5. High and Moderate Flood Risk Communities

Flood and erosion issues identified during the stakeholder consultation process for different communities are presented in the following sections. Additionally, flood and erosion issues from literature reviews and other sources are included in the sections below as available. Figure 5-1 shows high, moderate and low risk communities.

For the purposes of this study, communities were classified high, moderate or low risk based on the following guidelines:

High Risk

Major flooding significantly impacts approximately more than 15 people or homes. Rural flooding of roads, undersized culverts, bridge crossings/pipes and low level crossings may occur and could result in significant damages. Road flooding can isolate people. Homes, structures and roads may be within a flood hazard area. Farmland is temporarily flooded such that farmers cannot work the land.

Moderate Risk

Moderate flooding impacts more than approximately 5 people or homes. Rural flooding of roads, undersized culverts, bridge crossings/pipes and low level crossings may occur and could result in significant damages. Road flooding depth is low enough to maintain drivability or traffic is detoured. Farmland is temporarily flooded such that farmers cannot work the land.

Low Risk

Minor flooding impacts less than approximately 5 people or homes. Rural flooding of roads, undersized culverts, bridge crossings/pipes and low level crossings may occur and could result in minor to moderate damages. Road flooding depth is low enough to maintain drivability or traffic is detoured. Farmland is temporarily flooded such that farmers cannot work the land.

Terms which are useful in explaining flood risk and in examining flood risk areas, as defined by AESRD and are presented below. Figure 5-1 provides a visual representation of the definitions (AESRD, 2014).

Design Flood: The current design standard in Alberta is the one per cent flood, defined as a flood whose magnitude has a one percent chance of being equaled or exceeded in any year. Although it can be referred to as the 100-year flood, this does not mean that it will occur once every hundred years.

Design Flood Levels: Modelled water elevations within a flood hazard area based on design flood (one per cent flood event). Design flood levels do not change as a result of development or obstruction of flows within the flood fringe.

Encroachment Conditions: The flood hazard design case that assumes a scenario where the flood fringe is fully developed.

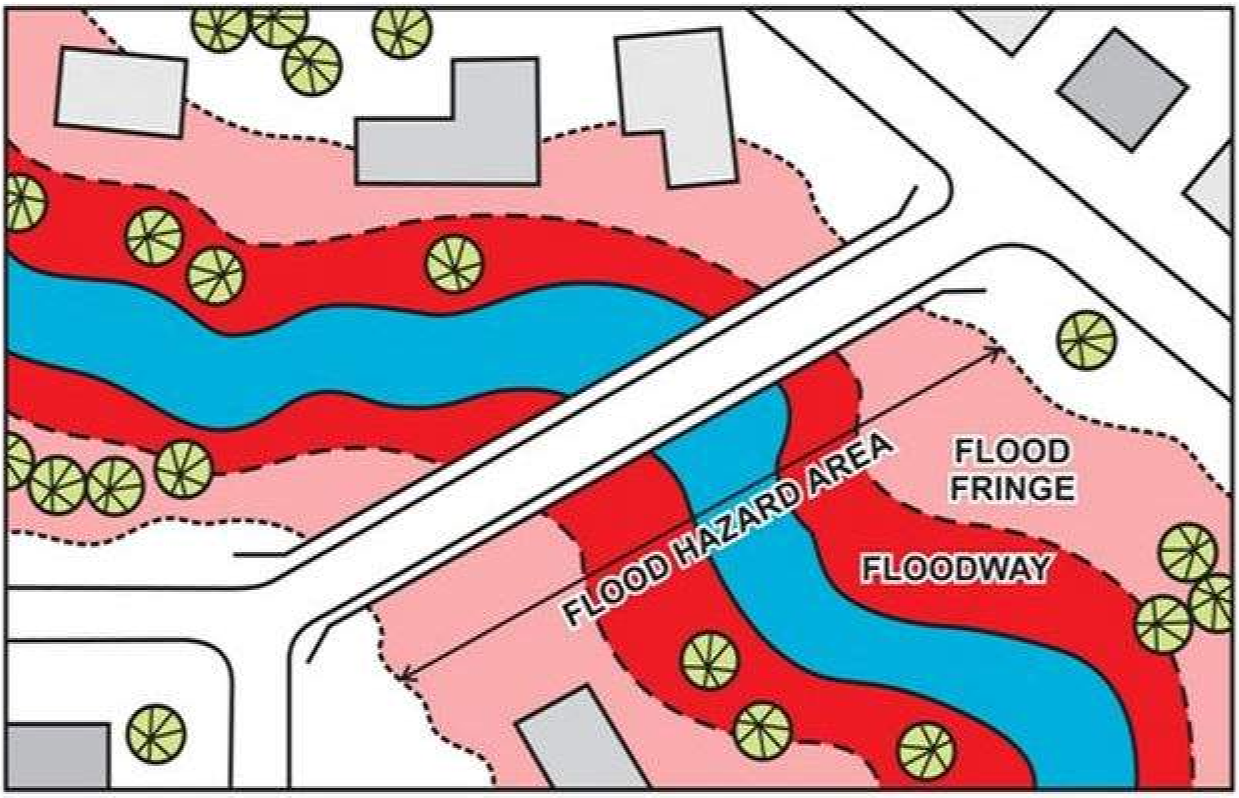
Flood Fringe: The portion of the flood hazard area which is outside of the floodway. Water in the flood fringe is generally shallower and flows more slowly than in the floodway. New development in the flood fringe may be permitted in some communities and should be flood-proofed.

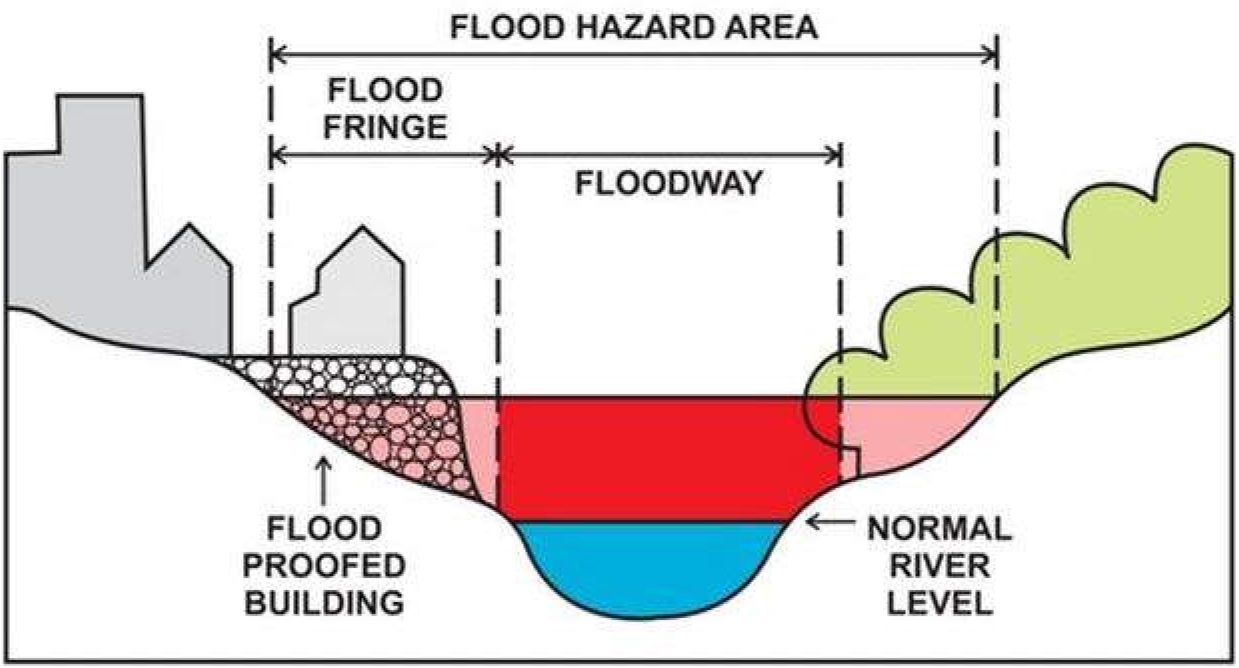
Flood Hazard Area: The flood hazard area is typically divided into floodway and flood fringe zones and may also include areas of overland flow.

Floodway: The portion of the flood hazard area where flows are deepest, fastest and most destructive. The floodway typically includes the main channel of the stream and a portion of the overbank area. New development is discouraged in the floodway.

Overland Flow: Areas of overland flow are part of the flood hazard area outside of the floodway, and are typically considered special areas of the flood fringe.

Flood Hazard Area Diagrams





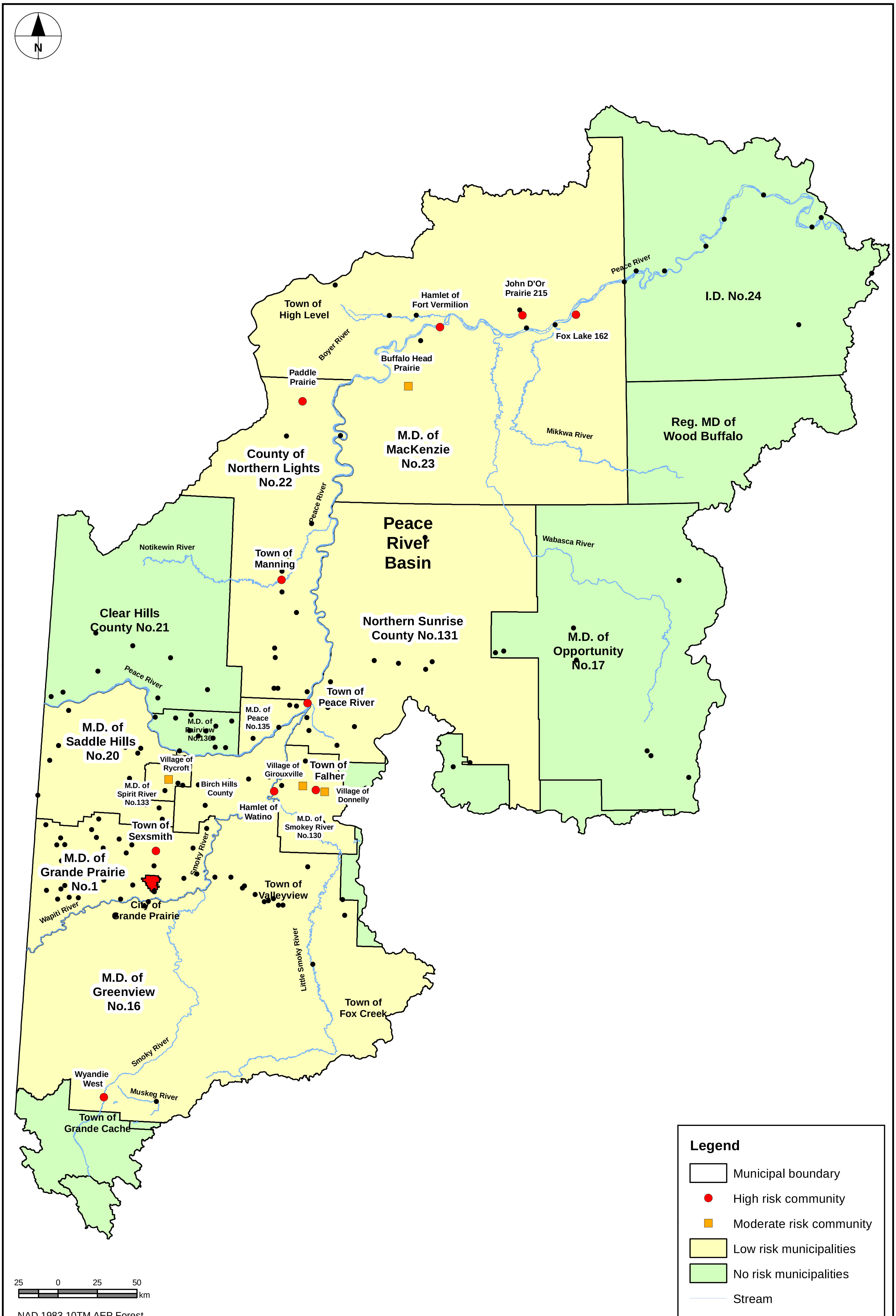
Source: Alberta Environment and Sustainable Resource Development
http://esrd.alberta.ca/water/programs-and-services/flood-hazard-identification-program/flood-hazard-mapping.aspx

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

Flood Hazard Area Definition Diagrams (AESRD)

AECOM

Figure: 5-1



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High, Moderate and Low Flood Risk Communities

Figure: 5-2

5.1 Town of Falher

5.1.1 Background

The Town of Falher is classified as a high flood risk community due to flood impacts to many homes. The location of the Town of Falher within the Peace River Basin is shown on Figure 5-2.

5.1.2 Historical Flood and Erosion Issues

Stakeholder identified historical flood issues are shown on Figure 5-1-1. The location of each reported flood issue is numbered with a map ID and classified as high, moderate or low risk. Each issue can be found by the corresponding map ID in Table A-1 in Appendix A.

The Town's storm system ties into a ditch along Second Street which connects to a flash flood control ditch running west which eventually discharges into an east-west drainage canal downstream of the Town, called the Winagami-Girouxville Canal, which ultimately discharges into Hunter Creek, north of the Town of Donnelly. Additionally, storm water flows from Desilets Drainage Project (ditch) located northeast of the Town of Falher discharges into the Winagami-Girouxville Canal upstream of the Town. Flow contribution from Desilets drainage project into the canal upstream of the flash flood ditch, and water back up in the canal downstream of the flash flood ditch, results in reduced flow capacity in the flash flood ditch and inhibits stormwater drainage away from Town. As a result, water ponds over manholes causing the Town's stormwater system to overload, and subsequently, contributes to basement flooding. Flooding experiences in the Town of Falher is considered local flooding, and river flooding is not a concern as the town is not located adjacent to a watercourse. Figure 5-1-2 shows flood photos from rainfall in July 2001.

Some major historical flooding events and resulting impacts are given below based on the Alberta Municipal Services Corporation Sewer Backup Report (2013) obtained from the Town of Falher:

- August 13, 2013: many streets were flooded due to heavy rainfall that backed-up storm sewer system. Unofficially, there was 9 cm (3.5 inches) in less than 1 hour
- Basement water damages were reported by 18 homeowners
- November 9, 2012: sewer back-up caused water damage to 1 home owner
- June 24, 2011: Basement water damages were reported by 44 home owners due to sewer back up. The town received over 7.5 cm (3 inches) of precipitation prior to Thursday night on June 23, 2011 and Friday June 24, 2011 morning precipitation of over 6.3 cm (2.5 inches)

A summary of flood events which have impacted the Town of Falher are shown in Table 5-1.

Table 5-1: Summary of Historical Flood Events - Town of Falher

Flooding Date	Flooding Event/Cause	Erosion Issues
2013 (August)	-Flooding of 18 homes due to heavy rainfall causing sewer surcharging and flooding -Lift stations were unable to keep up	None reported
2011 (June)	-Flooding of 44 homes due to heavy rainfall causing sewer surcharging and flooding -Lift stations were unable to keep up	None reported
2001 (July)	-Street flooding	None reported

5.1.3 Flood Hazard Mapping

The Town of Falher is not located adjacent to or near a natural watercourse. Therefore, no flood hazard mapping is required for the town.

5.1.4 Land Use

Land use and zoning maps were requested; however, none were available at the time of this study. Land use in the Town appears to consist of a combination of residential, commercial and some industrial. Farmlands are located around the Town of Falher.

5.1.5 Population Growth

Falher's population growth in the past two decades has been inconsistent, seeing both growth and reduction. Table 5-2 tabulates the population growth statistics for the Town of Falher, as reported by Statistics Canada Census data.

Table 5-2: Town of Falher Population Growth

Year	Population	% Change
2011	1,075	14.2
2006	941	-15.1
2001	1,109	-3.5
1996	1,149	

Source: Statistics Canada

5.1.6 Future Flood Risk and Damage Assessment

The Town of Falher has maintained a relatively constant population since 1996, according to Statistics Canada data. The Town's future flood damage potential will likely be similar to historical observed flood damages; however, existing or future land use and zoning maps were unavailable at the time of the study to assess if densification of residential areas within reported flood risk areas may occur. Residents may be at risk of overland flooding if the flash flood ditch located in the western part of town is overwhelmed by runoff from a large rainfall or snowmelt event. Additionally, surcharging of the Town's storm sewer may result in basement flooding throughout the town, as the sewer system is upstream of the flash flood ditch. The Town could incur similar flood damages and impacts as the 2013 and 2011 rainfall and snowmelt events which mainly resulted in flooding of homes and basements.

5.1.7 Flood Mitigation Alternatives

5.1.7.1 Flash Flood Control Ditch Improvement

In order to reduce flooding in the Town of Falher, improvements to the existing flash flood control ditch was studied. The scope of this option involved assessment of existing flash flood control ditch capacity. The concept of this option is to rehab the existing flood control ditch so that the design discharge can pass safely without flooding the town. The flash flood ditch alignment is shown on Figure 5-1-1.

The current geometry and characteristics of the flash flood control ditch are not included in any existing reports reviewed by AECOM. However, based on its history of flooding, it is evident that the ditch is unable to convey storm water following a significant rainfall or snowmelt event. The topography of surrounding land is quite flat with 0.1% sloping towards west.

Design Flow Estimation

Design discharge to be conveyed in the flash flood ditch, was calculated using the Rational Method. The following parameters were used:

- Weighted runoff coefficient of 0.4 for Town of Falher and 0.25 for area west of the town
- Design storm Intensity-Duration-Frequency (IDF) data taken from the published Environment Canada, IDF data for Watino, Alberta
- Time of concentration was calculated using Kirpich formula

Arc GIS was used to process LiDAR information. Surface topography was used to delineate the catchment area contributing runoff to the flash flood control ditch. The Town was included in the catchment area, as it has been reported that the town's storm water system discharges into this ditch. It was assumed that no runoff from south of Highway 49 will flow toward the flash flood ditch, as there does not appear to be any culverts crossing the highway in the area.

The peak discharge at inlet of the culvert under rail track, calculated using Rational Method, is 9.8 m^3/s. The upstream portion of the ditch along the 2nd Street, which collects the stormwater from the town area, has a design flow of 5.4 m^3/s.

Conceptual Design

Flash Flood Control Ditch Design

Bentley Flow Master was used to determine the required size of the ditch to convey the peak flow at 0.1% longitudinal slope. Manning's n value of 0.03 was used, corresponding to a grass lined channel. The elevation where the flash flood ditch ties into the Winagami-Girouxville Canal cannot be lower than the elevation of the canal bed. For that reason, it is proposed to increase the ditch capacity primarily by widening the channel bottom, and not lowering the channel bed. Where depth needs to be increased, it is proposed that berms be constructed on either side of the ditch. Along the east-west leg of the ditch, the berm to the south of the ditch will require a number of culverts in order to convey the overland flow from the farmland into the flash flood ditch. It is proposed that four culverts be installed along this berm, at equal distance along the east-west portion of the ditch. Table 5-3 shows the Flow Master results and the required geometry of the ditch at various stations, corresponding to increasing flow along the ditch. Flash flood ditch alignment and profile are shown on Figures 5-1-3 to 5-1-5. Figure 5-1-6 illustrates the flash flood ditch cross-section.

Table 5-3: Flash Flood Control Ditch Cross-section Dimensions

STA	Flow (m^3/s)	Ditch Bottom Width (m)	Side Slopes (H:V)	Normal Depth (m)	Recommended Depth (m)
0+400	5.4	4.0	4:1	1.0	1.3
1+000	6.5	4.0	4:1	1.1	1.6
1+400	7.6	5.5	4:1	1.2	1.6
2+250	8.7	5.5	4:1	1.3	1.6
2+750	9.8	5.5	4:1	1.3	1.6

Culvert Design

Culverts are designed to allow conveyance of flow through flash flood control ditch that intersect the roadway, using the information gathered from the hydrological assessment presented above. Culverts are modelled using HY-8 software (Federal Highway Administration, 2013). The HY-8 model is capable of modelling stream crossing structures, and calculates the back water levels and velocities downstream of proposed watercourse crossings. The data input into HY-8 software include the proposed culvert size, slopes, lengths, and immediate downstream channel dimensions to represent the back water conditions of the culverts.

Box culverts are proposed where the flash flood control ditch intersects existing roadway. The culverts along the south berm, along the east-west portion of the ditch, will each need to be able to convey a total flow of approximately 4.4 m^3/s. It is recommended that four 1000 mm diameter CSP culverts be installed at equal distance along the berm, in order to prevent overland flooding in the land south of the flash flood ditch. Each of these culverts will be able to convey 1.1 m^3/s of overland flow to the flash flood ditch, without overtopping the berm. The maximum Headwater to culvert diameter (HW/D) ratio is estimated at 1.5. Figure 5-1-7 shows the location of the culverts that will be upgraded or constructed.

5.1.8 Conceptual Cost Estimate

The cost to construct the flood control channel is estimated to be $6.1 million, in 2015 dollars, as summarized in Table 5-4. The Class D cost estimate includes a 10% mobilization and demobilization and 40% contingency. The cost estimate does not include the following:

- Cost of utility and pipeline realignment
- Cost to mitigate any environmental losses
- Land acquisition/purchase

Table 5-4: Flash Flood Control Ditch - Conceptual Cost Estimate

Item	Total Cost ($)
Channel	
Stripping	$207,300
Excavation	$74,175
Fill	$871,240
Topsoil	$612,900
Hydroseed	$103,650
Culverts	
Private Road U/S – 1800x1200 mm Culverts	$161,800
Private Farm Access (East)- 1800x1200 mm Box Culvert	$161,800
1800x1200mm Concrete Box Culvert - Bevelled End	$123,200
Private Farm Access (East)- 2400x1200 mm Box Culvert	$301,700
2400x1200mm Concrete Box Culvert - Bevelled End	$74,000
Twp Rd 781 and RR 215 - 2400x1200 mm Box Culvert	$450,700
D/S tie into Winagami-Girouxville Canal - 2400x1200 Box Culvert	$599,600
2400x1200mm Concrete Box Culvert - Bevelled End	$214,300
1000 mm diameter CSP Culvert - supply and install	$51,300
Sub-Total	**$4,017,000**

Item	Total Cost ($)
Mobilization & Demobilization (10%)	$401,700
Contingency (40%)	$1,606,800
Total	**$6,100,000**

5.1.9 Evaluation of Alternative

The conceptual cost of implementing the proposed ditch is $6.1 million. While it may be more cost effective to maintain the ditch in its current condition, flooding will likely remain a concern. In the past, up to 44 homes have been flooded. Flooding of homes can cost residents significant sums of money for repairs to flooding and water damage, and can also pose a health and safety risk to residents of Falher.

Without improvements to the stormwater drainage system, there may be a potential flood risk to a larger residential area in the event of a significant rainfall and snowmelt event. Additionally, farmlands to the south of the flash flood control ditch, as well as a cemetery on the west side of the town may be impacted by standing water in the event of a major flood event, potentially making these areas inaccessible.

The Flash Flood ditch currently discharges into the Winagami-Girouxville canal, which runs parallel to the rail line. If there are inadequacies with this main canal, this may heighten the flooding in the surrounding areas, and may damage rail, and road infrastructure in the area. An assessment of the Winagami-Girouxville canal and its flow capacity is recommended if the proposed ditch is taken to the preliminary design phase. Additionally, some property including farmland may have to be purchased to accommodate the proposed ditch alignment.

5.1.10 Environmental Review of Flood Mitigation Alternative

AECOM conducted an environmental overview desktop review for proposed flood mitigation works in the Town of Falher. The purpose was to compile information on existing conditions and to provide commentary on potential permitting requirements associated with possible flood mitigation alternative. The desktop review consisted of examining a variety of publically available ecological databases and reports. This desktop review does not follow the format of an Environmental Impact Assessment (EIA) due to the limited engineering, hydrological, geotechnical, hydrogeological, and geological information available for the location. This is considered an environmental overview desktop report and is intended as a general guidance document outlining some of the major environmental concerns and regulatory issues associated with potential flood mitigation projects, and their surrounding area

Various databases were searched to identify environmental factors within the Falher Area of Interest (AOI).

5.1.10.1 Wildlife and Species at Risk

Within the 20 km search radius of the Falher AOI, four birds and two mammals are listed by AESRD, Alberta *Wildlife Act*, COSEWIC, and/or SARA. In total, there are six species with an AESRD general status of “At Risk”, “May be at Risk” or “Sensitive” and one species listed with a SARA status of “Threatened” or “Endangered”. These species are:

- Birds:
  - Barred Owl
  - Least Flycatcher
  - Northern Harrier
  - Sharp-tailed Grouse

- Mammals:
  - Bobcat
  - Woodland Caribou

5.1.10.2 Fisheries

Flood mitigation design in Falher involves Winagami-Girouxville Canal and Huntington Creek which are unmapped waterbodies with no RAPs as per the AESRD COP (AESRD 2015b). There are no records of fish species present in either waterbody (AESRD 2013).

5.1.10.3 Applicable Legislation

For the Falher AOI, there are a number of legislations which may be applicable to the mitigation alternative including:

- *EPEA*
- *Migratory Birds Convention Act*
- *Water Act*
- *Alberta Wetland Policy*
- *Public Lands Act*
- *Historical Resources Act*
- *Provincial Parks Act*
- *Public Lands Act*
- *Wilderness Areas Ecological Reserves, Natural Areas and Heritage Rangelands Act*
- *Alberta Wildlife Act*

See Appendix D for further detail on the Applicable Legislation for the Falher AOI.

5.1.10.4 Discussion and Summary

The following environmental elements identified in the Falher AOI:

- Boreal Forest Natural Region, Dry Mixedwood Subregion
- 16 species with AESRD general listing, 1 species with SARA listing
- Migratory Bird Timing Window of April 15 – August 31
- Project description submitted for approval under EPEA

Required permitting and approvals are subject to change based on the final project design. Table 22 in Appendix D summarizes potential considerations which may be required in order for the project to adhere to applicable legislation.

5.1.11 Geotechnical Review of Flood Mitigation Alternative

5.1.11.1 Introduction

It is understood that improvements to the existing flash flood ditch is proposed for the Town of Falher. The assessment contains a desk study of the surficial geology of the proposed alignment and highlights potential issues. The proposed channel is approximately 1.5 m deep. Preliminary recommendations are also provided for the channel stability.

5.1.11.2 Methodology

Geological maps of Alberta from the Alberta Geological Survey were consulted to determine surficial geology of the proposed alignment. Water well drilling records in the area were checked however no stratigraphic data was available from them.

5.1.11.3 Subsurface Conditions

The proposed flash flood ditch; runs primarily through glaciolacustrine deposits.

5.1.11.4 Glaciolacustrine Deposits

Glaciolacustrine deposits material deposited within lakes by meltwater from glaciers. Glaciolacustrine deposits are primarily fine-grained sediments of clay in central portion of the lake and alternate layers of silty clay or silt and clay (varved clay) in peripheral zones. These deposits are weak, compressible and very uniform in a horizontal direction.

5.1.11.5 Discussion and Recommendations

Side Slopes

Glaciolacustrine deposits are anticipated to be encountered along the proposed channel alignment. Soil type should be confirmed during construction by drilling test holes. Cut slopes in low to medium plastic clay till or clay soils up to depths of 3 m should be sloped no steeper than 2.5H:1V. If high plastic clay is encountered, cut slopes should be sloped no steeper than 5H:1V. Areas where a high water table is encountered or areas of increased sand content will require the side slopes to be flattened. Plasticity and strength parameters should be confirmed during detailed design stage. An intrusive investigation should be conducted prior to construction to confirm subsurface conditions.

Erosion

All permanent slopes should be provided with some form of erosion protection to minimize potential of scour and erosion of the slope face. Erosion control synthetic mats or rip rap, and/or topsoil and seeding with a native seed mixture should be considered.

5.1.12 Conclusions and Recommendations

In order to mitigate the flood issues in the Town of Falher, improvements to the flash flood control ditch are required. The existing ditch and culverts appear to be undersized, and are unable to convey the peak flow from the town's stormwater system and cultivated lands to the south of the ditch. AECOM recommends increasing the cross-sectional area. Berms will be required on either side of the channel in order to achieve a depth of 1.3 - 1.6 m. Additionally, all culverts along the ditch need to be re-graded to convey the flow and to prevent water backup along the channel.

Flooding in the past has occurred due to water backing up into the flash flood control ditch from the Winagami-Girouxville Canal. If flooding remains an issue after the capacity of the flash flood ditch has been increased, further analysis will be required for the Winagami-Girouxville Canal in order to prevent water backing up into the flash flood ditch and flooding the Town of Falher. There are numerous drainage projects which contribute to the Winagami-Girouxville Canal, and assessment of the canal would include consideration of the entire drainage system.

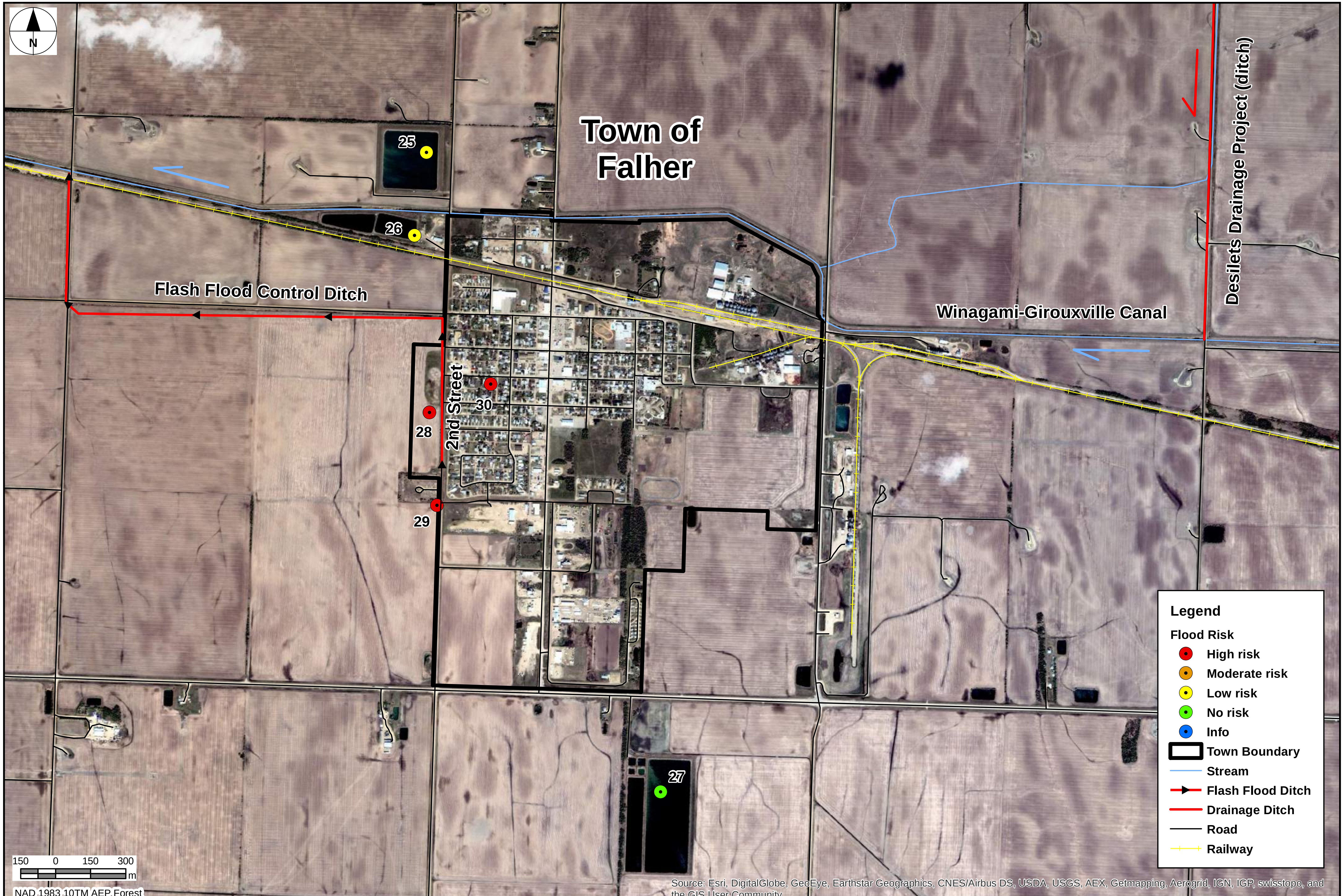

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Figure: 5-1-1

Town of Falher
Stakeholder Identified Historical Flood Issues

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Filename: P:\60334569\900-WORK\920-929 (GIS-GRAPHICS)\MAIN REPORT FIGURES\FIGURE 5-1-1 TOWN OF FALHER - STAKEHOLDER IDENTIFIED HISTORICAL FLOOD ISSUES.MXD
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Historical flooding in the Town of Falher

Historical flooding in the Town of Falher

Historical flooding in the Town of Falher, Photo taken July 18, 2001.

Historical flooding in the Town of Falher. Photo taken July 18, 2001.

Image Source: Town of Falher

Town of Falher
Flood Event Photos

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
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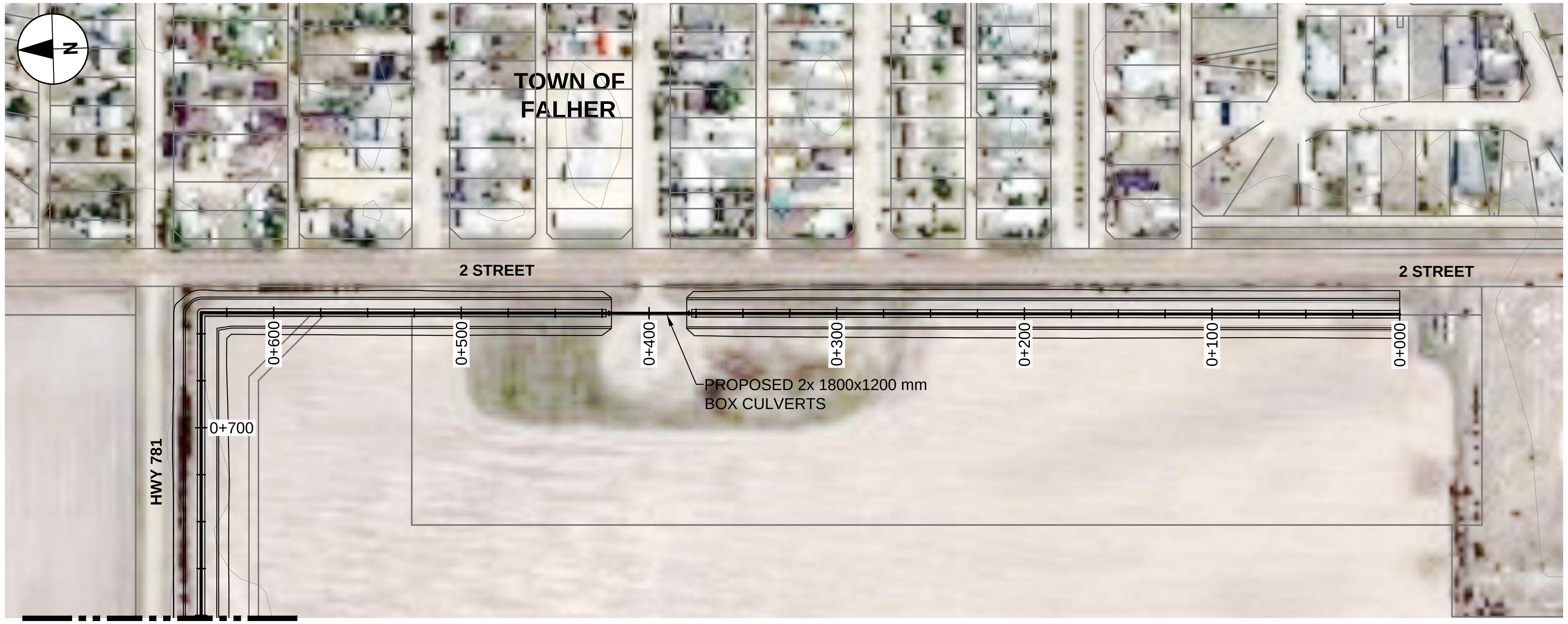
Figure: 5-1-2



MATCHLINE AT STA 0+800.000
REFER TO FIGURE 5-1-4

PLAN

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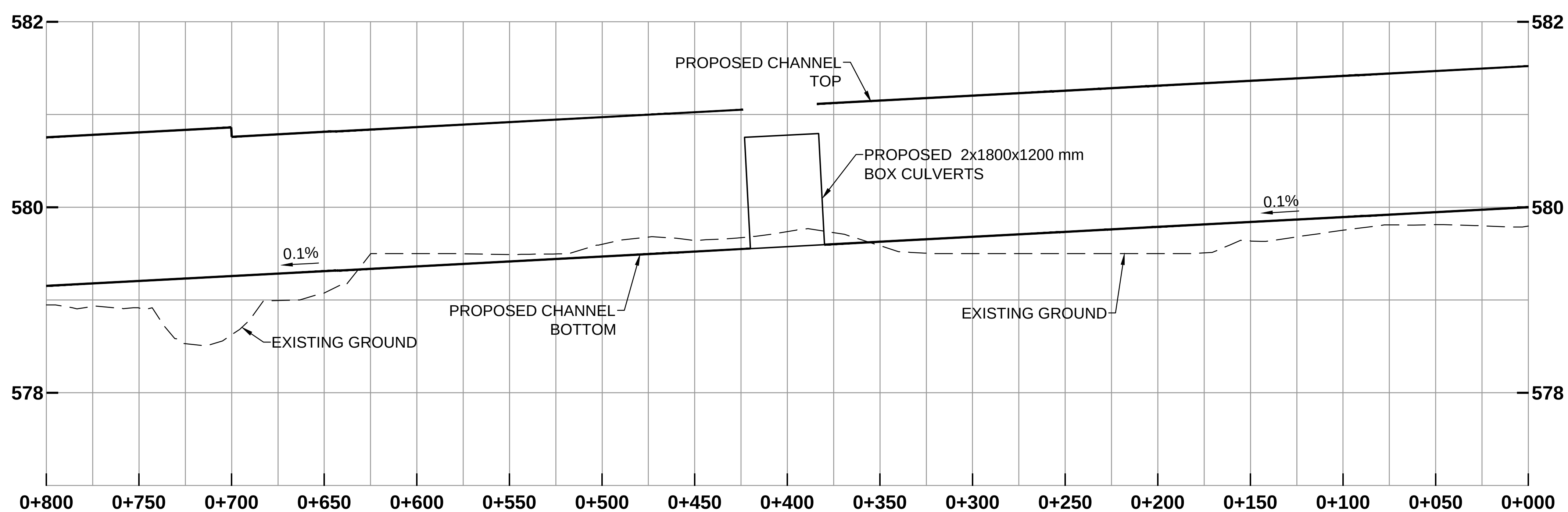

PROFILE

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V=1:15

AECOM

Figure: 5-1-3

Town of Falher
Flash Flood Ditch
Plan and Profile 1 of 3

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

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Designer:
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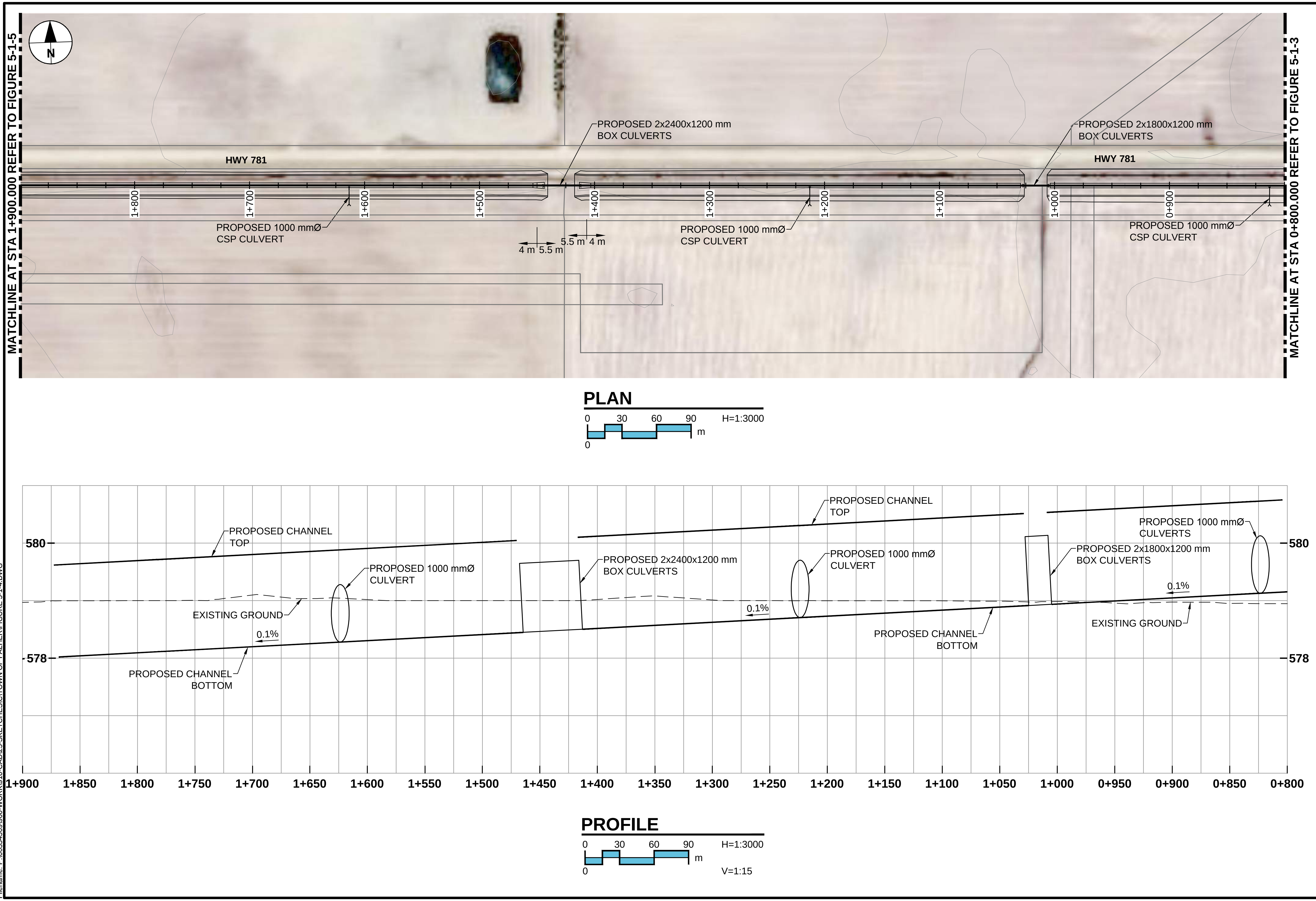

