figure 3-13 FWMIS Brook Trout Records for the BSP-1 Period (April 2 to June 15) in the Main Stem of Elbow River between Elbow Falls and Glenmore Reservoir

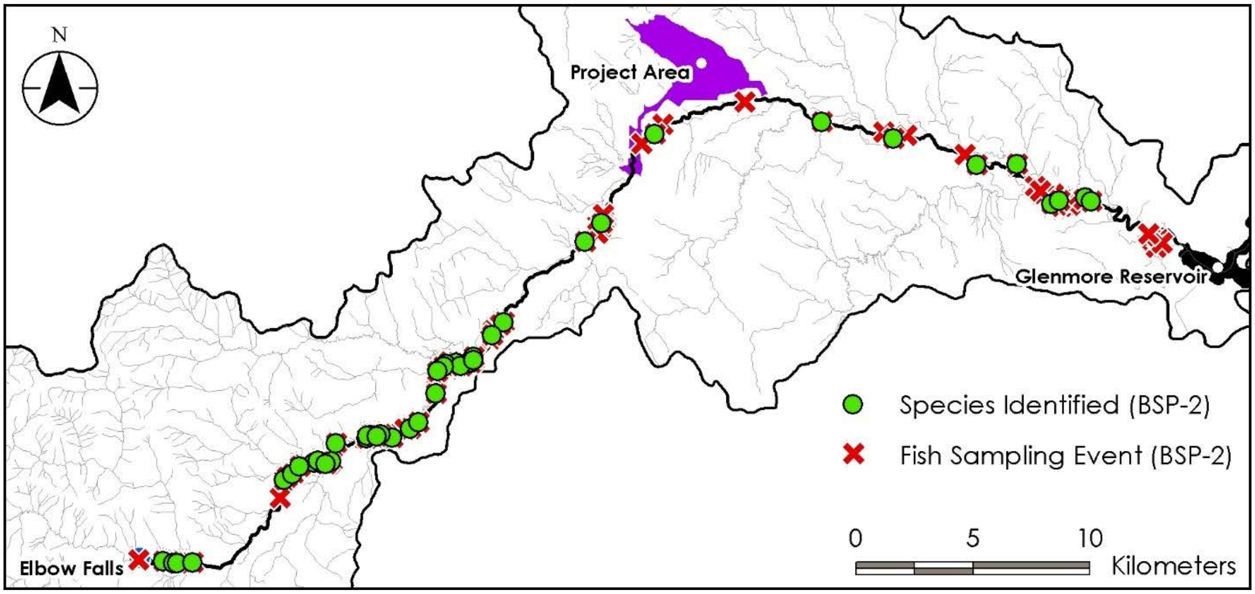

Figure 3-14 FWMIS Brook Trout Records for the BSP-2 Period (June 16 to September 25) in the Main Stem of Elbow River between Elbow Falls and Glenmore Reservoir

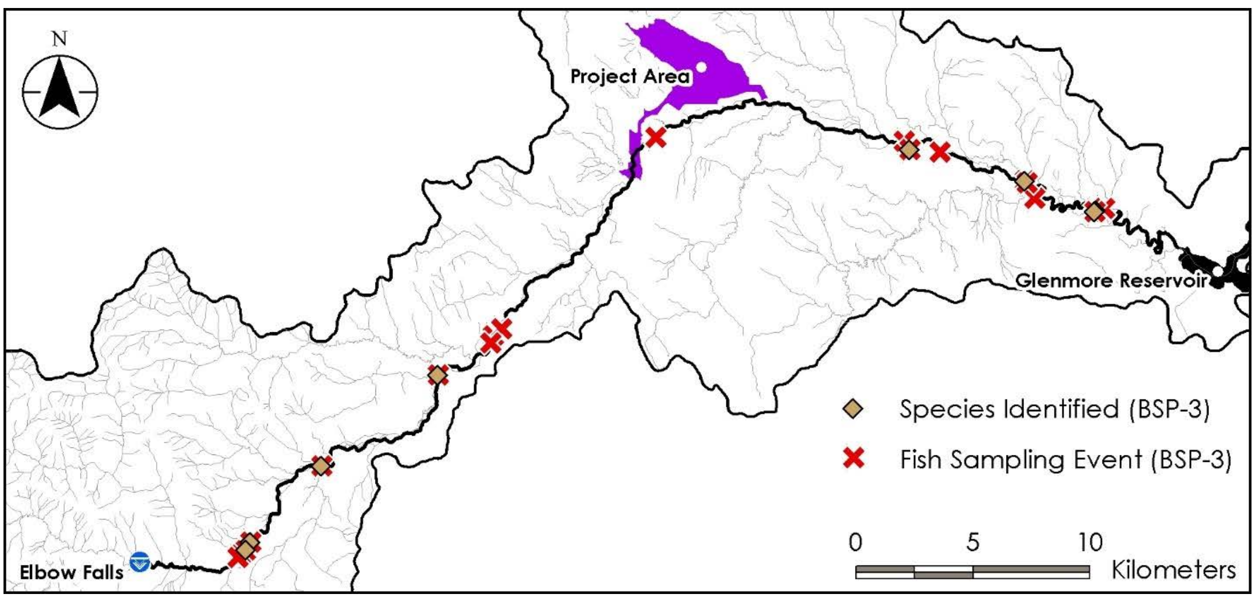

Figure 3-15 FWMIS Brook Trout Records for the BSP-3 Period (September 26 to December 1) in the Main Stem of Elbow River between Elbow Falls and Glenmore Reservoir

3.2.2.6 Rainbow Trout

Rainbow trout were reported during BSP-1, BSP-2, BSP-3 but not in BSP-4 (Figure 3-16 to Figure 3-18). In BSP-1, observations occurred just upstream of the Project area down to Glenmore Reservoir. In both BSP-2 and BSP-3, rainbow trout were observated from Elbow Falls to Glenmore Reservoir.

