Bioengineering Demonstration and Education Project
Bioengineering Efficacy Monitoring Plan

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Prepared for:

Alberta Environment and Parks
Suite 100, 3115 12 St. NE
Calgary, Alberta T2E 7J2

Prepared by:

Hemmera
An Ausenco Company

THURBER ENGINEERING LTD.

KERR WOOD LEIDAL
consulting engineers

Polster Environmental Services Ltd.

Terra Erosion Control Ltd.

O2 PLANNING + DESIGN

ACKNOWLEDGEMENT

The Bioengineering Efficacy Monitoring Plan (BEMP) is an important component of the Bioengineering Demonstration and Education Project (BDEP). It will provide data to support the use of bioengineering techniques as ecologically valuable and cost-effective alternatives to conventional engineering practices for bank erosion protection and riparian restoration.

The need for a longer term (10 year) monitoring plan to assess the BDEP was always envisioned as an integral part of BDEP. Development of the plan was supported and funded by Alberta Environment and Parks (AEP) as part of the design contract scope of work. Implementation of the Plan is the responsibility of the City of Calgary. Given the partnership between Alberta Environment and Parks and The City of Calgary in the development and implementation of BDEP, the BEMP could not have been developed without the input and guidance of a large number of individuals.

Greg Eisler (Hemmera) and Lisa Rear (Hemmera) were principal authors of the Plan, and supporting budget and schedule, which was informed by input from staff within The City of Calgary and Alberta Environment and Parks. Members of the Technical Team supporting AEP in the delivery of the BDEP also contributed to the Plan.

The following individuals and organizations provided technical input, to ensure the effectiveness of long-term monitoring activities, as well as institutional knowledge to ensure the effective integration of the BEMP and complimentary riparian restoration and monitoring initiatives within the City of Calgary:

- Trevor Rhodes (City of Calgary Water Resources)
- Jon Slaney (City of Calgary Water Resources)
- George Roman (City of Calgary Water Resources)
- Norma Posada (City of Calgary Water Resources)
- Sarah Marshall (City of Calgary Water Resources)
- Tim Walls (City of Calgary Parks)
- Kathryn Hull (Cows and Fish)
- David DePape (Alberta Environment and Parks)
- Kevin Brayford (Alberta Environment and Parks)
- Mike Gallant (Kerr Wood Leidal Associates Ltd.)
- Andrew Szojka (Kerr Wood Leidal Associates Ltd.)
- Pierre Raymond (Tera Erosion Control)
- Mike Magnan (02 Planning + Design)
- Mark Piciacchia (Hemmera)
- Mike Peckford (Hemmera)

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1.0 INTRODUCTION

Hemmera Envirochem Inc. (Hemmera) has prepared a *Bioengineering Efficacy Monitoring Plan* (BEMP) for Alberta Environment and Parks (AEP) Fisheries Habitat Enhancement and Sustainability (FISHES) Program, in partial fulfillment of the requirements of the Bioengineering Demonstration and Education project (the Project). The Project is being delivered under a formal partnership agreement between AEP and the City of Calgary (The City). As part of the partnership understanding, development of the BEMP is the responsibility of AEP, while implementation of the BEMP is the responsibility of The City. This report outlines the details of the proposed BEMP for Sites 1, 2, and 4 (**Figure 1**). It is understood that final refinements to this BEMP may be necessary, pending further discussions between The City and the FISHES Program and/or any changes to the Project's intended footprint occurring at construction.

Hemmera's team understands that AEP's primary goal is to achieve fish habitat enhancement and riparian restoration at flood affected and impacted sites using bioengineering techniques. Integrating education opportunities and objectives during project development will facilitate increased understanding of bioengineering techniques, as effective and ecologically valuable alternatives to hard engineering practices (i.e. controlled disruption of natural processes by using man-made structures) for bank erosion protection and associated riparian restoration, with a range of identified audiences.

The goals for the Project, as per the *Project Charter*, are to meet the following criteria:

- Effectively stabilize an area of unstable, steep bank.
- Initiate measurable restoration of flood affected habitat or creation of new fish habitat (e.g. bank overhangs, in-stream refugia, boulder clusters, large woody debris, shade/cover by riparian plantings, etc.).
- Design and construct methods to facilitate increased awareness and understanding of flood recovery processes, development of new educational programming targeting bioengineering techniques, and related design success factors.
- Improve riverbank aesthetics in the area.

Building on the Project goals, key objectives of the Bioengineering Demonstration and Education Project (BDEP) are:

- To monitor the overall effectiveness and cost of the Project, specifically in relation to a more conventional rip rap bank protection project.
- To evaluate the overall effectiveness and cost of the Project, specifically in relation to a more conventional rip rap bank protection project.
- To report on the overall effectiveness and cost of the Project, specifically in relation to a more conventional rip rap bank protection project.

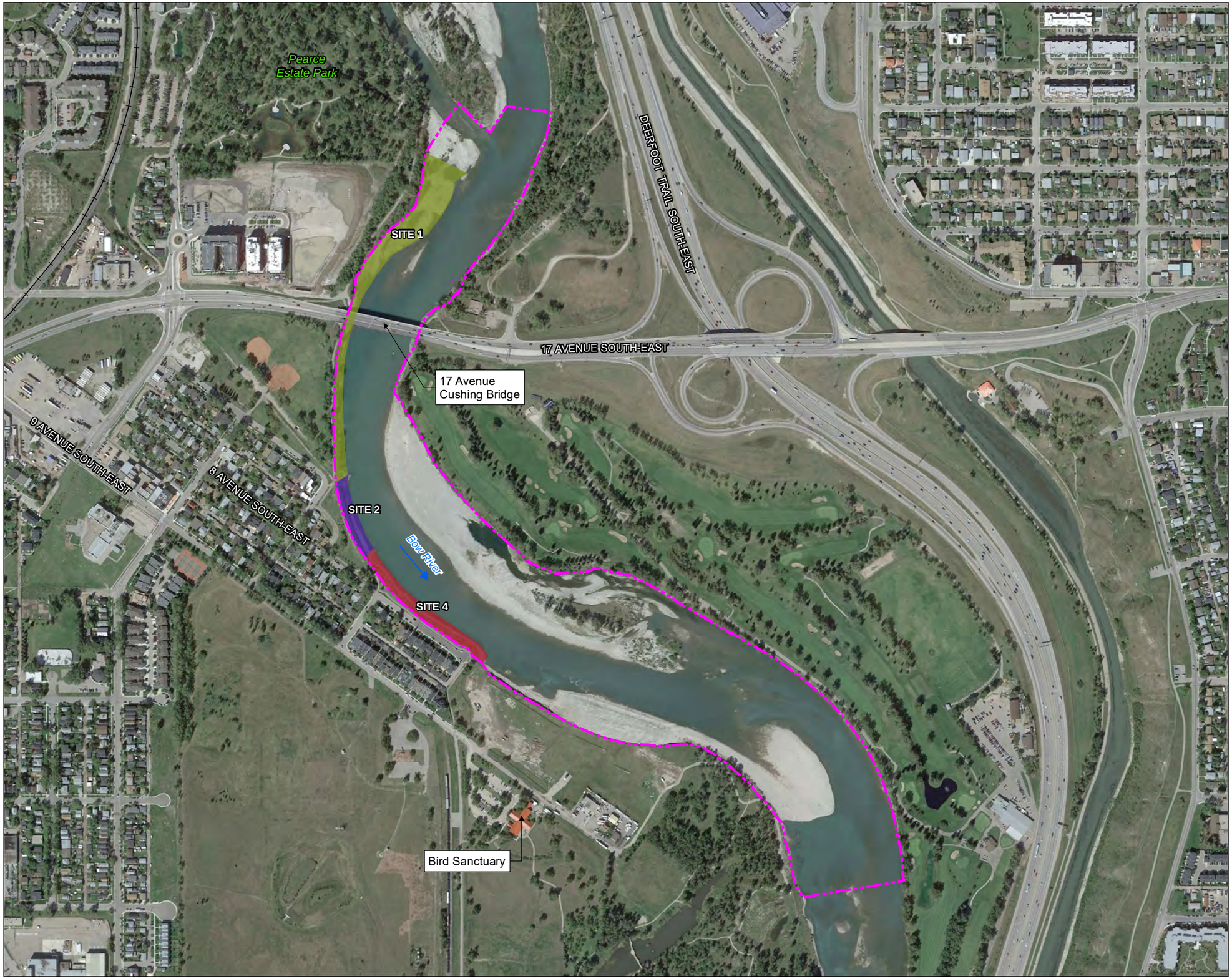
In this context, the BEMP is a critical tool to providing information to support understanding of the effectiveness of the physical works undertaken through the Project, with respect to the goals noted above, and support a comparison with conventional approaches to bank protection. However, an actual cost benefit analysis of the Project in relation to a more conventional riprap bank protection project is outside the scope of the BEMP.

