AQUATIC ENVIRONMENT ASSESSMENT
BRAGG CREEK FLOOD MITIGATION PROJECT
BRAGG CREEK, ALBERTA

Submitted to:

Alberta Environment and Parks

Submitted by:

Amec Foster Wheeler Environment & Infrastructure

On behalf of:

Rocky View County

July 2017

CT160213

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1.0 INTRODUCTION

The Hamlet of Bragg Creek is located in the foothills of the Rocky Mountains approximately 40 km southwest of the City of Calgary (Figure 1). A significant portion of the Hamlet is located within the floodplain of the Elbow River. The 2013 flood devastated many areas of the Hamlet and resulted in extensive damage to infrastructure, businesses and residences. Damages also included long-term financial loss to businesses due to interruption of services.

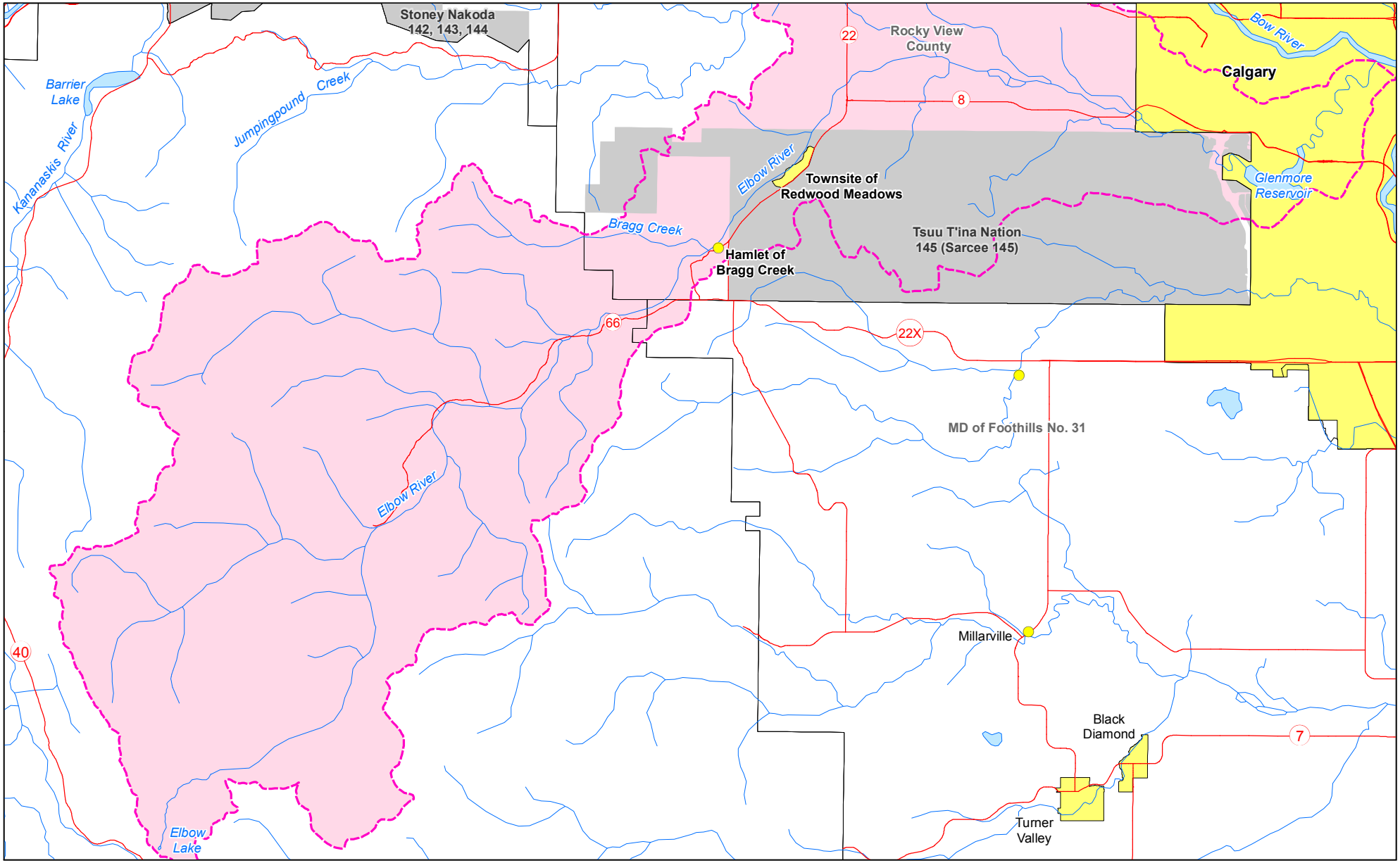
Following the flood, a conceptual flood mitigation design was developed for the Alberta Government's Southern Alberta Recovery Task Force. Rocky View County (RVC) then had a preliminary design for the flood mitigation developed and has received endorsement by the Province. RVC retained Amec Foster Wheeler Environment & Infrastructure (Amec Foster Wheeler) to proceed with detailed design and public consultation to complete the Bragg Creek Flood Mitigation Project. The flood mitigation project consists of barrier systems (dikes) on either side of the Elbow River and the confluence of Bragg Creek to protect flood prone areas. One barrier system will be located on the east side of the river and three barrier systems are proposed on the west side of the river. The total barrier system length is approximately 3.9 km.

1.1 Scope of Work

RVC also retained Amec Foster Wheeler to undertake the aquatic habitat assessment and assist in the preparation of environmental approval applications. The proposed works are subject to the requirements of the provincial *Water Act* and the federal *Fisheries Act.* This report provides baseline information regarding the aquatic environment in the vicinity to the proposed works, and is intended to support the Alberta Environment and Parks (AEP) *Water Act* application.

This report contains:

- the results of the aquatic habitat assessment;
- a fish habitat evaluation;
- an assessment of potential impacts to fish and fish habitat from the proposed works;
- mitigation measures; and
- Qualified Aquatic Environmental Specialist (QAES) recommendations.



Legend

Community | Lake | Elbow River Basin
Reserve Land | River | Highway

Sources: Calgary Regional Partnership
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DATE: June 2017	PROJECT: CT160213
PROJECTION/DATUM: 10TM/NAD83	ANALYST: JH

Rocky View County

Bragg Creek Flood Mitigation

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Location Map

Figure 1

2.0 METHODS

2.1 Background Information Review

Prior to completing the field survey, background information on fisheries resources in the Elbow River and Bragg Creek near the proposed project area was reviewed, e.g., fish inventories and the Fish and Wildlife Management Information System (FWMIS) database (AEP 2017).

2.2 Field Survey

An aquatic assessment and spawning survey was completed to verify existing fish habitat conditions and identify critical habitat that could potentially be affected by the proposed project. The aquatic habitat assessment and spawning survey on the Elbow River was conducted on 4 and 5 October 2016 by two Amec Foster Wheeler QAES. Additional habitat data on Bragg Creek was collected on 22 June 2017.

The aquatic assessment methods described in the following sections are in accordance with standard protocols outlined in the Guide to the Code of Practice for Watercourse Crossings (AENV 2001) and Alberta Transportation's (AT) Fish Habitat Manual (AT 2009). A spawning survey was conducted following standard Amec Foster Wheeler procedures.

2.2.1 Study Area

The study area was delineated relative to the proposed project to include the Elbow River 500 m upstream and 1,000 m downstream of the proposed project area, for a total of 3.9 km. This encompassed the anticipated zone of influence, based on the location of instream works and the substrate characteristics of the system (AENV 2001). A total of thirteen transects were surveyed over the study area.

Additionally, Bragg Creek was surveyed from the confluence with the Elbow River to approximately 100 m upstream. Within this section, five transects were surveyed on Bragg Creek.

2.2.2 Aquatic Habitat

At each transect, the following physical parameters were measured: channel width, wetted width, water depth, percent composition of pool/riffle/run/flat habitat types, bank shape/texture, riparian vegetation and bed material composition.

Other general stream features such as presence of bars, bank stability and percent composition of instream cover types were based on observations over the entire study area. In-situ water quality parameters were also recorded and included water temperature, specific conductance, dissolved oxygen (DO) and pH measurements. Geographic coordinates were recorded at all sites with a hand-held global positioning system (GPS) receiver. Digital photographs were taken to document dominant stream characteristics and important habitat features.

Fish habitat within the study areas were described using the classification system developed for small rivers and streams (R.L. & L. 1994; AT 2009).

2.2.3 Fish Inventory

Fish inventory information was compiled from the background information review. Fish presence and habitat use is well documented for the Elbow River and Bragg Creek, therefore, no fish sampling was conducted as part of the field assessment.

2.2.4 Spawning Survey

A spawning survey was completed along the entire surveyed area of the Elbow River. The QAES were evenly spread out across the river channel carefully wading upstream and scanning the river bottom. Fish spawning nests, also known as redds, were identified as conspicuous circular to oblong patches of recently cleaned substrate that contrast the surrounding substrate. Redds typically have a depression from the surrounding substrate and may have a 'mound' on the downstream end of the disturbance. If identified, redds would be measured, photographed and their location geo referenced with a GPS.

2.2.5 Fish Habitat Evaluation

Species specific habitat evaluations were based on the following criteria:

- habitat characteristics;
- fish species habitat requirements for various life stages;
- migration impediments; and
- professional judgement.

The criteria used to assess habitat quality and suitability was as follows:

- Poor – the aquatic environment does not provide basic habitat requirements to complete any part of a fish's life cycle; provides habitat for only a short period of each year, if at all; and it provides habitat for a limited number of fish or fish species; and no measurable contribution to the overall productive capacity of a system.
- Moderate – the aquatic environment possesses some of the habitat requirements to complete portions of the fish's life cycle, i.e., provides a capacity for fish production for a limited portion of the year, or for only part of the life stages of local fish (e.g., the study area may provide productive habitat during spring and/or summer, but become dry, anoxic or frozen for the remainder of the year).
- Good – the aquatic environment provides year-round habitat for a variety of fish species through all or most life stages (i.e., overwintering, spawning, rearing) and feeding habitat.

Habitat preferences of potential resident fish species in the Elbow River and Bragg Creek are provided in Appendix A.

3.0 AQUATIC HABITAT CHARACTERISTICS AND FISHERIES RESOURCES

General and local watershed characteristics, resident species and fish habitat are described in the following sections. Fish habitat maps are provided in Appendix B and field assessment data is provided in Appendix C.

3.1 Stream Classification

The Elbow River and Bragg Creek are Class C waterbodies based on AEP's Code of Practice for Watercourse Crossings – Calgary Management Area Map (ESRD 2012). Downstream of the Bragg Creek confluence, the Elbow River has a restricted activity period (RAP) that extends from 1 May to 15 July and 16 September to 15 April. Bragg Creek and the Elbow River above the confluence of Bragg Creek have a RAP extending from 1 September to 15 August.

3.2 Elbow River

3.2.1 Channel and Bank Characteristics

Within the study area, the Elbow River flows in an irregular meandering pattern through the Hamlet of Bragg Creek. Within the study area, the river has a moderate gradient (1%) and is frequently confined by the river valley and residential development (Appendix C).

Above the Balsam Avenue Bridge, the habitat is characterized by riffle/run sequences punctuated by pools and rapids over boulder, large cobble and bedrock outcrops (Appendix B). Substrates are predominately clean, coarse substrates with low embeddedness, and bedrock. Run habitat is generally shallow to moderate in depth. Deeper areas are associated with outside bends and channel bed scour. Higher gradient and turbulence is associated with exposed bedrock and large substrates.

Downstream of the Balsam Avenue Bridge, the river is frequently braided into a number of channels by transitory depositional features (mid-channel, point and side bars) (Appendix B). The habitat is predominately riffle and shallow to moderate depth run with the occasional rapids and cascade associated with exposed bedrock (Appendix B). Elevated bars and channel bed scouring are evident within this section (Appendix C).

Habitat potentially affected by the project is located along the margin of the river channel with slow to moderate flows over boulder, cobbles and bedrock substrates. During the survey, a portion of this area was in the dry. The habitat is commonly found throughout the study area and is not critical for resident fish to carry out any life stage activities.

3.2.2 Spawning Survey

No spawning redds were identified during the 4 October 2016 survey. Based on the channel gradient and predominately boulder, large cobble and bedrock substrates, spawning opportunities were limited. Areas of suitable sized substrates were noted, but no signs of spawning activity were observed. Prior to the 2013 flood event, two bull trout redds were identified 1 to 2 km downstream of the study area (AAR 2008). Historically, bull trout spawning

has been documented upstream near Elbow River Falls (AEP 2017). The main function of the study area is likely as a bull trout migration corridor to access preferred spawning areas.