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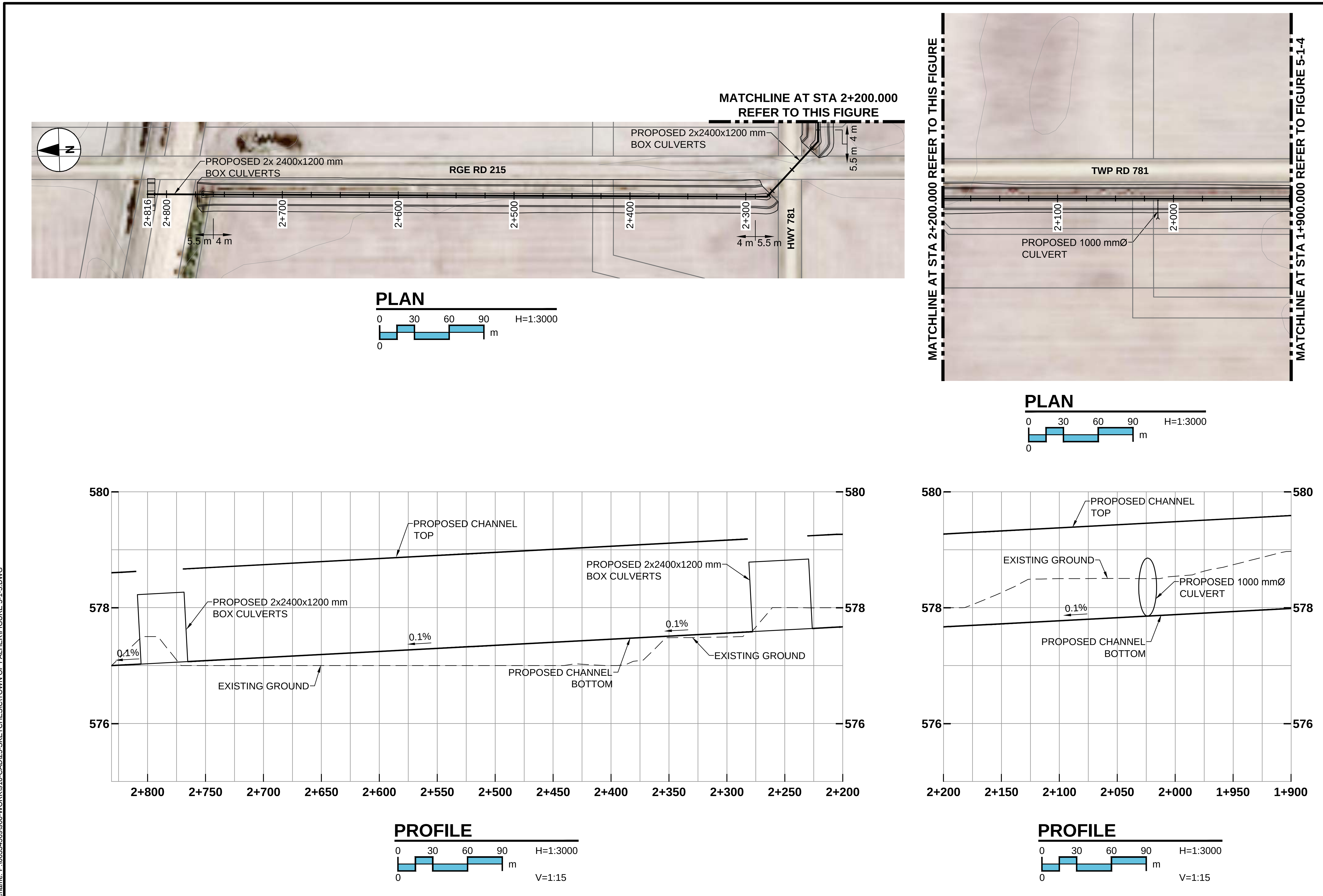
AECOM

Figure: 5-1-4

Town of Falher
Flash Flood Ditch
Plan and Profile 2 of 3

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569



AECOM

Figure: 5-1-5

Town of Falher
Flash Flood Ditch
Plan and Profile 3 of 3

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

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Designer:

Project Management Initials:

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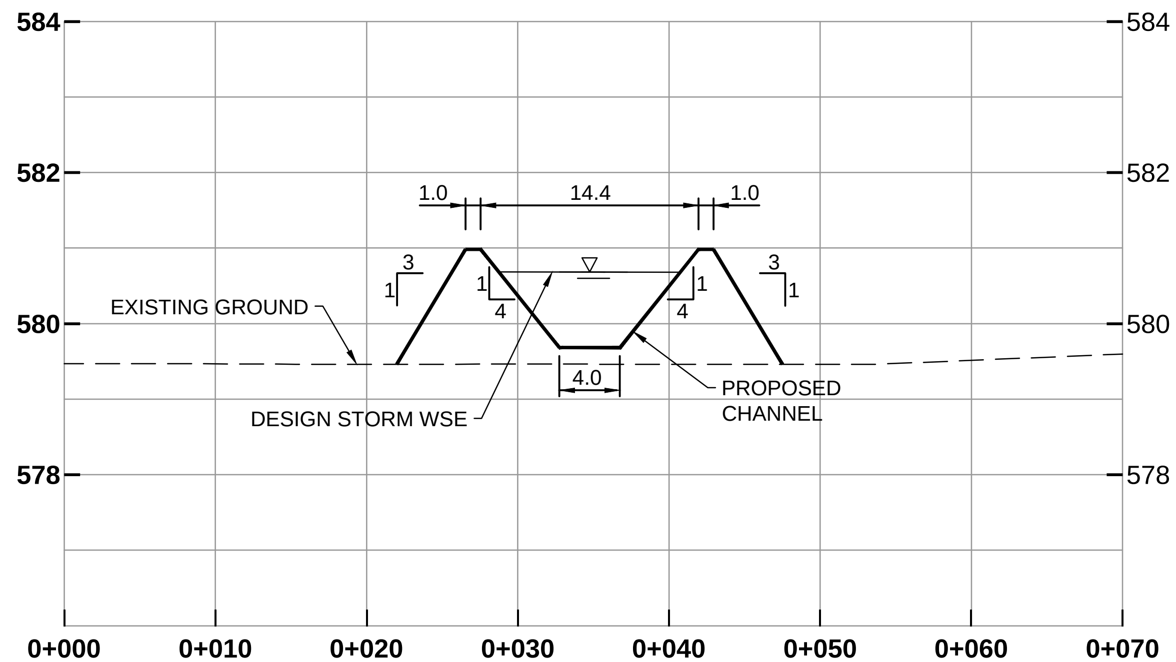

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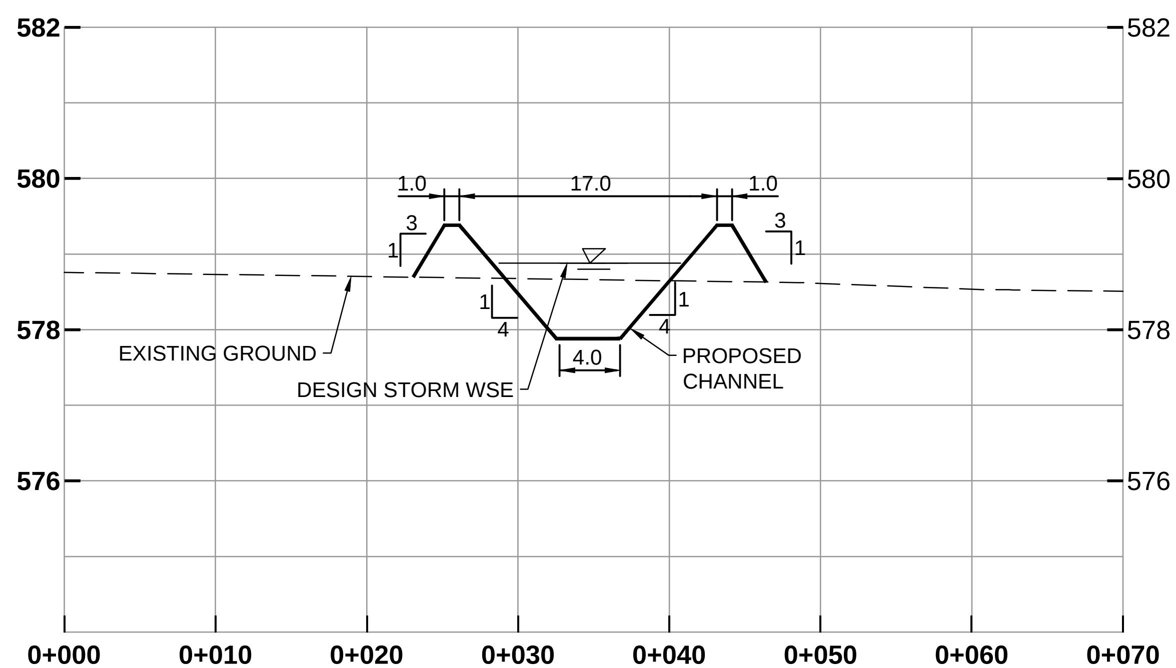

SECTION

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V=1:200

STATION 2+000.000

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Figure: 5-1-6

Town of Falher
Flash Flood Ditch
Cross Sections

Peace River Basin
Flood Mitigation Feasibility Study
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Project No.: 60334569

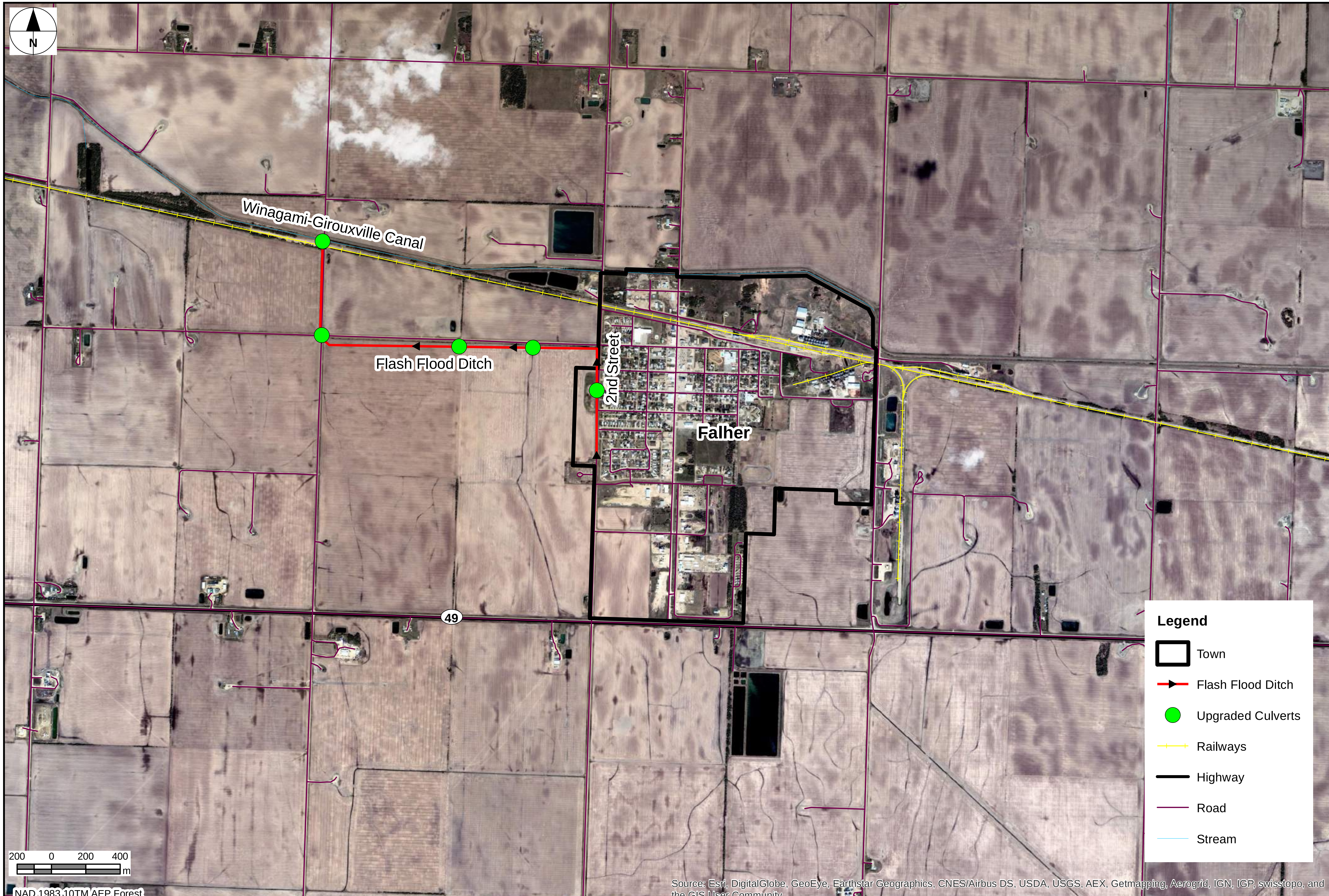

Figure: 5-1-7

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Town of Falher
Intrastructure Upgrade for Flash Flood Ditch

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

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Filename: P:\60334569\900-WORK\920-929 (GIS-GRAPHICS)\MAIN REPORT FIGURES\FIGURE 5-1-7 TOWN OF FALHER - INFRASTRUCTURE UPGRADE FOR FLASH FLOOD DITCH.MXD

5.2 Town of Manning

5.2.1 Background

Parts of the Town of Manning are located within the flood hazard area that was delineated by AESRD in 2000. Due to the existence of residential and commercial areas located within the delineated floodway and flood fringe areas, the Town is classified as a high risk community. The location of the Town of Manning in the Peace River Basin is shown on Figure 5-2.

5.2.2 Historical Flood and Erosion Issues

It was reported that the subdivisions north of the Town could be impacted due to meandering of the Notikewin River. The water treatment plant intake was reported to be at risk of flooding; however, water supply for the Town has not been interrupted due to intake flooding since the water reservoir has a large capacity. A flood occurred in 1935; however, no river flow was recorded before the installation of a stream gauge in 1961 and no other flood records are available. The Notikewin River at Manning Flood Risk Mapping Study by AESRD conducted in July 2000 reports that the largest recorded discharge was 504 m^3/s on May 23, 1964. The Town of Manning has not experienced flooding in recent history as reported during stakeholder consultations. There are no reports or records available of ice jam flooding in the Notikewin River at the Town of Manning.

5.2.3 Floodplain Mapping – AESRD (2000)

A flood risk mapping study was conducted by AESRD in July 2000 to determine the 1:100 year water surface elevation in the Notikewin River at the Town of Manning. An “interim” 1:100 year peak flow (obtained from a flood frequency analysis study by AESRD in March 1991) was used in a HEC-2 model and an interim flood hazard map was delineated including a floodway and flood fringe.

The 1:100 year peak flow was determined using flow data from 1961 to 1991 (30 years) obtained from Water Survey Canada stream gauge station 07HC001 (Notikewin River at Manning) and resulted in approximately 650 m^3/s using a Gumbel distribution. Cold-low frontal storms have produced flood flows far greater than maximum recorded flows in river basins surrounding the Notikewin River Basin. Even though no records are available that the Notikewin River Basin has experienced cold-low frontal storms, the large effect that such a storm could have on the Notikewin River flow was also considered in AESRD’s flood frequency analysis study in 1991 by using an Index Flood method. The method applied a multiplier of 12.06 to the 1:2 year flow of 215 m^3/s in order to estimate an interim 1:100 year peak flow of 2,590 m^3/s. More details about the Index Flood method can be found in AESRD’s Flood Frequency Analysis of the Notikewin River at Manning Floodplain Study (1991) in Appendix C.

AESRD’s flood risk mapping study (2000) indicates that during the interim 1:100 year flood event, all buildings and areas located west of Main Street and east of the Notikewin River and areas within First and Fourth Avenue will be inundated. The area located around the sewage lagoon would also be flooded while the lagoon itself may not be impacted as they are protected by dikes. The rest of the flood affected areas mainly consist of agricultural land.

The flood hazard area resulting from the interim 1:100 year peak flow was delineated by AESRD (2000) and is shown on Figure 5-2-1.

5.2.4 Land Use

Existing land use and zoning in the Town of Manning is shown on Figure 5-2-2. Populated areas west of Main Street and east of the Notikewin River consist mainly of residential, institutional and commercial zones and are located in the flood hazard area as delineated by AESRD in 2000. Future land use and zoning maps were requested but unavailable; therefore, it could not be determined if residential growth is planned to be restricted in the area west of Main Street and east of the Notikewin River. Additionally, a municipal infrastructure zone containing sewage lagoons and an urban reserve district zone is located in AESRD's flood hazard area located approximately 800 m downstream of the Main Street Bridge.

The zoning south of the Town along the west bank of the Notikewin River is designated as restricted residential and is located in AESRD's flood hazard area; therefore, it is likely not subject to densification of residential properties. Furthermore, satellite imagery does not show homes in the restricted residential zone south of the Town at the time of the study.

5.2.5 Population Growth

The Town of Manning's population growth in the past two decades has fluctuated; however, the Town has experienced a significant decrease in population from 2006 to 2011. It is unknown in which areas of Town the population has decreased.

Table 5-5 tabulates the population growth statistics for the Town of Manning, as reported by Statistics Canada Census data.

Table 5-5: Town of Manning Population Growth

Year	Population	% Change
2011	1,164	-22.0
2006	1,493	15.5
2001	1,293	-0.2
1996	1,295	

Source: Statistics Canada

5.2.6 Future Flood Risk and Damage Assessment

Future land use and zoning maps were unavailable at the time of the study; therefore, it could not be determined whether additional residential areas are planned within the flood hazard area. Population has decreased by 22% from 2006 to 2011; however, it is not known if population in the flood hazard area has decreased. Existing land use and zoning maps indicate there are residential zones within the flood hazard area where damage to homes and risk to residents are high during the "interim" 1:100 year flood event. The updated 1:100 year water surface elevation results in a smaller flood extent; however, still inundates most of the residences west of Main Street and east of the Notikewin River.

There are approximately 200 residential lots, a large restricted residential area and a medium sized low residential zone located within the flood hazard area that are at risk of future flooding during the interim and updated 1:100 year flood event; therefore, future risk of damage to homes and the potential for loss of life appear to be high.

The Town's sewage lagoons are located in the flood hazard area; however, are protected by dikes and may not flood if dike heights are above the "interim" and updated 1:100 flood water surface elevation. The Sewage lagoon dike heights were unavailable at the time of this study.

It should be noted that there are two schools close to the flood "interim" and the updated flood extents; Rosary and Manning Elementary. Manning elementary is separated from the flood extent by River Street and the flood waters may impinge onto the northeast corner of Rosary's school grounds, but appears not to flood the school.

5.2.7 Flood Mitigation Alternatives

A dike is proposed to mitigate flooding of the residences located west of Main Street and east of the Notikewin River and residences within First and Fourth Avenue in the Town of Manning during the updated 1:1000 year flood event. The following section provides a conceptual design of a flood protection dike followed by a cost estimate.

5.2.7.1 Flood Protection Dike

<u>*Design Flow Estimation*</u>

The 1:100 year peak flow determined by AESRD in 1991 is 650 m^3/s. However, to include the possibility of a cold-low frontal storm occurring over the Notikewin River Basin, the AESRD additionally determined an "interim" 1:100 year peak flow of 2,590 m^3/s by applying a multiplier of 12.06 on the 1:2 year peak flow. Details about how the interim 1:100 year peak flow was estimated and how it accounts for a cold-low frontal storm can be found in the Flood Frequency Analysis of the Notikewin River at Manning Floodplain Study (AESRD, 1991) in Appendix C.

In order to estimate the 1:100 year peak flow based on additional years of flow data, AECOM performed a flood frequency analysis of the Notikewin River at the Town of Manning. The updated 1:100 year peak flow estimate considers additional flow records from 1991 to 2012 and was obtained from Water Survey Canada stream gauge station 07HC001. The entire flow record from 1961 to 2012 (51 years) shows no abnormally high flows in the Notikewin River at the Town of Manning. Since the last 51 years of flow data shows no evidence of a cold-low frontal storm occurring over the Notikewin River Basin, AECOM recommends not to use the multiplier to estimate the 1:100 year peak flow.

The Method of Moments was used to determine the 1:100 year design flow for the Hamlets of Fort Vermilion and Watino; however, since the Method of Maximum Likelihood typically yields greater flow rates, it was used to determine the updated 1:100 and 1:1000 year peak flow to be conservative. The updated 1:100 and the 1:1000 year peak flow (716 and 1,230 m^3/s) are approximately 73% and 50% lower than the interim 1:100 year peak flow (2,590 $m^{3/}s$) respectively. Therefore, due to the uncertainty of a cold-low frontal storm occurring in the Notikewin River Basin, AECOM adopted the updated 1:1000 year peak flow as the design flow to further assess the extent of flooding in the Town of Manning and to design the flood protection dike.

AECOM recommends that the updated 1:1000 year design flow should be re-assessed during future flood studies, when more flow records are available, to confirm that no cold-low frontal storms have occurred and the updated 1:1000 year design flow remains a reasonable estimate.

The updated flood frequency analysis and results are provided in Appendix C.

Conceptual Design

A HEC-2 computer model was created by AESRD to determine the water surface elevation resulting from the "interim" 1:100 year peak flow of 2,590 m^3/s (2000). AECOM converted the original HEC-2 model to a HEC-RAS model and the simulation was re-run, including a proposed dike alignment, with the updated 1:1000 year design flow of 1,230 m^3/s. HEC-RAS cross sections showing the water surface elevations resulting from the 1991 interim 1:100 year peak flow and the updated 1:1000 year peak flow are shown on Figure 5-2-3.

Recent LiDAR data was used to determine the alignment of the dike such that the height would not exceed 3 m. The height of the dike was designed to incorporate a freeboard of 0.5 m above the updated 1:1000 year water surface elevation. The dike is approximately 1420 m long and the total dike height varies from approximately 2.5 to 3 m along the alignment.

The overall dike alignment and profile views of the dike are shown on Figures 5-2-4, 5-2-5 and 5-2-6.

The base width predominantly varies between 11 to 15 m; however, there are some portions of the alignment where the width increases up to 17 m due to steep eroded river banks. The side slopes are recommended to be no steeper than 2.5H:1V due to soil conditions; however, since the inside of the dike would not be exposed to water during the 1:1000 year flood, it was assumed to be stable at a 2H:1V slope under dry conditions. The outside dike side slope (the side slope extending downwards to the river) varies from 2.5H:1V to 2H:1V. The outside side slope of the dike consists of a steeper 2H:1V only in locations where the bottom width would exceed approximately 20 m if a 2.5H:1V side slope would be used. Typical cross sections of the dike are shown on Figure 5-2-7.

The proposed dike is recommended to be built using a low to medium plasticity clay with a 200 mm layer of top soil. The top soil is to be sodded with a naturalized seed mix since the right bank velocities along the dike alignment do not exceed approximately 1.0 m/s during the updated 1:1000 year peak flow.

5.2.8 Conceptual Cost Estimate

The cost to construct the flood protection dike is estimated to be approximately $2.2 million. The Class D cost estimate is shown in Table 5-6. A contingency of 40% was used in the cost estimate. The cost estimate does not include the following:

- Cost to mitigate any environmental losses
- Land acquisition/purchase

Table 5-6: Cost Estimate

Item	Item Cost
Stripping	$68,250
Sub-grade Preparation	$45,500
Clay Dike (low to medium plasticity)	$658,600
Grass Seeding	$34,125
Top Soil	$682,500
Sub-Total	**$1,488,975**
Mobilization & Demobilization (10%)	$148,898
Contingency (40%)	$595,590
Total	**$2,233,463**

5.2.9 Evaluation of Flood Mitigation Alternative

The conceptual cost of implementing the proposed dike is approximately $2.2 million (excluding land costs) and would protect approximately 200 lots and its residents located west of Main Street and east of the Notikewin River. The dike runs through approximately 14 lots and land would need to be purchased. Approximately four residents are located within the dike alignment and would be required to relocate. The upstream half of the dike would be constructed through a parks and recreation zone.

It should be noted that approximately two homes south of the Town and along the north bank of the Notikewin River and two homes east of Main Street Bridge and along the north river bank are within the flood hazard area and will not be protected by the proposed dike. Furthermore, the dike was designed to the updated 1:1000 year peak flow which does not consider the effect of a cold-low frontal storm. The impact and extent of the flood hazard area resulting from the “interim” 1:100 year flow would be much larger and would overtop the proposed dike.

The cost of the dike should be weighed against the potential flood risk to people, relocation costs and cost of flood related repairs to homes of residents currently within the flood hazard area. The option of moving all residents to a location outside of the flood hazard area may not present a more cost effective alternative since there are approximately 200 homes to be moved. It is suggested that this mitigation measure be studied further and that a cost benefit analysis be performed accordingly.

5.2.10 Environmental Review of Flood Mitigation Alternative

AECOM conducted an environmental overview desktop review for proposed flood mitigation works in the Town of Manning. The purpose was to compile information on existing conditions and to provide commentary on potential permitting requirements associated with possible flood mitigation alternatives. The desktop review consisted of examining a variety of publically available ecological databases and reports including the July 2000 Alberta Flood Mapping Study of the Notikewin River at the Town of Manning. This desktop review does not follow the format of an Environmental Impact Assessment (EIA) due to the limited engineering, hydrological, geotechnical, hydrogeological, and geological information available for the location. This is considered an environmental overview desktop report and is intended as a general guidance document outlining some of the major environmental concerns and regulatory issues associated with potential flood mitigation projects, and their surrounding area.

Various databases were searched to identify environmental factors within the Manning Area of Interest (AOI).

5.2.10.1 Historical Resources

A database search of the *Listing of Historic Resources* (current to March 2015) in GIS format revealed land with HRVs of 1 and 5 occurring in the Manning AOI. For further information on the HRVs within the Sexsmith AOI, see Appendix D.

5.2.10.2 Wildlife and Species at Risk

Within the 20 km search radius of the Manning AOI six birds, four mammals, and one reptile were listed by AESRD, Alberta *Wildlife Act*, COSEWIC, and/or SARA. In total, there are 10 species with an AESRD general status of “At Risk”, “May be at Risk” or “Sensitive” and two species listed with a SARA status of “Special Concern”, “Threatened” or “Endangered” including:

- Birds:
  - American Kestral
  - Barred Owl
  - Great Gray Owl
  - Least Flycatcher
  - Sharp-tailed Grouse
  - Trumpeter Swan
- Mammals:
  - American Bison (*Bison bison bison* and *Bison bison athabascae*)
  - Wolverine
  - Woodland Caribou
- Reptile
  - Red-sided Gartner Snake

5.2.10.3 Fisheries

The Manning AOI includes the Notikewin River. The Notikewin River is a Mapped Class C Water Body with a RAP of April 16th to July 15th as per the AESRD COP (AESRD 2015b).

Fifteen species of fishes have been captured that have the potential to exist within the watershed including five species of sportfish: Arctic Grayling, Burbot, Goldeye, Northern Pike, and Walleye. For a detailed list of these fish species, and their provincial status, refer to Appendix D – Environmental Overview.

5.2.10.4 Applicable Legislation

For the Manning AOI, there are a number of legislations which may be applicable to mitigation alternative including:

- *Fisheries Act*
- *Migratory Birds Convention Act*
- *Water Act*
- *Alberta Wetland Policy*
- *Public Lands Act*
- *Historical Resources Act*
- *Provincial Parks Act*
- *Wilderness Areas Ecological Reserves, Natural Areas and Heritage Rangelands Act*
- *Alberta Wildlife Act*

See Appendix D for further detail on the Applicable Legislation for the Manning AOI.

5.2.10.5 Discussion and Summary

The following environmental elements identified in the Manning AOI:

- Boreal Forest Natural Region, Dry Mixedwood Subregion
- HRVs of 1 and 5
- Open water wetlands
- Key Wildlife and Biodiversity Zone
- Class C River and Creek with RAP of April 16 – July 15
- 10 species with AESRD general listing, 2 species with SARA listing, 2 AESRD general status fish species
- Migratory Bird Timing Window of April 15 – August 31

Required permitting and approvals are subject to change based on the final project design. Table 16 in Appendix D summarizes potential considerations which may be required in order for the project to adhere to applicable legislation.

5.2.11 Geotechnical Review of Flood Mitigation Alternative

5.2.11.1 Introduction

A flood protection dike of approximately 1420 m long is proposed along the east bank of the Notikewin River in the Town of Manning. The proposed dike is to be approximately 3.0 m at its highest point. The assessment contains a desktop study of the surficial geology of the proposed alignment and highlights potential issues. Preliminary recommendations are also provided for the dike stability.

5.2.11.2 Methodology

Geological maps of Alberta from the Alberta Geological Survey were consulted to determine surficial geology of the proposed alignment. Water well drilling records in the area were checked however no stratigraphic data was available from them. A flood mapping study completed in July 2000 titled Alberta Flood Mapping Study Notikewin River at Manning was also referenced.

5.2.11.3 Subsurface Conditions

<u>Geological Maps</u>

The proposed flood prevention dike alignment runs primarily through fluvial deposits.

<u>Fluvial Deposits</u>

Fluvial deposits consist of sediments transported and deposited by streams and rivers. Fluvial deposits include well sorted stratified sand, gravel, silt, clay and organic sediments.

<u>Existing Report</u>

The Notikewin River Flood Mapping Study completed in 2000 indicated that the channel bed consisted of shallow gravel over soft cohesive shale. The banks are formed from silt, sand and erodible rock.

5.2.11.4 Discussion and Recommendations

General

Borrow material will be used for the dike construction. This borrow material may generally be obtained from shallow pits or from channels excavated adjacent to the dike which may produce fill material that is often heterogeneous. Selection of the dike section should be based on the properties of the poorest material that will be used. The use of low to medium plastic clay or clay till is preferable. The fluvial deposits in the area can also be used, provided assessment of the permeability and plasticity of soils is completed prior to construction. If low to medium plastic clay is not available, high plastic clay may be used with flatter slopes. Low to medium plastic clay side slopes no steeper than 2.5H:1V can be used to a maximum height of less than 3 m. Flatter side slopes no steeper than 5H:1V is recommended for high plastic clay. Material properties should be confirmed by drilling prior to construction. Sand and gravel is considered suitable provided impervious material is placed on the dike upstream side slopes.

The top of the dike should be constructed no less than 3 m to 3.6 m wide to allow for normal maintenance operations and flood fighting operations. The upstream side slope of the dike should be covered with sod or rip rap to protect against erosion.

If granular material of less than 1 m thick is present below the dike, this material should be removed and replaced with low to medium plastic clay or clay till, to minimize seepage beneath the dike. If the granular material is greater than 1 m thick other methods to control seepage below the dike should be considered. Seepage control measures may include:

- Cut off trenches;
- Upstream impervious blankets
- Downstream seepage berms
- Pervious toe trenches

As a minimum, any soil used for the dike should exhibit hydraulic conductivity equal or less than 10^{-5} m/sec.

Topsoil from borrow and dike foundation stripping can be stockpiled and spread over the excavated area after completion of borrow excavation.

Erosion

All permanent slopes should be provided with some form of erosion protection to minimize potential of scour and erosion of the slope face. Erosion control synthetic mats or rip rap, and/or topsoil and seeding with a native seed mixture should be considered.

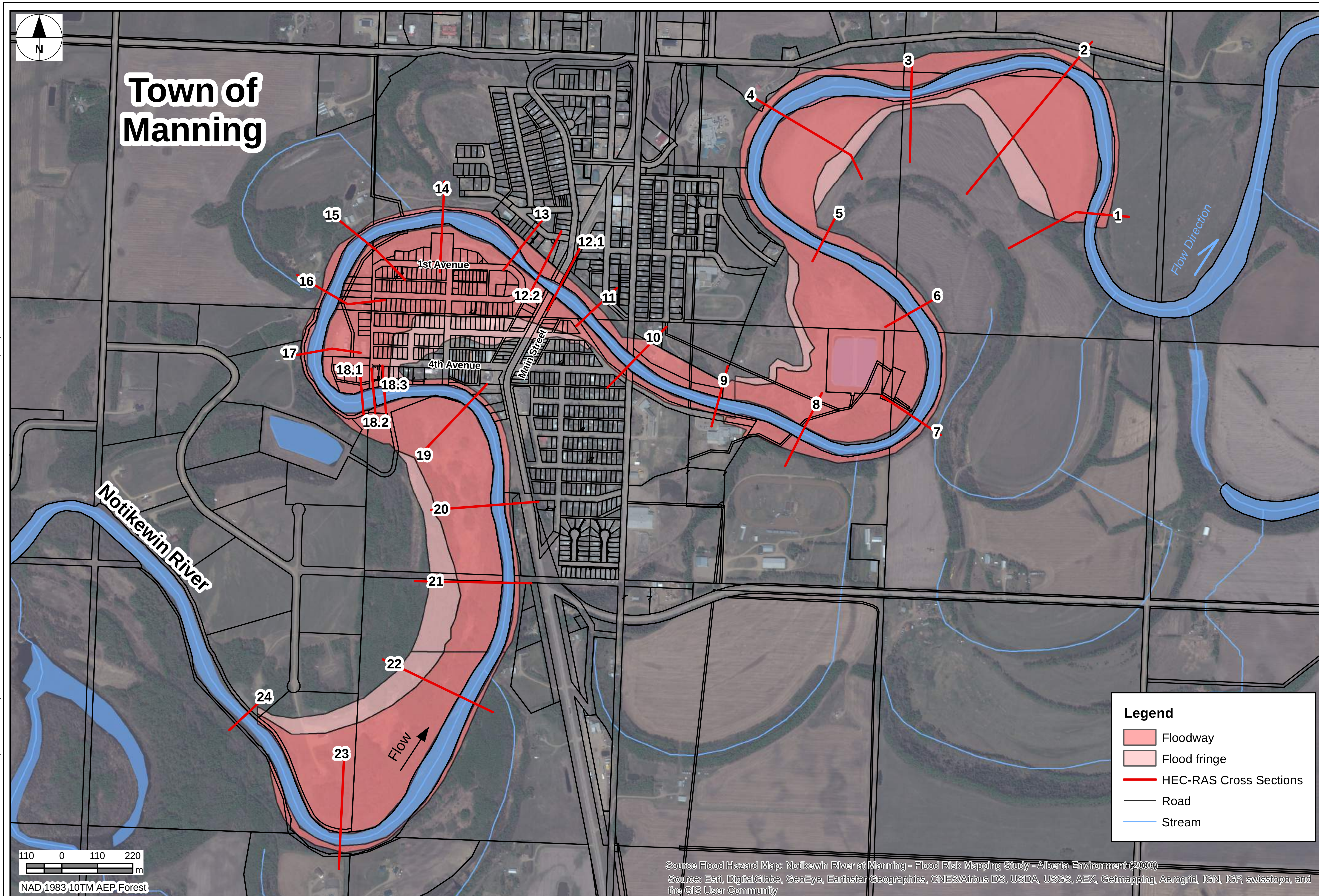
5.2.12 Conclusions and Recommendations

A flood protection dike is proposed that would protect approximately 200 homes during a 1:1000 year flood. Four homes would need to be relocated to create space for the dike alignment. The dike alignment intersects with an additional ten properties and land would need to be purchased. There are approximately two homes south of the Town and two homes east of Main Street Bridge that are not protected by the proposed dike. Two additional dikes would need to be constructed to protect each set of homes and was deemed to be too costly. It is recommended that the remaining residents are made aware of their location within the flood hazard area. Flood prevention alternatives may include relocating to higher ground or residents could raise their homes above the updated “interim” 1:100 year or updated 1:1000 year water level if possible. AECOM recommends that the updated 1:1000 year design flow should be re-assessed when more flow records are available for future studies, to confirm that no cold-low frontal storms have occurred and that the updated 1:1000 year design flow remains a reasonable estimate.

The proposed dike is approximately 1420 m long. The cost of the dike is estimated at approximately $2.2 million and would consist of a low to medium plasticity clay with 2.5 to 2H:1V outside side slopes (river side) and 2H:1V inside side slopes (Town side). Ideally, the dike should have a top width of 3 to 3.6 m to allow for easy access for maintenance vehicles and crews; however, a 1 m top width was selected to reduce total bottom width to minimize encroachment of the dike onto lots of adjacent residents.

A minimum dike side slope of 2.5H:1V was recommended after geotechnical investigations; however, with limited soil information. Therefore, it is recommended that an additional slope stability study be conducted to determine whether the side slopes can be constructed at a steeper 2H:1V if the proposed dike is taken to the preliminary design phase. The dike should be grassed and no additional scour protection is required since right left river bank velocities do not exceed approximately 1.0 m/s.

AECOM recommends that the Town of Manning restricts residential growth in the flood hazard area and develop an emergency evacuation plan. Additionally, it should be confirmed that there is sufficient space under the Main Street Bridge to construct the dike if taken to the preliminary design phase.