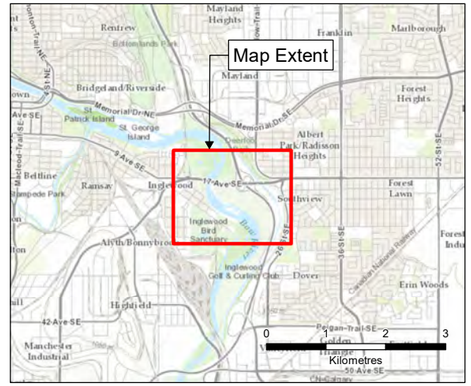
The scope of work for the BEMP involves post-construction monitoring over multiple years, with the first year of monitoring commencing in 2019, after anticipated Project construction is complete in December 2018. Subsequent monitoring will occur in 2020, 2021, 2023, and 2028. It is recommended that a visual inspection of the works be completed following any return event greater than 1:10, given this is the flood level on the Bow River where significant sediment transport will likely be realized. The BEMP also includes a contingency budget to support monitoring immediately following a significant flood event(s) that occurs post-construction and results in significant damage to Project works. A significant flood event is defined as 'a return event that causes enough damage to the works to require major repairs or re-construction'. Should this occur, the monitoring schedule would be reset to include monitoring in years 1, 2, and 4, post-reconstruction. Monitoring will include surveys for fish and fish habitat, riparian health, wildlife, and integrity of the bioengineering structures/installments. Monitoring visits will be conducted during select (and in some cases multiple) seasons in each monitoring year to capture the range of environmental conditions that may exist at the sites, and to ensure that sampling of biotic and abiotic elements occurs with appropriate timing. Details of each component are presented in subsequent sections. A summary of survey timing and level of effort is provided in **Section 4.0**, **Table 6.**

In support of The City's *Riparian Action Program*, The City is currently undertaking a 5-year Riparian Monitoring Program (RMP). An opportunity was identified for The City to undertake implementation of the BEMP, in concert with implementation of the RMP, as both initiatives have overlapping objectives, similar implementation timelines, and draw on similar monitoring activities. Additional detail on how implementation of the BEMP will be undertaken in an integrated manner with the RMP is included in **Section 2.0** (BEMP Implementation).

Bioengineering Efficacy Monitoring Plan
Bow River, Calgary, Alberta

Site Map





Legend

- Assessed Reach
- Site 1
- Site 2
- Site 4
- Direction of Flow
- Railway

Notes

1. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Basedata: Government of Alberta
- Aerial Image: Google Earth (imagery date: 8/22/2015)
- Inset Basemap: ESRI World Topographic Map

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Alberta Environment and Parks

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2.0 BEMP IMPLEMENTATION

In support of The City's *Riparian Action Program*, The City is currently undertaking a 5-year Riparian Monitoring Program (RMP). During the planning phase of BDEP, an opportunity was identified for The City to undertake implementation of the BEMP in concert with implementation of the RMP. While both initiatives have overlapping objectives, similar implementation timelines and draw on similar monitoring activities, there are also differences in the objectives of the two initiatives, which result, in some cases, in different monitoring activities. This section of the BEMP provides an overview of the overlaps and differences in monitoring approaches between the two programs.

The City's RMP focuses on bioengineering and riparian planting projects implemented by The City in the last ten years, as well as baseline Riparian Health Inventory (RHI) sites assessed since 2007.

The RMP involves two components: *Effectiveness Monitoring* and *Trend Monitoring*.

- **Effectiveness Monitoring** – Effectiveness monitoring will assess post-construction conditions to evaluate changes resulting from implemented restoration projects.
- **Trend Monitoring** – Trend monitoring will be used to establish the nature and direction of riparian health. The table below shows the overlap between the two programs.

A main deliverable of the RMP Phase 1 is a program *Monitoring Plan*, which will include the BDEP as a special project.

Table 1 Comparison of BEMP and RMP Monitoring Approaches: provides an overview of where the monitoring approaches in The City's RMP overlap with the BEMP, and where the objectives of the BEMP require a different approach or frequency of monitoring, relative to that employed in The City's RMP.

Table 1 Comparison of BEMP and RMP Monitoring Approaches

Monitoring Focus	BEMP	RMP
Fish and Fish Habitat	This component is part of the BEMP. The BEMP describes methods for monitoring of fish and fish habitat.	This component is currently not part of the overall RMP. The BEMP methods will be followed as part of the RMP for the BDEP sites.
Riparian Health	This component is part of the BEMP. The monitoring method for riparian health described in the BEMP includes a Riparian Health Assessment (RHA).	Riparian Health is a component of the overall RMP, and BEMP monitoring methods, including frequencies, will be part of the RMP monitoring. There are two monitoring procedures that will be included in the RMP to support the BEMP: • Completion of a revisit Riparian Health Inventory (RHI) in 2021 for the BOW95 Site (Cows and Fish 2016b). • The RMP includes a riparian/top-of-bank assessment component as part of its Bank Effectiveness Monitoring that will be integrated with Riparian Health Assessments (RHA). RHAs were not originally part of the RMP but will be undertaken to be consistent with the BEMP methods. The BEMP monitoring frequencies will be followed for RHAs.
Wildlife	This component is part of the BEMP. The BEMP describes methods for monitoring of wildlife.	This component is currently not part of the overall RMP. The BEMP methods will be followed as part of the RMP for BDEP sites.
Bioengineering Structural Integrity	This component is included in the BEMP. The BEMP describes timelines for monitoring that are more frequent than the RMP.	This component is part of the overall RMP. The BEMP monitoring frequencies will be followed for RMP implementation at BDEP sites. The RMP will define specific methods and analysis that align with the BEMP.
Reporting	BEMP implementation assumes one reporting of results will take place in every year in which monitoring activities are undertaken. A final report, summarizing the conclusions and findings of the overall monitoring programs, as well findings related to the individual components (e.g. fish, wildlife, structural integrity etc.), will be completed and provided to AEP within 6 months of the final monitoring event.	This component is part of the overall RMP, The BEMP monitoring findings will be integrated with the RMP reporting scope. Annual reports will be prepared as part of the RMP.

It should be noted that the RMP is currently structured as a 5-yr program, and the BEMP is a 10-yr monitoring program. However, the RMP is expected to continue beyond 5 years and will provide for the longer term monitoring and reporting requirements of the BEMP.

The City's RMP is intended to be a dynamic program that can be adapted, and modified, in response to the findings of the monitoring activities. As such, specific RMP monitoring requirements and methods may change in the future. The City will engage AEP, prior to making changes to monitoring approaches that apply to the BDEP sites, to ensure new approaches support the long-term objectives of BDEP.

In addition to sharing common monitoring objectives, as noted above, both the RMP and BEMP are aligned with, and supportive of, the goals and objectives of the Bioengineering Demonstration and Education Project Education Plan[1].

[1] Hemmera Envirochem Ltd., "Education Plan", *Bioengineering Demonstration and Education Project* (Prepared for Alberta Environment and Parks, 2017).

3.0 BASELINE DATA

The purpose of the Project's baseline data collection was to assess pre-construction environmental conditions for Sites 1, 2, and 4 (**Figure 1**). These baseline data form a reference condition, upon which project effects (bioengineering structures/installments), on the identified components, will be monitored and documented throughout the BEMP.

In addition to monitoring potential changes at each site, the BEMP is also planning to provide an analysis of the efficacy of the remediation methods, comparing Sites 1 and 2, where intensive bioengineering remediation is intended (e.g. fish shelters, rock clusters, box fascines), to Site 4, where less intensive elements are intended (e.g. vegetating existing riprap armouring). For comparative purposes, Site 4 has been selected to represent baseline conditions, from which anticipated successes at Sites 1 and/or 2 can be benchmarked. In this comparison, Site 4 represents a proxy to the traditional method of flood mitigation (hard armouring), albeit with some minor bioengineering enhancements, whereas Sites 1 and 2 are identified as the treatment reaches. It is expected that only a comparison of overall fish habitat suitability among the three sites will be possible, given the difference between treatments (i.e. the scope of bioengineering elements) designed for Sites 1, 2, and 4.

Hemmera led an on-site reconnaissance, by its Project team on July 18, 2016, to assess the conditions and identify bioengineering design, fish habitat, and education opportunities at each site. Prior to this site reconnaissance meeting, Skymatics Ltd. provided drone technology to document the existing baseline conditions of the Project area, particularly to facilitate the performance evaluation of each site regarding riparian vegetation, riverbank and slope stability, and fish and wildlife habitat. During this drone reconnaissance, aerial imagery of the riverbank and a video of the river's morphological features were obtained. A georeferenced flight path was documented for use in long-term monitoring of the Project. This electronic information is available upon request. While the sampling protocols and budget presented in the BEMP do not provide for visual monitoring of site conditions, the aerial imagery of pre-construction site conditions, collected during drone flights, could be used to support future monitoring of changes in site conditions post-construction.

3.1 FISH AND FISH HABITAT

Hemmera completed a baseline fish habitat assessment of riverine areas encompassing each of the three Project sites on March 27, 2017. Historical documentation of fish presence was determined using FWMIS[2] and aerial imagery from 2002 to 2016 was reviewed[3] to supplement field observations. Due to the existing database of previously documented fish species in the Bow River within the vicinity of the Project, fish

[2] Fisheries and Wildlife Management Information System (FWMIS), "Area-Specific Search Request (2017)", at *Fish and Wildlife Division: Alberta Environment and Sustainable Resource Development,* https://maps.srd.alberta.ca/FWIMT_Pub/Viewer/?TermsOfUseRequired=true&Viewer=FWIMT_Pub (accessed April, 2017).

