Town of Drumheller

Drumheller Resiliency and Flood Mitigation Program

Fish and Fish Habitat Assessment

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December 10, 2020

Town of Drumheller
Resiliency and Flood Mitigation Office
224 Centre Street
Drumheller, Alberta
T0J 0Y4

Darwin Durnie
Chief Resiliency and Flood Mitigation Officer

Dear Mr. Durnie:

Drumheller Resiliency and Flood Mitigation Program
Fish and Fish Habitat Assessment

Klohn Crippen Berger Ltd. (KCB) is pleased to submit this Fish and Fish Habitat Assessment associated with the Drumheller Resiliency and Flood Mitigation Program. This report is intended to provide pertinent information to support design of flood mitigation measures within the assessed reaches of the Red Deer River.

We trust this fulfils your requirements at this time. Please contact us if you have any questions or require anything further.

Yours truly,

KLOHN CRIPPEN BERGER LTD.

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Town of Drumheller

Drumheller Resiliency and Flood Mitigation Program

Fish and Fish Habitat Assessment

EXECUTIVE SUMMARY

In March of 2019, the Town of Drumheller (The Town) received federal and provincial government funding to improve flood readiness of the town, protect residences and property, and mitigate future flooding disasters along the Red Deer River. An assessment was completed that identified several neighbourhoods along the river which require flood mitigation measures or improvement to existing infrastructure to mitigate flood risks. The goal of the provincial government is to transfer the existing flood mitigation infrastructure from the provincial portfolio to the local municipality for ongoing operation and maintenance.

In addition to improving existing flood barrier infrastructure, The Town of Drumheller Resiliency and Flood Mitigation Program (DRFMP) intends to make room for the river where possible (i.e. 'Change the Channel'). Klohn Crippen Berger Ltd. (KCB) was retained to conduct a Fish and Fish Habitat Assessment to provide a high-level characterization of the aquatic environment within the vicinity of proposed flood mitigation reaches in order to support the anticipated design and permitting process for future projects. Fish habitat characterization and mapping were carried out within an approximately 14 km long section of the Red Deer River encompassing five flood mitigation reaches.

Temporary and permanent works associated with implementation of flood mitigation measures would have the potential to affect the aquatic environment. This could potentially include effects on fish habitat quantity and suitability, release of sediment, or other deleterious substances, direct harm to fish, or disruption of fish movement. The potential for adverse effects to occur during construction can likely be reduced through the application of mitigation and management measures. The direction, nature and magnitude of residual effects will ultimately depend on the design of the flood mitigation measures. It is recommended that consideration of the effects on habitat suitability for key life stages be considered when developing designs for the works, with emphasis on preserving riffle and run habitats used by several fish species for spawning.

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1 INTRODUCTION

1.1 Project Overview

In March of 2019, the Town of Drumheller (The Town) received federal and provincial government funding to improve flood readiness of the town, protect residences and property, and mitigate future flooding disasters along the Red Deer River. An assessment was completed that identified several neighbourhoods along the river which require flood mitigation measures or improvement to existing infrastructure to mitigate flood risks. The goal of the provincial government is to transfer the existing flood mitigation infrastructure from the provincial portfolio to the local municipality for ongoing operation and maintenance.

Klohn Crippen Berger Ltd. (KCB) was retained by The Town to conduct a Fish and Fish Habitat Assessment (FFHA) to provide a characterization of existing aquatic resources and identify key sensitivities within the vicinity of potential flood mitigation works. Five potential flood mitigation reaches (reach) of the Red Deer River were identified for assessment (Figure 1) as follows:

1. 55th Street
2. Midland
3. Newcastle
4. Centennial Park
5. Willow Estates

These five reaches encompass areas where structural flood mitigation works may be proposed in the future, such as new dike construction, upgrades to existing dykes, new pedestrian bridge construction, and/or riverbank erosion protection.

In addition to assessing existing aquatic resources, an objective of the FFHA was to identify potential effects on the aquatic environment and recommend mitigation strategies to minimize or eliminate potential effects. This report is intended to provide pertinent information to support design of flood mitigation measures within the assessed reaches of the Red Deer River.

1.2 Study Area

The Study Area was defined as the spatial extent at which environmental effects from potential project activities could occur. The Study Area was defined to include the channel and adjacent riparian areas of the Red Deer River, both within the immediate vicinity of the identified reaches where direct effects could potentially occur, as well as areas upstream and downstream of the reaches that could be indirectly affected (Figure 1).

2 METHODS

2.1 Review of Existing Information

Various sources of information were reviewed to establish an account of fish and aquatic habitat resources of the Red Deer River within the Study Area. The review included existing internal project reports, publicly available reports, aerial photograph interpretation, and the Fish and Wildlife Management Information System (FWMIS 2020). This information was used to compile a list of potentially occurring fish species. Provincial and Federal conservation status was reviewed to confirm species status designations and protective listings.

2.2 Fish Habitat Assessment

A site visit was conducted on October 28, 2020 to map and characterize fish habitat and the observations from the site visit form the basis for the current assessment. The assessment focused on confirming the accuracy of existing information by evaluating the availability and quality of fish habitat and measuring various parameters to support this assessment. Fish species known to occur in the Study Area were used to assess fish habitat suitability with respect to spawning, rearing, and overwintering potential. Habitat connectivity for migration was also assessed, with any barriers or disturbed areas described, recorded, and geo-referenced with a global positioning system (GPS). A habitat map depicting the classification of fish habitat and the location of fish habitat features was prepared. Areas of existing aquatic habitat that were considered representative were photographed with the location recorded.

To document fish habitat features, one 14 km long section of the Red Deer River was assessed through the Town of Drumheller. The assessed section of the river encompassed all five of the identified reaches: 55th Street, Midland, Newcastle, Centennial Park, and Willow Estates (Figure 1). Habitat mapping was conducted throughout this Study Area, which extended 500 m upstream of the farthest upstream extent of the 55th Street reach and 3 km downstream of the Willow Estates reach.

The Red Deer River within the Study Area exhibits characteristics of both small and large watercourses, including defined instream mesohabitats, as well as sections of broad uniform channel where fish habitat suitability is largely defined by bank structure. As a result, bank habitat type may be a more suitable indicator of fish habitat quality in some sections of the river. In order to provide a full account of fish habitat potential, classification of both instream and bank habitat features was carried out within the Red Deer River. Instream fish habitat units were mapped and classified according to O'Neil and Hildebrand (1986) (Table 2.1). This system defines distinct mesohabitat units within the channel based on depth, velocity, substrate characteristics, and the relative value to fish. Additional features contributing to habitat suitability were noted on the maps as shown in Table 2.2. Where concentrations of a particular substrate type were observed that were considered to represent a habitat feature of significance, substrate was noted on the map according to the classification system shown in Table 2.3 (Overton et al. 1997).