However, the study area does provide suitable spawning habitat for mountain whitefish. Historically, large numbers of mountain whitefish have been documented in the study area (AAR 2008).

3.2.3 Fish Cover

Within the study area, fish cover is provided by depth, surface turbulence, coarse substrates and trace amounts of overhanging vegetation and woody debris. The amount of cover available for fish is moderate.

3.2.4 Water Quality

During the survey, the Elbow River had a water temperature of 5.6°C, a pH of 8.13, a specific conductance of 407 µS/cm, and a DO concentration of 11.1 mg/L. All water quality parameters were within the guidelines for the protection of aquatic life in freshwater systems (CCME 2016).

3.3 Bragg Creek

3.3.1 Channel and Bank Characteristics

Within the study area, Bragg Creek is confined, flowing in an irregular meandering pattern through deciduous and coniferous forests before discharging into the Elbow River. (Appendix B) Residential housing flanks both banks of the creek.

Habitat within Bragg Creek was characterized by moderate to high water velocities and shallow depths (<0.7 m). Habitat was primarily run alternated by short riffle sections (Appendix B). Pool habitat was rare and only observed immediately downstream of the Bracken Road Bridge.

The bed materials ranged from fine materials to boulder, however primarily consisted of small and large cobbles (Appendix C). Streambed substrates ranged from unembedded to highly embedded. Banks were typically stable, vertical or sloping and heights ranged from 1.2 m to 3.5 m. Side bars were observed within the study area.

3.3.2 Fish Cover

Due to shallow depths within the study area, fish cover within Bragg Creek is assessed as low. Available cover is primarily provided by surface turbulence, boulders and overhanging vegetation. Limited cover is provided by depth, undercut banks, small woody debris and large woody debris.

3.3.3 Water Quality

At the time of survey, Bragg Creek had a water temperature of 11.2°C, pH of 6.9, specific conductance of 256 µS/cm and a dissolved oxygen level of 11.6 mg/L. All water quality parameters were within the guidelines for the protection of aquatic life in freshwater systems (CCME 2016).

3.4 Fisheries Resources

3.4.1 Fish Community

Within proximity to the proposed project, numerous fish community surveys have been conducted in the Elbow River from 1979 to 2014 (AEP 2017). A total of 11 fish species have been documented within 5 km of the proposed project location (Table 1). Sport fish species include brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), bull trout (*Salvelinus confluentus*), cutthroat trout (*Oncorhynchus clarki*), mountain whitefish (*Prosopium williamsoni*), and rainbow trout (*Oncorhynchus mykiss*) (AEP 2017).

Sucker and forage fish species include brook stickleback (*Culaea inconstans*), lake chub (*Couesius plumbeus*), longnose dace (*Rhynichthys cataractae*), longnose sucker (*Catostomus catostomus*), and white sucker (*Catostomus commersonii*) (AEP 2017). The majority of species found within the Elbow River have also documented in Bragg Creek (Table 1).

Table 1: Fish Species Documented in Bragg Creek and the Elbow River within 5 km of the Proposed Project

Common Name	Species Code[1]	Species Name	Elbow River	Bragg Creek
Sport Fish Species				
Brook Trout	BRTR	*Salvelinus fontinalis*	X	X
Brown Trout	BNTR	*Salmo trutta*	X	X
Bull Trout	BLTR	*Salvelinus confluentus*	X	X
Cutthroat Trout	CTTR	*Oncorhynchus clarki*	X	X
Mountain Whitefish	MNWH	*Prosopium williamsoni*	X	X
Rainbow Trout	RNTR	*Oncorhynchus mykiss*	X	X
Sucker Species				
Longnose sucker	LNSC	*Catostomus catostomus*	X	X
White sucker	WHSC	*Catostomus commersonii*	X	X
Forage Fish Species				
Brook stickleback	BRST	*Culaea inconstans*	X	
Lake chub	LKCH	*Couesius plumbeus*	X	
Longnose dace	LNDC	*Rhinichthys cataractae*	X	X

Note:
[1] Species code as per Mackay et al. (1990).

3.4.2 Special Status Species

Westslope cutthroat trout (*Oncorhynchus clarkii lewisi*), a subspecies of cutthroat trout, are listed as 'Threatened' provincially and federally (ESRD 2014 and GC 2017, respectively). Within the Elbow River drainage, their range is limited to the headwaters and the occurrence of pure-strain westslope cutthroat trout near the proposed works is unlikely (AWCTRT 2013). Of the species documented within the study area, only bull trout are listed as a "Threatened" by Alberta's Endangered Species Conservation Committee (ESRD 2014a) and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (COSEWIC 2017). None of the species documented are currently listed under Schedule 1 of the federal *Species at Risk Act* (GC 2017).

3.5 Fish Habitat Evaluation

Fish habitat suitability within the study reach was rated for its capacity to provide important life history functions. The overall habitat quality within the study area was rated as moderate to good. This rating is based on the habitat's ability to provide spawning, rearing, holding and overwintering habitat for sport fish, sucker and forage species.

3.5.1 Sport Fish

Sport fish habitat quality was evaluated for salmonids (trout and whitefish). These sport fish species were selected for discussion based on their documented occurrence within the vicinity of the study area.

Overall habitat for salmonids is rated as good, since the habitat has the potential to support all life stages. The study area contained a high percentage of clean, coarse substrate, coupled with preferred habitat diversity (Roberge et al. 2002). The dominant habitat throughout the surveyed reach is moderate to high velocity run, interspersed by shallow riffle areas on the channel bar margins. Rearing habitat is provided by the presence of velocity breaks, coarse substrate, and depth cover along the eroded bank sections, but lacks overhead cover. Shallow depths and boulder cover in Bragg Creek provides good rearing habitat for juvenile salmonids (Ford et al. 1995). The Elbow River provides good holding habitat for adults, with adequate depths, flow and habitat complexity.

Spawning habitat for salmonids is moderate; with areas of suitably sized gravel, low embeddedness and riffle and rapid habitats within the study area. Salmonids prefer clean gravel and cobble substrates for redd construction and spawning (Roberge et al. 2002). Spawning habitat within Bragg Creek was limited by substrate size and a lack of pool habitat often used for staging prior to spawning (Ford et al. 1995). In large rivers, broadcast spawning species (i.e., mountain whitefish) prefer to deposit eggs in shallow water over clean, cobble substrates directly upstream of riffle or rapid habitat (R.L. & L. 1997; Roberge et al. 2002).

Overwintering potential in this reach is moderate with some areas of depth with sufficient flow to provide overwintering refuge. DO levels are anticipated to remain high given the velocity and surface turbulence characteristics of the reach. No overwintering habitat for salmonids was observed within Bragg Creek.

3.5.2 Sucker Species

Overall habitat quality for sucker species is good within the surveyed area of the Elbow River. The study area contains preferred coarse substrates, flows and habitat diversity. Adult sucker species prefer clear water; riffle-run sections free of fines; and deep areas with adequate flow (Twomey et al. 1984). Rearing habitat for juvenile suckers is moderate to good, as the area contains sufficient depth, but has limited overhead cover and low velocity areas. Spawning habitat for sucker species is good due to the presence of suitable riffle habitat and coarse substrate. Overwintering habitat is good due presence of deep run areas and suitable velocity.

Bragg Creek provides limited potential habitat for sucker species due to moderate to high water velocities, a lack of pool habitat and limited overhead cover suitable for large bodied fish. Due to shallow depths, Bragg Creek does not provide overwintering potential for suckers.

3.5.3 Forage Fish

Overall habitat quality for forage fish species within the study area is moderate to good. Rearing and holding habitat is moderate as cover is limited to large substrates. Bragg Creek provides ideal longnose dace habitat due to shallow depths, high water velocities and preferred cover in the interstitial spaces of coarse substrates (Edwards et al. 1983). Spawning habitat is moderate to good for fish species that prefer coarse substrates and moderate velocities. Lake chub and longnose dace have been found to spawn in shallow water and deposit eggs amongst gravel, cobbles and boulders (Stewart and Watkinson 2007, Roberge et al. 2002). Overwintering habitat is good due to the presence of deep run areas with sufficient flow to maintain high DO levels over winter.

4.0 PROJECT DESCRIPTION AND CONSTRUCTION APPROACH

The following section provides a summary of the proposed works and construction approach. Project details are provided in the attached Design Report. Mitigation measures were developed in consultation with the project team to ensure the commitments were feasible given the engineering requirements and constraints for the project. All measures will be incorporated into the detailed design and environmental provisions of the contractor's tender package.

4.1 Project Description

The results of the engineering design and associated professional services completed to date are presented in the attached Design Report which presents the proposed flood mitigation designs. The Design Standard used for the design of the flood mitigation works was the 1:100-year design flood plus 0.6 m freeboard. The 1:100-year return period design discharge for the Elbow River at Bragg Creek that was used in this study was 990 m^3/s.

The total length of the flood mitigation structure is 3,922 m and consists of four barrier segments:

- East Bragg Creek Flood Barrier, length = 2,422 m;
- West Creek Bragg Flood Barrier – South, length = 590 m;
- West Bragg Creek Flood Barrier – North, length = 330 m; and
- Yoho Tinda Flood Barrier, length = 580 m (Figure 2).

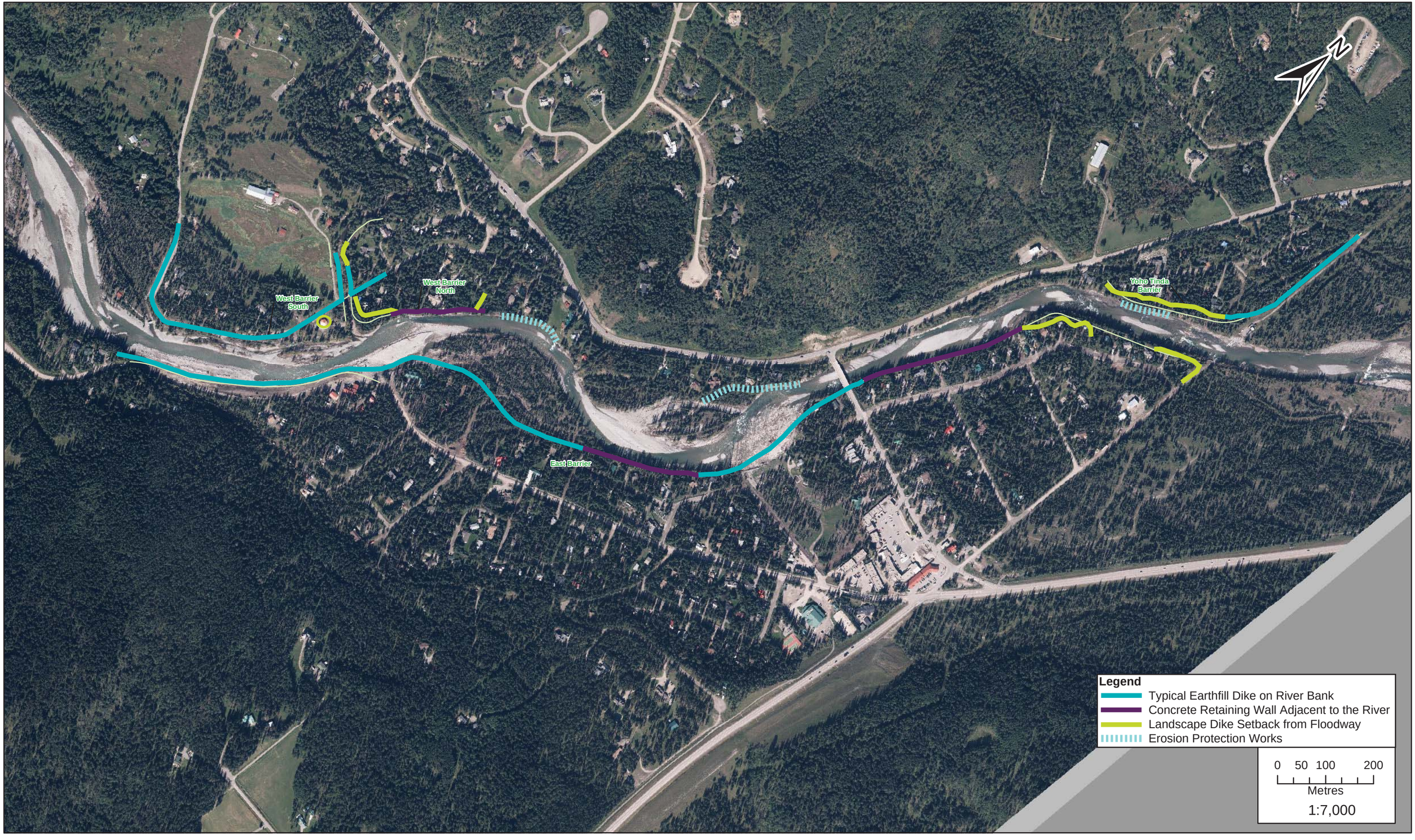
Numerous dike design sections were investigated and three primary design concepts were selected for the project:

- typical earthfill dike on river bank;
- concrete retaining wall adjacent to the river; and,
- landscape dike setback from floodway.