[3] Google Earth 7.1.5.1557. (2015), "Calgary, Alberta. 50°58'50.17"N 114°01'42.46"W. 3406 ft." *Digital Globe Imagery* (accessed March 2017)

sampling was not conducted. Supplemental information was reviewed, including morphological mapping conducted in 2014 by Klohn Crippen Berger[4], and a bathymetry survey conducted in July 2016 by Kerr Wood Leidal[5]. Detailed descriptions of habitat characteristics and potential, for each Site, are provided in the *Project's Fish and Fish Habitat Assessment Report*[6].

During the baseline fish habitat assessment, data were collected and assessed following Hemmera's protocols for fish habitat assessments[7], which will enable replicative, post-construction monitoring during the BEMP. However, should alternate analytics be preferred during the implementation of the BEMP (e.g. direct reference to Habitat Suitability Indices, or weighted habitat unit values), retroactive concordance of data may be required.

Habitat

In summary, the assessed reach of the Bow River (including Sites 1, 2, and 4) is characterized as a low gradient (2%) and a regular meander pattern that is frequently confined by its valley walls. The entire assessed reach is dominated by Class 1 run habitat (R1) (>1.0 m), alternating with various pool habitats (P1-deep, P2-moderate, and P3-shallow) along the right downstream bank (RDB). Habitat features in the assessed reach also include riffles, a Class 2 run habitat (R2) (0.75-1.0 m), and a backwater pool (BW) habitat. A snye habitat (backwater or side channel) is located along the left downstream bank (LDB), adjacent to the Inglewood Golf and Curling Club (**Figure 1**). The snye habitat likely has connectivity at its upstream extent, during high flow periods (e.g. during spring freshet). P1 habitat is present at the downstream extent of the assessed reach.

Substrate throughout the assessed reach is dominated by boulder and cobble in run habitats (R1 And R2), and cobble and large gravel in riffle habitats. Substrates within pool habitats (P1, P2, and P3) consist primarily of boulder, cobble, and fines. Gravel and fines dominate the snye habitat located along the LDB.. Throughout the assessed reach, maximum water depth ranges from 0.54m to 7.10m, with an average water depth of 1.54m[8].

Bankfull width in the assessed reach ranges from 105m to 230m, with an average width of approximately 163m. Wetted width ranges from 80m to 174m, with an average width of 116m. Bank stability throughout the assessed reach ranges from stable slopes, in areas armoured with riprap, to near vertical and unstable, along the RDB immediately downstream of the 17 Avenue Cushing Bridge. Additionally, some banks consist primarily of fines and cobble.

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4 Klohn Crippen Berger, "Calgary Rivers Morphology and Fish Habitat Study – Draft", *Technical Memo F-1: Existing Fish Habitat*. Draft report prepared for The City of Calgary, (April 2015).

5 Kerr Wood Leidal, "Project Site Topography" for the *Bioengineering Demonstration and Education Project*. Prepared for Hemmera Envirochem Inc., (2016).

6 Hemmera Envirochem Ltd., "Fish and Fish Habitat Assessment: Bow River, Alberta", *Bioengineering Demonstration and Education Project*, (2017).

7 Hemmera Envirochem Ltd., "fish Habitat Assessment".

8 Hemmera Envirochem Ltd., "fish Habitat Assessment".

The concentration of dissolved oxygen and pH were within, or exceeded, the Canadian Council of Ministers of the Environment (CCME) *Guidelines for the Protection of Freshwater Life*[9]. Conductivity and water temperature were within anticipated levels, based on time of year. Detailed water quality measurements were collected at Site 2[10].

Fish

The Bow River, from its headwaters to the confluence with the Oldman River, is known to support 35 fish species[11]. However, within the vicinity of the Project (i.e. between Bearspaw and Carseland Dams), only 22 of these species are likely to occur, including 11 sportfish species (Table 1).

Categorization of fish habitat potential focused on brown trout, rainbow trout, and mountain whitefish. These species were chosen for fish habitat potential ratings based upon presumed relative species abundance[12], being part of a CRA (commercial, recreational, or aboriginal) fishery, and construction effects on spawning season. These species are representative of all spawning seasons that will be affected by construction (both spring and fall). Habitat potential was graded based on the ability to provide spawning, rearing, adult feeding, and overwintering habitat. The fish habitat potentials were rated as:

- Essential: habitat that is rare, highly productive, sensitive, or vital in sustaining commercial, recreational or Aboriginal fisheries, or any species at risk, or is of management concern.
- Important: habitat that is important to the fish population for spawning, feeding, rearing, wintering, and migration and is not deemed to be critical to a specific population.
- Marginal: habitat characterized by low productive capacity that contributes marginally to fish production; includes habitat that is not available to fish due to natural permanent barriers.
- Unsuitable: no suitable habitat present for a specific fish species life history stage.

Ratings were based upon the professional judgement of the QAES, using an adaptation of habitat descriptions from the *BC Oil and Gas Commission*[13] and *BC Ministry of Forests, Lands, and Natural Resource Operations*[14], as well as various known habitat suitability characteristics for each species.

Important fish habitat potential was observed throughout the assessed reach for numerous sportfish species. Overall, wintering, migration, and rearing habitat was rated 'Important' for the species assessed (mountain whitefish, rainbow trout, and brown trout). Moderate depth and deep run habitats (R2 and R1),

9 Canadian Council of Ministers of the Environment (CCME), "Canadian Water Quality Guidelines for the Protection of Aquatic Life: Summary Table", *Canadian Environmental Quality Guidelines*, revised 2007 (Winnipeg: Canadian Council of Ministers of the Environment, 1999).
10 Hemmera Envirochem Ltd., "fish Habitat Assessment".
11 FWMIS, "Area-Specific Search Request".
12 FWMIS, "Area-Specific Search Request".
13 British Columbia Oil and Gas Commission*, Environmental Protection and Management Guide, Version 1.9,* Fort St. (John: Oil and Gas Commission, 2017).
14 British Columbia Ministry of Forests, Lands, and Natural Resource Operations [FLNRO], BC Ministry of Environment, and Fisheries and Oceans Canada, *Fish-stream Crossing Guidebook, revised ed*. (Victoria: Prac. Invest. Br., 2012).

observed along the entire reach, are likely to provide deep, slow habitat that is suitable for overwintering. Migration was rated 'Important', as no known barriers to fish migration exist between the Bearspaw and Carseland dams. Stream margins and low velocity habitat features, including snyes and backwater areas, offer rearing habitat for multiple species. The spawning potential for mountain whitefish and brown trout was rated 'Important', due to the abundance of suitable substrates, habitat types, and cover availability. Spawning activity by mountain whitefish and brown trout has been documented downstream of the Project area[15]. The spawning potential for rainbow trout was rated 'Marginal', as most of the lower Bow River watershed population spawns in tributaries located downstream of the Project, in the Highwood and Sheep River headwaters. Historically, low levels of spawning have been documented in the Project reach[16].

Table 2 Fish Species Documented in the Bow River near the Project

Common Name[17]	Scientific Name	Spawning Season[18]	Provincial Status[19]	Federal Status[20]
SPORTFISH				
Brook trout	*Salvelinus fontinalis*	Fall	Exotic/Alien	Not Listed
Bull trout	*Salvelinus confluentus*	Fall	At Risk	No Status
Brown trout	*Salmo trutta*	Fall	Exotic/Alien	Not Listed
Burbot	*Lota lota*	Winter	Secure	Not Listed
Cutthroat trout[a]	*Oncorhynchus clarki*	Spring	Exotic/Alien	Not Listed
Lake whitefish	*Coregonus clupeaformis*	Fall / Winter	Secure	Not Listed
Mountain whitefish	*Prosopium williamsoni*	Fall	Secure	Not Listed
Northern pike	*Esox Lucius*	Spring	Secure	Not Listed
Rainbow trout[b]	*Oncorhynchus mykiss*	Spring	Secure	Not Listed
Yellow perch[c]	*Perca flavescens*	Spring	Secure	Not Listed
Walleye	*Sander vitreus*	Spring	Secure	Not Listed

15 FWMIS, "Area-Specific Search Request", 2017; Golder Associates, *Fish Habitat inventory and habitat use assessment for the Bow River from Bearspaw dam to WID weir, volumes I and II.* (Prepared for Fisheries Management Division, Alberta Sust. Res. Dev., Calgary, AB. 2001).

16 Alberta Environment (AE) and Alberta Sustainable Resource Development (ASRD), "Appendix A: Fisheries Management Objectives" *Instream Flow Needs Determinations for the South Saskatchewan River Basin, Alberta, Canada*. http://aep.alberta.ca/water/programs-and-services/south-saskatchewan-river-basin-water-information/studies/instream-flows-needs.aspx (2003).

17 FWMIS, "Area-Specific Search Request"; Joseph S Nelson and Martin J. Paetz, *The Fishes of Alberta* (Edmonton: University of Alberta press, 1992).

18 Amanda Joynt and Michael Gary Sullivan, *Fish of Alberta* (Edmonton: Lone Pine Publishing, 2003); Nelson and Paetz, *The Fishes of Alberta.*

19 Government of Alberta, *Alberta Wild Species General Status Listing -2015, (Government of Alberta, 2017)*. http://aep.alberta.ca/fish-wildlife/species-at-risk/albertas-species-at-risk-strategy/general-status-of-alberta-wild-species/documents/SAR-2015WildSpeciesGeneralStatusList-Mar2017.pdf. (Accessed: March 2017).