Table 2.1 Habitat Classification System for Instream Habitat (Adapted from O'Neil and Hildebrand 1986)

Habitat Type	Class	Map Symbol	Description
Falls	n/a	FA	Highest water velocity; involves water falling over a vertical drop; impassable to fish
Cascade	n/a	CA	Extremely high gradient and velocity; extremely turbulent with entire water surface broken; may have short vertical sections, but overall is passable to fish; armoured substrate; may be associated with chute
Rapids	n/a	RA	Extremely high velocity; deeper than riffle; substrate extremely coarse (large cobble/boulder); instream cover in pocket eddies and associated with substrate
Riffle	n/a	RF	High velocity/gradient relative to run habitat; surface broken due to submerged or exposed bed material; shallow relative to other habitat types; coarse substrate; usually limited instream or overhead cover for juvenile or adult fish
Run (glide)	General	R	Moderate to high velocity; surface largely unbroken; usually deeper than RF; substrate size dependent on hydraulics
	1	R1	Deepest run habitat; generally deep/slow type; coarse substrate; high instream cover from substrate and/or depth
	2	R2	Moderate depth; high-mod instream cover except at low flow; generally deep/fast or moderately deep/slow type
	3	R3	Shallowest run habitat; low instream cover in all but high flows
Flat	n/a	FL	Area characterized by low velocity and near-uniform flow; differentiated from pool habitat by high channel uniformity; more depositional than R3 habitat
Pool	General	P	Discrete portion of channel featuring increased depth and reduced velocity relative to riffle/run habitats; formed by channel scour
	1	P1	Deepest pool habitat; high instream cover due to instream features and depth; suitable holding water for adults and for overwintering
	2	P2	Moderate depth; shallower than P1 with high-mod instream cover except during low flow conditions, not suitable for overwintering
	3	P3	Low depth and/or small; low instream cover at all but high flow events
Impoundment	n/a	IP	Includes pools which are formed behind dams; tend to accumulate sediment / organic debris more than scour pools; may have cover associated with damming structure
Backwater	n/a	BW	Discrete, localized area of variable size exhibiting reverse flow direction; generally produced by bank irregularities; velocities variable but generally lower than main flow; substrate similar to adjacent channel with higher percentage of fines
Snye	n/a	SN	Discrete section of non-flowing water connected to a flowing channel only at one end; generally formed in a side-channel or behind a peninsula

Table 2.2 Additional Habitat Mapping Features (Adapted from O'Neil and Hildebrand 1986)

Feature	Map Symbol	Description
Beaver Dam	XXXXX	Intact beaver dam location, potential fish blockage
Bar/Shoal	SIDE	Side or point bar
	MID	Mid-channel bar
	DIAG	Diagonal spanning bar or sequence of bars
Island	ISL	Island with rooted terrestrial vegetation cover

Table 2.3 Substrate Size Classes (Adapted from Overton et al. 1997)

Category	Map Symbol	Size Range (mm)
Fines (Silt/Clay/Sand)	Fn	<2
Gravel	Gr	2-64
Cobble	Co	64-256
Boulder	Bo	>256
Bedrock	Bd	Sheets or Outcrops

The classification system for bank habitat is shown in Table 2.4 (Hildebrand 1990). The bank types are defined based on mobility of the bank material and the classes were assigned based on characteristics of bank morphology such as substrate size, bank profile, shoreline irregularity, and presence of instream cover.

Table 2.4 Habitat Classification and Rating System for Bank Habitat (Adapted from Hildebrand 1990)

Type	Class	Map Symbol	Description
Armoured	1	A1	Natural armouring at shoreline - gravel, cobble and/or small boulder predominant; may or may not have well vegetated bank above; uniform shoreline configuration; instream/overhead cover limited to substrate
	2	A2	As in A1 with cobble, small and large boulder predominant; irregular shoreline producing small backwaters; instream/overhead cover limited to substrate and depth
	3	A3	Similar to A2 with more boulder; very irregular shoreline; low velocity backwater/eddy pools providing cover
	4	A4	Artificial (rip-rap) substrates consisting usually of boulder sized fill; shoreline usually regular; instream cover from substrate
Canyon	1	C1	Banks formed by valley walls; cobble/boulder/bedrock; stable at interface; abundant velocity cover from substrate/bank irregularities
	2	C2	Banks formed by valley walls; steep, stable bedrock; regular shoreline; occasional velocity cover from bedrock fractures
	3	C3	Banks formed by valley walls, primarily fines with some gravel/cobble at base; moderately eroded at bank-water interface; limited instream cover
Depositional	1	D1	Low relief, gently sloping bank; shallow, primarily fines; instream cover absent limited; generally associated with bars
	2	D2	Similar to D1 with gravel/cobble substrate; instream/overhead cover provided by substrate/turbulence; often associated with bars/shoals
	3	D3	Similar to D2 with coarser substrates (cobble/boulder); boulders often embedded; instream cover abundant from substrate; overhead cover from turbulence
Erosional	1	E1	High, steep eroded banks with terraced profile; unstable; fines; moderate-high offshore velocity; instream/overhead cover from submerged bank materials/vegetation/depth
	2	E2	Similar to E1 without the large amount of instream vegetative debris; offshore depths shallower
	3	E3	High, steep eroding banks; loose till deposits (gravel/cobble/sand); moderate-high velocities and depths; instream cover limited to substrate roughness
	4	E4	Steep, eroding/slumping highwall bank; primarily fines; moderate-high depths/velocities; instream cover limited to occasional BW formed by bank irregularities; overhead cover from depth
	5	E5	Low, steep banks, often terraced; fines; low velocity; shallow-moderate depth; no instream cover
	6	E6	Low slumping/eroding bank; substrate either cobble/gravel or silt with cobble/gravel patches; moderate depths; moderate-high velocities; instream cover from abundant debris/boulder; overhead cover from depth/overhanging vegetation

2.3 Environmental Effects Assessment

A high-level assessment was conducted to identify potential effects that implementation of flood mitigation activities could have on the aquatic environment. This assessment was focused on identifying key environmental sensitivities and habitat features of conservation importance, potential spatial and temporal constraints on future works, and general pathways of potential effect.

Based on the assessed potential for effects, mitigation measures were proposed to avoid or minimize specific potential concerns, as well as to manage the potential for adverse effects on the aquatic environment in general. This list of mitigation measures will provide a basis for management of environmental risk to be refined during future project-specific design.

3 EXISTING ENVIRONMENT

3.1 Regional Description

The Town of Drumheller is situated along the Red Deer River within the Northern Fescue Natural Subregion of the Grasslands Natural Region of Alberta (NRC 2006). The subregion is characterized by cultivated land interspersed with graminoid prairie pothole wetlands, watercourses, and lakes. Mosaics of buckbrush (*Symphoriocarpus occidentalis*) and rose (*Rosa* spp.) dominated shrublands and prairie grasslands are found on remnant undeveloped areas. Forests are uncommon and limited to river valleys. Badlands, coulees, and ravines associated with the Red Deer River in the Saskatchewan River drainage are unique landscape features that provide habitat for rare plants and animals (NRC 2006).

The mean annual daily temperature at the Sleepy Hollow weather station (located approximately 17 km northwest of the town center) is 3.3°C, with climate normals ranging from -12.7°C in January to 17.4°C in July (Environment Canada 2020). The mean annual precipitation is 409.1 mm, of which 321.1 mm falls as rain. The average annual snowfall is 87.6 cm, with heaviest snowfalls typically occurring during March (Environment Canada 2020). The Northern Fescue Natural Subregion is cooler and moister than other Grasslands natural subregions and is therefore more similar climactically to the Central Parkland Natural subregion to the north (NRC 2006).