Designs associated with each concept are illustrated in the Design Report. Additionally, there are several variations of these typical sections to suit site-specific conditions, including, Dike Adjacent to Highway 758, Dike to incorporate Bracken Road and Dike Setback from River. These concepts have been incorporated into the four barrier segments as appropriate considering site-specific conditions.

An assessment was undertaken to identify additional potential erosion prone areas where the barrier system will not be constructed at the riverbank. A total length of 580 m of erosion protection is proposed for three erosion prone areas where infrastructure may otherwise be at risk.

Figure 2 Bragg Creek Flood Mitigation Project - General Alignment Overview



The project will also include replacement of the existing bridge over Bragg Creek along Bracken Road as well as maintenance and armouring at the existing bridge over the Elbow River along Balsam Avenue. All work undertaken at both of the bridge sites will be completed and undertaken in accordance with AEP's *Code of Practice for Watercourse Crossings*.

All components of the work that require instream activity will be isolated from the main channel to ensure that fish are not directly affected and instream activities do not release sediment to downstream areas of the river.

4.2 Scheduling of Works

Table 2 summarizes the anticipated schedule for the remaining work and milestones that will dictate the construction period, as well as the proposed construction timing for the Project. The start and completion dates shown are estimates and subject to change as they depend on numerous variables which are beyond the full control of RVC including, but not necessarily limited to, the completion of the land acquisition, First Nations consultation, and applicable regulatory approvals process.

As indicated previously, RAPs for the Elbow River include 1 May to 15 July and 16 September to 15 April (downstream of the Bragg Creek confluence) and 1 September to 15 August (for Bragg Creek and the Elbow River upstream of the confluence of Bragg Creek). Isolation works will be constructed in 2018 outside of the RAP. Instream construction within isolated conditions will continue through till the spring of 2019. Isolation works will be removed outside of the RAP in 2019. Construction completion is anticipated by 31 October 2019.

Table 2: Proposed Project Schedule

Task	Anticipated Start Date	Anticipated Duration	Anticipated Completion Date
Land Acquisition	On-going		February 2018
AEP *Water Act* Application	04 July 2017	6 – 8 months	February 2018*
DFO *Fisheries Act* Application	04 July 2017	6 – 8 months	February 2018
Detailed Design	On-going	6 – 8 months	February 2018
Preparation of Tender, Specifications and Construction Drawings	01 March 2018	1 month	30 March 2018
Tendering Process and Award of Construction Contract	02 April 2018**	1 month	30 April 2018
Construction of Flood Mitigation Works	15 May 2018	6 – 8 months	31 January 2019
Reclamation and Site Clean-Up	01 May 2019	6 months	31 October 2019

Notes:
* Subject to completion of land acquisition and First Nations Consultation.
** Subject to receipt of all regulatory approvals.

4.3 Isolation and Instream Construction

Areas within the river or adjacent to the river that may become inundated during the construction period will be isolated outside of the RAP (i.e., summer 2018). Potential isolation

techniques are expected to consist of diversion channels to direct the flow away from the workspace and/or cofferdams that may be constructed of the following:

- sandbags;
- Aquadams/portadams;
- an outer face of riprap lined with a less pervious geo-synthetic or finer grained substrate;
- in-channel or floodplain gravels; or
- some combination of above.

Areas that have been identified as potentially requiring isolation are highlighted on Figure 3 and Figure 4.

Figure 3 Approximate Isolation Alignment (Southern Portion of Structure)

Figure 4 Approximate Isolation Alignment (Northern Portion of Structure)

5.0 FISHERIES CONCERNS AND CONSTRUCTION MITIGATION

This section identifies general fisheries concerns and mitigation for working in and around water bodies. Potential risks to fish and fish habitat from the project within the Elbow River and Bragg Creek include:

- siltation and erosion;
- interrupting fish movements and sensitive life stages;
- accidental releases of petroleum products to watercourses;
- alteration or loss of fish habitat and productivity changes; and
- spread of Whirling Disease.

The following sections discuss each of these potential impacts in further detail and identify appropriate mitigation measures to prevent or limit their effect on the aquatic environment. Additional mitigation, based on Fisheries and Oceans Canada (DFO) information, is presented in Appendix D. Construction will follow applicable best management practices (BMPs) and guidance from AEP and DFO.

5.1 Siltation and Erosion

Sediment has the potential to be released through the erosion of exposed surface soils, bank erosion, and disturbances of the channel bed. Direct effects to fish from siltation include physiological responses such as increased cough reflex, gill trauma, and stress in juveniles and adults, and population responses from decreased quality and availability of spawning habitat and increased egg mortality (Anderson et al. 1996). Fish species that utilize clean, well-oxygenated gravel substrates to spawn are particularly sensitive to sediment loading (i.e., siltation). This can fill the interstitial spaces of the gravel and cover eggs, which impairs egg gas exchange during incubation. Indirectly, increased sediment loads can decrease habitat quality and decrease the production of benthic invertebrates, which fish depend on for food.

Based on federal and provincial water quality guidelines (CCME 2016; ESRD 2014b), low concentrations, or short exposure periods generally result in minor effects that revert to normal conditions (i.e., sediment concentrations return to background levels) once the instream work is complete.

BMPs and environmental protection measures will be employed during instream construction, equipment operation, and materials handling.

5.1.1 Turbidity Monitoring

In order to further mitigate potential stream siltation, turbidity monitoring will be conducted during instream construction activities (i.e., installation and removal of instream isolation structures) to identify when corrective action is required. Protocols for turbidity monitoring are based on the CCME guidelines for the protection of aquatic life (CCME 2016), and the Provincial Environmental Quality Guidelines for Alberta Surface Waters (ESRD 2014b).

A background transect will be established upstream of the works in order to document the baseline turbidity levels within the system. Background readings will be taken once per day, unless changing weather, flow conditions, or upstream activities warrant updated background measurements. Detailed construction notes (i.e., a log of instream activity) and regular photographs of the work area will also be recorded.

Turbidity monitoring will be conducted during all instream works on an hourly basis. Three measurement transects will be established to capture the zone of influence. Transects will be positioned at 60 m, 120 m and 180 m downstream of the active construction area with a minimum of three sampling points distributed across the active channel. If a visible sediment plume is located along a sampling transect, one of the measurement points will be taken directly within this plume. In the event the visible plume extends beyond furthest downstream transect additional transects will be included to capture the full extent of the release.

Total Suspended Solids (TSS) levels with be compared to CCME guidelines at each sample location. At any given point, TSS levels shall not exceed 25 mg/L above the background reading. If levels exceed these criteria, construction will stop and the contingency plan will be implemented. The contractor will identify the cause of the release and alter the construction methods as required. Construction will only resume after readings at all sampling locations return to levels below this threshold.

In the case of an exceedance, crews will do everything possible to immediately correct the problem and prevent further releases. Having extra equipment (e.g., shovel excavators) and materials (i.e., erosion control devices) on-site in case a release occurs will expedite the response time. Temporary work stoppages and/or mobilization of additional resources may be required based on site conditions.

Once the source has been controlled, the time, location, magnitude, duration, cause and mitigation for the release will be reported to AEP's Energy & Environmental Response Line (1-800-222-6514).

5.1.2 Bank Erosion and Sediment Control Measures

To prevent erosion and sediment releases into the Elbow River or Bragg Creek, control measures will consider appropriate site drainage management and the use of sediment fences, V-ditches, berms, isolations and other suitable techniques where necessary. BMPs will be employed to minimize erosion and prevent the release of sediments entering the river. Specifically, the approach areas for equipment access are areas of potential sediment release. These areas will be monitored closely and if the potential for sediment release is identified, appropriate erosion and sediment controls installed.

Clean, rinsed material will be used for any part of the structure that borders the adjacent watercourse. Placement of this material will be done at a controlled pace to limit mobilization of surrounding sediment.

If the construction site must be abandoned for extended periods of time (due to material shortages, weather, etc.), banks will be stabilized and/or covered with geotextile fabric in a

manner that limits additional bank erosion and siltation of the adjacent watercourse. Material stockpiles and/or spoil piles will be stabilized and the appropriate erosion control measures implemented to mitigate sediment runoff. These measures will consider the possibility of high flow events and address these risks accordingly. Periodic inspection and maintenance will be undertaken to ensure temporary erosion and sediment controls are functional, and to implement remedial measures as required.

5.2 Fish Movements and Sensitive Life Stages

Proposed work will be completed within the RAP but work will be limited to the margins of the watercourses. The disruption of fish migration and passage will be minimized by limiting the duration of the construction equipment instream without isolation, completing as much instream work outside of the RAP as possible, and using isolations where feasible. Impacts to sensitive life stages of resident fish will be limited because all activity will be restricted to the watercourse margins.

Because of the duration of the proposed Project, instream works may need to occur during the RAP and additional mitigation would be implemented as outlined in the AEP Restricted Activity Period Fact Sheet (ESRD 2014c). Prior to any instream activity, spawning surveys will be conducted. If redds are observed at any proposed work area, work will be delayed and work within areas absent of spawning redds, would be initiated.

Fish potentially stranded within any isolations will need to be relocated. Following isolation, a qualified environmental professional will be retained to implement fish rescue operations. This work will follow the requirements of AEP's *Fish Research Licence.* All fish will be removed live from the isolated area prior to instream work and be placed in a downstream location that prevents them from being further disturbed by the proposed construction activities.

5.3 Accidental Petroleum Product Spills

Petroleum products have the potential to be released through refuelling activities, equipment leaks, exposed grease or accidental spills from heavy and light equipment operating in and around the Elbow River or Bragg Creek. Specific controls are stipulated in the following sections to prevent the introduction of petroleum products to the aquatic environment.

5.3.1 Equipment, Equipment Maintenance and Storage

During the Project, various pieces of construction equipment may be used, stored and maintained on-site. Construction crews will ensure that equipment is brought onto the site clean and in good condition to reduce the possibility of fuel, oil and fluid spills.

Daily vehicle and equipment inspections will be completed to ensure the equipment remains in good working condition, special attention paid to hydraulic lines and connections. This inspection will take place immediately prior to mobilization to site. A secondary inspection of excavators will take place on-site prior to entering the river channel. Any deficiencies noted during any inspection will be corrected immediately.

Excavators will use food grade hydraulic oil and a spill kit will be available on-site during all drilling operations and spares will be kept on shore at the laydown area.

All fuel storage areas will be located as described in Section 5.3.2 and fuel contained within a locked fuel storage tank.

5.3.2 Maintenance and Refuelling Areas

If machinery maintenance is required, suitable trucks and containers for the fuel, oils, lubricants and antifreeze required for maintenance purposes will be used. With the exception of pumps, equipment with limited mobility and emergency equipment, all other equipment will be fuelled and maintained in an area greater than 100 m from the watercourse. In the event that the 100 m buffer zone cannot be maintained, suitable containment measures will be implemented to prevent spills from reaching the adjacent watercourse.

On-site fuel storage will be done using industry standards and all fuel pumps must be self-contained in the service trucks. Designated fuelling trucks on-site will contain the following items:

- spill kit(s); and
- containers for used oil filters, oil, lubricants, antifreeze and other fluids and wastes.

5.3.3 Equipment Inspections

Prior to bringing equipment onto site, an inspection will be conducted and documented. The inspection will focus on the following items:

- equipment is clean (free of excess mud, dirt and oil);
- equipment is free of weeds and weed seeds;
- equipment is in good working order;
- a drip pan is available for equipment;
- contractor has a spill kit; and
- employees are trained on the refuelling; maintenance; and emergency spill response procedures.

5.4 Alteration or Loss of Fish Habitat and Productivity Changes

An ecohydraulic assessment was conducted on the pre- and post-construction channel geometry adjacent to the proposed project dike structures to determine likely impacts to fish habitat below the ordinary high water level (2-year return period). This assessment consisted of the following components:

- identification of channel and habitat alterations;
- assessment of hydraulic impacts to fish habitat;
- identification of direct habitat gain and/or loss;

- assessment of likely impact to productivity due to habitat changes;
- additional and total habitat impacts; and
- determination of outstanding fish habitat offsetting requirements

5.4.1 Identification of Channel and Habitat Alterations

The proposed flood mitigation structures consist of three types of changes to fish habitat, which include habitat destroyed, created, and altered. Descriptions of each type are included below with discussions regarding the implications to productivity and how they relate to site conditions.