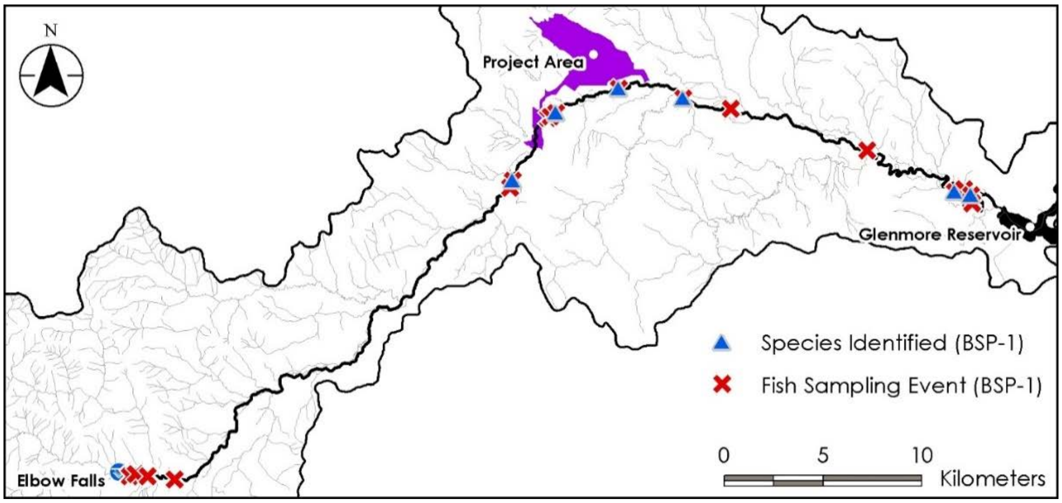

Figure 3-16 FWMIS Rainbow Trout Records for the BSP-1 Period (April 2 to June 15) in the Main Stem of Elbow River between Elbow Falls and Glenmore Reservoir

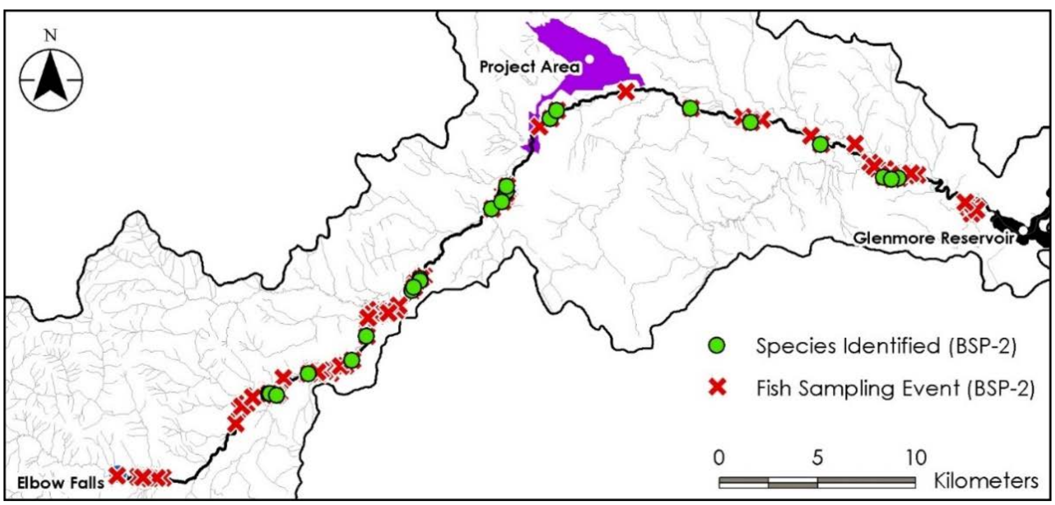

Figure 3-17 FWMIS Rainbow Trout Records for the BSP-2 Period (June 16 to September 25) in the Main Stem of Elbow River between Elbow Falls and Glenmore Reservoir

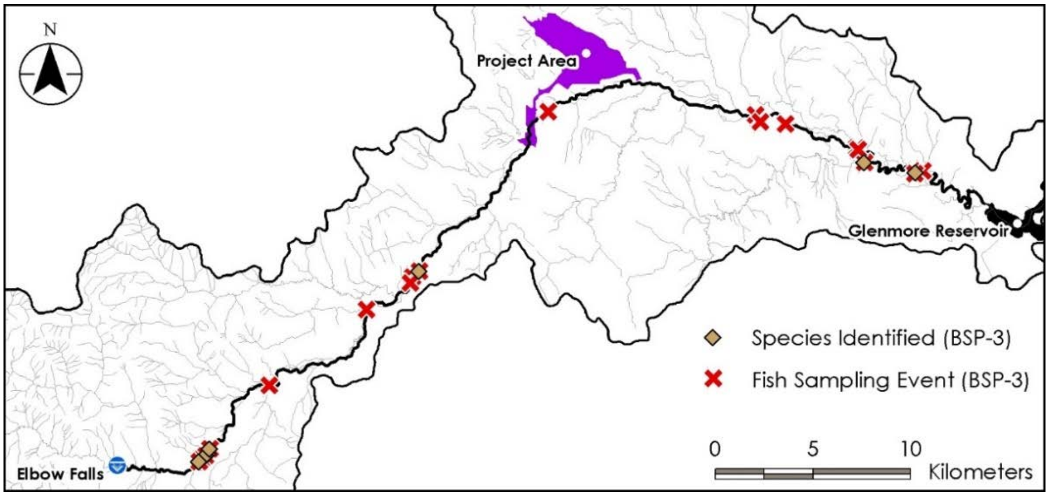

Figure 3-18 FWMIS Rainbow Trout Records for the BSP-3 Period (September 26 to December 1) in the Main Stem of Elbow River between Elbow Falls and Glenmore Reservoir

3.2.2.7 Northern Pike

A single record of northern pike was identified during the search (Figure 3-19). The fish was captured upstream of the Glenmore Reservoir in July 2002 (BSP-2).