The predominant land use in the Northern Fescue Natural Subregion is agriculture, recreation, and oil and gas activities (NRC 2006). The identified reaches occur along the Red Deer River and the associated riparian area. Potential works may include new structural flood mitigations or upgrades to existing structures and as such, the levels of existing ground disturbance vary between the identified sites.

3.2 Fish Species Occurrence

A query of the FWMIS database revealed that fish sampling has been conducted extensively throughout the Red Deer River within the Study Area (FWMIS 2020). According to the FWMIS database, previous fish sampling conducted within the Study Area resulted in the capture of 19 fish species. A total of 34 species are expected to potentially occur in this section of the Red Deer River (FWMIS 2020). Fish species and presence information is summarized in Table 3.1. The fish species assemblage is dominated by cool water species tolerant of relatively high water temperatures and high sediment loading, with cold water species such as salmonids expected to occur infrequently this far downstream of the mountain headwaters of the Red Deer River.

Of the species that have been reported, lake sturgeon (*Acipenser fulvescens*) are identified as 'Threatened' under the Alberta *Wildlife Act* (R.S.A. 2000, c. W-10). Lake sturgeon have been identified as 'Endangered' by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and are under consideration for listing under the Federal *Species at Risk Act* (S.C. 2002 c. 29), but do not currently have a federally designated protective status. Lake sturgeon have been previously documented within the Study Area (FWMIS 2020).

The Red Deer River is a mapped Class C watercourse according to the Alberta *Water Act* – Code of Practice for Watercourse Crossings (AEP 2019). This section of the Red Deer River has a RAP from April 16 to June 30 (ESRD 2012) to reduce the potential for effects to occur during periods of spawning, egg incubation, and early development.

Table 3.1 Fish Species Occurrence within the Study Area

Common Name	Scientific Name	Species Reported Within the Study Area[1]	Species Potentially Occurring Based on Distribution in Red Deer River[2]	Alberta General Status[3]	Alberta Wildlife Act Designation[4]	COSEWIC Status[5]	SARA Designation[6]
Brook stickleback	*Culaea inconstans*		X	Secure	Not Listed	Not Listed	Not Listed
Brook trout	*Salvelinus fontinalis*		X	Exotic/Alien	Not Listed	Not Listed	Not Listed
Brown trout	*Salmo trutta*		X	Exotic/Alien	Not Listed	Not Listed	Not Listed
Burbot	*Lota lota*	X		Secure	Not Listed	Not Listed	Not Listed
Emerald shiner	*Notropis atherinoides*	X		Secure	Not Listed	Not Listed	Not Listed
Finescale dace	*Phoxinus neogaeus*		X	Undetermined	Not Listed	Not Listed	Not Listed
Flathead chub	*Platygobio gracilis*	X		Secure	Not Listed	Not Listed	Not Listed
Goldeye	*Hiodon alosoides*	X		Secure	Not Listed	Not Listed	Not Listed
Lake chub	*Couesius plumbeus*	X		Secure	Not Listed	Not Listed	Not Listed
Lake sturgeon	*Acipenser fulvescens*	X		At Risk	Threatened	Endangered	Not Listed
Lake whitefish	*Coregonus clupeaformis*	X		Secure	Not Listed	Not Listed	Not Listed
Longnose dace	*Rhinichthys cataractae*	X		Secure	Not Listed	Not Listed	Not Listed
Longnose sucker	*Catostomus catostomus*	X		Secure	Not Listed	Not Listed	Not Listed
Mooneye	*Hiodon tergisus*	X		Secure	Not Listed	Not Listed	Not Listed
Mountain sucker	*Catostomus platyrhynchus*		X	Secure	Not Listed	Not at Risk	Not Listed
Mountain whitefish	*Prosopium williamsoni*		X	Secure	Not Listed	Not Listed	Not Listed
Northern pike	*Esox lucius*	X		Secure	Not Listed	Not Listed	Not Listed
Pearl dace	*Margariscus margarita*		X	Undetermined	Not Listed	Not Listed	Not Listed
Prussian carp	*Carassius gibelio*	X		Exotic/Alien	Not Listed	Not Listed	Not Listed
Quillback	*Carpiodes cyprinus*	X		Undetermined	Not Listed	Not Listed	Not Listed
Rainbow trout	*Oncorhynchus mykiss*		X	Secure	Not Listed	Not Listed	Not Listed
River shiner	*Notropis blennius*	X		Undetermined	Not Listed	Not Listed	Not Listed
Sauger	*Sander canadensis*	X		Sensitive	Not Listed	Not Listed	Not Listed
Shorthead redhorse	*Moxostoma macrolepidotum*	X		Secure	Not Listed	Not Listed	Not Listed
Spoonhead sculpin	*Cottus ricei*		X	May Be at Risk	Not Listed	Not at Risk	Not Listed
Spottail shiner	*Notropis hudsonius*		X	Secure	Not Listed	Not Listed	Not Listed
Trout perch	*Percopsis omiscomaycus*	X		Secure	Not Listed	Not Listed	Not Listed
Walleye	*Sander vitreus*	X		Secure	Not Listed	Not Listed	Not Listed
White sucker	*Catostomus commersoni*	X		Secure	Not Listed	Not Listed	Not Listed
Yellow perch	*Perca flavescens*		X	Secure	Not Listed	Not Listed	Not Listed

Notes:
1 FWMIS 2020
2 Longmore and Stenton 1981; Nelson and Paetz 1992; FWMIS 2020
3 General Status of Alberta Wild Species (GOA 2015)
4 Alberta *Wildlife Act* (R.S.A. 2000, c. W-10)
5 Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2020)
6 Species *at Risk Act* (S.C. 2002 c. 29)

3.3 Habitat Characteristics

The Red Deer River within the Study Area was a low gradient, irregular, sinuous channel that was occasionally confined by valley slopes. Mid-channel and side gravel bars, as well as islands, occurred infrequently constricting flow within the main channel causing riffle habitat. Riparian vegetation occurred frequently on both banks throughout the Study Area, though was frequently confined to a narrow band by adjacent development. There were numerous bridge crossings and outfall structures located within the Study Area.

The total area of aquatic habitat mapped within the Study Area of the Red Deer River was equal to 1,457,352 m^2. A summary of the area of each mesohabitat type and percentage of total area is shown in Table 3.2. Moderate depth run (R2) was the most prevalent habitat type (72.1%). Riffle (RF), snye (SN) and backwater (BW) habitat types occurred in relatively low proportions, and pool habitat types were not noted within the Study Area.

Table 3.2 Red Deer River Habitat Summary by Mesohabitat Type

Mesohabitat Type	Area m^2	% of Total Area
BW	3,371	0.2
R1	125,244	8.6
R2	1,051,138	72.1
R3	248,486	17.1
RF	14,171	1.0
SN	14,942	1.0
Total	**1,457,352**	**100**

The habitat within the upstream portion of the Study Area extending from the 55th Street reach to the Midland reach was characterized by shallow to moderate depth runs with a varied bottom profile providing infrequent pockets of riffle and backwater habitat (Figures 2-4) (Appendix I: Photographs 1-3). While banks in this stretch were predominantly characterized as low depositional or erosional and providing limited cover, a few sections of erosional bank did provide cover from overhanging vegetation and slumped bank material. Islands, as well as mid and side channel bars comprised of gravels were infrequent through this section of the Study Area. Natural bank armouring was noted infrequently within this portion of the Study Area, including one bank section directly adjacent to the 55th Street reach (Figure 2) (Appendix I: Photograph 2). At this location the left (north) bank had a gentle slope down from a stepped floodplain terrace, with natural armouring of cobbles (A1) at the bank toe. Gently sloping depositional bank habitat (D1) occurred upstream and downstream along the reach. No vegetation or debris occurred along the bank within the reach, with limited cover provided by coarse substrate at the toe. The adjacent instream habitat was a moderate depth run.