AECOM

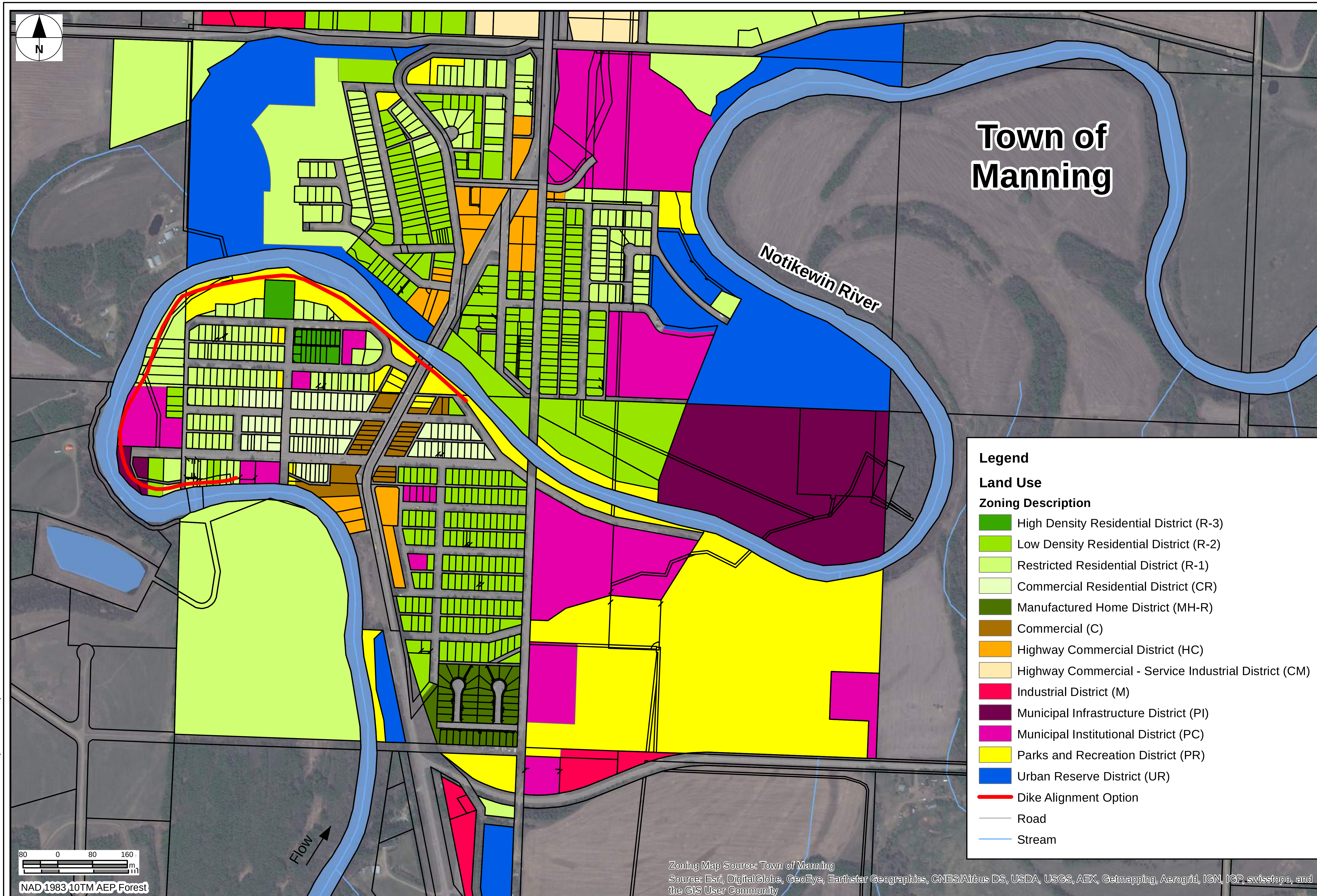
Figure: 5-2-1

Town of Manning
1:100 Year Flood Hazard Map (2000)

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

ANSI B 279.4mm x 431.8mm

Last saved by: MIREAULTC (2015-06-02) Last Plotted: 2014-03-18
Filename: P:\60334569\900-WORK\920-929 (GIS-GRAPHICS)\MAIN REPORT FIGURES\FIGURE 5-2-1 TOWN OF MANNING - 1 100 YEAR FLOOD HAZARD MAP (2000).MXD



AECOM

Figure: 5-2-2

Town of Manning
Existing Land Use and Zoning Map
with Dike Alignment

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

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Filename: P:\60334569\900-WORK\920-929 (GIS-GRAPHICS)\MAIN REPORT FIGURES\FIGURE 5-2-2 TOWN OF MANNING - EXISTING LAND USE ZONING MAP WITH DIKE ALIGNMENT.MXD

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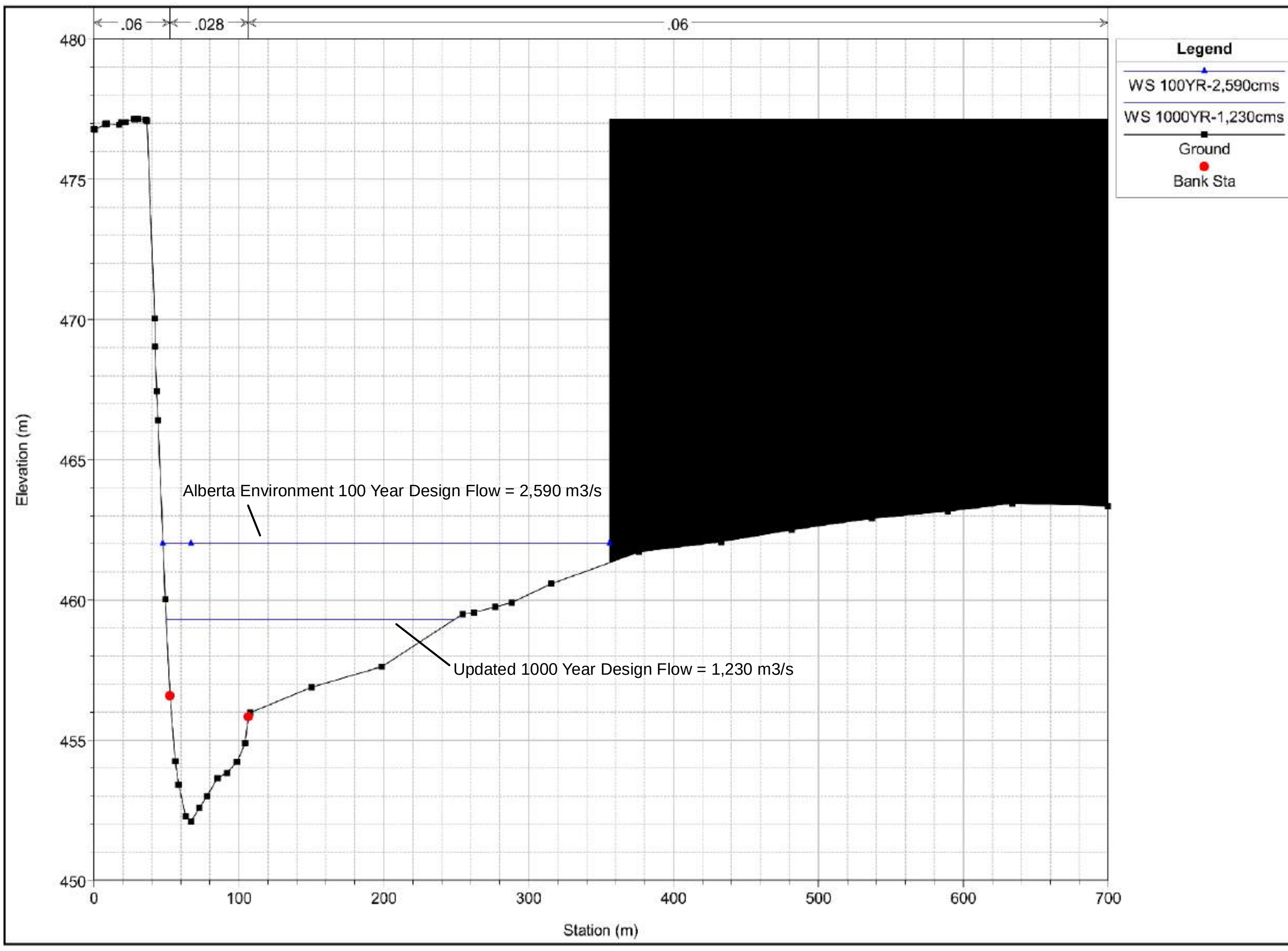
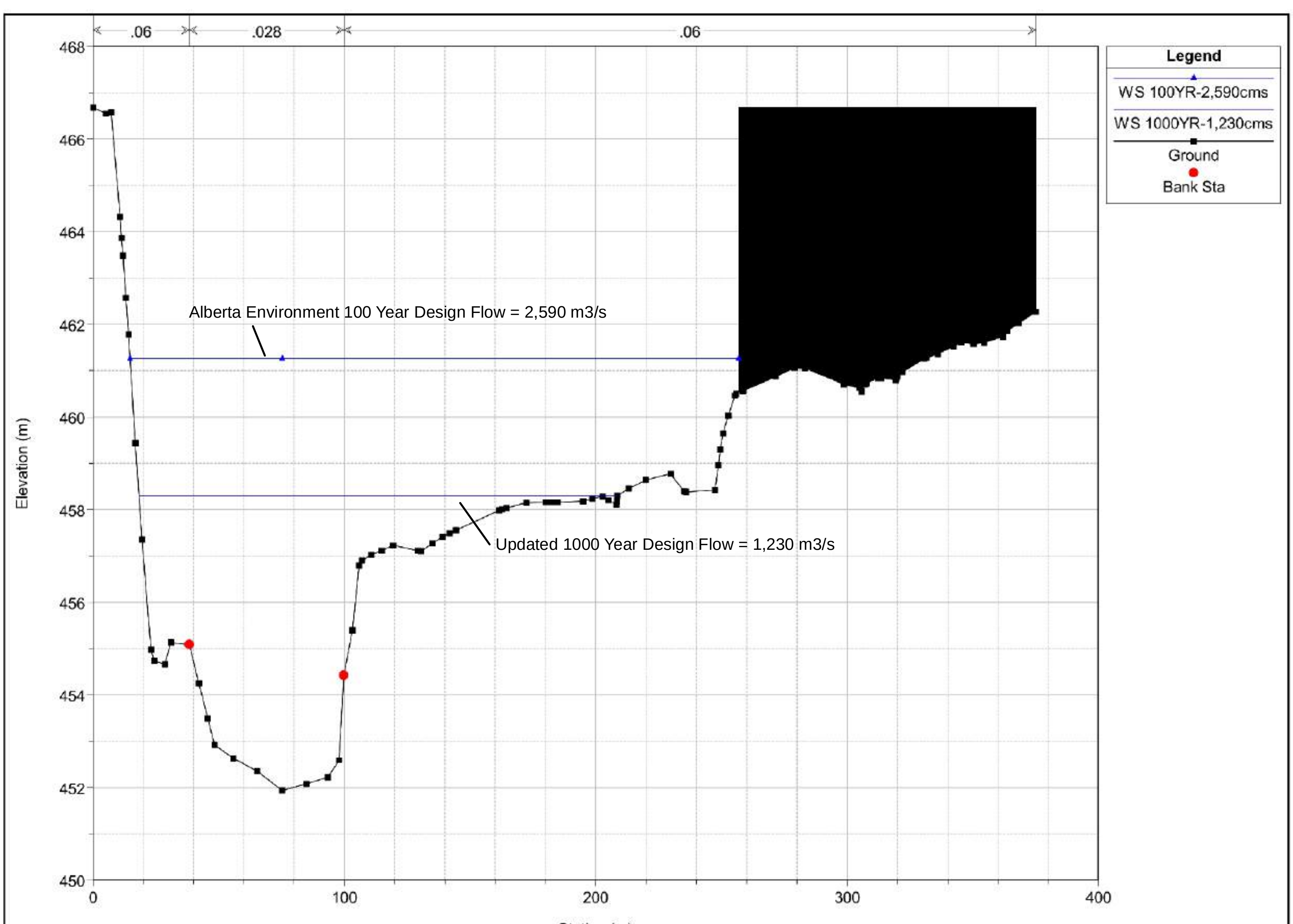
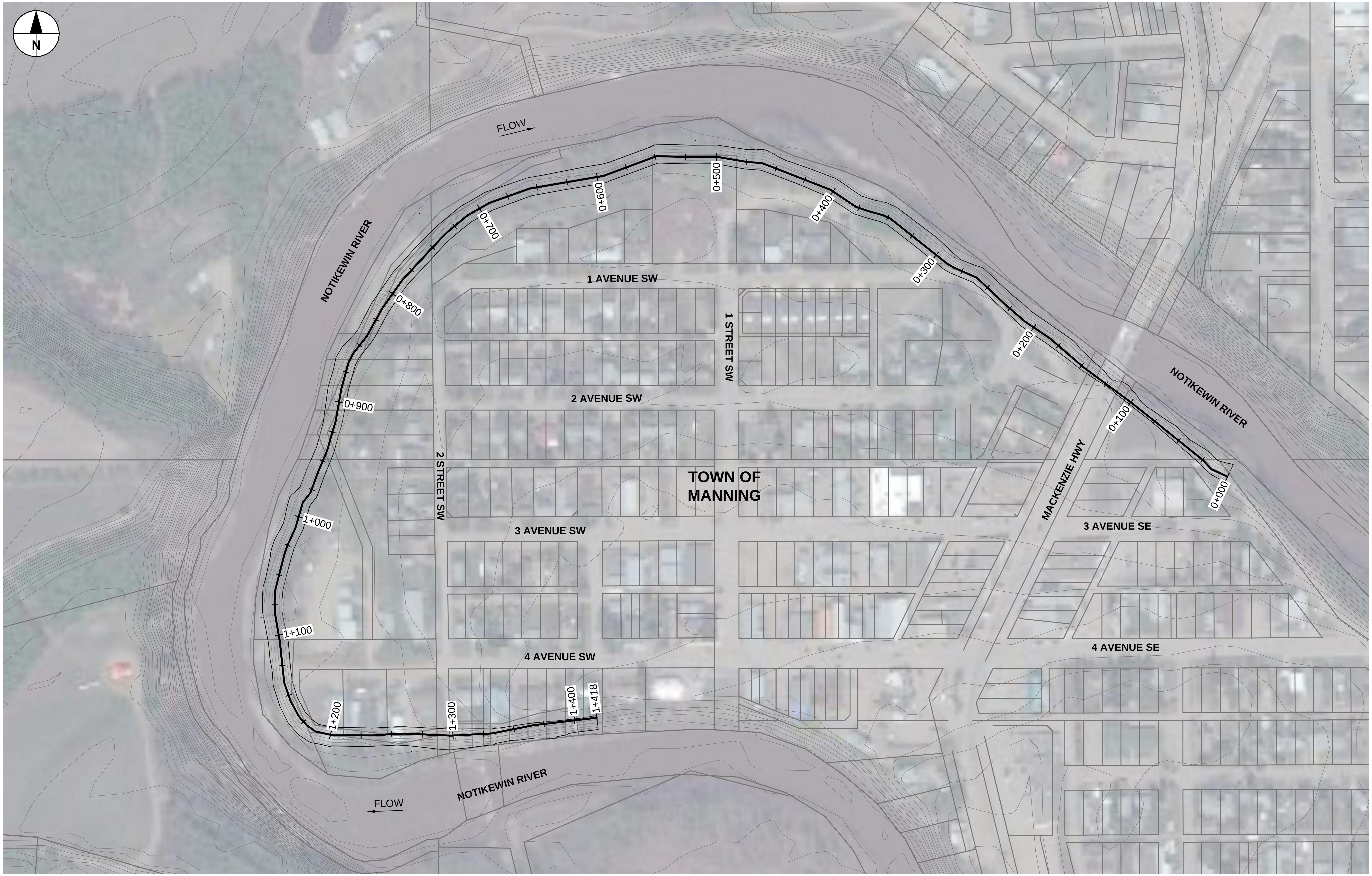


Upstream Cross Section #17



Downstream Cross Section #13



PLAN

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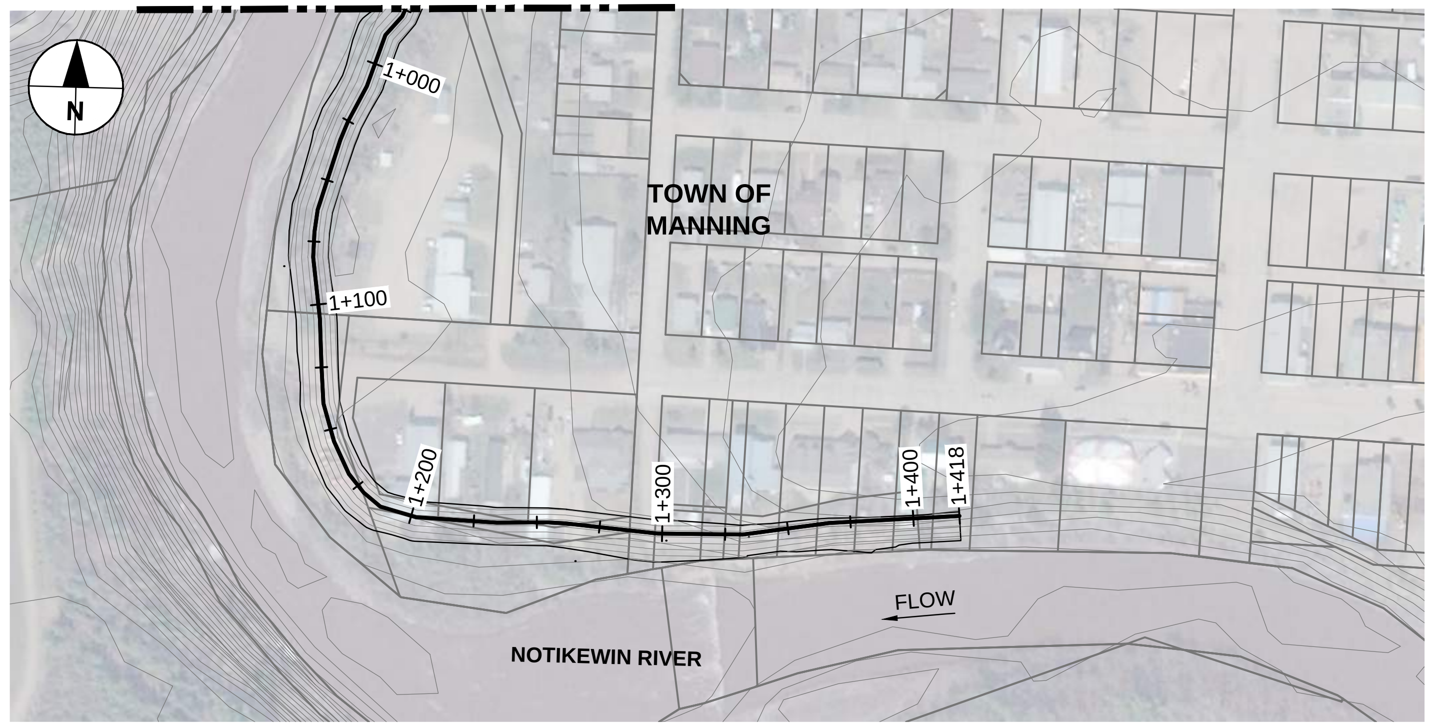
AECOM

Figure: 5-2-4

Town of Manning
Dike Overall Plan

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

MATCHLINE AT STA 0+950.000
REFER TO FIGURE 5-2-6



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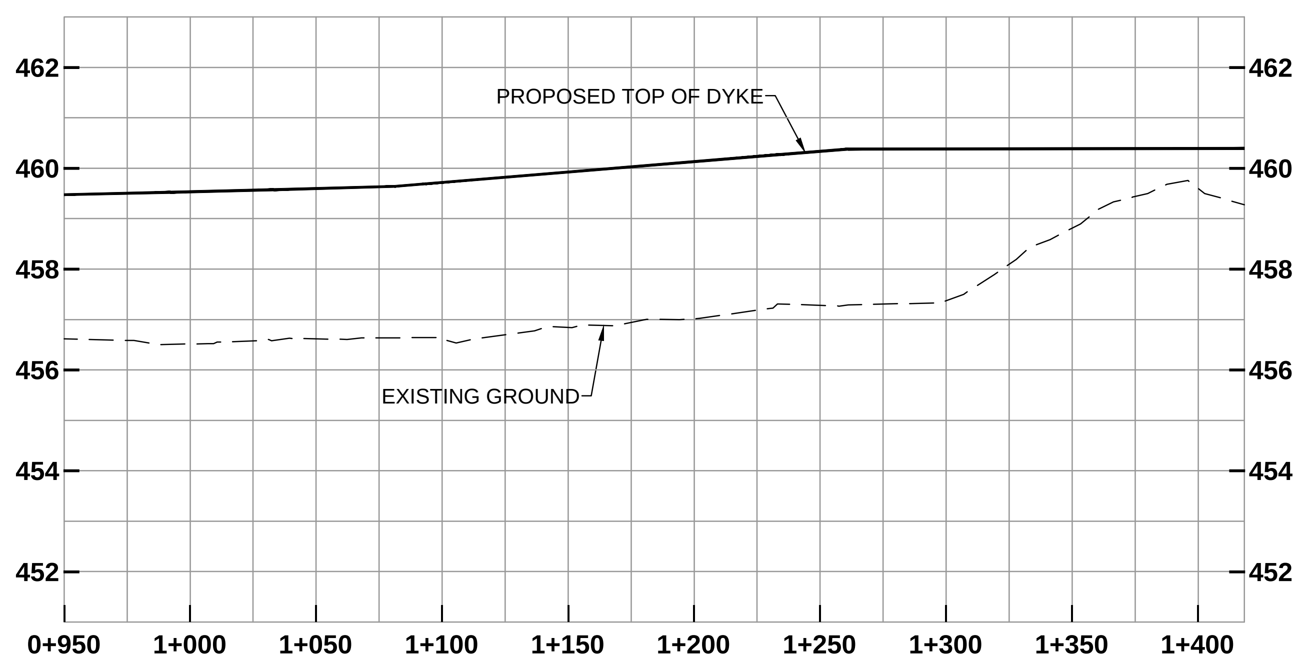

PROFILE

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AECOM
Figure: 5-2-5

Town of Manning
Dike Plan and Profile
Profile 1 of 2

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

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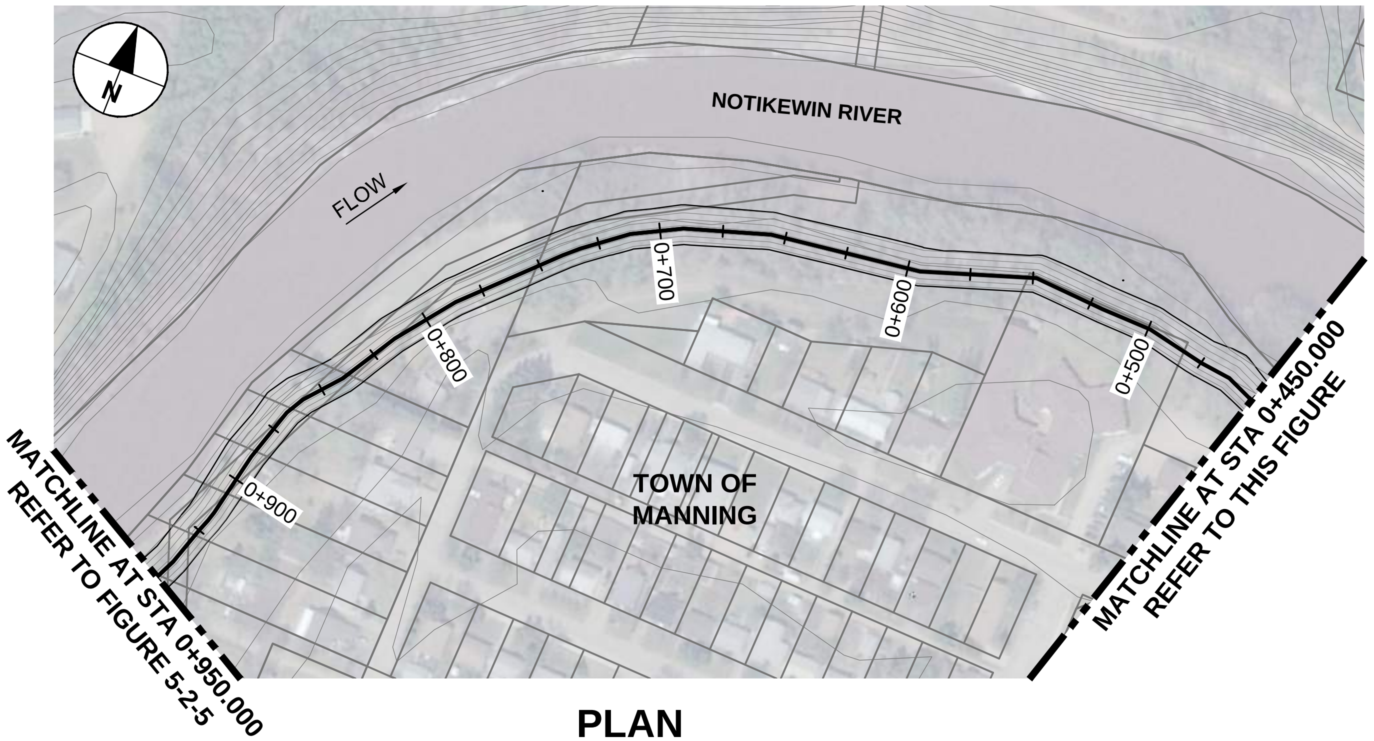

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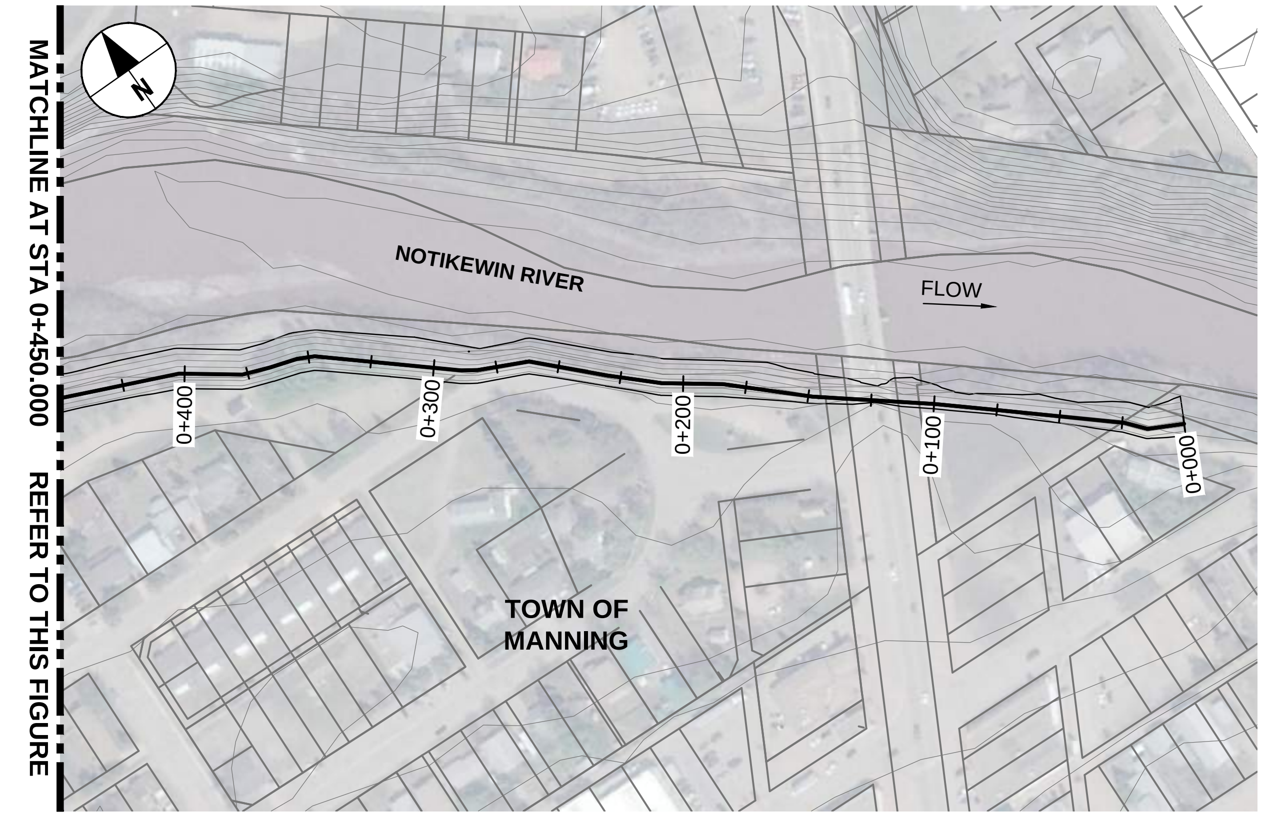

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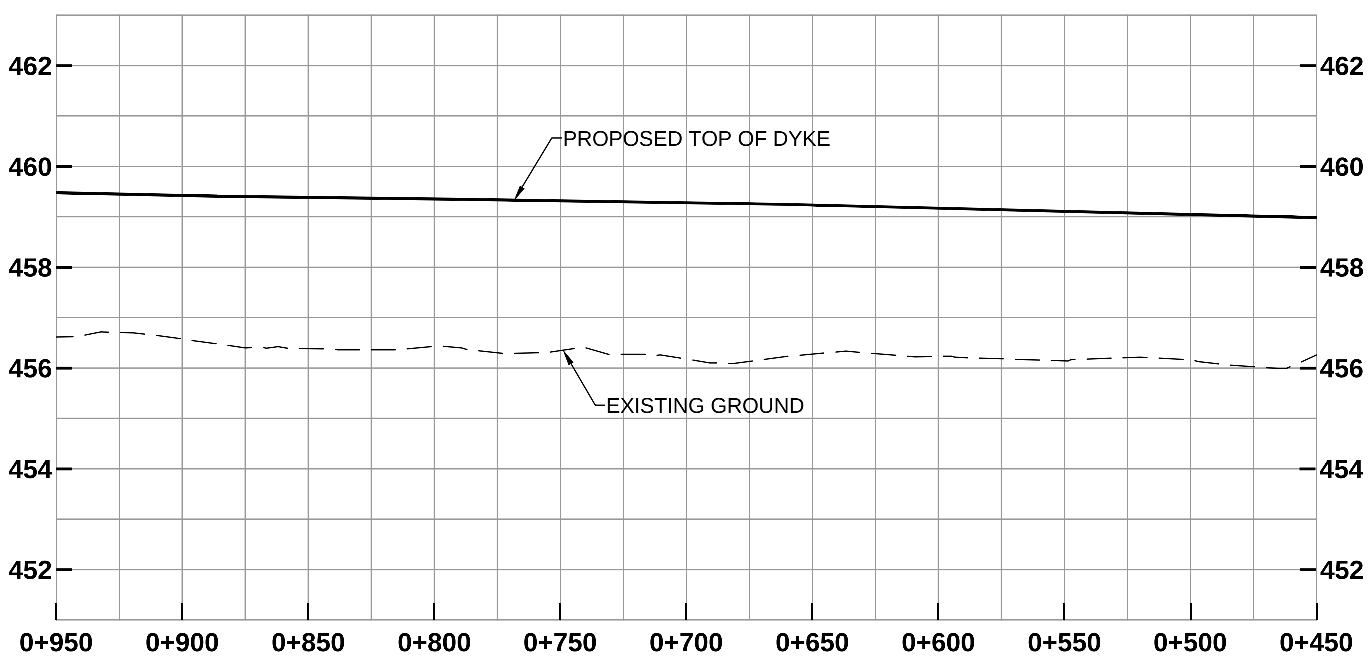

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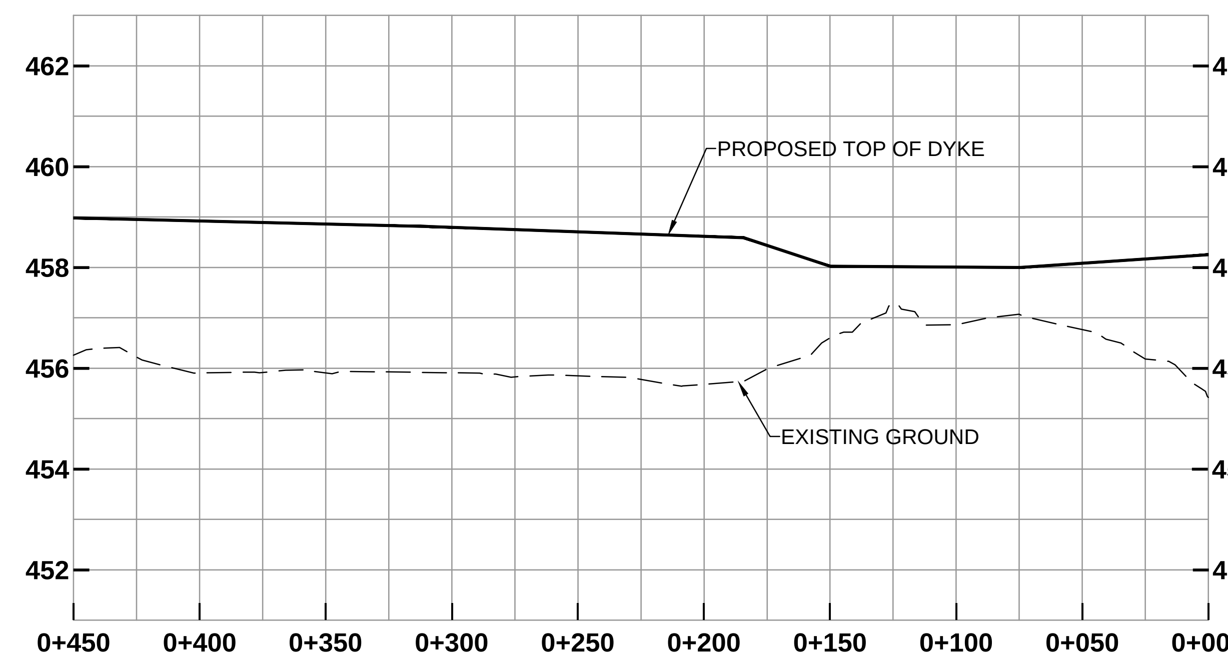

PROFILE

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AECOM

Figure: 5-2-6

Town of Manning
Dike Plan and Profile
Profile 2 of 2

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

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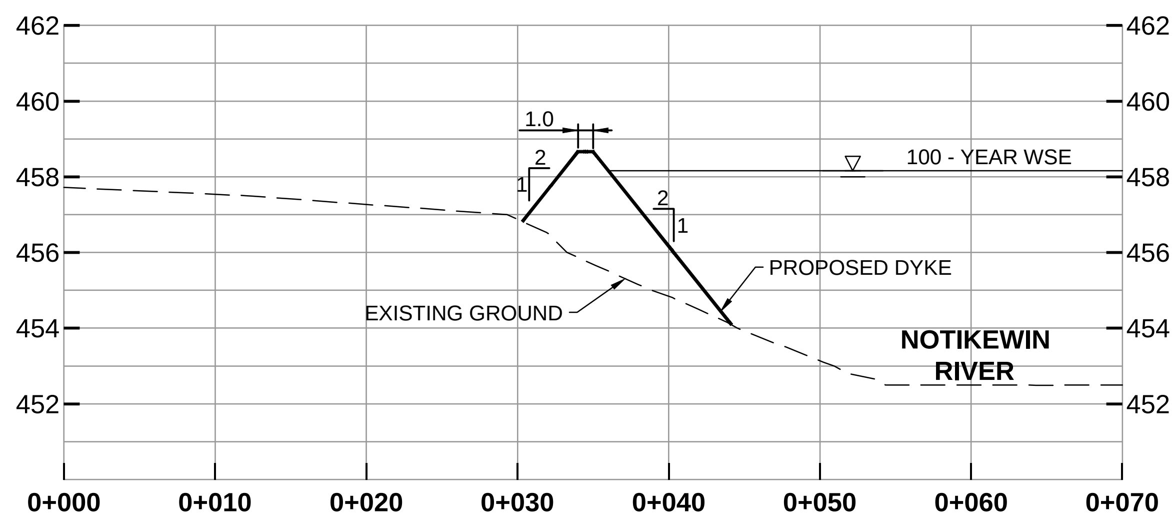

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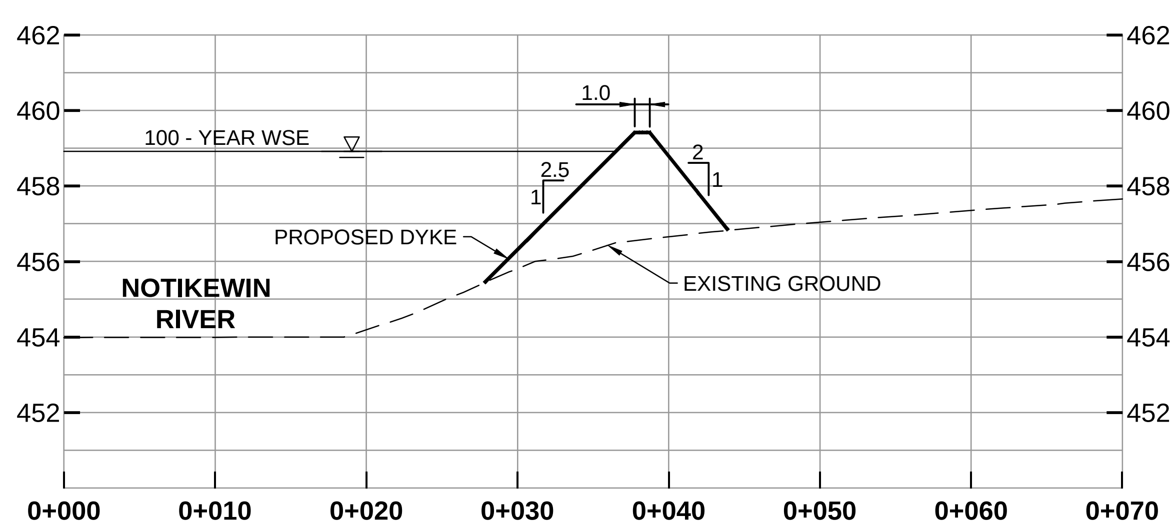

SECTION

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m
0 1 2 3 V=1:100

STATION 0+900.000

Town of Manning
Dike Cross Sections

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

AECOM

Figure: 5-2-7

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5.3 Town of Peace River

5.3.1 Background

The Town of Peace River is classified as a high flood risk community due to many reported flood issues and impacts to structures and residents. The location of the Town of Peace River within the Peace River Basin is shown on Figure 5-2.

5.3.2 Historical Flood and Erosion Issues

Stakeholder identified historical flood issues are shown on Figure 5-3-1. The location of each reported flood issue is numbered with a map ID and classified as high, moderate or low risk. Each issue can be found by the corresponding map ID in Table A-1 in Appendix A.

The downtown area experienced flash flooding due to rainfall in August 2013. Flooding has occurred due to snowmelt, rainfall, and river ice jams. Ice jams have occurred upstream of the town at the Smoky and Peace River confluence and at the Peace River Bridge and have caused the town's dikes to overtop. As a result, the dikes have been raised three times and have not been overtopped by river flooding since 1997. The dikes have a "bathtub" effect where flood waters are contained in the downtown core and are prevented from draining away. Many public facilities are at risk of flooding such as a pool, arena, and town shops.

Additionally, flood risk due to a high water table is an issue in residential areas north of downtown and in the Lower West Peace area. The water table is raised when the Peace River water level is high, causing basements to flood and is an annual concern. Basements are prohibited in new developments in Lower West Peace. Peace River's water level is affected by the release of water from the Bennet Dam by BC Hydro; as a result, BC hydro is in the process of mitigating high water table related flooding by installing nine relief wells in Lower West Peace. A total of 30 wells will be installed and it was reported successful in alleviating high water table related flooding. Basements located in the residential area north of downtown backed up with wastewater in 1992 and 1997 when lift stations were over capacity due to infiltration of water as a result of the high water table. Crews were required to bring in temporary pumps as an emergency measure and pump sewage from the lift stations directly over the dikes into the Peace River during the 2013 and 2014 flood events.

Pat's Creek intake is located northeast of downtown. The pipe runs under Highway 2 and under the town to an outfall located at the river bank southwest of downtown at approximately 100 Avenue and 98 Street.

The intake is affected by ice blockages, general debris, and debris related to beaver dam collapse upstream in Pat's Creek. The trash rack requires upgrading and the pipe is affected by deterioration. Flooding was caused due to a partial collapse of the pipe and debris blocking the intake in April 2013. Additionally, flooding due to snowmelt and rainfall in June 2013 and April 2014 caused water to back up through manholes and flooded the downtown area. The outlet was frozen in the spring of 2014 which caused water to back up into the pipe. As a result, water spilled out of a manhole located downtown and flooded towards a park along the Peace River bank. The dike was opened to release the flood water into the Peace River.

The Town of Peace River submitted an AESRD Alberta Community Resilience Program (ACRP) Grant Application for interim repairs to the Pat's Creek culvert in order to contain flood waters from Pat's Creek. The application was approved as of April 2, 2015 for a grant amount of $2,295,000 (Government of Alberta, 2015).

Increased runoff velocities due to deforestation and upsizing of AT culverts along Highway 2 were reported to exacerbate flooding and cause erosion south of the town. Additionally, Highway 744 east of Judah Hill has steep side slopes which have caused the slopes to erode. Homes located directly east of Judah Hill were flooded due to runoff from Judah Hill and the railway. Furthermore, drainage from the railway has caused erosion and has saturated the soil causing properties located on the hill to move. Movement of the hill has necessitated the relocation of a main sewer line running along the side of the hill. Currently, AT is monitoring seven unstable land slide locations in the vicinity of Judah Hill and repairs are underway for two additional ones. Erosion of backyards and lawns of homes in Shaftsbury Estates due to runoff flowing to the Peace River was also reported.

The water treatment plant is located at a high elevation and is not at risk of flooding. There is no power generation station in the Town of Peace River and transmissions lines have not been affected by past flooding. There are no officially designated flood risk areas in the town; however, the town does have a flood evacuation plan in place.

The Town of Peace River is impacted by a number of waterways coming into the area: Peace River, Heart River, Pat's Creek and the Smoky River which cause potential flooding hazards. Table 5-7 summarizes recorded recent and historical flood and erosion events which have affected the Town of Peace River in the recent past.

Table 5-7: Summary of Historical Flood Events - Town of Peace River

Flood Date	Flooding Event/Cause	Erosion Issues
2013 (August)	-Flash flooding of the downtown area due to snowmelt, rainfall and river ice jams	None reported
1997	-Ice jams at the Peace River Bridge caused overland flooding of the downtown area -Basements north of downtown backed up with wastewater	None reported
1992	-Ice jams at the Peace River Bridge caused overland flooding of the downtown area - Basements north of downtown backed up with wastewater	None reported
1986	-Ice jams at the Peace River Bridge caused overland flooding of the downtown area.	None reported

5.3.3 Flood Hazard Mapping

There is no flood hazard mapping available for the Town of Peace River.

5.3.4 Land Use

Land use and zoning maps were requested; however, none were available at the time of this study. Land use in the Town appears to consist of a combination of residential, commercial, some industrial, and park lands adjacent to the Peace River. The downtown area of the town is located on the east side of the Peace River.

5.3.5 Population Growth

The Town of Peace River has seen a fluctuation in population in the past 50 years, with a general trend towards increase in population. Table 5-8 shows population data for the Town of Peace River from 1966-2011, as reported in the Town's Municipal Development Plan.

Table 5-8: Town of Peace River Population Growth

Year	Population	% Change
2011	6,745	6.8
2006	6,315	1.2
2001	6,240	-4.5
1996	6,536	-2.7
1991	6,717	5.7
1986	6,355	5.2
1981	6,043	24.9
1976	4,840	-4.0
1971	5,039	23.3
1966	4,087	

Source: Town of Peace River Municipal Development Plan

5.3.6 Future Flood Risk and Damage Assessment

The Town's future flood damage potential may become higher due to the increase in population, and due to deterioration of the existing Pat's Creek culvert; however, at the time of the study no existing or future land use and zoning maps were available to assess if densification of residential areas are within reported at risk flood areas. The downtown area and residents living north of downtown may be at risk of flooding until the relief wells are in place to lower the water table in the area. The Town will continue to incur frequent costs associated with flood repair work if the issues are not addressed.

5.3.7 Flood Mitigation Alternatives

5.3.7.1 Existing Study – Pat's Creek Realignment Concept Study (AECOM, 2014)

AECOM has undertaken a study for the Pat's Creek Realignment Concept for Alberta Transportation. The draft report was submitted in November 2014 for Alberta Transportation's review. The study provides various diversion realignment alternatives for Pat's Creek with the purpose of preventing flooding of the Town of Peace River due to the flooding of the existing Pat's Creek tunnel, which was originally constructed in the 1960's. Pat's Creek Tunnel presents a number of flood risk concerns for the Town. The principal risk appears to be a result of the large debris flows present in the creek during floods. Debris is known to deposit at bends in the tunnel or along flat sloped sections near the outlet. The debris deposition has the potential to both raise water levels in the pipe and create blockages. High water levels in the pipe can result in backflow through unprotected openings, storm drains and access points, potentially flooding the Town. A debris blockage within the tunnel or at the inlet would cause water to back up through the tunnel and flow through Town. The dike along the edge of the Peace River prevents flood water from draining overland into the Peace River, resulting in a "bath tub" effect in downtown. An additional flood risk concern results from insufficient tunnel capacity, or reduced tunnel capacity as a result of high water events on the Peace River, which would submerge the Tunnel outlet.