20 Government of Canada, *Species at Risk Public Registry, A to Z Species Index,* 2017. https://www.registrelep-sararegistry.gc.ca/sar/index/default_e.cfm (Accessed: March, 2017).

Common Name[17]	Scientific Name	Spawning Season[18]	Provincial Status[19]	Federal Status[20]
NON-SPORTFISH				
Brook stickleback	*Culaea inconstans*	Spring / Summer	Secure	Not Listed
Fathead minnow	*Pimephales promelas*	Summer	Secure	Not Listed
Lake chub	*Couesius plumbeus*	Spring	Secure	Not Listed
Longnose dace	*Rhinichthys cataractae*	Spring / Summer	Secure	Not Listed
Longnose sucker	*Catostomus catostomus*	Spring	Secure	Not Listed
Mountain sucker	*Catostomus platyrhynchus*	Summer	Secure	Not at Risk
Prussian carp	*Carissius gibclio*	Spring / Summer	Exotic/Alien	Not Listed
Pearl dace	*Margariscus margarita*	Spring / Summer	Undetermined	Not Listed
Spoonhead sculpin	*Cottus ricei*	Spring	May be at Risk	Not at Risk
Trout-perch	*Percopsis omiscomaycus*	Spring / Summer	Secure	Not Listed
White sucker	*Catostomus commersoni*	Spring	Secure	Not Listed

Notes:
a Cutthroat trout in the Bow River near the Project represent introduced stocks and are not considered native stocks of Westslope Cutthroat Trout (*Onchorhynchus clarkii lewisi*).
b Rainbow trout in the Bow River near the Project represent introduced stocks and are not considered native stocks of Athabasca Rainbow Trout.
c The historical range of yellow perch does not include the Bow River. However, numerous specimens have been captured in irrigation canals near the Project area.

3.2 RIPARIAN HEALTH

Hemmera conducted a Riparian Health Assessment (RHA) for Sites 1, 2, and 4 on October 2, 2016[21], using the 'Alberta Wetland Health Assessment for Large River Systems methodology'[22]. A summary of the goals and objectives for the riparian component of the Bioengineering Demonstration and Education Project include the following:

- Monitor presence and abundance of invasive species to control their establishment and spread.
- Introduce native plant and shrub species to promote natural regeneration of the sites.
- Monitor the survivorship of riparian plantings.
- Install educational signage to convey key riparian and river health messages and project benefits.

The polygons or assessment boundaries identified for each site are described in **Table 3**.

21 Hemmera Envirochem Ltd., "Riparian Health Assessment: Bow River, Alberta", *Bioengineering Demonstration and Education Project* (2016).
22 Cows and Fish, *Alberta Lotic Wetland Health Assessment for Large River Systems (Survey) User Manual* (2016). http://cowsandfish.org/riparian/documents/AlbertaRiverSurveyManual.pdf

Table 3 Riparian Health Assessment Polygon Characteristics

Polygon	Assessment Boundary	Length (m)	Area (ha)
Site 1	Downstream of Harvie Passage, to upstream of The City of Calgary storm water outfall B-9; approximately 250 m downstream of the Cushing Bridge	591	2.75
Site 2	Adjacent to the downstream boundary of Site 1, at outfall B-9	128	0.44
Site 4	Boundary begins at the upstream edge of the riprap rock groyne and extends to the downstream riprap rock groyne	251	0.36

SITE 1

The overall rating of the riparian health in this polygon is 'degraded', given the presence of invasive weed species throughout the area. The species diversity and richness is greater upstream of Cushing Bridge, where a mature riparian forest with a well-developed canopy and understory is present on the west side of the Bow River, adjacent to the regional pathway. Approximately half of the riverbank length in the polygon (upstream of the Cushing Bridge) is accessible to animals (e.g. deer) for browsing. Historic erosion and unstable banks characterize the half of the site that is downstream of Cushing Bridge. The area continues to be extremely susceptible to erosion, given the nearly vertical banks and lack of stabilizing riparian vegetation. Most of the Site 1 polygon is classified as no land-use apparent (85%), with development and recreation (15%), for the boat launch ramp and the regional pathway, comprising the remainder of land use in the polygon. Hemmera[23] provides a full list of native and invasive plant species.

SITE 2

The overall rating of the riparian health in this polygon is 'static', given the top of bank and upland areas of the polygon are maintained as green spaces by The City of Calgary. There is limited regeneration of balsam poplar along the toe of the riverbank, and the riparian species present are reflective of species that quickly colonize disturbed areas. No land use is apparent for the majority (70%) of the polygon, with the rest of the land use designated as turf grass (mowed lawn) (20%) and recreation (regional pathway) (10%). Adjacent land use is primarily residential development (50%), roads (30%) and turf (lawns) (20%). Hemmera provides a full list of native and invasive plant species[24].

SITE 4

The overall rating of the riparian health in this polygon is 'improving', due to the extensive riparian planting program conducted in 2014 by Golder Associates Ltd. As part of The City of Calgary's 2013 flood remediation and bank stabilization works. Some natural (i.e. not planted) regeneration of sandbar willow was observed among the planted species. The entire polygon is categorized as no land use apparent and

[23] Hemmera Envirochem Ltd. "Riparian Health Assessment".
[24] Hemmera Envirochem Ltd. "Riparian Health Assessment".

serves primarily as green space along the regional pathway. Adjacent land use is comprised of turf lawns (50%), residential development (30%), recreation (regional pathway) (10%) and roads (10%). Hemmera provides a full list of native and invasive plant species[25].

Riparian health was scored based on parameters from the vegetation and soil/hydrology categories, as stated in the referenced methods[26]. Scores are summarized in Table 4. The health ratings are categorized as follows:

- Healthy (80 – 100%): Little or no impairment to riparian functions.
- Healthy but with Problems (60 – 79%): Some impairment to riparian functions due to human or natural causes.
- Unhealthy (<60%): Impairment to many riparian functions due to human or natural causes.

Table 4 Riparian Health Assessment Scores for Project Sites

Parameter	Site		
	1	2	4
Vegetation			
Vegetation Health Rating (%)	54%	33%	28%
Soil / Hydrology			
Soil / Hydrology Health Rating (%)	33%	25%	29%
Overall			
Overall Health Rating (%)	43%	29%	29%
Overall Health Rating Category	Unhealthy	Unhealthy	Unhealthy

The health rating category results of the RHA were compared to the results of the Cows and Fish *Riparian Health Inventory Summary Report* for the BOW95 Site[27], which overlaps with the Project locations. The overall 'Unhealthy' rating of Site 1, Site 2 and Site 4, was consistent with the conclusions of the Cows and Fish *Riparian Assessment* for those areas.

Overall, the riparian health of the current Project area is considered 'Unhealthy' due to the heavily disturbed condition, which resluted from severe bank erosion, historical bank protection efforts, and human use. Site 4 is 'improving' given the riparian planting that was part of stream bank restoration and stabilization work after the 2013 flood. The Project's bioengineering designs and landscape planting plans are intended to improve the riparian health of the Project lands, and contribute to fish and terrestrial wildlife habitat value, ultimately increasing biodiversity in the Project area.

25 Hemmera Envirochem Ltd. "Riparian Health Assessment".
26 Cows and Fish, *Wetland Health Assessment*.
27 Cows and Fish, "Riparian Health Inventory Summary Report: BOW95" Inglewood Bioengineering Demo Proposed Site, Calgary (2016).

3.3 BENTHIC MACROINVERTEBRATES

Background information related to the benthic invertebrate community in Project area, collected in 2017, has been provided below for context only. While it is acknowledged that benthic invertebrates provide an indicator of stream health, monitoring of trends related to benthic invertebrates will not form part of the scope of the BEMP. Studies have shown[28] that benthic invertebrates recover quickly from short-term disturbances, suggesting that there is limited value in monitoring this parameter as part of the BEMP's proposed 10 year monitoring period. Additionally, significant in-stream disturbance has already occurred in this reach of the Bow River from other flood mitigation works (e.g. Harvey Passage), making it very difficult to establish a baseline for benthic macroinvertebrate assessment.

The general aquatic environment for Sites 1, 2, and 4 consist of riffles and Class 1 runs (1.0 m), with boulder, cobble, gravel, and fines[29]. Based on these characteristics, it is expected that a benthic community would be composed largely of benthic invertebrates associated with larger particle size and swift water, such as orders Ephemeroptera (Mayflies), Plecoptera (Stoneflies), and Trichoptera (Caddisflies) (EPT), with some Chironomidae and burrowing species. In general, a higher percentage of EPT in a stream suggests a healthier aquatic ecosystem, as EPT have lower tolerance for environmental changes and pollution, compared to others such as the Chironomidae family, which can survive in areas with a higher fine sediment load and pollutant concentration[30].

A report prepared for Alberta Environment (AENV)[31] on the Bow River, classified the aquatic ecosystem health of primary producers in the upper reaches of this watershed as 'good', and 'marginal' in the middle reach downstream of The City of Calgary. In general, there are limited data for benthic invertebrates in the Bow River at the site locations.

