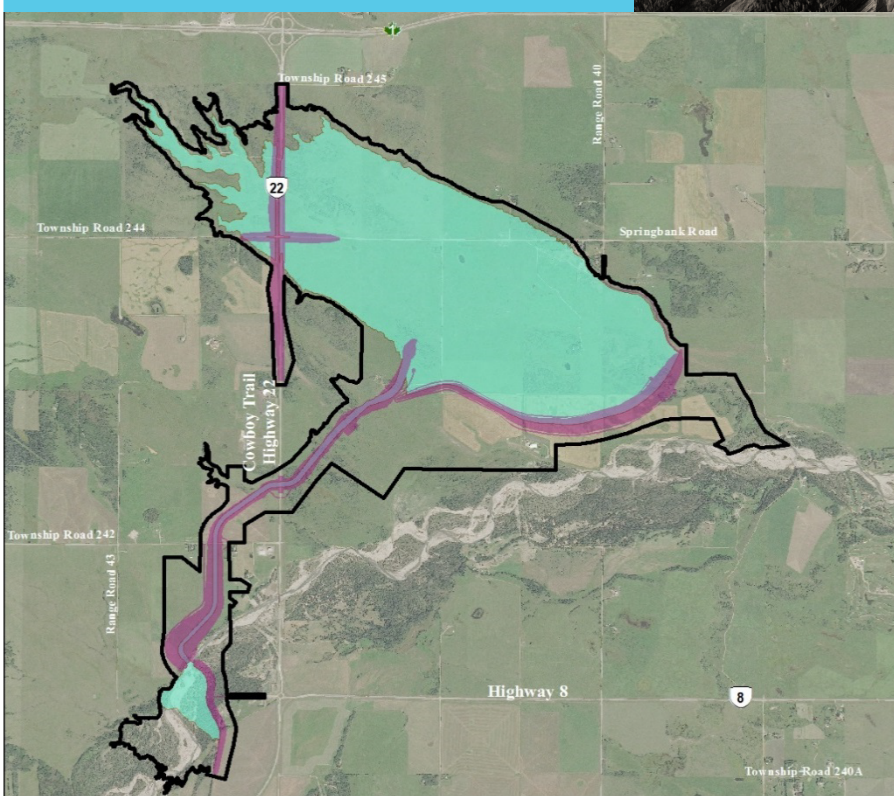
Springbank Off-stream Reservoir Project



Fish and Fish Habitat Offset Measures Plan

February 2022

Alberta Transportation and Economic Corridors

7.0 OFFSET MEASURES PLAN

7.1 OFFSETTING CRITERIA AND CONSIDERATIONS

The objective of offsetting is to counterbalance unavoidable HADD and fish mortality resulting from Project -related activities. Alberta Transportation's Offset Measures Plan (OMP) has been prepared to fulfill the requirements of the *Fisheries Act* and *SARA*.

Alberta Transportation's OMP includes the following fish habitat designs:

- Elbow River Side Channels
- Brook Trout Removal Program
- Elbow River Watershed Remediation

The OMP is driven by Project requirements, regulatory objectives, and stakeholder feedback. The following considerations were identified and informed the OMP for the Project:

- Alberta Transportation considered the schedule to construction and 'time lag' between construction and habitat availability with the offsetting options:
  - Options that require a short duration of time to achieve habitat establishment (i.e., instream features such as pools, vegetation that can establish within relatively few seasons) are considered desirable because they reduce time lags between Project effects and offsets.
  - Options that can reduce threats to bull trout (i.e., habitat fragmentation, competition) or improve bull trout habitat quality are considered desirable because they can potentially increase bull trout productivity and abundance.
  - Projects that are located within Alberta Transportation-owned land, or public land, were considered more desirable than options on private land or options that would require a third-party agreement. This is because the time associated with additional negotiations could delay offset construction by years, thereby increasing the duration that habitat loss is not counterbalanced.
  - Options that do not rely on re-designating current Public Land Use Zones to achieve offset effectiveness were considered more desirable. This is because the time associated with public consultation for a land use change could delay offset construction by years, thereby increasing the duration that habitat loss is not counterbalanced.

- Offsetting options should provide some benefit to the Elbow River fish populations, including bull trout, a species that is listed as Threatened under SARA. This objective can be partially met through offsets near the Project location in the middle reach of the Elbow River. Due to the relatively low abundance of bull trout near the Project, offsets should be partially located in an area where bull trout abundance is higher relative to the middle reach of the Elbow River (e.g., upstream of Elbow Falls).
- Alberta Transportation has received feedback from DFO that indicates offsetting options should be localized to the Elbow River watershed..
- Alberta Transportation considered the priorities identified in DFO's *Policy for applying measures to offset adverse effects on fish and fish habitat under the Fisheries Act* (DFO 2019b) in the selection of offsetting opportunities. These guiding principles include:
  - Guiding Principle 1: "*Measures to offset should support fisheries management objectives and give priority to the restoration of degraded fish habitat.*"
    - Alberta Transportation has considered this Guiding Principle through the context of AEP's fishery management objectives, which are to provide and maintain a domestic and recreational fishery for native species (i.e., bull trout, mountain whitefish) and non-native species (i.e., hybridized cutthroat trout, brown trout, brook trout) in the Elbow River (AEP 2021b). This objective considers maintaining populations of fish to allow Indigenous communities to exercise their Treaty Rights to fish in the Elbow River and provide recreational sportfishing opportunities to the public (AEP, 2021a).
    - In addition, Alberta Transportation has considered the objectives of the Recovery Strategy for Bull Trout (DFO 2020a), which identifies watersheds where recovery efforts should be prioritized. AEP has indicated that areas in the upper Elbow River watershed afford the best opportunities for bull trout recovery based on current distribution, habitat quality, and abundance.
    - While the Elbow River watershed has been subjected to development and anthropogenic disturbance, there has been minimal permanent development in its upper reaches and its headwaters. Options within the watershed were explored in depth and Alberta Transportation could not identify anthropogenically disturbed areas, in high value bull trout habitat, of the size and scale being contemplated for offset.
  - Guiding Principle 2: "*Benefits from measures to offset should balance the adverse effects resulting from the works, undertakings or activities.*".
    - Alberta Transportation has considered this Guiding Principle by evaluating projects for their overall habitat surface areas that can be generated from the offsetting options, as well as the type of habitat that can be provided through the offset measures. Habitats that generate high surface areas, or habitats that can provide limiting features for fish in the Elbow River, are considered valuable. In addition, options that can increase bull trout productivity should be prioritized.

- Guiding Principle 3: "*Measures to offset should provide additional benefits to the ecosystem.*"
  - Alberta Transportation has considered this Guiding Principle through opportunities that can provide habitat features that are currently limiting in the Elbow River system..
- Guiding Principle 4: "*Measures to offset should generate self-sustaining benefits over the long term.*"
  - Alberta Transportation has considered this through options that can increase the productivity of the local fishery, through in-kind and out-of-kind offsets that can enhance water quality, habitat quality, or directly improve fish populations.

- Offset options should consider Indigenous group feedback received on the Project, including preliminary feedback received on potential offsetting options presented during meetings on November 26, 2020, and January 26, 2021. Feedback received includes the following:
  - Some groups questioned whether offset options outside of the Elbow River watershed would appropriately counterbalance effects of the Project and expressed a preference for options that are within the Elbow River watershed. Other groups expressed that offsetting should maximize surface area habitat, with less emphasis on the location of the Project.
- The Offset Measures Plan should consider the feedback that has been received from Dr. Post (Post, 2022) and Geoprocess (Geoprocess, 2022) regarding preliminary offset concepts related to Canyon Creek, the Elbow River Side Channels, and the Brook Trout Removal Program for the Project.
- Offset options should consider flood resiliency, or the number of years that the offsets may be available to the fishery should a flood event occur.
- Offset options should consider the risk of brook trout immigration to areas that provide high quality bull trout habitat.
- Costs associated with approvals or agreements, construction, and ongoing maintenance of the offsetting options.
- For offsetting options that are located within public land, Alberta Transportation has also considered the current social and recreational values that the area provides, and how the offsets may be viewed by public users.

7.2 ADAPTIVE MANAGEMENT

While estimating the potential Project effects on fish habitat is generally straightforward, Alberta Transportation recognizes there are uncertainties associated with entrainment estimates related to death of fish associated with the Project. Factors causing this uncertainty include the frequency of Project operations, the magnitude of flood events, the fish populations in the Elbow River at the time of flood, the effectiveness of fish exclusion measures, the number of fish entrained by Project operations, the duration from Project activation to reservoir release, the number of fish that exit the reservoir through the lower outlet channel during reservoir release, and the effectiveness of fish rescue efforts.

To address this uncertainty, Alberta Transportation is proposing an adaptive approach for offsetting Project effects related to fish entrainment and fish mortality. This will allow appropriate offset measures to be established based on initial effects estimates and post-flood monitoring in a responsive and effective manner.

Alberta Transportation proposes the following offsetting approach for potential effects to fish due to entrainment from the Project:

- Alberta Transportation will offset for potential entrainment effects based on an initial entrainment effects estimate due to the Project, authorized by DFO (i.e., an operational threshold as proposed in Section 6.4.2).
  - The operational threshold in the *Fisheries Act* Authorization will represent a total number of individual fish that may be lost as a result of flood operation over the Authorization period (e.g., 10 years of operation). To facilitate compliance monitoring, estimates of individual fish loss may be provided to correspond to different flood magnitudes. These itemized estimates can provide indication of whether the overall threshold is appropriate over the duration of Authorization period.
- Post-flood monitoring results in the reservoir and in the Elbow River will confirm whether initial entrainment effect estimates were appropriate. Monitoring will be conducted during years of flood operation and is further described in Section 9.3.2.
- If post-flood monitoring confirms the initial entrainment effect estimates were appropriate, no additional offsetting measures would be required.
- If post-flood monitoring confirms the initial entrainment effect estimates were underestimated, additional offsetting measures will be instituted by AEP (as the reservoir operator) under authorization from DFO.
- Throughout this process, once offset measures are established, their performance will be monitored to confirm effectiveness and success.
  - If offset measures are not performing as expected, modifications to the offset measures or additional offset measures may be required. Other potential offset measures are described in Section 7.7.

Alberta Transportation believes this proposed approach addresses the uncertainty related to entrainment estimates and death of fish estimates and can be effectively managed and enforced through a *Fisheries Act* authorization. Alberta Transportation also recognizes that some of the initial offset measures, or additional measures described in Section 7.7 may result in higher offset quantities than required for the Project and would be interested in habitat banking, should the opportunity arise.

7.3 OFFSET 1: ELBOW RIVER SIDE CHANNELS

Offset measures at Elbow River Side Channels are proposed to address Project effects associated with HADD of fish habitat associated with the Elbow River fish community. Two side channel offsets are proposed (adjacent to the reservoir, approximately 3.5 km downstream of the diversion inlet and 3.5 km upstream of the confluence with the low-level outlet (Figure 7.1) and are designed to mimic the type of habitat that is present within the construction footprint. The Elbow River Side Channels also provides an out-of-kind offset measure to counterbalance the potential mortality of fish species as a result of flood operation.

7.3.1 Elbow River Side Channel Setting

Both side channels are within the bed and banks of the Elbow River and both were activated during the 2013 flood. After floodwaters receded, the side channels became disconnected from the main channel.

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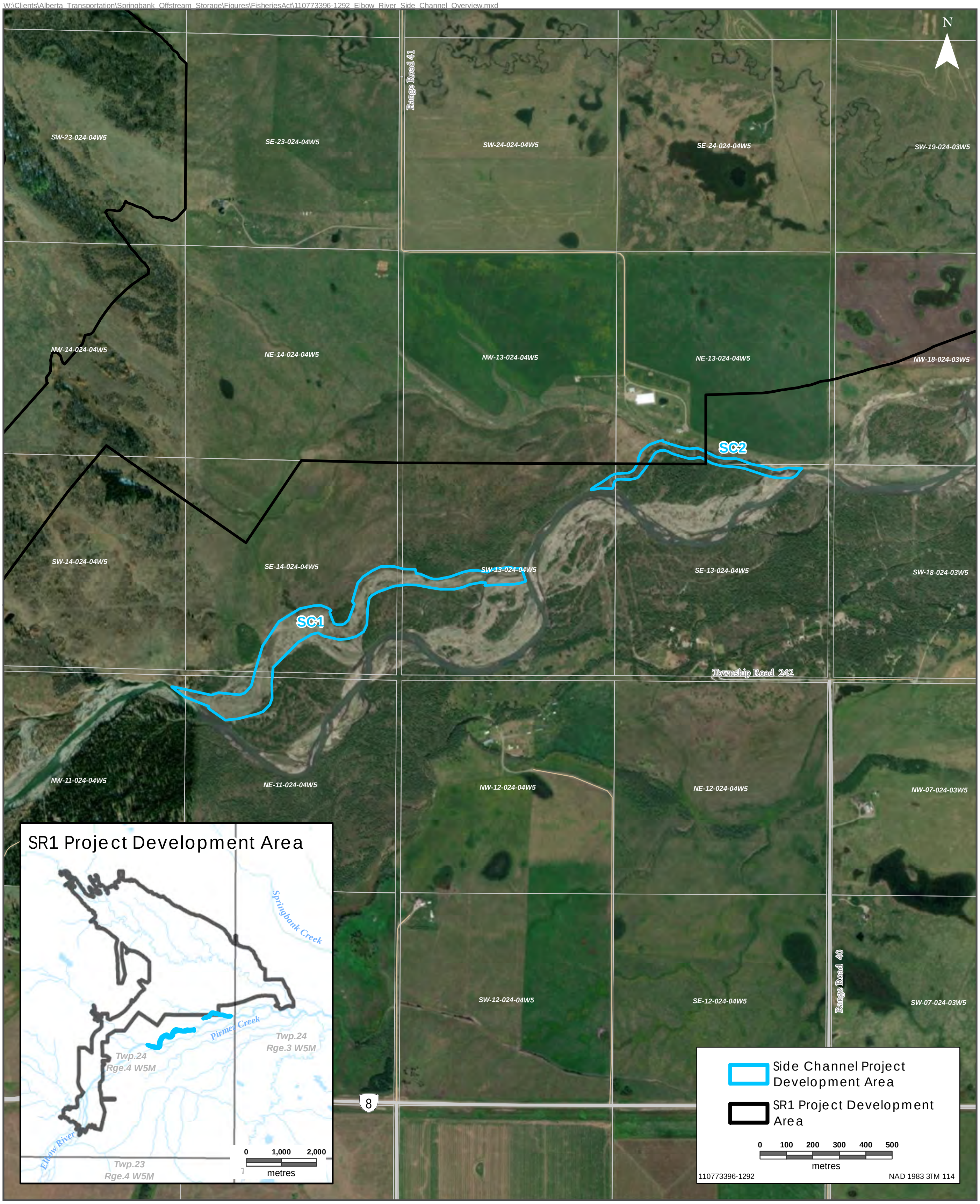

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ALBERTA TRANSPORTATION SPRINGBANK OFF-STREAM RESERVOIR PROJECT ENVIRONMENTAL IMPACT ASSESSMENT

Elbow River Side Channels Location

Figure 7.1

7.3.2 Elbow River Side Channels Design Basis

Table 7.1 outlines the parameters that serve as the design basis for the side channels.

Table 7.1 Design Basis Details

Parameter	Design Basis	
Base Data		
Base Topographic Data	Bare Earth Digital Elevation Model (DEM) prepared for the Government of Alberta flown October 2, 2015	
Reference Aerial Imagery Years	1962, 1982, 2011, 2015, 2020	
Elbow River Hydrology[a]		
Low Flow for Connectivity	3.2 m^3/s	December – March Average Mean Flow
Fall Flow for Fall Spawners	6.5 m^3/s	October – November Average Mean Flow
Mean Open Water Flow	14.6 m^3/s	May- October Average Mean Flow
Normal Spring Flow	25.8 m^3/s	Mean June Flow
Bankfull Flow	70 m^3/s	2-year Flood Flow
Resiliency Flow for Habitat Features	160 m^3/s	100-year flow with Project activated
Resiliency Flow for Permanent Features	160 m^3/s	100-year flow with Project activated
Fish Targets for Design Consideration [b]		
General Fish Habitat Goal	The offset project will be designed to provide spawning habitat and rearing habitat for juveniles of resident fish species	
Target Fish Species	Rainbow Trout, Brown Trout, Mountain Whitefish	
Fish Life-Stages	Redds, Fry, Juveniles, Adult, Adult Spawning	
Fish Habitat Features	Riffles, pools, wood features, overhanging vegetation (cover), runs, pocket waters, cobbles, boulders	
Fish Habitat Target Priorities	Maximize habitat area Create instream cover (boulder features, riffle features, holding pools) and overhanging cover (riparian vegetation, wood debris)	
NOTES: [a] Hydrology data is presented in Alberta Transportation 2018. [b] Obtained from HSI information presented in Appendix B of this application.		

7.3.3 Design Description

7.3.3.1 Project Extents

Conceptual design drawings of the proposed works are provided in Appendix J. The Elbow River Side Channels will be located immediately south of the Project reservoir footprint and 1 km downstream of the Highway 22 bridge across the Elbow River. The Project is proposed on lands comprising the bed and shore of the Elbow River (Public Land) and lands owned by Alberta Transportation. The site features two separate side channels within the Elbow River floodplain. The first side channel (SC1) is 1,715 m long and would feature the re-activation of an abandoned side channel to the north (river-left) of the Elbow River main channel. The second side channel (SC2) is 970 m long and would also use existing river features to create new wetted habitat with abandoned Elbow River side channels to the north of the main channel. The second side channel (SC2) is located 450 m downstream (east) of SC1.

7.3.3.2 Reference Reach

A reference reach is a stable stream that represents the same potential stream type, valley type, flow regime, sediment regime, streambank type and riparian vegetation community as the existing reach (Rosgen 2011). For design purposes, a references reach is “a reach of stream outside the project reach that is used to develop design criteria for the project reach” (Federal Interagency Steam Restoration Working Group 1998).

Alberta Transportation has selected a side channel reference reach of the Elbow River that is downstream of the proposed offset project site and in the state that it was observed to be in 1982 as a reference reach for this design. This reference reach of the Elbow River is 6 km southeast (downstream) of SR1 and 7 km west (upstream) of the Calgary city limit. The reference reach provides comparable fish habitat to the construction footprint.

Prior to 1982, there was a long period of relatively low peak flows within the Elbow River in this reach. In the 14 years prior to 1982, there were no peak flows in the Elbow River greater than 170 m^3/s (Water Survey of Canada 2021) which is reflective of approximately a 7-year flood event (Golder Associates Ltd. 2018). In the 32 years prior to 1982, there were no peak flows in the Elbow River greater than approximately a 15-year flood event. This period of relative stability provides a good reference reach for what the Elbow River could be expected to look like following construction of the Project when flood flows (up to the 100-year event) are limited to 160 m^3/s.

The exact date of the air photo in Figure 7.2 is unknown but based on the wetted edge channel, it is assumed to represent normal or low flows. The reference reach features a 10 m to 15 m wide mainstem active channel, with an average 100 m meander belt width and an average meander wavelength of 380 m long. To the south of the mainstem a side channel splits-off from the main channel for 1.9 km before meeting back up to the mainstem channel to the east. The side channel features a 6 m to 10 m wide active channel width, a 40 m meander belt width and an average meander wavelength of 210 m. Between the two channels is a heavily vegetated area with mature trees and shrubs. The floodplains appear to be vegetated with grasses and trees while gravel bars are generally limited to the inside meander bends or small channel splits. The bifurcation angle of the side channel from the mainstem is approximately 40°.

This reference reach has been used to inform the design of the alignment, meander belt width, meander wavelength and ratio of stable riparian vegetation to exposed gravel bars. Finally, the existence of this stable, reference reach just downstream of the Project area suggests that the Elbow River is capable of sustaining stable side channels with extensive riparian vegetation during periods of hydrologic stability.