AECOM's proposed diversion alternatives, as presented in the Pat's Creek Realignment Concept Study are described in the paragraphs below. The various Pat's Creek alignments within the town of Peace River are shown in Figure 5-3-2.

Pat's Creek Diversion Alternative

Pat's Creek Diversion is shown on Figure 5-3-2. This alternative includes constructing a diversion that would redirect flood flows to an adjacent drainage basin. The adjacent drainage basins are those of the Heart River to the south, and an unnamed tributary to the Peace River to the north. The study indicated that diverting water to the north, into the unnamed tributary, does not appear to be possible. However, a diversion south into a tributary to the Heart River would be possible.

A tunnel connecting the two valleys would have to be bored with a tunnel boring machine (TBM) since the entrenchment depths of the valleys, 55 m and 190 m for Pat's Creek and Heart River respectively, preclude open cut construction methods. The tunnel slope would be approximately 0.05 m/m, with flow velocities approaching 15 m/s. The outlet of the tunnel would be within the borders of Green Valley Provincial Park.

The diversion of Pat's Creek into the Heart River would present numerous environmental concerns for the Heart River basin. Additionally, a geotechnical assessment would be required in order to determine the level of effort required to construct the diversion.

In 2014, AECOM estimated the cost for this diversion alternative as upwards of $187 million.

98 Street Diversion Alternative

The 98 Street Diversion Alternative is shown on Figure 5-3-2. The 98 Street Diversion of Pat's Creek aligns the diversion around downtown by re-aligning the creek to flow north. The 98 Street alternative is intended to investigate the concept of constructing the tunnel under the road right-of-way in order to minimize conflicts and construction costs. The tunnel inlet would be located in the vicinity of the existing culvert inlet. The tunnel would then be located under 98 Street right-of-way up to the intersection with the Highway 2 on-ramp.

Disadvantages with the alignment include sharp bends in the tunnel and a large decrease in pipe slope part way along the alignment, both of which may create opportunities for debris accumulation and blockages. In addition, the inlet would need to be designed to accommodate a significant flow transition, since the inlet is not aligned with the existing direction of flow. This transition may result in debris accumulation at the inlet.

The feasibility of this alignment would depend, in part, on geotechnical constraints at the inlet, which is located at the west end of an unstable area known as the Kaufmann Slide.

In 2014, AECOM estimated the cost for this diversion alternative as $54.1 million.

Northern Alternative

The Northern Alternative is shown on Figure 5-3-2. The Northern Alternative is similar to the 98 Street Alternative in that a tunnel would be bored through the Peace River valley bank from Pat's Creek inlet up to the 98 Street intersection with the Highway 2 on ramp, at which point the tunnel could either be extended to the Peace River using open cut construction methods, or an open channel could be constructed. The total re-alignment length would be approximately 1000 m.

The advantage of the Northern Alternative is that the alignment is straight, presenting fewer opportunities for blockages in the tunnel. In addition, the alignment is not constrained by the 98 Street right-of-way, allowing for more flexibility in the alignment location as well as design and construction. The disadvantage with the alignment is that stream flow at the inlet would need to be forced into a sharp bend at high velocity as it transitions into pipe flow.

A geotechnical investigation is required to confirm soil conditions along the alignment and to determine if movement is occurring in the vicinity of the proposed tunnel and tunnel inlet, and what mitigation alternatives would be required to stabilize the hillside prior to boring.

In 2014, AECOM estimated the cost for this diversion alternative as $52.3 million.

Southern Alternative

The Southern Alternative is shown on Figure 5-3-2. The Southern Alternative alignment is located east of Highway 2, passing through the banks of the Peace River valley. Flow from Pat's Creek would drain into the tunnel inlet in the vicinity of the existing culvert inlet. Flow would discharge into Heart River just upstream of the 101 Street Bridge. The total re-alignment length would be approximately 980 m.

The advantage of the Southern Alternative is that the tunnel would be relatively straight, with a constant slope, which may reduce the potential for debris to create a blockage within the tunnel. In addition, the flow transition at the inlet is also relatively straight, which would minimize the risk of debris accumulation and blockage at the inlet.

A disadvantage of the Southern Alternative is that the tunnel would be located up to 40 m below ground, since it passes through a portion of the banks of the Peace River valley. The majority of the tunnel would have to be bored using a TBM.

A geotechnical investigation is required to confirm soil conditions along the alignment and to determine if movement is occurring in the vicinity of the proposed tunnel and tunnel inlet, and what mitigation alternatives would be required to stabilize the hillside prior to boring.

In 2014, AECOM estimated the cost for this diversion alternative as $67.9 million.

96 Avenue Alignment Alternative

The 96 Avenue Alignment Alternative is shown on Figure 5-3-2. The 96 Avenue alignment alternative goes through downtown Peace River, along 96 Avenue. The tunnel would be constructed with open cut methods, with the majority of the alignment requiring shoring or soil stabilization to keep the construction limits within the road right of way.

The advantages that this alignment presents over the existing alignment is that: 1) Less care of water is required during construction, 2) The tunnel alignment is relatively straight, with one large radius curve, which would reduce the risk of blockages, and 3) The work would involve new construction, likely with fewer constrictions, which may be less expensive than replacing the existing structure.

Disadvantages with the alignment arise primarily from the utility conflicts along the street. There will likely be storm water conflicts with catch basin leads, and collector pipes. A gravity drainage sewer pipe runs along the 96 Avenue, and additional pipes cross at each intersection. In addition, the sewer trunk flowing to the treatment plant crosses the alignment at 94 Street.

In 2014, AECOM estimated the cost for this diversion alternative as $35.9 million.

Maintain Existing Alignment

The Exiting Alignment is shown on Figure 5-3-2. The final alternative presented in the 2014 study is to maintain the existing alignment while upgrading the tunnel to extend the service life. This alternative has been investigated previously by MPA Engineering in 2005, with one critical 20 m section lined in the winter of 2012 using 4948 x 2600 mm tunnel plate liner.

One alternative proposed by MPA to extend the service life by 50 years is to line the entire section of tunnel under the Town of Peace River, presumably using a tunnel plate liner similar to that used in the work already completed. MPA estimated that the lining work, including a concrete floor, would cost around $10.8 million (2012).

The disadvantage of this alternative is that the lining constricts the tunnel, which may already be under capacity, resulting in a risk of increased blockages and flooding. To help mitigate the flooding risk, all access points to the tunnel, including storm drains and access hatches, should be designed to prevent back flooding into the town in the event that the tunnel's capacity is exceeded.

One option available for this alternative would be to increase the capacity of the tunnel by reconstructing it with a larger cross sectional area. Discussions with the Town indicate that there is a fibre optic utility conflict and a horizontal constriction caused by existing development along the alignment which may influence tunnel material type, construction methodology, and estimated cost. For cost comparison purposes, the cost of this alternative is estimated to be $35.9 million, similar to the 96 Avenue alignment alternative.

The second alternative to maintain the existing rehab tunnel can be achieved by constructing a series of retention ponds upstream of the tunnel inlet so that the design flow will not exceed the capacity of the rehab tunnel. A detailed study on this alternative can be completed in the future.

5.3.7.2 Judah Hill Area – Proposed Mitigation Alternative

Homes have been flooded in Judah Hill area, located close to 114 Avenue and 101 Street shown as #79 on Figure-5-3-1. The main reason of the flooding is the runoff from the Judah Hill and the railway. It is recommended to construct a ditch on the east of the rail track, to capture runoff from Judah Hill. The ditch alignment will take runoff north east to drain into the existing drainage path that eventually drains into the Peace River.

5.3.7.3 Non Structural Flood Mitigation Alternatives

Erosion has been reported in the Shaftesbury Estates area (#78, Figure 5-3-1) due to surface runoff draining through home owner's backyard, into the Peace River. The primary reason is increased velocities due to deforestation of an area to the west. It is recommended to understand surface water hydrology and conduct a stormwater management study for the area. A stormwater study will help to identify the cause of flooding and alternatives can be developed to mitigate erosion issues.

Erosion has been reported on steep side slopes of Highway 744 in the area shown as #85 on Figure 5-3-1. It is recommended to implement erosion control best management practices, such as mulching, hydro seeding, or installing an erosion control blanket in the area. Another alternative may be constructing a short berm to intercept run-off along the contour of the slope, reducing the effective length of the steep slope, thereby reducing erosion potential.

Basement sewer back up and overland flooding has been an issue in the area on the east side of the Peace River directly south of the wastewater treatment plant (#88, Figure 5-3-1). Sewage is pumped directly into river when necessary to prevent back up in homes. It is recommended to understand the surface water hydrology and conduct a stormwater management study for the area. A stormwater study will help to identify the cause of flooding and sewer backups and alternatives can be developed to mitigate flooding and backup issues.

The area south of the Heart River Bridge in the Town of Peace River, located south of the downtown core, has flooded due to runoff and snowmelt, back up of Pat's Creek, and from ice jams in the Peace River. It is recommended to understand the surface water hydrology and conduct a stormwater management study for the area. A stormwater study will help to identify the cause of flooding and alternatives can be developed to mitigate flooding. Additionally, improvements to Pat's Creek (discussed in Section 5.3.7.1) may also reduce the risk of flooding in the area, by minimizing the potential of backup in Pat's Creek.

5.3.8 Conceptual Cost Estimates

Table 5-9 summarizes the high-level conceptual costs of each of the Pat's Creek alternatives, as reported in the 2014 study. All costs include a 50% contingency. All alternatives around downtown and the 96 Avenue alternative all include a $3 million price to replace the existing tunnel with 1200 mm storm pipe. This concept, and the estimated cost, was proposed by MPA Engineering Ltd., in their Pat's Creek Culvert Repair Presentation (unknown date). The 1200 mm concrete storm pipe would be required to capture the water from the storm water management system which is currently connected to the tunnel.

Table 5-9: Cost Estimate Summary

Alternatives	Estimated Cost (Million $)
Diversion Alternative	
Pat's Creek Diversion	>186.9
Alternatives Around Downtown	
Northern Alignment	52.3
Southern Alignment	67.9
Alternatives Through Downtown	
Existing Alignment – Install Liner	10.8
Existing Alignment – Reconstruct with New Larger Tunnel	35.9
96 Avenue Alignment	35.9

5.3.9 Evaluation of Alternatives

The following guidelines were established in AECOM's report to evaluate the tunnel alignment alternatives (2014):

1. A tunnel with a constant slope and a straight alignment will provide the least risk for blockages. Large radius bends would not add additional risk. It is generally recommended, for tunnel boring considerations, to have a minimum radius of 200 m.
2. A tunnel that is constructed outside the downtown area is preferable, to reduce flood risks to the highest density development.
3. The tunnel inlet should have a relatively straight transition from open channel to closed conduit flow. Forcing flow into a sharp bend increases bank erosion and debris deposition risks, unless specifically accommodated in the inlet design.
4. The tunnel should consist of a single barrel. Multiple barrels present a greater risk of debris accumulation and blockages.

5. The tunnel should be constructed to be accessible by heavy machinery such as a skid steer, to allow for efficient debris removal after floods.

The Southern Alignment achieves all the guideline recommendations. It is a relatively straight alignment with a constant slope, located outside downtown, with a relatively straight flow transition at the inlet. It presents potential environmental and hydraulic capacity concerns to the Heart River as well as geotechnical stability concerns along the alignment which require further investigation.

The Northern Alignment is a more cost effective alternative than the Southern Alignment. Challenges to the alignment including an abrupt flow transition at the inlet and changes in pipe slope can be accommodated through a large radius curve at the inlet and an open channel section at the downstream end. The concept of providing an open channel for the downstream end of the alignment is appealing since it reduces flood risks from blockages, however, its feasibility may depend on property, geotechnical, and Highway embankment constraints which would require further investigation. This alignment presents significant geotechnical challenges including hillside and Highway embankment stability which require further investigation.

The 98 Street Alignment is very comparable to the Northern Alignment alternative, and as such, has similar challenges and advantages.

The two alignments proposed through downtown do not meet the guideline recommendations in that they are located in downtown, and would require a number of bends and changes in slope. However, either of the two alignments may prove to be a feasible cost effective alternative if it is decided that an alignment through downtown is acceptable.

5.3.10 Environmental Review of Flood Mitigation Alternatives

AECOM conducted an environmental overview desktop review for proposed flood mitigation works in the Town of Peace River. The purpose was to compile information on existing conditions and to provide commentary on potential permitting requirements associated with possible flood mitigation alternatives. The desktop review consisted of examining a variety of publically available ecological databases and reports. This desktop review does not follow the format of an Environmental Impact Assessment (EIA) due to the limited engineering, hydrological, geotechnical, hydrogeological, and geological information available for the location. This is considered an environmental overview desktop review and is intended as a general guidance document outlining some of the major environmental concerns and regulatory issues associated with potential flood mitigation projects, and their surrounding area.

Various databases were searched to identify environmental factors within the Peace River Area of Interest (AOI). The proposed flood mitigation for this AOI involves re-aligning the Pat’s Creek storm pipe that discharges into the Peace River. Several re-alignment options are being examined:

- Northern Alternative (discharges north of the existing outfall)
- 96th Avenue Alternative (involves twinning the storm pipe, and a second outfall north of the exiting outfall)
- Southern Alternative (discharges south of the existing outfall)

5.3.10.1 Historical Resources

A database search of the *Listing of Historic Resources* (current to March 2015) revealed land with Historical Resource Values (HRVs) of 1, 4 and 5 occurring in the Peace River AOI. For further information on the HRVs within the Peace River AOI, see Appendix D.

5.3.10.2 Wildlife and Species at Risk

Within the 20 km search radius of the Peace River AOI seven birds, one mammal and two insects were listed by AESRD, Alberta *Wildlife Act*, COSEWIC, and/or SARA. In total, there are 10 species listed with an AESRD general status of “At Risk”, “May be At Risk”, or “Sensitive”, and two species listed with a SARA status of “Special Concern”, “Threatened” or “Endangered” including:

- Birds:
  - American Kestrel
  - Bald Eagle
  - Barred Owl
  - Cape May Warbler
  - Great Gray Owl
  - Sharp-tailed Grouse
  - Short-eared Owl
- Mammals:
  - Woodland Caribou
- Insects:
  - Alberta Arctic
  - Old World Swallowtail

5.3.10.3 Fisheries

The Peace River and the Heart River are Mapped Class C Water Bodies with a Restricted Activity Period (RAP) of April 16th to July 15th. Pat’s Creek is a mapped Class D stream, with no RAP. However, the proposed AOI for Pat’s Creek is within 2 km of the Peace River and is considered a Class C water body with a RAP of April 16th to July 15th as per the AESRD COP (AESRD 2015b).

Pat’s Creek only has one documented fish species (Brook Stickleback), while there are 29 species of fish documented in the Peace River, representing sportfish, minnows, suckers, trout-perch, and sculpins. Nineteen species of fishes have been documented in the Heart River, representing sportfish, minnows, suckers, trout-perch, and sculpins. For a detailed list of these fish species, and their provincial status, refer to Appendix D – Environmental Overview.

5.3.10.4 Applicable Legislation

For the Peace River AOI, there are a number of legislations which may be applicable to the Pat’s Creek diversion to the Peace River including:

- *Canadian Environmental Assessment Act*
- *Fisheries Act*
- *Migratory Birds Convention Act*
- *Water Act*
- *Alberta Wetland Policy*
- *Public Lands Act*
- *Historical Resources Act*
- *Provincial Parks Act*
- *Wilderness Areas Ecological Reserves, Natural Areas and Heritage Rangelands Act*
- *Alberta Wildlife Act*

See Appendix D for further detail on the Applicable Legislation for the Peace River AOI.

5.3.10.5 Discussion and Summary

The following environmental elements have been identified in the Peace River AOI:

- Boreal Forest Natural Region, Dry Mixedwood Subregion
- HRVs of 1, 4, and 5
- Open water wetlands
- Key Wildlife and Biodiversity Zone
- Class C River and Creek with RAP of September 10 – July 15
- 10 species with AESRD general listing, 2 species with SARA listing, 7 AESRD general status fish species
- Migratory Bird Timing Window of April 15 – August 31

Required permitting and approvals are subject to change based on the final project design. Table 10 in Appendix D summarizes potential considerations which may be required in order for the project to adhere to applicable legislation.

5.3.11 Geotechnical Review of Flood Mitigation Alternatives

5.3.11.1 Introduction

Pat's Creek stormwater drainage pipe which runs through the Town of Peace River will be realigned. The current alignment runs beneath Pat's Creek road, turns south at 98 Avenue and then west at 99 Avenue, until it drains into the Peace River. Several realignment alternatives are being considered. It is expected that the realignment alternatives will consist of a corrugated steel pipe, installed using open cut with shoring to keep the construction limits within the road right of way where required, with trenchless construction consisting of the use of a tunnel boring machine (TBM) where required. At this time the invert depth and diameter of pipe has not been determined.

5.3.11.2 Methodology

Geological maps of Alberta from the Alberta Geological Survey were consulted to determine surficial geology of the proposed alignment. Test holes drilled in the vicinity of Pat's Creek road for the twinning of Highway 2 were also consulted. The test hole locations were between 10 m and 500 m from the proposed alignment alternatives.

5.3.11.3 Subsurface Conditions

The proposed Pat's Creek realignment runs through fluvial deposits.

Fluvial Deposits

Fluvial deposits consist of sediments transported and deposited by streams and rivers. Fluvial deposits include well sorted stratified sand, gravel, silt, clay and organic sediments.

Test hole Logs

Northern Alternative and 98 Street Alternative

Test hole logs TH11-11, TH11-12, TH11-17 and TH11-18 from the 2011 intrusive investigation for the Twinning of Highway 2 indicate that cohesive material consisting of either clay or clay fill is expected to be near the surface and extends to a depth of approximately 3.5 m below ground surface (mBGS). One test hole indicates gravel and sand beneath the clay. Another test hole indicates alternating sand and clay layers between 0.5 m and 1.3 m thick. Both test holes terminated at 9.5 mBGS. Hydrostatic pressure was encountered in TH11-17 where the water level was measured at the top of the standpipe, approximately 1 m above ground level.

96 Avenue Alternative

Test hole logs TH11-07, TH11-08, TH11-09, TH11-10, TH11-19 and TH11-20 from the 2011 intrusive investigation for the Twinning of Highway 2 indicate that the material within the top 6 m can be expected to be low to medium plastic clay. Gravel was encountered at the surface in test hole TH11-08 and gravel and sand was encountered beneath the clay in TH11-07, TH11-09 and TH11-10. Bedrock consisting of sandstone was encountered between 8.5 mBGS and 13 mBGS. The measured groundwater level was recorded at 7.5 mBGS.

Test hole logs close to Peace River indicate high plastic clay may be encountered at the surface near the river.

Southern Alternative

Test hole logs TH11-03, TH11-04, TH11-05 and TH11-06 from the 2011 intrusive investigation for the Twinning of Highway 2 indicate cohesive material at surface. Test hole TH11-06 contained sand within the top meter, and sand was found intermittently throughout the other test holes. Below 4 mBGS the clay was highly plastic. All test holes terminated at 9.5 mBGS.

5.3.11.4 Discussion and Recommendations

Suitability

The anticipated ground conditions along the proposed alignments are likely to encounter medium to high plastic clay with sand and gravel pockets. Higher plastic clay may be encountered near the river. These materials are suitable to support the steel pipe. Bearing support should be checked prior to installation. Local areas of soft or inadequate strengths should be removed and replaced.

Side Slopes

Temporary side slopes within the low to medium plastic clay can be cut no steeper than 2.5H:1V. If space restrictions require a narrower footprint, shoring can be used to stabilize the sides of the excavation. Where wet or sand layers are encountered the slopes should be flattened or an appropriate method of shoring should be used. Where high plastic clay is encountered side slopes should be flattened to at least 5.0H:1V. Plasticity and other soil properties should be confirmed prior to construction.

Side slopes through loose sand should be shored.

The presence of a water table within cut sections may have a significant effect on the stability of the slope. The water table should be considered in the design at its maximum anticipated elevation. Dewatering may be required to lower the water table during construction.

Trenchless Construction

It is understood that there may be some areas that require installation of the pipe using trenchless construction consisting of the use of a tunnel boring machine (TBM). The use of a TBM requires the excavation of entrance and exit pits at each end of tunnel. From the entrance the TBM removes material in front of the cutting head and installs pipe as it advances until it reaches the exit pit.

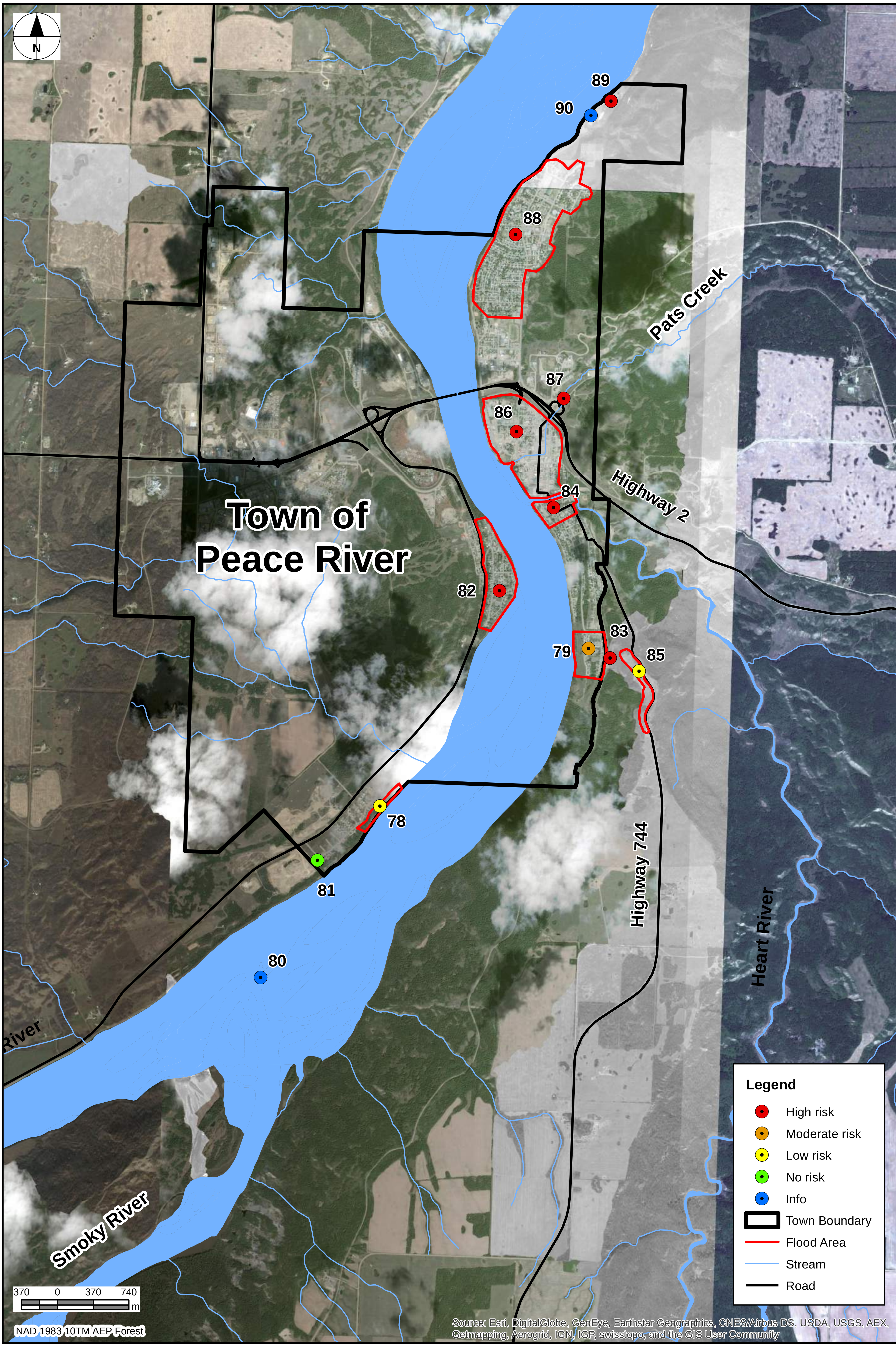
Ground conditions should be confirmed prior to construction by drilling test holes to confirm soil type and groundwater level.

5.3.12 Conclusions and Recommendations

The Pat's Creek Realignment Concept Study has not yet been finalized, and is believed to be under review by both AESRD and AT. There are many stakeholders involved in the Pat's Creek Realignment concept, and for that reason, AECOM has no recommendations regarding the presented alternatives at this time.

Last saved by: MIREAULTC (2015-06-02) Last Plotted: 2014-03-18
Filename: P:\60334569\900-WORK\920-929 (GIS-GRAPHICS)\MAIN REPORT FIGURES\FIGURE 5-3-1 TOWN OF PEACE RIVER - STAKEHOLDER IDENTIFIED HISTORICAL FLOOD ISSUES.MXD

ANSI B 279.4mm x 431.8mm

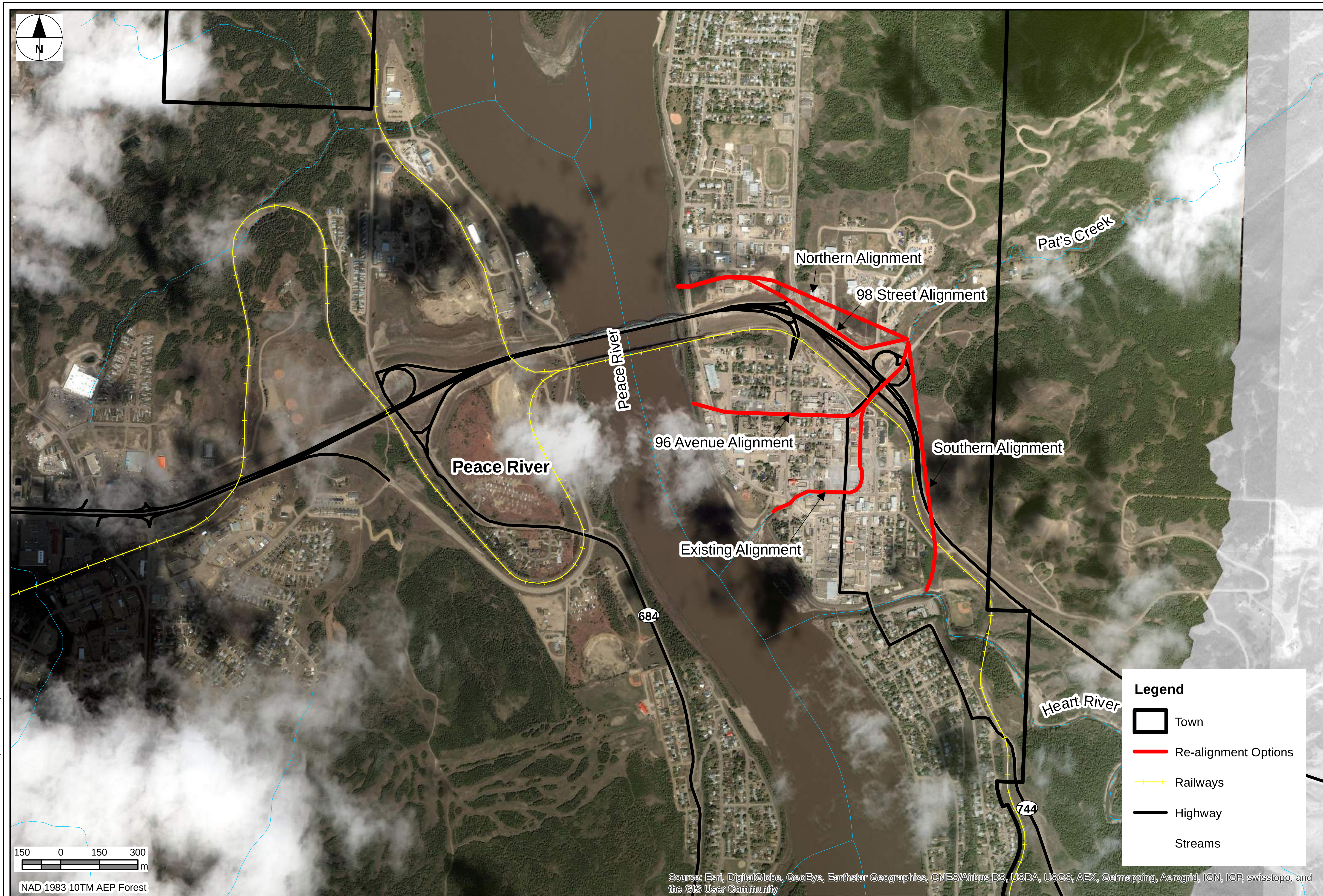


Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

Town of Peace River
Stakeholder Identified Historical Flood Issues

AECOM

Figure: 5-3-1



AECOM

Figure: 5-3-2

Town of Peace River
Pat's Creek Realignment Alternatives

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

ANSI B 279.4mm x 431.8mm

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Filename: P:\60334569\900-WORK\920-929 (GIS-GRAPHICS)\MAIN REPORT FIGURES\FIGURE 5-3-2 TOWN OF PEACE RIVER PAT'S CREEK REALIGNMENT ALTERNATIVES.MXD

5.4 Town of Sexsmith

5.4.1 Background

The Town of Sexsmith is classified as a high flood risk community since annual flooding occurs at two locations in town and impacts to residents, homes and infrastructure are significant. The location of the Town of Sexsmith within the Peace River Basin is shown on Figure 5-2.

5.4.2 Historical Flood and Erosion Issues

Stakeholder identified historical flood issues are shown on Figure 5-4-1. The location of each reported flood issue is numbered with a map ID and classified as high, moderate or low risk. Each issue can be found by the corresponding map ID in Table A-1 in Appendix A

The town experiences annual flooding along 106 Street due to snowmelt resulting in a one week road closure and annual repair costs to re-gravel the road of $5,000 to $10,000. The town flooded in 2007 and during a reported 1:100 year flood event in July 2011 due to rainfall and snowmelt respectively. The area around residences located in the northeast part of town floods annually due to spring snowmelt and approximately 30 homes were flooded during large flood events in 2007 and July 2011. Additionally, a creek running at a flat slope (0.1%) through the Town flooded homes in the southeast part of Town adjacent to the CN rail line in 2007 and 2011. CN rail brought in pumps to alleviate flooding since there was concern that the rail line may overtop. Furthermore, two gas wells located along 100 Street and Township Road 734 were flooded in 2007 and 2011 and undersized culverts were replaced at both locations. No residences were reported to be flooded in the Town of Sexsmith after the culverts were upgraded. Table 5-10 summarizes recent and historical flood events in the Town of Sexsmith.

Table 5-10: Summary of Historical Flood Events - Town of Sexsmith

Flooding Date	Flooding Event/Cause	Erosion Issues
2011 (July)	Snowmelt and rainfall	None reported
2007	Snowmelt and rainfall	None reported

5.4.3 Flood Hazard Mapping

There is no flood hazard mapping available for the Town of Sexsmith as there are no major watercourses running through or adjacent to the town.

5.4.4 Land Use

Land use and zoning maps were requested; however, none were available at the time of this study. Land use in the Town appears to consist of a combination of residential, commercial and some industrial. Farmlands are located around the Town of Sexsmith.

5.4.5 Population Growth

The population of the Town of Sexsmith has increased steadily in the past two decades. Table 5-11 shows population data for the Town of Sexsmith as reported by Statistics Canada census.

Table 5-11: Town of Sexsmith Population Growth

Year	Population	% Change
2011	2,418	22.8
2006	1,969	19.1
2001	1,653	11.6
1996	1,481	

Source: Statistics Canada

5.4.6 Future Flood Risk and Damage Assessment

The Town of Sexsmith has experienced a steady population increase since 1996 according to Statistics Canada. The Town's future flood damage potential may be high due to the increase in population; however, no existing or future land use and zoning maps were available at the time of the study to assess if densification of residential areas within reported flood risk areas. Residents may be at risk of flooding in northeast and southeast part of town from the town creek if the upsized culvert crossings located at Highway 2 and Township Road 734 prove to be insufficient during a large rain and snowmelt event. The town could incur similar flood damages and impacts as the 2007 and 2011 rain and snowmelt events which mainly resulted in homes and basements flooding. Additionally, 106 Street floods annually costing approximately $5,000 to $10,000. The Town will continue to incur yearly costs associated with flood repair work if the issues are not addressed.

5.4.7 Flood Mitigation Alternative

An alternative was designed to mitigate flooding of 106 Street located on the west side of the Town as shown on Figure 5-4-1. Annual flooding results in costly repairs to the road in the order of $5,000 to $10,000 annually. The ditch along the west side of 106 Street appears to be unable to convey stormwater following a significant rainfall or snowmelt event. Factors that contribute to the ditch flooding are steep slopes of upstream catchment areas resulting in high flows reaching a completely flat section of ditch along 106 Street. An enlargement and steepening of the entire existing ditch alignment is proposed to mitigate future flooding. Additionally, culverts located up and downstream of the ditch were sized to convey the increased discharge. The following section provides a conceptual design for the ditch and culverts including a cost estimate.

5.4.7.1 106 Street Ditch and Culvert Upgrade and Alignment

Existing geometry of the ditch along the west side of 106 Street was unknown at the time of this study and was not included in any existing reports reviewed by AECOM. The existing ditch was therefore assumed to be a half meter deep with 3H:1V side slopes and a one meter wide ditch bottom. The ditch currently discharges into a pond or wetland before flow is conveyed under railway tracks through a CN culvert. It was assumed that the pond and CN culvert have enough capacity to accommodate increased flows and runoff volume since no further data was available.

<u>*Design Flow Estimation*</u>

An XP-SWMM computer model was used to simulate the existing condition and to aid with the conceptual design for the proposed ditch and culverts.

Recent LiDAR data was used to delineate the catchment area contributing runoff to the 106 Street ditch. A steep hill south of Township Road 734 between Range Road 61 and 62 was delineated. Runoff from the hill was assumed to drain to the 106 Street ditch through a culvert under Township Road 734. An area directly west of 106 Street was delineated and determined to contribute runoff to the ditch in addition to the hill south of Township Road 734. A combination of historical maximum snowmelt and rainfall data in May was obtained from climate normals and was used as input parameters for the model to simulate stakeholder reported flooding of 106 Street. Historical rainfall and snowmelt depths were used to obtain the peak flow to design the ditch and size the culverts.

The following assumptions were made to determine the modelling parameters:

- Rainfall depth of the 2 Year 12 Hour Chicago storm distribution event in Grande Prairie in May = 32.7 mm
- Extreme temperature recorded in May = 31.3°C
- Extreme snow depth in May = 17.5 cm
- Impervious ratio = 40% (Assumes approximately 40% of the ground is frozen during snowmelt)
- Manning's n value = 0.03 for channel

Conceptual Design

The XP-SWMM model was used to determine the geometry of the proposed ditch that can convey the peak discharge from the contributing catchment areas with a minimum 0.30 m of freeboard. The model resulted in a peak discharge of 1.95 m^3/s in the ditch. The proposed ditch alignment with a profile view and typical ditch cross sections are shown on Figure 5-4-2 and Figure 5-4-3 respectively.

Culvert Design

Culverts are modelled using XP-SWMM and HY-8 software (Federal Highway Administration, 2013). The HY-8 model is capable of modelling stream crossing structures, and calculates the back water levels and velocities downstream of proposed watercourse crossings. The data input into HY-8 software include the proposed culvert size, slopes, lengths, and immediate downstream channel dimensions to represent the back water conditions of the culverts.

The culvert located upstream of the ditch under Township Road 734 (south culvert) and the culvert located one block north, will be required to convey a total flow of approximately 1.35 and 1.95 m^3/s respectively. It is recommended that the south and north culverts are 1000 mm CSP and are to be installed at a 1.0% minimum slope respectively. The portion of the ditch directly downstream of the north culvert has a steep slope and must be protected against scour due to high velocities. Riprap class 1M is recommended to ensure that the ditch is protected based on the flow velocity. If the ditch design is taken to the preliminary design phase, it is recommended that an appropriate outlet structure is to be designed where the ditch discharges into the pond. Figure 5-4-2 shows the location of the culverts that will be upgraded or constructed.

5.4.8 Conceptual Cost Estimate

The cost to construct the 106 Street ditch is estimated to be approximately $1.0 million. The Class D cost estimate is included in Table 5-12. A contingency of 40% was used in the cost estimate. The cost estimate does not include the following:

- Cost to mitigate any environmental losses
- All cost associated with increased flow in the Stormwater Pond or wetland, including erosion protection.
- Cost of utility trench and pipeline realignment

- Land acquisition/purchase

Table 5-12: Conceptual Cost Estimate - 106 Street Ditch

Item	Item Cost ($)
Channel	
Stripping	$44,910
Excavation	$300,000
Topsoil	$134,730
Hydroseed	$22,455
Culvert Upgrades	
2 x 1200 mm diameter CSP culvert – supply and install	$39,200
Class 1M Riprap	$118,580
Sub-Total	**$659,875**
Mobilization & Demobilization (10%)	$65,988
Contingency (40%)	$263,950
Total	**$989,813**

5.4.9 Evaluation of Alternative

The conceptual cost of implementing the proposed ditch is approximately $1.0 million. Since the annual cost to repair the road is approximately $5,000 to $10,000 and some property including farmland may have to be purchased to accommodate the proposed ditch alignment, it may be more cost effective to make the annual repairs. However, there may a potential flood risk to a large residential area located directly east of 106 Street. The residential area may be impacted if 106 Street floods during a larger rain or snowmelt event than has previously occurred. Farmlands to the west of 106 Street may be impacted by standing water and not be accessible for some time due to flooding. Additionally, the road is closed for one to two weeks annually. The proposed ditch may be a desirable alternative for the Town of Sexsmith when considering the potential flood impacts and associated risk to the adjacent residential development in addition to the cost.

5.4.10 Environmental Review of Flood Mitigation Alternative

AECOM conducted an environmental overview desktop review for proposed flood mitigation works in the Town of Sexsmith. The purpose was to compile information on existing conditions and to provide commentary on potential permitting requirements associated with possible flood mitigation alternatives. The desktop review consisted of examining a variety of publically available ecological databases and reports. This desktop review does not follow the format of an Environmental Impact Assessment (EIA) due to the limited engineering, hydrological, geotechnical, hydrogeological, and geological information available for the location. This is considered an environmental overview desktop report and is intended as a general guidance document outlining some of the major environmental concerns and regulatory issues associated with potential flood mitigation projects, and their surrounding area.

Various databases were searched to identify environmental factors within the Sexsmith Area of Interest (AOI).

5.4.10.1 Wildlife and Species at Risk

Within the 20 km search radius of the Sexsmith AOI, 13 birds, six mammal and three amphibians were listed by AESRD, Alberta *Wildlife Act*, COSEWIC and/or SARA. In total, there are 21 species with an AESRD general status of “At Risk”, “May be at Risk” or “Sensitive”, and six species listed with a SARA status of “Special Concern”, “Threatened” or “Endangered”. These species are:

- Birds:
  - Barred Owl
  - Bay-breasted Warbler
  - Black-throated Green Warbler
  - Brown Creeper
  - Canada Warbler
  - Cape May Warbler
  - Common Yellowthroat
  - Eastern Phoebe
  - Least Flycatcher
  - Northern Pygmy-owl
  - Piping Plover
  - Sora
  - Western Tanager
- Mammals:
  - Grizzly Bear
  - Hoary Bat
  - Northern Long-eared Bat
  - Silver-haired Bat
  - Woodland Caribou
- Amphibians
  - Canadian Toad
  - Northern Leopard Frog
  - Western Toad

5.4.10.2 Fisheries

The proposed flood mitigation strategies for the Sexsmith AOI involve works in an unmapped, Class D stream which runs through the Town of Sexsmith. This stream has no Restricted Activity Period. No fish species have been recorded within this watercourse.

5.4.10.3 Applicable Legislation

For the Sexsmith AOI, there are a number of legislations which may be applicable to the mitigation alternative including:

- *Fisheries Act*
- *Migratory Birds Convention Act*
- *Water Act*
- *Alberta Wetland Policy*
- *Public Lands Act*
- *Historical Resources Act*
- *Provincial Parks Act*
- *Wilderness Areas Ecological Reserves, Natural Areas and Heritage Rangelands Act*
- *Alberta Wildlife Act*

See Appendix D for further detail on the Applicable Legislation for the Sexsmith AOI.

5.4.10.4 Discussion and Summary

The following environmental elements identified in the Sexsmith AOI:

- Parkland Natural Region, Peace River Parkland Subregion
- Open water and marsh wetlands
- 21 species with AESRD general listing, 6 species with SARA listing
- Migratory Bird Timing Window of April 15 – August 31

Required permitting and approvals are subject to change based on the final project design. Table 12 in Appendix D summarizes potential considerations which may be required in order for the project to adhere to applicable legislation.

5.4.11 Geotechnical Review of Flood Mitigation Alternative

5.4.11.1 Introduction

A ditch upgrade is proposed along the west side of 106 Street located west of the Town of Sexsmith. The assessment contains a desktop study of the surficial geology of the proposed ditch alignment and highlights potential issues. The proposed ditch is approximately 3 m at its deepest point. Preliminary recommendations are also provided for the channel stability.