- **Habitat Destroyed**: This is the loss of fish habitat as a result of the channel encroachment due to the proposed project. This is the only change to habitat for these proposed works that has serious potential to cause reductions to productivity, i.e., serious harm to fish and fish habitat.
- **Habitat Created**: This habitat is created due to changes in hydraulic conditions as a response to changes in channel geometry. For example, encroachment on one side of the channel may provide increased inundation on the opposing streambank. This is the only change to habitat that has a high likelihood to cause increases to productivity, i.e., directly offset serious harm to fish and fish habitat of habitat destroyed.
- **Habitat Altered**: This habitat is altered in a substantial way, yet is still available to be used as aquatic habitat. The proposed structures are primarily constructed with riprap while the native substrate is primarily bedrock. These habitat alterations will likely result in some minor improvements to habitat quality (e.g., improved hydraulic complexity and cover for small fish) and some minor reductions in habitat quality (e.g., less nearby mature riparian vegetation), however it is unlikely a measureable impact to productivity would occur due to this altered habitat as the major characteristics between bedrock and riprap are similar.

5.4.2 Assessment of Hydraulic Impacts to Fish Habitat

A two-dimensional hydraulic model was used to determine localized changes to hydraulics within the impacted reach of the Elbow River adjacent to the proposed flood mitigation structures. This assessment was considered under the perspective of habitat suitability and likely changes to productivity. The purpose of this exercise is to identify regions of habitat alterations which are more likely to impact productivity, and conversely, which regions of habitat alterations are less likely to impact productivity. This assessment helps to inform the overall identification of necessary offsetting requirements to ensure a high likelihood of avoiding serious harm to fish or fish habitat.

5.4.3 Identification of Direct Habitat Gain and/or Loss

The identification of changes to the 2-year wetted perimeter due to the proposed flood mitigation works will cause the following impacts to available habitat within the Elbow River. Habitat destroyed is calculated from the reduction in the post-construction 2-year wetted perimeter (Figure 5). Habitat created is calculated from the increase in the post-construction 2-year wetted perimeter. These estimated changes to habitat area are listed below. They do not consider the likely changes to productivity as a result of duration of habitat availability and hydraulic characteristics.

- 7,137 m^2 of habitat destroyed;
- 1,054 m^2 of habitat created; and
- 6,083 m^2 of net habitat loss.

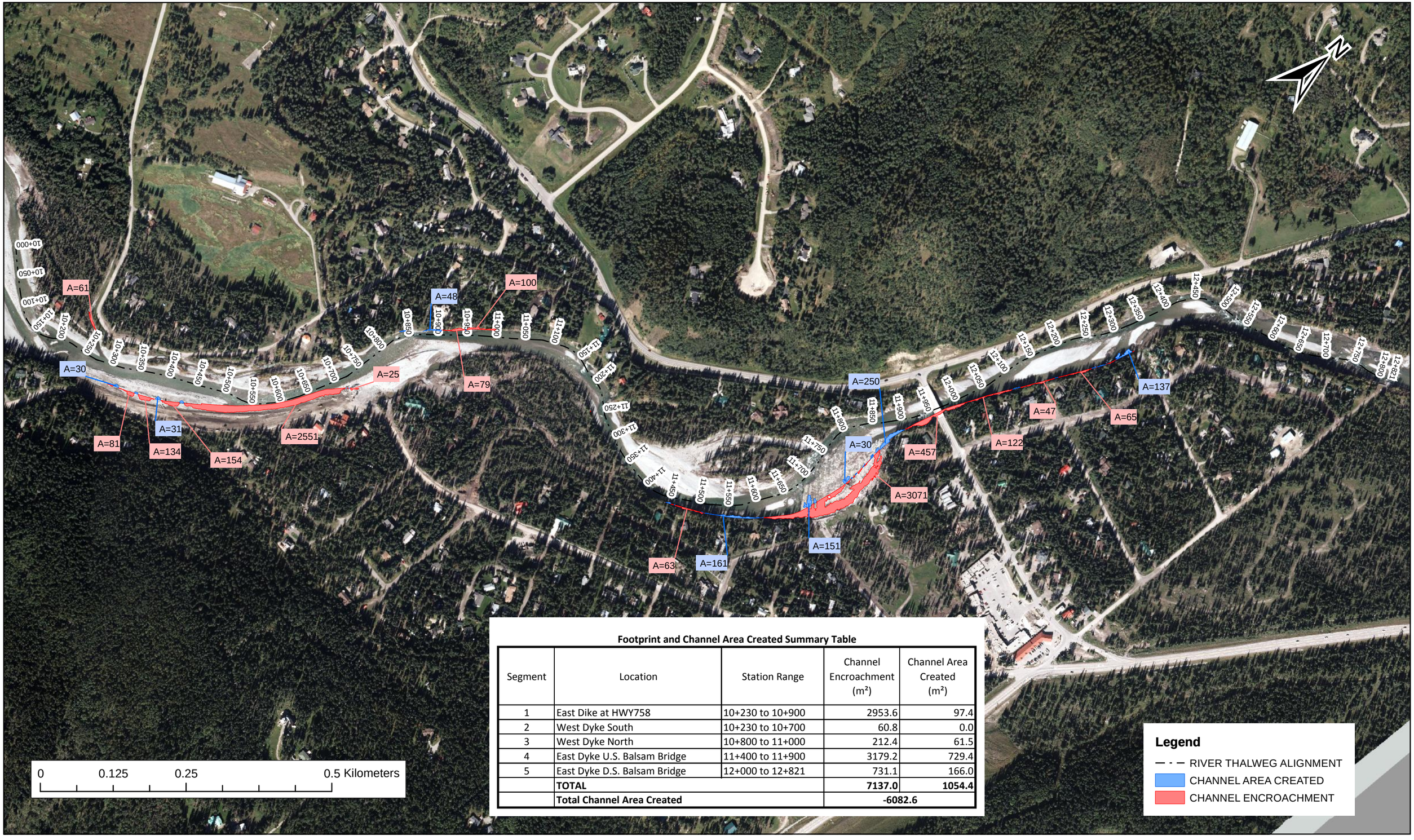
5.4.4 Assessment of Likely Impact to Productivity due to Habitat Changes

The proposed works will result in changes in area (destruction or creation) to 8,191m^2 of habitat (7,137 m^2 + 1,054 m^2), which may have potential negative or positive implications on the ecosystem's productivity. There is 7,137 m^2 of habitat loss, which will likely result in a loss of productivity, while there is 1,054 m^2 of habitat created, which will likely result in a gain of productivity. However, based on the period of inundation and hydraulic characteristics during inundation, these areas may have varying levels of impact on productivity when affected by the proposed works. For example, affected habitat areas that are only available during an ordinary high water event will have limited importance for direct in-stream productivity benefits as the habitat is only available for one to two weeks every other year, as opposed to habitat near the thalweg which is available year-round.

In certain circumstances where habitat is only inundated for a very short period of time (less than one week per year), such as the large gravel bar adjacent to the east bank upstream of the Balsam Bridge (between Station 11+600 to 11+900). Substrate in this area was severely degraded during the 2013 flood and vegetation will likely re-establish over the next five to ten years. In the long-term, this area will even further restrict in-stream habitat availability in a 2-year high water event, resembling the heavily vegetated riparian areas present prior to the 2013 flood. Thus, these areas should be considered more appropriately as riparian zones with intermittent inundation rather than direct in-stream habitat.

A conservative estimate would be to assume these areas of intermittent inundation of less than 30 cm at the 2-year level would be twice as beneficial to direct in-stream productivity as riparian zones. This assumption is conservative because for the majority of the year when there is no inundation, this area provides lower quality riparian habitat than a fully vegetated riparian area. In general, we can assume a riparian to in-stream habitat ratio of 10:1, based on previous offsetting measures approved by Fisheries and Oceans Canada within the Bow River basin. Therefore to be conservative, we will use a 5:1 ratio for intermittent to in-stream habitat (i.e., less of a reduction of the amount of habitat).

Figure 5 Channel Encroachment And Channel Area Created at 2-Year Flood Level



Footprint and Channel Area Created Summary Table

Segment	Location	Station Range	Channel Encroachment (m²)	Channel Area Created (m²)
1	East Dike at HWY758	10+230 to 10+900	2953.6	97.4
2	West Dyke South	10+230 to 10+700	60.8	0.0
3	West Dyke North	10+800 to 11+000	212.4	61.5
4	East Dyke U.S. Balsam Bridge	11+400 to 11+900	3179.2	729.4
5	East Dyke D.S. Balsam Bridge	12+000 to 12+821	731.1	166.0
	TOTAL		**7137.0**	**1054.4**
	Total Channel Area Created		**-6082.6**	

The intermittent inundated area between 11+600 to 11+900 consists of 3,071 m^2 of habitat loss and 431 m^2 of habitat gain, or a net habitat loss of 2,640 m^2. Considering the 5:1 ratio proposed, we will use an equivalent habitat loss area of 528 m^2. Table 3 outlines the likely productivity-area impacts to available habitat due to the proposed flood mitigation works.

Table 3: Modelled Habitat Impacts due to the Project

Habitat Type	Habitat Loss (m^2)	Habitat Gain (m^2)	Net Habitat Loss (m^2)
Direct	4,066	623	3,443
Intermittent[1]	614[2]	86[2]	528[2]
Total	**4,680**	**709**	**3,971**

Notes:
[1] Intermittent habitat is defined as in-stream habitat with less than 30 cm depth at 2-year water level.
[2] Equivalent habitat area based on 5:1 ratio of intermittent to in-stream habitat.

5.4.5 Additional Habitat Impacts

There are two additional components of habitat area impacts within the Bragg Creek flood barrier and the erosion protection components of the project. Hydraulic modelling has not been conducted on these components due to the simplicity of the sites and therefore considering the direct footprint areas provides a conservative estimate to the habitat impacts.

- Bragg Creek flood barrier: the net Bragg Creek channel area created is 200 m^2; and
- Elbow River erosion protection: the net decrease of channel area is 205 m^2.

5.4.6 Total Habitat Impacts

Based on all three components of the proposed works, a total of 3,976 m^2 along the margins of the Elbow River will be lost due to the development of the project (Table 4).

Table 4: Total Habitat Loss due to the Proposed Project

Project Component	Habitat Loss (m^2)
Elbow River Flood Protection	3,971
Elbow River Erosion Protection	205
Bragg Creek Flood Protection	-200[1]
Total	**3,976**

Note:
[1] Negative value indicates habitat created.

5.4.7 Determination of Outstanding Habitat Offsetting Requirements

Identification of offsetting measures will require an assessment of suitable approaches to offset the proposed impacts, which may consist of in-stream and/or riparian enhancements within suitable areas to ensure the benefits will affect the system's productivity. Suitable offsetting measures will consider the 3,976 m^2 of lost habitat. RVC is currently working with Fisheries and

Oceans Canada to develop a suitable offset, and will consult with AEP as the plan progresses. The approved offset will be consistent with *Water Act* and *Fisheries Act* requirements.

5.5 Whirling Disease

Whirling disease is caused by *Myxobolus cerebralis,* a microscopic parasite of salmonid fish, including trout and whitefish. The organism possesses a complex lifecycle that requires a salmonid fish and an aquatic-worm, *Tubifex*, as hosts. The disease is caused by a parasite which can affect nerves and cause cartilage damage. This may cause the fish to abnormally whirl around in a tail-chasing behaviour and/or to display a characteristic blackened tail. This disease can cause high levels of mortality in some fish, but it is not known how it will impact Alberta fish populations (AEP 2016).

To prevent the spread of Whirling Disease in Alberta, all equipment that may come in contact with the stream environment (water, sediment, aquatic flora and fauna) must arrive and depart the worksite clean and dry. Care should be taken to ensure water from cleaning does not re-enter any nearby waterways through runoff, ditches, or storm drains.

6.0 QAES RECOMMENDATIONS

The following details have been incorporated in the project design to minimize the effects to the aquatic ecosystem:

- additional mitigation would be implemented during the RAP as outlined in the ESRD Restricted Activity Period Fact Sheet (ESRD 2014c);
- most instream works will be completed outside of the RAP, minimizing the potential impacts to sensitive life stages of resident fish;
- instream works will be isolated;
- fish rescue will be conducted to remove potentially stranded fish from within the isolated work areas;
- an offset plan which addresses the loss of 3,976 m^2 of habitat along the margins of the Elbow River, will be developed to meet *Fisheries Act* and *Water Act* requirements; and
- the construction will adhere to the mitigation measures described in Section 5.0 and Appendix D.