7.3.3.3 Hydraulic Modelling

The proposed channels have been modelled using the 2-dimensional modelling capabilities of HEC-RAS Version 6.0.0 Beta software. Both channels and the Elbow River main channel have been included into a single model extending 3.3 km long. The model geometry is based on Bare Earth Digital Elevation Model (DEM) prepared for the Government of Alberta flown October 2, 2015. The model roughness values are based on site photos and available literature. In general, the channel roughness was assumed to be 0.035, while the overbank roughness varied from 0.045 to 0.07. The results of the modelling is further discussed through a presentation of design elements described in this Offset Measures Plan, and more specifically in Section 7.3.3.7.

7.3.3.4 Side Channel 1

Side Channel 1 will begin 1 km downstream of the Highway 22 bridge over the Elbow River. The proposed 1,715 m long side channel will be constructed entirely within the Elbow River floodplain and follows existing avulsion channels that are typically activated during flood events only. The proposed design deepens and connects these existing avulsion channels within the floodplain to allow them to carry water during low and normal flow periods. In addition, the proposed design incorporates fish habitat features including riffles, pools, boulders, runs, woody debris and riparian plantings to create high-quality fish habitat. Figure 7.3 illustrates the proposed Side Channel 1 and the Elbow River main channel during 2-year flood (70 m^3/s) conditions.

Figure 7.2 Elbow River Reference Reach

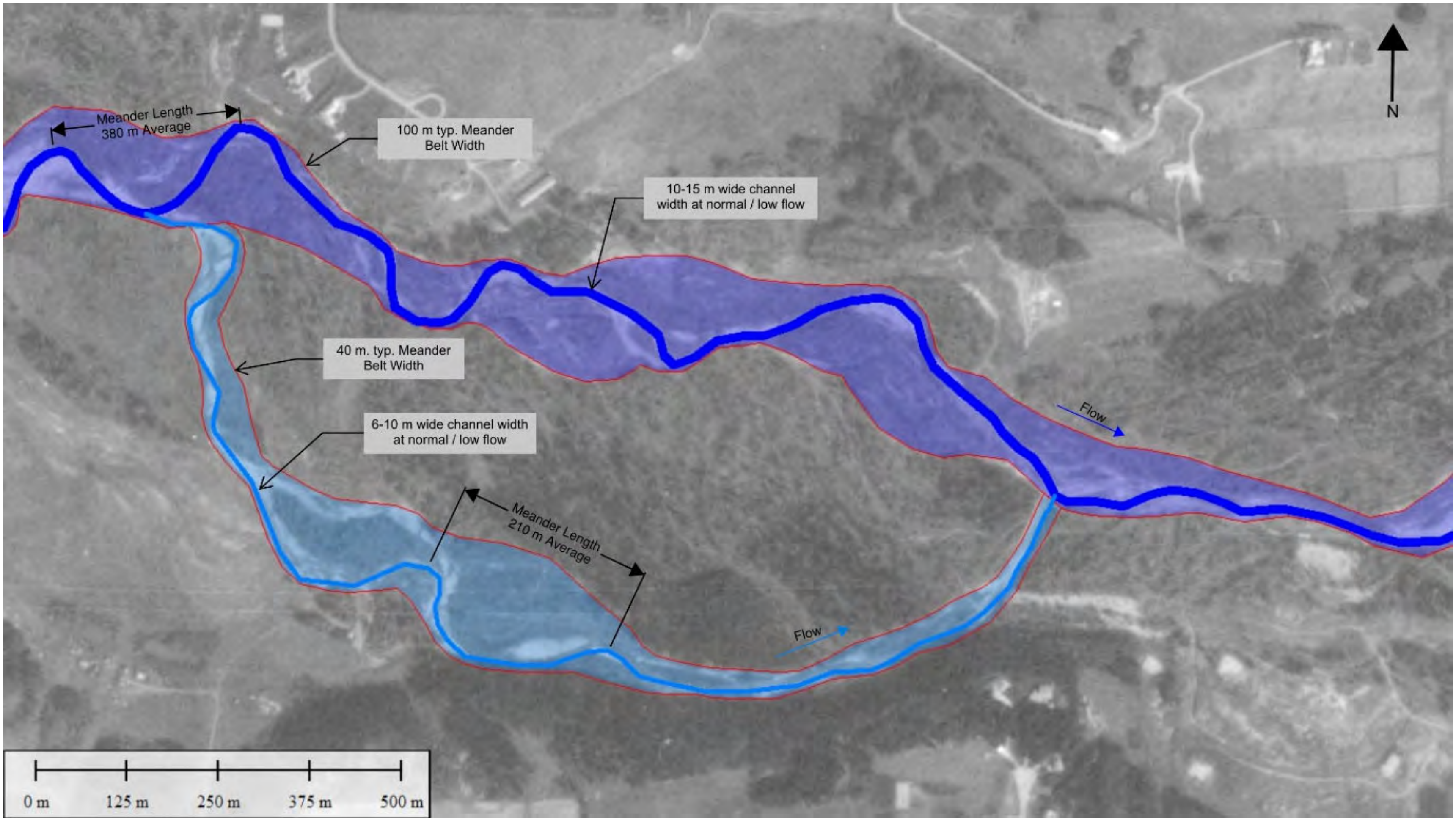

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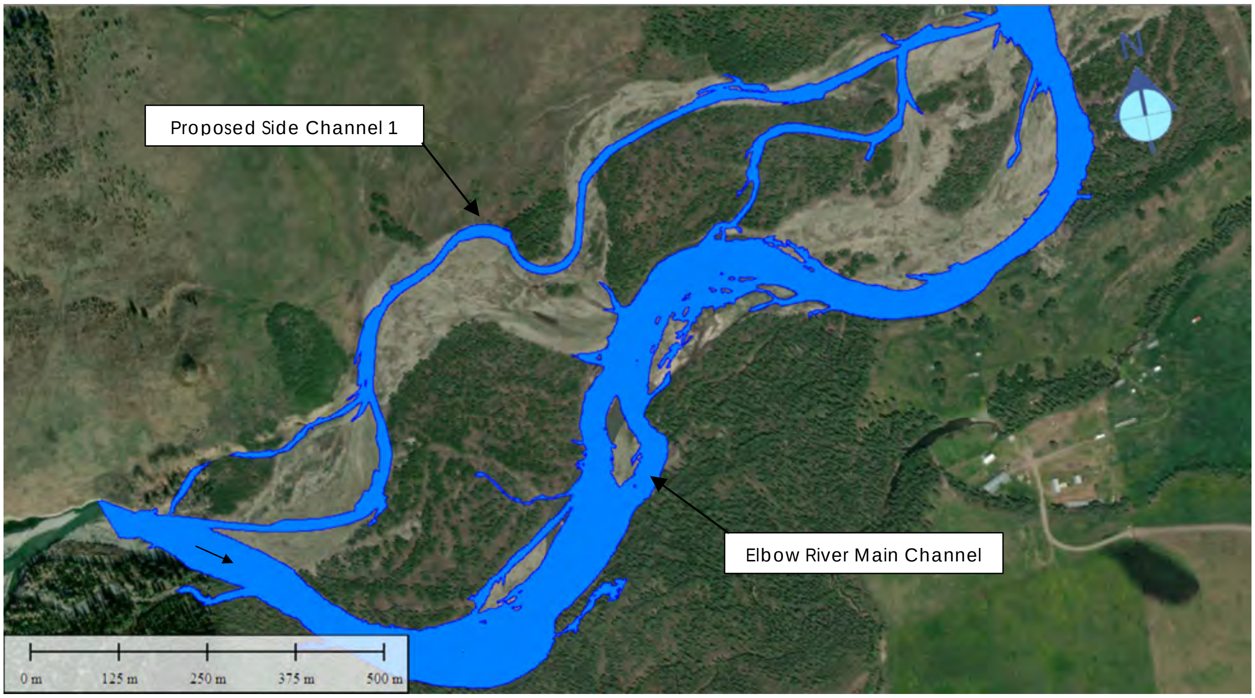
Figure 7.3 Side Channel 1 Inundation Area during 2-year Flood



The geometry of the side channel has been designed to maximize the fish habitat during normal flow conditions and to mimic natural conditions. Additional priorities include: ensuring adequate flow during low flow conditions, providing deeper pools for overwintering or extreme low flow conditions and creating a channel that is resilient to erosion and deposition.

The proposed channel features an 8 m bottom width with 1H:1V side slopes grading up to the existing Elbow River floodplain. The bottom of the channel features a slight (5%) grade toward the centre of the channel to focus the flow during extreme low flow conditions. The average banks are 1.1 m higher than the thalweg of the side channel. The banks are overtopped when flows exceed the Elbow River bankfull flow of 70 m^3/s (total Elbow River main channel and side channel flow).

The proposed channel profile features an average 0.64% grade that connects to the Elbow River main channel at both ends.

Side Channel 1 connects back to the Elbow River main channel approximately 3.1 km downstream of the Highway 22 bridge.

Table 7.2 illustrates the average side channel hydraulics as modelled using 2-dimensional HEC-RAS modelling.

Table 7.2 Upstream Side Channel (SC1) Design Hydraulics

Flow Metric	Total Elbow River Flow (m^3/s)	SC1 Average Hydraulics				
		Flow (m^3/s)	Wetted Width (m)	Depth (m)	Velocity (m/s)	Total Wetted Area in Side Channel (m^2)
Normal Fall Flow	6	1.6	10	0.4	0.5	16,800
Open Water Mean	14	2.7	11	0.5	0.7	18,400
Bankfull Flow	70	16.0	14	0.6	1.0	23,900
Flood Flow	160	33.7	19	0.7	1.2	31,900

7.3.3.5 Side Channel 2

Side Channel 2 begins 0.5 km downstream of Side Channel 1. The proposed works include deepening and widening an existing side-channel that is currently disconnected to the main channel and does not currently carry flow during normal and low flow conditions. This side channel existed prior to the 2013 flood and has a remained in its current state after the 2013 flood. The proposed works follow the same alignment as the existing side channel. Photo 7.1 and Photo 7.2 illustrate the existing conditions of this disconnected side channel.

Photo 7.1 Looking downstream at existing disconnected side channel near outlet with Elbow River

Photo 7.2 Existing disconnected side channel looking upstream

During the design process, Stantec recognized that 300 m of the existing side channel featured adequate hydraulic features to allow it to remain with no alterations. That is, the proposed works will not be changing the existing side-channel within this 300 m length.

The proposed works include deepening and widening the side-channel for 355 m upstream of this area and 140 m downstream of this area to create a 970 m long channel. This will result in the connection of this side channel to the Elbow River main channel during normal and low flow conditions.

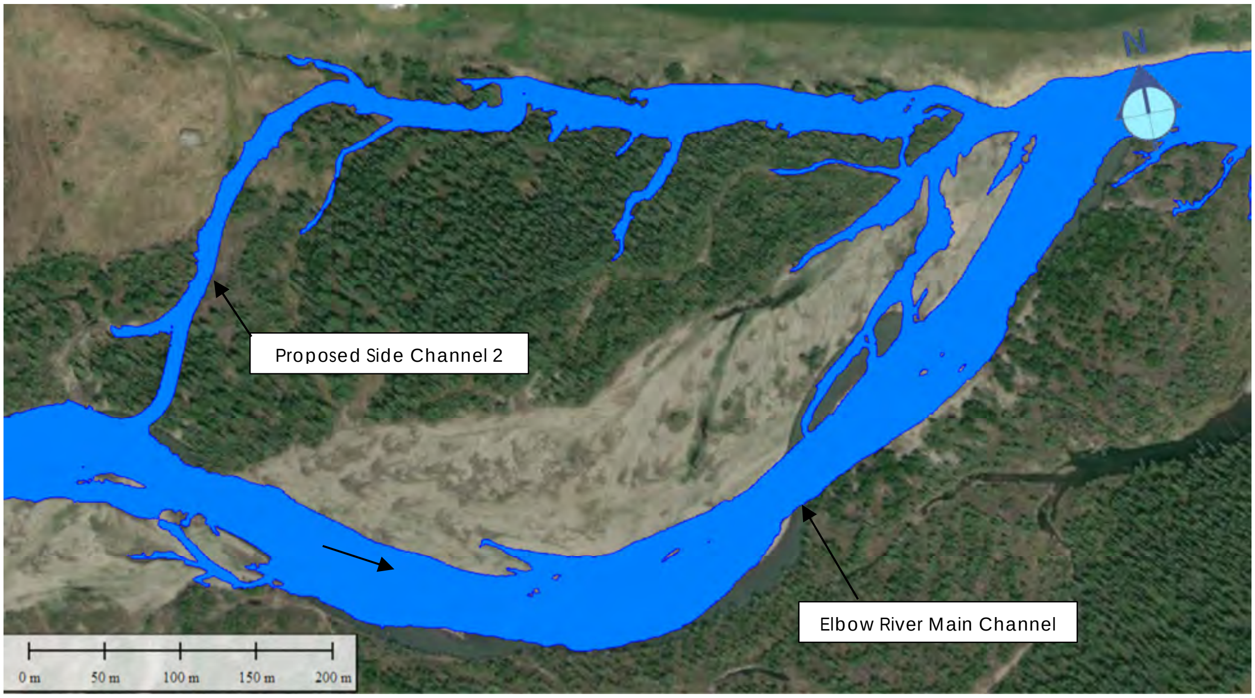
Figure 7.4 illustrates the proposed Side Channel 1 and the Elbow River main channel during 2-year flood (70 m^3/s) conditions.

Where channel work is proposed, the work includes excavating an 8 m bottom width with 1H:1V side slopes grading up to the existing Elbow River floodplain while minimizing the impacts to existing mature vegetation on both banks. In addition, the proposed design incorporates fish habitat features including riffles, pools, boulders, runs, woody debris and riparian plantings to create high-quality fish habitat.

The bottom of the channel features a slight (5%) grade toward the centre of the channel to focus the flow during extreme low flow conditions. The average banks are 1.1 m high from the side channel thalweg.

The proposed channel profile features an average 0.59% grade that connects to the Elbow River main channel at both ends. Riffle and pool features are incorporated into the design and are discussed in more detail later in this section.

Figure 7.4 Side Channel 2 Inundation Area during 2-year Flood



Side Channel 2 connects back to the Elbow River main channel 970 m downstream of the inlet.

Table 7.3 illustrates the average side channel hydraulics as modelled using 2-dimensional HEC-RAS modelling.

Table 7.3 Downstream Side Channel (SC2) Design Hydraulics

Flow Metric	Total Elbow River Flow (m^3/s)	SC2 Average Hydraulics				
		Flow (m^3/s)	Wetted Width (m)	Depth (m)	Velocity (m/s)	Total Wetted Area in Side Channel (m^2)
Normal Fall Flow	6	0.9	9	0.3	0.4	8,400
Open Water Mean	14	1.7	11	0.4	0.4	10,900
Bankfull Flow	70	10.1	14	0.6	1.0	13,900
Flood Flow	160	29.0	27	0.7	1.2	26,400

7.3.3.6 Side Channel Features

The side channels will include riverine features with the intent of mimicking the hydraulic, bank and bed features that are found locally on the Elbow River near the construction footprint of the Project.

Runs

Runs are deep and relatively swift-flowing reaches with little surface agitation compared to riffles and have no major flow obstructions. They can appear as flooded riffles or elongated laterally scoured areas with water considered too swift to be described as pool habitat. Under mean annual flow conditions, the runs in the proposed side-channels are an average of 11 m wide, 0.6 m deep, and feature average velocities of 1.1 m/s. Habitat within the runs will be enhanced with log rootballs and boulders described within this section.

Riffles

Riffles are shallow reaches with swiftly flowing turbulent water and sometimes contain partially exposed substrate.

The riffles have been designed based on the methodology described by Robert Newbury (Newbury, Gaboury, & Bates, 1997). The riffles are intended to add hydraulic complexity, enhance pools, re-aerate flows and assist fish passage. The typical recommended spacing of riffles is based on the bankfull channel width of 15 m wide. Newbury recommends riffles are spaced 4 times to 6 times channel width therefore, the channel has been designed with riffles at a 60 m to 90 m spacing interval. The designed riffles are 0.5 m high with a 2H:1V foreslope and a 20H:1V backslope. Under mean annual flow conditions, the riffles in the proposed side-channels are an average of 11 m wide, 0.3 m deep and feature average velocities of 2.1 m/s.

Pools

Pools are deeper sections of stream containing low velocities relative to other macrohabitat units in a reach. The side channel features 5 pools, creating approximately 275 m linear meters of pool habitat. Under mean annual flow conditions, the pools in the proposed side-channel are an average of 14 m wide, between 1.5 m and 2.5 m deep and feature average velocities of 0.1 m/s. Habitat within the pools will be enhanced with log rootballs and boulders described within this section.

Log Rootballs

Woody debris logs with rootballs are to be keyed into the banks to enhance the fish habitat of the watercourse. The logs be typically 4 m long with trunk diameters of 0.4 m and include the rootball. The shank of the log will be fully buried within the bank. The logs will provide "instream feeding, resting and security cover for juvenile and adult fish" and can provide "nursery habitat for fry, allowing them to escape faster currents and predators (Alberta Transportation, 2009). In addition, they will "enhance habitat by providing cover, drop-in nutrients and hydraulic diversity" (Babakaiff, Hay, & Fromuth, 1997)The logs are to be sourced from the existing Elbow River floodplain within the construction area. The logs are to be keyed a minimum of 3.5 m into the bank with the rootball extending out from the bank. Class 2 riprap will be placed in the excavated key area to mitigate the risk of the log becoming dislodged by high flows or floating debris. Photo 7.3 below provides an example of a constructed log with rootball feature.

Photo 7.3 Example of log with rootball feature

Boulders

Fish habitat boulders are to be placed within the side channels to increase instream fish cover and to create local scour pools (Alberta Transportation, 2009). The 500 mm (average) diameter boulders will be installed in groups of three and installed in the locations identified on the design drawings. Photo 7.4 below provides an example of a boulder cluster feature.

Photo 7.4 Example of boulder cluster feature

Riparian Plantings

Riparian plantings consisting of native vegetation will be installed along both banks of the channel at the locations identified in the design drawings. The plantings will provide cover and shade for fish species, stabilize the channel banks, reduce bank erosion and filter surface runoff thereby removing suspended solids before they enter the watercourse (Alberta Transportation, 2009). Additional details regarding the riparian plantings are provided on the design drawings.

Large Woody Debris atop the Floodplain

There are many areas within the project extents where large woody debris exists from recent flooding. This debris provides valuable habitat potential for aquatic and terrestrial organisms. The debris that is located within the excavation area is to be moved to just adjacent to the excavation area along the sides of the channel. The debris that is located adjacent to the excavation area is to remain. Following construction, the debris will provide cover habitat for fish and promote the riparian ecosystem. No debris will be removed from the floodplain.

Channel Bed Material

As part of the EIA, a surface and sub-surface sediment sampling program was conducted within the LAA to quantify bed material gradation (Alberta Transportation, 2018). The sampling included 6 sites between the Highway 22 Bridge and Twin Bridges. The results of this analysis is illustrated in Table 7.4.

Table 7.4 Elbow River Surface and Sub-Surface Particle Sampling

	D30	D50	D90
Surface – Field Sieved	29 mm	42 mm	82 mm
Shallow Subsurface	10 mm	21 mm	63 mm

The proposed side channels will be constructed by excavating within the existing historic Elbow River substrate. We assume that the proposed bed of the side channels will consist of in-situ materials similar to those encountered in the bar samples discussed above. It is also assumed that the channel bed of the side channel will feature a similar D50 (42 mm) following construction, that is reflective of the surface samples.

The tractive force method, along with the relationship between particle diameter and critical tractive force, to inform the stability, erodibility and sediment transport capacity of the proposed channels. Studies of stable channels (Lane, 1953) suggest that the relationship between tractive force and bed material diameter at incipient motion is the tractive force (kg/m²) = diameter of particle (cm). Based on a median channel bed particle size of 42 mm, the critical tractive force would be 4.2 kg/m² or 41.2 N/m².