5.4.11.2 Methodology

Geological maps of Alberta from the Alberta Geological Survey were consulted to determine surficial geology of the proposed alignment. Water well drilling records in the area were also reviewed.

5.4.11.3 Subsurface Conditions

Geological Maps

The proposed diversion channel alignment runs primarily through glaciolacustrine deposits.

Glaciolacustrine Deposits

Glaciolacustrine deposits material deposited within lakes by meltwater from glaciers. Glaciolacustrine deposits are primarily fine-grained sediments of clay in central portion of the lake and alternate layers of silty clay or silt and clay (varved clay) in peripheral zones. These deposits are weak, compressible and very uniform in a horizontal direction.

Water Well Records

Records in the area indicate that clay till is expected to extend to depths between 14 and 18 mBGS. The till is underlain by bedrock consisting of either clay shale or sandstone. The reports do not indicate the strength or the plasticity of the till or bedrock. The reports indicate the static water level varies from surface to 18 mBGS.

5.4.11.4 Discussion and Recommendations

Side Slopes

Till or glaciolacustrine clay is anticipated to be encountered along the proposed channel alignment. Soil type should be confirmed during construction by drilling test holes. Cut slopes in low to medium plastic clay till or clay soils up to depths of 3 m should be sloped no steeper than 2.5H:1V. If high plastic clay is encountered, cut slopes should be sloped no steeper than 5H:1V. Areas where a high water table is encountered or areas of increased sand content will require the side slopes to be flattened. Plasticity and strength parameters should be confirmed during detailed design stage. An intrusive investigation should be conducted prior to construction to confirm subsurface conditions.

Erosion

All permanent slopes should be provided with some form of erosion protection to minimize potential of scour and erosion of the slope face. Erosion control synthetic mats or rip rap, and/or topsoil and seeding with a native seed mixture should be considered.

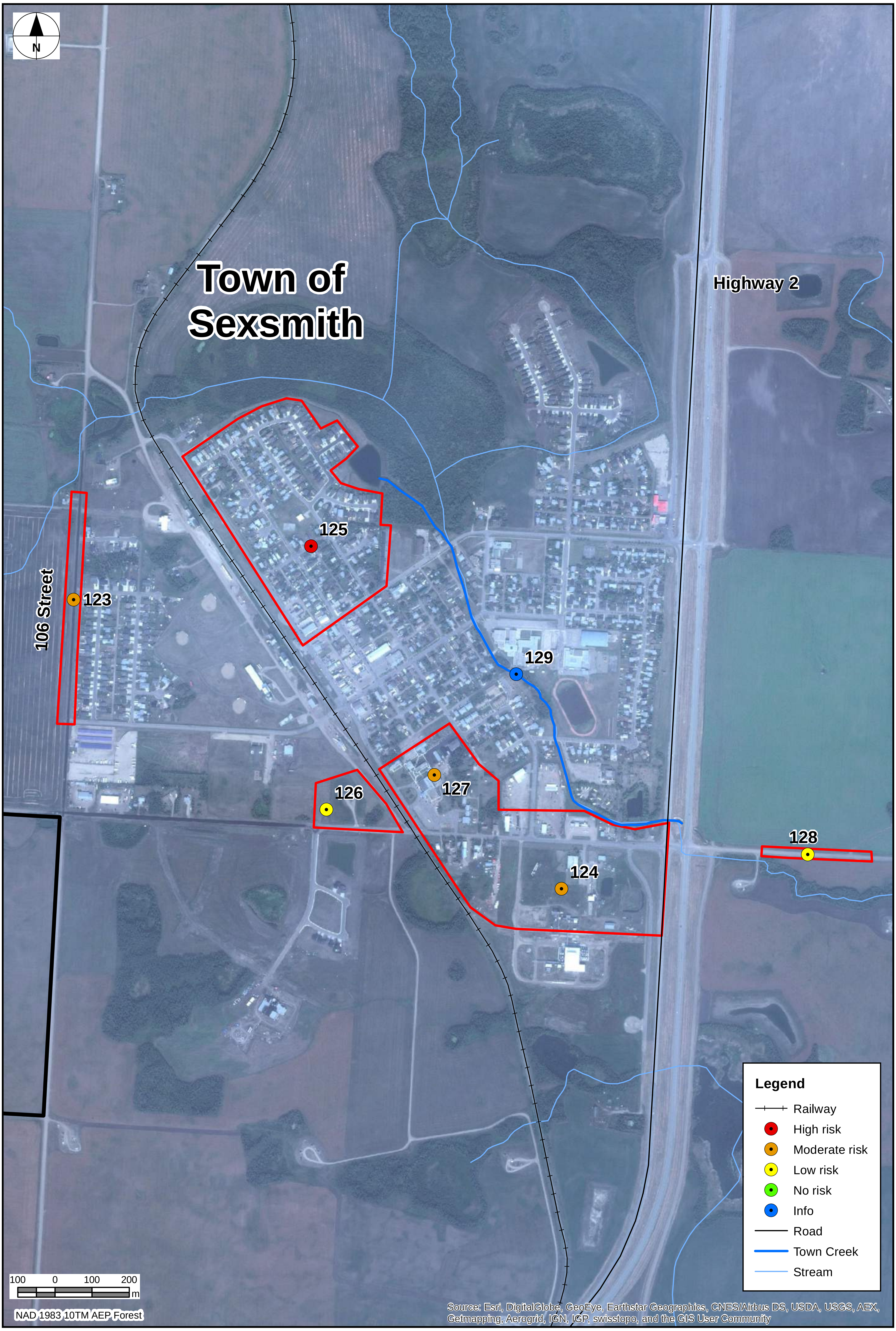
5.4.12 Conclusions and Recommendations

The reported flood issues by the Town of Sexsmith have included flooding due to undersized culverts under Highway 2 (stream outlet location) causing water to back up into the Town’s creek and flooding areas northeast and southeast in the Town. Since the culverts were upsized no flooding has occurred from the Town creek or the main outlet location for the stream. It appears that the culvert upgrades have addressed the flood issues at the stream outlet; however, since the area in the northeast portion of the Town is relatively flat some snowmelt flooding may still occur in that area. It is recommended that the Town conducts a stormwater drainage assessment study to further understand and resolve any local flood issues.

The proposed ditch and culverts mitigate annual flooding of 106 Street located west of the Town. The existing ditch and culverts appear to be undersized, and are unable to convey the peak flow to the stormwater pond or wetland downstream of the ditch. AECOM recommends increasing the depth and slope of the existing ditch. Additionally, the cross-sectional area of the ditch is to have a 1.0 m wide bottom and 3H:1V side slopes. The culverts north and south of the ditch need to be ungraded to convey the peak flow and to prevent water from backing up in the ditch.

The 106 Street ditch currently discharges into a pond or wetland before flow is conveyed under railway tracks through a CN culvert. The CN culvert discharges into a stream that connects to a stormwater pond located directly north of the Town and is adjacent to a residential area. Stormwater discharges from the pond into a stream that runs through the Town. Finally, the streamflow is conveyed through a set of culverts under Highway 2 away from the Town and eventually reaches a receiving water body. The current storage capacity of the ponds and peak flow capacity of the CN culvert and Town stream was unavailable at the time of the study. It was assumed that the ponds, CN culvert and the Town stream have enough capacity to accommodate increased flows and runoff volume due to the proposed ditch. Residents located in the vicinity of the stormwater ponds, Town stream and Highway 2 culverts may be impacted by flooding if the ponds or stream cannot store or convey the increased flow.

An assessment of the ponds storage and flow capacity of the CN culvert is recommended if the proposed ditch is taken to the preliminary design phase.



Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

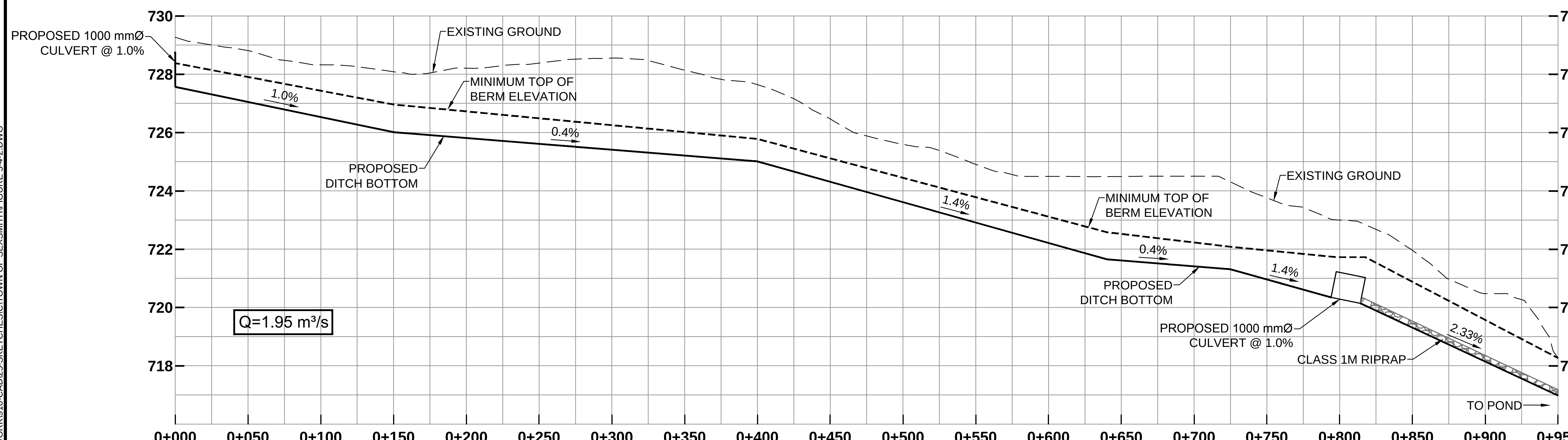
Town of Sexsmith
Stakeholder Identified Historical Flood Issues

AECOM

Figure: 5-4-1

PLAN

0 30 60 90 m H=1:3000



PROFILE

0 30 60 90 m H=1:3000

0 0.5 1 1.5 V=1:50

Town of Sexsmith
Ditch Alignment and Profile

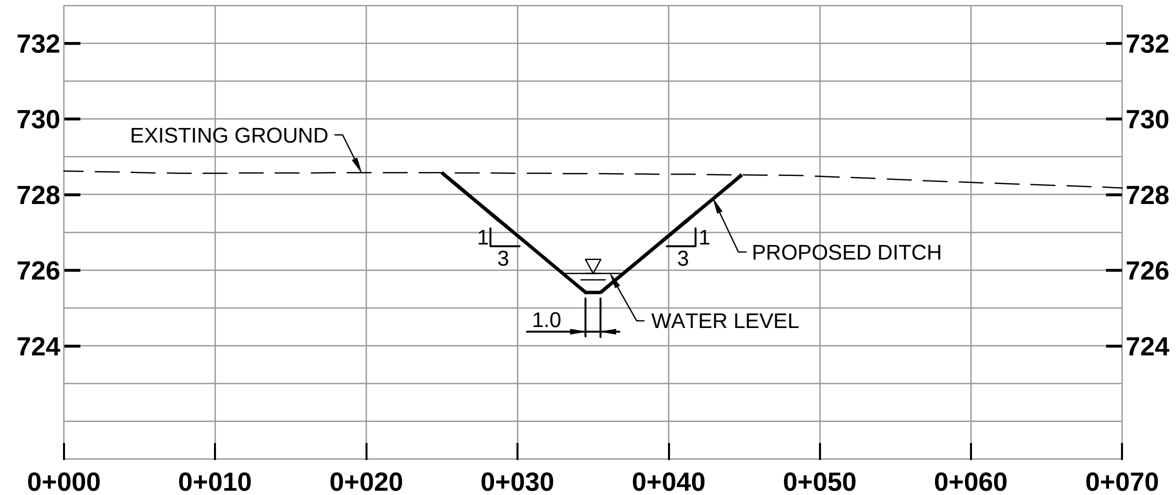
Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

AECOM

Figure: 5-4-2

ANSI B 279.4mm x 431.8mm
Approved:
Checked:
Designer:
Project Management Initials:

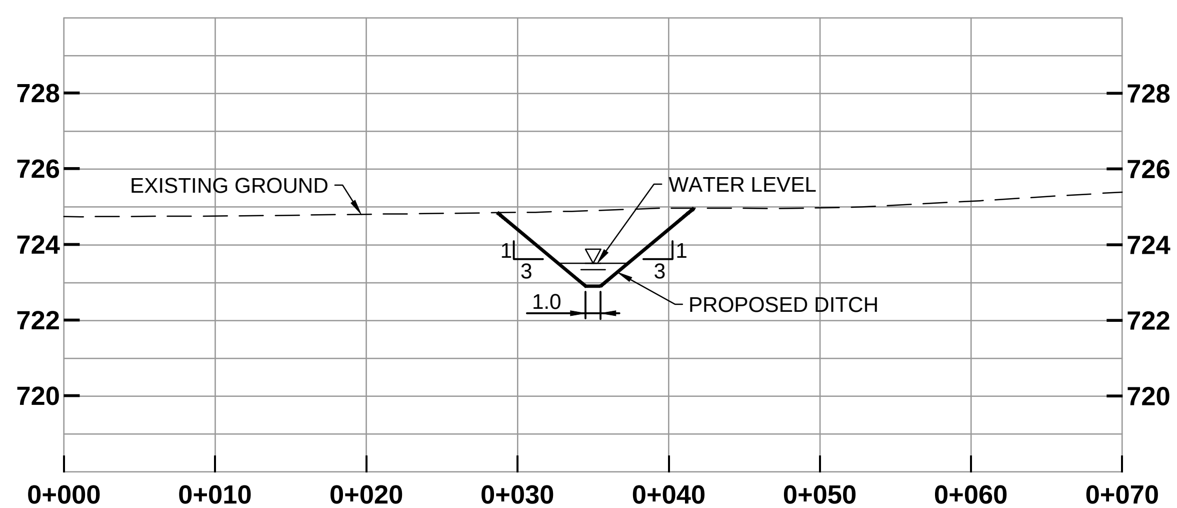
Last saved by: DANIELSC(2015-07-06) Last Plotted: 2015-07-06
Filename: P:\60334569\900-WORK\910-CAD\25-SKETCHES\TOWN OF SEXSMITH\FIGURE 5-4-2.DWG



SECTION

0 5 10 15 H=1:500
m
0 1 2 3 V=1:100

STATION 0+300.000



SECTION

0 5 10 15 H=1:500
m
0 1 2 3 V=1:100

STATION 0+550.000

AECOM

Figure: 5-4-3

Town of Sexsmith
Ditch Typical Cross Sections

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

5.5 Hamlet of Fort Vermilion

5.5.1 Background

The Hamlet of Fort Vermilion is located along the banks of Peace River and is classified as a high flood risk community. The location of the Hamlet of Fort Vermilion within the Peace River Basin is shown on Figure 5-2.

5.5.2 Historical Flood and Erosion Issues

Stakeholder identified historical flood issues are shown on Figure 5-5-1. The location of each reported flood issue is numbered with a map ID and classified as high, moderate or low risk. Each issue can be found by the corresponding map ID in Table A-1 in Appendix A.

The Peace River at Fort Vermilion Flood Risk Mapping Study indicates that the greatest flood in the history of Fort Vermilion occurred in 1934 when an ice-jam downstream from the hamlet caused the flood waters to overflow the banks of Peace River (Alberta Environment, 2000). The ice-jam occurred where the river divides into three channels, approximately 3.5 km downstream of the hamlet. It was reported that about 1.8 m of water was present at the current location of the airport. The road in the vicinity of the airport flooded in 1963 and 1964. The study indicated that the buildings developed along the river and in the airport area would be flooded if the 1934 flood event would reoccur. The river intake at the water treatment plant located south of the Peace River was damaged due to flooding twice in last twenty years due to heavy rainfall. The service was not interrupted but ability to recharge the reservoir was affected.

A summary of flood events which have impacted the Hamlet of Fort Vermilion are shown in Table 5-13.

Table 5-13: Summary of Historical Flood Events - Hamlet of Fort Vermilion

Flooding Date	Flooding Event/Cause	Erosion Issues
1990	Rainstorm event	None reported
1964	Flooding of road near the airport	None reported
1963	Flooding of road near the airport	None reported
1934	Ice-jam downstream caused overflow of the Peace River	None reported

5.5.3 Flood Hazard Mapping – AESRD (2000)

Alberta Environment (AESRD) completed a Flood Risk Mapping Study for the Peace River at the Hamlet of Fort Vermilion in July 2000. This study concluded that the calculated 1990 flood flow of 12,640.00 m^3/s would be equal to or greater than 1:100 year flood. The 1:100 year peak flow was extrapolated using the maximum instantaneous flow produced by the 1990 flood event in Peace River at town of Peace River and a rating curve for the Peace River (prepared by Water Survey Canada for the Peace River at Fort Vermilion). High watermarks from the 1990 flood event were also used to calibrate a HEC-2 model which modeled the 1:100 year storm for the area (AESRD, 2000).

The flood hazard map developed by Alberta Environment for this study (Figure 5-5-2) indicate that the 1:100 year flood event does not affect the Hamlet of Fort Vermilion, as the high water levels are confined within the river channel banks. However, a 1934 ice jams in the Peace River raises a concern for inundation of the Hamlet of Fort Vermilion. Ice jams have been monitored since the 1934 ice jam event inundated much of the town and water levels due to ice jam have remained well below those recorded in 1934.

5.5.4 Land Use

Land use and zoning maps were requested; however, none were available at the time of this study. Land use in the Hamlet appears to consist of a combination of residential, commercial, and some industrial. Farmlands are located south of the Hamlet. The Hamlet of Fort Vermilion is bordered by the Peace River to the north. The Fort Vermilion Airport is located on the east side of the Hamlet.

5.5.5 Population Growth

The Hamlet of Fort Vermilion's population growth in the past decade has remained fairly consistent. Table 5-14 tabulates the population growth statistics for the Hamlet of Fort Vermilion, as reported by Statistics Canada Census data. Limited data was found on the population of the hamlet.

Table 5-14: Hamlet of Fort Vermilion Population Growth

Year	Population	% Change
2011	727	1.8
2006	714	

Source: Statistics Canada

5.5.6 Future Flood Risk and Damage Assessment

The Hamlet's future flood damage potential will likely remain the same in the foreseeable future; however, at the time of the study no existing or future land use and zoning maps were available to assess if densification of residential development area within reported at risk flood areas. Flooding risks arise primarily from the potential of ice jams in the Peace River, near the Fort Vermilion Airport. Ice jams are unpredictable, and for that reason it is difficult to determine the flood risk and damage potential for the Hamlet.

5.5.7 Flood Mitigation Alternatives

No proposed alternative.

5.5.8 Flood Hazard Mapping Study Review/Update

1:100 Year Peak Flow and River Capacity Estimation

In order to estimate the 1:100 year peak flow based on additional years of flow data from the WSC gauge station, AECOM performed a flood frequency analysis for the Hamlet of Fort Vermilion. This peak flow was used to further assess the potential of flooding in the Hamlet of Fort Vermilion and the airport area. The flood frequency analysis results are provided in Appendix C. The analysis indicated that the 1:100 year peak flow is higher than the value used in the 2000 flood mapping study (14,797 m^3/s versus 12,640 m^3/s).
FlowMaster by Bentley was used to determine whether Peace River is able to convey the updated 1:100 year peak flow as discussed in previous section. The recent LiDAR data was used to determine the approximate Peace River cross sections of three of the HEC-2 cross sections used by AESRD in the 2000 flood mapping study, as shown on Figure 5-5-2. The LiDAR data does not represent the total cross section of the river, as the river bed elevation underneath the water surface is unknown. The cross sections were modified by lowering the bottom elevations to approximate river bed elevation until the AESRD 1:100 year surface elevations at these three cross sections were produced with a flow of 12,640 m^3/s. Once a suitable river cross section was produced, Flow Master was re-run with

the calculated peak flow of 14,797 m^3/s in order to determine the water surface elevation for the newly calculated peak flow. The new high water levels were then compared to the top elevation of the Peace River bank at the respective cross-sections to determine if flooding is a concern. Table 5-15 details the results of this analysis.

The results of the analysis confirm that the water levels of the Peace River at Fort Vermilion during a 1:100 year rainfall event will not result in flooding of the town or airport area even with an increased peak flow. Therefore, no mitigation methods will be required to protect the Hamlet of Fort Vermilion from inundation during the 1:100 year flood event

Table 5-15: River Flow and Depth Results

Cross Section No.*	Manning's n (Alberta Environment, 2000)	Water Level at 12,640 m^3/s (m)	Water Level at 14,797 m^3/s (m)	Top of River Bank Elevation (m)
5	0.018	252.96	253.95	258
7	0.019	253.26	253.87	254.5
10	0.019	253.52	254.03	259.5

*Notes: *cross-sections correspond to the cross sections used by Alberta Environment for HEC-2 analysis*

5.5.9 Conceptual Cost Estimate

No cost estimate has been prepared, as AECOM is not recommending any flood mitigation alternatives for the Hamlet of Fort Vermilion for the 1:100 year flood.

5.5.10 Evaluation of Alternative

Flooding of the town and the airport area remains a possibility in the event of a major ice jam. Ice jams are a common occurrence in the Peace River downstream of the Hamlet of Fort Vermilion, where the river splits into three channels. In 1934, an ice jam resulted in high water levels of 256.95 m along cross section 9 shown on Figure 5-5-2. This is approximately 2.5 m above the top of the river bank near the airport, according to recent LiDAR data. Therefore, in order to protect the airport and town areas from ice jam flooding due to high water levels, the construction of a dike may be considered. In order to protect from high water levels similar to those experienced in 1934, the dike would have to extend along the banks of the Peace River, from the town to east of the airport area, with a top elevation of approximately 257 m or higher. The total length of the dike would be approximately 5 km. It should be noted that water elevations experienced during an ice jam event are unpredictable and depend on a wide variety of factors. As such, at this time AECOM does not recommend the construction of a dike to protect against high water levels due to an ice jam. A detailed ice jam flooding study should be conducted in future for this purpose.

5.5.11 Environmental Review of Flood Mitigation Alternative

AECOM conducted an environmental overview desktop review for proposed flood mitigation works in the Hamlet of Fort Vermilion. The purpose was to compile information on existing conditions and to provide commentary on potential permitting requirements associated with possible flood mitigation options. The desktop review consisted of examining a variety of publically available ecological databases and reports. This desktop review does not follow the format of an Environmental Impact Assessment (EIA) due to the limited engineering, hydrological, geotechnical, hydrogeological, and geological information available for the location. This is considered an environmental overview desktop report and is intended as a general guidance document outlining some of the major environmental concerns and regulatory issues associated with potential flood mitigation projects, and their surrounding area.

Various databases were searched to identify environmental factors within the Fort Vermilion Area of Interest (AOI).

5.5.11.1 Historical Resources

A database search of the *Listing of Historic Resources* (current to March 2015) revealed land with HRVs of 1 through 5 in the Fort Vermilion AOI. For further information on the HRVs within the Fort Vermilion AOI, see Appendix D.

5.5.11.2 Vegetation and Rare Plants

A search of ACIMS for rare species (or species of conservation concern) identified occurrences of two plants in the Fort Vermilion project AOI. These are Cary's Arctic (*Oeneis chryxus caryi*) and Palaeno Sulphur (*Colias palaeno*).

5.5.11.3 Wildlife and Species at Risk

Within the 20 km search radius of the Fort Vermilion AOI, 36 birds, one mammals, and two amphibians are listed by AESRD, Alberta *Wildlife Act*, COSEWIC, and/or SARA. In total, there are 31 species with an AESRD general status of "At Risk", "May be at Risk" or "Sensitive" and seven species listed with a SARA status of "Special Concern", "Threatened" or "Endangered". These species are listed in Table 18 of Appendix D.

5.5.11.4 Fisheries

The Fort Vermilion AOI includes the Peace River. The Peace River is a Mapped Class C Water Body with a RAP of April 16th to July 15th as per the AESRD COP (AESRD 2015b).

Twenty-nine species of fishes have been captured that have the potential to live within the AOI representing sportfish, minnows, suckers, trout-perch, and sculpins. For a detailed list of these fish species, and their provincial status, refer to Appendix D – Environmental Overview.

5.5.11.5 Applicable Legislation

For the Fort Vermilion AOI, there are a number of legislations which may be applicable to the Ice Jam dike mitigation alternative including:

- *Fisheries Act*
- *Migratory Birds Convention Act*
- *Water Act*
- *Alberta Wetland Policy*
- *Public Lands Act*
- *Historical Resources Act*
- *Provincial Parks Act*
- *Wilderness Areas Ecological Reserves, Natural Areas and Heritage Rangelands Act*
- *Alberta Wildlife Act*

See Appendix D for further detail on the Applicable Legislation for the Fort Vermilion AOI.

5.5.11.6 Discussion and Summary

The following environmental elements identified in the Fort Vermilion AOI:

- Boreal Forest Natural Region, Dry Mixedwood Subregion
- HRVs of 1, 2, 3, 4, and 5
- Open water, swamp, and marsh wetlands
- Key Wildlife and Biodiversity Zone
- Class C River and Creek with RAP of April 16 – July 15
- 40 species with AESRD general listing, 7 species with SARA listing, 7 AESRD general status fish species
- Migratory Bird Timing Window of April 30 – August 15

Required permitting and approvals are subject to change based on the final project design. Table 20 in Appendix D summarizes potential considerations which may be required in order for the project to adhere to applicable legislation.

5.5.12 Geotechnical Review of Flood Mitigation Alternative

5.5.12.1 Introduction

A flood protection dike along the banks of Peace River will be required if the Hamlet of Fort Vermilion decides to upgrade based on ice jams. At this time the geometry of the dike is not available including height and length. This assessment contains a desk study of the surficial geology of the proposed alignment and highlights potential issues. Preliminary recommendations are also provided for the dike stability.

5.5.12.2 Methodology

Geological maps of Alberta from the Alberta Geological Survey were consulted to determine surficial geology of the proposed alignment. Records from drilling water wells in the area were checked however no stratigraphic data was available from them.

5.5.12.3 Subsurface Conditions

Geological Maps

In case a dike is required to provide flood protection, the alignment will run primarily through glaciolacustrine deposits.

Glaciolacustrine Deposits

Glaciolacustrine deposits material deposited within lakes by meltwater from glaciers. Glaciolacustrine deposits are primarily fine-grained sediments of clay in central portion of the lake and alternate layers of silty clay or silt and clay (varved clay) in peripheral zones. These deposits are weak, compressible and very uniform in a horizontal direction.

5.5.12.4 Discussion and Recommendations

General

A flood protection dike along the banks of Peace River will be required if the Hamlet of Fort Vermilion decides to upgrade based on ice jams. Borrow material will be used for the dike construction. This borrow material may generally be obtained from shallow pits or from channels excavated adjacent to the dike which may produce fill material that is often heterogeneous. Selection of the dike section should be based on the properties of the poorest material that will be used. The use of low to medium plastic clay or clay till is preferable. The glaciolacustrine deposits in the area can also be used for dike construction, provided assessment of the permeability and plasticity of soils is completed prior to construction. If low to medium plastic clay is not available, high plastic clay may be used with flatter slopes. Low to medium plastic clay side slopes no steeper than 2.5H:1V can be used to a maximum height of less than 3 m. Flatter side slopes no steeper than 5H:1V is recommended for high plastic clay. Material properties should be confirmed by drilling prior to construction. Sand and gravel is considered suitable provided impervious material is placed on the dike upstream side slopes.

The top of the dike should be constructed no less than 3 m to 3.6 m wide to allow for normal maintenance operations and flood fighting operations. The upstream side slope of the dike should be covered with sod or rip rap to protect against erosion.

If granular material of less than 1 m thick is present below the dike, this material should be removed and replaced with low to medium plastic clay or clay till, to minimize seepage beneath the dike. If the granular material is greater than 1 m thick other methods to control seepage below the dike should be considered. Seepage control measures may include:

- Cut off trenches;
- Upstream impervious blankets
- Downstream seepage berms
- Pervious toe trenches

As a minimum, any soil used for the dike should exhibit hydraulic conductivity equal or less than 10^{-5} m/sec.

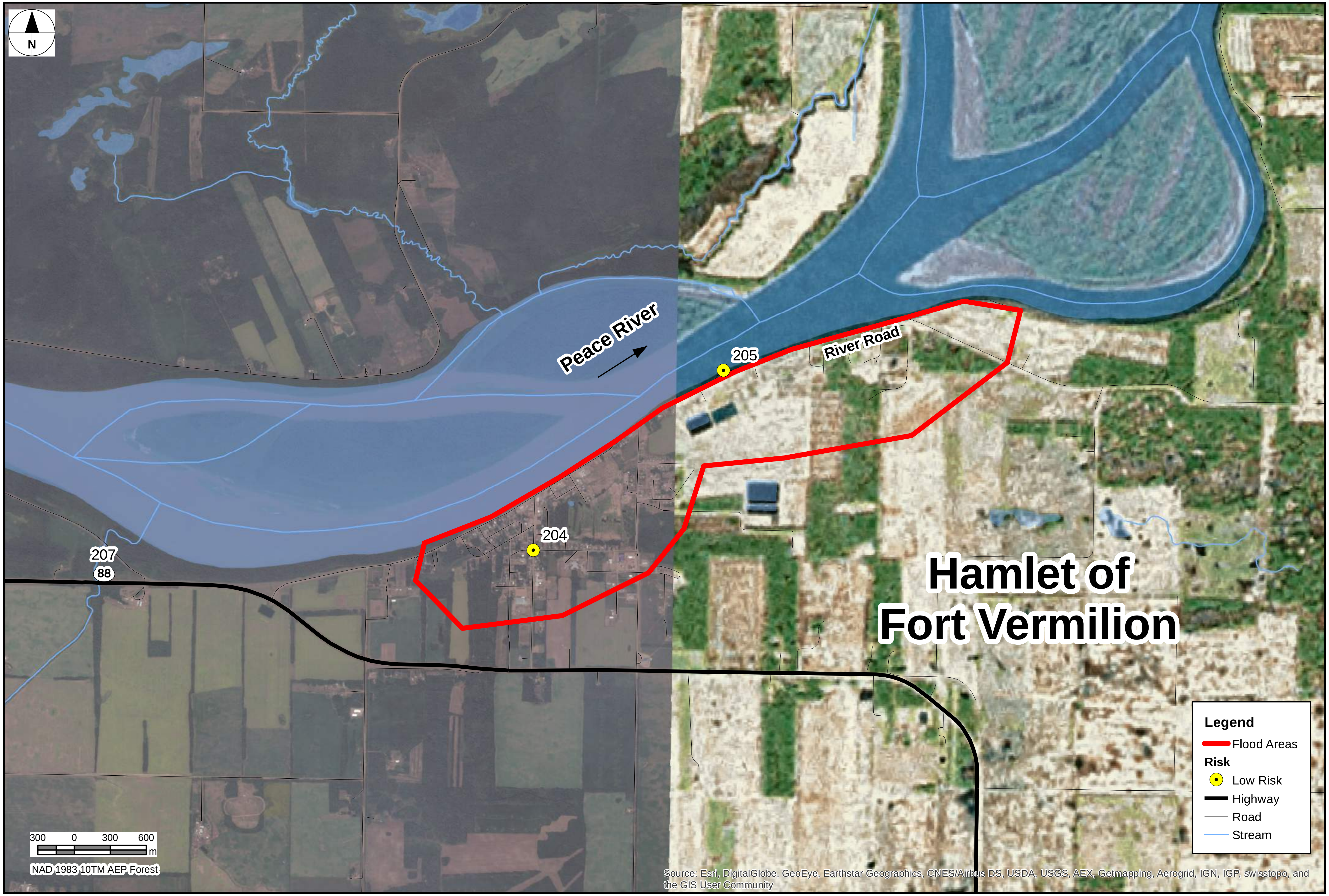
Topsoil from borrow and dike foundation stripping can be stockpiled and spread over the excavated area after completion of borrow excavation.

Erosion

All permanent slopes should be provided with some form of erosion protection to minimize potential of scour and erosion of the slope face. Erosion control synthetic mats or rip rap, and/or topsoil and seeding with a native seed mixture should be considered.

5.5.13 Conclusions and Recommendations

Following a review of the existing flood mapping study for Fort Vermilion, and the completion of a frequency analysis for the Peace River at Fort Vermilion, AECOM has concluded that the town and airport areas are not at risk of flooding during a 1:100 year flood event. Approximate high water levels of the Peace River at three locations in the Hamlet of Fort Vermilion were calculated using Bentley Flow Master. From these results it can be concluded that during the 1:100 year flood event, the Hamlet of Fort Vermilion will not be inundated due to high water levels in the Peace River. The town may experience flooding due to an ice jam event. To mitigate this risk, a dike could be considered along the banks of the Peace River through the hamlet, downstream past the airport area; however a detailed ice jam flooding study should be conducted prior to carrying out any upgrades.



AECOM

Figure 5-5-1

Hamlet of Fort Vermilion
Stakeholder Identified Historical Flood Issues

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

ANSI B 279.4mm x 431.8mm

Last saved by: MIREAULTC (2015-06-02) Last Plotted: 2014-03-18
Filename: P:\60334569\900-WORK\920-929 (GIS-GRAPHICS)\MAIN REPORT FIGURES\FIGURE 5-5-1 HAMLET OF FORT VERMILION - STAKEHOLDER IDENTIFIED HISTORICAL FLOOD ISSUES.MXD

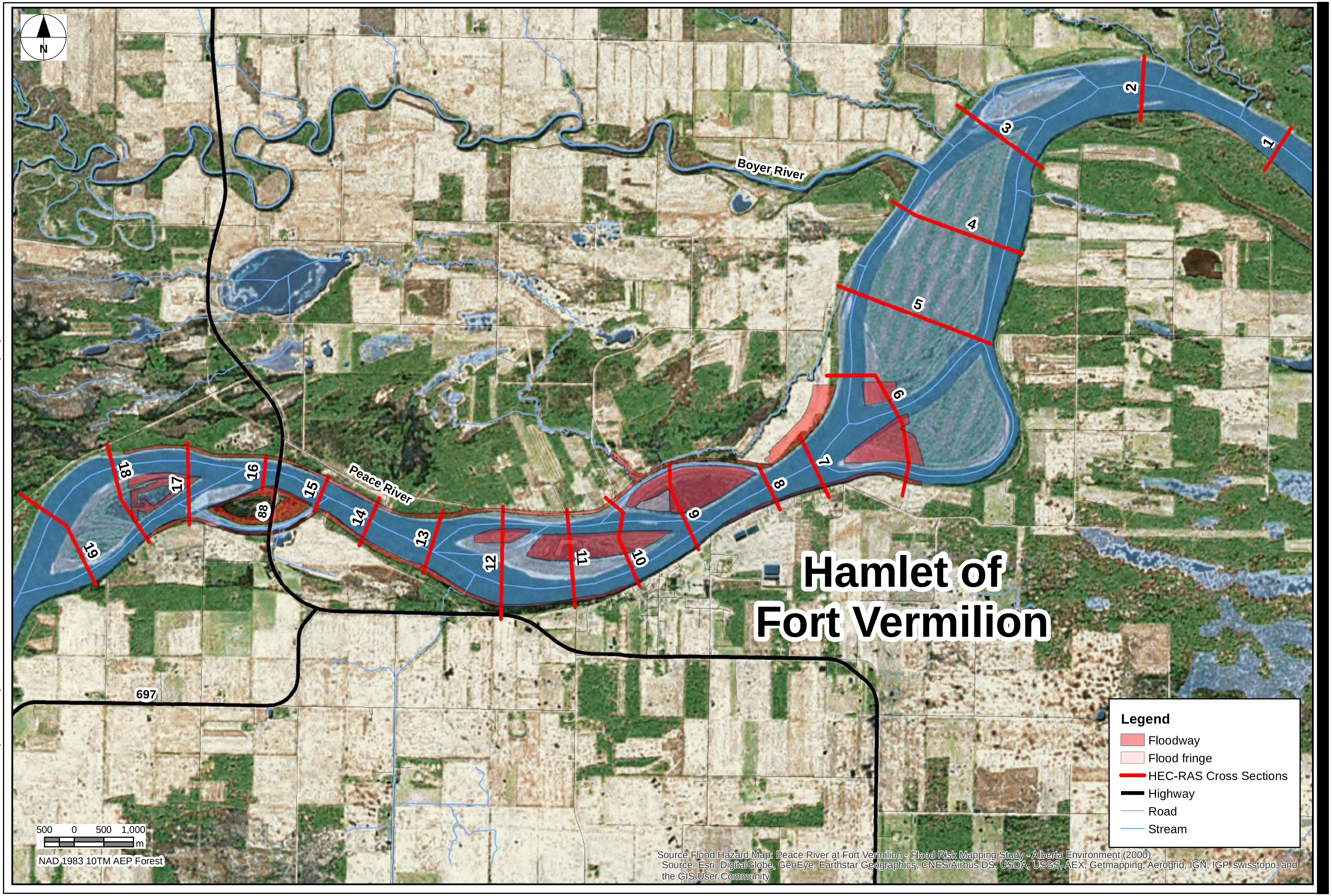


Figure 5-5-2

Hamlet of Fort Vermilion
1:100 Year Flood Hazard Map (2000)

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

5.6 Hamlet of Watino

5.6.1 Background

Parts of the Hamlet of Watino are located within the flood hazard area that was delineated by AESRD in 1996. Therefore, the Town is classified as a high flood risk community. The flood hazard areas were delineated for the Smoky River, which runs through the Hamlet of Watino. The location of the Hamlet of Watino in the Peace River Basin is shown on Figure 5-2.

5.6.2 Historical Flood and Erosion Issues

Stakeholder identified historical flood issues are shown on Figure 5-6-1. The location of each reported flood issue is numbered with a map ID and classified as high, moderate or low risk. Each issue can be found by the corresponding map ID in Table A-1 in Appendix A

Annual river flooding occurs due to rain and spring snowmelt inundating land directly southwest of the Smoky River Bridge. River bank erosion of the Smoky River is an ongoing issue. The May 2011 snowmelt and rainfall event caused flooding of farmlands south and west of the Smoky River Bridge. There was no flooding reported in Watino due to river ice jams. Summer cottages and holiday trailers are located close to the river bank directly northeast of the Smoky River Bridge. Twelve residences were evacuated during the May 2011 snowmelt and rain event. The river banks did not overtop; however, the bank was heavily eroded. River bank erosion is an ongoing issue. Currently, the some parts of the river bank located directly northeast of the Smoky River Bridge have eroded from approximately 45 degrees to a vertical face.

Table 5-16 summarizes historical events of flooding in the Hamlet of Watino.

Table 5-16: Summary of Historical flood Events - Hamlet of Watino

Flood Date	Flooding Event/Cause	Erosion Issues
2011 (May)	Snowmelt and rainfall caused flooding of farmlands south and west of the Smoky River Bridge	River bank heavily eroded
1990* (June)	Spring snowmelt and rainfall	None reported
1982* (July)	Spring snowmelt and rainfall	None reported
1972* (June)	Spring snowmelt and rainfall	None reported

Source: Northwest Hydraulics Consultants Flood Risk Mapping Study 1996

5.6.3 Flood Hazard Mapping - Northwest Hydraulics Consultants (1996)

Northwest Hydraulics Consultants (NHC) conducted a Flood Risk Mapping Study of the Hamlet of Watino in 1996 for AESRD, which indicates historical flooding occurred in the area on June 1972, July 1982 and June 1990. The greatest flood occurred on June 13, 1990 (1:50 year). The 1990 flood event trapped debris at the CN railway bridge. The CN railway bridge deck has insufficient free board making it susceptible to submergence during a major flood event. The major cause of flooding in the area is due to early spring snowmelt and rainfall. The 1:100 year flood high water mark reported in the NHC study is at 381.1 m. NHC conducted a flood frequency analysis and determined the 1:100 year peak flow to be 12,700 m^3/s. The 1:100 peak flow was used in a HEC-2 model and a flood hazard map was delineated including a floodway and flood fringe (Northwest Hydraulic Consultants, 1996).

The flood hazard area delineated by NHC is shown on Figure 5-6-2 and indicates that 1:100 year event would flood farmlands around the Hamlet including homes located northeast of the Smoky River Bridge.

5.6.4 Land Use

Existing and future land use and zoning maps were requested from the Hamlet of Watino. However, none were available at the time of this study. Land use in the Hamlet appears to consist of residential and some industrial. Residential properties appear to be spread out and appear to partly consist of summer cottages and holiday trailers located along the Smoky River banks as reported by stakeholders. Additionally, farmlands are located around the Hamlet of Watino.

5.6.5 Population Growth

The Hamlet of Watino is located in Birch Hills County. The population growth statistics for Birch Hills County, as reported by Statistics Canada census data, are reported in Table 5-17 Population data for the Hamlet of Watino were unavailable at the time of this study. The population of Watino appears to be small and has decreased significantly as reported during stakeholder consultation meetings.

Table 5-17: Birch Hills County Population Growth

Year	Population	% Change
2011	1,582	7.6
2006	1,470	-10.6
2001	1,644	-2.3
1996	1,682	

Source: Statistics Canada

5.6.6 Future Flood Risk and Damage Assessment

Future land use and zoning maps were unavailable at the time of the study; therefore, it could not be determined whether additional residential areas are planned within the flood hazard area. However, it appears unlikely that residential areas will densify within the flood hazard area since a decline in population growth was reported during stakeholder consultations. There are approximately 20 homes located within the flood hazard area that are at risk of flooding during a 1:100 year flood event; therefore, potential risk of damage to homes and loss of life appear to be high.

Erosion of the Smoky River banks is an ongoing concern and may potentially undercut the river bank at some locations over time if large flood events continue to recur. The CN railway bridge may potentially be damaged by floating debris since the 1:100 year flood event was reported to trap debris against the bridge deck during past flood events.