If the mitigations, specifications, and the final offset plan, which will be approved by AEP and Fisheries and Oceans Canada, outlined within this report are followed, there should be no change to the productivity of the Elbow River or Bragg Creek. Final construction approvals will be subject to DFO and AEP project review.

7.0 CLOSURE

This report is based on the information and conditions available at the time of completion as referenced throughout the report. Amec Foster Wheeler has performed its services in a manner consistent with the standard of care and skill ordinarily exercised by members of the profession practicing in Alberta at the time that the services were performed. If you have any questions, please feel free to contact the undersigned at 403-248-4331.

Kind regards,

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Appendix A

Summary of Fish Habitat Requirements

Table A-1: Habitat Requirements for Fish Species Historically Documented within Bragg Creek and the Elbow River

Fish Species	Spawning	Rearing (juvenile)	Holding (Adult)	Overwintering
Sport Fish Species				
brook trout (*Salvelinus fontinalis*) BKTR FALL Actually a char species[6] Normal maximum life span is 8 years[4] Hybrid of brook and lake trout is called a "splake" [4]; Splakes are human-made hybrids[5] Brook and brown trout sometimes hybridize in Alberta[4] Brook trout aging done via scales[7]	▶ Spawn in September to November, usually over gravel beds in shallow streams or gravelly shallow area of lakes; ▶ Spawn in stream tributaries and sometimes groundwater upwelling areas in lakes with gravel substrate; ▶ Spawning occurs during the daytime; ▶ Male arrives first on spawning grounds and defines a territory, female builds redds up to 20 cm deep over 2 days[5]; female deposits eggs then covers eggs with gravel once fertilized; ▶ Preferred spawning substrate is 3-80 mm; and ▶ Preferred spawning depth is >9 cm.	▶ Maturity is usually reached at ages 2-4; ▶ Preferred cover type is cobble substrate; ▶ Preferred habitat type is stream margins; ▶ Optimum temperature for growth is between 12-15˚C; Seek temperatures below 20˚C, and as a result, will move to deeper water; and ▶ Primary food is macro invertebrates and secondary food is zooplankton.	▶ Feed on adult and larval insects. Will also eat worms, leeches, clams, snails, frogs, crayfish, and other fish species; ▶ Stream resident fish are most commonly found in pool habitat with low water velocities; ▶ Preferred cover types are rock and undercut banks; ▶ 7.0 mg/L or more are optimal; ▶ Stream gradients up to 13% do not limit upstream-directed dispersal; and ▶ Presence of large woody debris in the stream channel which creates and maintains pool habitat.	▶ Complex habitat with limited reduction in flow during winter; and ▶ Deeply undercut banks and deep water provide preferential winter habitat.
brown trout *(Salmo trutta)* BNTR FALL	▶ Late fall to early winter (October to February), when water temps are <9˚C; ▶ Typically prefer shallow (1-7 cm), gravely headwaters; ▶ Move upstream in natal streams to spawn or in the case of lakes/reservoirs, move into tributaries; ▶ Potential spawning sites are characterized; ▶ By upwelling of water through the gravel or by the presence of water currents flowing downward into the gravel; and ▶ Spawning sites are often located at the head of riffle areas or the	▶ Hatching occurs in late April; young typically hide under rocks; fry prefer run-riffle habitat; juveniles move to slow flowing deep water such as pools; ▶ Juveniles are found in shallower water and lower velocities than adult BNTR; ▶ >15% of the total stream area is assumed to provide adequate cover for fry and juveniles; and ▶ Drift-feeders.	▶ Occur in streams, beaver ponds and lakes; feed on terrestrial/aquatic insects, fish and other invertebrates and vertebrates; tend to lie in deep pools or under cover (e.g., banks or snags); can withstand higher temperatures than BKTR; ▶ Optimum range ~12-19˚C, max temp. is 27.2; >34% cover is optimal; ▶ 50-70% pools, 30-50% riffle-run habitat with areas of slow, deep water, banks are well vegetated and stable, abundant instream	▶ Continue to feed throughout the winter but at reduced levels, drift feeders, visual feeders. Ice cover my affect feeding by limiting light; and ▶ Aggregate downstream of a groundwater source.

Fish Species	Spawning	Rearing (juvenile)	Holding (Adult)	Overwintering
	tail of pools where gravel slopes gently upward and sedimentation has less effect.		cover, and stable annual flows and temp. regimes; and ▶ Adult BNTR seek cover more than any other trout species.	
bull trout (*Salvelinus confluentus*) BLTR FALL Reach sexual maturity 5-7 years[2] 3 life history strategies; stream resident, fluvial, adfluvial[2]	▶ Fall; September or October; ▶ Female digs redd; ▶ Takes place in areas typically influenced by groundwater upwelling; and ▶ Preferred substrate is gravel-cobble (16 mm – 64 mm) and <10% fine sediment.	▶ Emerge in spring; Seek low velocity backwaters and side channels with heterogeneous structure; ▶ Prefer pool-run habitats, cobble boulder substrate with easy access to higher velocity waters with abundant food; and ▶ Selection of water depth and substrate varies between seasons.	▶ Optimal temperature ≤15°C; ▶ Opportunistic feeding on invertebrate and vertebrate prey; ▶ Fluvial adults strongly associate with pools in summer with large woody debris in low tributary reaches; and ▶ Adfluvial most abundant in deeper sections of lake however use a diversity of lake habitat depending on life stage.	▶ Return to same overwintering habitat with high fidelity after completing spawning migration; ▶ Overhead, instream cover and lack of anchor ice important; and ▶ May seek out groundwater as a thermal refuge.
cutthroat trout (*Salmo clarki*) CTTR **SPRING**	▶ Small, gravelly tributary streams; 10°C; May to August (depends on location); ▶ Constructs redds in gravel substrate (2-64 mm); ▶ Redds are approx. 0.7x0.4 m^2; and ▶ The timing of spawning migration and spawning varies between systems and may be related to distance travelled, water levels and temperature.	▶ Hatch by August; Young remain in gravel for a week then disperse; ▶ Fry inhabit areas of low velocity with cover; water velocities <0.08 to 0.3 m/s; juveniles prefer water depths <0.4-0.75 m and velocities 0.25-0.5 m/s; silt-free, cobble/gravel substrate with cover; ▶ 15-25% cover is adequate;	▶ Associated with riffle-pool complexes near bank cover; eats insects, crustaceans, and fish; ▶ Often found at the upstream ends of pools; ▶ 15-25% cover is adequate; and ▶ Prefer well vegetated banks.	▶ Slow deep pools (sheltered from high flows) for adults to congregate in; ▶ Juveniles prefer boulder/cobble and other instream structures or in off-channel habitat (sloughs, beaver ponds); and ▶ Groundwater influx and absence of anchor ice.
mountain whitefish *(Prosopium williamson)* MNWH FALL	▶ Spawning occurs from October to February; ▶ No nests are constructed, eggs are deposited in gravel. Eggs incubate over the winter and hatch in early spring (i.e., March); ▶ 6˚C is the optimum incubation temperature; ▶ Riffle habitat with pools for staging; substrate ranging from sand and fine gravels to boulders and rocks; substrate free of silt and algae; general water depth	▶ Emergent fry move to the margins of streams and backwaters downstream of spawning areas for several weeks; ▶ The young form schools and tend not to hide under rocks, as do most stream salmonids, they thus may not compete for space with brown trout; ▶ Optimum temperature for growth is between 9-12˚C; ▶ DO is >5.63 mg/L;	▶ Runs, riffles and deep pools, lakes; ▶ Inhabit lakes and large rivers, apparently preferring large streams to small; It may inhabit small, turbid pools as well as cold, deep lakes, but tends to stay in the upper 4.6-6.1 m and seldom occurs below 20 m; and ▶ Bottom fauna are the main food; small drifting animals are a major food item in streams and	▶ Hold in deep pools.

Fish Species	Spawning	Rearing (juvenile)	Holding (Adult)	Overwintering
	0.1-1.0 m; velocity 0.4-1.0 m/s; and ▶ Small tubercles may develop on the lateral scales prior to spawning (more pronounced on males than females).	▶ Preferred cover types are cutbanks, woody debris, aquatic vegetation; and ▶ Prefer depths less than 3 m.	terrestrial insects are occasionally eaten.	
rainbow trout *(Onchorychus mykiss)* RNTR SPRING	▶ Commences at ~ 6°C and occurs from January to July; ▶ Migrate into spawning stream before ice-breakup; ▶ Small tributaries or outlet streams of river and lakes; ▶ Redds are in gravel substrate at the head of a riffle or downstream edge of a pool; ▶ Water depth 0.15 to 0.25 m; and ▶ Preferred spawning substrate is between 4-100 mm.	▶ Remain in gravel for 2 weeks after hatching; ▶ Silt-free rocky substrate in riffle-run areas; ▶ An approx. 1:1 pool-to-riffle ratio, with areas of slow , deep water; ▶ Well vegetated stream banks and abundant instream cover; ▶ Relatively stable water flow, temperatures regimes and stream banks; ▶ Margins of lakes and streams; and ▶ Cobble and woody debris are their preferred cover types.	▶ Cool oxygen-rich waters; prefer water temps <20°C; tolerate temps up to 28°C if there is sufficient oxygen; ▶ Optimum temp for growth 10-14˚C; ▶ Swift flowing waters, edges of fast current, heads of rapids or fast riffles; cobble/boulder substrate; water velocities 0.2-0.3 m/s; ▶ Feed on aquatic insects, mysids, snails, leeches, other fish, fish eggs; and ▶ Prefer cobble to boulder habitat.	▶ Groundwater influx and absence of anchor ice; ▶ Slow deep pools (sheltered from high flows) for adults to congregate in; ▶ Juveniles overwinter in shallow areas of low velocity near stream margins, with rubble being the principle cover; and ▶ >10% of substrate is between 10-40 cm.

Fish Species	Spawning	Rearing (juvenile)	Holding (Adult)	Overwintering
Large-Bodied Forage Fish Species				
longnose sucker *(Catostomus catostomus)* LNSC SPRING	▶ Spawn from late May to early July; Enter spawning stream as soon as temperature exceeds 5˚C; ▶ Occurs in shallow, moderately flowing water over a coarse gravel to cobble substrate; ▶ The spawning act is repeated numerous times broadcasting small numbers of tiny sticky eggs with each trial; ▶ Shallows of streams or areas of lakes; gravel substrate; water depth 0.15-0.28 m; ▶ Spawn before white sucker; ▶ A female moves from quiet water near shore into group of males near stream centre. 2-4 males crowd around one female, clasping or beating against her with their anal fins and thrashing about. The spawning act last 3-5s and my occur 6-40 timer per hour; and ▶ Male develops large red lateral line during spawning.	▶ Fry remain within gravel for 1-2 weeks then disperse to bottoms of deeper, cooler lakes and clear rivers; ▶ Fry feed on zooplankton and diatoms; and ▶ Often in association with vegetation and sandy substrates.	▶ Adult fish feed primarily on bottom invertebrates such as immature insects, freshwater shrimp, small clams and crustaceans; Plants, algae and detritus.	▶ Presumably occurs in deeper sections of large lakes and rivers.
white sucker *(Catostomus commersoni)* WHSC SPRING	▶ Spawn in spring (early May to early June); ▶ Adults migrate from lakes into gravelly streams when steam temperature first reaches 10˚C; ▶ Shallow water; occasionally in rapids; ▶ Preferred spawning velocity is 30-60 cm/s; they select moderate stream velocities for spawning; and ▶ Fertilized eggs adhere to gravel in riffles or drift downstream where they adhere to the substrate in areas with water of slow velocities.	▶ Fry emerge 9-11 days after hatching and drift downstream at night; ▶ Fry (12 mm) feed on surface plankton and other invertebrates near the surface; and ▶ At 16-18 mm, when the mouth moves from terminal to ventral, there is a shift to bottom feeding.	▶ Adults are bottom feeders; prefer warm, shallow lakes and tributary rivers of large lakes; ▶ Optimum white sucker habitat is assumed to have a pool to riffle ration of 1:1; ▶ pH ranges from 5 to 9; and ▶ Pools and riffles of creeks and rivers, warm shallow lakes and embayments of larger lakes usually at depths of 6-9 m.	▶ Presumably occurs in lakes and large rivers.