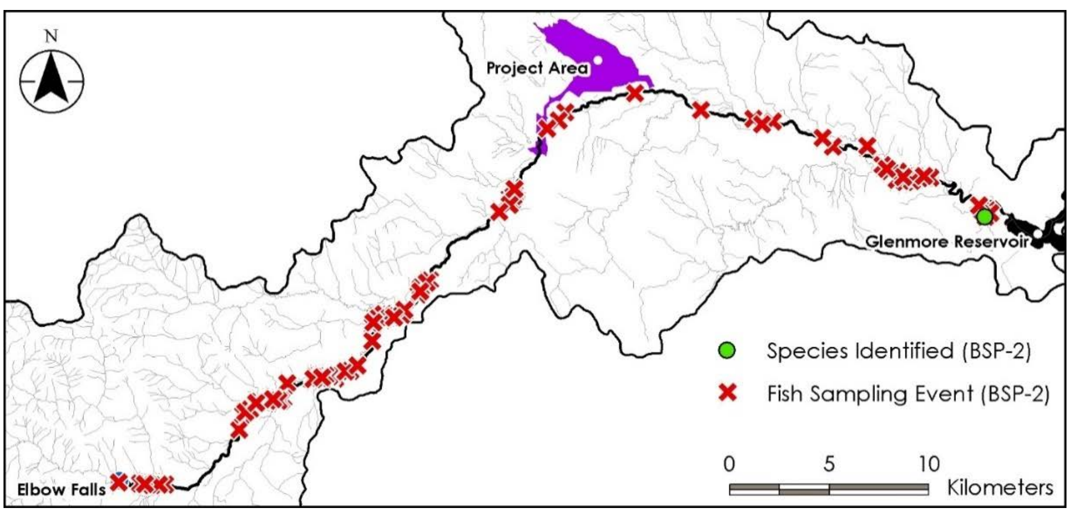

Figure 3-19 FWMIS Northern Pike Records for the BSP-2 Period (June 16 to September 25) in the Main Stem of Elbow River between Elbow Falls and Glenmore Reservoir

3.2.2.8 Burbot

Burbot were reported during BSP-1, BSP-2 and BSP-3 but not in BSP-4 (Figure 3-20 to Figure 3-22). In both BSP-1 and BSP-3, observations only occurred between the Project area and Glenmore Reservoir. In BSP-2, observations of burbot occurred from just upstream of the Project area down to Glenmore Reservoir.

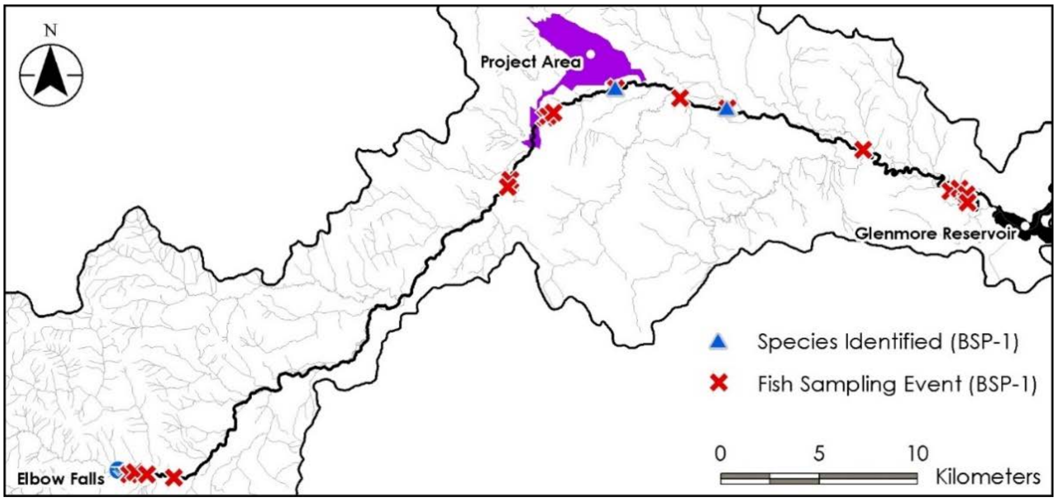

Figure 3-20 FWMIS Burbot Records for the BSP-1 Period (April 2 to June 15) in the Main Stem of Elbow River between Elbow Falls and Glenmore Reservoir

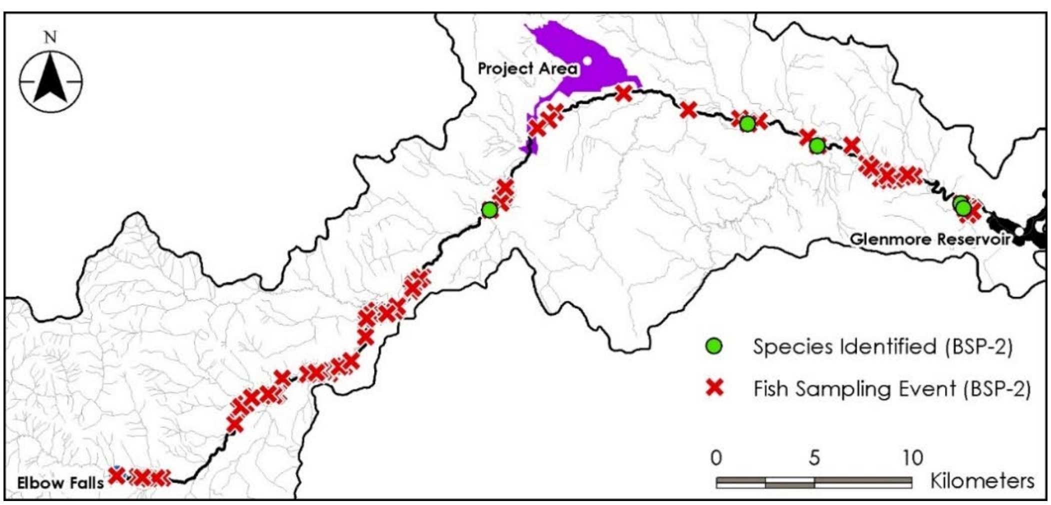

Figure 3-21 FWMIS Burbot Records for the BSP-2 Period (June 16 to September 25) in the Main Stem of Elbow River between Elbow Falls and Glenmore Reservoir