As sediment supply to the Elbow River is dominated by supply from mountain tributaries (Hudson, 1983), the D_{dom} is approximately equivalent to the D_{90} and is typically the largest bedload size transported during more frequent flood flows (Bunte & Abt, 2001). Using the same relationship as described above, the critical tractive force for the D_{90} is estimated to be 80.4 N/m². This reflects the typical tractive force to transport the largest bedload size encountered in the Elbow River within this reach.

The 2-D hydraulic modelling was used to quantify the shear (tractive) forces within the side channels. The average shear forces in the side channels and main channel for the range of flows listed in Table 7.5 below.

Table 7.5 Average Shear Force in the Proposed Side Channels and Main Channel

Discharge (m³/s)	Average Shear Force (N/m²)		
	Main Channel	**Side Channel 1**	**Side Channel 2**
6.0	9.4	8.2	9.1
14.0	13.4	11.4	5.1
70.0	27.5	22.6	20.1
160.0	35.7	33.5	31.2

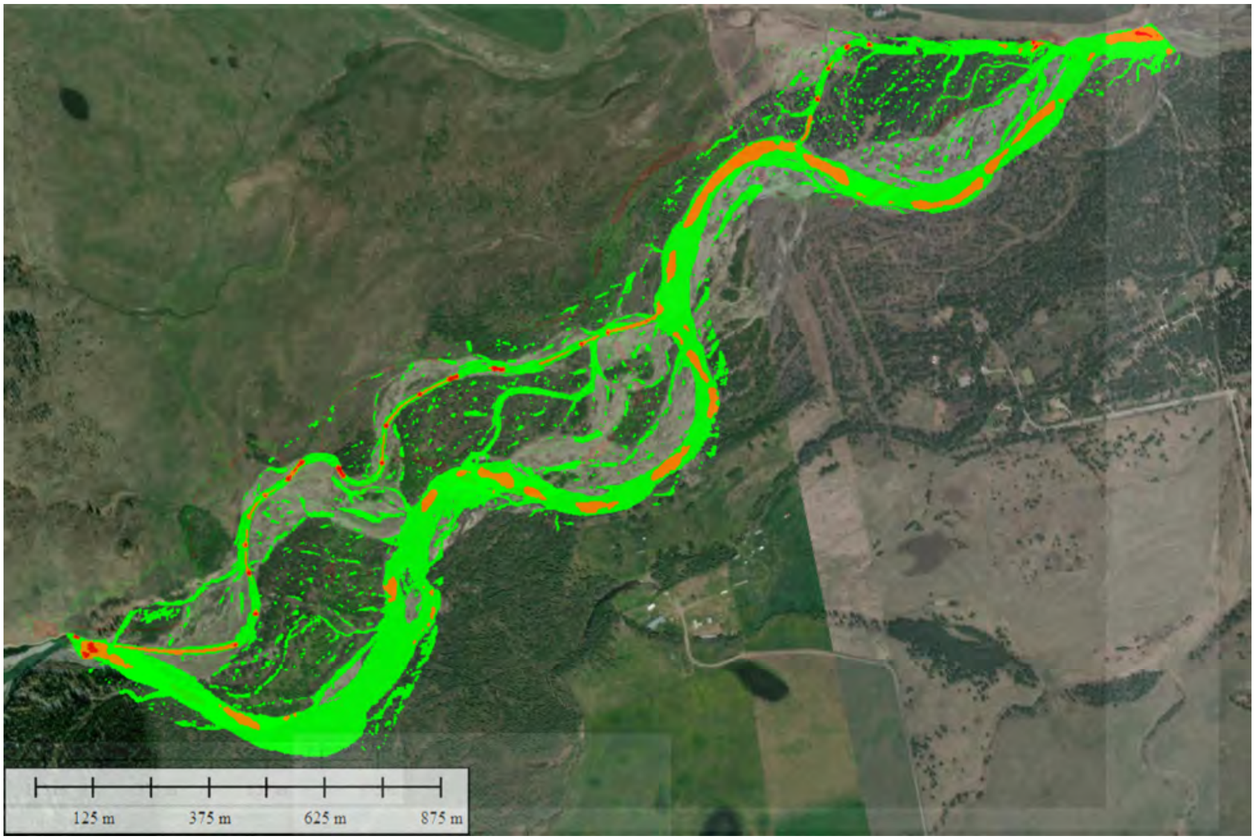
The average shear force analysis suggests that the shear forces in the channel are less than the critical tractive force (41.2 N/m^2) for the median particle size of 42 mm. This suggests that the side channels will remain stable from a general bed erosion perspective and that the sediment regime of the side channels will be similar to that of the main channel.

Another important consideration is the spatial distribution of the shear forces within the side channels and main channel. Figure 7.5 illustrates the spatial distribution of the shear forces within the main channel and side channels during the 2-year flood event (70 m^3/s). Areas with shear forces with less than the critical shear stress of 41.2 N/m^2 are illustrated in green, areas with shear forces between 41.2 N/m^2 and 80.4 N/m^2 and areas with shear forces greater than 80.4 N/m^2 are illustrated in red.

Figure 7.5 suggests the following:

- The green area indicates that the vast majority of the main channel and side channels experience shear forces less than that which would be required to mobilize the median particle (42 mm).
- There are areas (in orange) within the main channel and side channels where the shear forces are between 41.2 N/m^2 and 80.4 N/m^2. These areas would be expected at riffle crests and high velocity areas where the bed would be expected to consist of particles between the D_{50} and the D_{90}.
- There are red areas at the crests of the riffles in the side channels where the shear forces greater than 80.4 N/m^2 thus suggesting that the shear forces are greater than the D_{90}. One would expect erosion and scouring of these areas if the bed material is not armoured. In response to this, the proposed riffle crests will be composed of rocks larger than 82 mm to maintain their stability. Additional discussion regarding the sizing of these riffle crests is provided below.
- The areas at the inlets and outlets of the side channels are orange indicating that the shear forces in these areas are between 41.2 N/m^2 and 80.4 N/m^2. This is intentionally designed to maintain the velocity, shear and bedload transport at the inlets and outlets of the side channels so as to mitigate the risk of deposition in these locations which could impact the flow within the side channels.

Figure 7.5 Spatial Distribution of Shear Force Relative to Critical Tractive Force for 70 m³/s



Riffle Material

The riffle crests are intended to provide channel stability to the side-channel as grade control structures and therefore must be resilient to movement during the design flood condition of 160 m³/s.

The rocks in the riffle crests have been sized using the same shear force results as determined using the 2D hydraulic model. The shear forces for the design flood event of 160 m³/s at the riffle crests range between 130 N/m² and 212 N/m². This suggests that the minimum rock size D_{50} to remain stable at these locations is 212 mm in diameter. Newbury recommends a safety factor of 1.5 be applied to rock sizing using the tractive force method (Newbury, Gaboury, & Bates, 1997). Therefore, the recommended rock sizing for the riffle crests using this approach would be rocks with D_{50} equal to 318 mm.

In addition to the above, additional methods were considered to estimate the required median rock size for the riffle crests, and these considerations are described in Table 7.6. Input data was derived from the 2D hydraulic model results and factors of safety varied depending on the method used as per the reference material recommendations.

Table 7.6 Riffle Crest Rock Sizing

Rock Sizing Method	Typical Application	Inputs	Factor of Safety	Crest Rock Size (D_{50})
(Newbury, Gaboury, & Bates, 1997)	Riffles	Shear force (212 N/m²)	1.5	318 mm
(Catchments and Creeks Pty Ltd., 2004)	Waterway riffles	Crest flow velocity (3.5 m/s)	1.2	450 mm
(Abt & Johnson, 1991)	Overtopping, grade protection, 2% to 20%	Unit discharge (10 m³/s/m), riffle backslope (0.05 m/m)	1.2	570 mm

Based on the above analyses, Class 2 angular riprap with a median diameter of 500 mm is proposed for the crests of the riffles. The rocks will be keyed into the bed and banks to mitigate flanking and scouring.

Inlet Armouring

Select areas of the inlets will be armoured with Class 2 angular riprap to provide resiliency during high flood events.

Excavated Material

All of the excavated material will consist of Elbow River alluvium (boulders, cobbles, gravels, sand and silt), and will be re-purposed as site material for habitat creation. Excavated boulders of size that match the design specifications are to re-incorporated into the proposed side channel to provide additional habitat benefits. Excavated cobbles of size that match the design specifications are to be placed along the banks of the proposed side channel to provide additional erosion protection and habitat benefits. All other excavated material is to be deposited in a ‘rough and loose’ pattern within the areas indicated on the contract drawings. All excavation deposition areas are within un-vegetated, Elbow River floodplain areas.

The estimated volume of excavation for the side channels are 28,100 m³ and 2,500 m³ for the upstream (SC1) and downstream (SC2) side channels, respectively.

Vegetation

Three plant complexes were chosen to provide diversity to the site and allow for vegetation resilience with varying water levels. Placement of each complex is dependent on these levels with the Riparian Edge Complex located closest to the mean annual water level and the Upland Shrub Complex above the 100-year flood water level. The Transition Zone Complex straddles the space between these two groups and is predominantly focused around the bankfull water level.

Due to its close proximity to the waters edge the Riparian Edge Complex is made up of three willow species that thrive on wet soil conditions. Various sizes of these species are planted to allow for diversity in cover and to ensure vegetation massing in the event that one size does not establish. The Transition Zone Complex includes balsam poplars, a predominant riparian tree species in the Foothills Parkland subregion, two other willow species and red osier dogwood, all of which require a close water source and can withstand periods of inundation. Above the 160 m^3/s water level, the Upland Shrub Complex will have a lower chance of inundation. The soils at this elevation are dryer so shrub species such as saskatoon, silverberry, rose, and snowberry will be planted. All of the species in these complexes are native species within the broadleaf forest, coniferous forest and mixed forest areas bordering the Elbow River.

Channel Resiliency

The long-term resiliency of the side channels depends on their ability to convey sediment without aggradation or degradation. A stable and resilient side-channel is one that requires little maintenance and is able to convey sediment. Recent studies suggest that the mechanisms that affect the morphodynamic change of a side channel include “1) a difference in channel slope between the side channel and the main channel and 2) bend flow just upstream of the bifurcation” (Denderen, 2017).

As a design guideline the geometry of a side channel is considered favorable and at a decreased risk of aggradation (Mosselman, 2001) if the following conditions are met:

1. The ratio of the side-channel length to the main channel length is smaller than 1.5
2. The angle between the main channel and side channel is smaller than 90 degrees
3. The angle between the side channel floodplain flow lines during a flood is 45 degrees or smaller
4. The side channel takes off from an outer bend of the main channel.

Table 7.7 illustrates the proposed channels as compared to the above design guidelines.

Table 7.7 Side Channel Design Guideline Comparison

Criteria	Target	Side Channel 1	Side Channel 2
The ratio of the side-channel length to the main channel length	< 1.5	0.81	0.97
The angle between the main channel and side channel is smaller than 90 degrees	< 90°	42°	41°
The angle between the side channel floodplain flow lines during a flood	<45°	14°	37°
The side channel takes off location	Outer Bend	Outer Bend	Outer Bend

Based on the guidelines noted above, both channels are considered to be stable and at a low risk of aggradation.

Another study (van Denderen, Schielen, Blom, Kleinhans, & Hulscher, 2016) suggests that there are four parameters which influence the evolution of a side channel system:

1. **The ratio of the slope of the side channel to the slope of the main channel** - If the side channel slope is larger than the main channel, it can result in a switch of the channels. If the side channel slope is smaller than the main channel, this causes a deceleration in the side channel and creates local aggradation. The Elbow River average channel slope is 0.51% while the two proposed side channels feature average slopes of 0.64% and 0.59% for Side Channel 1 and 2, respectively. Given the relative similarity in slopes, one would expect only minor aggradation in the side channels over time.
2. **The bifurcation angle** – As the bifurcation angle increases, the width of the flow separation zone increases. Bifurcation angles equal to or greater than 60° (in combination with small slopes) can cause a plug bar at the inlet. The proposed side channels feature bifurcation angles less than 60°.
3. **The effect of bend flow** – The inlet of a side channel along the outer bend results in less sediment into the side channel due to the spiral flow of the river bend. Conversely, side channel inlets located on the inside of a bend can experience sediment deposition causing a point bar and therefore blockage of the inlet. The proposed side channels are located along the outside banks at or immediately downstream of outer bends of the Elbow River main channel.
4. **Bank erosion** – Bank erosion can result in the widening of the side channel and channel switching of flow from the main channel to the side channel. The proposed existence of the SR1 diversion results in a reduction in flood magnitude and subsequent reduction in the risk of erosion within the side channels and main channel.

The location of the sites downstream of the Project diversion structure will also provide a measure of flood resiliency to the side-channels. The attenuation of flood flows down the Elbow River can also reduce the volume of sediment flowing down the river (and into the side-channels) during a major flood event. The reduction in sediment flow reduces the risk of aggradation of the channels while the reduction in peak flood flow reduces the risk of erosion or degradation of the channels.

7.3.3.7 Analysis of Hydraulic Conditions

As part of the hydraulic modelling, a hydraulic assessment was completed to determine the potential impacts of the side channels on the main channel of the Elbow River. The assessment was completed using the same modelling as described in Section 7.3.3.3.

First, the existing conditions (without the proposed works) were modelled to develop a baseline understanding of the hydraulics of the Elbow River main channel. Next, the proposed side channels (SC1 and SC2) were added to the geometry to understand the hydraulics of the side channels and the change in hydraulics in the Elbow River main channel.

The assessment considered the flows, the shear forces, the average wetted width, the average depth, the average velocity and the total wetted area for the main channel and side channel for the normal fall flow (6 m^3/s), open water mean flows (14 m^3/s), bankfull / 2-year flood flow (70 m^3/s) and design flood flow (160 m^3/s).

The following section provide a detailed description of the flow analysis and a summary of the other hydraulic parameters. Appendix K provides a more in-depth analysis of the other hydraulic parameters.

Flow Analysis

The flow analysis used the depth and velocity information from the 2-D hydraulic model to estimate the flows in the main channel and side channels. The results of the flow analyses are provided in Table 7.8 and Table 7.9 below.

The hydraulic analysis suggests that the proposed side channels will convey between 12% and 26% of the overall Elbow River flow during the above noted flow events. On average, the Side Channel 1 conveys 22% of the total Elbow River flow while Side Channel 2 conveys 15% of the total Elbow River flow.

Table 7.8 Flow Distribution for Side Channel 1 (SC1)

	Existing Conditions	Proposed Conditions		
	Main Channel (m^3/s)	Main Channel (m^3/s)	Side Channel (m^3/s)	% of Total Flow in Side Channel
Normal Fall Flow	6.0	4.4	1.6	26%
Open Water Mean	14.0	11.3	2.7	19%
Bankfull Flow	70.0	54.0	16.0	23%
Flood Flow	160.0	126.3	33.7	21%

NOTE:
* Flow values have been rounded to the nearest 0.1

Table 7.9 Flow Distribution in Side Channel 2 (SC2)

	Existing Conditions	Proposed Conditions		
	Main Channel (m^3/s)	Main Channel (m^3/s)	Side Channel (m^3/s)	% of Total Flow in Side Channel
Normal Fall Flow	6.0	5.1	0.9	15%
Open Water Mean	14.0	12.3	1.7	12%
Bankfull Flow	70.0	59.9	10.1	14%
Flood Flow	160.0	131.0	29.0	18%

NOTE:
* Flow values have been rounded to the nearest 0.1

Other Hydraulic Parameters

The following bullets describe the hydraulic performance of the side channel and main channel. Additional description of these items is provided in Appendix K.

- The proposed works result in decrease in the average wetted width of the main channel by an average of 11% adjacent to Side Channel 1 and 14% adjacent to Side Channel 2. For the range of flows, the total wetted width of the river (combining the proposed side channel and the main channel following construction) increases by an average of 6.5 m as compared to existing conditions.
- The proposed works result in decrease in the average depth of the main channel by an average of 0.05 m or 13% adjacent to Side Channel 1 and an average of 0.04 m or 7% adjacent to Side Channel 2. The average depth of the side channels is very comparable to the average depth of the main channel. This suggests that the proposed channel is appropriate for the Elbow River's hydraulic regime.

- During the low flow period (6 m^3/s), the proposed works result in an average decrease in depth of 0.04 m in the main channel adjacent to Side Channel 1 and an average decrease of 0.01 m in the main channel adjacent to Side Channel 2. We note that during this low flow period, the proposed side channels feature average deeper flows than those in the main channel under existing conditions. This suggests that the side channels will provide a significant benefit to the fishery during these critical low flow periods.
- The proposed works result in decrease in the average velocity of the main channel of 8% adjacent to Side Channel 1 and 5% adjacent to Side Channel 2. The average velocity of the side channels is very comparable to the average velocity of the main channel.
- There is not a significant change in the shear stress within the main channel adjacent to either side channel as a result of the proposed works. This suggests that the proposed works will not impact the sediment transport capacity of the main channel and the construction of the side channel will not result in general channel aggradation.
- The side channels have similar shear forces as the adjacent main channel and would therefore be expected to pass sediment in a similar manner as the main channel.
- The average shear forces in both side channels and the main channel are below the critical tractive force for a median particle size of 42 mm.

7.3.4 Fish Habitat

The side channels can provide some features that were considered limiting within the construction footprint. In addition, the side channels offer habitat downstream of the diversion inlet that may be limited over time as a result of flood mitigation from Project operations.

The habitat considerations of the construction footprint (as described in Section 6.1.1) form the basis of the Elbow River Side Channels design. The geometry of the channels has been designed to accommodate fall flows that align with mountain whitefish and brown trout velocity and depths that are indicated in each respective HSI parameter (Addley, 2003). In addition, the two side channels will include a variety of fish habitat treatments such as root wads, log jams, pools, islands, and riffles that will contribute to fish habitat complexity and provide rearing and refuge habitat for fry and juveniles, which was considered a limiting feature of the construction footprint. The substrate of the side channels will be composed of native gravels and cobbles that already exist beneath the layer of larger cobbles and organics within the floodplain. The substrate composition of the side channels will align with the substrate profile and spawning habitat potential that was observed within the construction footprint.

The proposed side channels result in a slight reduction of wetted area of the main channel of the Elbow, but a net gain in wetted area for the lower Elbow River HUC. Hydraulic modelling suggests that minor changes to the hydraulics (e.g., depth, velocity, wetted width) are anticipated (as described above in Section 7.3.3.7 and in Appendix K). These changes are reflective of natural side channel formations that develop as a result of high magnitude floods experienced in the Elbow River. Deep run habitat will persist throughout the lower Elbow River and depth will be maintained such that changes to temperature are not expected.

Table 7.10 below provides a summary of habitat loss associated with the construction footprint and the habitat gained through design of the side channels.

Table 7.10 Summary of Habitat Features in the Construction Footprint, and Intended Habitat Features of the Elbow River Side Channel

Fish Species	Habitat Feature Comparison[1]	
	Construction Footprint	**Elbow River Side Channels**
Mountain Whitefish	• Good spawning habitat potential offered through depth, riffles, cobble substrate • Good habitat for adults, juveniles, and fry based on depth, velocity, and substrate	• Good spawning habitat potential is expected due to hydrology design basis, riffle features, and cobble substrate. • Good habitat potential is expected for adults, juveniles and fry based on depth, velocity, and substrate
Brown Trout and Rainbow Trout	• Low to moderate spawning habitat potential offered, limited by substrate size • Moderate habitat potential for adults and juveniles based on depth and velocities • Moderate to low habitat potential based on depth and velocities	• Spawning habitat potential may be improved with the introduction of large gravels as part of design • Good habitat potential for adults and juveniles based on depth and velocities • Moderate habitat potential is expected based on depth and velocities
Bull Trout	• Unsuitable for spawning due to absence of groundwater upwellings and appropriate gravels for constructing redds • Low suitability for adults due to lack of depth and cover, some habitat afforded in backwater and scour pools • Unsuitable for fry and juveniles due to inappropriate depths and lack of velocity refugia • Low to moderate suitability for juveniles	• Unsuitable for spawning; design is not based in a location known to offer groundwater upwellings for bull trout • Moderate habitat may be provided for adults and juveniles due to the complexity of instream habitat features that are provided through the design. • Low to moderate suitability may be offered to fry due to the complexity of instream habitat features provided through the design.