Fish Species	Spawning	Rearing (juvenile)	Holding (Adult)	Overwintering
Forage-Fish Species				
brook stickleback (*Culea inconstans*) BRST SPRING/EARLY SUMMER	▶ Spring-early summer (April to July); ▶ Male builds an oval shaped nest with vegetation held together with its own kidney secretions; ▶ Builds nests in shallow water, on the stems of grass, reeds, or on substrate bottom; ▶ Males aerates and defends eggs until they hatch 21 days later; and ▶ Males turn jet black before nest building and others turn black after the nest is complete.	▶ Presumably similar to adult stage.	▶ Small, boggy headwater streams, shallow lake margins, ponds, and clear pools and backwaters of creeks and small rivers; usually associated with aquatic vegetation; occasionally brackish water; preferred water temperature 21.3°C; and ▶ Eats insect larvae, crustaceans, eggs and larvae of other fish, snails, oligochaetes and algae.	▶ High tolerance to low oxygen concentration.
lake chub (*Couesius plumbeus*) LKCH SUMMER Few live more than 5 yrs Large minnow commonly reaching 102 mm[2]; Largest recorded was 227 mm	▶ June to mid-August; ▶ Migrate from lakes to tributary streams in early spring and spawn when temperatures 14-19˚C; ▶ No nests, non-adhesive eggs are deposited among cobble and ▶ Boulder.	▶ Presumably similar to adult stage; and ▶ Feed on plankton.	▶ Cool water in both lakes and streams, wide range of depths from 15 cm shoals in streams to rocky habitats along lakeshores; ▶ Food preference variable but typically insects, zooplankton, and algae; some large LKCH will eat fish; ▶ Sight-feeding predator; ▶ Instream cover consists of coarse substrate, vegetation, woody debris, submergent and emergent vegetation; and ▶ Prefers runs, flats and pools in rivers, in lakes prefer <2 m depth[5].	▶ DO is greater than 1.0 mg/L; and ▶ Presumably in deeper water.
longnose dace *(Rhinichthys cataractae)* LNDC SPRING/SUMMER	▶ May to early August; ▶ Riffle areas containing gravel substrate; and ▶ Males are highly territorial when guarding spawning area. Eggs are expelled, fertilized and deposited between coarse substrate, male expels female from territory.	▶ The young fish live in quiet, shallow water at the edge of rivers or lakes until they are about 4 months old, when they move into faster and deeper water.	▶ Rivers, small creeks and occur in fast flowing streams; ▶ Can also occur in lakes over boulder or gravel substrate; ▶ Prefer riffle habitat in boulder, cobble, rubble substrate; ▶ Feeds on aquatic insects; and ▶ Prefer instream cover between 25%-75% and preferred instream cover is bedrock, boulder, rubble and cobble substrate.	▶ DO is greater than 2.0 mg/L; and ▶ Presumably in deeper water.

Note:
References available upon request.

Appendix B

Fish Habitat Maps

ANSI B 432mm x 279mm

N

R3
(LG, SC, LC)

GRAVEL BAR

RF (SC, LC)

R3

R3
(LG, SC, SG)

ELBOW RIVER

GRAVEL BAR

RF

RF

P

R3
(SC, LG)

RF
(LC, SC)

RA (Bo, LC)

GRAVEL BAR

RF (LG, SG)

RF

GRAVEL BAR

T13

R3
(SC, LG)

RF

R3

P

RF (LC, LG)

GRAVEL BAR

R2 (LC, SC)

RF (Bo, LC)

GRAVEL BAR

R3

GRAVEL BAR

RF (Bo, LC)

RF (LC, Bo)

RF (Bo, LC, SC)

RF (Bo, LC, SC)

R3
(LC, SC)

T12

SN

LEGEND:

HABITAT		SUBSTRATE	
FA	FALLS	F	FINES
RA	RAPID	SG	SMALL GRAVEL
SN	SNYE	LG	LARGE GRAVEL
R1	CLASS 1 RUN	SC	SMALL COBBLE
R2	CLASS 2 RUN	LC	LARGE COBBLE
R3	CLASS 3 RUN	Bo	BOULDER
P	POOL HABITAT	Bd	BEDROCK
R	RUN HABITAT		
RF	RIFFLE HABITAT		
BW	BACKWATER HABITAT		
T1	TRANSECT MARKERS		
	LARGE WOODY DEBRIS		

0 40 80

1:2000 Meters

amec foster wheeler

CLIENT

ROCKY VIEW COUNTY
Cultivating Communities

PROJECT NAME
BRAGG CREEK FLOOD MITIGATION

SHEET TITLE
FISH HABITAT MAP 1

PROJECT NUMBER
CT160213

FIGURE NUMBER
B1

ISSUE/REVISION
A

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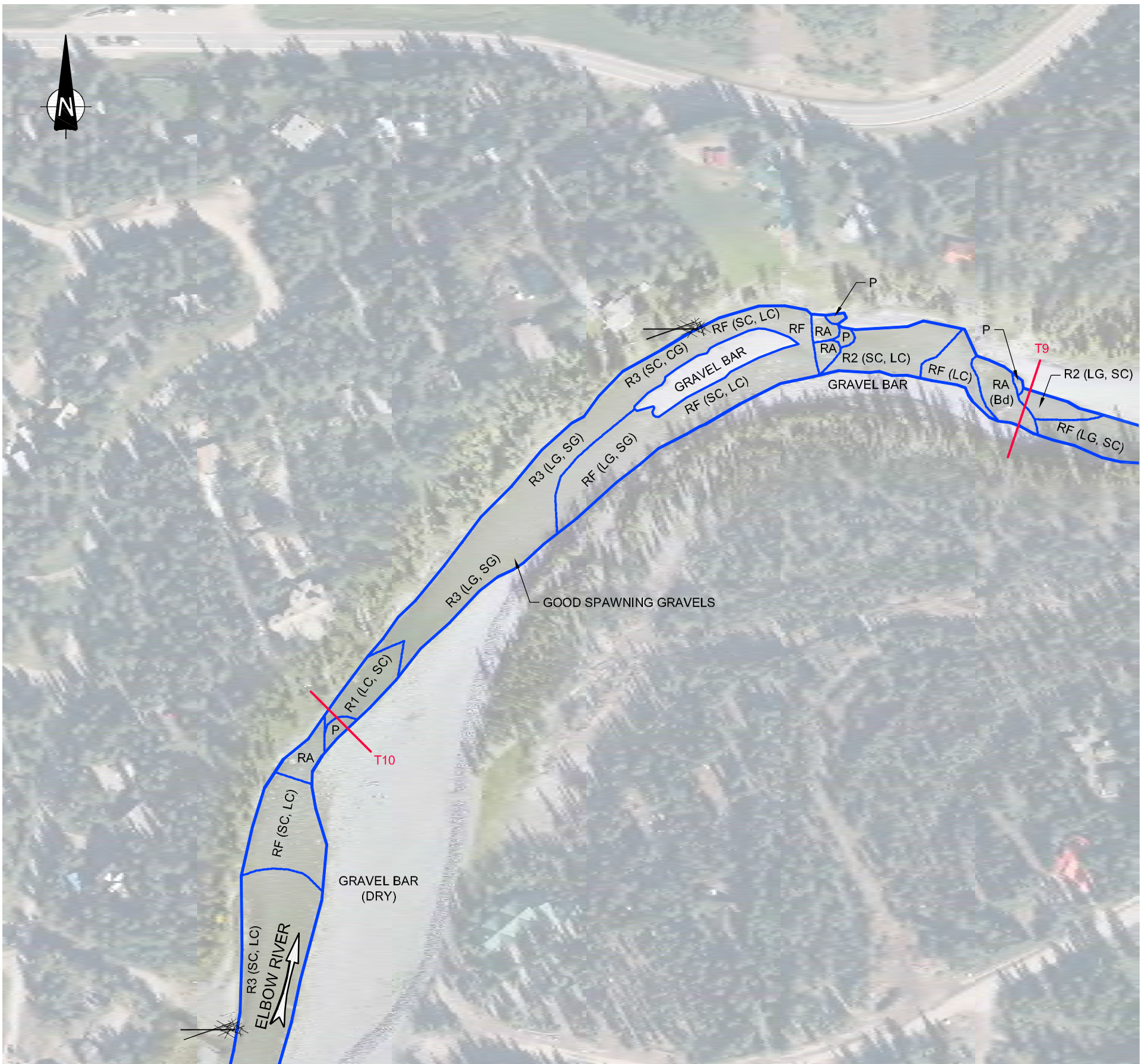

LEGEND:

HABITAT		SUBSTRATE	
FA	FALLS	F	FINES
RA	RAPID	SG	SMALL GRAVEL
SN	SNYE	LG	LARGE GRAVEL
R1	CLASS 1 RUN	SC	SMALL COBBLE
R2	CLASS 2 RUN	LC	LARGE COBBLE
R3	CLASS 3 RUN	Bo	BOULDER
P	POOL HABITAT	Bd	BEDROCK
R	RUN HABITAT		
RF	RIFFLE HABITAT		
BW	BACKWATER HABITAT		
T1	TRANSECT MARKERS		
	LARGE WOODY DEBRIS		

0 40 80

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CLIENT

ROCKY VIEW COUNTY
Cultivating Communities

PROJECT NAME
BRAGG CREEK FLOOD MITIGATION

SHEET TITLE
FISH HABITAT MAP 2

PROJECT NUMBER
CT160213

FIGURE NUMBER
B2

ISSUE/REVISION
A

LEGEND:

HABITAT		SUBSTRATE	
FA	FALLS	F	FINES
RA	RAPID	SG	SMALL GRAVEL
SN	SNYE	LG	LARGE GRAVEL
R1	CLASS 1 RUN	SC	SMALL COBBLE
R2	CLASS 2 RUN	LC	LARGE COBBLE
R3	CLASS 3 RUN	Bo	BOULDER
P	POOL HABITAT	Bd	BEDROCK
R	RUN HABITAT		
RF	RIFFLE HABITAT		
BW	BACKWATER HABITAT		
T1	TRANSECT MARKERS		

0 40 80

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amec foster wheeler

CLIENT

ROCKY VIEW COUNTY
Cultivating Communities

PROJECT NAME
BRAGG CREEK FLOOD MITIGATION

SHEET TITLE
FISH HABITAT MAP 3

PROJECT NUMBER
CT160213

FIGURE NUMBER
B3

ISSUE/REVISION
A

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1:2000 Meters

amec foster wheeler

CLIENT: Rocky View County, Cultivating Communities

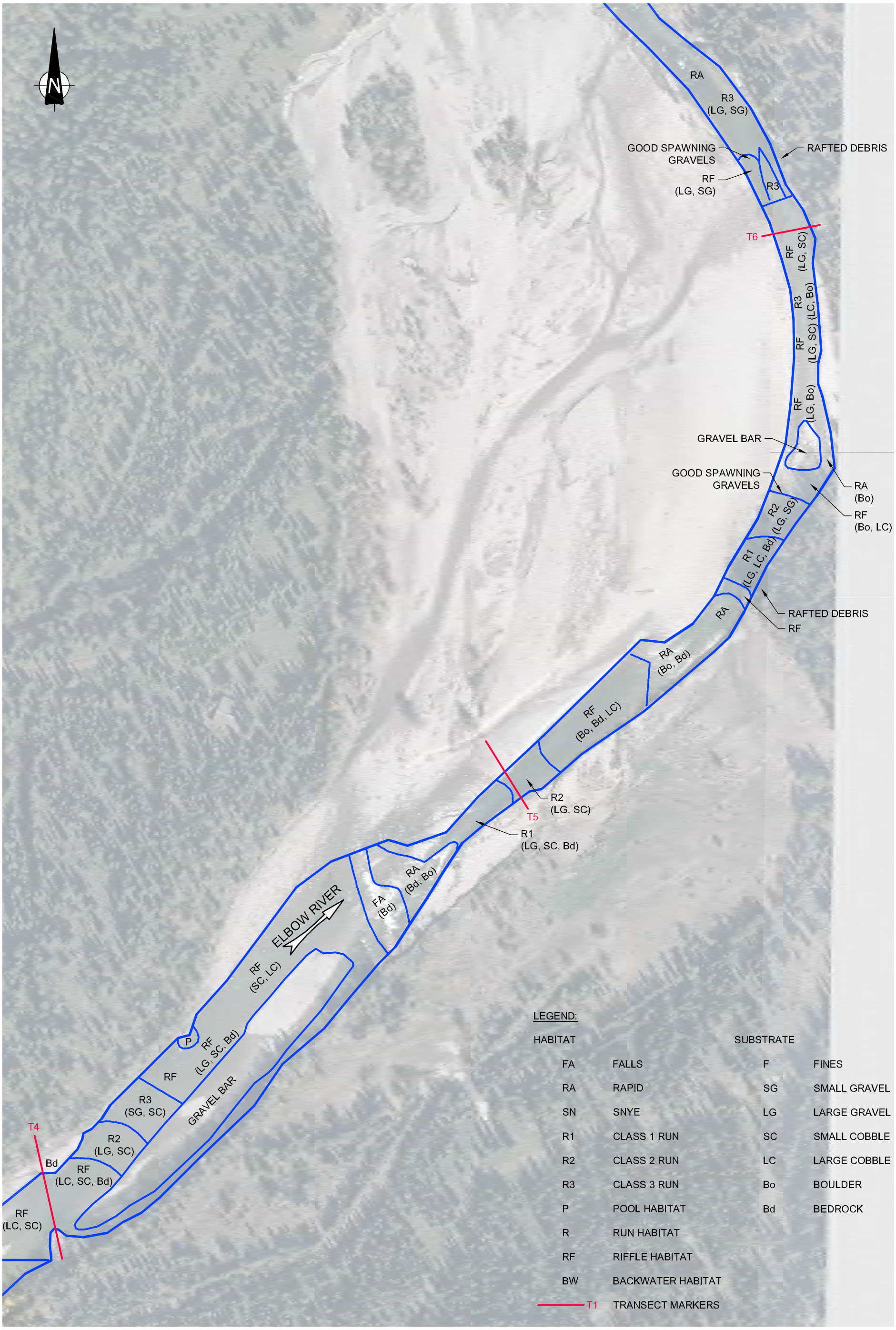
PROJECT NAME: BRAGG CREEK FLOOD MITIGATION