5.6.7 Flood Mitigation Alternative

A dike is proposed to mitigate flooding of the residences located on the north bank of the Smoky River located northeast of Smoky River Bridge in the Hamlet of Watino for the 1:100 year flood event. The following section provides a conceptual design of a flood protection dike followed by a cost estimate.

5.6.7.1 Flood Protection Dike

Design Flow Estimation

The 1:100 year peak flow determined by Northwest Hydraulic Consultants is 12,700 m^3/s (1996). The updated 1:100 year peak flow estimate considers additional flow records from 1996 to 2012 obtained from WSC stream gauge station 07GJ001. In order to estimate the 1:100 year peak flow based on the additional years of recorded flow data, AECOM performed a flood frequency analysis of the Smoky River using flow data from WSC stream gauge station 07GJ001. The updated 1:100 year peak flow was determined to be 12,800 m^3/s. The updated 1:100 year peak flow was used to further assess the extent of flooding in the Hamlet of Watino and to design the flood protection dike.

The updated flood frequency analysis and results are provided in Appendix C.

Conceptual Design

A HEC-2 computer model was created by NHC in 1996 to determine the water surface elevation with a 1:100 year peak flow of 12,700 m^3/s. AECOM converted the original HEC-2 model to a HEC-RAS model and the simulation was re-run with the updated 1:100 year peak flow of 12,800 m^3/s including the proposed dike alignment. HEC-RAS cross sections showing the water surface elevations resulting from the 1996 and the updated 1:100 year peak flows are shown on Figure 5-6-3.

Recent LiDAR data was used to determine the alignment of the dike such that the height would not exceed 3 m. The height of the dike was designed to incorporate a freeboard of 0.5 m above the updated 1:100 year water surface elevation. The dike is approximately 825 m long with a top width of 1 m. The total dike height varies from approximately 2.5 to 3 m along the alignment. The dike alignment and profile view are shown on Figure 5-6-4.

The base width predominantly varies between 15 to 17 m; however, there are some portions of the alignment where the width increases up to 20 m due to steep eroded river banks. The side slopes are recommended to be no steeper than 2.5H:1V due to soil conditions; however, since the north side of the dike would not be inundated during a 1:100 year flood it was assumed to be stable at a 2H:1V slope under dry conditions. The south side slope varies from a 2.5H:1V to 2H:1V. The south side slope of the dike consists of a steeper 2H:1V side slope only in locations where the bottom width would exceed approximately 20 m if a 2.5H:1V slope would be used. Typical cross sections of the dike are shown on Figure 5-6-5.

The proposed dike is recommended to be built using a low to medium plasticity clay with a 200 mm layer of top soil. The top soil is to be sodded with a naturalized seed mix since the left bank velocities along the dike alignment do not exceed 0.5 m/s during the updated 1:100 year peak flow.

5.6.8 Conceptual Cost Estimate

The cost to construct the flood control dike is estimated to be $1.3 million. The Class D cost estimate is included in Table 5-18. A contingency of 40% was used in the cost estimate. The cost estimate does not include the following:

- Cost to mitigate any environmental losses
- Land acquisition/purchase

Table 5-18: Conceptual Cost Estimate - Dike Construction

Item	Item Cost
Stripping	$54,630
Sub-grade Preparation	$36,420
Clay dike (low to medium plasticity)	$502,100
Grass Seeding	$27,315
Top Soil	$273,150
Sub-Total	**$893,615**
Mobilization & Demobilization (10%)	$89,362
Contingency (40%)	$357,446
Total	**$1,340,423**

5.6.9 Evaluation of Alternative

The conceptual cost of implementing the proposed dike is approximately $1.3 million and would protect approximately 16 homes and its residents. There appear to be four homes located within the 825 m long dike alignment; therefore, their land and homes would need to be purchased and its residents relocated to construct the dike. It should be noted that approximately three homes further east along the north bank of the Smoky River are within the flood hazard area and will not be protected by the proposed dike. The dike alignment was determined not to be feasible to extended farther east due to low ground elevations that would result in dike heights larger than 3 m.

The cost of the dike should be weighed against the potential flood risk to people, relocation costs and cost of flood related repairs to homes of residents currently within the flood hazard area. The option of moving all residents to a location outside of the flood hazard area may potentially present a more cost effective alternative when all factors are considered.

5.6.10 Environmental Review of Flood Mitigation Alternative

AECOM conducted an environmental overview desktop review for proposed flood mitigation works in the Hamlet of Watino. The purpose was to compile information on existing conditions and to provide commentary on potential permitting requirements associated with possible flood mitigation alternatives. The desktop review consisted of examining a variety of publically available ecological databases and reports. This desktop review does not follow the format of an Environmental Impact Assessment (EIA) due to the limited engineering, hydrological, geotechnical, hydrogeological, and geological information available for the location. This is considered an environmental overview desktop report and is intended as a general guidance document outlining some of the major environmental concerns and regulatory issues associated with potential flood mitigation projects, and their surrounding area.

5.6.10.1 Historical Resources

A database search of the *Listing of Historic Resources* (current to March 2015) revealed land with HRVs of 4 and 5 in the Watino AOI. For further information on the HRVs within the Watino AOI, see Appendix D.

5.6.10.2 *Wildlife and Species at Risk*

Within the 20 km search radius of the Watino AOI, seven birds, one mammal and two amphibians were listed by AESRD, Alberta *Wildlife Act*, COSEWIC and/or SARA. In total, there are 10 species with an AESRD general status of “At Risk”, “May be at Risk” or “Sensitive” including:

- Birds:
  - American Kestral
  - Barred Owl
  - Least Flycatcher
  - Northern Goshawk
  - Northern Harrier
  - Sharp-tailed Grouse
  - Swainson’s Hawk
  - Trumpeter Swan
- Mammals:
  - Bobcat
- Amphibians
  - Long-toed Salamander

5.6.10.3 *Fisheries*

The Watino AOI includes the Smoky River. The Smoky River is a Mapped Class C Water Body with a RAP of September 10th to July 15th as per the AESRD COP (AESRD 2015b).

Twenty-one species of fishes have the potential to live within the watershed including eight species of sportfish: Arctic Grayling, Burbot, Goldeye, Mountain Whitefish, Northern Pike, Rainbow Trout, and Walleye (AESRD 2013, Table 4). For a detailed list of these fish species, and their provincial status, refer to Appendix D – Environmental Overview.

5.6.10.4 *Applicable Legislation*

For the Watino AOI, there are a number of legislations which may be applicable to mitigation alternative including:

- *Fisheries Act*
- *Migratory Birds Convention Act*
- *Water Act*
- *Alberta Wetland Policy*
- *Public Lands Act*
- *Historical Resources Act*
- *Provincial Parks Act*
- *Wilderness Areas Ecological Reserves, Natural Areas and Heritage Rangelands Act*
- *Alberta Wildlife Act*

See Appendix D for further detail on the Applicable Legislation for the Watino AOI.

5.6.10.5 Discussion and Summary

The following environmental elements identified in the Watino AOI:

- Boreal Forest Natural Region, Dry Mixedwood Subregion
- HRVs of 4 and 5
- Open water wetlands
- Key Wildlife and Biodiversity Zone
- Class C River with RAP of September 10 – July 15
- 10 species with AESRD general listing, 4 AESRD general status fish species
- Migratory Bird Timing Window of April 15 – August 31

Required permitting and approvals are subject to change based on the final project design. Table 5 in Appendix D summarizes potential considerations which may be required in order for the project to adhere to applicable legislation.

5.6.11 Geotechnical Review of Flood Mitigation Alternative

5.6.11.1 Introduction

A flood protection dike of approximately 825 m long is proposed along the north bank of Smoky River in the Hamlet of Watino. The dike is approximately 3 m at its highest point. The assessment contains a desktop study of the surficial geology of the proposed alignment and highlights potential issues. Preliminary recommendations are also provided for the dike stability.

5.6.11.2 Methodology

Geological maps of Alberta from the Alberta Geological Survey were consulted to determine surficial geology of the proposed alignment. Water well drilling records in the area were checked however no stratigraphic data was available from them. A flood risk mapping study completed in July 1996 titled Watino Flood Risk Mapping Study was also reviewed.

5.6.11.3 Subsurface Conditions

Geological Maps

The proposed flood protection dike alignment runs primarily through fluvial deposits.

Fluvial Deposits

Fluvial deposits consist of sediments transported and deposited by streams and rivers. Fluvial deposits include well sorted stratified sand, gravel, silt, clay and organic sediments.

Existing Report

The Watino Flood Risk Mapping Study completed in 1996 indicates that the river channel bed consists of a gravelly-boulder material. The coarse material extends to a depth of 10 m below ground surface and overlies clay. The bank consists of gravel overlain by silt/sand. Soft bedrock is exposed along the reaches where the channel impinges on a valley wall.

5.6.11.4 Discussion and Recommendations

General

Borrow material will be used for the dike construction. This borrow material may generally be obtained from shallow pits or from channels excavated adjacent to the dike which may produce fill material that is often heterogeneous. Selection of the dike section should be based on the properties of the poorest material that will be used. The use of low to medium plastic clay or clay till is preferable. The fluvial deposits in the area can also be used, provided assessment of the permeability and plasticity of soils is completed prior to construction. If low to medium plastic clay is not available, high plastic clay may be used with flatter slopes. Low to medium plastic clay side slopes no steeper than 2.5H:1V can be used to a maximum height of less than 3 m. Flatter side slopes no steeper than 5H:1V is recommended for high plastic clay. Material properties should be confirmed by drilling prior to construction. Sand and gravel is considered suitable provided impervious material is placed on the dike upstream side slopes.

The top of the dike should be constructed no less than 3 m to 3.6 m wide to allow for normal maintenance operations and flood fighting operations. The upstream side slope of the dike should be covered with sod or rip rap to protect against erosion.

If granular material of less than 1 m thick is present below the dike, this material should be removed and replaced with low to medium plastic clay or clay till, to minimize seepage beneath the dike. If the granular material is greater than 1 m thick other methods to control seepage below the dike should be considered. Seepage control measures may include:

- Cut off trenches;
- Upstream impervious blankets;
- Downstream seepage berms;
- Pervious toe trenches

As a minimum, any soil used for the dike should exhibit hydraulic conductivity equal or less than 10^{-5} m/sec.

Topsoil from borrow and dike foundation stripping can be stockpiled and spread over the excavated area after completion of borrow excavation.

Erosion

All permanent slopes should be provided with some form of erosion protection to minimize potential of scour and erosion of the slope face. Erosion control synthetic mats or rip rap, and/or topsoil and seeding with a native seed mixture should be considered.

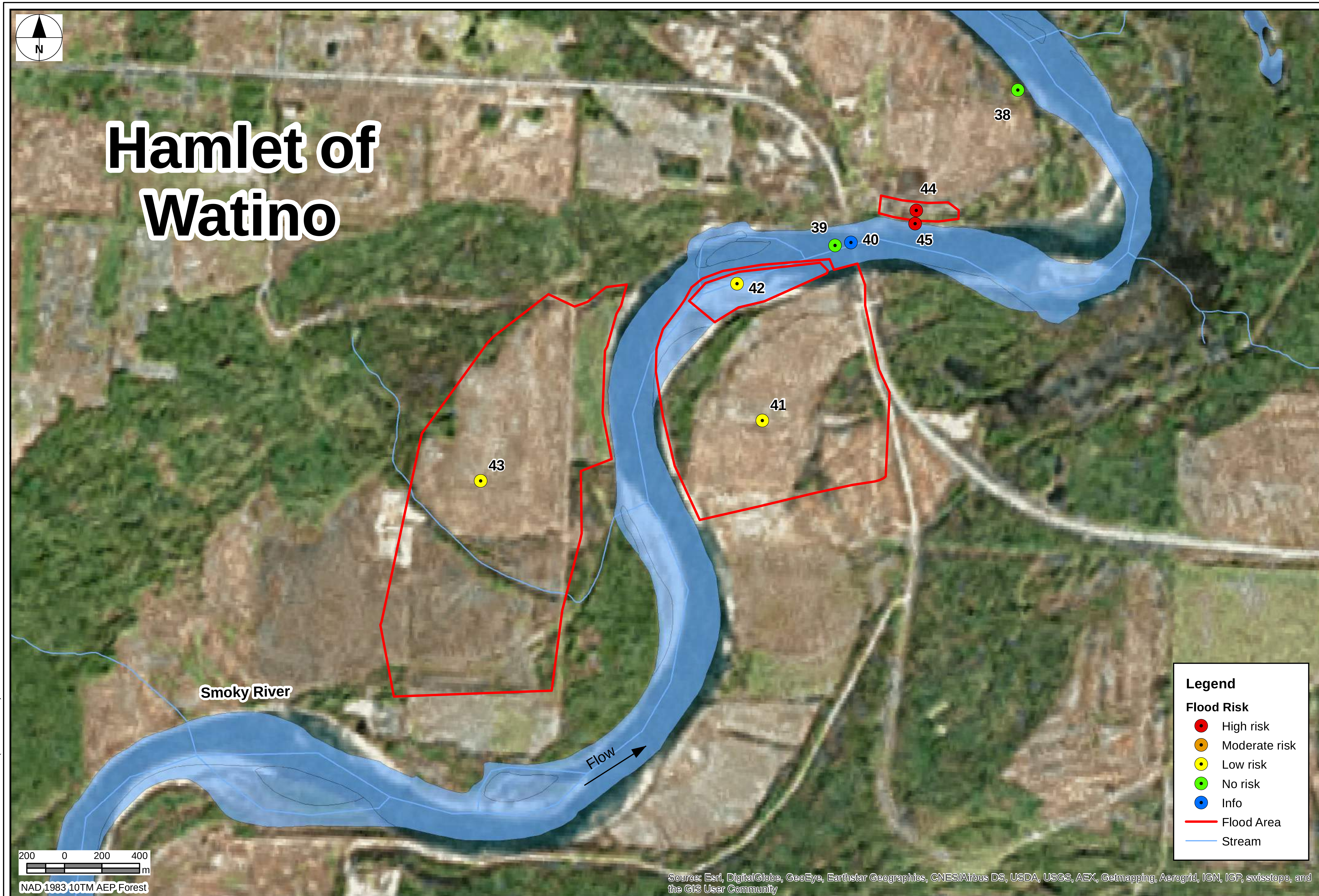
5.6.12 Conclusions and Recommendations

Currently, there are approximately 23 homes in the flood hazard area of the Hamlet of Watino. A dike is proposed that would protect 16 homes during a 1:100 year flood. Four homes would need to be relocated to make room for the dike alignment. Low ground elevations prevent a dike to be constructed to protect the remaining three homes since this would result in high dike heights of over 3 m. It is recommended that the remaining residents are made aware of their location within the flood hazard area. Flood prevention alternatives may include relocating to higher ground or residents could raise their homes above the 1:100 year water level if possible.

The proposed dike would be approximately 825 m long. The cost of the dike is estimated at approximately $1.3 million and would consist of a low to medium plasticity clay with 2.5 to 2H:1V south side slopes and 2H:1V north side slopes. Ideally, the dike should have a top width of 3 to 3.6 m to allow for easy access for maintenance vehicles and crews; however, a 1 m top width was selected to reduce total bottom width to minimize encroachment of the dike onto lots of adjacent residents. The dike should be grassed and no additional scour protection is required since the left river bank velocities do not exceed 0.51 m/s.

A minimum dike side slope of 2.5H:1V was recommended after geotechnical investigations; however, with limited soil information. Therefore, it is recommended that an additional slope stability study be conducted to determine whether the side slopes can be constructed at a steeper 2H:1V if the proposed dike is taken to the preliminary design phase. The dike would be grassed and no additional scour protection is required since the left river bank velocities are do not exceed 0.51 m/s.

AECOM recommends that the Hamlet of Watino restricts residential growth in the flood hazard area and explores other alternatives next to a flood protection dike such as moving residents outside of the flood hazard area and develop an emergency evacuation plan. Furthermore, it is recommended that CN rail investigates alternatives to protect the CN rail bridge during a 1:100 year flood event. Currently, the bridge deck has insufficient freeboard to pass the 1:100 year flow. Debris may be caught up against the bridge deck and could potentially cause damage. Additionally, it should be confirmed that there is sufficient space under the Smoky River Bridge to construct the dike if taken to the preliminary design phase.



AECOM

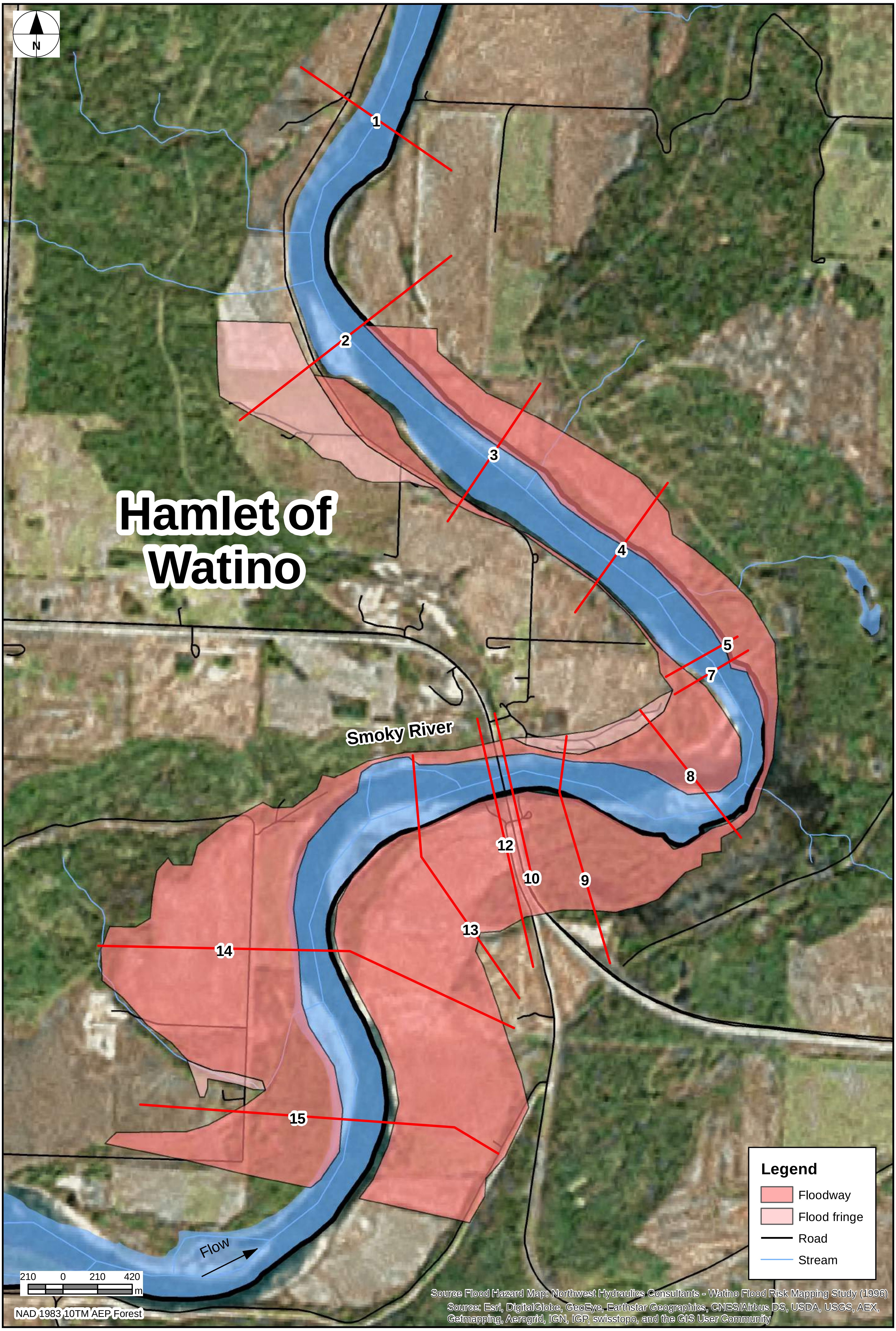
Figure: 5-6-1

Hamlet of Watino
Stakeholder Identified Historical Flood Issues

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

ANSI B 279.4mm x 431.8mm

Last saved by: MIREAULTC (2015-06-02) Last Plotted: 2014-03-18
Filename: P:\60334569\900-WORK\920-929 (GIS-GRAPHICS)\MAIN REPORT FIGURES\FIGURE 5-6-1 HAMLET OF WATINO - STAKEHOLDER IDENTIFIED HISTORICAL FLOOD ISSUES.MXD

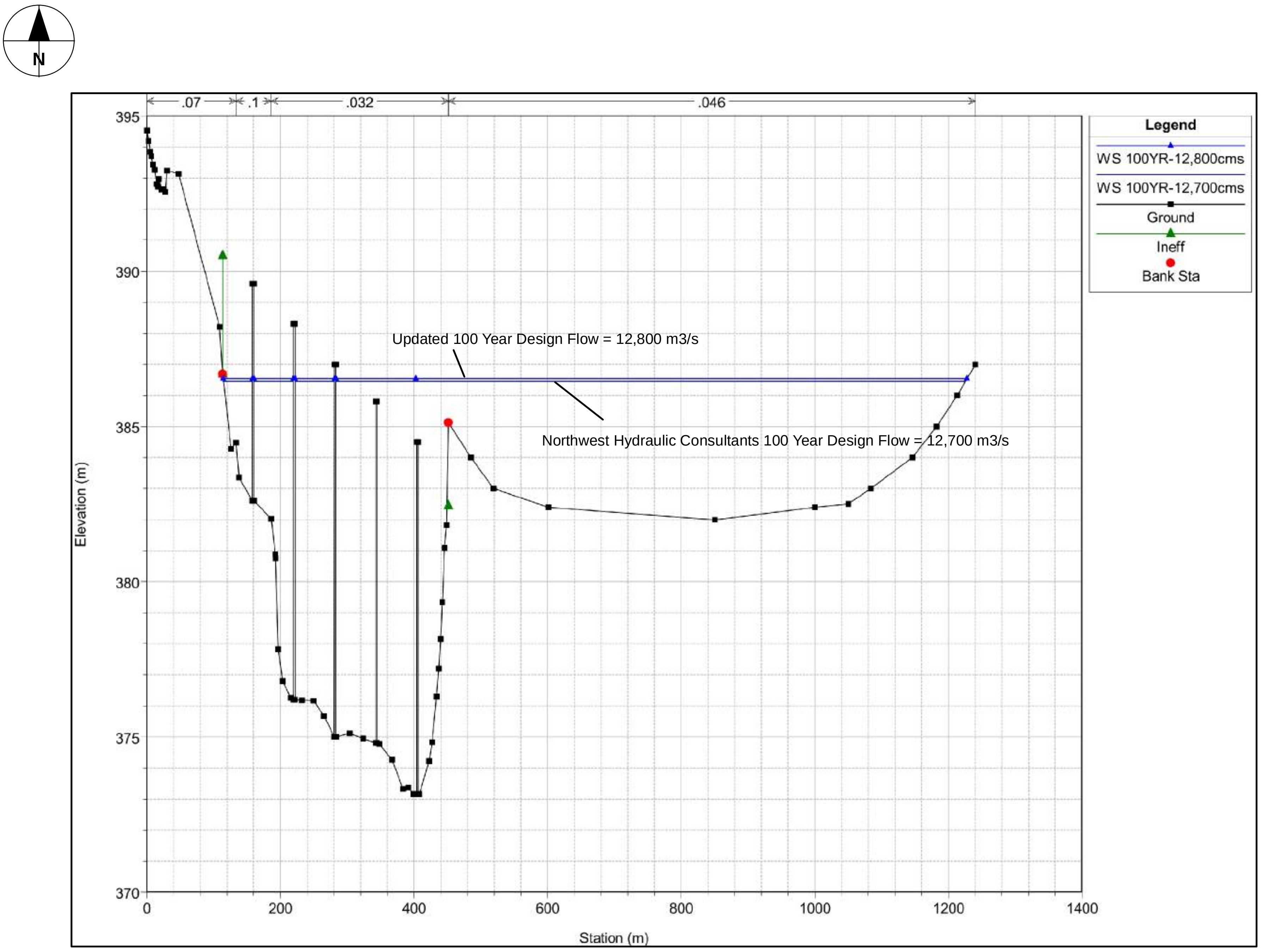


Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

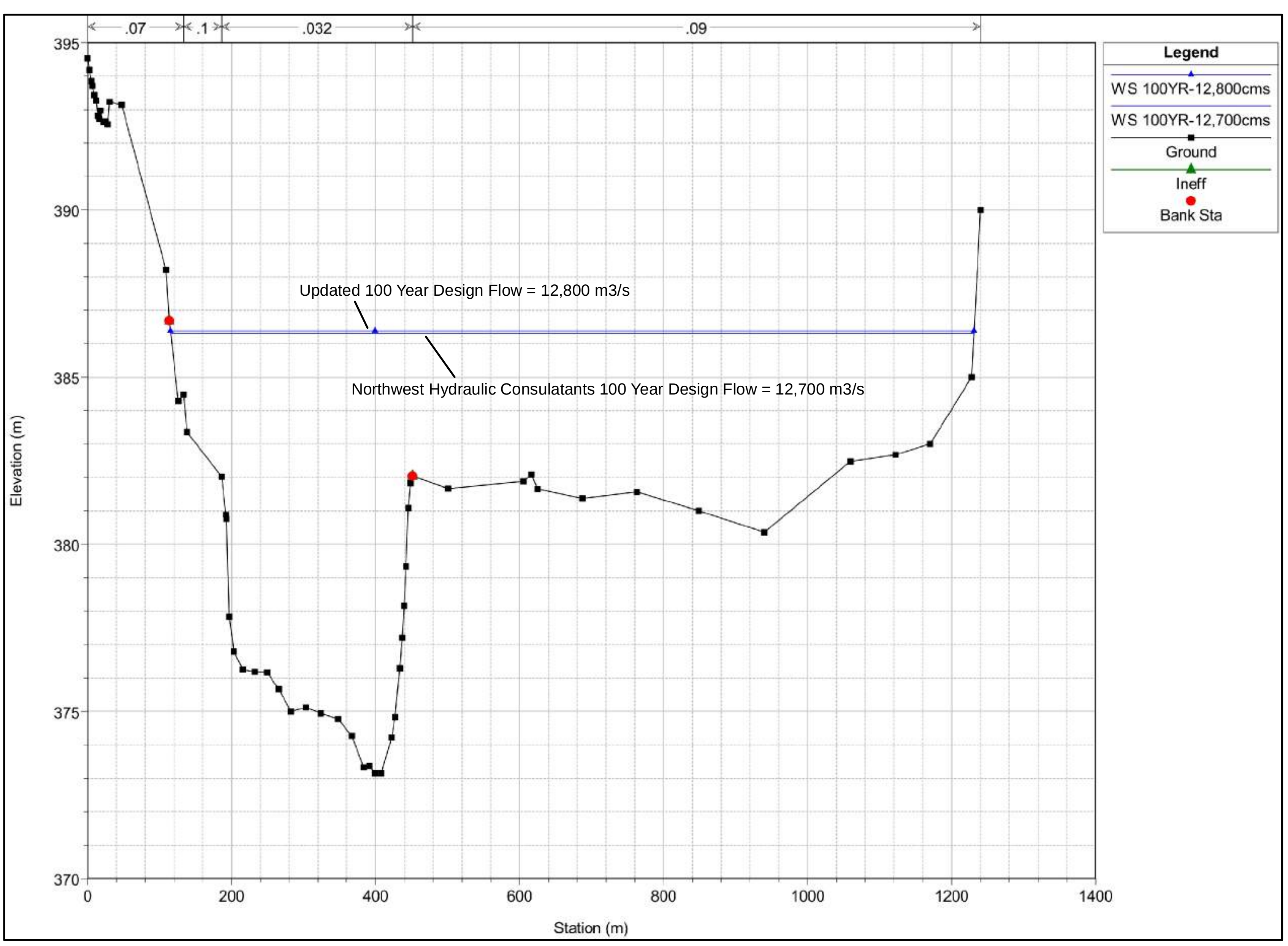
Hamlet of Watino
1:100 Year Flood Hazard Map (1996)

AECOM

Figure: 5-6-2



Upstream Cross Section #10



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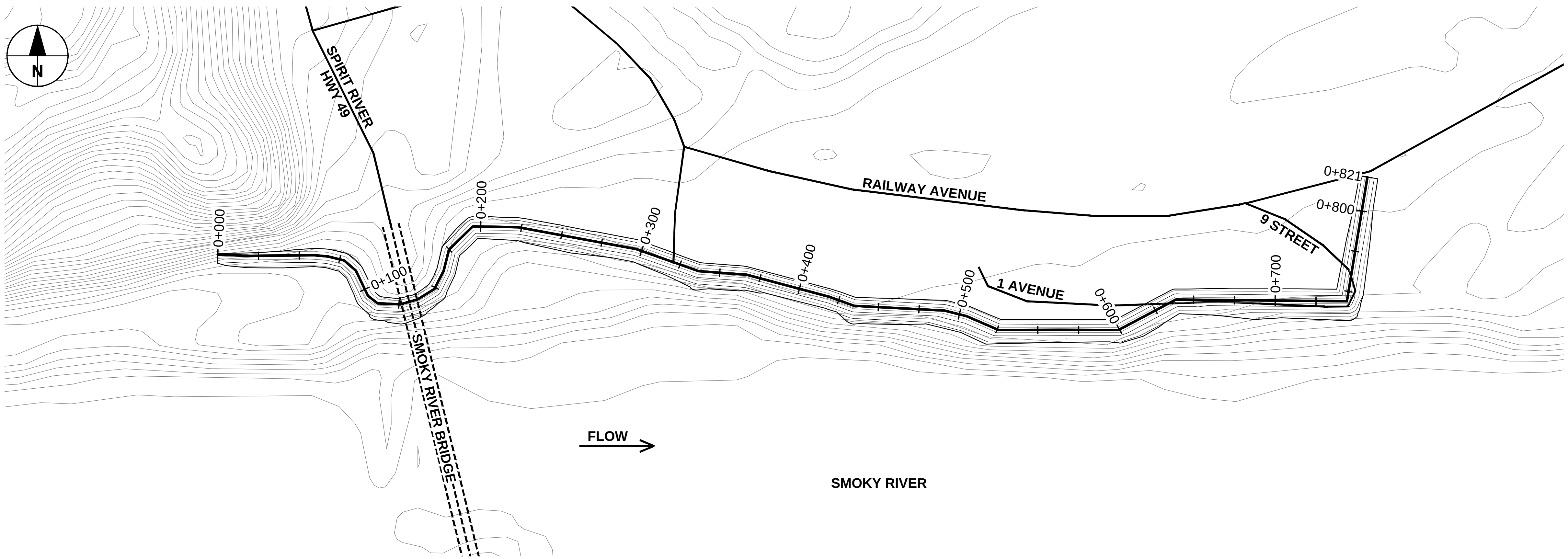

PLAN

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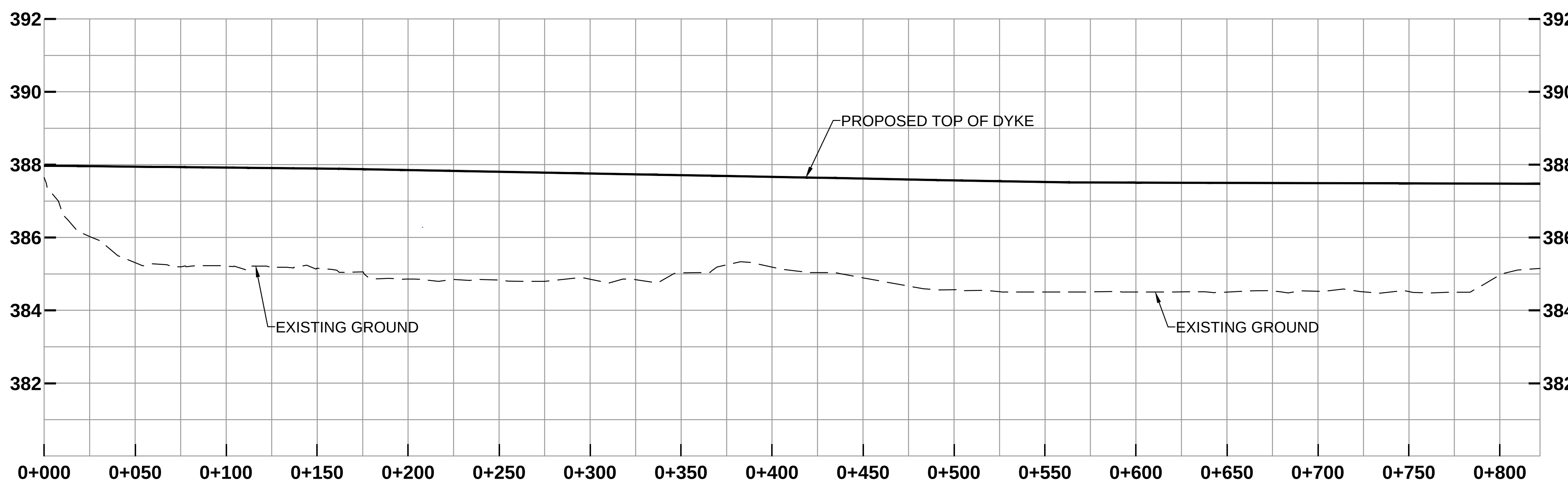

PROFILE

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AECOM

Figure: 5-6-4

Hamlet of Watino
Dike Plan and Profile

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

ANSI B 279.4mm x 431.8mm

Approved:

Checked:

Designer:

Project Management Initials:

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Filename: P:\60334569\900-WORK\910-CAD\25-SKETCHES\C\HAMLET OF WATINO\FIGURE 5-6-5.DWG
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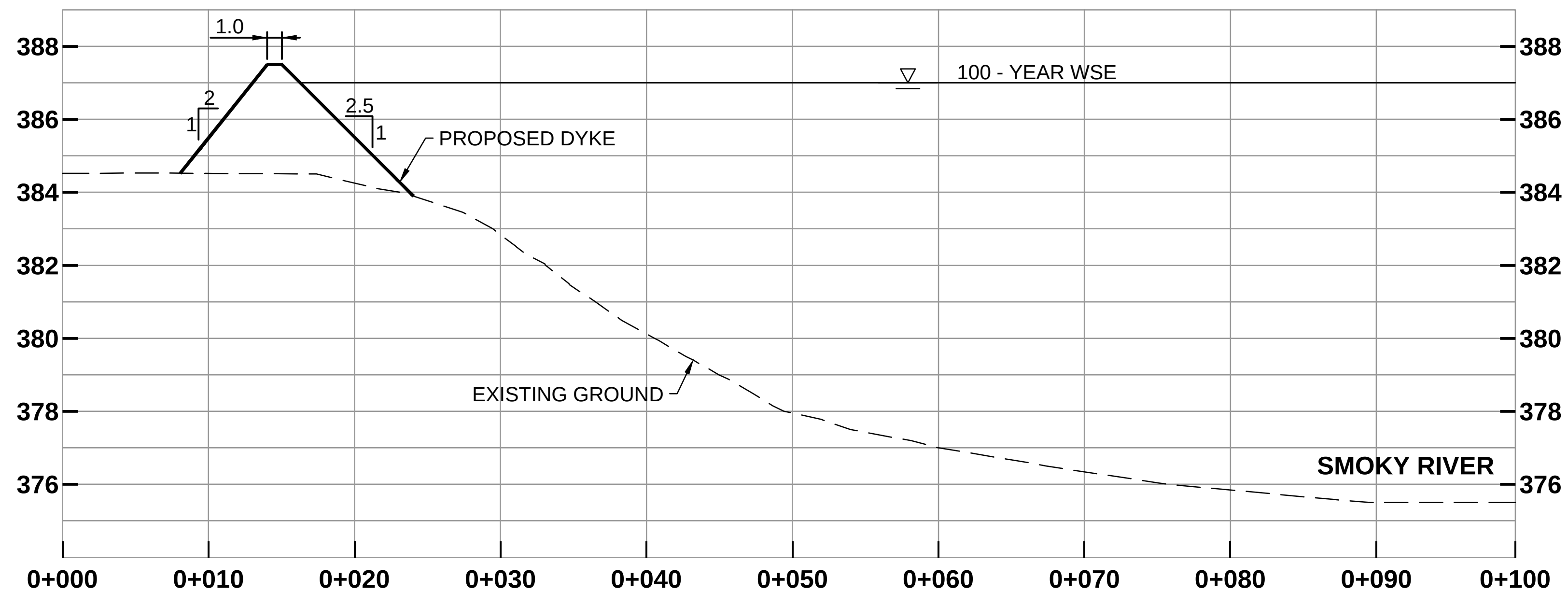

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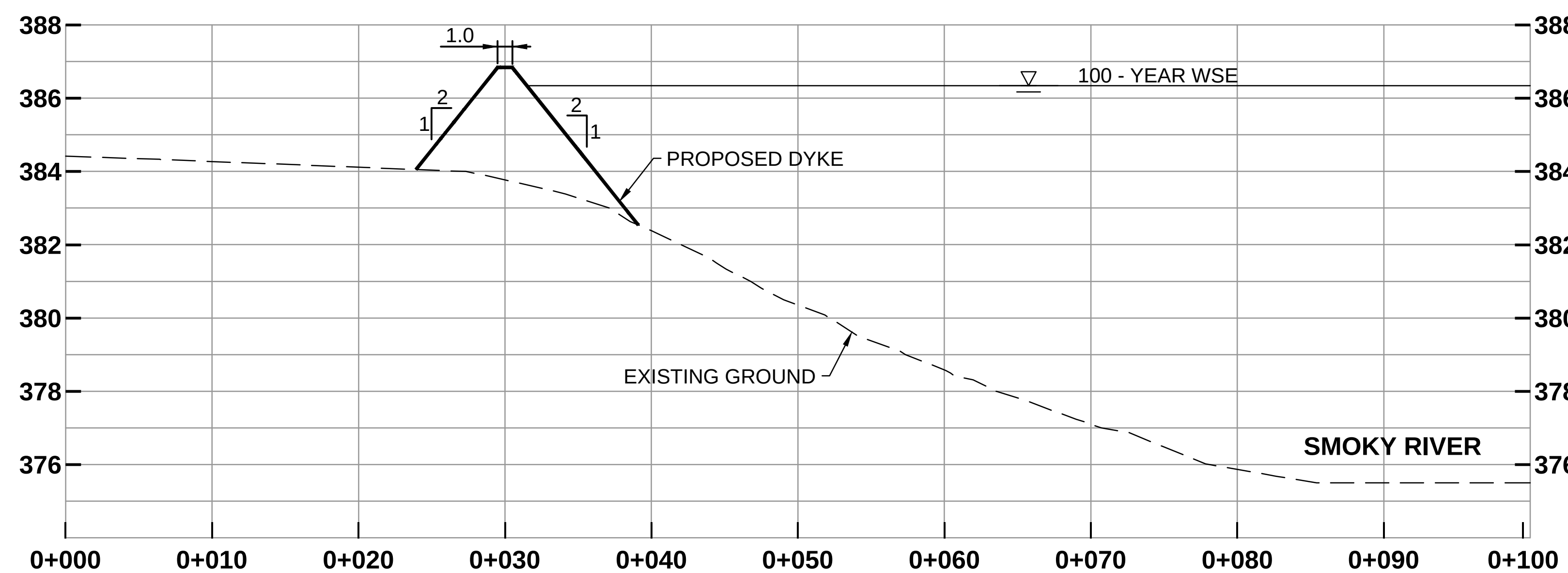

SECTION

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0 1 2 3 V=1:100

STATION 0+725.000

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

Hamlet of Watino
Dike Cross Sections

AECOM

Figure: 5-6-5

5.7 First Nations and Métis

First Nation settlements are present throughout the study area and stakeholder consultations with Alberta Emergency Management Agency (AEMA) indicated that many mapped settlements are not at risk of flood and some are uninhabited. There is one Métis settlement called Paddle Prairie located in the study area which was contacted directly. The Wyandie settlement does not have official Métis status, but have been included in the study. There was limited information available from stakeholder consultations regarding flood issues in Fox Lake, John d'Or Prairie, Paddle Prairie and Wyandie West. During initial consultation flood and population information pertaining to First Nations and Métis was gathered from AEMA; however, AECOM attempted to contact AEMA with follow up inquiries, but did not receive further information. Therefore, analysis of the flood issues including flood mitigation alternatives was not possible in this study. More detailed information about possible flood issues impacting Fox Lake, John D'Or Prairie, Paddle Prairie and Wyandie West should be obtained to develop flood mitigation plans. Possible flood mitigation may include, but are not limited to, structural and non-structural alternatives such as: flood protection dikes, diversion channels, relocating residents to higher ground, raising homes above the flood level and emergency flood response plans.

Stakeholder identified historical flood issues and the locations of First Nations and Métis settlements discussed in the following sections are shown on Figure 5-7-1 and Figure 5-7-2 respectively. The location of each reported flood issue is numbered with a map ID and classified as high, moderate or low risk. Each issue can be found by the corresponding map ID in Table A-1 in Appendix A.

5.7.1 Little Red Cree First Nation

The Little Red Cree Tribe is located in Mackenzie County No.23 as shown on Figure 5-7-2. There are two Little Red Cree First Nation reserves which have been classified as high flood risk. Flood risk in Fox Lake and John D'Or Prairie reserve are outlined in the following sections.