NOTE:

[1] Habitat features of the Elbow River Side Channels are based on anticipated outcome of design. Post-construction monitoring will confirm actual habitat features and will be summarized in future reports to DFO.

The estimated habitat surface area generated from the Elbow River Side Channels is 40,600 m^2 at bankfull flow. This estimated surface area will be refined upon completion of detailed hydraulic modelling of the side channels during subsequent design phases.

7.3.5 Construction

Construction will be sequenced such that the channels are excavated in dry conditions by retaining a buffer between the excavated areas upland and the Elbow River to minimize sediment introduced to the Elbow River during the RAP. This buffer will act as earthen ‘plugs’ or berms at the inlet and outlet of the side channels; these berms are not to be constructed, but rather are comprised of in-situ material. A flow barrier will be constructed within the earthen berms to further minimize the risk of sedimentation in the Elbow River. The flow barriers will consist of lock blocks or bulk bags wrapped in poly sheeting. The height of this barrier will be such that the risk of overtopping is minimized.

Depending on groundwater seepage conditions at the time of construction, additional flow barriers may be built to control ponded water. In addition, water pumping may be required to facilitate the construction process.

Instream work will be required to armour the inlet and outlet of the channels. In addition, removal of the earthen berms and isolation materials will include instream work. The timing for removal of the earthen berms and flow barriers will be scheduled to avoid the RAP, and the sequence of removal will be strategized to minimize the potential release of sediment into the side channels and the Elbow River.

Construction will align with the mitigation measures that are described in Section 5.0 of this application for working in water.

7.3.6 Timing of Offset

Detailed design and tender package preparation are currently in progress for the Elbow River Side Channels. Pending DFO acceptance of this option, Alberta Transportation will apply for necessary permits and approvals through provincial regulatory agencies (e.g., Water Act, Public Lands Act, Historical Resources Act) to begin construction in fall 2022, concurrent with construction of the Project. and instream work will be scheduled to avoid the RAP of the Elbow River. Once completed and connected to the Elbow River, the side channels will afford immediate new habitat to the Elbow River fish community. The side channels will be operational before construction of the Project is completed so that fish are able to immediately access and utilize the new constructed habitat in the side channels. The constructed coarse substrate will allow for development of benthic invertebrate communities. Benefits to resident fish will continue to be realized as riparian vegetation matures and affords additional overhead cover for fish, provides shade for temperature regulation, and input of terrestrial invertebrates (i.e., food source for fish).

7.4 OFFSET 2: BROOK TROUT REMOVAL PROGRAM

One of the primary threats to the Saskatchewan-Nelson rivers population of bull trout is competition and hybridization with introduced eastern brook trout (DFO, 2020a). Brook trout were introduced to Alberta in the early 1900s for recreational purposes. This species competes with native bull trout and native westslope cutthroat trout, both listed under Schedule 1 of the *Species at Risk Act*. Research has suggested that brook trout competitively displace bull trout (DFO, 2020a) due to direct niche overlap for their entire lifecycles.

AEP undertook an experimental brook trout suppression program at Quirk Creek between 1998 and 2008, where fishing was completed each year to destroy brook trout and count native trout species. AEP's objective was to evaluate whether the abundance of native species increased following brook trout removal. This study suggested that westslope cutthroat trout abundance increased following brook trout suppression; whereas, bull trout abundance did not increase. AEP suggested in their October 1, 2021 presentation to DFO and Alberta Transportation that further suppression or complete eradication of brook trout may facilitate a rebound effect in the bull trout populations.

Alberta Transportation proposes further brook trout removal efforts in the upper Elbow River watershed, and migration barriers at tributaries to the Elbow River to minimize or eliminate immigration of brook trout into areas where bull trout populations exist. The intent of these removal efforts is to increase bull trout productivity and habitat availability in areas with known populations in the Elbow River watershed. This offset serves as both an in-kind replacement for the death of fish (i.e., through measures that increase bull trout productivity), in-kind replacement for loss of habitat (i.e., through habitat enhancement by removing competition) and an out-of-kind replacement for death of fish (i.e., habitat credits to offset death of fish).

7.4.1 Setting

The Brook Trout Suppression program would involve eradicating or suppressing brook trout from major tributaries of the Elbow River watershed including:

- Quirk Creek
- Prairie Creek
- Elbow Lake

7.4.2 Design Basis

The design assumes that suppression or eradication of brook trout will provide benefits for native bull trout within the Elbow River watershed upstream of Elbow Falls.

Fish barriers are typically classified into the following barrier modes (Blackburn et. al., 2021):

- Leaping barriers – the height and/or distance of the barrier exceeds the fish's leaping ability at burst speed.
- Swimming velocity barriers – the stream velocity exceeds the fish's burst swimming speed
- Swimming depth barriers – the flow depth is insufficient for the fish to pass over the barrier
- Swimming turbulence barriers – Turbulent water creates velocity and orientation difficulties and/or decreased fluid density thereby reducing swimming power.

In order to reduce the construction footprint and impacts to the watercourse, leaping barriers are proposed. To inform the design of barriers to brook trout from accessing the Quirk Creek and Prairie Creek, a review of available literature of the leaping capabilities of Brook Trout was explored:

- In laboratory settings, brook trout have been recorded jumping 73.5 cm waterfalls provided the plunge pools were at least 40 cm deep (Kondratieff and Myrick, 2004). This same study found that shallow plunge pools (10 cm deep) prevented brook trout from all size classes from jumping waterfalls 43.5 cm or more in height (Kondratieff and Myrick, 2004).
- Another study analyzed the non-native brook trout movements and noted that "nearly vertical falls within steep stream sections appeared to inhibit upstream movement" and that marked brook trout ascended 1.2 m high falls (Adams et. al, 2000). This study did not however identify the depth of the pool immediately downstream of this step.
- The Connecticut Department of Energy and Environmental Protection found that a 1.5 ft (0.46 m) drop was enough to create a barrier for wild brook trout (Murphy, 2020).
- The United Stated Department of Agriculture National Engineering Handbook provides maximum jump height for a variety of salmonids including steelhead, chinook, coho, cutthroat, chum and sockeye. Brook trout is not mentioned but is closest to the cutthroat trout which is noted as having a 0.9 m maximum jump height (NEH, 2007).

Based on the available literature, we propose that the fish barriers consist of a 1 m high vertical drop in the channel combined with channel measures immediately downstream of the drop to limit the development of a scour pool from which fish can accelerate to jump over the barrier.

In addition to the barrier itself, pools will be created on both sides at a distance of 8 m (minimum) of the barrier to allow for personnel to collect fish, monitor fish and move fish to allow for the movement of fluvial bull trout or westslope cutthroat trout if required.

7.4.3 Design Description

The design of this offset measure features two primary tasks: construction of fish barriers and Brook Trout eradication.

7.4.3.1 Fish Barriers

AEP has identified Quirk Creek and Prairie Creek as two major tributaries of the Elbow River watershed that would be suitable for creating fish barriers to prevent brook trout immigration. Active features such as a fish box will be considered in the design, such that native species can be relocated upstream and downstream of the barriers during migration periods.

Design of the fish barriers is currently in progress, and the details provided in this Application for Authorization are conceptual. Further development of the designs will continue and feedback from DFO will be considered. The following subsections provide information that is being considered as part of the design.

Prairie Creek

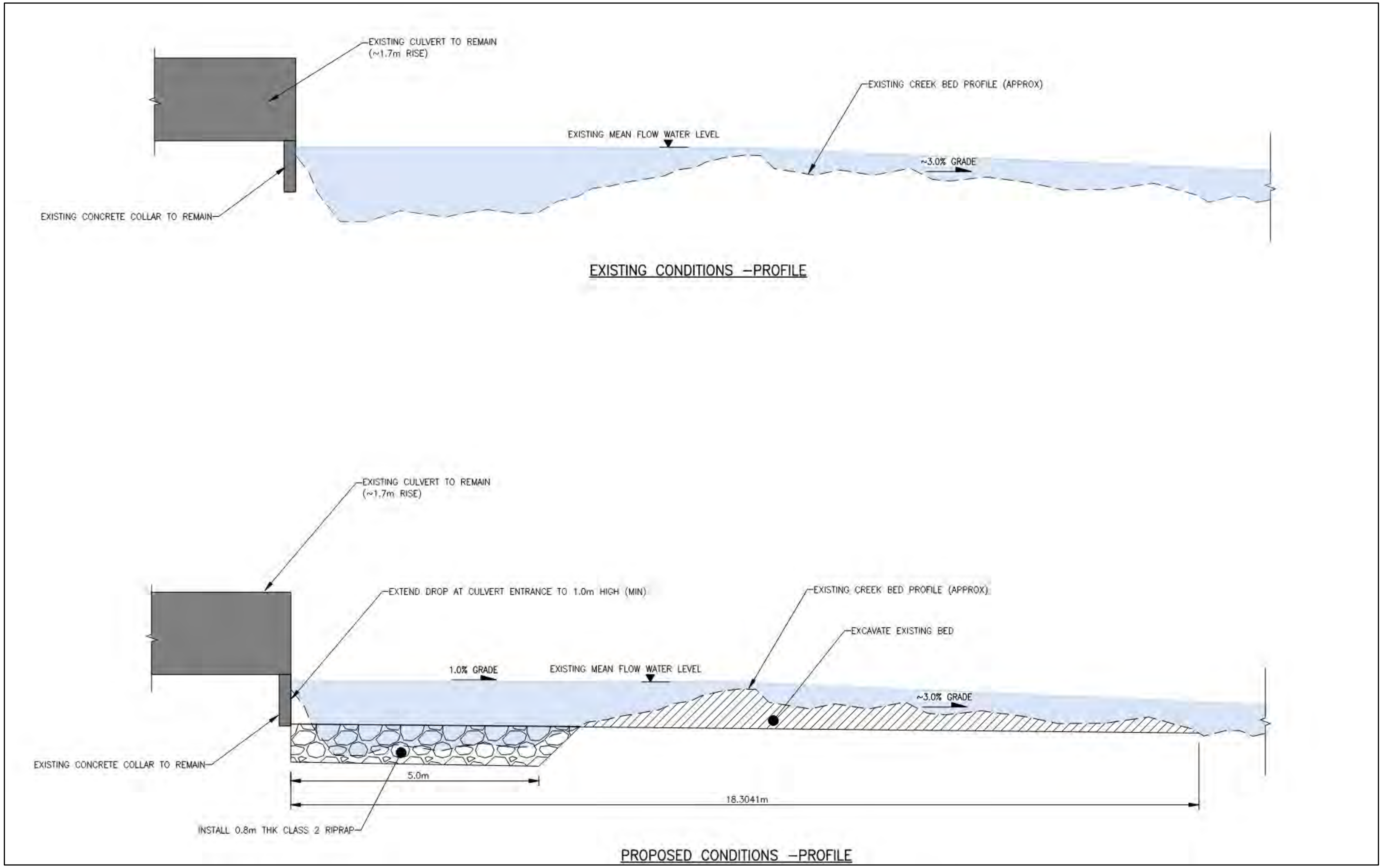
Near the downstream end of Prairie Creek, just before it joins with the Elbow River, the creek passes through a bridge sized culvert under Highway 66. The culvert is 11 m long and features a diameter of 5,131 mm (Alberta Transportation Bridge File Database, 2020). The downstream end of the culvert features a concrete collar on both sides and a concrete step at the downstream invert (Photo 7.5). The culvert offers an opportunity to create a barrier that can isolate fish from travelling up Prairie Creek.

The proposed barrier design (Figure 7.6) consists of modifying the existing culvert to prevent fish passage. This will be accomplished by excavating the Prairie Creek channel immediately downstream of the culvert to create a drop height of approximately 1.2 m from the downstream invert of the pipe to the bed of the channel. The channel banks around the culvert outlet and the bed of the channel at the culvert outlet will be armoured with 0.8 m thick Class 2 (D_{50} = 500 mm) angular riprap to disspate the energy as water falls from the culvert pipe. The channel bottom will be armored and graded at a 1% slope downward away from the culvert for approximately 5 m. Beyond these 5 m, the channel will be graded using native alluvium to tie in to the existing creek profile. The banks of the channel and slopes adjacent to the culvert will be no steeper than 2H:1V.

The combination of the 1.2 m drop, plus the armoured bed will create a scenario where the fish do not have a pool to jump from to overcome the drop height. The armouring will also prevent the development of a scour pool at the culvert outlet that could create a deeper pool at the outlet.

Photo 7.5 Looking upstream at outlet of existing culvert under Highway 66

Figure 7.6 Proposed Fish Barrier at Prairie Creek



Quirk Creek

Quirk Creek does not have the same culvert opportunity that Prairie Creek offers, nor does it have as easy construction access. Despite this, the same design approach will be used for Quirk Creek. The design will consist of the development of 1.0 m drop within the channel with aromouring immediately downstream to prevent the deveelopment of a scour pool.

Two potential locations have been identified for a barrier. These locations will be verified in the field in Spring 2022 (when snow conditions allow) to determine the exact location. Additional locations such as bedrock outcrops may also be considered if they offer opportunities to create a barrier with less disturbance to the creek.

Location 1 (Figure 7.7) is near the confluence with the Elbow River and has a greater length of Quirk Creek upstream of the barrier and may offer some bedrock outcrops to help facilitate the barrier but may have construction access issues. This location also features high channel banks that could enhance the resiliency of the barrier and minimize the risk of channel migration around the barrier.

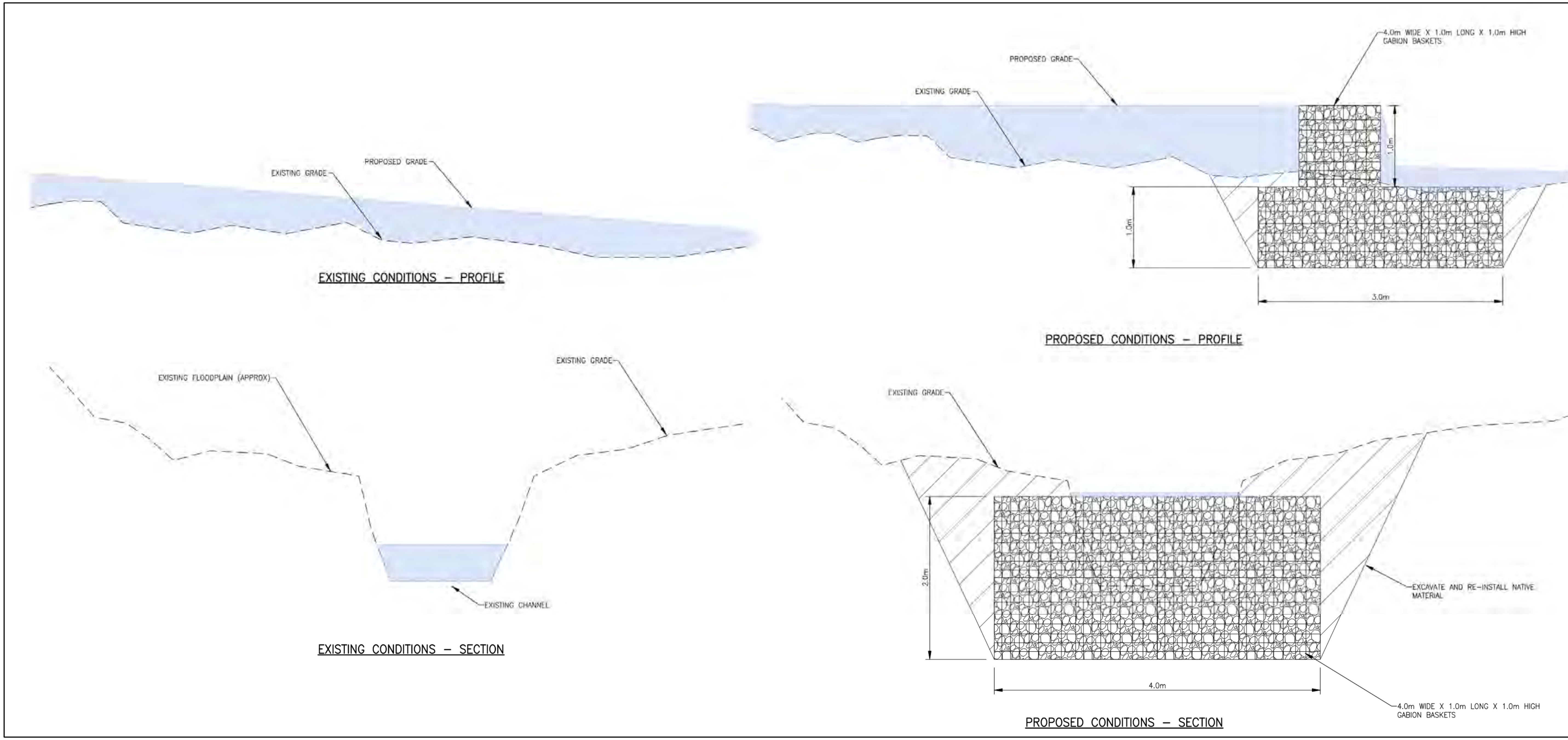
Figure 7.7 Quirk Creek Potential Barrier Locations

Location 2 is 1.4 km up Quirk Creek from the Elbow River. This location is at an existing ford crossing that appears to be used by OHV. This offers good construction access but does not appear to offer bedrock outcrops to help facilitate the barrier. This location features lower banks and may require additional erosion protection to mitigate channel migration around the barrier.

Access to either location will use existing OHV trails and backcountry roads from the MacLean Creek Staging Area. The design has taken these access constraints into account to develop a barrier that can be built using a combination of light construction material and locally sourced materials. No new trails are proposed to allow construction access.

The barrier (Figure 7.8) will be composed of 4 m long x 1 m high x 1 m wide gabion baskets. The baskets consist of PVC coated, galvanized steel, double twisted wire that will be filled with local gravels (minimum 100 mm diameter) and cobbles. Four baskets will be connected together to create the drop and downstream apron. Should local conditions not allow for adequate material (due to quantity or size of rock), gravels and cobble may be imported. The gabion structure will create a 1 m high barrier with a 2.5 m long apron immediately downstream of the barrier.

Figure 7.8 Quirk Creek Fish Barrier



7.4.4 Brook Trout Removal and Bull Trout Recovery Plan

Two general approaches exist to remove brook trout: mechanical (i.e., fishing each waterbody to depletion) or chemical (piscicide) applications for the targeted waterbodies. The preferred option will be implemented upon further discussions with DFO and AEP. For the purposes of this Offset Measures Plan, some preliminary considerations for both approaches have been included. Alberta Transportation has also included recommendations and rationale for a preferred approach (Section 7.4.4.3).

A Brook Trout Removal and Bull Trout Recovery Plan will be developed by AEP prior to implementation of removal efforts. This Plan will include a detailed protocol related to the selected approach for brook trout removal. This Plan will be available for circulation to Indigenous groups and regulators to facilitate additional permissions and permits that will be obtained prior to program implementation. The Plan will be reviewed and approved by DFO prior to implementation. It is possible that additional regulatory approvals may be required (e.g., fish rescue license, permit for the application of rotenone) prior to implementation of the procedures below.

7.4.4.1 Option 1: Chemical Removal

Chemical removal of brook trout would consist of direct application of rotenone to the targeted waterbodies. Piscicides have been used globally as a fisheries management tool to eradicate some or all fish in a waterbody so that they can be re-stocked with native or more desirable species in the absence of competition, disease, or predation (Lennon et al., 1970). Most piscicides (e.g., rotenone, antimycin) kill all fish and invertebrates in a waterbody; however, there are selective piscicides available for certain species (e.g., 3-trifluoromethyl-4-nitrophenol or TFM for sea lamprey). Selective piscicides are not available for brook trout and their eradication will require a broad-spectrum chemical such as rotenone.