SHEET TITLE: FISH HABITAT MAP 4

PROJECT NUMBER: CT160213

FIGURE NUMBER: B4

ISSUE/REVISION: A



LEGEND:

HABITAT		SUBSTRATE	
FA	FALLS	F	FINES
RA	RAPID	SG	SMALL GRAVEL
SN	SNYE	LG	LARGE GRAVEL
R1	CLASS 1 RUN	SC	SMALL COBBLE
R2	CLASS 2 RUN	LC	LARGE COBBLE
R3	CLASS 3 RUN	Bo	BOULDER
P	POOL HABITAT	Bd	BEDROCK
R	RUN HABITAT		
RF	RIFFLE HABITAT		
BW	BACKWATER HABITAT		
T1	TRANSECT MARKERS		

0 40 80

1:2000 Meters

amec foster wheeler

CLIENT

ROCKY VIEW COUNTY
Cultivating Communities

PROJECT NAME
BRAGG CREEK FLOOD MITIGATION

SHEET TITLE
FISH HABITAT MAP 5

PROJECT NUMBER
CT160213

FIGURE NUMBER
B5

ISSUE/REVISION
A

Appendix C

Habitat Assessment Data

General Watercourse Survey Data					
Stream Name: Elbow River		Project: Bragg Creek Flood Mitigation		UTM Location: 11U 670929E 5647412N	
Date:4-Oct-2016	Time: 8:45	Site Length (m): 3900	Access: Foot	Agency: AMEC FW	Crew: RF/DF
Chemical Data					
Water Temperature (°C): 5.6		pH: 8.13		Conductivity (µS/cm): 407	
Time of Temperature (24h): 9:45		Turbidity (NTU): -		Dissolved Oxygen (mg/L): 11.1	
Watercourse Characteristics					
Pattern: IR		Islands: N		Bars: SIDE, DIAG, MID	
Coupling: DC		Confinement: FC		Gradient: 1%	

Transect Information					
Transect	**T1**	**T2**	**T3**	**T4**	**T5**
Easting	670941	671026	671169	671400	671647
Northing	5647536	5647819	5647969	568117	5648368
Watercourse Channel					
Channel width (m) – top of bank	47	49	56	55	65
Channel width (m) – to 1:2 high water	-	-	-	-	-
Wetted width (m)	28	20	51	21	15.4
Depth @ 25% width	0.32	0.63	0.28	0.75	0.74
Depth @ 50% width	0.38	0.78	0.32	0.35	0.79
Depth @ 75% width	0.32	0.70	0.36	0.54	0.72
Maximum Depth (m)	0.66	1.31	1.23	0.75	0.79
Ordinary High Water Mark (m)	0.45	0.48	0.42	0.40	-
Pool/Riffle/Run/Rapid	0/20/75/5	5/15/75/5	5/25/65/5	5/45/50/0	20/20/45/15
Left Bank					
Height (m)	1.55	2.00	2.15	1.90	-
Shape	S	V	V	V	V
Texture	F,G,C	Be	G,C,Be	G,C,Bo	G,C,Bo,Be
Riparian vegetation	G,S,C,D	C,D	C	G,S,C,D	-
Bank Stability	MS	S	MU	MS	MS
Right Bank					
Height (m)	2.75	2.00	2.40	1.50	-
Shape	V	V	-	V	V
Texture	F,G,C,Be	Be	F,G,C,Be	Be	G,C,Be
Riparian vegetation	G,S,C,D	G,S,C,D	G,S,C,D	G,S,C,D	S,C,D
Bank Stability	US	S	MU	MS	MS
Bed Material (%)					
Organic materials	0	0	0	0	0
Fine sediments (<2mm)	0	0	0	0	0
Small gravel (2-16mm)	10	0	5	5	5
Large gravel (18-64mm)	30	25	40	10	45
Small cobble (64-128mm)	35	45	35	30	40
Large cobble (128-256mm)	20	25	15	40	10
Boulder (>256mm)	5	5	5	10	0
Bedrock	0	0	0	5	0
Embeddedness	UE	UE	UE	UE	UE

Watercourse Cover Data (%):	**Total Cover: Moderate**		**Crown Closure: None**
Undercut bank: -	Large woody debris: TR	Surface turbulence: 40	Instream Vegetation: -
Small woody debris: -	Boulder: 45	Overhanging vegetation: -	Depth of the watercourse: 15
Turbidity: -			

Photo 1: Facing upstream from transect 1 showing slow velocity run habitat and the Balsam Ave Bridge. 4 October 2016

Photo 2: Rafter large woody debris on the left bank of transect 2. 4 October 2016

Photo 3: Typical riffle habitat downstream of transect 3. 4 October 2016

Photo 4: Falls between transects 4 and 5. 4 October 2016

CLIENT: ROCKY VIEW COUNTY	**SURVEY DATE: 4 OCTOBER 2016**
DATE: JUNE 2017	**JOB No.: CT160213**
SUMMARY OF PHYSICAL AND CHEMICAL DATA ELBOW RIVER	**Figure C-1**

General Watercourse Survey Data						
Stream Name: Elbow River		Project: Bragg Creek Flood Mitigation		UTM Location: 11U 670929E 5647412N		
Date: 4-Oct-2016	Time: 13:00	Site Length (m): 3900	Access: Foot	Agency: AMEC FW		Crew: RF/DF
Transect Information						
Transect		**T6**	**T7**	**T8**	**T9**	**T10**
Easting		671793	670864	670818	670581	670293
Northing		5648650	5647272	5647047	5646969	5646819
Watercourse Channel						
Channel width (m) – top of bank		27	58	56	41	71
Channel width (m) – to 1:2 high water		-	-	-	-	-
Wetted width (m)		19	22	20	23	11
Depth @ 25% width		0.65	0.55	1.01	0.40	0.60
Depth @ 50% width		0.53	0.42	1.02	0.44	1.10
Depth @ 75% width		0.45	0.70	1.14	0.58	1.00
Maximum Depth (m)		0.67	0.70	1.14	0.58	1.20
Ordinary High Water Mark (m)		0.55	0.35	0.14	0.49	0.40
Pool/Riffle/Run/Rapid		0/15/85/0	5/20/65/10	15/10/70/5	10/30/60/0	10/35/55/0
Left Bank						
Height (m)		0.55	2.65	2.10	1.52	4.00
Shape		S	V	V	V,S	V
Texture		F,G,C,Bo,Be	G,C,Bo,Be	Be	F,G,C,Bo,Be	Bo,Be
Riparian vegetation		-	S,C,D	G,S,C	S,C,D	S,C
Bank Stability		-	MS	-	MS	S
Right Bank						
Height (m)		3.00	0.65	0.70	0.75	0.70
Shape		V	S	-	S	S
Texture		F,S,C,Bo	C,Bo,Be	F,G,C,Bo	F,G,C	G,C,Bo
Riparian vegetation		G,S,C	S	-	S,C,D	-
Bank Stability		US	S	-	S	S
Bed Material (%)						
Organic materials		0	0	0	0	0
Fine sediments (<2mm)		5	0	0	0	0
Small gravel (2-16mm)		10	0	20	0	0
Large gravel (18-64mm)		30	5	15	15	0
Small cobble (64-128mm)		50	5	30	25	30
Large cobble (128-256mm)		5	10	15	35	40
Boulder (>256mm)		0	10	10	5	20
Bedrock		0	70	10	20	10
Embeddedness		UE	UE	UE	UE	UE

Photo 5: Facing downstream from transect 6 showing typical run habitat and left cut bank with large woody debris. 4 October 2016

Photo 6: Looking downstream from transect 7 showing large bedrock outcrop along the right bank and the Balsam Ave Bridge in the distance. 5 October 2016

Photo 7: Facing upstream from transect 9 showing riffle habitat over bedrock substrate. 5 October 2016

Photo 8: Left bank at transect 10 showing large woody debris and adjacent residential housing. 5 October 2016.

CLIENT: ROCKY VIEW COUNTY	**SURVEY DATE: 5 OCTOBER 2016**
DATE: JUNE 2017	**JOB No.: CT160213**
SUMMARY OF PHYSICAL AND CHEMICAL DATA ELBOW RIVER	**Figure C-1**

General Watercourse Survey Data					
Stream Name: Elbow River		Project: Bragg Creek Flood Mitigation		UTM Location: 11U 670929E 5647412N	
Date:5-Oct-2016	Time: 10:00	Site Length (m): 3900	Access: Foot	Agency: AMEC FW	Crew: RF/DF
Transect Information					
Transect		**T11**	**T12**	**T13**	**Mean**
Easting		670231	670093	669783	-
Northing		5646549	5646418	5646317	-
Watercourse Channel					
Channel width (m) – top of bank		31	61	109	56
Channel width (m) – to 1:2 high water		-	-	-	-
Wetted width (m)		23	28	22	23
Depth @ 25% width		0.23	0.32	0.15	0.51
Depth @ 50% width		0.35	0.37	0.65	0.58
Depth @ 75% width		0.28	0.34	0.20	0.56
Maximum Depth (m)		0.35	0.37	0.90	0.82
Ordinary High Water Mark (m)		0.38	0.39	-	0.40
Pool/Riffle/Run/Rapid		0/95/5/0	0/90/10/0	0/30/65/5	6/35/56/4
Left Bank					
Height (m)		2.00	2.00	2.15	2.05
Shape		V	V	V,S	-
Texture		G,C	G,C,Bo	G,C,Bo	-
Riparian vegetation		-	S,C,D	S,D	-
Bank Stability		S	S	S	-
Right Bank					
Height (m)		2.30	0.55	1.56	1.57
Shape		V	S	S	-
Texture		C,Bo	G,C,Bo	G,C,Bo	-
Riparian vegetation		-	-	C	-
Bank Stability		S	S	S	-
Bed Material (%)					
Organic materials		0	0	0	0
Fine sediments (<2mm)		0	0	0	0
Small gravel (2-16mm)		0	0	0	4
Large gravel (18-64mm)		0	10	10	18
Small cobble (64-128mm)		10	20	25	29
Large cobble (128-256mm)		35	40	40	25
Boulder (>256mm)		55	30	25	14
Bedrock		0	0	0	9
Embeddedness		UE	UE	UE	-

Notes:
Channel Pattern: TM = tortuous meanders, ME = regular meanders, IM = irregular meanders, IR = irregular wandering, SI = sinuous, ST = straight
Coupling: DC = decoupled, PC = partially coupled, CO = coupled
Islands: N = none, O = occasional, I = irregular, F = frequent, S = split, AN = anastomosing
Confinement: EN = entrenched, CO = confined, FC = frequently confined, OC = occasionally confined, UN = unconfined, NA = not applicable
Bars: N = none, SIDE = sediment deposition intermittent along the sides of streams, DIAG = mid-stream sediment deposition diagonally aligned to stream axis, MID = mid-stream sediment deposition aligned parallel to stream axis, SPAN = sediment deposition continuous along the sides of stream, BR = sediment deposition forms a number of small channels separated by bars
Shape: U = undercut banks, V = vertical, S = sloping, O = overhanging
Texture: F = fines, G = gravels, C = cobbles, B = boulders
Riparian Vegetation: N = none, G = grasses, S = shrubs, C = coniferous, D = deciduous, M = mixed C and D types
Bank Stability: S = stable, MS = moderately stable, MU = moderately unstable, US = unstable
Substrate Embeddedness : UE = Unembedded, L = Low, M = Moderate, H = High