5.7.1.1 Fox Lake 162 Reserve

Fox Lake is located on the south side of the Peace River in the M.D. of Mackenzie No. 23 as shown on Figure 5-7-2. It was reported that Fox Lake has a population of approximately 3000 people. Water sources mainly consist of private wells and cisterns. Emergency preparedness plans that are currently in place include preparations to fly residents out of the area in the event of flooding. Given that Fox Lake has a sizable population and is an isolated community, it has been classified as a high risk flood community. It may prove difficult to get food, water and medical aid to residents during a flood since the reserve is far north and isolated.

5.7.1.2 John D'Or Prairie 215 Reserve

John D'Or Prairie is located approximately 12 km north of the Peace River in the M.D. of Mackenzie No.23 as shown on Figure 5-7-2. The population of the reserve is approximately 1000 people and it was reported that the reserve floods annually. A flood occurred in 2013 which resulted in a bridge closure. Flooding was reported from the Laurence River, which is a tributary to the Peace River. Three homes located along the river were flooded and residents were evacuated. However, since John D'Or Prairie is an isolated community with a large population it has been classified as a high flood risk community. It may prove difficult to get food, water and medical aid to John D'Or Prairie during a flood since the reserve is far north and isolated.

5.7.2 Métis

5.7.2.1 Paddle Prairie Métis Settlement

Paddle Prairie is located in the County of Northern Lights No.22 as shown on Figure 5-7-2. Boyer River floods annually due to spring snowmelt; however, exact location of flooding and impacts are unknown. In 2012, 15 homes were flooded following spring snowmelt. A number of residents experienced sewer back up into their homes; however, the number of occurrences are unknown. It was reported that the water treatment plant has been not experienced flood issues. Roads are flooded annually, but remain drivable. Paddle Prairie is classified as a high risk flood community since 15 homes were impacted due to the 2012 flood event.

5.7.2.2 Wyandie West (Métis Coop)

Wyandie West is located in the M.D. of Greenview No.16 as shown on Figure 5-7-2. Wyandie West is a Métis Coop and does not have official status. It was reported by AEMA that the community is in a flood zone. The population impacted by flooding is unknown; however, the community is classified as a high risk of flood due to its location within a flood zone.

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Filename: P:\60334569\900-WORK\920-929 (GIS-GRAPHICS)\MAIN REPORT FIGURES\FIGURE 5-7-1 FIRST NATIONS AND METIS - STAKEHOLDER IDENTIFIED HISTORICAL FLOOD ISSUES.MXD

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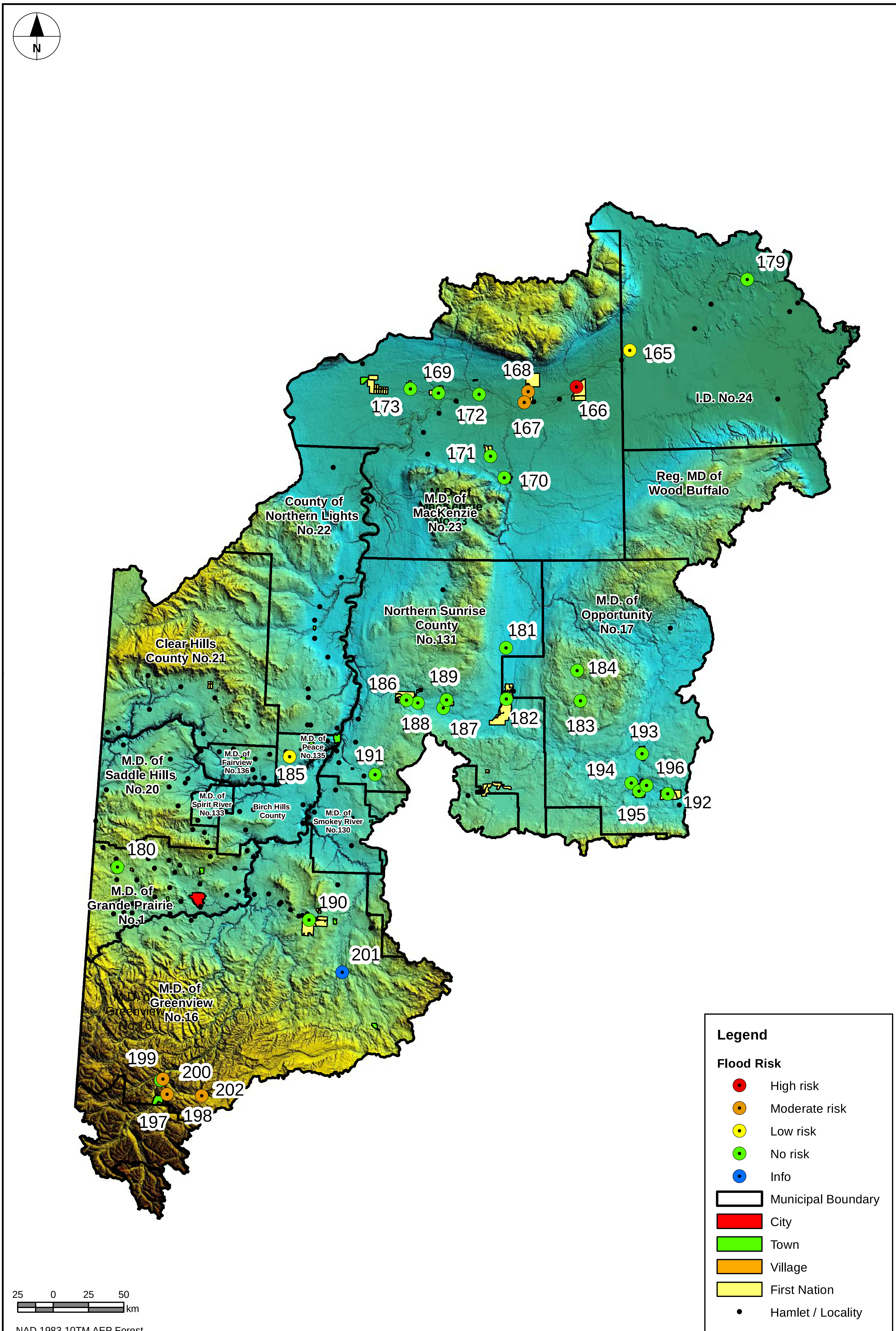

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Project No.: 60334569

First Nations and Metis
Stakeholder Identified Historical Flood Issues

Figure: 5-7-1

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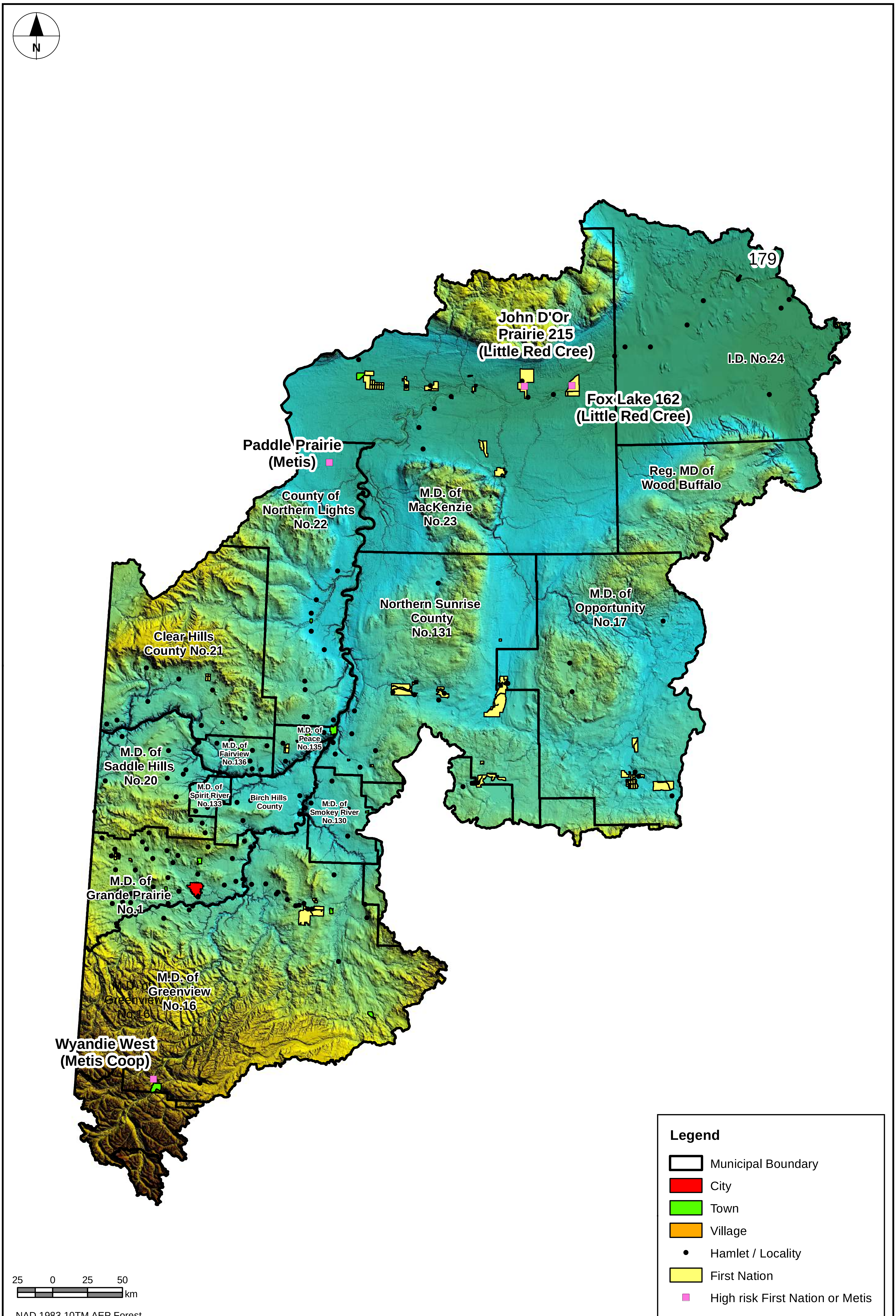

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High Risk First Nations and Metis

AECOM

Figure: 5-7-2

5.8 Village of Donnelly

5.8.1 Background

The Village of Donnelly is classified as a moderate flood risk community due to significant, but infrequent, flood impacts to residents and homes. The village has only experienced one flooding event that impacted residents and homes. Additionally, the village is not located adjacent to any rivers or creeks, and as such, the risk to the village is seen as moderate rather than high. The location of the Village of Donnelly within the Peace River Basin is shown on Figure 5-2.

5.8.2 Historical Flood and Erosion Issues

Stakeholder identified historical flood issues are shown on Figure 5-8-1. The location of each reported flood issue is numbered with a map ID and classified as high, moderate or low risk. Each issue can be found by the corresponding map ID in Table A-1 in Appendix A.

The village experienced flooding of 15 homes in two residential blocks in 2007 due to overland flooding from Winagami-Girouxville drainage canal located northeast of the village. A culvert blocked by ice caused snowmelt runoff to overtop the road and flow towards the village. Main floors as well as basements were flooded, including the village office. Photos of the 2007 flood event are shown in Figure 5-8-2.

5.8.3 Flood Hazard Mapping

The Village of Donnelly is not located adjacent to or near a natural watercourse. There is no flood hazard mapping available for the Village of Donnelly.

5.8.4 Land Use

Land use and zoning maps were requested; however, none were available at the time of this study. Land use in the Village appears to consist primarily of residential, as well as some commercial and industrial. Farmlands are located around the Village of Donnelly.

5.8.5 Population Growth

Donnelly's population in the past two decades has been inconsistent, seeing both growth and reduction. Table 5-19 tabulates the population growth statistics for the Village of Donnelly, as reported by Statistics Canada Census data.

Table 5-19: Village of Donnelly Population Growth

Year	Population	% Change
2011	305	4.1
2006	293	-22.3
2001	377	0.5
1996	375	

Source: Statistics Canada

5.8.6 Future Flood Risk and Damage Assessment

The Village of Donnelly has experienced a general trend of a decrease in population since 1996, according to Statistics Canada. The Town's future flood damage potential may be lower due to the decrease in population; however, at the time of the study no existing or future land use and zoning maps were available. Residents appear to be at risk of flooding due to overflow in the Winagami-Girouxville canal, in the event of an ice or debris blockage. Flooding has not occurred due to any other occurrences.

5.8.7 Flood Mitigation Alternative

5.8.7.1 Non-Structural Flood Mitigation Alternative

There has only been one reported flooding event in the Village of Donnelly, which was due to the overland flooding resulting from a blocked culvert, located northeast of the Village. Due to the one-time occurrence, it is likely that this culvert is sufficiently sized to convey peak flows, and only presents a flooding risk to the village when the culvert is blocked with debris or ice. The location of this culvert is shown as #23 on Figure 5-8-1. AECOM recommends that the Village develops a maintenance plan which will specify that the problem culvert must be annually or seasonally inspected to determine if the culvert is blocked with ice or debris. In the event of a blockage, the culvert should be cleared of ice or debris manually to prevent flooding.

Another mitigation alternative could include upsizing the problem culvert. However, as mentioned above, the culvert is likely sufficiently sized when clear of ice and debris. Upsizing the culvert would be more costly than seasonal inspections and maintenance, and there would still be the possibility of ice blocking a larger sized culvert.

5.8.8 Conceptual Cost Estimate

N/A

5.8.9 Evaluation of Alternative

N/A

5.8.10 Environmental Review of Flood Mitigation Alternative

N/A

5.8.11 Geotechnical Review of Flood Mitigation Alternative

N/A

5.8.12 Conclusions and Recommendations

AECOM recommends that the Village annually inspects the culverts which caused the 2007 flooding event, and insure that there are no debris or ice blockages. This maintenance practice should provide a cost effective way of preventing overland flooding in the Village of Donnelly, similar to the 2007 event.

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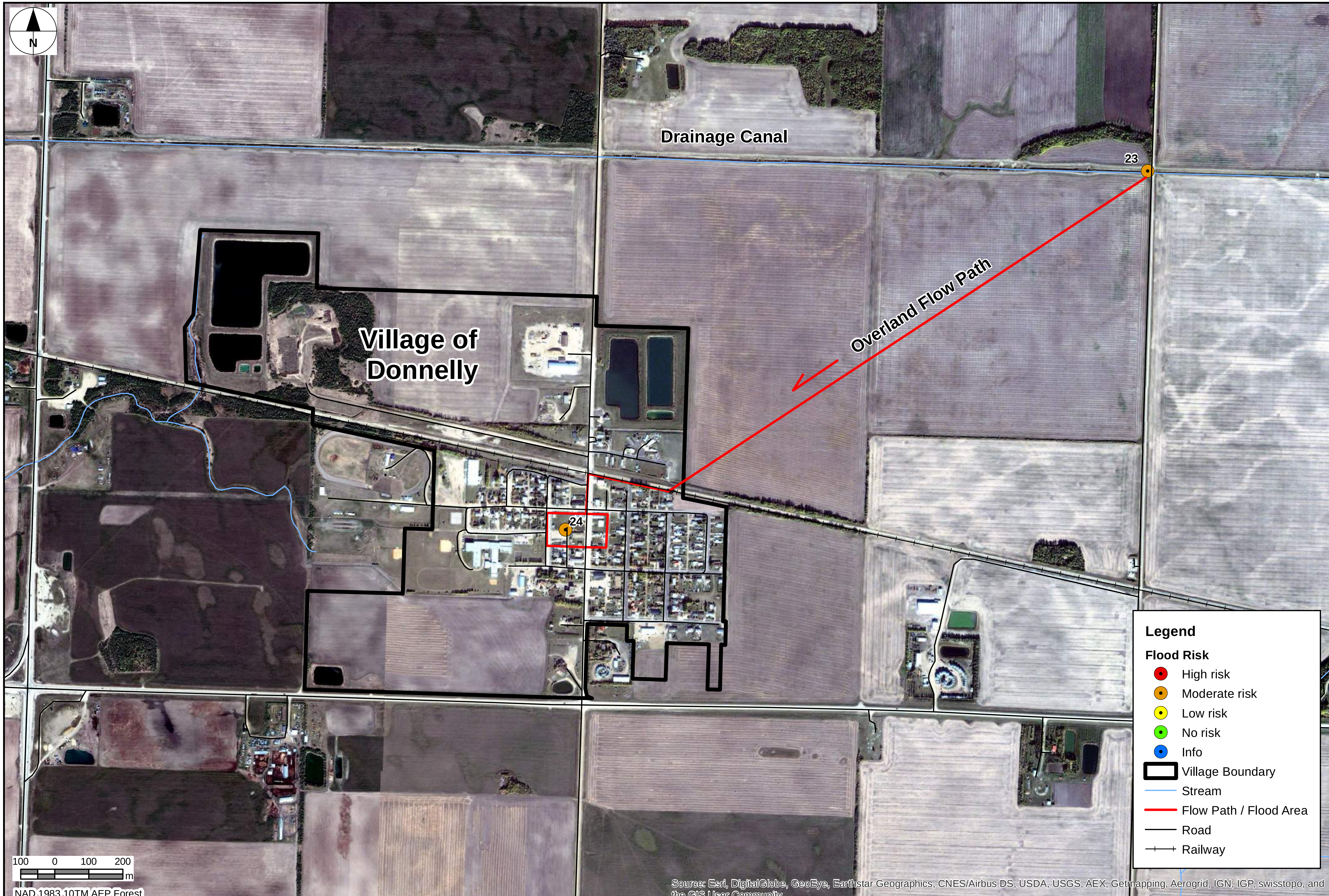

Filename: P:\60334569\900-WORK\920-929 (GIS-GRAPHICS)\MAIN REPORT FIGURES\FIGURE 5-8-1 VILLAGE OF DONNELLY - STAKEHOLDER IDENTIFIED HISTORICAL FLOOD ISSUES.MXD

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AECOM

Figure: 5-8-1

Village of Donnelly
Stakeholder Identified Historical Flood Issues

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Flooding in Donnelly. Photo taken April 17, 2007.

Flooding in Donnelly. Photo taken April 17, 2007.

Flooding in Donnelly. Photo taken April 17, 2007.

Image Source: Village of Donnelly

Figure: 5-8-2

Village of Donnelly
Flood Event Photos

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5.9 Village of Girouxville

5.9.1 Background

The Village of Girouxville is classified as a moderate flood risk community due to significant flood impacts to residents and homes. The village is not located adjacent to any natural watercourses. The location of the Village of Girouxville within the Peace River Basin is shown on Figure 5-2.

5.9.2 Historical Flood and Erosion Issues

Stakeholder identified historical flood issues are shown on Figure 5-9-1. The location of each reported flood issue is numbered with a map ID and classified as high, moderate or low risk. Each issue can be found by the corresponding map ID in Table A-1 in Appendix A.

The village experienced basement flooding of 6 homes in April/May of 2003 due to spring snowmelt runoff. Furthermore, a heavy rainfall in August 2013 caused the drainage canal running north-south along the Village of Girouxville to overflow. Flood waters drained into the ditch along the railway tracks and south through a culvert across the railway tracks where one home was flooded.

A summary of flood events which have impacted the Village of Girouxville are shown in Table 5-20.

Table 5-20: Summary of Historical Flood Events - Village of Girouxville

Flooding Date	Flood Event/Cause	Erosion Issues
2013	Overflow of Village’s drainage canal, and caused one home to flood	None reported
2003	Spring melt caused 6 homes to flood	None reported

5.9.3 Flood Hazard Mapping

The Village of Girouxville is not located adjacent to or near a natural watercourse. There is no flood hazard mapping available for the Village of Girouxville.

5.9.4 Land Use

Land use and zoning maps were requested; however, none were available at the time of this study. Land use in the Village appears to consist primarily of residential, as well as some commercial and industrial. Farmlands are located around the Village of Girouxville.

5.9.5 Population Growth

Girouxville’s population has been steadily decreasing in the past two decades. Table 5-21 tabulates the population growth statistics for the Village of Girouxville, as reported by Statistics Canada Census data.

Table 5-21: Village of Girouxville Population Growth

Year	Population	% Change
2011	266	-5.7
2006	282	-7.8
2001	306	-7.8
1996	332	

Source Statistics Canada

5.9.6 Future Flood Risk and Damage Assessment

The Village of Girouxville has experienced a general trend of a decrease in population since 1996, according to Statistics Canada. The Town's future flood damage potential may be lower due to the decrease in population; however, at the time of the study no existing or future land use and zoning maps were available.

5.9.7 Flood Mitigation Alternative

5.9.7.1 Non-Structural Flood Mitigation Alternatives

The reported flooding events which impacted the Village of Girouxville were due to stormwater and snowmelt runoff and overflowing of the Winagami-Girouxville canal. For this reason, AECOM recommends that a stormwater management study be conducted for the Village and surrounding area. A stormwater study will help to identify the cause of the flooding and detailed mitigation alternatives may be developed following the completion of a stormwater study.

5.9.8 Conceptual Cost Estimate

N/A

5.9.9 Evaluation of Alternative

N/A

5.9.10 Environmental Review of Flood Mitigation Alternative

N/A

5.9.11 Geotechnical Review of Flood Mitigation Alternative

N/A

5.9.12 Conclusions and recommendations

AECOM recommends that the Village of Girouxville conducts a stormwater study for the area in order to propose flood mitigation alternatives after significant rainfall or snowmelt events.

AECOM

Figure: 5-9-1

Village of Girouxville
Stakeholder Identified Historical Flood Issues

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

5.10 Village of Rycroft

5.10.1 Background

The Village of Rycroft is classified as a moderate flood risk community due to minor flood impacts to residents and homes, but more significant impacts to infrastructure such as roadways, culverts and the river intake for the water treatment plant. The location of the Village of Rycroft within the Peace River Basin is shown on Figure 5-2.

5.10.2 Historical Flood and Erosion Issues

Stakeholder identified historical flood issues are shown on Figure 5-10-1. The location of each reported flood issue is numbered with a map ID and classified as high, moderate or low risk. Each issue can be found by the corresponding map ID in Table A-1 in Appendix A.

Flooding has occurred over a long time within and south of the Village of Rycroft, due to surface runoff from the area south of the village. The village experienced flooding of ditches and culverts in 1990, 2011, and 2013 along a stream running north through the village. A significant flood in 1990 resulted in large amounts of debris being accumulated on the railway bridge upstream of Highway 49 in Rycroft. In addition, the 1990 flood washed out the Highway bridge (BF 70797) located 11 km downstream of Rycroft. The Village and M.D. administrations consider the June 1990 flooding to be the worst flooding of the village in living history. Three homes were damaged in 1990 and some businesses and homes were damaged during the 2013 flood.

The river intake at the water treatment plant located northwest of the Village of Rycroft was damaged by flooding in June/July 2011 due to a rainfall event. Service was not interrupted. Homes were close to flooding; however, they were not impacted.

A farmer constructed temporary snow ditches to convey runoff from farmland to the storm system along Township Road 782 and caused 0.30 m (1 ft.) of flooding at a portion near the power station located at the southeast corner of the village. However, the power station is historically not at risk of flooding. Photos of flooding in the Village of Rycroft can be found in Figure 5-10-2.

A summary of flood events which have impacted the Village of Rycroft are shown in Table 5-22.

Table 5-22: Summary of Historical Flood Events - Village of Rycroft

Flooding Date	Flood Event/Cause	Erosion Issues
2013	-ditches and culverts flooded -homes and businesses were damaged	None reported
2011	-ditches and culverts flooded -river intake to WTP was damaged following a heavy rainfall event	None reported
1990	-three homes damaged -ditches and culverts flooded	None reported

5.10.3 Flood Hazard Mapping

There is no available flood hazard mapping for the Village of Rycroft.

5.10.4 Land Use

Existing land use and zoning in the Village of Rycroft is shown on Figure 5-10-3. Land use and zoning was obtained from the Village of Rycroft. Populated areas south of the rail tracks consist mainly of residential, commercial zones and parks and municipal reserve areas. Future land use and zoning maps were requested but unavailable; therefore, it could not be determined if residential growth is planned to be restricted in the area south of the railway tracks. The zoning north of the railway and of the Spirit River consists of commercial zones.

5.10.5 Population Growth

Rycroft's population has both increased and decreased in the past two decades. Table 5-23 tabulates the population growth statistics for the Village of Rycroft, as reported by Statistics Canada Census data.

Table 5-23: Village of Rycroft Population Growth

Year	Population	% Change
2011	628	-1.6
2006	638	4.8
2001	609	-8.7
1996	667	

Source: Statistics Canada

5.10.6 Future Flood Risk and Damage Assessment

The Village of Rycroft has experienced a general trend of a decrease in population since 1996, according to Statistics Canada. The Town's future flood damage potential may be lower due to the decrease in population; however, at the time of the study no existing or future land use and zoning maps were available to assess if densification of residential development are within reported at risk flood areas. Residents appear to be at risk of flooding due to overflow from an unnamed tributary which runs through the village. The risk of the tributary flooding its banks remains the same, in the event that no flood mitigation alternatives are put in place.

5.10.7 Flood Mitigation Alternatives

5.10.7.1 By-pass Channel

The Village of Rycroft, in northwestern Alberta, has been subjected to flooding during extreme runoff events. Significant flooding occurred in June 1990, April 1996, and April 1997. The June 1990 flood had a return period of approximately 200 years. The unnamed tributary to the Spirit River, south of Highway 49 and within the Village of Rycroft is known to spill over its top of banks. Flooding has occurred over a long time within and south of the Village of Rycroft, due to surface runoff from the area south of the village.

To reduce the flooding in the Village, a by-pass channel alternative is studied. The scope of this alternative involved the assessment of flood diversion to the Spirit River at conceptual stage. The concept of this alternative is diverting flow of 3 m^3/s from unnamed tributary into the Spirit River.

The assessment was a desktop review of available information. The design components include inlet structure, by-pass channel and a culvert. The capacity of the Spirit River for flood discharge has not been assessed in this study and it was assumed that the by-pass flow can be accommodated.

Overview and Assumptions

In order to reduce discharges through the Village of Rycroft, a diversion channel for diverting flow from unnamed tributary can be constructed that will reduce the 1:100 year flow rate flowing through the Village of Rycroft. It is proposed that of the total 4.4 m^3/s (1:100 year) flow, 3.0 m^3/s would route to the Spirit River and the remaining 1.4 $^3/s$ would flow through the village. The by-pass channel is shown on Figure 5-10-3.

The following assumptions have been made for the assessment of the diversion channel:

- Village of Rycroft can handle a peak discharge event of 1.4 m^3/s based on the existing channel capacity.
- Additional studies would need to be conducted on the ability of Spirit River to accommodate the increased flow and volume that would result from an increase in the diversion from unnamed tributary during a flood event.

Design Flow

Based on AECOM's 2009 flood frequency analysis, the 1:100 year flow is estimated to be 4.4 m^3/s at the Village of Rycroft. This flow rate was adopted as the design discharge for the by-pass channel. So, the by-pass channel would be constructed such that a peak flow of approximately 1.4 m^3/s would be routed through the Village of Rycroft and approximately 3.0 m^3/s would be routed through the by-pass channel into the Spirit River during the 1:100 year flood.

Conceptual Design

Bypass Channel

An approximately 1.7 km long by-pass channel was considered to divert water from unnamed tributary to Spirit River. The By-pass channel is designed based on 3.0 m^3/s design discharge. The upstream and downstream invert of the channel is 605.7 m and 604.0 m. The channel was designed as a trapezoidal section with bed width 2.5 m and longitudinal slope 0.1 %. Based on the proposed by-pass channel cross-section, the estimated flow velocity is 0.7 m/s and flow depth during 1:100 year flood event is 0.9 m. The proposed by-pass channel will be lined with grass to provide erosion protection. The side slope was set at 3H:1V. By-pass alignment and profile are shown on Figure 5-10-4 and 5-10-5. Figure 5-10-6 illustrates the channel cross-section.

Spirit River

The proposed by-pass channel will divert water into the Spirit River. To divert 3 m^3/s in Spirit River, it should be confirmed that the river has enough capacity and that the flow will diverted in a controlled manner. Additional study will be required to analyze the impact of additional flow into the Spirit River.

Headworks

The proposed headworks location for this alternative is approximately 55.7525°N and 118.7097°W. The major structures include 6.5 m long diversion weir and removing or abandoning of 1x900 mm corrugated steel pipe (CSP) culvert and the existing 900 mm CSP will control a maximum flow of 1.4 m^3/s downstream.

Control Structure Design

Two control structures will be required to maintain the flow of 1.4 m^3/s through the Village of Rycroft and 3.0 m^3/s diverted into the by-pass channel. HEC-RAS model was developed to estimate the 1:100 year water surface elevation close to the control structure. Analytical approach was used to estimate the flow through the existing

2x900 mm CSP culverts and by-pass channel. A 6.5 m wide weir was used to control the flow into the by-pass channel and the weir crest of the structure was set at 606.60 m. It is proposed to remove or abandon 1x900 CSP culvert to control the flow through the Village of Rycroft. The overall headworks layout plan is shown on Figure 5-10-7 and rating curves for the control structures are presented on Figure 5-10-7.

Conflicts

A number of conflicts have been identified to construct the by-pass channel. Four existing culverts will need to be upgraded and one new culvert will need to be installed along the diversion alignment. The culverts will be upgraded at two private access roads, CN rail, Range Road 54 and a culvert will be installed at Township Road 782.

During the 1:100 year flood, the Spirit River will carry an additional 3.0 m^3/s flow due to the construction of the by-pass channel. From simple culvert capacity exercise, it seems that 1200 mm corrugated steel pipe should have enough capacity. Figure 5-10-3 shows the location of the culverts that will be upgraded or constructed.

Proposed Constructed Diversion

For the purposes of this investigation, a diversion channel is assumed with a rating curve that would limit the discharge flow rate to the Village of Rycroft to a maximum of 1.4 m^3/s for the 1:100 year flood event. Table 5-24 provides the stage versus outflow capacity for the existing culvert and the proposed weir.

Table 5-24: Rating Curve for Constructed By-pass Channel to Spirit River

Stage (m)	Inflow to diversion point (m^3/s)	Flow to Village of Rycroft (m^3/s)	Diversion to Spirit River (m^3/s)
0.0	0.00	0.00	0.00
0.1	0.02	0.02	0.00
0.2	0.09	0.09	0.00
0.3	0.20	0.20	0.00
0.4*	**0.34**	**0.34**	**0.00**
0.5	0.61	0.48	0.13
0.6	1.01	0.65	0.36
0.7	1.44	0.78	0.66
0.8	1.89	0.88	1.01
0.9	2.30	0.89	1.41
1.0	2.96	1.10	1.86
1.1	3.59	1.25	2.34
1.2	4.21	1.35	2.86
1.25**	**4.53**	**1.40**	**3.13**
1.3	4.87	1.45	3.42
1.4	5.58	1.58	4.00
1.5	6.26	1.65	4.61

**Weir Crest Elevation, **1:100 year Water Surface Elevation*

5.10.8 Conceptual Cost Estimate

The cost estimate for by-pass channel is in the order of $2.6 million, in 2015 dollars, as summarized in Table 5-25. The estimate includes a 10% mobilization and demobilization and 40% contingency. The cost estimate does not include the following:

- Cost to mitigate any environmental losses
- All cost associated with increased flow in the Spirit River, including channel improvements, erosion protection.
- Cost of utility trench and pipeline realignment
- Land acquisition/purchase

Table 5-25: By-pass Channel - Conceptual Cost Estimate

Item	Total Cost ($)
Inlet Control Structure	
Removal of 1x900 CSP Culvert	$3,000
6.5 m long Diversion Weir	$50,000
Channel	
Stripping	$108,840
Excavation	$1,100,000
Hydroseed	$100,000
Culverts	
Private Road 1x1200mm CSP	$12,000
CN Rail 1x1200mm CSP – Trenchless Installation	$60,000
Private Road 1x1200mm CSP	$12,000
Range Road 54 1x1200mm CSP	$14,400
Township Road 782 1x1200mm CSP – Trenchless Installation	$90,000
Outlet Structure	
Riprap Chute	$150,000
Sub-Total	**$1,701,000**
Mobilization & Demobilization (10%)	$170,100
Contingency (40%)	$680,400
Estimated Total	**$2,600,000**

5.10.9 Evaluation of Alternative

The conceptual cost of implementing the proposed by-pass channel is $2.6 million. The cost of flooding repairs in the past is unknown. It may be more cost effective to pay for flood damage repairs as they occur, it is likely that flooding will remain a concern and may cause major damage to infrastructure. Residents and farmers may continue to construct temporary ditches to convey runoff from their land, which can redirect flood waters to important public infrastructure, such as the power station in the southeast corner of the village. Repairs to such infrastructure may result in costly repair fees, and may also affect the utilities which are available to the residents in the town. Additionally, farmlands surrounding the village may be impacted by standing water and not be accessible for some time due to flooding, and crop production may be effected.

5.10.10 Environmental Review of Flood Mitigation Alternative

AECOM conducted an environmental overview desktop review for proposed flood mitigation works in the Village of Rycroft. The purpose was to compile information on existing conditions and to provide commentary on potential permitting requirements associated with possible flood mitigation options. The desktop review consisted of examining a variety of publically available ecological databases and reports. This desktop review does not follow the format of an Environmental Impact Assessment (EIA) due to the limited engineering, hydrological, geotechnical, hydrogeological, and geological information available for the location. This is considered an environmental overview desktop report and is intended as a general guidance document outlining some of the major environmental concerns and regulatory issues associated with potential flood mitigation projects, and their surrounding area.

Various databases were searched to identify environmental factors within the Rycroft Area of Interest (AOI).

5.10.10.1 Wildlife and Species at Risk

Within the 20 km search radius of the Rycroft AOI two birds and one mammals were listed by AESRD, Alberta *Wildlife Act*, COSEWIC, and/or SARA. In total, there are three species with an AESRD general status of “At Risk”, “May be at Risk” or “Sensitive” and one species listed with a SARA status of “Special Concern”, “Threatened” or “Endangered”. These species are:

- Birds:
  - Barred Owl
  - Trumpeter Swan
- Mammals:
  - Woodland Caribou

5.10.10.2 Fisheries

The unnamed stream running through the Rycroft AOI is an unmapped Class D stream with no Restricted Activity Period (AESRD 2015b). The Spirit River is a mapped Class D stream, which also has no RAP (AESRD 2015b).

No fish species were documented in the unnamed stream. Two non-sportfish species have been documented in the Spirit River For a detailed list of these fish species, and their provincial status, refer to Appendix D – Environmental Overview.

5.10.10.3 Applicable Legislation

For the Rycroft AOI, there are a number of legislations which may be applicable to the mitigation alternative including:

- *Canadian Environmental Assessment Act*
- *Land Use Bylaw No. 77-07*
- *Fisheries Act*
- *Migratory Birds Convention Act*
- *Water Act*
- *Alberta Wetland Policy*
- *Historical Resources Act*
- *Provincial Parks Act*

- *Public Lands Act*
- *Wilderness Areas Ecological Reserves, Natural Areas and Heritage Rangelands Act*
- *Alberta Wildlife Act*

See Appendix D for further detail on the Applicable Legislation for the Rycroft AOI.

5.10.10.4 Discussion and Summary

The following environmental elements identified in the Rycroft AOI:

- Parkland Natural Region, Peace River Parkland Subregion
- Open water wetlands
- 3 species with AESRD general listing, 1 species with SARA listing
- Migratory Bird Timing Window of April 15 – August 31
- Project submission to CEAA to determine if EA is required

Required permitting and approvals are subject to change based on the final project design. Table 25 in Appendix D summarizes potential considerations which may be required in order for the project to adhere to applicable legislation.

5.10.11 Geotechnical Review of Flood Mitigation Alternative

5.10.11.1 Introduction

It is understood that a diversion channel from an unnamed tributary to the Spirit River is proposed near the Village of Rycroft. This assessment contains a desk study of the surficial geology of the proposed alignment and highlights potential issues. The proposed ditch is to be approximately 4.4 m deep at its deepest point. Preliminary recommendations are also provided for channel stability.

5.10.11.2 Methodology

Geological maps of Alberta from the Alberta Geological Survey were consulted to determine surficial geology of the proposed alignment. Water well drilling records in the area were checked however no stratigraphic data was available from them.

5.10.11.3 Subsurface Conditions

The proposed diversion channel alignment runs primarily through glaciolacustrine deposits.

Glaciolacustrine Deposits

Glaciolacustrine deposits material deposited within lakes by meltwater from glaciers. Glaciolacustrine deposits are primarily fine-grained sediments of clay in central portion of the lake and alternate layers of silty clay or silt and clay (varved clay) in peripheral zones. These deposits are weak, compressible and very uniform in a horizontal direction.

5.10.11.4 Discussion and Recommendations

Side Slopes

Glaciolacustrine deposits are anticipated to be encountered along the proposed channel alignment. Soil type should be confirmed during construction by drilling test holes. Cut slopes in low to medium plastic clay till or clay soils up to depths of 3 m should be sloped no steeper than 2.5H:1V. If high plastic clay is encountered, cut slopes should be sloped no steeper than 5H:1V. Areas where a high water table is encountered or areas of increased sand content will require the side slopes to be flattened. Plasticity and strength parameters should be confirmed during detailed design stage. An intrusive investigation should be conducted prior to construction to confirm subsurface conditions.

Erosion

All permanent slopes should be provided with some form of erosion protection to minimize potential of scour and erosion of the slope face. Erosion control synthetic mats or rip rap, and/or topsoil and seeding with a native seed mixture should be considered.

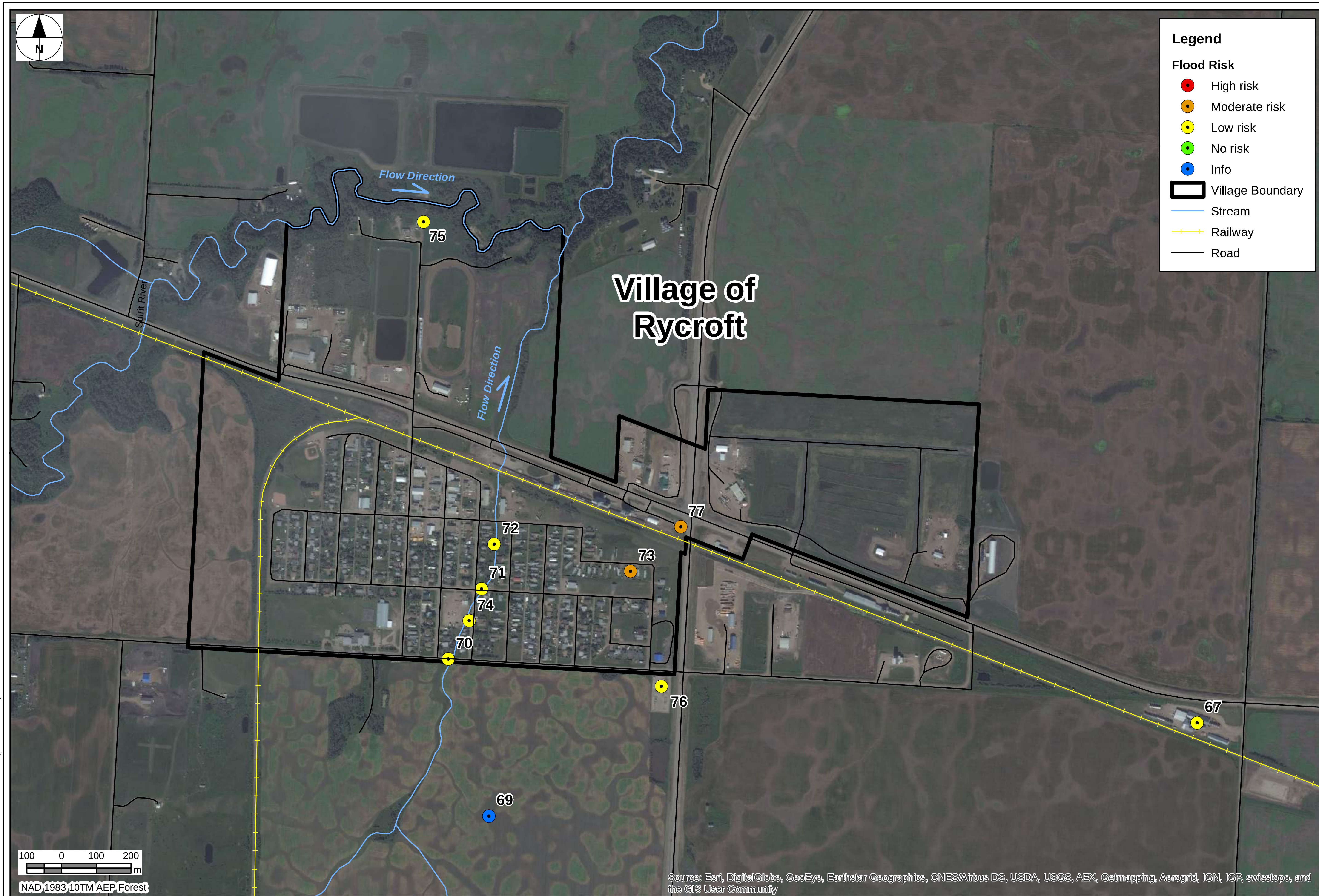
5.10.12 Conclusions and Recommendations

Currently along the unnamed tributary, the flooding affects a large residential and commercial area within the developed part of the Village of Rycroft and a small agricultural area north of Highway 49. The flooding also affects residential backyards, commercial areas and streets in the Village of Rycroft.

In general, it can be said that the flooding within the Village of Rycroft is due to insufficient land drainage south of and through the Village of Rycroft. The unnamed tributary though the village is best described as a ditch that flows through residential backyards and commercial properties. During large discharges in the unnamed tributary, the flow overtops the banks of the tributary and flows overland toward the east where it ponds before draining through an adjacent drainage system.