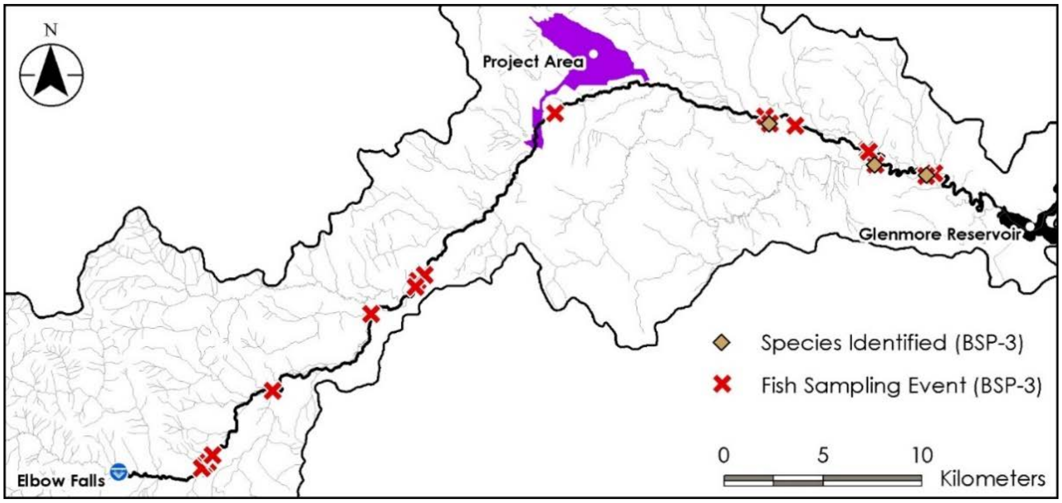

Figure 3-22 FWMIS Burbot Records for the BSP-3 Period (September 26 to December 1) in the Main Stem of Elbow River between Elbow Falls and Glenmore Reservoir

3.3 FISH HABITAT SUITABILITY

3.3.1 Brown Trout

3.3.1.1 Adult

A mapbook displaying $HSI_{ADULT\ BNTR}$ values for each mapped macrohabitat feature is provided in Attachment F. The HSI results are summarized in Table 3-33. The total surface area for each adult brown trout LHV is provided in Table 3-34.

Table 3-33 Summary of HSI Values and Surface Areas for Adult Brown Trout

HSI Value Range	Surface Area (ha)	% of Total Area
0.00	453.17	54.7
0.01-0.09	133.89	16.2
0.10-0.24	165.34	19.9
0.25-0.49	56.97	6.9
0.50-1.00	19.51	2.4

Table 3-34 Summary of LHV Areas for Adult Brown Trout

Habitat Variable	LHV Area (ha)	% of Total Area
Depth	194.37	23.5
Velocity	102.20	12.3
Substrate	40.62	4.9
Cover	560.49	67.6

The majority of surveyed habitat (54.7%) is not suitable (HSI=0) for adult brown trout. Only 2.4% of the total surveyed area has HSI values greater than 0.5 for adult brown trout.

Cover had the highest LHV area for adult brown trout. Most surveyed habitat contained little to no functional fish cover. Shallow depth had the second highest LHV area for adult brown trout. The average depth of main channel habitat is 0.36 m (Table 3-23) which is at the low end of the adult brown trout depth suitability index. High velocities are somewhat limiting (LHV area =12.3%) and substrates are rarely limiting (LHV area = 4.9%) because ideal substrates (i.e., gravels and cobbles) are available throughout the surveyed area.

3.3.1.2 Juvenile

A mapbook displaying $HSI_{JUVENILE\ BNTR}$ values for each mapped macrohabitat feature is provided in Attachment F. The HSI results are summarized in Table 3-35. The total surface area for each juvenile brown trout LHV is provided in Table 3-36.

Table 3-35 Summary of HSI Values and Surface Areas for Juvenile Brown Trout

HSI Value Range	Surface Area (ha)	% of Total Area
0.00	392.96	47.4
0.01-0.09	240.17	29.0
0.10-0.24	96.81	11.7
0.25-0.49	43.55	5.3
0.50-1.00	55.37	6.7

Table 3-36 Summary of LHV Areas for Juvenile Brown Trout

Habitat Variable	LHV Area (ha)	% of Total Area
Depth	78.98	9.5
Velocity	142.34	17.2
Substrate	63.48	7.7
Cover	535.05	64.6

Almost half of surveyed habitat is not suitable (HSI=0) for juvenile brown trout. Only 6.7% of the total surveyed area has HSI values greater than 0.5 for juvenile brown trout.

As with adult brown trout, cover had the highest LHV area. Most surveyed habitat contained little to no functional fish cover. High velocity, which has optimal suitability between 0.06 m/s and 0.4 m/s, had the second highest LHV area. Substrate and depth are generally not limiting factors for juvenile brown trout (limiting in less than 10% of total area).

3.3.1.3 Fry

A mapbook displaying $HSI_{FRY\ BNTR}$ values for each mapped macrohabitat feature is provided in Attachment F. The HSI results are summarized in Table 3-37.

The total surface area for each brown trout fry LHV is provided in Table 3-38.

Table 3-37 Summary of HSI Values and Surface Areas for Brown Trout Fry

HSI Value Range	Surface Area (ha)	% of Total Area
0.00	661.23	79.8
0.01-0.09	0.31	0.0
0.10-0.24	7.88	1.0
0.25-0.49	58.42	7.0
0.50-1.00	101.03	12.2

Table 3-38 Summary of LHV Areas for Brown Trout Fry

Habitat Variable	LHV Area (ha)	% of Total Area
Depth	8.66	1.0
Velocity	540.47	65.2
Substrate	318.58	38.4
Cover	42.52	5.1

Almost 80% of surveyed habitat is unsuitable (HSI=0) for brown trout fry. The variable with the highest LHV area is velocity (65.2%) because velocities above 1 m/s are considered unsuitable to brown trout fry. These velocities are common in active channel riffle and run habitats (Table 2-7) which area significant proportion of surveyed area (Table 3-2 and Table 3-3). Depth had a low LHV area (1.0%) because depths of less than 0.4 m are considered highly suitable to brown trout fry and habitat in the suitable depth range is available throughout the surveyed area (Table 3-24). Total % cover also had a low LHV area (5.1%) because areas devoid of cover are moderately suitable (HSI=0.5) to brown trout fry, since fry can use larger substrate materials for cover. Substrate had the second highest LHV area (38.4%) because of a lack of suitability to brown trout fry for substrate materials smaller than cobble, as well as the low suitability of small and large boulders.

A total of 12.2% of the surveyed area has HSI values of 0.5. No values greater than 0.5 are identified.

3.3.1.4 Spawning

A mapbook displaying $HSI_{SPAWNING\ BNTR}$ values for each mapped macrohabitat feature is provided in Attachment F. The HSI results are summarized Table 3-39. The total surface area for each brown trout spawning LHV is provided in Table 3-40.