The portion of the Study Area extending from the upstream end of the Midland reach near the old rail bridge, to the downstream extent of the Newcastle reach featured moderate to high depth run habitat (Figures 5-7). This section also included a few larger areas of riffle habitat, including the largest documented riffle near the upstream end of the island located northwest of Newcastle Beach (Appendix I: Photograph 4). The side channel associated with the island overlapped the downstream portion of the Midland reach and was characterized by snye habitat at the time of assessment (Appendix I: Photographs 5-6). Exposed coarse substrates within the side channel would potentially provide areas of shallow run and riffle habitat with seasonal variations in flow. Abundant overhanging vegetation was present along this side channel. Banks in this portion of the Study Area were frequently armoured with areas of large natural boulder armouring as well as artificial riprap.

The mainstem portion of the Midland reach upstream from the island was characterized by a combination of depositional (D1), erosional (E5), and armoured bank habitat types with little cover available (Figure 5). A shallow run occurred adjacent to the upstream portion of the Midland reach, divided from the main channel by a series of mid-channel gravel bars. Shallow riffle habitat with concentrated gravel substrate occurred between the bars and gravel also occurred in concentration within the shallow run habitat in the main channel through this area. Downstream from this area of high channel diversity, a single channel with moderate depth run habitat was present, transitioning to a deep run mid-way through the Midland reach (Figure 6).

The Newcastle reach occurred opposite the downstream end of the Midland reach and included the greatest concentration of deep run habitat within the entire Study Area. Aside from the shallow, turbulent riffle at the head of the large island, the habitat through the reach entirely consisted of high or moderate depth run. The upstream portion of the reach included erosional and armoured bank habitat types with varying availability of cover, primarily associated with substrate roughness (Figures 6 and 7). A steep, eroding bank slope was present on the right (south) bank downstream of the riffle. The downstream portion of the reach had depositional bank habitat consisting of a broad gravel point bar through the area of the Newcastle Beach and public boat launch (Appendix I: Photograph 7).

The portion of the Study Area adjacent to the Centennial Park reach was characterized by moderate depth runs interspersed with small pockets of riffle, snye and backwater habitat (Figures 7 and 8) (Appendix I: Photograph 8). Shallow riffle and run habitat associated with a mid-channel gravel bar occurred at the downstream end of the reach. Riprap armouring was present surrounding the abutments of the Highway 56 bridge (Appendix I: Photograph 9), while the right (south) bank was composed of low erosional and depositional sections with little available cover. One section of the right bank near the middle of the reach included a steeper erosional bank profile (E6) with more abundant cover at the toe provided by overhanging vegetation, woody debris, and slumped bank material. The left (north) bank was characterized by a mix of natural armouring and a section confined by the valley wall (C3).

The area adjacent to the Willow Estates reach consisted entirely of shallow to moderate depth run habitats (Figures 9 and 10). A large island occurred directly downstream of the reach (Appendix I: Photographs 10-11), resulting in constriction of the channel to form a shallow run with concentrated coarse substrates near the head of the island. Low erosional and depositional banks with limited instream or overhead cover were noted along the right (south) bank along the Willow Estates reach. The left (north) bank opposite entirely consisted of low depositional habitat (D1), with the exception of a small stretch of natural armouring (A1) north of the island. An ephemeral watercourse entered the river on the right bank at the downstream margin of the reach. There was no discharge in the small, incised channel at the time of assessment and the watercourse appeared to primarily convey stormwater runoff.

The remainder of the Study Area downstream of the Willow Estates reach was almost entirely composed of moderate depth runs with one section of deeper run observed. Low depositional banks occurred on the left (north) side of the river while the right (south) bank was dominated by low erosional sections, with neither bank providing substantial structural or overhead cover for fish in this section (Figures 10 to 12).

3.4 Fish Habitat Suitability

Spawning Habitat

The infrequent shallow riffle and run habitat with concentrations of coarse substrate that occurred within the Study Area would provide suitable spawning habitat for several of the potentially occurring species. Good spawning potential would be available for longnose sucker (*Catostomus catostomus*) and white sucker (*Catostomus commersoni*). These species are noted to preferentially select moderate velocity riffles over clean gravel and cobble materials (Scott and Crossman 1973; Nelson and Paetz 1992). Likewise, these areas would provide potentially suitable spawning habitat for walleye (*Sander vitreus*). Walleye broadcast spawn in turbulent water, or shoals over cobble and gravel substrates and the fertilized eggs settle into crevices (Nelson and Paetz 1992). It is possible that the large, turbulent riffle adjacent to the Newcastle reach could provide suitable spawning habitat for lake sturgeon as they prefer swift water or rapids over clean substrates (Scott and Crossman 1973; Nelson and Paetz 1992). Brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) would be expected to occur only rarely within the Study Area. Suitable spawning habitat for these species occurred in relatively low abundance and was considered to represent an important feature, where present. Areas of high value as spawning habitat were documented in the vicinity of Midland, Newcastle, Centennial Park, and Willow Estates reaches.

Spawning habitat potential for species such as northern pike (*Esox lucius*) and yellow perch (*Perca flavescens*) that require vegetation as a spawning substrate was low. Instream vegetation occurred infrequently. Flooded terrestrial vegetation would potentially be available during high discharge events, but suitable spawning habitat for these species would otherwise be expected to occur in tributaries.

Nursery and Rearing Habitat

The Study Area was considered to provide potentially suitable rearing habitat for all fish species. Suitable cover for rearing was provided primarily by coarse substrates and surface turbulence in shallow riffle and run areas. Structural bank cover was found infrequently throughout the Study Area and consisted mainly of sections of erosional bank with overhanging vegetation. Woody debris and slumped bank material were also present in limited quantities. Islands, side channels and gravel bars occurred sporadically throughout the Study Area, increasing habitat diversity, and providing cover for rearing.

Migration and Movement Potential

Within the mainstem of the Red Deer River, there were no identified barriers to fish passage, migration, or movement throughout the Study Area. One beaver dam was identified in the side channel associated with the large, vegetated island to the northwest of Newcastle Beach (Appendix I: Photograph 12). During higher seasonal flows, the presence of the beaver dam may pose a barrier to movement within the side channel but would not hinder fish movement throughout the Study Area as a whole. Likewise, low seasonal discharge within side channel habitat would restrict movement and pose a risk of fish stranding.

Overwintering Habitat

Overwintering habitat potential was considered to be high for all species. The moderate to deep run habitat dominant throughout the Study Area would provide suitable habitat under typical winter conditions. The deep run in the vicinity of the island within the Newcastle reach would be considered a high suitability overwintering habitat where fish would likely congregate in winter. Deep water would provide suitable cover for adult holding habitat adjacent to foraging areas.