Chemical applications can be an appropriate response to biological pests and invasive species where complete eradication is required for successful re-colonization of native species (Britton et al., 2010; Lintermans, 2000; Ling, 2003). The application of rotenone in fisheries management is generally constrained to relatively small or enclosed waterbodies because its application is non-selective and has effect on the aquatic ecosystem (e.g., all vertebrate and invertebrate species). Brook trout have been eradicated from Hidden Lake in Banff National Park (Parks Canada, 2021) and Helen Lake (CBC, 2020) through rotenone application, and re-stocking efforts are planned for westslope cutthroat trout in the future. Rotenone has also been used to eradicate introduced rainbow trout (*Oncorhynus mykiss*) from a mountain stream, upstream of an impassable barrier to fish and re-colonized with native mountain galaxias (*Galaxias olidus*) (Lintermans, 2000).

Rotenone is recognized as a safe piscicide through Health Canada's Pest Management Regulatory Agency (Health Canada, 2017) that degrades rapidly (e.g., half-life of 12 to 84 hours) when exposed to heat, light, oxygen, and alkalinity. Rotenone is considered a toxic compound in large concentrations; however, it poses negligible risk to human health and wildlife at low concentrations that are used to eradicate fish (AEP, 2020b; Wellmark, 2018; Oregon Department of Fish and Wildlife, 2011; Health Canada, 2017). Rotenone is moderately mobile through soil, and it is possible for rotenone to affect invertebrates within the bed and banks of a treated stream until the compound is degraded (Health Canada, 2017). Rotenone can be neutralized with the application of potassium permanganate to the waterbody (AEP, 2020b), which can lessen the effect on downstream ecosystems.

A conceptual strategy for brook trout removal and bull trout recovery is presented below.

Year 1

- Construct fish barriers on Quirk Creek and Prairie Creek in early open water season. Elbow Lake does not require a barrier, because an impassable waterfall exists downstream of the lake (approximately 3.5 km downstream); the intent of eradicating brook trout from this location is to prevent downstream emigration to the Elbow River watershed, and provide opportunity to stock the area locally with native species.
- Conduct fish rescues to remove native trout and desirable prey species from target waterbodies. Fish rescue methods, sequencing, and level of effort will be confirmed during the development of the Brook Trout Removal and Bull Trout Recovery Plan.
  - It is expected that extensive fishing efforts will be undertaken in Quirk and Prairie Creek to retain desirable species (e.g., bull trout, westslope cutthroat trout). Discussions are ongoing regarding the relocation of these species; options may exist to retain the fish in a large capacity holding tank or release them to the mainstem of the Elbow River. These details will be confirmed during the development of the Brook Trout Removal and Bull Trout Recovery Plan.
  - Discussions are ongoing regarding the need for fish rescue efforts in Elbow Lake due to the unlikely presence of desirable species.
- Apply rotenone to the upper reaches of Quirk Creek and Prairie Creek. Rotenone will also be applied to Elbow Lake. The Brook Trout Removal and Bull Trout Recovery Plan will outline a protocol and mitigation measures to minimize changes to water quality in the mainstem of the Elbow River. Considerations include, but are not limited to:
  - The concentrations of rotenone will be determined based on the minimum concentrations required to achieve desired effect of eradicating brook trout, while minimizing downstream effects. Potassium permanganate will be considered in the protocol to neutralize rotenone once its effects are realized in the creeks.

- It is assumed that no native species or SARA-listed species are present at the time of piscicide application.
- A spatial boundary will be defined where rotenone is applied; this boundary will consider many factors including flows, channel morphology, and temperature at the time of application. It is assumed that rotenone application in the upper reaches of the creeks will flow and affect fish populations downstream; however, careful consideration will be given to the application such that effects on the mainstem of the Elbow River are minimized.

- Remove and dispose of fish that have been eradicated through an approach approved by AEP.
- Monitor water quality following the application of rotenone through a protocol that is set forth in the Brook Trout Removal and Bull Trout Recovery Plan.

Year 2

- A monitoring program will be implemented one year after the application of rotenone. Monitoring methods will be described in the forthcoming Brook Trout Removal and Bull Trout Recovery Plan, and will include at minimum:
  - Monitor waterbodies for fish presence, particularly to confirm whether brook trout were successfully eradicated after the application of rotenone
  - Monitor benthic invertebrate community abundance and composition as an indication of the return of habitat (e.g., prey availability) for native species
- A second application of rotenone could be applied, if required.

Year 3 (if required)

- A second year of monitoring may be required to either confirm eradication of brook trout from the waterbodies or allow adequate time for benthic invertebrate populations to return to levels that support a native fish population.
- Relocation efforts will be required at the barriers to facilitate upstream and downstream movement of native species.

Year 4

Active measures are being considered for the fish barriers (e.g., fish box, fish fences) on Quirk Creek and Prairie Creek such that native fish can be relocated upstream and downstream during migration periods. Relocation efforts are expected to continue on an annual basis. Monitoring will determine whether these features provide adequate assistance to restore native populations. Upstream migration to Elbow Lake from the Elbow River is likely limited to re-stocking. Based on the monitoring results of Years 2 and 3, re-stocking efforts may be undertaken in Year 4 (or potentially delayed to Year 5) to re-populate the waterbodies with desirable species. The exact timing of the restocking efforts will be based on monitoring results.

Similar re-stocking efforts are currently planned by Parks Canada and serve as an example where brook trout were eradicated from waterbodies to restore native populations (Parks Canada, 2021; CBC, 2020). The intent is to re-stock these waterbodies with genetically pure westslope cutthroat trout, in collaboration with AEP. The protocols implemented from this re-stocking program will be carefully monitored as an example of procedures that can be applied to the proposed Offset Measures Plan. Forthcoming details from Parks Canada will be requested and integrated into the Brook Trout Removal Plan and Bull Trout Recovery Plan.

Bull trout are not currently reared in a hatchery facility in Alberta; however, opportunity exists to undertake such efforts. Remote site incubation and brood stock rearing efforts are currently underway (AEP, 2021c) for westslope cutthroat trout and infrastructure exists to undertake similar efforts for bull trout. The Creston National Fish Hatchery in Montana has successfully reared bull trout brood stock by collecting eggs and milt from several wild populations in the Flathead Valley to stock watersheds in Glacier National Park (US Fish and Wildlife Service, 2021, pers. comm.), and have extended an offer to share knowledge with the Government of Alberta if such efforts are required.

7.4.4.2 Option 2: Mechanical Removal

Mechanical removal of brook trout would consist of manually removing fish from targeted waterbodies to destroy brook trout that are identified in fishing efforts. Conceptual brook trout removal plans through manual means would consider the following:

Year 1

- Construct fish barriers on Quirk Creek and Prairie Creek in early open water season. Elbow Lake does not require a barrier; the intent of eradicating brook trout from this location is to prevent downstream emigration to the Elbow River watershed.
- Fish all three waterbodies to depletion. Fish rescue methods, sequencing, and level of effort will be confirmed during the development of the Brook Trout Removal and Bull Trout Recovery Plan.
  - It is expected that extensive fish sampling effort will be undertaken in Quirk and Prairie Creek to retain desirable species. Discussions are ongoing regarding the relocation of these species; options may exist to retain the fish in a large capacity holding tank or release them to the mainstem of the Elbow River. These details will be confirmed during the development of the Brook Trout Removal and Bull Trout Recovery Plan.
  - Destroy brook trout that are encountered during fishing efforts through ethical means identified by AEP.

Year 2

- A monitoring program will be implemented one year after the fishing efforts have been completed. Monitoring methods will be described in the Brook Trout Removal and Bull Trout Recovery Plan, and will include at minimum:
  - Monitor waterbodies for fish presence, particularly to confirm whether brook trout were successfully eradicated through manual efforts.
- Additional fishing effort would be undertaken, if required.
- Relocation efforts will be required at the barriers to facilitate upstream and downstream movement of native species.

Year 3 (if required)

- A second year of monitoring may be required to either confirm eradication of brook trout from the waterbodies. The abundance of native species would be monitored.
- Relocation efforts will be required at the barriers to facilitate upstream and downstream movement of native species.

Year 4

- Relocation efforts will be required at the barriers to facilitate upstream and downstream movement of native species on an annual basis. Based on the monitoring results of Years 2 and 3, re-stocking efforts may be undertaken in Year 4 to re-populate the waterbodies with desirable species. Re-stocking plans would be similar to those described above for Option 1 – Chemical removal.

7.4.4.3 Evaluation of Brook Trout Removal Options

The proposed method to remove brook trout will be confirmed upon further discussion with DFO and AEP Fisheries Management. Studies suggest that chemical removal may be more effective at eliminating brook trout from the creeks, as they are considered a highly successful invasive species and residual brook trout following mechanical removal may limit program success. However, the effectiveness of piscicides in achieving desire population outcomes needs to be balanced with the potential risks to water quality associated with chemical treatment in the Elbow River. Further investigations will be conducted to confirm the feasibility of each option prior to implementation.

7.4.5 Fish Habitat

The intent of these removal efforts is to increase bull trout productivity and habitat availability in areas with known populations of bull trout in the Elbow River watershed. This offset serves as an in-kind replacement for the death of fish and loss of habitat (i.e., increased productivity and habitat quality), and an out-of-kind replacement for death of fish (i.e., increased habitat quality).

The elimination of brook trout from Elbow Lake, Quirk Creek, and Prairie Creek would reduce competitive displacement and afford habitat to bull trout that are present in the upper Elbow River HUC. With this concept, offset benefits offered through this program can be viewed as a direct increase in habitat areas that are available to native species, in the absence of brook trout. The following assumptions are applied to estimate habitat afforded through the removal of brook trout (estimates for all 3 waterbodies included in Table 7.11):

- Habitat gained is represented by the absence of competition for bull trout
- It is assumed that approximately 60% of the total area of the waterbodies afford moderate to high quality habitat units for bull trout
- Habitat areas can be calculated through desktop estimates using the 1:20,000 Altalis hydrology dataset
- For example, Quirk Creek total area is approximately 84,948 m^2
- Habitat gained for bull trout in Quirk Creek = 84,948 m2 * 0.6% = 50,969 m^2

Studies on Quirk Creek offer some conceptual calculations on potential increase to native trout productivity in the absence of brook trout. Bull trout density declined in Quirk Creek since the 1970s, presumably due to increased competition with brook trout. If an assumption is made that bull trout can return to pre-brook trout densities, it is estimated that the offsets may net roughly 1,500 bull trout of all life stages. This estimate is based on expert advice received through DFO (Post, 2022). In the absence of empirical data on Prairie Creek, similar assumptions and logic are applied such that a net increase of 1,500 bull trout is assumed for the purposes of this Application.

Abundance increases in Elbow Lake will likely be driven by native fish re-stocking efforts. An initial estimate of 2,000 fish has been included to reflect stocking efforts that are typically undertaken by AEP, assuming that some natural attrition occurs during the initial stocking effort. Table 7.11 includes a summary of surface areas and increased productivity that is afforded to native species through the removal of brook trout. These estimates will be further developed through discussions with DFO and through the progression of the Brook Trout Removal and Bull Trout Recovery Plan.

Table 7.11 Potential Habitat Gained and Increase Productivity associated with the Brook trout Removal and Bull Trout Recovery Plan

Waterbody	Waterbody Surface Area	Potential Habitat Afforded to Bull Trout	Potential Productivity Increase
Elbow Lake	48,724 m^2	29,234 m^2	2,000 native trout (i.e., bull trout or westslope cutthroat trout)
Quirk Creek	84,948 m^2	50,969 m^2	1,500 bull trout
Prairie Creek	82,138 m^2	49,283 m^2	1,500 bull trout
Total for Brook Trout Removal Program		129,486 m^2	3,000 bull trout and 2,000 native trout

7.4.6 Construction

7.4.6.1 Fish Barriers

Prairie Creek

Access to the Prairie Creek fish barier will be via Highway 66. A laydown area can be constructed adjacent to the highway immediately to the east of the site. From the laydown area, the contractor can access the Creek downstream of the existing culvert.

Prior to construction, the contractor will install a dam and pump system to transmit flow through the culvert and around the work area. Construction will be schedueld outside of the resitricted activity period and during low flow conditions. At the downstream end of the work area, a bulk bag or sandbag dam will be constructed to limit fish travel upstream while work is proceeding. Once the work area is isolated from the creek, the work area will be fished using an electro-fisher and fish will be released downstream of the work area. Finally, existing water within the work area wil be pumped out and released in a vegeated area where it cannot re-enter the watercourse. Construction will follow mitigation measures presented in Section 5.1.

Following construction of the barrier, the dam and pump system as well as the downstream bulk bag or sandbag dam will be removed. Flow will then be allowed back through the culvert and over the newly constructed barrier.

Quirk Creek

Access to the Quirk Creek fish barier will be via OHV trails and roads from the McLean Creek Staging Area. A laydown area can be constructed within an unvegetated area adjacent to site.

Prior to construction, the contractor will install a dam and pump system to transmit flow around the work area. Construction will be scheduled outside of the resitricted activity period and during low flow conditions. At the downstream end of the work area, a bulk bag or sandbag dam will be constructed to limit fish travel upstream while work is proceeding. Once the work area is isolated from the creek, the work area will be fished using an electro-fisher and fish will be released downstream of the work area. Finally, existing water within the work area wil be pumped out and released in a vegeated area where it cannot re-enter the watercourse. Construction will follow mitigation measures presented in Section 5.1.

Following construction of the barrier, the dam and pump system as well as the downstream bulk bag or sandbag dam will be removed. Flow will then be allowed back through the channel and over the newly constructed barrier.

7.4.7 Timing of Offset

The Brook Trout Removal Program is being proposed to counterbalance potential impacts to the Elbow River watershed as a result of Project flood operation. Pending acceptance by DFO, Alberta Transportation will design the fish barriers and fish boxes, collect baseline data, apply for provincial regulatory approvals (e.g., Water Act, Public Lands Act), and progress the Brook Trout Removal Plan in 2022. This option will be implemented concurrently with construction of the Project (i.e., spring or summer 2023).

7.5 OFFSET 3: ELBOW RIVER WATERSHED REMEDIATION

Erosion and sedimentation within the Elbow River watershed contribute to habitat degradation through a change in water quality and sediment composition. Sedimentation can reduce habitat quality, aquatic productivity and fish population abundance at a watershed level. Following the 2013 flood, AEP undertook a program to remediate numerous areas that were identified to contribute disturbance and sedimentation on sensitive fish habitat in southern Alberta, through the Southern Alberta Fisheries Habitat Enhancement and Sustainability Program (FISHES Program, AEP, 2022). Remediation was prioritized based on habitat sensitivity and risk to the watershed, and efforts to remediate sites were primarily focused on flood damage and measures that reduce cumulative sediment inputs into rivers. Alberta Transportation is proposing to undertake similar efforts to the FISHES program through remediation 13 sites in the middle Elbow River HUC to address riparian health and sediment sources in an area that provides known bull trout critical habitat. These measures provide an in-kind offset through improved habitat quality within the watershed, and an out-of-kind offset for the death of fish.

AEP conducted fish habitat and riparian health assessments within the Elbow River watershed using the field protocol: *Evaluating the Condition of Streams and Riparian Management Areas* (FREP, 2020). This field protocol rates riparian health by collecting data that pertains to channel morphology condition, vegetation, erosion and channel stability, and fish habitat features. AEP has identified habitat remediation at sites within the Elbow River watershed that are categorized as properly functioning condition but at high risk or not functioning properly (i.e., site is in poor condition). In addition, some sites have been identified as a Crossing Remediation Opportunity. These sites are typically locations where OHVs ford across watercourses. Finally, some sites have been identified as Sediment Management and Habitat Restoration opportunities. These sites generally include locations where sediment input or turbidity is affecting water quality and where there has been travel instream or in the riparian zone which has affected fish habitat at the site.

Design of the sediment remediation sites is currently in progress, and the details provided in this Application for Authorization are conceptual. Further development of the designs will continue and feedback from DFO will be considered. The following subsections provide information that is being considered as part of the design.

7.5.1 Setting

Nine sites have been identified in the Elbow River watershed for offsetting that are high-risk or not functioning properly. In addition, four trails have been identified for decommissioning due to the sediment risks that the trails pose to the Elbow River watershed. The sites are located near seasonal tributaries or ephemeral draws that are connected to the Elbow River, within an area that comprises of the West Bragg Creek Day Use area and the MacLean Creek Public Land Use Zone. The sites on the north side of the Elbow River are affected by recreational activity and cattle; sites and trails on the south side of the Elbow River are affected by recreational activity, cattle, and off highway vehicle (OHV) use.

7.5.2 Design Basis

Remediation measures at the project sites identified by AEP are intended to provide erosion mitigation, riverbank stabilization, overhead cover for sites within the upper Elbow River watershed. The remediation measures will be designed to be resilient to the bankfull flow (2-year flood) conditions upon project completion. As the vegetation establishes, the resiliency of the measures will increase. The remediation measures will include typical bioengineering measures and will rely on the proper installation and maintenance of riparian vegetation.

Some sites include the decommissioning of OHV trails within the watershed. Decommissioning measures will include the use of natural materials (rocks, logs, rootballs), lumber fences and grading to dissuade use of the trails. The intent of these works will be to allow for the natural revegetation of these trails to reduce sediment input into the watercourses in the local area thereby reducing the negative impacts to the Elbow River fishery.

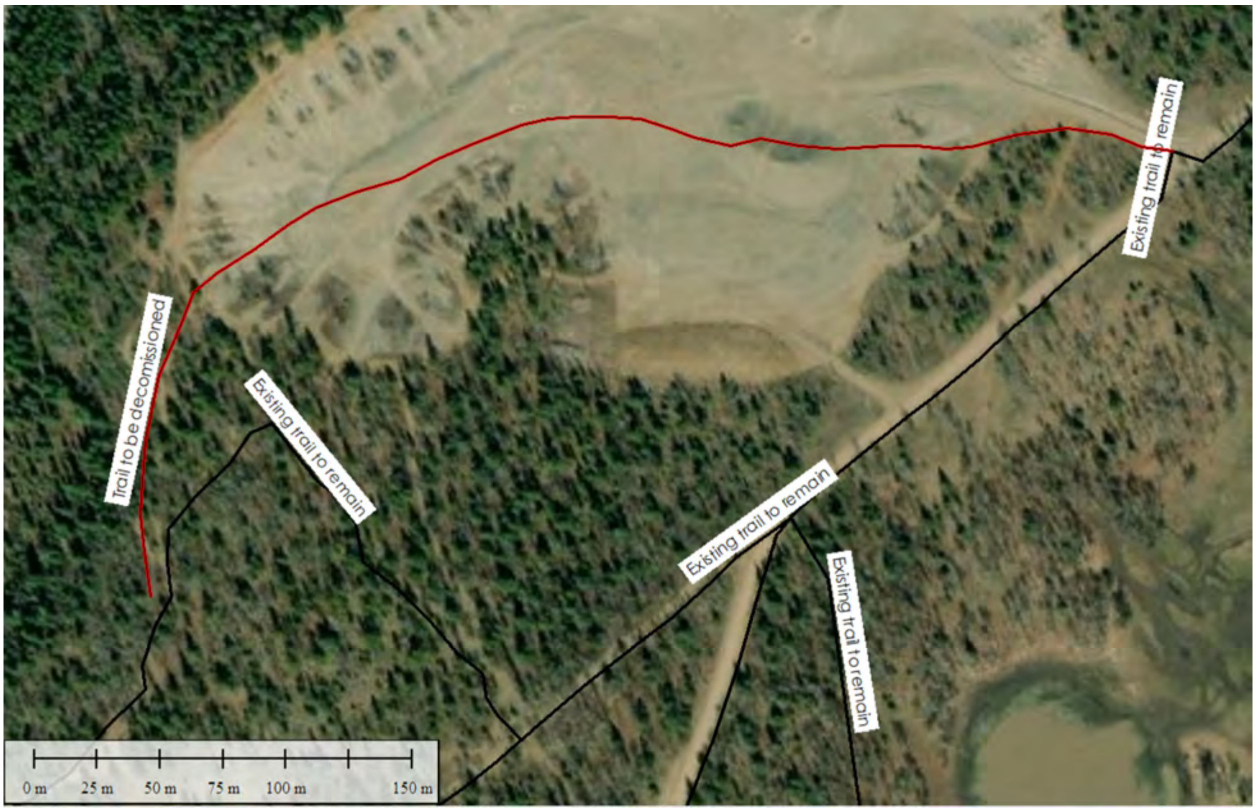
The remediation design measures are based on data provided by AEP, including a brief description of each site. Site photos and topographic survey of the sites were not available at the time of preparation of these design measures. Once the snow in these areas melts in spring 2022, Alberta Transportation will visit each of these sites to obtain site photographs and validate the proposed design measures. If site conditions vary considerably from those assumed herein, modifications to the designs to maximize the positive impacts to the watercourses may be completed.