While not required to support BEMP implementation, as part of Phase 1 of The City's RMP, baseline sampling of the benthic invertebrate community at the Project location was conducted in 2017.

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28 Anderson et al. "Impacts and Recovery in a Coldwater Stream Following a Natural Gas Pipeline Crossing Installation" Proceedings of the International Pipeline Conference 1998: American Society of Mechanical Engineers. (1998); Collier et al. "Stream Ecology. Bouncing Back: How fast can stream invertebrates recolonize?" *Water and Atmosphere* 10.2 (2002); Reid, S.M. and P.G. Anderson. "Effects of Sediment Released During Open cut Pipeline Water Crossings". *Canadian Water Resources Journal* 24.3 (1999); Reid, S.M. et al. "Effects of natural gas pipeline water crossing replacement on the benthic invertebrates and fish communities of Big Darby Creek, OH". 7th International Symposium on Environmental Concerns in Right of Way Management, Calgary, AB (2002).

29 Hemmera Envirochem Ltd., "fish Habitat Assessment".

30 Benoit, C. et al. "Aquatic Insects as Water Quality Indicators in the Elbow River Watershed, Alberta".*ENSC 502*. University of Calgary (2016).

31 North/South Consultants, *Summary Report of the Initial Assessment of Ecological Health of Aquatic Ecosystems in Alberta: Water Quality, Sediment Quality and Non-Fish Biota*. Prepared for Alberta Environment (Edmonton, 2007).

3.4 WILDLIFE

A desktop review of available wildlife information was completed using the Fisheries and Wildlife Management Information System[32]. The results are summarized in **Table 5,** and provided in **Appendix A**. This species summary report identified several listed species within 1km of the Project site. A search of the Wildlife Sensitivity Maps indicated that Sites 1, 2, and 4 overlap with key range layers for bald eagles, golden eagles, prairie falcons, and sharp-tailed grouses[33].

Table 5 Provincially or Federally Listed Species with Documented Occurrences within 1 km of Project Sites

Species	Scientific Name	Provincial Ranking[34]	SARA Schedule[35]	COSEWIC Ranking[36]
Bald eagle	*Haliaeetus leucocephalus*	Sensitive	-	-
Baltimore oriole	*Icterus galbula*	Sensitive	-	-
Eastern kingbird	*Tyrannus tyrannus*	Sensitive	-	-
Common nighthawk	*Chordeiles minor*	Sensitive	Schedule 1	Threatened
Great blue heron	*Ardea herodias*	Sensitive	-	-
Harlequin duck	*Histrionicus histrionicus*	Sensitive	-	-
Least flycatcher	*Empidonax minimus*	Sensitive	-	-
Northern goshawk	*Accipiter gentilis*	Sensitive	-	-
Silver-haired bat	*Lasionycteris noctivagans*	Sensitive	-	-
Sora	*Porzana carolina*	Sensitive	-	-
Western grebe	*Aechmophorus occidentalis*	Sensitive	No Schedule	No Status
Western wood-pewee	*Contopus sordidulus*	Sensitive	-	-

A terrestrial assessment,, including wildlife species, was conducted in 2016[37]. This assessment is described in the Project's *Preliminary Natural Assessment Report*[38]. It is notable that wildlife habitat observed at the three sites contained riparian habitat that could provide nesting sites for various breeding bird species, including bank swallows and raptors, such as bald eagles.

32 FWMIS, "Area-Specific Search Request".
33 Alberta Environment and Parks. *Wildlife Sensitivity Maps* (2017). http://aep.alberta.ca/forms-maps-services/maps/wildlife-sensitivity-maps/default.aspx. (accessed on 13 April 2017)
34 Alberta Environment and Parks. *Wild Species Status Search* (2017). http://aep.alberta.ca/fish-wildlife/species-at-risk/wild-species-status-search.aspx. (accessed on 13 April 2017)
35 Environment and Climate Change Canada (ECCC). *Species at Risk Public Registry Species Index* (2017). http://www.registrelep-sararegistry.gc.ca/sar/index/default_e.cfm
36 ECCC, *Species at Risk*.
37 Hemmera Envirochem Ltd. "Riparian Health Assessment".
38 Hemmera Envirochem Ltd.. "Preliminary Natural Site Assessment, Bow River, Alberta". *Bioengineering Demonstration and Education Project*, 2017.

Riparian habitat with exposed banks can provide areas for nesting bank swallow colonies. The *Final Design Report*[39] identified a bank swallow colony near Site 2. This bank swallow colony was also observed during site reconnaissance, along with another bank swallow colony near Site 4[40]. Bank swallows are listed by AEP as Sensitive in Alberta[41] . They are listed as Threatened by COSEWIC, and have no status under SARA[42].

Site 1 contains several mature trees that have the potential to support breeding for some of the avifauna species in **Table 5**. These trees will be removed, as part of Project activities, outside of the nesting season for breeding birds in nesting zone B4 (April 22 - August 17)[43] There are no mature trees in Sites 2 and 4 that would support breeding. No great blue heron rookeries were observed at any of the sites during the site visits. Surrounding habitat at Peace Estate Park and adjacent neighbourhoods to the Sites contained forested areas that may also provide nesting habitat for raptors.

3.5 BIOENGINEERING STRUCTURES/INSTALMENTS

The designed bioengineering bank protection and fish habitat enhancement measures are based on the information, design basis, and analysis presented by KWL[44], and are designed to withstand the assumed river and ice forces described in this report. They are also meant to be relatively resilient and self-healing, as rock riprap shifts and self-launches in response to river and ice forces. In this manner, the proposed works are meant to avoid a catastrophic loss of integrity, but are otherwise categorized as perpetual maintenance structures.

Drone reconnaissance conducted by Skymatics Ltd. documented the existing baseline conditions of the Project area, by collecting photos of the riverbank along a georeferenced flight path. While the sampling protocols and budget presented in the BEMP do not provide for visual monitoring of site conditions, these aerial images of pre-construction conditions could be used to support future monitoring of changes post-cinstruction. This electronic information is available from Skymatics upon request.

The success of the Project depends significantly on quality of installation, quality of live material used (e.g. dormancy of live cuttings, stock handling until placement) and maintenance, including weeding, watering, mulching, mowing, and monitoring. Inspection of these works is important to identify any damage to the works as early as possible, to ensure the structures are repaired in a timely manner. Permanent photo locations should be set when structures are installed. Monitoring and maintenance costs will be included in annual budgets to guarantee lengthy service life of these structures.

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39 Kerr Wood Leidal Associates Ltd., *Final Design Report Bioengineering Demonstration and Education Project (BDEP), Technical Memorandum*. Prepared for Alberta Environment and Parks (2017).

40 Hemmera Envirochem Ltd., “Preliminary Natural Site Assessment”; Hemmera Envirochem Ltd., »Technical Memorandum : Summary of Terrestrial Assessments” *Bioengineering Demonstration and Education Project*. Prepared for Alberta Environment and Parks, 2017.

41 Alberta Environment and Parks. *Wild Species Status.*

42 ECCC, *Species at Risk*

43 Environment and Climate Change Canada (ECCC), *General Nesting Periods of Migratory Birds in Canada* (2016). http://www.ec.gc.ca/paom-itmb/default.asp?lang=En&n=4f39a78f-1#_fig01

44 Kerr Wood Leidal Associsates Ltd., *Final Design Report.*

4.0 BIOENGINEERING EFFICACY MONITORING PLAN

The detailed description of proposed bioengineering treatments for Sites 1, 2, and 4 are provided in the *Final Design Report*[45] and summarized in **Table 5**. All data and site details obtained from the BEMP outlined below will be reported each year in which monitoring occurs, as well as discussed cumulatively and comparatively at either the five or ten year post-construction monitoring interval. Annual monitoring reports will be made available to all stakeholders involved in the educational component of the Project.

The BEMP will focus on evaluating potential enhancement values at and among all of the sites over a ten-year period. Elements that will be included during the BEMP are fish and fish habitat, riparian heath, wildlife, and structural integrity considerations. The scope, frequency and timing of efficacy monitoring visits are unique for each of these elements, and are defined independently below.

Although a total of five monitoring years (2019, 2020, 2021, 2023, and 2028), over a 10-year period, have been scheduled for BEMP activities, it is anticipated that in the event of significant flood event(s) contingency monitoring may be required to assess potential damage to the Project's works. In this instance, a resetting of the BEMP monitoring frequency will be needed and will be dependant on the timing of the flood event(s). Although the timing of this contingency monitoring is not confirmed in the BEMP, a contingency budget is included for this purpose in the Project budget (Appendix B).

4.1 FISH AND FISH HABITAT

All assessments of fish habitat use and potential will be completed by a crew of either two or three, depending on the potential use of a boat, and led by a Qualified Aquatic Environment Specialist (QAES). Assessments for Sites 1, 2, and 4 will be completed in multiple seasons (spring, summer, fall, and winter), in each of 2019, 2020, 2021, 2023, and 2028.