4 EFFECTS ASSESSMENT

4.1 Potential Effects and Proposed Mitigation Measures

Implementation of flood mitigation measures in the vicinity of the Red Deer River could likely be subject to the requirements of the Federal *Fisheries Act* (R.S.C. 1985, c. F-14) and the Provincial *Water Act* (R.S.A 2000, c. W-3). Approval or authorization under these *Acts* could be required. The *Fisheries Act* (1985) prohibits causing the death of fish by means other than fishing (Section 34) and the harmful alteration, disruption or destruction of fish habitat (Section 35). The *Water Act* (2000) regulates activities conducted in the publicly-owned channel of a water body that may: alter flow, level, or location of water; cause erosion of the bed and banks or mobilization and transport of sediment; or cause an effect on the aquatic environment.

Potential effects on fish and fish habitat could include:

- changes in habitat quantity or suitability;
- introduction of sediment;
- introduction of deleterious substances; or
- direct harm to fish or disruption of fish movement.

4.1.1 Changes in Habitat Quantity or Suitability

The permanent physical effects of future works could potentially include both changes in habitat quantity and suitability. For the purpose of quantifying these effects, the top of bank or high water level defining the extent of potential fish habitat within the channel would be represented by the 1:2 year water level. For physical works requiring lateral encroachment into the channel through infilling or excavation, the plan view area between the water level intersection with the pre-construction top-of-bank and the predicted post-construction bank would represent the change in habitat quantity. The footprint of any works occurring below the 1:2 year water level intersection with the post-construction bank would represent habitat still available to fish but potentially altered as a result of changes in substrate and bank composition. Alteration of habitat could potentially include a change in substrate composition as a result of armouring or decreased bank complexity and availability of cover. In addition to the physical footprint of construction works, changes in habitat suitability could also potentially occur as a result of altered water depth and velocity in the vicinity of any flood mitigation works.

Planning flood mitigation measures that avoid encroachment into the river channel below the 1:2 year water level would reduce the potential for adversely affecting fish habitat and could also reduce the regulatory review burden. Authorization of habitat loss under the *Fisheries Act* (1985) typically requires that adverse effects be offset through the implementation of compensation measures such as fish habitat creation or enhancement, adding cost to the project, as well as follow-up monitoring requirements.

Adverse effects on habitats identified as relatively high value potential spawning areas should be avoided to reduce the magnitude of residual effects on fish habitat. Direct impact on spawning areas should be avoided, as well as applying mitigation and observing the RAP to limit the potential for indirect effects to occur.

4.1.2 Introduction of Sediment

Construction-related sediment input to water bodies can affect water quality and aquatic habitat in both the immediate construction zone and in downstream areas. Sediment suspended in the water column can affect aquatic organisms directly and indirectly. Deposition of sediment over aquatic macrophytes, algae, and periphyton can affect growth, photosynthetic activity, and community composition (Brookes 1986; Barko and Smart 1986; Wood and Armitage 1997; Robertson et al. 2006; Izagirre et al. 2009). Suspended sediment can affect primary productivity by reducing light penetration. It can also affect benthic invertebrate and zooplankton community abundance and species composition by altering substrate composition, impeding respiration and filter feeding, and reducing periphyton food value and zooplankton prey density (Rosenberg and Snow 1975; McCabe and O'Brien 1983; Zettler and Carter 1986; Shaw and Richardson 2001; Robertson et al. 2006). Effects of increased suspended sediment on fish can include physiological impacts (such as reducing disease tolerance, growth, egg survival, and oxygen exchange via gills), reduced habitat quality and suitability, and reduced food availability (Cordone and Kelly 1961; Bruton 1985; Newcombe and MacDonald 1991; Robertson et al. 2006).

Erosion and sedimentation can have effects in both the short- and long-term. Construction activities have the potential to result in the release of sediment into the watercourse through surface runoff over disturbed work areas, instream construction, and the destabilization of banks. Works requiring modification of the bed and banks of the Red Deer River in the vicinity of the identified sites would need to incorporate measures for controlling erosion and sedimentation. Works extending into the wetted channel of the river would require care of water measures such as an isolation structure (e.g., cofferdam or floating sediment curtain) to control the potential for sediment to be transported downstream. Depending on the nature of the proposed structures, dewatering of instream isolation areas. Turbidity monitoring would need to be conducted during installation and removal of instream isolation measures, as well as during periods of active instream construction, to document compliance with applicable water quality guidelines (ESRD 2014; CCME 1999) and to allow for active management of observed effects. Instream works would need to be conducted outside of the RAP to avoid causing effects during the sensitive spawning and incubation periods.

Long-term sediment release would generally be a result of a chronic problem related to the design or construction of instream structures, or in the reclamation of areas disturbed by construction activities. The bed and banks in the immediate vicinity of physical works such as a flood barrier should be protected, if necessary, to minimize scouring and erosion. Disturbed areas should be revegetated to reduce the potential for erosion.

4.1.3 Introduction of Deleterious Substances

Hydrocarbon based fuels, hydraulic fluids, and lubricants would be used in construction machinery working within the floodplain of the river and spills or leaks could potentially occur. These substances may enter the watercourse directly or be deposited in the riparian area and be transported into the watercourse by surface runoff. Hydrocarbons can have a direct effect on development and growth of eggs and juvenile fish (Carls et al. 1999; Heintz et al. 2000); oxygen transport via gill filaments (Hart 1974); and fish health by causing histo-pathological damage in the gills, liver, and kidney (Al-Kindi et al. 2000). Polycyclic aromatic hydrocarbons (PAH) may affect fish by inducing immunotoxicity through an assortment of intra-cellular mechanisms (Reynaud and Deschaux 2006). In addition, hydrocarbons may indirectly affect fish by reducing dissolved oxygen levels within the water column, covering spawning substrate, and impacting invertebrate and macrophyte populations (Hart 1974; Werner et al. 1985).

Vehicles and construction equipment, particularly tracked machinery, may also transport biological contaminants to and from the site. These could include noxious or invasive terrestrial or aquatic species such as Didymo algae or diseases such as whirling disease. Invasive species have the potential to cause loss of biodiversity, degradation of water quality, and disruption of ecosystem functions.

4.1.4 Direct Harm to Fish and Disruption of Fish Movement

Fish move between habitats frequently to access food, cover, or other habitat features. These requirements vary by species as well as life stage and often necessitate migration over large distances to satisfy specific habitat requirements such as for spawning substrates or overwintering conditions. Although some natural, non-permanent barriers to fish movement may exist at times (e.g. beaver dams), the addition of barriers to fish movement through anthropogenic means can have harmful effects on fish populations.

Temporary isolation of instream work areas could result in stranding of fish. Fish trapped within isolation areas could also be directly harmed through exposure to high sediment concentrations, or as a result of entrainment or impingement in pumps if the isolations were dewatered. To reduce the potential for fish to be harmed, a fish rescue would need to be conducted within any isolation areas to capture and relocate stranded fish. If dewatering of the isolation areas was required, fish screens should be installed at pump intakes in accordance with applicable guidelines (DFO 1995) and the isolation areas inspected during drawdown to detect stranded fish.