Table 3-39 Summary of HSI Values and Surface Areas for Spawning Brown Trout

HSI Value Range	Surface Area (ha)	% of Total Area
0.00	472.86	57.0
0.01-0.09	4.09	0.5
0.10-0.24	258.12	31.1
0.25-0.49	61.43	7.4
0.50-1.00	32.17	3.9

Table 3-40 Summary of LHV Areas for Spawning Brown Trout

Habitat Variable	LHV Area (ha)	% of Total Area
Depth	42.52	5.13
Velocity	398.18	48.04
Substrate	433.89	52.4
Cover	142.08	17.1

The majority of surveyed habitat is considered not suitable (HSI=0) for brown trout spawning. Only 3.9% of the total surveyed area is determined to have HSI values greater than 0.5 for brown trout spawning.

Suitable depths for spawning are readily available throughout the surveyed area and depth had a low LHV Area. However, velocity and substrate had the highest LHV areas (approximately half of the surveyed area).

A defined velocity range of between 0.25 and 0.75 m/s is considered most suitable to spawning. Generally, active channel riffle and run habitat maintain velocities that are too fast (greater than 0.75 m/s) for brown trout spawning, except for microhabitat areas at run boundaries/shorelines. Contrastingly, main channel still water habitat (i.e., edgewater, backwatered channel confluence, or flat habitat) and most inactive channels do not maintain sufficient velocities to support brown trout spawning. Macrohabitat units displaying velocities in the suitable range are predominantly active channel glides (fast and slow) and pools as well as inactive channel riffles and runs.

Brown trout spawning substrate suitability is also a defined range requiring either small or large gravel substrates to provide habitat suitable for spawning. The absence of these substrate types as dominant or subdominant materials limits the suitability of habitat.

3.3.2 Bull Trout

3.3.2.1 Adult

A mapbook displaying $HSI_{ADULT\ BLTR}$ values for each mapped macrohabitat feature is provided in Attachment G. The HSI results are summarized in Table 3-41. The total surface area for each adult bull trout LHV is provided in Table 3-42.

Table 3-41 Summary of HSI Values and Surface Areas for Adult Bull Trout

HSI Value Range	Surface Area (ha)	% of Total Area
0.00	453.67	54.7
0.01-0.09	232.68	28.1
0.10-0.24	78.04	9.4
0.25-0.49	22.97	2.8
0.50-1.00	41.51	5.0

Table 3-42 Summary of LHV Areas for Adult Bull Trout

Habitat Variable	LHV Area (ha)	% of Total Area
Depth	225.06	8.7
Velocity	110.75	13.4
Cover	552.15	66.6

The majority of surveyed habitat (54.7%) is considered not suitable (HSI=0) for adult bull trout. Only 5.0% of the total surveyed area is determined to have HSI values greater than 0.5 for adult bull trout.

Like brown trout, cover had the highest LHV area. Most surveyed habitat contained little to no functional fish cover. Velocity and depth had markedly lower LHV areas compared with cover (13.4 and 8.7%, respectively), for adult bull trout.

3.3.2.2 Juvenile

A mapbook displaying $HSI_{JUVENILE\ BLTR}$ values for each mapped macrohabitat feature is provided in Attachment G. The HSI results are summarized in Table 3-43.

The total surface area for each juvenile bull trout LHV is provided in Table 3-44.

Table 3-43 Summary of HSI Values and Surface Areas for Juvenile Bull Trout

HSI Value Range	Surface Area (ha)	% of Total Area
0.00	220.65	26.6
0.01-0.09	8.86	1.1
0.10-0.24	138.54	16.7
0.25-0.49	329.05	39.7
0.50-1.00	131.77	15.9

Table 3-44 Summary of LHV Areas for Juvenile Bull Trout

Habitat Variable	LHV Area (ha)	% of Total Area
Depth	72.08	8.7
Velocity	437.25	52.8
Substrate	217.84	26.3
Cover	89.33	10.8

A total of 26.6% of surveyed habitat is considered not suitable (HSI=0) for juvenile bull trout. The majority of surveyed habitat (57.5%) had an HSI value in the range of 0.01 and 0.49. Only 15.9% of the total surveyed area is determined to have HSI values greater than 0.5 for juvenile bull trout.

Velocity in active channels is the most commonly limiting variable as velocity suitability decreases above 0.5 m/s and velocities above 1.4 m/s are unsuitable for juvenile bull trout. This corresponded to a high LHV area for velocity (52.8%). Substrate is the next highest LHV area (26.3%), primarily because substrates smaller than cobble are considered unsuitable for juvenile bull trout. Because juvenile bull trout commonly utilize cobble and large substrates as cover, low contributions of total % cover (less than 15%) are still considered suitable to juvenile bull trout. As a result, total % cover correspond to a low LHV area (10.8%). Depths between 0.2 and 0.9 m are highly suitable to juvenile bull trout and these depths occur in most of the surveyed area (Table 3-24). As a result, depth also has a low LHV area.

3.3.2.3 Fry

A mapbook displaying $HSI_{FRY\ BLTR}$ values for each mapped macrohabitat feature is provided in Attachment G. The HSI results are summarized in Table 3-45.

The total surface area for each bull trout fry LHV is provided in Table 3-46.

Table 3-45 Summary of HSI Values and Surface Areas for Bull Trout Fry

HSI Value Range	Surface Area (ha)	% of Total Area
0.00	661.23	79.8
0.01-0.09	0.31	0.0
0.10-0.24	7.88	1.0
0.25-0.49	3.36	0.4
0.50-1.00	156.09	18.8

Table 3-46 Summary of LHV Areas for Bull Trout Fry

Habitat Variable	LHV Area (ha)	% of Total Area
Depth	61.38	7.4
Velocity	485.15	58.5
Substrate	217.55	26.3

A total of 79.8% of surveyed habitat is considered not suitable (HSI=0) for bull trout fry. A total of 18.8% of the surveyed area is determined to have HSI values greater than 0.5 for bull trout fry.

Velocity corresponded to the highest LHV area (58.5%) because velocities of less than 0.6 m/s are highly suitable (HSI=1) whereas velocities greater than 1.2 m/s are not suitable (HSI=0), rendering all active channel riffle and run habitat as unsuitable based on velocities (Table 2-7). Substrate had the next highest LHV area (26.3%), primarily because substrates smaller than cobble are unsuitable for bull trout fry, and boulders are rated as low suitability (HSI=0.1). Depths between 0.08 and 0.4 m are highly suitable to bull trout fry and these depths occur in most of the surveyed area (Table 3-24). As a result, depth corresponded to a low LHV area 7.4%.