SPRING

A spring assessment of fish use, occurring post-ice-off, but pre-freshet (late April to May), will be completed for all sites. The goal is to document fish presence during the potential spawning period of rainbow trout and to best observe the condition, functionality, and use of underwater elements by fish (e.g. boulder cluster, riprap apron, crib wall fish shelters). Fish sampling (e.g. electrofishing) during the spring period is unlikely, given its concurrence to a presumed spawning period of rainbow trout; all fish observations will be completed by underwater camera or via snorkelling surveys. This assessment will include a spawning survey (redd survey) focussing on rainbow trout, which will extend from 500m upstream of Site 1, through all riverine habitat adjacent to Sites 2 and 4, to 500m downstream of the downstream extent of Site 4. Given the comparatively subjective nature of underwater observations and potential for limited rainbow trout spawning, comparative analysis of pre and post-construction observations will yield limited value. Rather, observations made during these assessments are intended exclusively to provide validation of fish use of the Project's enhancement structures.

[45] Kerr Wood Leidal Associsates Ltd., *Final Design Report.*

SUMMER

A more comprehensive fish habitat assessment, including quantification of in-stream and near-stream characteristics of value to fish, will be completed post-freshet (July – August) in each sampling year (summer assessment). The timing is intended to coincide with declining water levels, increasing water clarity, and the growing season for riparian vegetation. Based on this timing, it is anticipated that permission to sample fish communities will be granted by AEP Fisheries Management staff, since rainbow trout fry emergence (if spawning occurs in the area) will have occurred and that spawning by other species of management concern will not have begun. The same timing (or as near as possible) will be used in each subsequent summer sampling season.

During the summer assessment, habitat data will be collected to quantify in-stream and near-stream conditions and document habitat enhancement values. Enhancement values will be compared to those predicted by the Project's DFO Self Assessment Analysis[46]. Habitat assessment data will be collected at the site location, as well as upstream to 100m and downstream to 600m from the site location, and will include:

- Transect data approximately every 100m in the assessed reach, including measurements of bankfull width, wetted width, and bank height, recorded to the nearest 0.1m.
- A photographic assessment of fish habitat enhancements (e.g. boulder clusters) and bank stabilization features (e.g. bank riprap) installed at the site locations (Site 1-1 to Site 1-4) to support visual assessments of physical habitat quality and stability.
- Collection of water quality data (e.g. dissolved oxygen, temperature, conductivity, and pH) from site locations and reference location. A reference water quality sampling location will be established upstream of the Project area, at the same location used for the benthic invertebrate assessment (**Section 3.1.3**). Water quality parameters (dissolved oxygen, conductivity, pH, and water temperature) can be collected using a handheld water quality meter, such as a YSI 556. and CHEMets Kit (Dissolved Oxygen K-7512). Water quality data will be compared against standards identified in the Canadian Council of Ministers of the Environment (CCME) *Guidelines for the Protection of Freshwater Organisms*[47].
- Channel pattern, substrate type, confinement, embeddedness, stream shading, stage, in-stream and near-stream cover (e.g. overhanging vegetation, woody debris, in-stream vegetation, boulder, undercut banks, and depth), and other water body characteristics. Refer to the Project's QAES report for a complete listing of characteristics to be reported on.

46 Hemmera Envirochem Ltd., "fish Habitat Assessment".
47 CCME, "Canadian Water Quality Guidelines".

Based on data collected, and observations made, during the summer assessment, fish habitat potential ratings will be assigned, using the same qualification as defined in the Project's QAES report, as 'essential', 'important', 'marginal', or 'unsuitable'. Alternatively, habitat data collected during the BEMP can be translated to accommodate other sampling/analytic protocols, particularly if there is a preference to enable evaluation of enhancement values according to HSI indices and weighted habitat unit (WHU) values.

The presence and relative abundance of fish will be assessed during the summer assessment, potentially with a proxy baseline evaluation against values from AEP Resource Management index sampling results from nearby and similarly characterized habitat. Single pass electrofishing and passive trapping methods will be used in each sampling year and will be replicated using equipment and effort as near identical between years as possible (e.g. placement of traps will occur at the same locations and electrofishing effort will be maintained among years). All water quality and fisheries work will follow applicable regulatory guidelines, as cited in the Fish and Fish Habitat Assessment Report[48]. Note that if a motorized boat is used for potential assessments, a Vessel Operation Restriction Regulations Permit approval will be required from the of the Navigation Protection Program (Transport Canada). Fish sampling will use the following methods:

- A portable electrofisher (e.g.,Smith Root™ Type VI-A or 2.5 GPP) mounted on zodiac inflatable boat will be used over the entire length of the site locations.
- G-type minnow traps, placed at site locations as determined by a QAES and at bioengineering instalments (e.g. Site 1-3 and Site 1-4).

Captured fish will be recorded by species, length, and weight, and returned unharmed to the capture location. Catch per Unit Effort (CPUE) by species will be recorded as an indirect measure of fish abundance at the site location and reference site. Location of fish relative to habitat unit types (e.g. riffle, run, back water), and fish habitat enhancements (e.g. boulder clusters) will be documented to determine fish use of differing habitat types and enhancements. Fish species composition and abundance data will be compared with historical data (if available), as well as between the sites.

FALL

Like the spring assessment, observations of the use of Project enhanced elements will be completed in each sampling year, in late October or early November (fall assessment). Using an underwater camera, observations will be collected via boat, shore, or snorkel surveys. The assessment will be used to observe the potential use of habitat within, and adjacent to, in-stream enhancement features (e.g. boulder cluster, riprap apron, crib wall fish shelters), particularly by fall spawning species (e.g. brown trout). The fall assessment will include a spawning survey (redd survey) focussing on brown trout, which will extend from 500m upstream of Site 1, through all riverine habitat adjacent to Sites 2 and 4, to 500m downstream of the downstream extent of Site 4. Sampling of mountain whitefish eggs will also be completed using kick nets or water propulsion pumps at transects downstream from suitable mountain whitefish spawning habitat.

[48] Hemmera Envirochem Ltd., "fish Habitat Assessment".

Transect locations and sampling efforts will be established in the first sampling event and replicated in each subsequent year. As with the spring survey, resulting spawning data is only to provide validation of fish use of the Project's enhancement structures during critical life stages.

WINTER

A shore-based winter assessment (January) will be conducted at Sites 1-3 and Site 1-4, conditions and safety permitting, to confirm or refute the potential of overwinter use of the fish shelter constructed under the vegetated timber crib wall[49]. An assessment will also be conducted at Site 2-1 and Site 2-2 to confirm or refute the potential of overwintering use of near-bank habitat, adjacent to the box fascines. Sampling will likely require the use of underwater camera(s), or opportunistic snorkel observations, ice cover and flow conditions permitting.

4.2 RIPARIAN HEALTH

The RHA for the sites will be conducted in the late summer/early fall of 2019, 2020, 2021, 2023, and 2028 by an ecologist and/or a vegetation/wetland specialist. Given the expected concurrence of The City's RMP (at least over the first five years, post-construction), BEMP methods and analysis of the RHA will be as defined as those employed in The City's RMP. The RHA methods that will be used as part of The City's RMP include:

- RHAs for Sites 1, 2, and 4 are concurrent with the Bank Effectiveness Monitoring of these sites as part of the RMP. This will follow the *Alberta Wetland Health Assessment for Large River Systems* methodology[50]. As the sites are part of a Large River RHA, 15 parameters will be assessed, from which an overall health rating will be determined.
- As part of the Trend Monitoring component of the RMP, a revisit of the 2016 BOW95 RHI Polygon will be conducted at 5-year intervals. This polygon extends from the 17 Avenue SW Bridge to the downstream extent of Site 4. This will entail completion of a detailed Riparian Inventory following the Cows and Fish *Alberta Lotic Wetland Inventory* protocol[51]. A Riparian Health Assessment Score is derived from the detailed vegetation and physical RHI data. Health score ratings for RHI and RHA sites are based on the same scoring convention for the same 15 parameters, but more in-depth monitoring data on plant community composition and structure is collected for RHIs.

49 Kerr Wood Leidal Associsates Ltd., *Final Design Report.*
50 Cows and Fish, *Wetland Health Assessment*.
51 Cows and Fish. *Alberta Lotic Wetland Inventory Form User Manual* (2017). *http://cowsandfish.org/riparian/documents/2017AlbertaLoticInventoryManualCowsandFish.pdf*

4.3 WILDLIFE

Wildlife surveys will occur in the monitoring years 2019, 2020, 2021, 2023, and 2028, during the month of June, to assess breeding bird activity. This assessment will be completed in accordance with the Sensitive Species Inventory Guidelines[52] for breeding bird surveys on each affected site. Other surveys specific to each site include:

SITE 1

- A nest search will be conducted during monitoring years, from Site 1-1 to Site 1-4, to identify any nesting species, including raptors.
- While not provided for in the sampling protocols or budget presented in the BEMP, remote camera installation and/or track counts could be an ancillary wildlife monitoring activity, to determine if wildlife corridors proposed at Site 1-1 and Site 1-2 are actively being used. This would likely require four visits/year to change data cards and batteries. Track counts might be an opportunity for citizen science.

SITE 2

- A nest search will be conducted during monitoring years, from Site 2-1 to Site 2-2, to identify any nesting species, including raptors and bank swallows. Bank swallow colonies will be monitored to determine the number of breeding adults present.

SITE 4

- A nest search will be conducted during monitoring years, from Site 4-1 to Site 4-3, to identify any nesting species, including raptors and bank swallows. Bank swallow colonies will be monitored to determine the number of breeding adults present.