Permanent works should be designed to avoid extending into the channel further than the existing bank, where feasible, and should avoid affecting velocities along the bank sufficiently to impede fish passage. Temporary isolation areas should not restrict more than a third of the wetted width of the channel, allowing adequate room for fish passage around the work areas.

4.2 Summary of Effects Assessment

The results of the high-level assessment of effects and recommended mitigation measures are summarized in Table 4.1 below.

Table 4.1 Summary of Potential Effects and Mitigation Measures

Project Activity	Effect Description	Mitigation and Management
Site clearing, construction works, and equipment operation	Introduction of deleterious substances	▪ Equipment should be cleaned and in good working order prior to arriving on-site. ▪ Equipment fueling should be conducted at a designated location and in a manner, that reduces the potential for release to the watercourse. ▪ Equipment working instream should be operated with biodegradable hydraulic oils and lubricants. ▪ Stationary equipment and hazardous materials should be stored within a secondary containment to prevent release to the environment. ▪ A spill contingency plan should be in place and spill kits should be readily accessible on-site.
Clearing, bank excavation, and installation of flood mitigation structures	Introduction of sediment	▪ Erosion and Sediment Control measures should be implemented. ▪ The footprint of disturbance surrounding the structures should be minimized. ▪ Disturbance of established vegetation should be minimized. ▪ Instream works should be completed outside of the RAP (April 16 to June 30). ▪ Isolation structures should be installed to reduce the potential for sediment release to the Red Deer River. ▪ Turbidity monitoring should be carried out in accordance with an established Turbidity Monitoring Plan (TMP) to confirm compliance with water quality guidelines (ESRD 2014, CCME 1999) and to recommend additional mitigation measures. ▪ Materials should be stockpiled away from the watercourse and protected with erosion and sediment control measures. ▪ If dewatering of the isolation areas is required, water should be discharged to a stable vegetated location to reduce the potential for scour of the stream bed and banks.
Isolation of instream works	Temporary loss of fish habitat within the vicinity of the mitigation works	▪ The duration of instream works should be limited and should occur outside of the RAP (April 16 to June 30). ▪ The temporary isolation areas should not restrict more than a third of the wetted width of the channel, allowing adequate room for fish passage around the work area and access to suitable habitat.
	Stranding of fish within isolation area	▪ Fish rescue should be conducted to capture and relocate fish stranded within isolation areas, as required.
Dewatering of isolation areas	Entrainment or impingement of fish in dewatering pumps	▪ If dewatering is required, pumps should be equipped with intake screens in compliance with applicable guidelines (DFO 1995).
Encroachment of flood mitigation measures below the 1:2 year water level	Potential for decrease in fish habitat quantity	▪ A decrease in habitat quantity could potentially require mitigation through habitat offsetting or similar measures.
Installation of bank protection and flood mitigation structures below the 1:2 year water level	Potential decrease in fish habitat suitability through a change in substrate composition or decrease in availability of cover	▪ The footprint of the infrastructure should be minimized while promoting future stability and operability. ▪ The footprint of disturbance surrounding the structure should be minimized. ▪ Design of flood mitigations should aim to maintain or improve habitat suitability for key life stages where feasible.
	Potential decrease in fish habitat suitability through the alteration of river depths and velocities	▪ The footprint of the infrastructure should be minimized while promoting future stability and operability. ▪ The footprint of disturbance surrounding the structure should be minimized. ▪ Design of flood mitigations should aim to maintain or improve habitat suitability for key life stages where feasible.

5 CONCLUSIONS AND RECOMMENDATIONS

Temporary and permanent works associated with implementation of flood mitigation measures will have the potential to affect the aquatic environment. This could potentially include effects on fish habitat quantity and suitability, release of sediment, or other deleterious substances, direct harm to fish, or disruption of fish movement. The potential for adverse effects to occur during construction can likely be reduced through the application of mitigation and management measures. The direction, nature and magnitude of residual effects will ultimately depend on the design of the flood mitigation measures. It is recommended that consideration of the effects on habitat suitability for key life stages be considered when developing designs for the works, with emphasis on preserving riffle and run habitats used by several fish species for spawning.

6 CLOSING

This report is an instrument of service of Klohn Crippen Berger (KCB). The report has been prepared for the exclusive use of The Town of Drumheller (Client) for the specific application to the Drumheller Resiliency and Flood Mitigation Program, and it may not be relied upon by any other party without KCB's written consent.

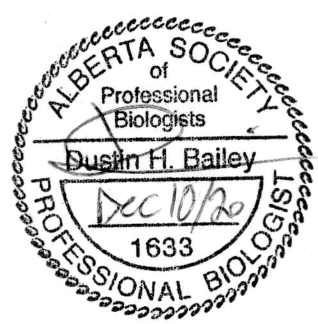
KCB has prepared this report in a manner consistent with the level of care, skill and diligence ordinarily provided by members of the same profession for projects of a similar nature at the time and place the services were rendered. KCB makes no warranty, express or implied.

Use of or reliance upon this instrument of service by the Client is subject to the following conditions:

1. The report is to be read in full, with sections or parts of the report relied upon in the context of the whole report.
2. The Executive Summary is a selection of key elements of the report. It does not include details needed for the proper application of the findings and recommendations in the report.
3. The observations, findings and conclusions in this report are based on observed factual data and conditions that existed at the time of the work and should not be relied upon to precisely represent conditions at any other time.
4. KCB should be consulted regarding the interpretation or application of the findings and recommendations in the report.

Yours truly,

KLOHN CRIPPEN BERGER LTD.



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FIGURES

Legend

- Detailed Habitat Map Sheets
- Stations
- Centreline

0 2.5 Kilometers

NOTES:
1. HORIZONTAL DATUM: NAD_1983_CSRS_10TM_AEP_Forest
2. GRID ZONE: 12
3. IMAGE SOURCE: ESRI
4. Map scale is as indicated when printed on 11" x 17" paper.

CLIENT

DRUMHELLER
RESILIENCY AND FLOOD MITIGATION OFFICE

DRUMHELLER VALLEY

Klohn Crippen Berger

PROJECT
DRUMHELLER RESILIENCY AND FLOOD MITIGATION PROGRAM
FISH AND FISH HABITAT ASSESSMENT

TITLE
Fish Habitat Map - Overview

SCALE	PROJECT No.	FIG No.
1:32,000	A03409A01	1

File: \\int.klohn.com\ProjData\A\CGY\Alberta\A03409A01 DRFMP Fish Habitat Assessment\400 Drawings\GIS\mxd\201210_DrumhellerFFHA_Overview.mxd Date: December 23, 2020 Time: 09:48:57 AM Creator: : DBailey

Legend

Ephemeral_Watercourse	GN - Groyne	P3 - Pool	BW - Backwater	Fn - Fine
Bank Characteristics	MID - Mid-channel Bar	R1 - Run	IP - Impoundment	Gr - Gravel
Stations	SIDE - Side Bar	R2 - Run	RF - Riffle	Co - Cobble
Centreline	ISL - Island	R3 - Run	CA - Cascade	Bo - Boulder
BVR - BVR Dam	P1 - Pool	FL - Flat	FA - Falls	
	P2 - Pool	SN - Snye	RA - Rapid	

0 250 Metres

NOTES:
1. HORIZONTAL DATUM: NAD_1983_CSRS_10TM_AEP_Forest
2. GRID ZONE: 12
3. IMAGE SOURCE: The Town of Drumheller 2019
4. Map scale is as indicated when printed on 11" x 17" paper.
5. Notation of a substrate sub-class indicates a concentrated occurrence of a substrate type.
6. Bank habitat classification system is defined in report Table 2.4.