3.3.2.4 Spawning

A mapbook displaying $HSI_{SPAWNING\ BLTR}$ values for each mapped macrohabitat feature is provided in Attachment G. The HSI results are summarized in Table 3-47. The total surface area for each bull trout spawning LHV is provided in Table 3-48.

Table 3-47 Summary of HSI Values and Surface Areas for Spawning Bull Trout

HSI Value Range	Surface Area (ha)	% of Total Area
0.00	656.30	79.2
0.01-0.09	3.08	0.4
0.10-0.24	80.39	9.7
0.25-0.49	30.32	3.7
0.50-1.00	58.78	7.1

Table 3-48 Summary of LHV Areas for Spawning Bull Trout

Habitat Variable	LHV Area (ha)	% of Total Area
Depth	82.89	10.0
Velocity	683.58	82.5
Substrate	52.72	6.4
Cover	102.27	12.3

The majority of surveyed habitat (79.2%) is not suitable (HSI=0) for bull trout spawning. Only 7.1% of the total surveyed area have HSI values greater than 0.5 for bull trout spawning.

Suitable depths for bull trout spawning are readily available throughout the surveyed area, and depth corresponds to a low LHV area as a result (10.0%). However, velocity had a very high LHV area (82.5%) because ideal velocities (HSI=1) are associated with a small velocity range (between 0.4 and 0.6 m/s). Velocities less than 0.1 m/s or greater than 1.2 m/s are not suitable for spawning (HSI=0). Generally, active channel riffle and run habitat maintain velocities that are too fast (greater than 1.2 m/s) for bull trout spawning, except for microhabitat areas at run boundaries/shorelines. Main channel still water habitat (i.e., edgewater, backwatered channel confluence, or flat habitat) and most inactive channels do not maintain sufficient velocities to support bull trout spawning. Macrohabitat units displaying velocities in the suitable range are predominantly active channel glides (fast and slow), pools, and inactive channel riffles and runs.

Bull trout spawning substrate is highly suitable (HSI=1) where substrates contain small or large gravel and moderately suitable (HSI=0.5) where substrate consists of cobble. These substrate types are available throughout the survey area and, as a result, substrate corresponds to a low LHV area (6.4%).

3.3.3 Mountain Whitefish

3.3.3.1 Adult

A mapbook displaying $HSI_{ADULT\ MNWH}$ values for each mapped macrohabitat feature is provided in Attachment H. The HSI results are summarized in Table 3-49. The total surface area for each adult mountain whitefish LHV is provided in Table 3-50.

Table 3-49 Summary of HSI Values and Surface Areas for Adult Mountain Whitefish

HSI Value Range	Surface Area (ha)	% of Total Area
0.00	140.89	17.0
0.01-0.09	38.63	4.7
0.10-0.24	89.59	10.8
0.25-0.49	468.55	56.5
0.50-1.00	91.21	11.0

Table 3-50 Summary of LHV Areas for Adult Mountain Whitefish

Habitat Variable	LHV Area (ha)	% of Total Area
Depth	451.53	54.5
Velocity	374.26	45.2

Suitable habitat for adult mountain whitefish is available throughout the surveyed area. Only 17.0% of the l surveyed area is not suitable (HSI=0). The majority of surveyed habitat (72%) is associated with an HSI value between 0.01 and 0.49. Only 11.0% of the surveyed area has HSI values greater than 0.5.

Adult mountain whitefish habitat has similar LHV areas for depth (54.5%) and velocity (45.2%). Depths above 0.55 m are highly suitable (HSI=1) to adult mountain whitefish. Depths less than 0.25 m are associated with a low index value, and they are distributed throughout the surveyed area (Table 3-24). Velocities above 0.4 m/s and below 1 m/s are most suitable to mountain whitefish (e.g., fast glide habitat). Velocities below 0.2 m/s and above 1.2 m/s are associated with the lowest suitability values. Therefore, high velocities associated with active channel riffle and run habitat, as well as low velocities associated with still water habitats or most inactive channel areas, are associated with low HSI values for adult mountain whitefish.

3.3.3.2 Juvenile

A mapbook displaying $HSI_{JUVENILE\ MNWH}$ values for each mapped macrohabitat feature is provided in Attachment H. The HSI results are summarized in Table 3-51. The total surface area for each juvenile mountain whitefish LHV is provided in Table 3-52.

Table 3-51 Summary of HSI Values and Surface Areas for Juvenile Mountain Whitefish

HSI Value Range	Surface Area (ha)	% of Total Area
0.00	53.71	6.5
0.01-0.09	38.78	4.7
0.10-0.24	85.10	10.3
0.25-0.49	153.26	18.5
0.50-1.00	498.03	60.0

Table 3-52 Summary of LHV Areas for Juvenile Mountain Whitefish

Habitat Variable	LHV Area (ha)	% of Total Area
Depth	483.32	58.3
Velocity	220.82	26.6
Substrate	84.2	10.2

Suitable habitat for juvenile mountain whitefish is available throughout the surveyed area. The majority of surveyed habitat (60%) is associated with an HSI value greater than 0.5. A total of 33.5% of the surveyed area has HSI values between 0.01 and 0.49, and only 6.5% of the surveyed area is not suitable (HSI=0).

Juvenile mountain whitefish associate with a wide range of velocities and, as a result, velocity is less commonly limiting (26.6%) when compared to adult whitefish habitat. In contrast, depth is the primary limiting factor because shallow depths (less than 0.35 m) are available throughout the surveyed area, and they correspond to HSI values less than 0.5. Large gravel and cobble substrates are most common throughout the surveyed area (Table 3-6 to Table 3-9), and they correspond with the highest HSI values of all substrate categories for juvenile mountain whitefish. As a result, substrate is a limiting habitat variable in 10.2% of the surveyed area.

3.3.3.3 Fry

A mapbook displaying $HSI_{FRY\ MNWH}$ values for each mapped macrohabitat feature is provided in Attachment H. The HSI results are summarized in Table 3-53. The total surface area for each mountain whitefish fry LHV is provided in Table 3-54.