4.4 BIOENGINEERING STRUCTURAL INTEGRITY

The bioengineering structures and instalments are intended to provide long-term bank protection. Bioengineering structures and instalments at Sites 1, 2, and 4 summarized in **Table 6**[53] will be inspected during monitoring years 2019, 2020, 2021, 2023, and 2028 at key intervals, including:

- A high-water inspection during annual freshet events (June/July);
- A summer inspection, during the growing season in late August, will enable vegetation survivorship evaluations.

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52 Environment and Sustainable Resource Development (ESRD), *Wildlife Management: Sensitive Species Inventory Guidelines* (Government of Alberta, 2013) http://aep.alberta.ca/fish-wildlife/wildlife-management/documents/SensitiveSpeciesInventoryGuidelines-Apr18-2019.pdf

53 Kerr Wood Leidal Associsates Ltd., *Final Design Report.*

Monitoring of the structural integrity, stability and operational effectiveness of the bioengineering features will be the priority during these site visits, and remedial needs will be reported immediately so that corrective actions can be implemented. BEMP structural integrity monitoring will focus on the long-term structural integrity of bioengineering structures (i.e. long term performance of physical structures) including identifying typical ongoing maintenance that may be required, such as after the annual freshet.

BEMP structural integrity monitoring will be provided by the RMP, which includes detailed structural integrity monitoring protocols, as part of its Bank Effectiveness Monitoring component, which overlaps with the BEMP Bioengineering Structural Integrity component. BEMP timelines will be followed for the Project as part of the RMP, but the RMP will define specific monitoring methods, analysis, and reporting.

Protocols for monitoring the structural integrity of bioengineering structures, as described above, are separate and distinct from the monitoring of physical works that is required and will be undertaken as part of the BDEP construction contract (i.e. quality monitoring relative to design specifications).

Drone reconnaissance conducted by Skymatics Ltd. documented the existing baseline conditions of the Project area, by collecting photos of the riverbank along a georeferenced flight path. While the sampling protocols and budget presented in the BEMP do not provide for visual monitoring of site conditions, these aerial images of pre-construction conditions could be used to support future monitoring of changes post-cinstruction. This electronic information is available from Skymatics upon request.

Table 6 Summary of Bioengineering Techniques Proposed by the Project

Technique Name	Description	Proposed Location
Box Fascine	Fascine bundles placed at the toe of an eroding bank and secured between wooden poles[54].	Site 2-1, Site 2-2
Brush Layer	Row(s) of live cuttings placed in a crisscrossed or overlapping manner between layers of soil, with tips protruding beyond the face of the fill[55].	Site 1-3, Site 1-4 Site 2-1, Site 2-2
Brush Mattress	A layer of interlaced/adjacent live cuttings placed on the face of the riverbank[56].	Site 1-4 Site 2-2
Container Shrub Planting	Planting container stock seedling species that are selected for beneficial attributes, such as being fast growing, a natural colonizer, deep rooting, a nitrogen fixer, and a food producer[57].	Site 1-2, Site 1-3, Site 1-4 Site 2-2 Site 4-1, Site 4-2

54 AMEC, "Streambank Erosion and Potential Remedial Measures*", Design Guidelines for Erosion and Flood Control Projects Streambank and Riparian Stability Restoration.* Report submitted to The City of Calgary (2012), Guideline A.

55 D. H. Gray and R. Sotir, *Biotechnical & Soil Bioengineering Slope Stabilization: A Practical Guide for Erosion Control* (New York: John Wiley and Sons, 1996); AMEC, "Streambank Erosion", Guideline I1.

56 AMEC, "Streambank Erosion", Guideline I5.

57 AMEC, "Streambank Erosion", Guideline H; AMEC, "Streambank Erosion", Guideline L.

Technique Name	Description	Proposed Location
Contour Fascine	Fascines are live cuttings that are tied together in long bundles. Contour fascines are installed in shallow trenches constructed with a contour, and anchored in the trench using stakes[58].	Site 1-3, Site 1-4 Site 2-2
Live Staking	Insertion of live cuttings into the ground, to promote root growth and leaf-out[59].	Site 1-1, Site 1-2 Site 2-2 Site 4-3
Hedge Brush Layer	Layers of interlaced/adjacent live cuttings and rooted stock placed on the face of the riverbank[60].	Site 1-3, Site 1-4
Joint Planting	Live staking existing riprap to improve riparian, aquatic, and terrestrial habitats, while also improving aesthetics[61].	Site 4-3
Native Species Seeding	Planting of native stream bank and riparian species that are selected for beneficial attributes, such as being fast growing, a natural colonizer, deep rooting, a nitrogen fixer, and food producer[62].	Site 1-2, Site 1-3, Site 1-4 Site 2-2 Site 4-1, Site 4-2, Site 4-3
Soil-Covered Riprap	Covering existing riprap bank protection with soil and vegetation to improve riparian, aquatic, and terrestrial habitats, while also improving aesthetics[63].	Site 4-1
Vegetated Soil Wraps	Consists of brush layers interspersed between layers of soil, wrapped in natural geotextile materials that provide reinforcement[64].	Site 1-3, Site 1-4
Vegetated Timber Crib Wall	Consists of a hollow, box-like, interlocking arrangement of structural timber, filled with suitable backfill material, and layers of live cuttings[65].	Site 1-3, Site 1-4
Void-filled Riprap	Planting material inserted into void-spaces in existing riprap bank protection and planted with live cuttings or container shrub plantings, to improve riparian, aquatic, and terrestrial habitats, while also improving aesthetics[66].	Site 4-2, Site 4-3

58 AMEC, “Streambank Erosion”, Guideline I2.

59 Gray and Sotir, *Bioengineering Slope Stabilization*; AMEC, “Streambank Erosion”, Guideline H.

60 H.M. Schiechtl and R. Stern, *Water Bioengineering Techniques for Watercourse Bank and Shoreline Protection* (Boston: Wiley-Blackwell, 1997); Gay Muhlberg and Nancy Moore, *Streambank Revegetation and Protection: A Guide for Alaska*, revised by Jeanne Walter and Dean Hughes (Juneau: Alaska Department of Fish and Game, 2005).

61 AMEC, “Streambank Erosion”, Guideline F.

62 AMEC, “Streambank Erosion”, Guideline L.

63 John McCullah and Donald Gray, *NCHRP Report 544*: *Environmentally Sensitive Channel- and Bank-Protection Measures* (Washington: Transportation Research Board, 2005).

64 Gray and Sotir, *Bioengineering Slope Stabilization*; McCullah and Gray, *Environmentally Sensitive.*

65 Gray and Sotir, *Bioengineering Slope Stabilization*; AMEC, “Streambank Erosion”, Guideline E.

66 Wulliman J. and D. Johns, *Demonstration Projects Illustrating Void-Filled Riprap Applications in Stream Restoration* (Lakewood: Prepared by Muller Engineering Company, Inc. for Urban Drainage and Flood Control District, 2011).

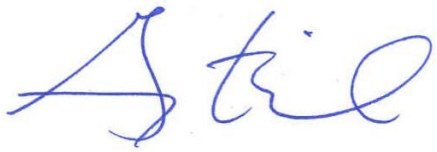
5.0 MONITORING SCHEDULE

The BEMP schedule for the Project Sites is presented in **Appendix C**. The schedule presented does not take into account potentially catastrophic flood events (such as the 2013 flood event), which could impact the ecological features and physical structures constructed as part of BDEP. However, the BEMP budget presented in **Appendix B** does include a contingency for undertaking additional 'baseline' data collection, following a potentially catastrophic flood event. In the case of such an event, and depending on the specific circumstances, the assumed monitoring schedule presented in **Appendix C** could be modified as required to provide for the most effective approach to monitor the long-term bio-efficacy of BDEP.

6.0 CLOSURE

We sincerely appreciate the opportunity to have assisted with this project. If there are any questions regarding the scope of work, or the preliminary budget anticipated to complete the work, please do not hesitate to contact the undersigned by phone.

Report was prepared by:
Hemmera Envirochem Inc.



Greg Eisler, P.Biol, R.P.Bio.
Senior Aquatics Biologist
403.264.0671 (309)
geisler@hemmera.com

Report peer reviewed by:
Hemmera Envirochem Inc.