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FISH AND FISH HABITAT ASSESSMENT

TITLE
Fish Habitat Map - Detail
(Sheet 1 of 11)

SCALE	PROJECT No.	FIG No.
1:3,000	A03409A01	2

File: \\int.klohn.com\ProjData\A\CGY\Alberta\A03409A01 DRFMP Fish Habitat Assessment\400 Drawings\GIS\mxd\201222_DrumhellerFFHA_Detail.mxd Date: December 22, 2020 Time: 16:54:58 PM Creator: : DBailey

Legend

- Ephemeral_Watercourse
- Bank Characteristics
- Stations
- Centreline
- BVR - BVR Dam
- GN - Groyne
- MID - Mid-channel Bar
- SIDE - Side Bar
- ISL - Island
- P1 - Pool
- P2 - Pool
- P3 - Pool
- R1 - Run
- R2 - Run
- R3 - Run
- FL - Flat
- SN - Snye
- BW - Backwater
- IP - Impoundment
- RF - Riffle
- CA - Cascade
- FA - Falls
- RA - Rapid
- Fn - Fine
- Gr - Gravel
- Co - Cobble
- Bo - Boulder

0 250 Metres

NOTES:
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PROJECT
DRUMHELLER RESILIENCY AND FLOOD MITIGATION PROGRAM
FISH AND FISH HABITAT ASSESSMENT

TITLE
Fish Habitat Map - Detail
(Sheet 2 of 11)

SCALE	PROJECT No.	FIG No.
1:3,000	A03409A01	3

File: \\int.klohn.com\ProjData\A\CGY\Alberta\A03409A01 DRFMP Fish Habitat Assessment\400 Drawings\GIS\mxd\201222_DrumhellerFFHA_Detail.mxd Date: December 22, 2020 Time: 16:54:58 PM Creator: : DBailey

Legend

Ephemeral_Watercourse	GN - Groyne	P3 - Pool	BW - Backwater	Fn - Fine
Bank Characteristics	MID - Mid-channel Bar	R1 - Run	IP - Impoundment	Gr - Gravel
Stations	SIDE - Side Bar	R2 - Run	RF - Riffle	Co - Cobble
Centreline	ISL - Island	R3 - Run	CA - Cascade	Bo - Boulder
BVR - BVR Dam	P1 - Pool	FL - Flat	FA - Falls	
	P2 - Pool	SN - Snye	RA - Rapid	

0 250 Metres

NOTES:
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PROJECT
DRUMHELLER RESILIENCY AND FLOOD MITIGATION PROGRAM
FISH AND FISH HABITAT ASSESSMENT

TITLE
Fish Habitat Map - Detail
(Sheet 3 of 11)

SCALE 1:3,000 | PROJECT No. A03409A01 | FIG No. 4

File: \\int.klohn.com\ProjData\ACGY\Alberta\A03409A01 DRFMP Fish Habitat Assessment\400 Drawings\GIS\mxd\201222_DrumhellerFFHA_Detail.mxd Date: December 22, 2020 Time: 16:54:58 PM Creator: DBailey

Legend

Ephemeral_Watercourse	GN - Groyne	P3 - Pool	BW - Backwater	Fn - Fine
Bank Characteristics	MID - Mid-channel Bar	R1 - Run	IP - Impoundment	Gr - Gravel
Stations	SIDE - Side Bar	R2 - Run	RF - Riffle	Co - Cobble
Centreline	ISL - Island	R3 - Run	CA - Cascade	Bo - Boulder
BVR - BVR Dam	P1 - Pool	FL - Flat	FA - Falls	
	P2 - Pool	SN - Snye	RA - Rapid	

0 250 Metres

NOTES:
1. HORIZONTAL DATUM: NAD_1983_CSRS_10TM_AEP_Forest
2. GRID ZONE: 12
3. IMAGE SOURCE: The Town of Drumheller 2019
4. Map scale is as indicated when printed on 11" x 17" paper.
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6. Bank habitat classification system is defined in report Table 2.4.

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PROJECT: DRUMHELLER RESILIENCY AND FLOOD MITIGATION PROGRAM FISH AND FISH HABITAT ASSESSMENT

TITLE: Fish Habitat Map - Detail (Sheet 4 of 11)

SCALE: 1:3,000 | PROJECT No.: A03409A01 | FIG No.: 5

File: \\int.klohn.com\ProjData\A\CGY\Alberta\A03409A01 DRFMP Fish Habitat Assessment\400 Drawings\GIS\mxd\201222_DrumhellerFFHA_Detail.mxd Date: December 22, 2020 Time: 16:54:58 PM Creator: : DBailey

Legend

Ephemeral_Watercourse	GN - Groyne	P3 - Pool	BW - Backwater	Fn - Fine
Bank Characteristics	MID - Mid-channel Bar	R1 - Run	IP - Impoundment	Gr - Gravel
Stations	SIDE - Side Bar	R2 - Run	RF - Riffle	Co - Cobble
Centreline	ISL - Island	R3 - Run	CA - Cascade	Bo - Boulder
BVR - BVR Dam	P1 - Pool	FL - Flat	FA - Falls	
	P2 - Pool	SN - Snye	RA - Rapid	

NOTES:
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2. GRID ZONE: 12
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DRUMHELLER VALLEY

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PROJECT
DRUMHELLER RESILIENCY AND FLOOD MITIGATION PROGRAM
FISH AND FISH HABITAT ASSESSMENT

TITLE
Fish Habitat Map - Detail
(Sheet 5 of 11)

SCALE	PROJECT No.	FIG No.
1:3,000	A03409A01	6

File: \\int.klohn.com\ProjData\A\CGY\Alberta\A03409A01 DRFMP Fish Habitat Assessment\400 Drawings\GIS\mxd\201222_DrumhellerFFHA_Detail.mxd Date: December 22, 2020 Time: 16:54:58 PM Creator: : DBailey

Legend

Ephemeral_Watercourse	GN - Groyne	P3 - Pool	BW - Backwater	Fn - Fine
Bank Characteristics	MID - Mid-channel Bar	R1 - Run	IP - Impoundment	Gr - Gravel
Stations	SIDE - Side Bar	R2 - Run	RF - Riffle	Co - Cobble
Centreline	ISL - Island	R3 - Run	CA - Cascade	Bo - Boulder
BVR - BVR Dam	P1 - Pool	FL - Flat	FA - Falls	
	P2 - Pool	SN - Snye	RA - Rapid	

0 250 Metres

NOTES:
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2. GRID ZONE: 12
3. IMAGE SOURCE: The Town of Drumheller 2019
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FISH AND FISH HABITAT ASSESSMENT

TITLE
Fish Habitat Map - Detail
(Sheet 6 of 11)

SCALE	PROJECT No.	FIG No.
1:3,000	A03409A01	7

File: \\int.klohn.com\ProjData\A\CGY\Alberta\A03409A01 DRFMP Fish Habitat Assessment\400 Drawings\GIS\mxd\201222_DrumhellerFFHA_Detail.mxd Date: December 22, 2020 Time: 16:54:58 PM Creator: : DBailey