7.5.3 Design Description

A brief description of the existing conditions at each of the sites as well as the conceptual design remediation measures are provided in the following sections. The naming convention used in this application (i.e., FID#) was provided by AEP Fisheries Management through high-level desktop data and has been carried forward in the proposed concepts below.

7.5.3.1 FID1

Remediation Site	FID1
Type	Trail Decommissioning
Existing Conditions Details	540 m long
Proposed Remediation Design	Trail Closure with Rollback (see Appendix L for Typical)

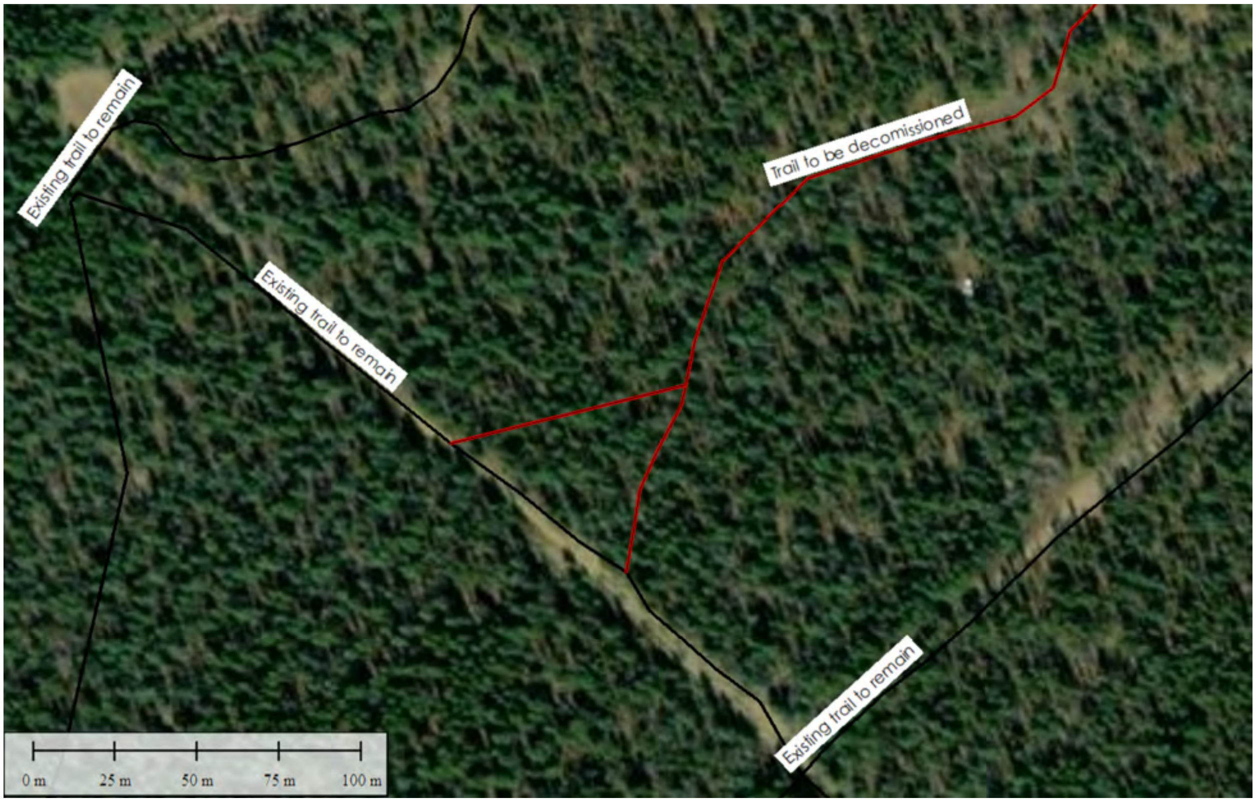


7.5.3.2 FID2

Remediation Site	FID2
Type	Trail Decommissioning
Existing Conditions Details	570 m long, includes fords
Proposed Remediation Design	Trail Closure with Rollback along trail (see Appendix L for Typical) Ford rehabilitation at ford locations (see Appendix L for Typical)

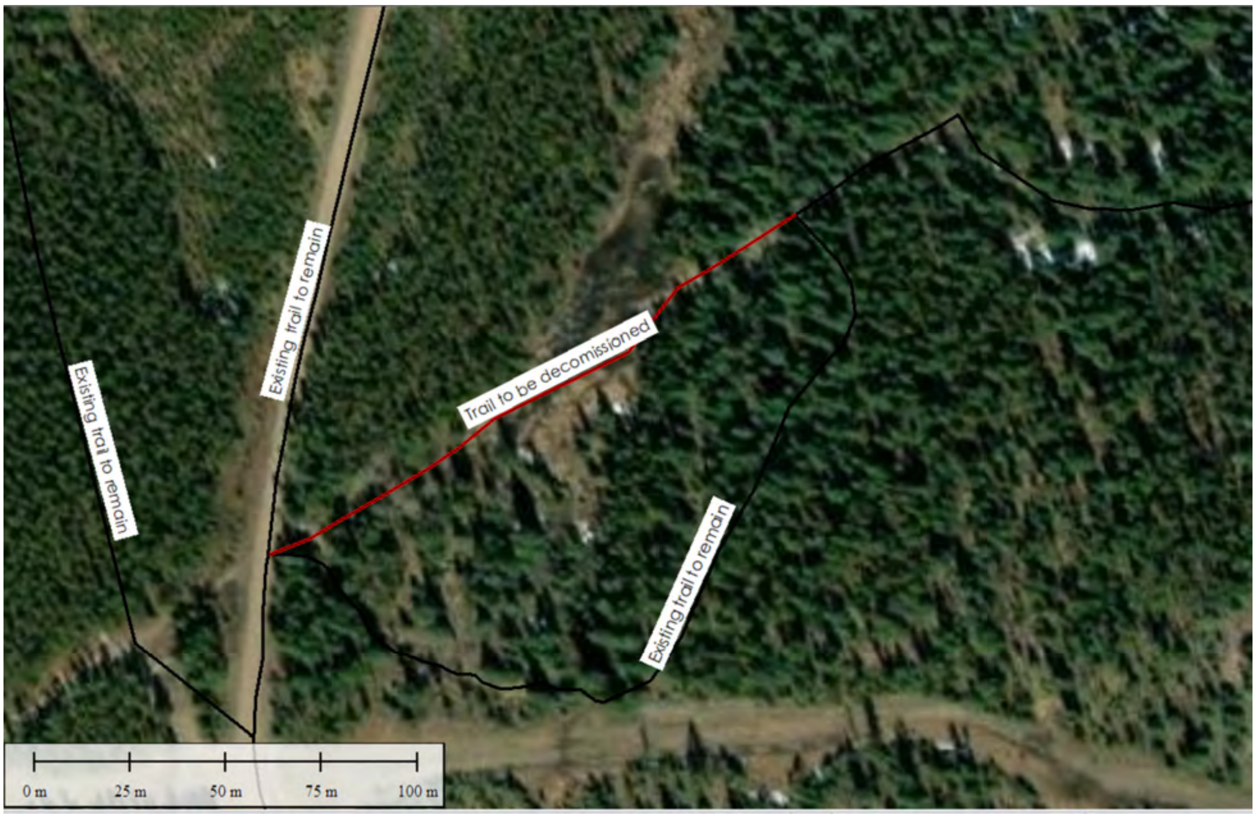
7.5.3.3 FID3

Remediation Site	FID3
Type	Trail Decommissioning
Existing Conditions Details	75 m long
Proposed Remediation Design	Trail Closure with Rollback along trail (see Appendix L for Typical)



7.5.3.4 FID4

Remediation Site	FID4
Type	Trail Decommissioning
Existing Conditions Details	165 m long, truck trail
Proposed Remediation Design	Trail Closure with Rollback along trail (see Appendix L for Typical) Ford rehabilitation at ford locations (see Appendix L for Typical)

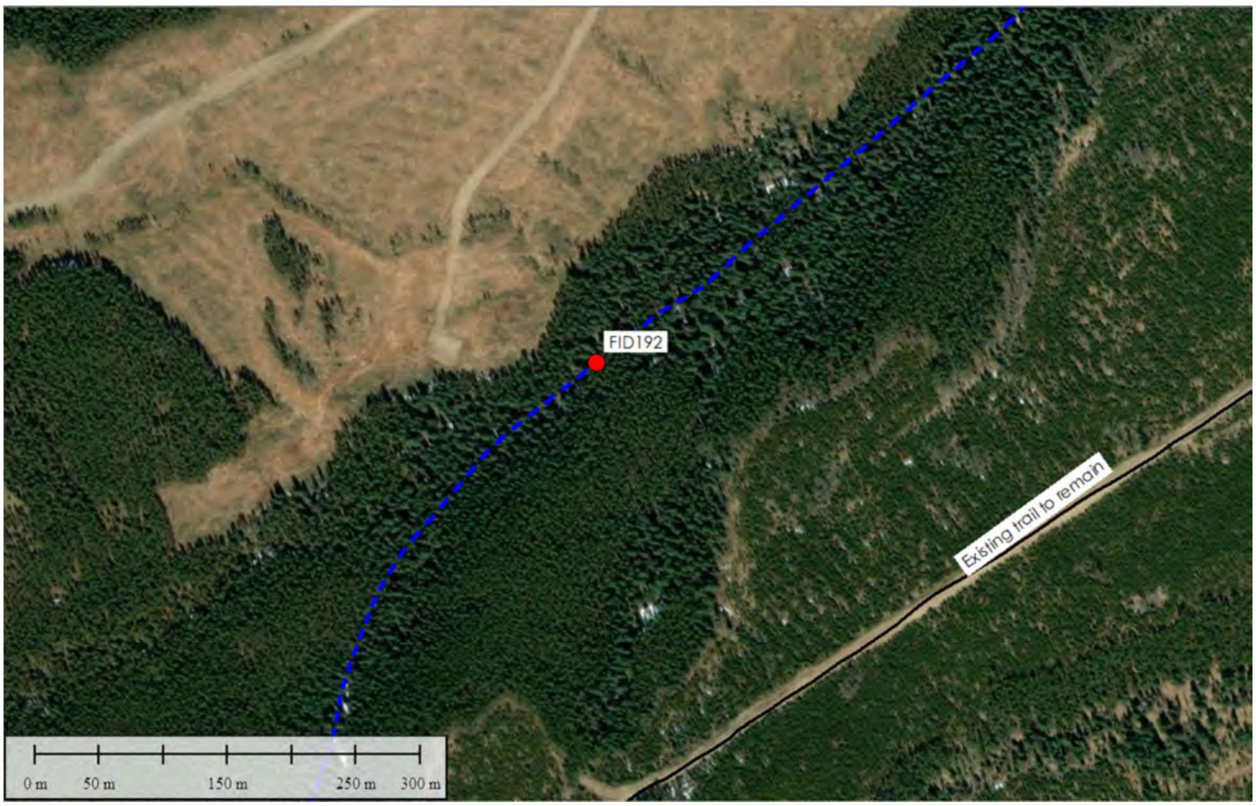


7.5.3.5 FID036

Remediation Site	FID036
Type	Properly functioning, at risk
Existing Conditions Details	Sedimentation due to trail upstream and livestock
Proposed Remediation Design	Install cobble ford to limit erosion and sedimentation (see typical drawing in Appendix L). Install wattle fence along watercourse to restore riparian health along banks (see typical drawing in Appendix L).

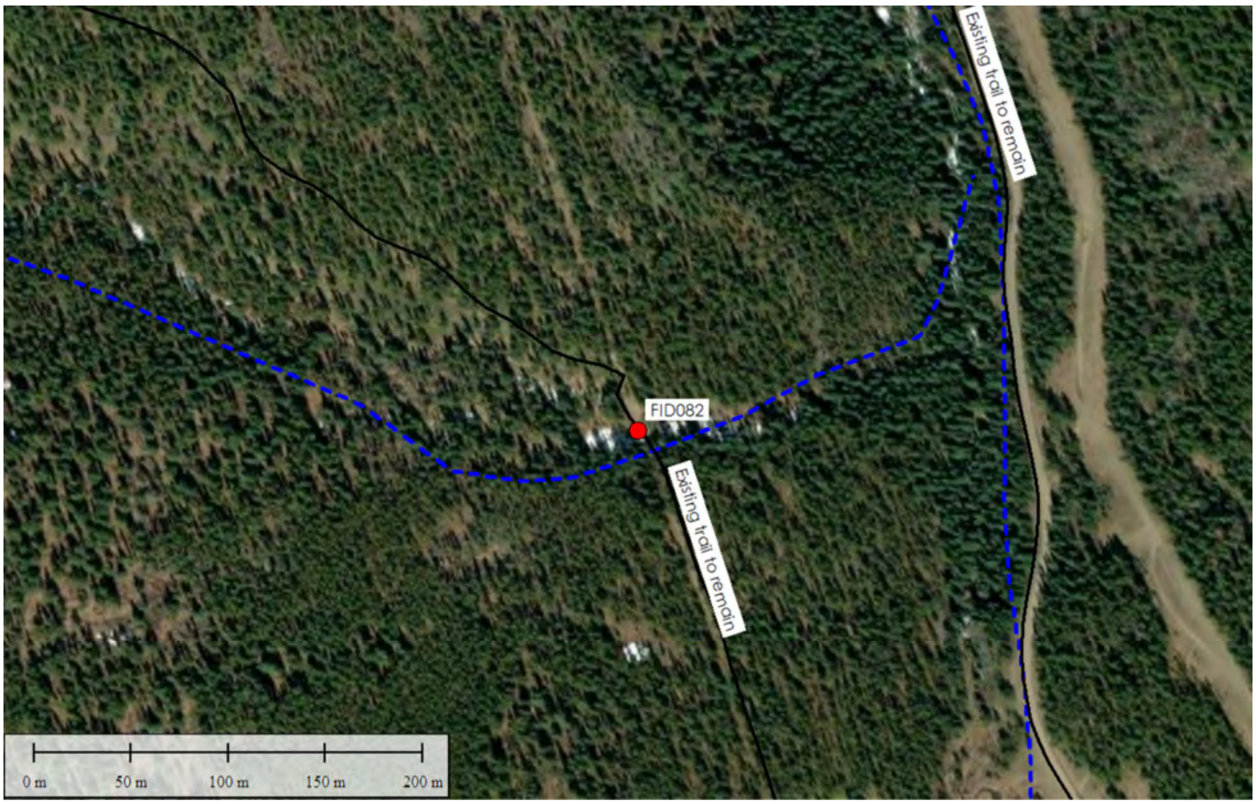
7.5.3.6 FID192

Remediation Site	FID036
Type	Properly functioning, at risk
Existing Conditions Details	Trampling due to livestock
Proposed Remediation Design	Install Post and Rail Fence and rollback (see typical in Appendix L) to direct livestock and trail users away from disturbed bank areas. Remediate banks and riparian area using live fascine rolls (see typical in Appendix L).



7.5.3.7 FID082

Remediation Site	FID082
Type	Properly functioning, high risk
Existing Conditions Details	Erosion and sedimentation issues due to road surface and ditches eroding
Proposed Remediation Design	Install cobble ford to limit erosion and sedimentation (see typical drawing in Appendix L)



7.5.3.8 FID020

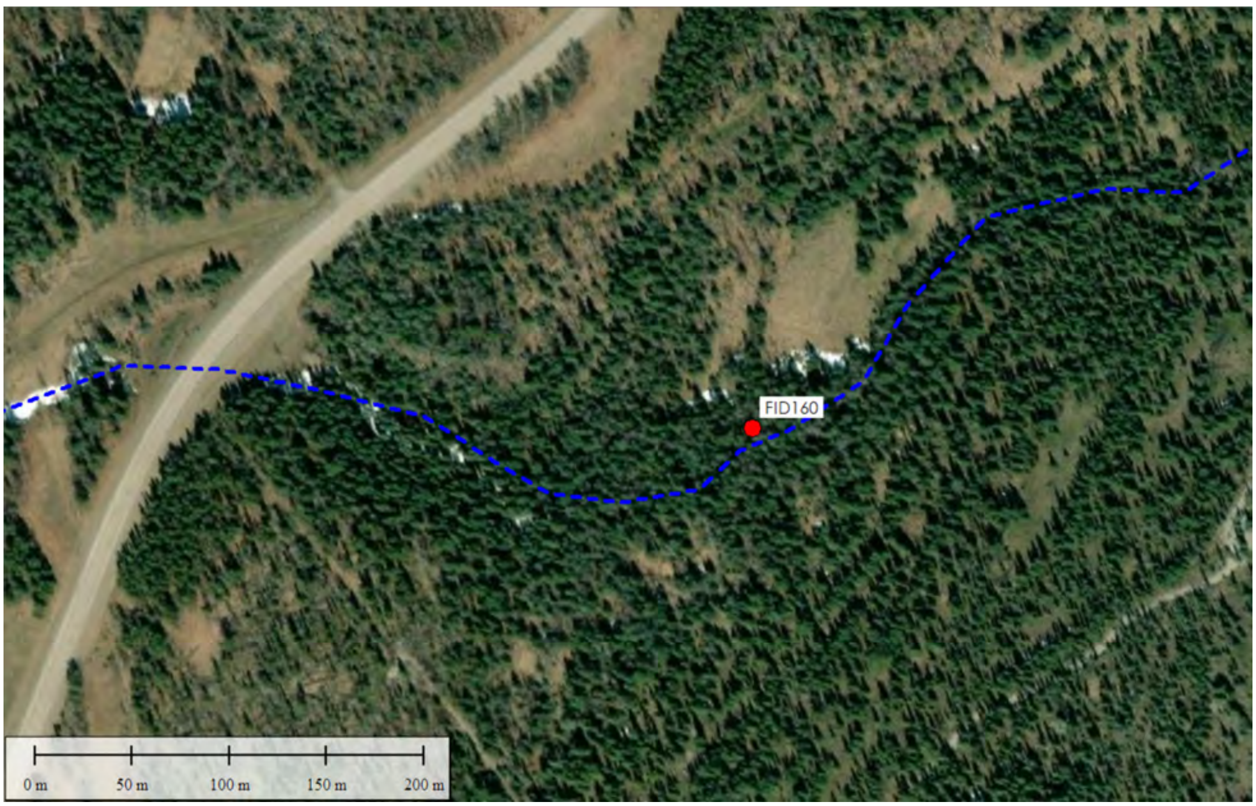
Remediation Site	FID020
Type	Properly functioning, high risk
Existing Conditions Details	Sediment and trampling issue due to livestock and recreation
Proposed Remediation Design	Install rollback adjacent to trail to reduce livestock and recreation impacts. Install riparian vegetation to limit sediment into the watercourse.