Table 3-53 Summary of HSI Values and Surface Areas for Mountain Whitefish Fry

HSI Value Range	Surface Area (ha)	% of Total Area
0.00	181.43	21.9
0.01-0.09	346.36	41.8
0.10-0.24	23.92	2.9
0.25-0.49	59.22	7.1
0.50-1.00	217.94	26.3

Table 3-54 Summary of LHV Areas for Mountain Whitefish Fry

Habitat Variable	LHV Area (ha)	% of Total Area
Depth	167.23	20.2
Velocity	485.15	58.5
Substrate	63.92	7.7

The majority of surveyed habitat has HSI values for mountain whitefish fry of 0 (21.9%) or 0.01-0.09 (41.8%). Only 10% of surveyed habitat has HSI values of 0.10-0.49, and 26.3% of surveyed habitat has HSI values greater than 0.5.

Velocity is the most commonly limiting habitat variable (58.5%). Habitat is considered highly suitable (HSI=1) for fry at velocities below 0.7 m/s. Suitability steadily declines at velocities above 0.7 m/s; velocities of 1.25 m/s are unsuitable. Macrohabitats associated with velocities above 0.7 m/s are exclusively active channel riffle and run habitat, which account for 485.15 ha (58.5%) of the surveyed area. Depth is the second most common limiting habitat variable for mountain whitefish fry. The most suitable depth range (HSI=0) for mountain whitefish fry is between 0.3 m and 1.15 m. The majority of the surveyed area contained depths in the most suitable range (Table 3-24). However, depths less than 0.3 m are also common, and they account for most areas where depth is a limiting habitat variable.

Large gravel is the most suitable substrate type for mountain whitefish fry, and larger substrates (e.g., cobble, boulder) are associated with an index value of 0.5. Since most habitat in the surveyed area contains either large gravel or cobble (Table 3-6 to Table 3-9), substrate is not a commonly limiting habitat variable for mountain whitefish fry (7.7%).

3.3.3.4 Spawning

A mapbook displaying $HSI_{SPAWNING\ MNWH}$ values for each mapped macrohabitat feature is provided in Attachment H. The HSI results are summarized in Table 3-55. The surface area for each mountain whitefish spawning LHV is provided in Table 3-56.

Table 3-55 Summary of HSI Values and Surface Areas for Spawning Mountain Whitefish

HSI Value Range	Surface Area (ha)	% of Total Area
0.00	235.32	28.4
0.01-0.09	24.85	3.0
0.10-0.24	52.95	6.4
0.25-0.49	158.18	19.1
0.50-1.00	357.56	43.2

Table 3-56 Summary of LHV Areas for Spawning Mountain Whitefish

Habitat Variable	LHV Area (ha)	% of Total Area
Depth	523.91	63.21
Velocity	305.29	36.8
Substrate	94.7	11.4

The availability of mountain whitefish spawning habitat is greater than that for redd-spawning fish species. A total of 28.4% of the surveyed area is unsuitable for spawning by mountain whitefish (HSI=0). A total of 28.5% of the surveyed area has an HSI value ranging between 0.01 and 0.49. A total of 43.2% of the surveyed area has an HSI value greater than 0.5.

Depths of greater than 0.5 m are most suitable for mountain whitefish spawning (HSI=1). However, depths less than 0.5 m account for the majority of the surveyed area (Table 3-24) and, as a result, depth has the highest LHV area (63.21%) for the mountain whitefish spawning index. The second highest LHV area is associated with velocity (36.8%). Velocities ranging between 0.4 m/s and 1.1 m/s are most suitable (HSI=1) for mountain whitefish spawning, and they are mostly associated with fast glides, riffles, and runs in active channel areas. Low velocities unsuitable for spawning (less than 0.15 m/s; HSI=0) are associated with still water areas in active channels and most inactive channel areas, except for riffle and run habitat. These areas comprise most of the survey area where velocity is a limiting habitat variable. Mountain whitefish can spawn on a wide range of substrates, from small gravel to boulder, but the suitability index for substrate is highest (HSI=1) for cobble, the most common substrate type found in the survey area (Table 3-6 to Table 3-9). As a result, substrate has a low LHV area (11.4%) compared to depth and velocity.

3.3.4 Rainbow Trout

3.3.4.1 Adult

A mapbook displaying $HSI_{ADULT\ RNTR}$ values for each mapped macrohabitat feature is provided in Attachment I. The HSI results are summarized in Table 3-57. The total surface area for each adult rainbow trout LHV is provided in Table 3-58.

Table 3-57 Summary of HSI Values and Surface Areas for Adult Rainbow Trout

HSI Value Range	Surface Area (ha)	% of Total Area
0.00	171.83	20.7
0.01-0.09	66.68	8.0
0.10-0.24	425.69	51.4
0.25-0.49	124.50	15.0
0.50-1.00	40.18	4.8

Table 3-58 Summary of LHV Areas for Adult Rainbow Trout

Habitat Variable	LHV Area (ha)	% of Total Area
Depth	327.74	39.5
Velocity	165.13	19.9
Substrate	68.98	8.32
Cover	267.54	32.3

Only 20.7% of the surveyed area is not suitable (HSI=0) to adult rainbow trout. The majority of surveyed habitat (74.4%) is associated with an HSI value between 0.01 and 0.49. Only 4.8% of the surveyed area has HSI values greater than 0.5 for adult rainbow trout.

Depth has the highest LHV area (39.5%) for adult rainbow trout. Depths greater than 1 m are highly suitable (HSI=1) to adult rainbow trout, whereas depths between 0.15 m and 1 m produce a linear range of index values between 0 and 1. Most habitat in the surveyed area is relatively shallow, with depths in the 0.15 m to 1.0 m range (Table 3-24). Cover has the second highest LHV area (32.3%) for adult rainbow trout habitat suitability because most surveyed habitat contained little to no functional fish cover. Velocity corresponds with an LHV area of 19.9% of the surveyed area. Ideal velocities for adult rainbow trout (HSI=1) are in the range of 0.1 m/s to 0.8 m/s. As a result, low HSI values for velocity are predominately associated with fast flowing units such as active channel riffle and run habitat.

3.3.4.2 Juvenile

A mapbook displaying $HSI_{JUVENILE\ RNTR}$ values for each mapped macrohabitat feature is provided in Attachment I. The HSI results are summarized in Table 3-59. The total surface area for each juvenile rainbow trout LHV is provided in Table 3-60.