Photo 9: Looking upstream from transect 11 showing existing riprap bank protection 5 October 2016

Photo 10: Typical riffle habitat downstream of transect 11. 5 October 2016

Photo 11: Existing riprap bank protection along the right bank extending past transects 11 and 12. 5 October 2016

Photo 12: Looking upstream from transect 12 showing run habitat transitioning into riffle habitat. 5 October 2016

CLIENT: ROCKY VIEW COUNTY	**SURVEY DATE: 5 OCTOBER 2016**
DATE: JUNE 2017	**JOB No.: CT160213**
SUMMARY OF PHYSICAL AND CHEMICAL DATA ELBOW RIVER	**Figure C-1**

General Watercourse Survey Data						
Stream Name: Bragg Creek		Project: Bragg Creek Flood Mitigation			UTM Location: 11U 670194E 56546703N	
Date: 22-Jun-2017	Time: 11:00	Site Length (m): 3900	Access: Foot		Agency: Amec FW	Crew: RF/CF
Chemical Data						
Water Temperature (˚C): 11.2		pH: 6.90			Conductivity (µS/cm): 256	
Time of Temperature (24h): 11:15		Turbidity (NTU): -			Dissolved Oxygen (mg/L): 11.6	
Watercourse Characteristics						
Pattern: IM		Islands: N			Bars: SIDE	
Coupling: DC		Confinement: CO			Gradient: -	
Transect Information						
Transect		**T1**	**T2**	**T3**	**T4**	**T5**	**Mean**
Easting		670238	670219	670194	670166	670121	-
Northing		5646677	5646688	5646703	5646711	5646727	-
Watercourse Channel							
Channel width (m) – top of bank		-	-	-	-	-	-
Channel width (m) – to 1:2 high water		8.0	8.0	7.0	7.5	8.0	7.7
Wetted width (m)		7.0	7.0	4.0	6.0	7.0	6.2
Depth @ 25% width		0.25	0.32	0.34	0.65	0.06	0.32
Depth @ 50% width		0.16	0.23	0.25	0.57	0.23	0.29
Depth @ 75% width		0.17	0.22	0.22	0.40	0.17	0.24
Maximum Depth (m)		0.25	0.35	0.40	0.65	0.23	0.38
Ordinary high water mark (m)		0.30	0.30	0.25	0.25	0.40	0.30
Pool/Riffle/Run		0/15/85	0/10/90	0/10/90	20/0/80	0/20/80	4/11/85
Left Bank							
Height (m)		0.2	2.0	1.5	1.5	1.2	1.3
Shape		S	V	S	V	V	-
Texture		G,G,C,Bo	F,G,C,Bo	F,G,C,Bo	F,G,C,Bo	F,G,C,Bo	-
Riparian vegetation		G,S	G,S,C,D	G,S,C,D	G,S,C,D	G,S,C,D	-
Bank Stability		S	S	S	S	S	-
Right Bank							
Height (m)		0.5	3.0	3.0	2.0	3.5	2.4
Shape		V	V	V	V	V	-
Texture		F,G,C,Bo	F,G	F,G,C	F,G,C	F,G,C,	-
Riparian vegetation		G,S	G,S,C,D	S,C,D	G,S,C,D	G,C,D	-
Bank Stability		S	S	S	S	S	-
Bed Material (Dominance)							
Organic materials		0	0	0	0	0	0
Fine sediments (<2mm)		0	15	10	35	5	13
Small gravel (2-16mm)		0	5	5	5	5	4
Large gravel (18-64mm)		15	15	15	10	15	14
Small cobble (64-128mm)		60	25	20	20	25	30
Large cobble (128-256mm)		20	30	30	20	35	27
Boulder (>256mm)		5	10	20	10	15	12
Bedrock		0	0	0	0	0	0
Substrate Embeddedness		UE	M	L	L	UE	-
Watercourse Cover Data (%)		**Total Cover: Low**			**Crown Closure: Moderate**		
Undercut bank: 2		Large woody debris: 1		Surface turbulence: 40		Instream Vegetation: -	
Small woody debris: 2		Boulder: 40		Overhanging vegetation: 10		Depth of the watercourse: 5	
Turbidity: -							

Notes:
Channel Pattern: TM = tortuous meanders, ME = regular meanders, IM = irregular meanders, IR = irregular wandering, SI = sinuous, ST = straight
Coupling: DC = decoupled, PC = partially coupled, CO = coupled
Islands: N = none, O = occasional, I = irregular, F = frequent, S = split, AN = anastomosing
Confinement: EN = entrenched, CO = confined, FC = frequently confined, OC = occasionally confined, UN = unconfined, NA = not applicable
Bars: N = none, SIDE = sediment deposition intermittent along the sides of streams, DIAG = mid-stream sediment deposition diagonally aligned to stream axis, MID = mid-stream sediment deposition aligned parallel to stream axis, SPAN = sediment deposition continuous along the sides of stream, BR = sediment deposition forms a number of small channels separated by bars
Shape: U = undercut banks, V = vertical, S = sloping, O = overhanging
Texture: F = fines, G = gravels, C = cobbles, B = boulders
Riparian Vegetation: N = none, G = grasses, S = shrubs, C = coniferous, D = deciduous, M = mixed C and D types
Bank Stability: S = stable, MS = moderately stable, MU = moderately unstable, US = unstable
Substrate Embeddedness : UE = Unembedded, L = Low, M = Moderate, H = High

Photo 2 – Looking downstream from transect 2 showing the confluence of Bragg Creek and the Elbow River. 22 June 2017

Photo 1 – Looking upstream at high velocity riffle habitat and the Bracken Road Bridge. 22 June 2017

Photo 3 – Looking downstream from the Bracken Road Bridge. 22 June 2017

Photo 4 – Looking upstream from the Bracken Road Bridge. 22 June 2017

CLIENT: ROCKY VIEW COUNTY	**SURVEY DATE: 22 JUNE 2017**
DATE: JUNE 2017	**JOB No.: CT160213**
SUMMARY OF PHYSICAL AND CHEMICAL DATA BRAGG CREEK	**Figure C-2**

Appendix D

Measures to Avoid Harm

The following mitigation measures have been adapted from DFO's *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO 2016b) and will be implemented during the works.

Timing

- Time instream construction activities to respect the RAP in order to protect sensitive life stages of resident fish.
- Minimize duration of instream works.
- Conduct instream work during periods of low flow to further reduce the risk to fish and their habitat or isolate the work area from flow.
- Schedule work to avoid wet, windy, and rainy periods that may increase erosion and sedimentation.

Design

- Design and plan instream works to minimize the loss or disturbance to aquatic habitat.
- Design and construct approaches to the watercourse such that they are perpendicular to the watercourse to minimize loss or disturbance to riparian vegetation.
- Avoid building structures on meander bends, braided streams, alluvial fans, active floodplains or any other area that is inherently unstable and may result in erosion and scouring of the stream bed or the built structures.
- Undertake all instream activities in isolation of open or flowing water to maintain the natural flow of water downstream and avoid introducing sediment into the watercourse.

Spill Management

- Plan activities near water such that deleterious materials do not enter the watercourse.
- Develop a spill response plan that is to be implemented immediately following a sediment release or spill of a deleterious substance.
- Ensure spill kits are kept on site and in good working order.
- Ensure that building material used in a watercourse has been handled and treated in a manner to prevent the release or leaching of substances into the water that may be deleterious to fish.

Erosion and Sediment Control

Develop and implement an Erosion and Sediment Control Plan for the site that minimizes risk of sedimentation of the watercourse during all phases of the project. Erosion and sediment control measures will be maintained until all disturbed ground has been permanently stabilized, suspended sediment has resettled to the bed of the watercourse or settling basin and runoff water is clear. The plan will, where applicable, include:

- Installation of effective erosion and sediment control measures before starting work to prevent sediment from entering the watercourse;
- Measures for managing water flowing onto the site, as well as water being pumped/diverted from the site such that sediment is filtered out prior to the water entering a watercourse;
- Site isolation measures (e.g., silt boom or silt curtain) for containing suspended sediment where in-water work is required (e.g., dredging, infilling);
- Measures for containing and stabilizing waste material (e.g., dredging spoils, construction waste and materials, uprooted or cut aquatic plants, accumulated debris) above the high water mark of nearby water bodies to prevent re-entry;
- Regular inspection and maintenance of erosion and sediment control measures and structures during the course of construction; and
- Removal of non-biodegradable erosion and sediment control materials once site has been stabilized.

Shoreline Revegetation and Stabilization

- Clearing of riparian vegetation will be kept to a minimum: use existing trails, roads or cut lines wherever possible to avoid disturbance to the riparian vegetation and prevent soil compaction.
- Minimize the removal of natural woody debris, rocks, sand or other materials from the banks and below the ordinary high water mark. If material is removed from the watercourse, set it aside and return it to the original location once construction activities are completed.
- Immediately stabilize shoreline or banks disturbed by any activity associated with the project to prevent erosion and/or sedimentation, preferably through revegetation with native species.
- Restore bed and banks of the watercourse to their original contour and gradient; if the original gradient cannot be restored due to instability, a stable gradient that does not obstruct fish passage will be restored.
- If replacement rock reinforcement/armouring is required to stabilize eroding or exposed areas, then ensure that appropriately-sized, clean rock is used; and that rock is installed at a similar slope to maintain a uniform bank/shoreline and natural stream/shoreline alignment.
- Remove all construction materials from site upon project completion.
- Do not remove riparian vegetation if the riparian area is identified as part of critical habitat of an aquatic listed species at risk.

Fish

- Ensure that all in-water activities, or associated in-water structures, do not interfere with fish passage.
- Retain a qualified environmental professional to ensure applicable permits for relocating fish are obtained and to capture any fish trapped within an isolated/enclosed area at the work site and safely relocate them to an appropriate location in the same waters. Fish may need to be relocated again, will flooding occur on the site.
- Screen any water intakes or outlet pipes to prevent entrainment or impingement of fish. Entrainment occurs when a fish is drawn into a water intake and cannot escape. Impingement occurs when an entrapped fish is held in contact with the intake screen and is unable to free itself.

Any capture and relocation of an endangered or threatened aquatic species at risk will require approval from DFO.

Pump Screens

In freshwater, follow these measures for design and installation of intake end of pipe fish screens to protect fish where water is extracted from fish-bearing waters:

- Screens will be located in areas and depths of water with low concentrations of fish throughout the year;
- Screens will follow all guidance outlined in DFO's Freshwater Intake End-of-Pipe Fish Screen Guidelines (DFO 1995);
- Screens will be located away from natural or artificial structures that may attract fish that are migrating, spawning, or in rearing habitat;
- The screen face will be oriented in the same direction as the flow;
- Ensure openings in the guides and seals are less than the opening criteria to make "fish tight";
- Screens will be located a minimum of 300 mm (12 in.) above the bottom of the watercourse to prevent entrainment of sediment and aquatic organisms associated with the bottom area;
- Structural support will be provided to the screen panels to prevent sagging and collapse of the screen;
- Heavier cages or trash racks can be fabricated out of bar or grating to protect the finer fish screen, especially where there is debris loading (woody material, leaves, algae mats, etc.);
- Provisions will be made for the removal, inspection, and cleaning of screens; and
- Ensure regular maintenance and repair of cleaning apparatus, seals, and screens is carried out to prevent debris-fouling and impingement of fish.

Machinery Operation and Maintenance

- Ensure that machinery arrives on site in a clean condition and is maintained free of fluid leaks, invasive species and noxious weeds.
- Whenever possible, operate machinery on land above the high water mark, on ice, or from a floating barge in a manner that minimizes disturbance to the banks and bed of the watercourse.
- Limit machinery fording of the watercourse to a one-time event (i.e., over and back), and only if no alternative crossing method is available. If repeated crossings of the watercourse are required, construct a temporary crossing structure.
- Use temporary crossing structures or other practices to cross streams or water bodies with steep and highly erodible (e.g., dominated by organic materials and silts) banks and beds. For fording equipment without a temporary crossing structure, use stream bank and bed protection methods (e.g., swamp mats, pads) if minor rutting is likely to occur during fording.
- Wash, refuel, and service machinery and store fuel and other materials for the machinery in such a way as to prevent any deleterious substances from entering the water.
- Do not ford, place crossing materials or operate machinery on the bed of a waterbody where SARA-listed shellfish occur, or critical habitat or residences of freshwater SARA-listed aquatic species occur.