Legend

Ephemeral_Watercourse	GN - Groyne	P3 - Pool	BW - Backwater	Fn - Fine
Bank Characteristics	MID - Mid-channel Bar	R1 - Run	IP - Impoundment	Gr - Gravel
Stations	SIDE - Side Bar	R2 - Run	RF - Riffle	Co - Cobble
Centreline	ISL - Island	R3 - Run	CA - Cascade	Bo - Boulder
BVR - BVR Dam	P1 - Pool	FL - Flat	FA - Falls	
	P2 - Pool	SN - Snye	RA - Rapid	

0 250 Metres

NOTES:
1. HORIZONTAL DATUM: NAD_1983_CSRS_10TM_AEP_Forest
2. GRID ZONE: 12
3. IMAGE SOURCE: The Town of Drumheller 2019
4. Map scale is as indicated when printed on 11" x 17" paper.
5. Notation of a substrate sub-class indicates a concentrated occurrence of a substrate type.
6. Bank habitat classification system is defined in report Table 2.4.

CLIENT

DRUMHELLER RESILIENCY AND FLOOD MITIGATION OFFICE

DRUMHELLER VALLEY

Klohn Crippen Berger

PROJECT
DRUMHELLER RESILIENCY AND FLOOD MITIGATION PROGRAM
FISH AND FISH HABITAT ASSESSMENT

TITLE
Fish Habitat Map - Detail
(Sheet 7 of 11)

SCALE	PROJECT No.	FIG No.
1:3,000	A03409A01	8

File: \\int.klohn.com\ProjData\A\CGY\Alberta\A03409A01 DRFMP Fish Habitat Assessment\400 Drawings\GIS\mxd\201222_DrumhellerFFHA_Detail.mxd Date: December 22, 2020 Time: 16:54:58 PM Creator: : DBailey

Legend

Ephemeral_Watercourse	GN - Groyne	P3 - Pool	BW - Backwater	Fn - Fine
Bank Characteristics	MID - Mid-channel Bar	R1 - Run	IP - Impoundment	Gr - Gravel
Stations	SIDE - Side Bar	R2 - Run	RF - Riffle	Co - Cobble
Centreline	ISL - Island	R3 - Run	CA - Cascade	Bo - Boulder
BVR - BVR Dam	P1 - Pool	FL - Flat	FA - Falls	
	P2 - Pool	SN - Snye	RA - Rapid	

NOTES:
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FISH AND FISH HABITAT ASSESSMENT

TITLE

Fish Habitat Map - Detail
(Sheet 8 of 11)

SCALE	PROJECT No.	FIG No.
1:3,000	A03409A01	9

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Legend

Ephemeral_Watercourse	GN - Groyne	P3 - Pool	BW - Backwater	Fn - Fine
Bank Characteristics	MID - Mid-channel Bar	R1 - Run	IP - Impoundment	Gr - Gravel
Stations	SIDE - Side Bar	R2 - Run	RF - Riffle	Co - Cobble
Centreline	ISL - Island	R3 - Run	CA - Cascade	Bo - Boulder
BVR - BVR Dam	P1 - Pool	FL - Flat	FA - Falls	
	P2 - Pool	SN - Snye	RA - Rapid	

0 250 Metres

NOTES:
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DRUMHELLER VALLEY

Klohn Crippen Berger

PROJECT
DRUMHELLER RESILIENCY AND FLOOD MITIGATION PROGRAM
FISH AND FISH HABITAT ASSESSMENT

TITLE
Fish Habitat Map - Detail
(Sheet 9 of 11)

SCALE	PROJECT No.	FIG No.
1:3,000	A03409A01	10

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Legend

- Ephemeral_Watercourse
- Bank Characteristics
- Stations
- Centreline
- BVR - BVR Dam
- GN - Groyne
- MID - Mid-channel Bar
- SIDE - Side Bar
- ISL - Island
- P1 - Pool
- P2 - Pool
- P3 - Pool
- R1 - Run
- R2 - Run
- R3 - Run
- FL - Flat
- SN - Snye
- BW - Backwater
- IP - Impoundment
- RF - Riffle
- CA - Cascade
- FA - Falls
- RA - Rapid
- Fn - Fine
- Gr - Gravel
- Co - Cobble
- Bo - Boulder

0 250 Metres

NOTES:
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2. GRID ZONE: 12
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PROJECT
DRUMHELLER RESILIENCY AND FLOOD MITIGATION PROGRAM
FISH AND FISH HABITAT ASSESSMENT

TITLE
Fish Habitat Map - Detail
(Sheet 10 of 11)

SCALE	PROJECT No.	FIG No.
1:3,000	A03409A01	11

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Legend

- Ephemeral_Watercourse
- Bank Characteristics
- Stations
- Centreline
- BVR - BVR Dam
- GN - Groyne
- MID - Mid-channel Bar
- SIDE - Side Bar
- ISL - Island
- P1 - Pool
- P2 - Pool
- P3 - Pool
- R1 - Run
- R2 - Run
- R3 - Run
- FL - Flat
- SN - Snye
- BW - Backwater
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Fn - Fine

Gr - Gravel

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0 250 Metres

NOTES:
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FISH AND FISH HABITAT ASSESSMENT

TITLE

Fish Habitat Map - Detail
(Sheet 11 of 11)

SCALE	PROJECT No.	FIG No.
1:3,000	A03409A01	12

File: \\int.klohn.com\ProjData\CGY\Alberta\A03409A01 DRFMP Fish Habitat Assessment\400 Drawings\GIS\mxd\201222_DrumhellerFFHA_Detail.mxd Date: December 22, 2020 Time: 16:54:58 PM Creator: DBailey

APPENDIX I

Photographs

Appendix I
Photographs

Photograph 1 **Tail end of a small riffle and a high erosional (E3) bank upstream of the 55 Street flood mitigation reach.**

Photograph 2 **Upstream view towards small island with the beginning of natural bank armour shown adjacent to the 55 Street flood mitigation reach on the left (north) bank.**

Photograph 3 **Depositional bank (D2) with side gravel bar and associated backwater downstream of the 55 Street flood mitigation reach on the right (south) bank.**

Photograph 4 **Largest riffle documented within the Study Area located between the Midland and Newcastle flood mitigation reaches.**

Photograph 5 Looking upstream from the upstream extent of the side channel overlapping the Midland flood mitigation reach.

Photograph 6 Looking downstream from the downstream extent of the side channel overlapping the Midland flood mitigation reach.

Photograph 7 Depositional bank habitat (D1-D2) consisting of a broad gravel point bar through the area of the Newcastle Beach and public boat launch.

Photograph 8 View of left (north) bank across from the Centennial flood mitigation reach.

Photograph 9 **Riprap armouring surrounding the abutments of the Highway 56 bridge, looking at the right (south) bank.**

Photograph 10 **Looking downstream at the large island downstream of the Willow Estates flood mitigation reach.**

Photograph 11 Looking upstream at the large island downstream of the Willow Estates flood mitigation reach.

Photograph 12 Beaverdam located in the side channel overlapping the Midland flood mitigation reach.