7.5.3.9 FID114

Remediation Site	FID114
Type	Properly functioning, high risk
Existing Conditions Details	Sedimentation issue due to culvert and road and livestock
Proposed Remediation Design	Install Post and Rail Fence (see typical in Appendix L) to direct livestock and trail users away from disturbed bank areas. Restore approximately 8 m of bank using coble toe, vegetated soil wraps and plantings on the upper bank (see Cobble toe with Soil Wrap Typical in Appendix L).

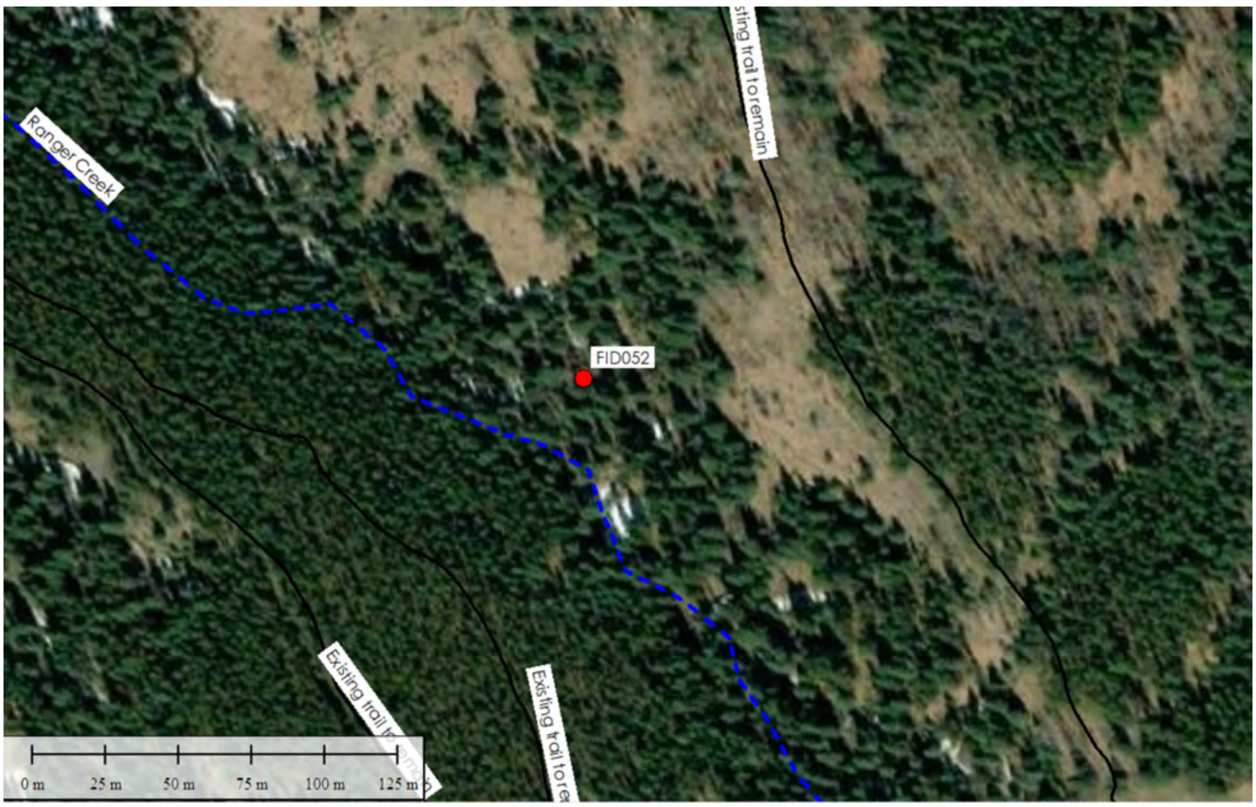
7.5.3.10 FID160

Remediation Site	FID160
Type	Not properly functioning
Existing Conditions Details	Sedimentation issue due to livestock
Proposed Remediation Design	Install Post and Rail Fence (see typical in Appendix L) to direct livestock and trail users away from disturbed bank areas. Restore approximately 8 m of bank using coble toe, vegetated soil wraps and plantings on the upper bank (see Cobble toe with Soil Wrap Typical in Appendix L).



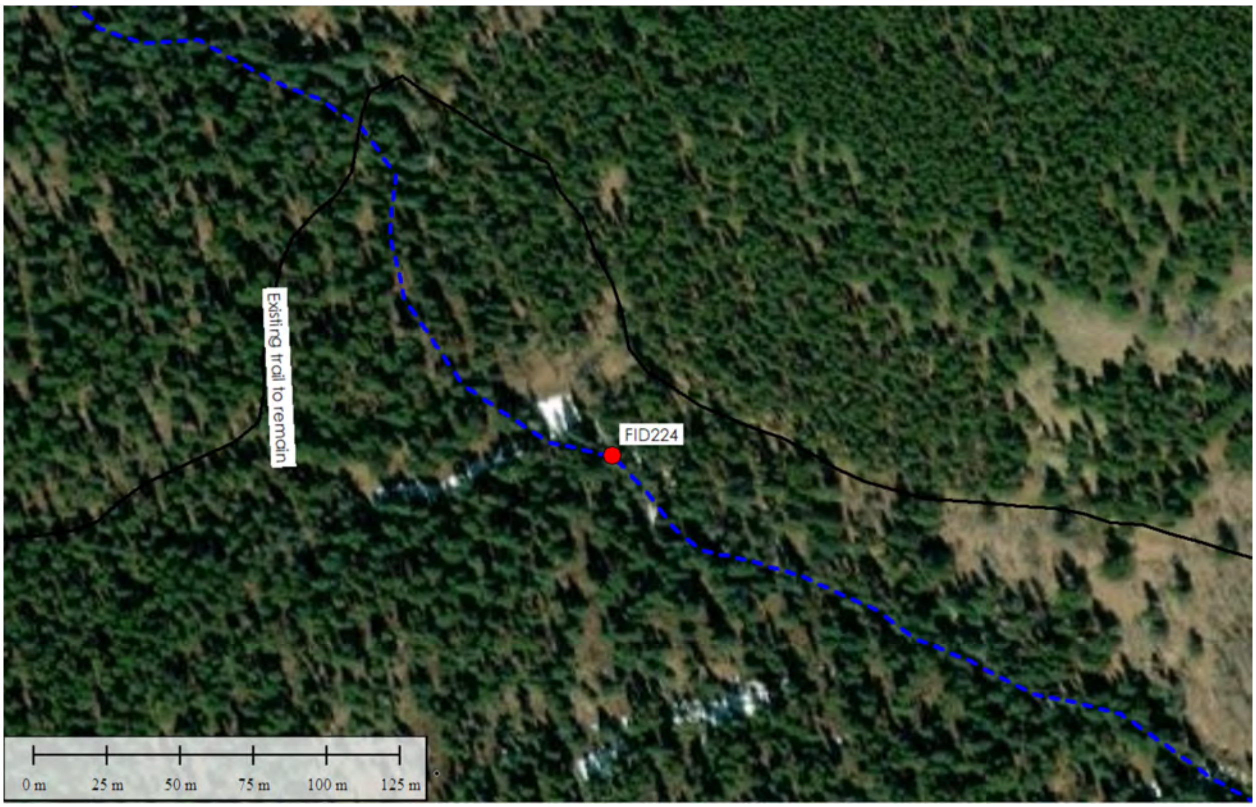
7.5.3.11 FID052

Remediation Site	FID052
Type	Properly functioning, high risk
Existing Conditions Details	Sedimentation issue due to recreation trails and livestock
Proposed Remediation Design	Install Post and Rail Fence (see typical in Appendix L) to direct livestock and trail users away from disturbed bank areas. Restore approximately 12 m of bank using coble toe, vegetated soil wraps and plantings on the upper bank (see Cobble toe with Soil Wrap Typical in Appendix L).



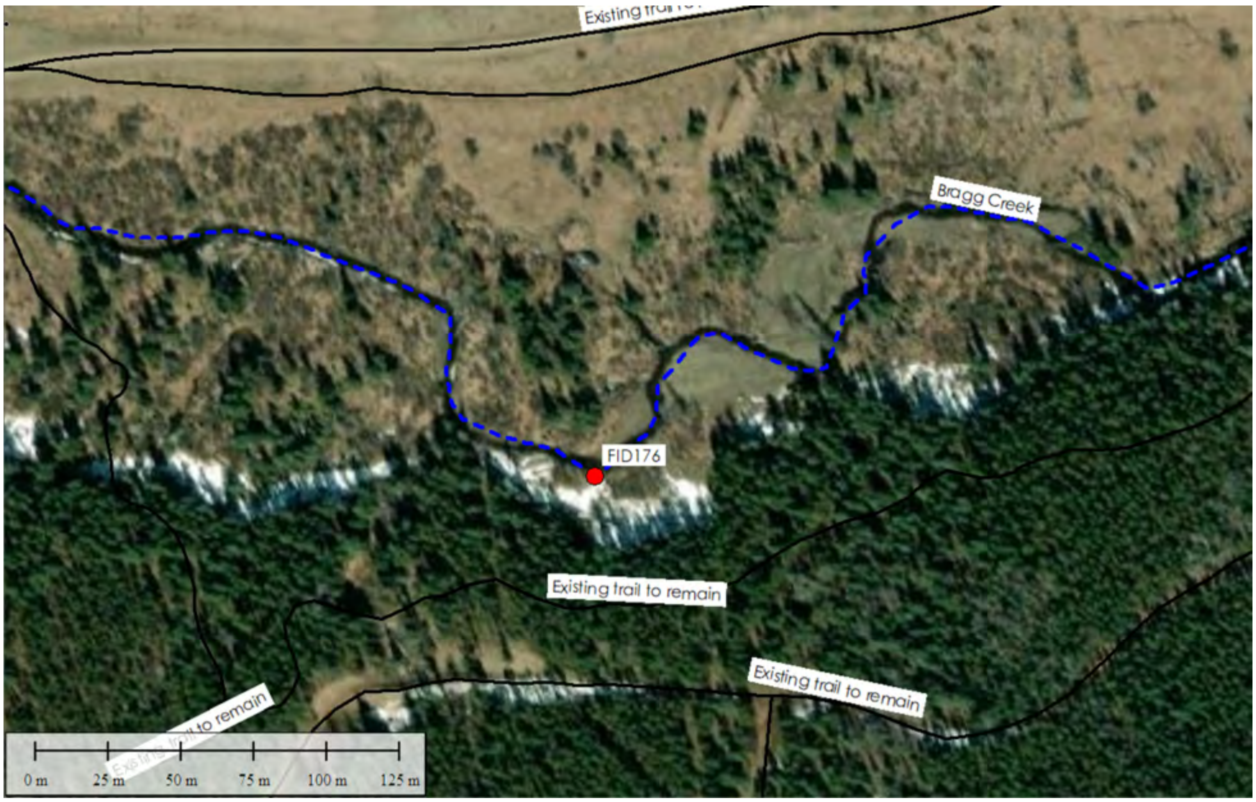
7.5.3.12 FID224

Remediation Site	FID224
Type	Properly functioning, high risk
Existing Conditions Details	Sedimentation issue due to trail and bridge upstream and livestock
Proposed Remediation Design	Install Post and Rail Fence (see typical in Appendix L) to direct livestock and trail users away from disturbed bank areas. Remediate banks and riparian area using live fascine rolls (see typical in Appendix L).



7.5.3.13 FID176

Remediation Site	FID176
Type	Not properly functioning
Existing Conditions Details	Sedimentation issue due to road issues, ditch issues and recreation.
Proposed Remediation Design	Road cross ditching and/or log waterbar to direct surface runoff away from watercourse and toward exiting vegetated area. Restore approximately 10 m of bank using coble toe, vegetated soil wraps and plantings on the upper bank (see Cobble toe with Soil Wrap Typical in Appendix L). Install signage to inform recreational trail users to avoid area while reclamation is undergoing.



7.5.4 Fish Habitat

The intent of the Elbow River Watershed Remediation Program is to improve riparian health and reduce sediment sources in the middle Elbow River watershed, in an area that provides known bull trout critical habitat. These measures provide an in-kind offset through improved habitat quality within the watershed, and an out-of-kind offset for the death of fish.

The reduction of sedimentation is assumed to improve habitat quality through direct improvements to water quality and substrate composition. Monitoring will be conducted prior to implementation of the remediation efforts to establish baseline water quality and substrate composition. It is expected that additional offset monitoring will be undertaken following remediation of the sites to confirm realized improvements.

High-level estimates of habitat quantity are included in this application based on an assumption that an improvement in water quality can result in an improvement to downstream habitat in the Elbow River. Over time, water quality improvements will lessen siltation to substrates and afford improved habitat for salmonid species that require cold clean gravels for spawning. Habitat calculations assume the following:

- Habitat improvements are based on the cumulative improvement of 9 drainage areas that currently contribute sediment to the Elbow River Watershed
- The total drainage area of the Elbow River watershed is approximately 1,220 km^2
- Each remediation site can be viewed as a measure that reduces sediment volume in the Elbow River drainage area, thereby improving water quality and habitat. Water quality improvements can translate to habitat unit enhancement over time, and a factor of 50% improvement of sedimentation in the drainage area will result in improved habitat units in the Elbow River
- Each remediation site can be viewed as a percent improvement to the Elbow River drainage area
  - For example, site FID082 has a drainage area of 2.59 km^2 or 0.21% of the flow to the Elbow River at any given time
  - The area of the Elbow River (i.e., Elbow Falls to Glenmore Reservoir) is 4,562,000 m^2 (as estimated through 1:20,000 Altalis hydrology layers)
  - It is assumed that sedimentation volume in FID082 can be reduced by 50%
  - Habitat enhancement = 4,562,000 m^2 * 0.21% * 0.5% = 4,850 m^2 of habitat area enhanced

Table 7.12 includes an estimate of habitat improvements calculated using the rationale above.

Table 7.12 Estimated Areas of Habitat Improvement through the Elbow River Watershed Remediation Program

FID	Drainage Area (km^2)	% of Elbow River Catchment	Habitat Improvements (m^2)
FID1	0.00	0.00%	N/A
FID2	0.00	0.00%	N/A
FID3	0.00	0.00%	N/A
FID4	0.00	0.00%	N/A
FID036	5.57	0.46%	10,400
FID192	1.08	0.09%	2,000
FID082	2.59	0.21%	4,850
FID020	2.23	0.18%	4,200
FID114	3.12	0.26%	5,850
FID160	3.13	0.26%	5,850
FID052	2.92	0.24%	5,450
FID224	0.45	0.04%	850
FID176	31.55	2.59%	59,000
		Total	**98,450**

7.5.5 Construction

Construction of the works will depend on the work area's proximity to the watercourse and disturbance required within the watercourse. The construction methodologies have been split into three types: (1) out of stream work, (2) bank work, and (3) instream work.

7.5.5.1 Out of Stream Work

Out of stream work includes work such as construction of fences, trail decommissioning, installation of roll back and similar work that does not involve work within the bed and banks of any adjacent watercourses. This work will be completed using erosion and sediment control best practices such as using temporary silt curtains and limiting the project footprint to the minimum to reduce impacts to existing vegetation. No isolation measures or fish rescues will be required for this work.

7.5.5.2 Bank Work

Bank work includes any proposed work from the top of bank to the toe of bank. This work will be completed during low flow periods and outside the restricted activity periods (if applicable). The bank work will be completed behind silt curtains or turbidity curtains (depending on flow conditions) to isolate the local bank from the watercourse. The isolation will not extend into the channel more than 1/3 of the existing channel width. Fish rescue and screened pumping from the isolated area will be required and completed.

7.5.5.3 Instream Work

Instream work includes proposed work that extends across the entire channel such as ford rehabilitation, installation of cobble fords, and similar work. This work will be completed using either a dam and pump flow bypass system or a culvert flow bypass system. Both methods will allow for the work area to be isolated from the creek at the upstream and downstream ends. Once isolated, a fish rescue will be completed within the work area. While construction is ongoing, groundwater inflow into the work area will be pumped to a vegetated area near the site.

7.5.6 Timing of Offset

The Elbow River Watershed Remediation Program is being proposed to counterbalance potential impacts to the Elbow River watershed as a result of Project flood operation. Pending acceptance by DFO, Alberta Transportation will collect baseline data, design the remediation sites, and apply for provincial regulatory approvals (e.g., Water Act, Public Lands Act) in 2022. This option will be implemented concurrently with construction of the Project (i.e., spring or summer 2023).

7.6 QUANTITATIVE ANALYSIS OF OFFSETTING MEASURES

Habitat offset quantities have been estimated from desktop analyses, and the Government of Alberta is committed to undertaking further field-based analyses to confirm quantities of each offset measure post-construction.

7.6.1 Consideration for Time Lags

The Project can be viewed as having two distinct schedules associated with activities that may result in effects to fish and fish habitat. Effects are associated with construction (i.e., habitat affected by footprint disturbance), and flood operation (i.e., habitat affected by change in flows, and death of fish due to entrainment). The effects associated with construction are driven by the schedule for instream work; whereas the effects associated with operation are based on the occurrence of future floods.

Alberta Transportation has proposed the Elbow River Side Channels offset measure as a ‘like for like’ solution that addresses habitat loss associated with the construction footprint. Construction of the Elbow River Side Channels is scheduled to coincide with construction of the Project; such time lag associated with loss of habitat is minimized for construction activities. A multiplier has not been proposed for construction offset requirements, because the habitat within the Elbow River Side Channels is expected to be functional as soon as flows are connected.

The schedule to implement the Brook Trout Removal Program and the Elbow River Watershed Remediation Program will be determined through further discussions with DFO. For the purposes of this Application for Authorization, it is assumed that the benefits of both operational offsets are functional prior to flood operation of the Project. For this reason, a multiplier has not been proposed for flood operation offset requirements. Should a flood occur prior to completion of the operational offset programs, the Government of Alberta will assume that a multiplier of 1.5 will be added to the offsets.

7.6.2 Estimated Quantities

The total offsetting quantities required as a result of HADD and Death of Fish related to the Project construction and operation are summarized in Table 7.13 below. Estimates are based on preliminary estimates for Death of Fish (Section 6.4.2) and habitat equivalency (Section 6.4.1), which will be refined through ongoing discussions with DFO. An updated analysis of offsetting measures will be provided accordingly. Net habitat values are presented for two scenarios; one in the event that operational offsets are implemented prior to a flood (i.e., no multiplier), and one where a flood occurs prior to the implementation of operational offsets (i.e., multiplier of 1.5).

Table 7.13 Quantitative Analysis of Project Effects and Offsetting Gains

Phase	Description	Habitat and Productivity Affected	Habitat and Productivity Gained
Construction	Permanent HADD	-1,839 m^2	+40,600 m^2 through Elbow Side Channels
	Temporary HADD	-16,761 m^2	
Operation	Permanent HADD	-78,747 m^2	+129,486 m^2 through brook trout removal program +98,450 m^2 through Elbow River Watershed Remediation +3,000 bull trout through Brook Trout Removal Program +2,000 native trout through Brook Trout Removal Program
	Death Fish (Bull Trout)	-537 bull trout	
	Death of Fish (Elbow River Non-Listed Species)	-17,653 m^2	
Totals		-115,000 m^2 and 537 bull trout	+268,536 m^2 habitat +3,000 bull trout +2,000 native trout
Net Habitat Area for Construction Footprint		+22,000 m^2	
Net Habitat Area for All Project Phases – if operational offsets are implemented before a flood occurs		+153,536 m^2	
Net Habitat Area All Project Phases – if a flood occurs before operational offsets are implemented[1]		+123,936 m^2	

NOTES:

Updated post-construction and post-flood operation monitoring will result in updates to the quantities presented above. Offset requirements will be evaluated on an ongoing basis through reports submitted to DFO based on a schedule determined by DFO.

1. Assumes that 144,600 m^2 offset would be required (a factor of 1.5 applied to 96,400 m^2 associated with operational HADD and death of fish) if the project is activated before operational offsets are implemented.