Table 3-59 Summary of HSI Values and Surface Areas for Juvenile Rainbow Trout

HSI Value Range	Surface Area (ha)	% of Total Area
0.00	121.32	14.6
0.01-0.09	126.75	15.3
0.10-0.24	305.35	36.8
0.25-0.49	231.37	27.9
0.50-1.00	44.07	5.3

Table 3-60 Summary of LHV Areas for Juvenile Rainbow Trout

Habitat Variable	LHV Area (ha)	% of Total Area
Depth	126.46	15.3
Velocity	139.20	16.8
Substrate	227.26	27.4
Cover	336.13	40.6

A total of 14.6% of surveyed habitat is not suitable (HSI=0) for juvenile rainbow trout. The majority of surveyed habitat (80.0%) has an HSI value in the range of 0.01 to 0.49. Only 5.3% of the surveyed area has HSI values greater than 0.5 for juvenile rainbow trout.

Cover has the highest LHV area for juvenile rainbow trout (40.6%) because most surveyed habitat contained little to no functional fish cover. Substrate has the second highest LHV area (40.6%) because habitat containing boulders is most suitable. Small and large boulders are relatively uncommon throughout the surveyed area compared to gravel and cobble substrates (Table 3-6 to Table 3-9).

Velocity and depth have similarly low LHV areas (16.8% and 15.3%, respectively). Velocities above 1.55 m/s are unsuitable to rainbow trout, and they are representative of velocities associated with active channel riffles and runs in the study area (1.2 m/s and 1.35 m/s respectively, Table 2-7) correspondto velocity suitability values of 0.4 and 0.25, respectively, which are limiting. Depths between 0.45 m and 1.35 m are highly suitable to juvenile rainbow trout (HSI=1). However, depth suitability values linearly range between 0 and 1 for depths of 0.06 m and 1 m, respectively. Depth is a limiting habitat variable primarily for shallower depths within this range.

3.3.4.3 Fry

A mapbook displaying $HSI_{FRY\ RNTR}$ values for each mapped macrohabitat feature is provided in Attachment I. The HSI results are summarized in Table 3-61. The surface area for each rainbow trout fry LHV is provided in Table 3-62.

Table 3-61 Summary of HSI Values and Surface Areas for Rainbow Trout Fry

HSI Value Range	Surface Area (ha)	% of Total Area
0.00	531.08	64.1
0.01-0.09	134.94	16.3
0.10-0.24	74.49	9.0
0.25-0.49	35.02	4.2
0.50-1.00	53.34	6.4

Table 3-62 Summary of LHV Areas for Rainbow Trout Fry

Habitat Variable	LHV Area (ha)	% of Total Area
Depth	13.19	1.6
Velocity	510.19	61.6
Substrate	226.62	27.3
Cover	79.65	9.6

The majority of surveyed habitat (61.6%) is not suitable (HSI=0) for rainbow trout fry. Only 6.4% of the surveyed area is determined to have HSI values greater than 0.5 for rainbow trout fry.

Velocity in active channels is the most commonly limiting variable because velocity suitability decreases above 0.4 m/s (e.g., fast glide) and velocities above 1 m/s (e.g., active channel riffle and run habitat) are unsuitable for rainbow trout fry. As a result, velocity has the highest LHV area (61.6%). Substrate has the next highest LHV area (27.3%), primarily because only cobble or small boulder substrates are most suitable to rainbow trout fry, and they corresponded to HSI values greater than 0.05. Because rainbow trout fry commonly utilize cobble and large substrates as cover, areas with low contributions of total % cover (less than 25%) are suitable to rainbow trout fry. As a result, total % cover has a relatively low LHV area (9.8%). Depths between 0.08 m and 0.4 m are highly suitable (HSI=1) to rainbow trout fry and depths greater than1 m are unsuitable (HSI=0). These depths occur in most of the surveyed area (Table 3-24). As a result, depth had the lowest LHV area (1.6%).

3.3.4.4 Spawning

A mapbook displaying $HSI_{SPAWNING\ RNTR}$ values for each mapped macrohabitat feature is provided in Attachment I. The HSI results are summarized in Table 3-63. The surface area for each rainbow trout spawning LHV is provided in Table 3-64.

Table 3-63 Summary of HSI Values and Surface Areas for Spawning Rainbow Trout

HSI Value Range	Surface Area (ha)	% of Total Area
0.00	337.17	40.7
0.01-0.09	39.72	4.8
0.10-0.24	295.93	35.7
0.25-0.49	115.95	14.0
0.50-1.00	40.28	4.9

Table 3-64 Summary of LHV Areas for Spawning Rainbow Trout

Habitat Variable	LHV Area (ha)	% of Total Area
Depth	100.95	12.2
Velocity	630.52	76.1
Substrate	155.15	18.7

As spring spawners, rainbow trout spawn under a markedly different flow regime than encountered during the fall survey period. As a result, spawning HSI values may not be representative of values encountered for the surveyed area in the spring, particularly in relation to depths and velocities.

A total of 40.7% of surveyed habitat is not suitable (HSI=0) for rainbow trout spawning. The majority of surveyed habitat (54.5%) has an HSI value in the range of 0.01 and 0.49. Only 4.9% of the surveyed area has HSI values greater than 0.5 for rainbow trout spawning.

Velocity has the highest LHV area for rainbow trout spawning (76.1%). A velocity range between 0.4 m/s and 0.8 m/s is most suitable to spawning (HSI=1). Velocities less than 0.2 m/s or greater than 1.3 m/s are not suitable for spawning (HSI=0). Velocity is limiting for 291 ha of active channel riffle habitat, 140 ha of active channel run habitat, and 137 ha of still water habitats (i.e., edgewater, backwatered channel confluence, flat, and beaver impoundment).

Rainbow trout spawning substrate suitability is highest where small gravel (HSI=1), moderate for large gravel (HSI=0.45), and low for cobble (HSI=0.01). Other substrate types are unsuitable for rainbow trout spawning. Relatively low proportions of small gravel are distributed throughout the surveyed area (Table 3-6 to Table 3-9) and habitat suitability for substrate is primarily limited by large gravel (HSI=0.45) where highly suitable depths and velocities are present. As a result, the LHV area for substrate is 18.7%.

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