Lisa Rear, MET, P.Biol.
Risk Assessor/Biologist
403.264.0671 (302)
lrear@hemmera.com

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APPENDIX A

Fish and Wildlife Species Summary Report

Fish and Wildlife Internet Mapping Tool (FWIMT)

(source database: Fish and Wildlife Management Information System (FWMIS))

Species Summary Report

Report Created: 13-Apr-2017 09:51

Species present within the current extent :

Fish Inventory	Wildlife Inventory	Stocked Inventory
BROWN TROUT	BALD EAGLE	RAINBOW TROUT
LONGNOSE DACE	BALTIMORE ORIOLE	
MOUNTAIN WHITEFISH	COMMON NIGHTHAWK	
RAINBOW TROUT	EASTERN KINGBIRD	
	GREAT BLUE HERON	
	HARLEQUIN DUCK	
	LEAST FLYCATCHER	
	NORTHERN GOSHAWK	
	SILVER-HAIRED BAT	
	SORA	
	WESTERN GREBE	
	WESTERN WOOD-PEWEE	

Buffer Extent

Centroid (X,Y):	Projection	Centroid: (Qtr Sec Twp Rng Mer)	Buffer Radius:
569118, 5651980	10-TM AEP Forest	NW 12 24 1 5	1 kilometers

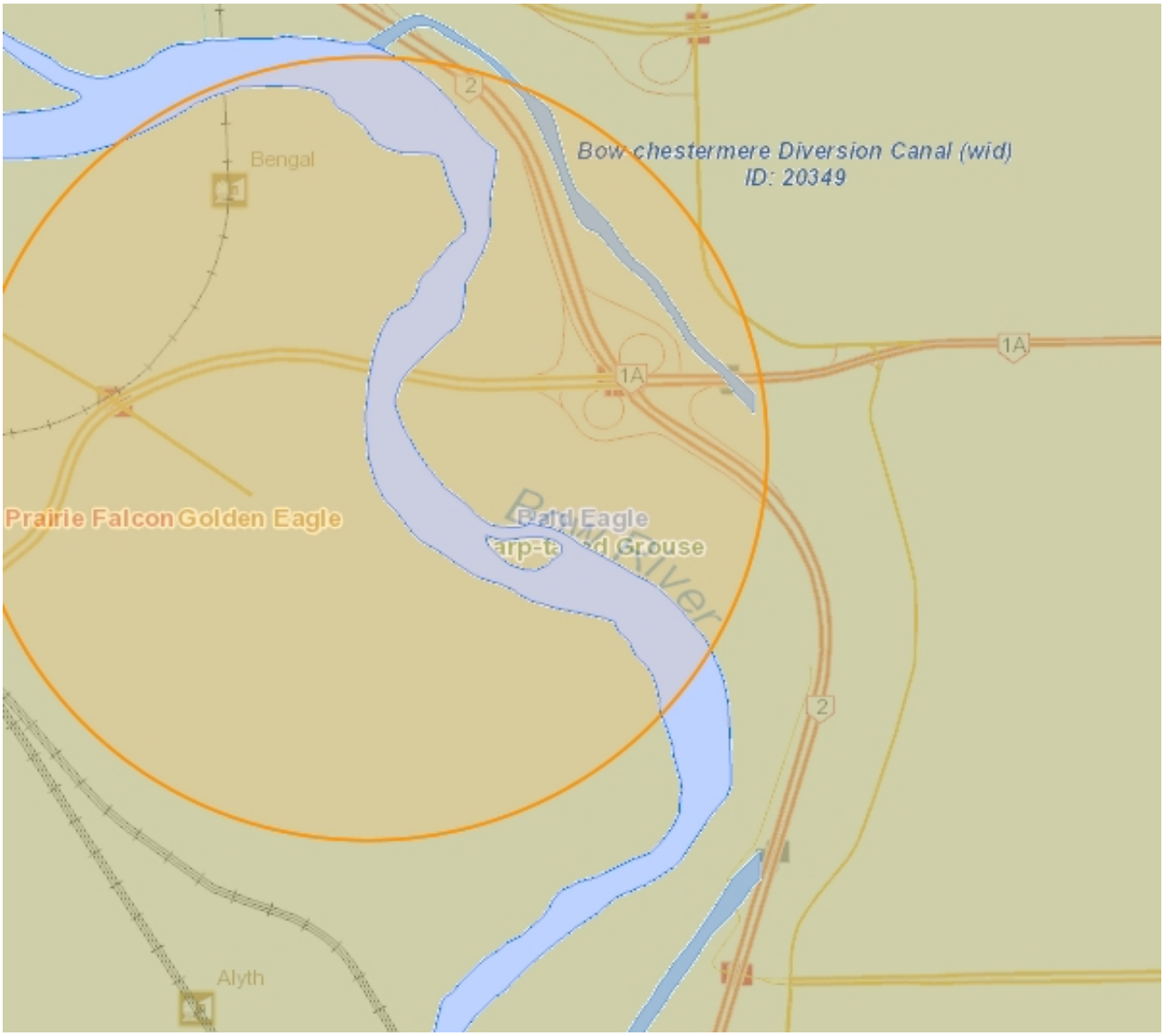
Contact Information

For contact information, please visit:

http://aep.alberta.ca/about-us/contact-us/fisheries-wildlife-management-area-contacts.aspx

13-Apr-2017 09:51

Map Results



APPENDIX B

Bio-Efficacy Monitoring Plan Projected Cost Estimate (December 12, 2017) - Summary

Appendix B: Bio-Efficacy Monitoring Plan Projected Cost Estimate (December 12, 2017) - Summary

Service Description	Details/Amount	TOTAL LABOUR HOURS	TOTAL LABOUR COST	Disbursements (exclusive of markup and GST)				TOTAL DISBURSEMENTS	SERVICE TOTAL
				Field Equipment, Supplies and Sample Shipping	Vehicle Rental	Laboratory Analytical[1]	Utility Locate and Surveying Subcontractor		
2019 Year 1									
Fish Habitat	4 times/year (included management of all other tasks over scope of project)	414	$55,959.75	$11,715.00	$1,250.00			$12,965.00	$68,924.75
Riparian Health	Annual	77	$9,822.75	$60.00	$250.00			$310.00	$10,132.75
Wildlife	Annual	75	$9,591.75	$380.00	$250.00			$630.00	$10,221.75
Bioengineering Structures	2 times/year	70	$9,943.50	$80.00	$500.00			$580.00	$10,523.50
2020 Year 2									$99,802.75
Fish Habitat	4 times/year	414	$55,959.75	$11,715.00	$1,250.00			$12,965.00	$68,924.75
Riparian Health	Annual	77	$9,822.75	$60.00	$250.00			$310.00	$10,132.75
Wildlife	Annual	75	$9,591.75	$380.00	$250.00			$630.00	$10,221.75
Bioengineering Structures	2 times/year	70	$9,943.50	$80.00	$500.00			$580.00	$10,523.50
2021 Year 3									$99,802.75
Fish Habitat	4 times/year	414	$55,959.75	$11,715.00	$1,250.00			$12,965.00	$68,924.75
Riparian Health	Annual	77	$9,822.75	$60.00	$250.00			$310.00	$10,132.75
Wildlife	Annual	75	$9,591.75	$380.00	$250.00			$630.00	$10,221.75
Bioengineering Structures	2 times/year	70	$9,943.50	$80.00	$500.00			$580.00	$10,523.50
2023 Year 5									$99,802.75
Fish Habitat	4 times/year	414	$55,959.75	$11,715.00	$1,250.00			$12,965.00	$68,924.75
Riparian Health	Annual	77	$9,822.75	$60.00	$250.00			$310.00	$10,132.75
Wildlife	Annual	75	$9,591.75	$380.00	$250.00			$630.00	$10,221.75
Bioengineering Structures	2 times/year	70	$9,943.50	$80.00	$500.00			$580.00	$10,523.50
2028 Year 10									$99,802.75
Fish Habitat	4 times/year	414	$55,959.75	$11,715.00	$1,250.00			$12,965.00	$68,924.75
Riparian Health	Annual	77	$9,822.75	$60.00	$250.00			$310.00	$10,132.75
Wildlife	Annual	75	$9,591.75	$380.00	$250.00			$630.00	$10,221.75
Bioengineering Structures	2 times/year	70	$9,943.50	$80.00	$500.00			$580.00	$10,523.50
2028 Cumulative Reporting									$99,802.75
Cumulative Report	Fisheries	140	$16,401.00					$0.00	$16,401.00
Cumulative Report	Riparian	53	$6,210.75					$0.00	$6,210.75
Cumulative Report	Wildlife	53	$6,210.75					$0.00	$6,210.75
Cumulative Report	Bioengineering	53	$6,210.75					$0.00	$6,210.75
									$35,033.25
Contingency Planning (in the event of a flood event at a TBD level)									
Assuming a scenario of a significant flood event (at a level to be determined) in spring 2020 requiring a re-sequencing of the monitoring program while retaining the sunset date of 2027 (tens years post-construction), monitoring would occur as orginally intended in 2020, 2022 and 2027, with the addition of replicated monitoring in 2021. This would enable a 'reset' for trend analysis and result in monitoring in the year of the flood as well as years 1, 2 and 6 post-flood .		636	$85,317.75	$12,235.00	$2,250.00	$0.00	$0.00	$14,485.00	$99,802.75
	TOTAL ESTIMATE	4115	$546,939.75	$61,175.00	$11,250.00	$0.00	$0.00	$72,425.00	$633,849.75
								GST	$31,692.49
	PROJECT TOTAL								$665,542.24

APPENDIX C

Bioengineering Efficacy Monitoring Plan Schedule

Appendix C: Bioengineering Efficacy Monitoring Plan Schedule

Monitoring Component	Season	2019												2020												2021												2023												2028											
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Fish and Fish Habitat	Spring				■												■												■												■												■										
	Summer							■												■												■												■												■						
	Fall									■												■												■												■												■			
	Winter	■												■												■												■												■											
Riparian Health	Fall								■												■												■												■												■			
Wildlife	Summer						■												■												■												■												■						
Bioengineering Structural Stability	Spring						■												■												■												■												■						
	Summer								■												■												■												■												■						