7.6.3 Habitat Banking and Scaling Effort in Offset Measures Plan

The quantitative analysis shown in Table 7.13 suggests that the proposed Offset Measures Plan may result in a net increase in habitat quantity of 153,536 m^2 if implemented prior to flood operation, or 123,936 m^2 if implemented after flood operation. Alberta Transportation requests that DFO recognize additional habitat realized through the Offset Measures Plan as banked habitat credit. Alternatively, the operational offsets will be sized to the scale of offset that is required to counterbalance effects of the Project. For example, this could be achieved through scaling the Brook Trout Removal Program (Section 7.4) to implement removal efforts at one or two waterbodies, rather than all three. Upon completion of post-construction monitoring efforts at these offset locations, habitat quantities could be re-evaluated as required (i.e., undertaking more offset effort, or banking excess habitat gained through the program). Scaling could also be achieved as part of the Elbow River Watershed Remediation Program (Section 7.5) by implementing a select number of remediation sites rather than all of the sites discussed in Section 7.5. Realized habitat would be verified through post-construction monitoring programs and offset requirements would be re-evaluated if required.

7.7 OTHER POTENTIAL OFFSET MEASURES

Alberta Transportation recognizes there are uncertainties associated with entrainment estimates related to death of fish associated with the Project. Factors causing this uncertainty include the frequency of Project operations, the magnitude of flood event, the fish populations in the Elbow River at the time of flood, the effectiveness of fish exclusion measures, the number of fish entrained by Project operations, the duration from Project activation to reservoir release, the number of fish that exit the reservoir through the lower outlet channel during reservoir release, and the effectiveness of fish rescue efforts.

To address this uncertainty, Alberta Transportation is proposing an adaptive approach for offsetting Project effects related to fish entrainment and fish mortality. This will allow appropriate offset measures to be established based on initial effects estimates and post-flood monitoring in a responsive and effective manner. Alberta Transportation's proposed approach to adaptively manage offsetting requirements is outlined in Section 7.2.

Alberta Transportation is proposing to offset Project effects through the measures described in Sections 7.3, 7.4, and 7.5 to satisfy the requirements of the *Fisheries Act* Authorization. It is understood that the *Fisheries Act* Authorization will encompass a specified period that may be shorter than the life of the Project (e.g., Authorization period may require renewal after 10 years) and Project effects will be reviewed upon Authorization renewal. Alberta Transportation proposes a monitoring approach described in Section 9.0 to track compliance with the conditions of the Authorization and will continue discussions related to compliance monitoring with DFO.

Alberta Transportation acknowledges that additional measures may be required in the future to remain in compliance beyond the initial Authorization period. Alberta Transportation will implement additional offsetting measures in the future, should post-flood monitoring or offset monitoring results (both further described in Section 9.0) suggest that the effects of the Project are larger than initially estimated subject to impacts of flood events in the future (i.e., size; frequency). Alberta Transportation shall enter into discussions with DFO upon review of the monitoring results in the future to determine the quantity and type of additional offset that might be required. Alberta Transportation is proposing several additional offset measures in the Elbow River watershed that can be included in the Authorization as needed, if additional offset is required in the future. These offset measures are presented in Table 7.14. These options would be investigated for feasibility as needed; and this list may be revised in the future if the proposed additional offsets are no longer feasible, or if new opportunities arise.

Table 7.14 Other Potential Offset Measures for the Project

Offset Measure	Description	Considerations
Genetic Studies on Native Trout Populations	The Government of Alberta can undertake studies on the genetic composition of native trout populations to further provincial fishery management objectives related to bull trout and westslope cutthroat trout population recovery.	• Complementary measure that does not require extensive regulatory approvals • Meets DFO Guiding Principles • Effort is directed to recovery of SARA-listed species • Project costs are moderate • Program objectives can directly address ongoing research initiatives for the province
Canyon Creek Rehabilitation	A preliminary review of historic imagery and site observations made in June 2021 suggests that the areas of Canyon Creek that experience hyporheic flow have increased since the 2013 flood and may be resulting in longer extents of ‘dry’ riverbed at low water levels. Fish movement between Canyon Creek and Elbow River is thought to occur during high water events when flow is continuous. It is possible that the bull trout population in the Elbow River is maintained through immigrations from the upper Elbow River or Canyon Creek (AEP 2021a). Proposed offsets could include the design of a channel in the middle reach of Canyon Creek to mimic pre-flood conditions. This includes narrowing of the active channel through re-establishment of a floodplain and providing a deeper channel profile in effort to daylight the flow and maintain bedform features and habitat. Canyon Creek excavations could be designed to re-introduce instream habitat complexity through bends, pools, riffles, and runs. Riparian vegetation could be installed in areas where cover is limited to increase habitat complexity through overhead cover and shade. Re-introducing habitat complexity may improve habitat within Canyon Creek for resident species to carry out their life stages.	• Located on public land, approvals can be secured within 1 year of design and time lag to achieving habitat is short. • Habitat surface areas are high. • Meets DFO Guiding Principles. • Located within an area that is mapped critical habitat for bull trout and meets Bull Trout Recovery Strategy. • Located within an area that has bull trout and westslope cutthroat trout. • Can be designed for low flood resiliency. • Ongoing maintenance would be required. • Project costs are moderate. • Project could be scale to omit channel excavation and focus on riparian plantings and woody debris installations.

Table 7.14 Other Potential Offset Measures for the Project

Offset Measure	Description	Considerations
Milburn Creek Tributary and Confluence Enhancements	Milburn Creek enters the Elbow River at River Spirit Golf Course and is highly modified. Habitat enhancement and creation at the confluence of Milburn Creek to provide improved refuge habitat. Milburn Creek is downstream of the Project and this option aims to enhance refuge habitat that fish will seek during a flood.	• Located on private land, would require an agreement with the River Spirit Golf Course to construct improvements. • Habitat surface area is low. • Meets DFO Guiding Principles. • Tributary is not mapped critical habitat, but improvements could indirectly improve critical habitat through water quality improvements. • Location benefits from flood resiliency achieved with the Project (i.e., downstream of the diversion structure); habitat can be made available for an extended duration of time. • Addresses Indigenous group concern of keeping offsets localized to the Elbow River watershed. • Project costs are low to moderate.
Egg Incubation Boxes	Egg incubation boxes are devices that contain fish eggs for natural incubation in the river. This option would commit the Government of Alberta to instate a naturalized stocking program to rear resident trout species. The program could include a variety of trout species but there is opportunity to focus on species like bull trout. This effort would be ongoing, and not exclusive to a flood event given the time and investment required to establish the program. Egg incubation boxes could be added to the main channel of the Elbow River or included as an additional feature of another offsetting site, such as the Elbow River Side Channel or Canyon Creek.	• Due to the nature of the offset option, land acquisition or flood resiliency is not of concern. • Precedent exists for similar programs within the Government of Alberta. • Provides an opportunity for in-kind offsets for fish mortality, can be implemented in an episodic manner. • Addresses Indigenous group concern of keeping offsets localized to the Elbow River watershed., as egg boxes can be added to the main stem of Elbow River or one of its tributaries. • Project costs are moderate.

Table 7.14 Other Potential Offset Measures for the Project

Offset Measure	Description	Considerations
McLean Creek Culverts and Sediment Management	The McLean Creek Public Land Use Zone (PLUZ) is a very popular off-roading area. The disturbance to the creeks in the PLUZ from the off-highway vehicle (OHV) use has increased the rate of sediment release into McLean Creek, and subsequently the Elbow River. In the absence of land use changes (whether it is partial or full closure of the area), offsets in the McLean Creek area are not expected to provide large-scale changes in sediment control or measurable improvements to the Elbow River watershed. This is because most of the sedimentation in the McLean Creek area appears to be a result of trail rutting and runoff, rather than water crossings. Offsetting at McLean Creek could include settling ponds constructed on each of the main tributaries to McLean Creek pond and immediately upstream of the pond itself. The ponds would need a considerable amount of residence time for settling because of the fine particle size of the sediment observed in the creek. The offsetting could also include the re-connection of the larger McLean Creek to the Elbow River by implementing culvert passage improvements at the Highway 66 and McLean Creek Trail and Highway 54. A naturalized fishway can be retrofitted to the McLean Creek pond dam and there appears to be sufficient space to do this an effective manner. Improvements to fish passage would only be done in conjunction with land-use changes, in order to avoid the encouragement of fish movement into an area that could result in fish mortality. Erosion control measures would inherently require the closure of select trails and fordings or land use changes. Erosion and sediment control measures alone would be insufficient without exclusion and enforcement. A localized approach to exclusion of OHVs, which targets high impact areas, may be an option , but may lead to uncertainty regarding the realized benefits of offsetting. Potential changes to the use of the site for this purpose would have to be balanced against the popularity of the area for those uses.	• Success of the offsetting enhancements relies on land use changes within a PLUZ that currently accommodate off-highway vehicles. Such land use changes would require extensive public consultation that could result in a time lag of years to achieve intended benefits to habitat with no guarantees of an actual change in land use. • Habitat surface areas are moderate. • Meets DFO Guiding Principles. • Tributary is not mapped critical habitat for bull trout, but improvements could indirectly improve critical habitat through water quality improvements. • Design could provide moderate flood resiliency. • Addresses Indigenous group concern of keeping offsets localized to the Elbow River watershed. • Project costs would be high.

Table 7.14 Other Potential Offset Measures for the Project

Offset Measure	Description	Considerations
Elbow River Constructed Habitat	Bioengineered enhancements can be designed along the Elbow River to increase bank habitat complexity. Features such as root wads, tree revetments, boulder clusters, and substrate improvements can be included. Locations are flexible and multiple sites can be proposed. Alberta Transportation can rely on the habitat suitability index (HSI) model that was developed for the Project to target areas currently provide limited habitat for bull trout.	• Located on public land, approvals can be secured within 1 year of design and time lag to achieving habitat is short. • Habitat surface areas are low to moderate. • Partially meets DFO Guiding Principles; this is because the offset aims to enhance areas that currently provide some habitat complexity and the realized benefit may be low. • Located within an area that is mapped critical habitat for bull trout and meets Bull Trout Recovery Strategy. • Bull trout abundance in this area is low and offset requirements would be partially fulfilled. • If constructed downstream, location benefits from flood resiliency achieved with the Project (i.e., downstream of the diversion structure); habitat can be made available for an extended duration of time. Moderate flood resiliency if located upstream of the Project. • Ongoing maintenance would be required. • Addresses Indigenous group concern of keeping offsets localized to the Elbow River watershed. • Could result in mixed perception from the public, if efforts are directed to an area of the Elbow River that is currently undisturbed. • Project costs are moderate to high.

Table 7.14 Other Potential Offset Measures for the Project

Offset Measure	Description	Considerations
Kananaskis River Realignment Enhancements	The Kananaskis River was straightened and armored as part of the construction of the Highway 40 corridor. The straightening has also resulted in increased flow velocities in the Kananaskis River during higher flows, and reduced habitat value through this section of the river. Options at this site include the construction of cover along the riprap in the straight sections of the Kananaskis River using woody debris secured with riprap. The works would be in the right bank because of the access, and would be limited to the bank structure. The channel currently has some variability and the rock and wood structures will further enhance it for passage and refuge during high flows. Overbank cover quality is good, but further bioengineering of the bank by retrofitting the disturbed area with joint planted willows could improve shade. The Kananaskis River is not regulated for flood control, but the Upper and Lower Kananaskis Reservoirs do inherently provide some flood control relief. That noted, this site is also downstream of some very large mountain tributaries and flood risk is still very high. Cabling woody debris must be avoided because of navigation hazards; therefore, rock and wood bracing must be used to secure the wood to the bank.	• Located on public land, approvals can be secured within 1 year of design and time lag to achieving habitat is short. • Habitat surface areas are low to moderate. • Partially meets DFO Guiding Principles; this is because the offset aims to enhance areas that currently provide some habitat complexity and the realized benefit may be low. • Located within an area that is mapped critical habitat for bull trout and meets Bull Trout Recovery Strategy. • Located within an area that has bull trout. • Can be designed for moderate flood resiliency. • Ongoing maintenance would be required. • Is located outside of the Elbow River watershed; therefore some concerns may be raised by Indigenous groups regarding the value of the offsets. • Project costs are moderate.

Table 7.14 Other Potential Offset Measures for the Project

Offset Measure	Description	Considerations
Side Channel to Kananaskis River at Mount Lorette Pond	The Kananaskis River Realignment discussed above includes river modifications that have isolated a historic oxbow and created the Mount Lorette Pond. The pond is a popular day-use area with wheelchair accessible fishing. A side channel to the Kananaskis River could be designed where Mount Lorette pond currently exists. The day-use area may need to be removed or re-designed to accommodate the side channel. Flood resiliency considerations given above to the Kananaskis River realignment would also apply to design of this site. In addition, Highway 40 would cross the side channel at two locations and design considerations would have to be given to appropriate highway crossings.	• Located on public land, approvals can be secured within 1 year of design and time lag to achieving habitat is short. • Habitat surface areas are low to moderate. • Partially meets DFO Guiding Principles; this is because the offset aims to enhance areas that currently provide some habitat complexity and the realized benefit may be low. • Located within an area that is mapped critical habitat for bull trout and meets Bull Trout Recovery Strategy. • Located within an area that has bull trout. • Can be designed for moderate flood resiliency. • Ongoing maintenance would be required. • Is located outside of the Elbow River watershed; therefore some concerns may be raised by Indigenous groups regarding the value of the offsets. • Project costs are moderate. • Project is located within a popular day use area and the loss of the area may not be acceptable to the public.

Table 7.14 Other Potential Offset Measures for the Project

Offset Measure	Description	Considerations
Side Channel to Kananaskis River Near Kananaskis Village	A side channel to the Kananaskis River could be designed near Kananaskis Village. Options could include the addition of a walking trail to integrate visitor experience. Flood resiliency considerations given above to the Kananaskis River realignment would also apply to design of this site.	• Located on public land; however, the location is within the undistributed landscape of the provincial park and approval timing could be delayed by consultations. • Habitat surface areas are moderate. • Meets the DFO Guiding Principles. • Located within an area that is mapped critical habitat for bull trout and meets Bull Trout Recovery Strategy. • Located within an area that has bull trout. • Can be designed for moderate flood resiliency. • Ongoing maintenance would be required. • Is located outside of the Elbow River watershed; therefore some concerns may be raised by Indigenous groups regarding the value of the offsets. • Project costs are high. • Project is located within undistributed landscape within the provincial park and construction timing may conflict with wildlife habitat use.

Table 7.14 Other Potential Offset Measures for the Project

Offset Measure	Description	Considerations
Ghost River Re-instatement of Roads or Bridge Fords	This option is located at the far west end of the Ghost River road, where the road now terminates at a flood damaged crossing. Recreational users who aim to access the rock climbing features in the headwaters of the Ghost River currently ford the river at several AEP designated locations. This remote section of river can see a surprising amount of vehicle traffic through the river because of its popularity as a climbing destination. These ford crossings can have an impact on water quality and fish habitat (including SARA listed bull trout). The fordings are signed by AEP; however, navigation is sometimes difficult, and it is anticipated that many users ford where convenient. The offsetting options here could include stabilizing stream bed to facilitate or better formalize the vehicle crossing. This could reduce the amount of sediment release at the designated fordings. A more comprehensive approach to this reach of the Ghost River would be to re-construct the low-grade service road and bridges to eliminate the conflict between the fish and the recreational users. In 2013 the Ghost River experienced flooding that washed out much of the floodplain. Floodwaters were highly turbulent and carrying a considerable amount of debris. These floodwaters damaged the existing road infrastructure. Fording upgrades would need to consider flood resiliency.	• Road is owned by TransAlta and would require a third-party agreement to undertake the work. The time lag associated with securing an agreement to proceed with construction is unknown. • Portion of road where offset it proposed is only accessed infrequently by recreationalists and there may be limited harm from the designated fording sites and in the coarse substrate and dynamic environment (i.e., realized habitat value is uncertain). • Habitat surface areas are moderate. • Meets DFO Guiding Principles. • Located within an area that is mapped critical habitat for bull trout and meets Bull Trout Recovery Strategy. • Located within an area that has bull trout and westslope cutthroat trout. • Can be designed for moderate flood resiliency. • Ongoing maintenance would be required. • Is located outside of the Elbow River watershed; therefore some concerns may be raised by Indigenous groups regarding the value of the offsets. • Project costs are high.

Table 7.14 Other Potential Offset Measures for the Project

Offset Measure	Description	Considerations
Barrier Dam and Flow Stabilization on Kananaskis River	The Kananaskis River flows are currently driven by hydropeaking operations that have led to decreased habitat suitability for bull trout and westslope cutthroat trout. Dams on the river have also introduced barriers to fish movement. A fishway at Barrier Dam could be constructed to re-connect fish passage in the Lower reach of the Kananaskis River which would, in turn, connect it to large portions of the Bow river upstream of the Kananaskis Dam at Highway 1A. The next upstream most artificial barrier on the Kananaskis River would then be at Pocaterra Dam, which impounds Lower Kananaskis Lake. Barrier Dam is of considerable height (visual estimate is 50 m) and the downstream channel is confined by a narrow canyon. There are limited options for fish passage mitigation measures due to this geometry. A fishway here would likely need to be a synthetic ladder structure such as a denil or step-pool. Assuming a minimum of 5:1 H:V slope, the structure would need to extend (or zig-zag) a length of 250 m or more, into the canyon. This is conceptually the minimum geometry to provide passage for adult sportfish and the structure would need to be longer, to be a shallower slope for juveniles. The design of a structure would also be challenged by varying water levels on barrier lake form hydro operations and may make such an arrangement not feasible. Behavioral characteristics of fish species on the Kananaskis River may also challenge success in achieving passage at such a structure. Option to modify water license and operating conditions at Barrier Dam and Kananaskis Lakes Dam to stabilize flow within the Kananaskis River and increase habitat suitability for native species. This offset measure would likely result in costs and benefits far above the requirements for a single project. If the Government of Alberta were to pursue this option, Alberta Transportation expects the Project's contribution to the costs of the option to be commensurate to the offsets required for the Project. Alberta Transportation notes that this option would require third-party agreements with TransAlta and potential engagement with Indigenous groups and other stakeholders.	• Option would require a third-party agreement with TransAlta to modify flows that are currently within their operational license. The time lag associated with securing this agreement is unknown, but could take years. • The cost to offset lost hydro production would be on an annual basis and far in excess of a typical offset. • Realized habitat value is unknown. It is possible that TransAlta's flows currently meet instream flow needs for the area; would require modelling to quantify further benefits to the ecosystem. • Chance of success in providing fish passage at Barrier Dam is deemed to be low. • Assume to partially meet DFO Guiding Principles, would require more studies to evaluate benefits. • Located within an area that is mapped critical habitat for bull trout, could provide broad benefits to the area if habitat value is realized. • Due to nature of the project, flood resiliency can be achieved. • Is located outside of the Elbow River watershed; therefore some concerns may be raised by Indigenous groups regarding the value of the offsets. • Project costs are high.

7.7.1 Complementary Measures

In addition to the offset measures identified in Table 7.7, Alberta Transportation has identified the following complementary measures that could be applied to offset the loss of productivity associated with the Project:

- Provide some support for a fish population research study on a reference river in southern Alberta that has a bull trout population. Implementing similar field methodology to the 2021 Elbow River Fish Population Assessment may provide insight into bull trout population trends. This information can further inform DFO and AEP of potential effects of Project operation and can guide fishery management decisions regarding recreational fishing activity in the Elbow River.
- Flood damage repair for fish habitat in the upper Elbow River watershed following a future flood event. AEP has undertaken fish habitat enhancements for flood damage repair following the 2013 flood, through the Southern Alberta Fisheries Habitat Enhancement and Sustainability (FISHES) Program. A similar type of enhancement project could be undertaken in the future to correspond to flood operation and flood impacts in the upper Elbow River.
- A forest hydrology and water quality study of the upper Elbow River watershed could be undertaken. This study would help better understand the City of Calgary's source water protection needs in the Elbow River watershed and facilitate future planning needs that may have cumulative effects with flood operation.