The proposed by-pass channel would cost approximately $2.6 million and would consist of inlet control structure, by-pass channel, and outlet structure. The inlet control structure will be required to maintain the flow of 1.4 m^3/s through the Village of Rycroft and 3.0 m^3/s diverted into the by-pass channel. The by-pass channel is designed as a trapezoidal section with bed with 2.5 m and longitudinal slope of 0.1% and 3H:1V side slopes. The by-pass channel would be lined with grass and no additional erosion protection is required since the velocities do not exceed 0.8 m/s.

It is recommended that the Village of Rycroft explore other alternatives such as improving the capacity of the unnamed tributary and upgrading all culverts along the unnamed tributary through the Village, to convey 1:00 year flow and to prevent water back up.



AECOM

Figure: 5-10-1

Village of Rycroft
Stakeholder Identified Historical Flood Issues

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

June 1990 flood. Looking west toward the Village of Rycroft from Highway 2. Photo provided by the Village of Rycroft for previous study by AECOM.

April 1996 flood. Looking west along the south side of the railway line from Highway 2. Photo provided by the Village of Rycroft from a previous study by AECOM.

April 1996 flood. Start of overtopping of Hwy 49 near Hwy 2. Photo provided by the Village of Rycroft for a previous study by AECOM.

April 1997 flood. Flooding in Rycroft immediately west of Highway 2. Photo provided by the Village of Rycroft for a previous study by AECOM.

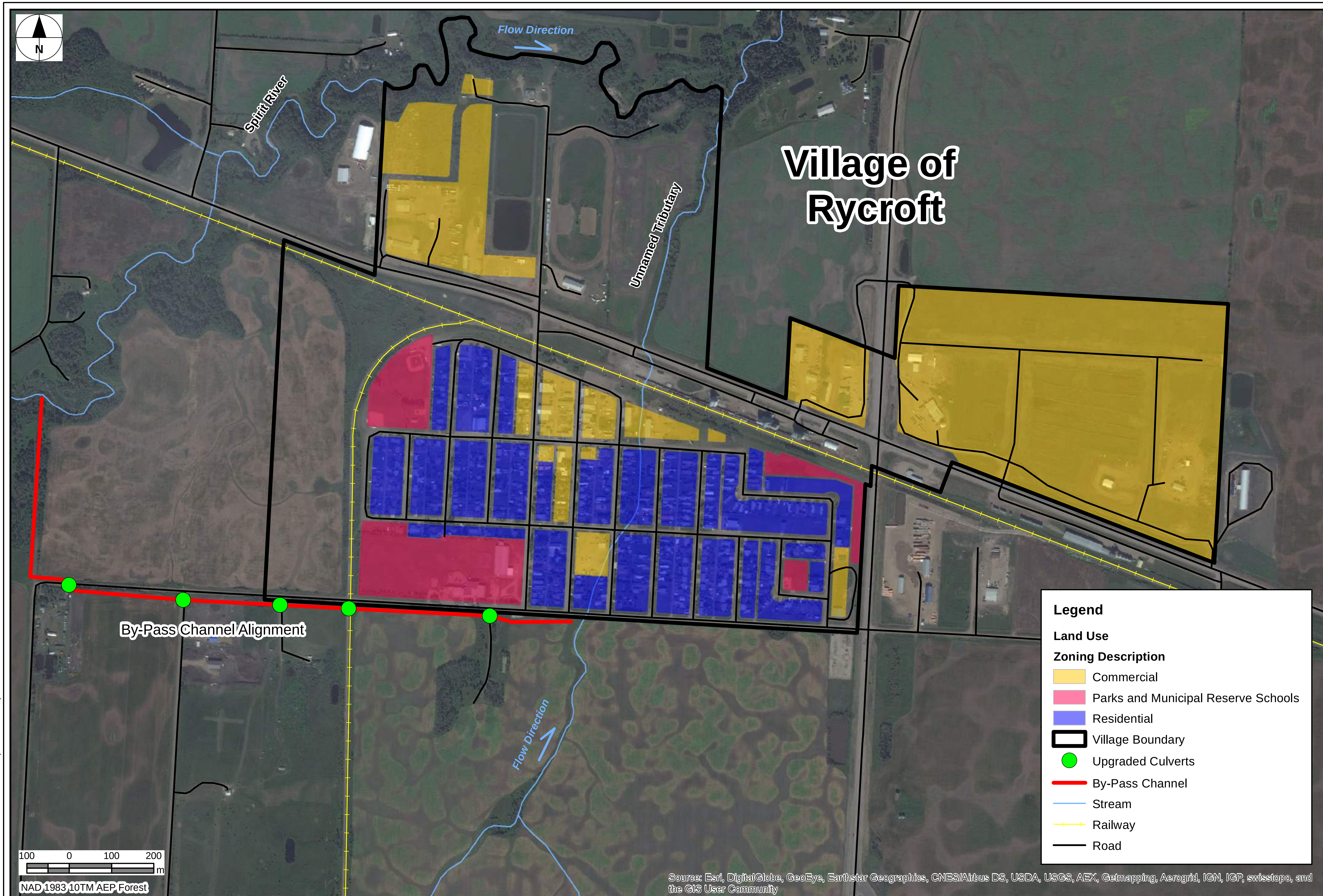
Image Source: Village of Rycroft

AECOM

Figure: 5-10-2

Village of Rycroft
Flood Event Photos

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment andSustainable Resource Development
Project No.: 60334569

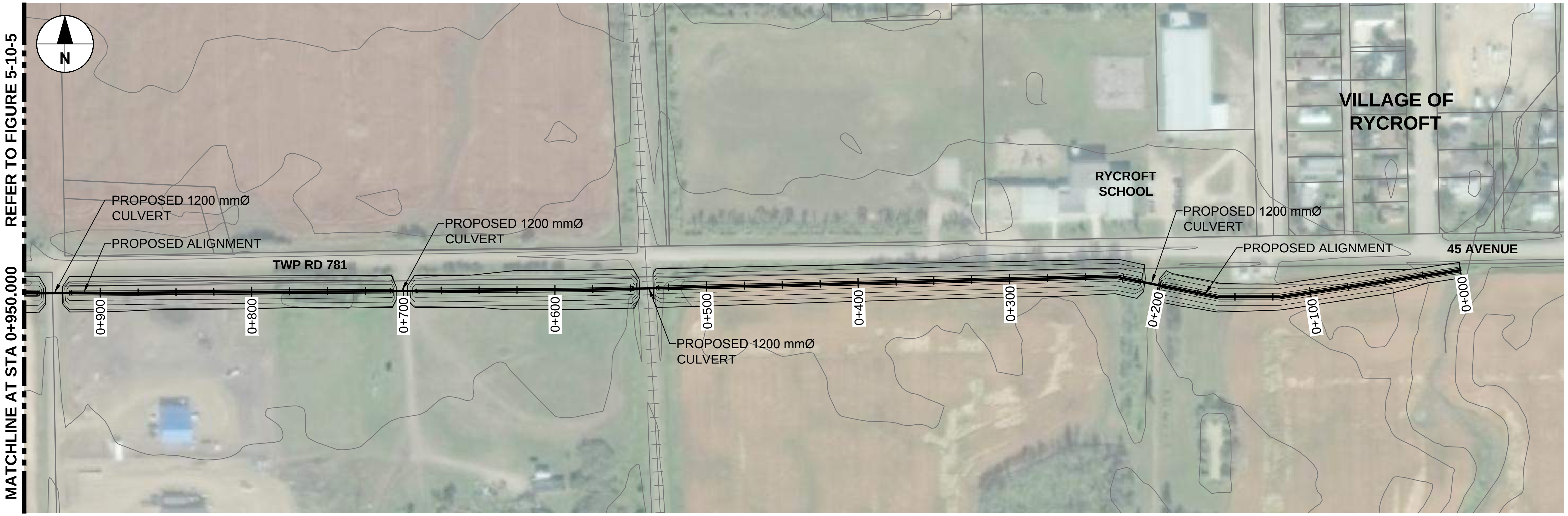


AECOM

Figure: 5-10-3

Village of Rycroft
Existing Land Use and Zoning Map
with By-pass Alignment

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569



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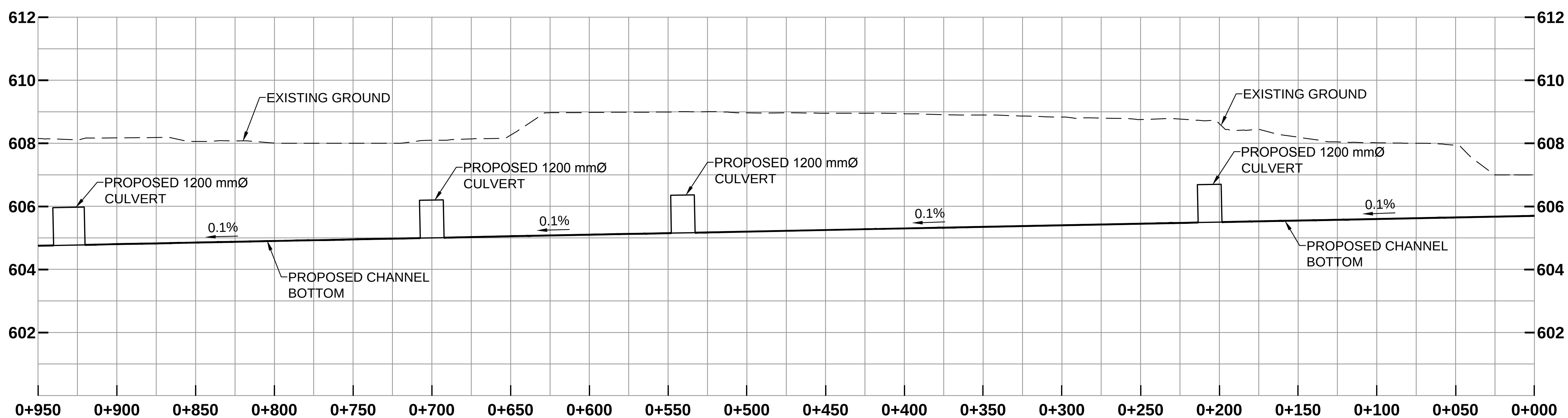

PROFILE

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AECOM

Figure: 5-10-4

Village of Rycroft
By-Pass Channel
Plan and Profile 1 of 2

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

ANSI B 279.4mm x 431.8mm

Project Management Initials: Designer: Checked: Approved:

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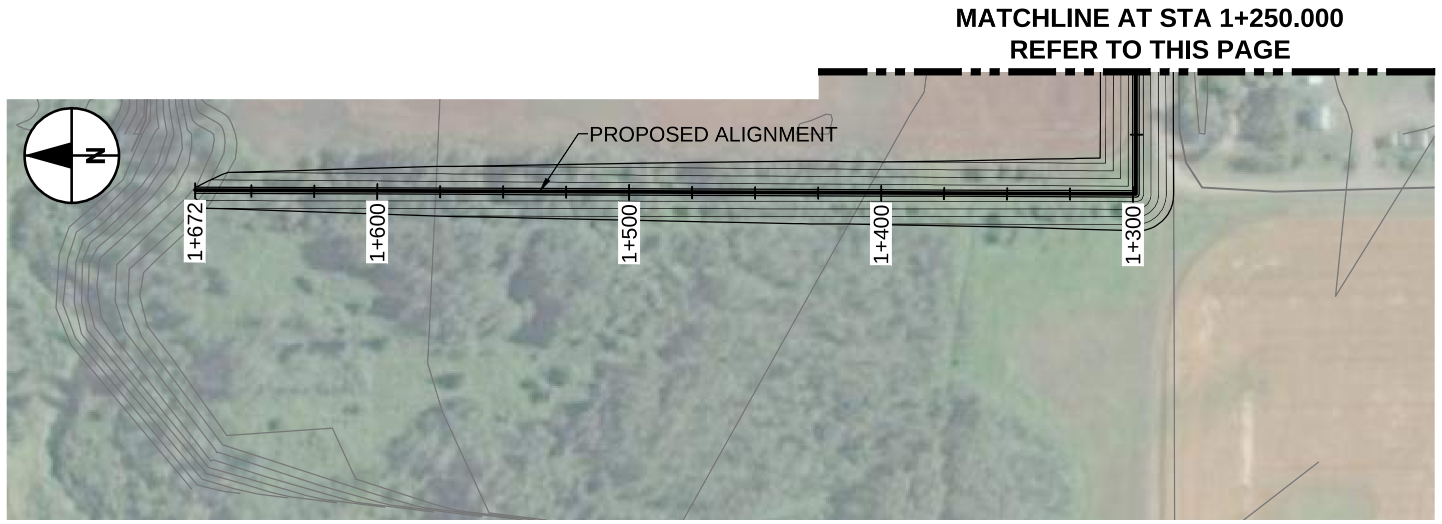
Filename: P:\60334569\900-WORK\910-CAD\25-SKETCHES\C\VILLAGE OF RYCROFT\FIGURE 5-10-4.DWG



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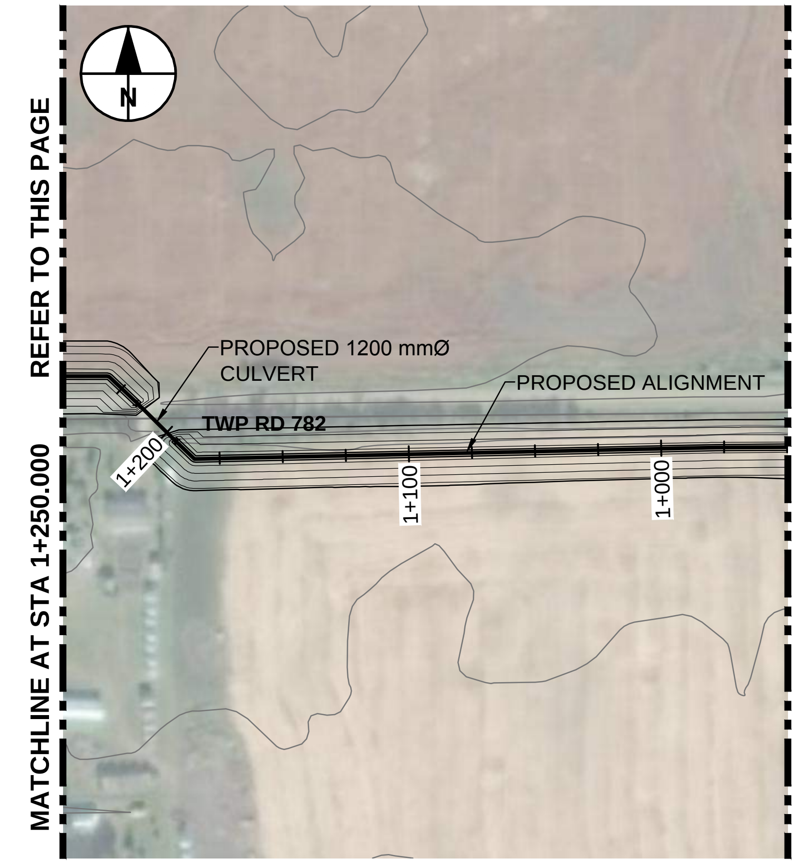

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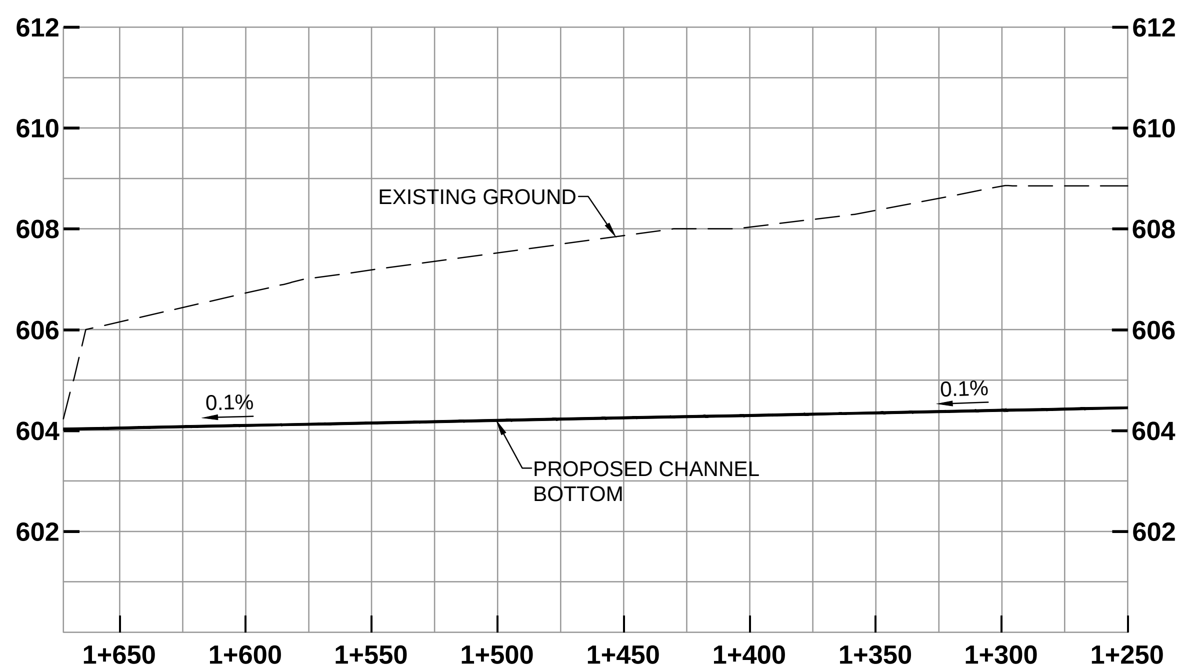

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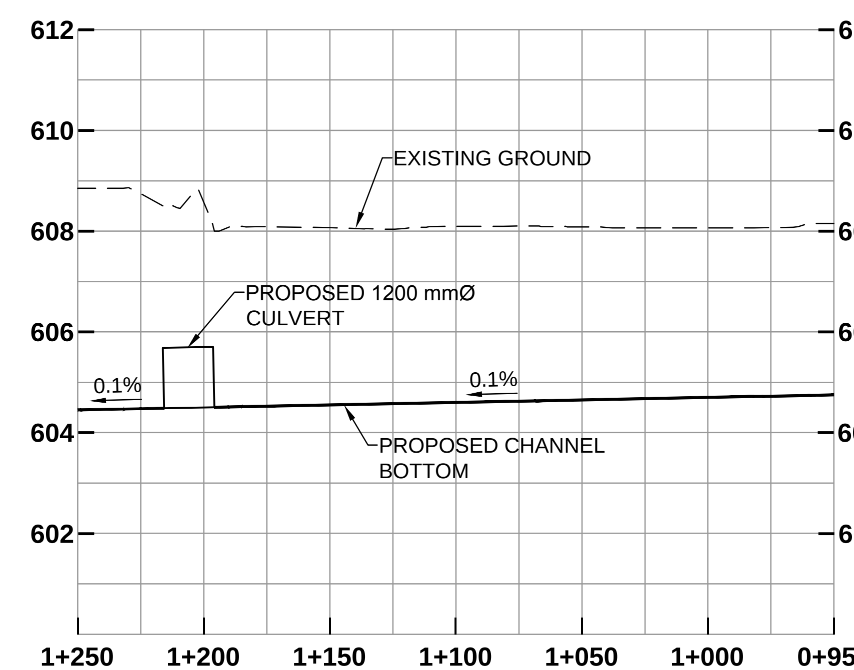

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AECOM

Figure: 5-10-5

Village of Rycroft
By-Pass Channel
Plan and Profile 2 of 2

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

Project Management Initials: Designer: Checked: Approved: ANSI B 279.4mm x 431.8mm

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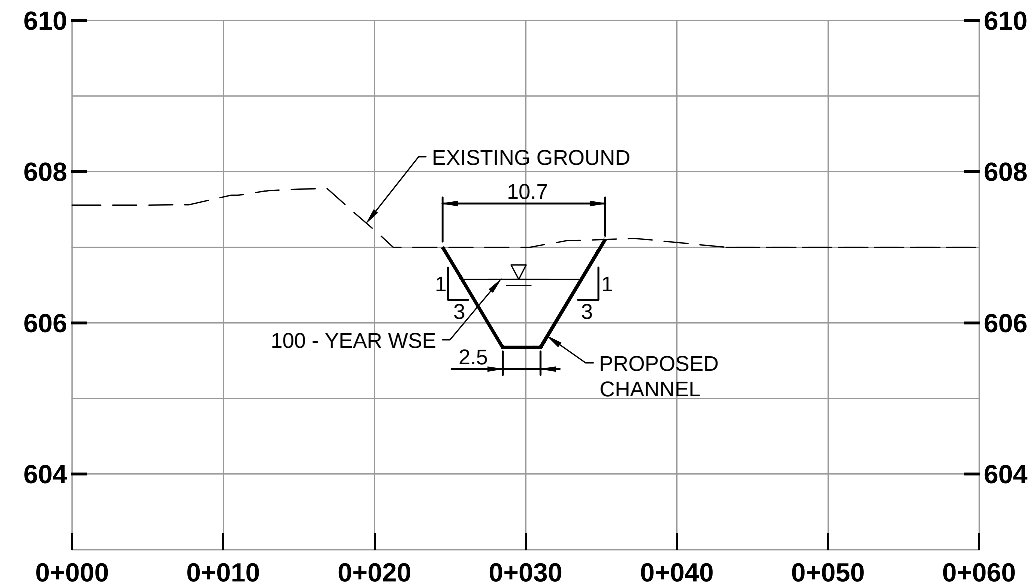
Filename: P:\60334569\900-WORK\910-CAD\25-SKETCHES\C\VILLAGE OF RYCROFT\FIGURE 5-10-5.DWG



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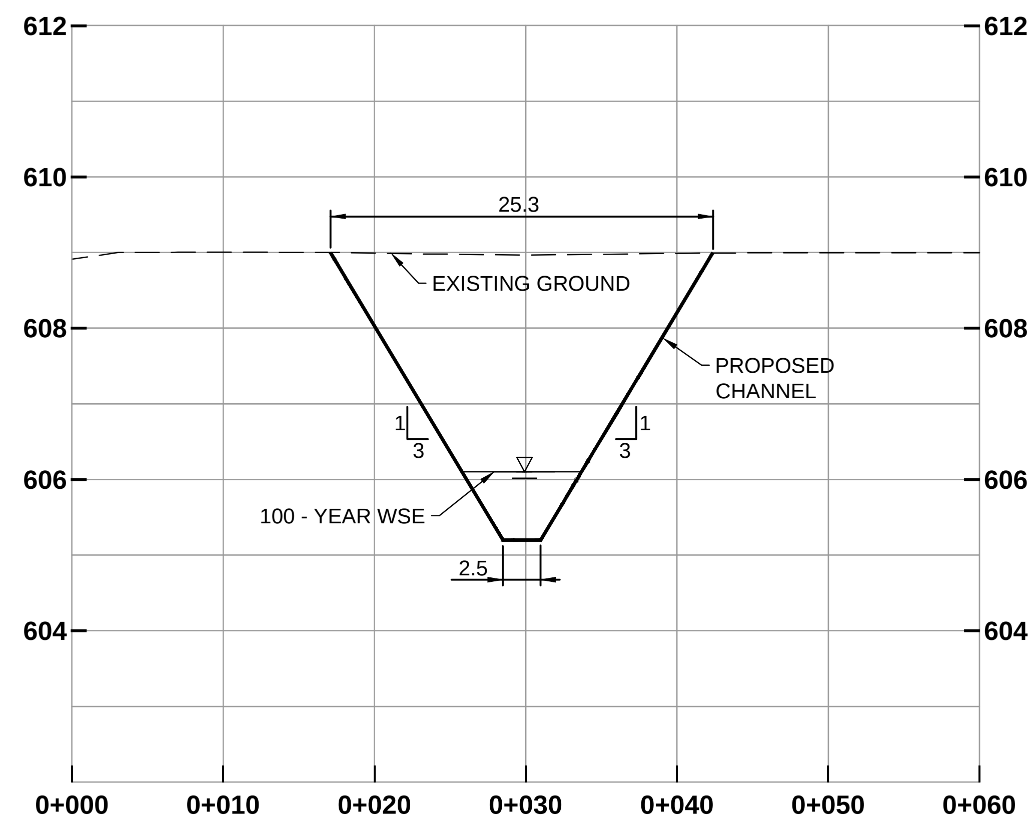
m
0 2 4 6 V=1:200

STATION 0+025.000



SECTION

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m
0 2 4 6 V=1:200

STATION 0+500.000

AECOM

Figure: 5-10-6

Village of Rycroft
By-Pass Channel
Cross Sections

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

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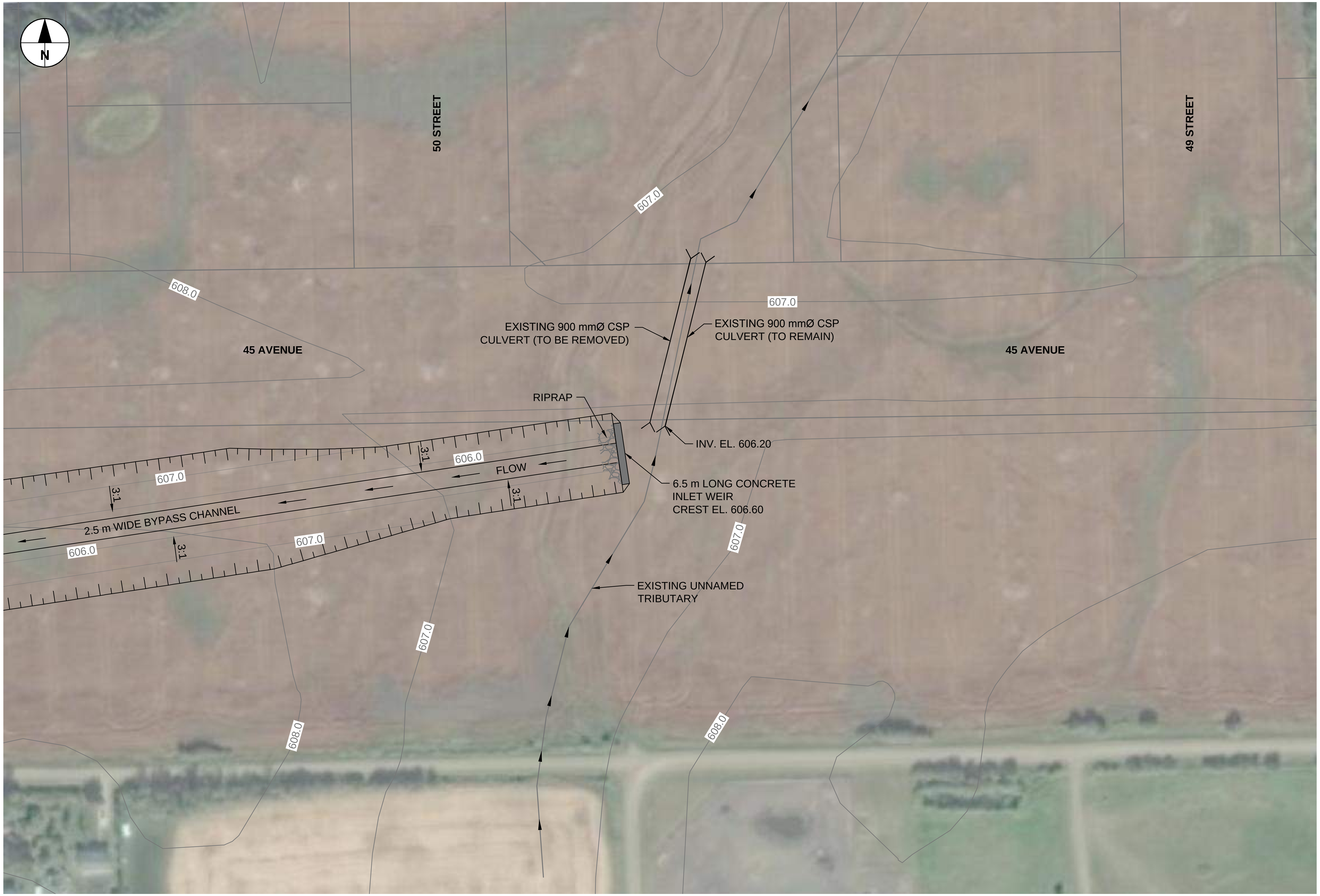

PLAN

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Village of Rycroft
By-Pass Channel
Conceptual Headworks Plan

Figure: 5-10-7

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

ANSI B 279.4mm x 431.8mm

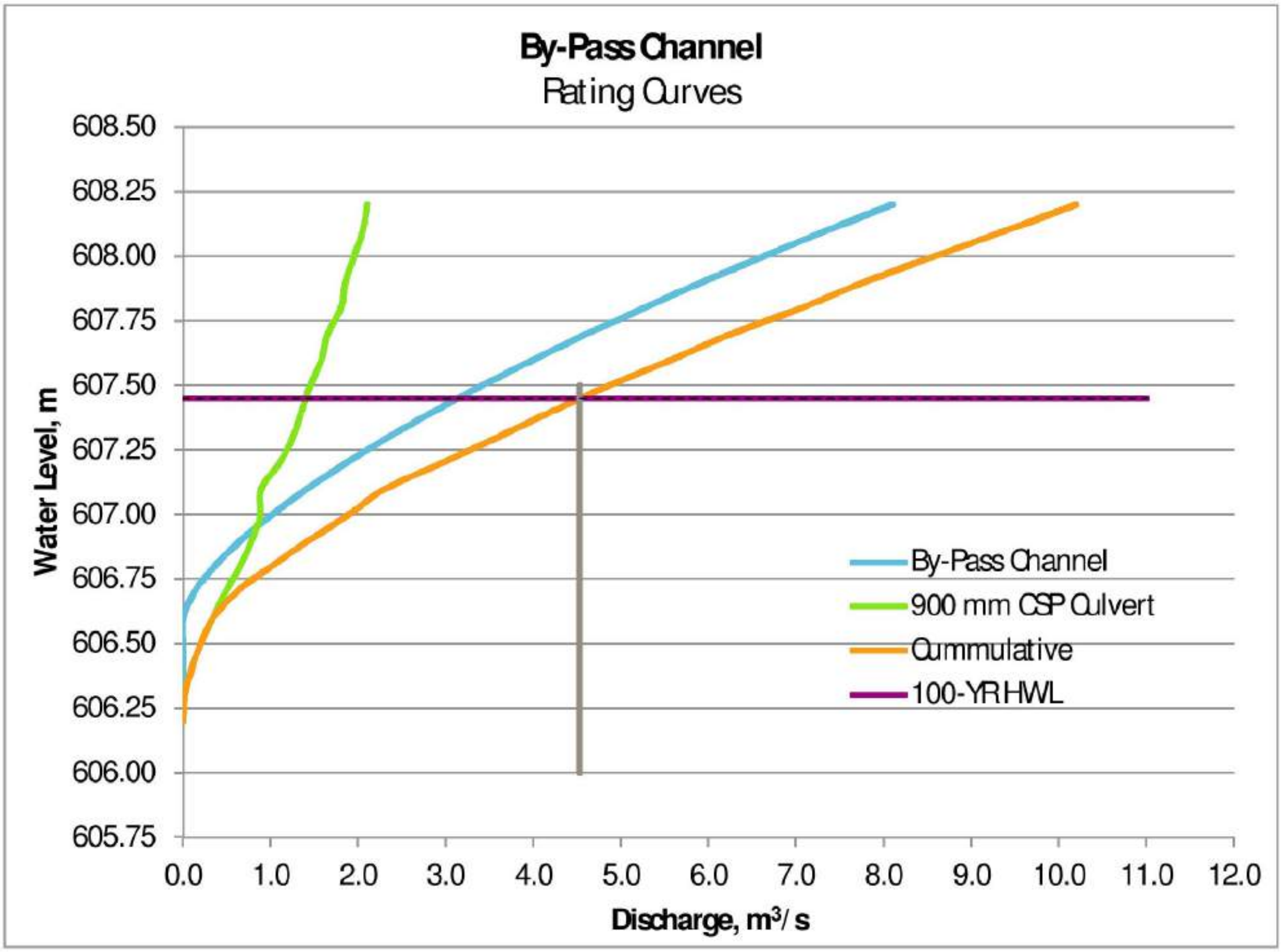
Approved:

Checked:

Designer:

Project Management Initials:

Last saved by: DANIELSC(2015-07-06) Last Plotted: 2015-07-06
Filename: P:\60334569\900-WORK\910-CAD\25-SKETCHES\C\VILLAGE OF RYCROFT\FIGURE 5-10-7.DWG



Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

Village of Rycroft
Rating Curve for Proposed Weir and Existing 900mm CSP Culvert

AECOM

Figure: 5-10-8

5.11 Hamlet of La Crete / Buffalo Head Prairie

5.11.1 Background

The Buffalo Head Prairie area is located south of the Hamlet of La Crete, in Mackenzie County. The area appears to be a moderate flood risk community due to reported flood issues and impacts on structures and residents. The location of the Hamlet of La Crete, and the Buffalo Head Prairie area within the Peace River Basin are shown on Figure 5-2.

5.11.2 Historical Flood and Erosion Issues

Stakeholder identified historical flood issues are shown in Figure 5-11-1. The location of each reported flood issue is numbered with a map ID and classified as high, moderate or low risk. Each issue can be found by the corresponding map ID in Table A-1 in Appendix A.

In 2013, the Buffalo Head Prairie area experienced significant snow melt which resulted in flooding. A stakeholder meeting held with Mackenzie County established that there is approximately 8,000 hectares of farm land in the area which floods annually. The spring runoff from the area flows northwest to Bear River, which then overflows its banks and floods the farmland. Through engagement with Mackenzie County, it was indicated that the flooding caused damage to public infrastructure. Additionally, it was reported that there is annual erosion issues due to fast flowing spring runoff in the area.

The County has submitted an application to AESRD’s Alberta Community Resilience Program (ACRP) Grant Application. The application is for the construction of a flood control channel with retention pond in the Buffalo Head Prairie Area in order to mitigate flooding due to overland flow. The diversion channel will route overland flows west to Steephill Creek.

5.11.3 Flood Hazard Mapping

There is no flood hazard mapping available for the Hamlet of La Crete or Buffalo Head Prairie.

5.11.4 Land Use

Land use and zoning maps were requested; however, none were available at the time of this study. Most of the subject area consists of privately owned farm land located south of the Hamlet of La Crete. Some of the land is owned by the province. The Buffalo Head Prairie store is located west of Highway 697, and currently, water ponding in this area is an issue due to poor drainage. There is no land use mapping available for the Buffalo Head Prairie area.

5.11.5 Flood Mitigation Alternative

5.11.5.1 Buffalo Head Prairie Drainage Improvements Study (2014) Review

The County retained DCL Siemens Engineering Ltd. (DCL) to perform a study on the Drainage Improvements for Buffalo Head Prairie. In January 2014, an interim report, titled Buffalo Head Prairie Drainage Improvements, was submitted by DCL to Mackenzie County which included three flood mitigation alternatives. All three alternatives provided a diversion channel running from east to west towards the Steephill Creek in order to capture runoff from the upstream areas to the south, and prevent flooding of Buffalo Head Prairie area. The first two diversion channel alignments presented in the interim report are identical, but differ in the channel slopes, and as a result the amount of required excavation differs between the alternatives. Alternative 3 presented in the interim report partially utilizes existing ditches along Highway 697 and is approximately 400 m further south than the other two mitigation alternative alignments. Additionally, Option 3 diversion alignment starts approximately 500 m west of the Bear River and crosses Highway 697. Figure 5-11-2 shows the alignment of the chosen diversion channel. In the interim report it was recommended that for all alternatives, a ponding area be provided in addition to the diversion channel in order to provide relief to the Steephill Creek during high flow events (DCL Siemens Engineering Ltd., 2014a).

Following submission of the interim report to the Mackenzie County, one alternative was chosen to proceed to preliminary design stage and a report was prepared by DCL which analysed the chosen flood mitigation method. Alternative 3 was analysed in the Buffalo Head Prairie Drainage Preliminary Design Report produced by DCL (2014b). An analysis was completed by DCL using XP-SWMM, using snow depth and melt data from the Town of High Level and the Hamlet of Fort Vermilion.

Runoff generated from a drainage area of 80 km^2 will be diverted to proposed retention pond located on the east of the Steephill Creek without having a significant impact on the Peace River Basin. Flooding and erosion will be reduced by a proposed retention pond which will have a capacity of 200,000 m^3, as reported by DCL. It should be noted that AECOM did not have access to the XP-SWMM model created by DCL for peak discharge calculation.

<u>Design Flow Estimation</u>

AECOM used XP-SWMM to model the estimated peak discharge conveyed in the diversion channel, modelling a combination of snowmelt and rainfall event. The estimation of April/May snowmelt peak flow and the simulation of rainfall during the snowmelt time were modeled using the XP-SWMM hydrodynamic model. The hydrological processes considered in the model are an extreme rainfall record, depression storage, surface runoff, infiltration and evaporation. The snowmelt runoff is based on an historical extreme temperature, snowmelt coefficient and snow depth record for the snowmelt season. Other initial model input parameters are specifically chosen according to basin characteristics such as delineated basin area, slope, basin wide and imperviousness ratio. The model indicated that the peak flow conveyed into the diversion channel is approximately 51.5 m^3/s. The following parameters were used to establish the peak flow:

- Total Area = 8000 ha
- Basin Width = 6200 m
- Slope = 2.5%
- Rainfall depth of 2 year 6 hour storm event in Notikewin = 34.5 mm
- Extreme temperature recorded = 32.2°C
- Extreme snow depth in April = 10 cm
- Impervious ratio = 40% (Assumes approximately 40% of the ground is frozen during snowmelt)

<u>Diversion Channel Capacity Estimation</u>

For the purposes of this study, AECOM used Bentley FlowMaster, a hydraulic analysis and design software, to determine whether the channel proposed by DCL is able to convey the peak flow for the Buffalo Head Prairie Area. The channel slope used in the analysis is the weighted average of the channel slopes as reported in DCL's interim report. The general cross section (3 m wide bottom, 2H:1V side slopes, and 3 m channel depth) of the channel provided in DCL's preliminary design report is unable to convey this flow, as it has a capacity of approximately 47 m^3/s. It is recommended that the cross section be increased to have 3H:1V side slopes, and a 3.5 m wide bottom. With a flow of 51.5 m^3/s, the water depth would be 2.7 m, allowing for a 0.3 m freeboard, given a total channel depth of 3 m.

5.11.6 Conceptual Cost Estimate

A conceptual cost estimate was prepared by DCL and is reported in the Buffalo Head Prairie Drainage Preliminary Design Report (2014), based on the diversion channel alternative chosen for the report. The total estimated cost for the project, including the excavation of the diversion channel, retention pond, as well as contingency and engineering fees was reported to be \$6.8 million, in 2014 dollars. The total estimated cost based on AECOM's recommended channel, as described in the section above, using estimated 2015 unit rates, is in the order of \$19.7 million, as summarized in Table 5-26. The cost estimate does not include the following:

- Cost to mitigate any environmental losses
- All cost associated with increased flow in the Steephill Creek, including channel improvements, erosion protection.
- Cost of utility trench and pipeline realignment
- Land acquisition/purchase
- Upgrades required for stormwater retention pond
- Additional riprap required for check dams

The cost estimate is based on the following assumptions and should be confirmed during detail design stage.

- The by-pass channel should have 3.5 m wide bottom, 3H:1V side slopes and 2 m high embankment on north and south side of the channel.
- The excavation quantities are based on 3 m cut along the by-pass channel alignment.
- 1000 mm CSP culverts are proposed at every 500 m interval, under the south berm to convey runoff into the by-pass channel.
- The channel and stormwater pond excavation unit price cost of \$4/m^3 as mentioned in the preliminary report DCL Siemens Engineering seems to be on the lower side and it is recommended to use unit price indicated below.
  - \$10 excavation cost for stormwater pond is based on haul distance of 2 km.
  - \$7.50 excavation cost for channel excavation is based on haul distance of 4 km.

Table 5-26: Diversion Channel - Conceptual Cost Estimate

Item	Total Cost ($)
Diversion Channel	
Clearing and Grubbing	$918,000
Topsoil stripping and restoration	$459,000
Traffic accommodation and control	$60,000
Common excavation to be trucked off site and covered	$2,565,000
Preparation of channel subgrade and install vegetative cover c/w biodegradable straw mats	$4,590,000
Installation of rip-rap check dam every 400 m	$180,000
Install bank protection at ditch bend	$300,000
Upgrade culvert at Twp Rd 1044	$100,000
Upgrade culvert at Provincial Highway	$100,000
Install culverts under south berms	$780,000
Retention Pond	

Item	Total Cost ($)
Preparation of pond subgrade	$50,000
Common excavation of stormwater retention pond	$3,000,000
Sub-Total	**$14,279,500**
Mobilization & Demobilization (5%)	$714,000
Contingency (15%)	$2,142,000
Engineering (12%)	$1,714,000
GST (5%)	$800,000
Estimated Total	**$19,700,000**

5.11.7 Evaluation of DCL’s Diversion Channel Alternative

DCL provided a preliminary design report for Alignment alternative 3, originally described in DCL’s Buffalo Head Prairie Drainage Improvements report. This flood mitigation alternative was chosen above two other alternatives presented in DCL’s Buffalo Head Prairie Drainage Improvements report, as mentioned earlier, and is the mitigation measure that the County has submitted to ACRP. Benefits of this alternative compared to the other two, are that the alignment (DCL, 2014a):

- Reduces the potential for flooding of the Buffalo Head Prairie store, located west of Highway 697, which has been an issue in the past;
- Utilizes an existing south and north drainage ditch (Buffalo Head Prairie Drainage Improvements, 2014).

5.11.8 Environmental Review of Flood Mitigation Alternative

AECOM conducted an environmental overview desktop review for proposed flood mitigation works in the Hamlet of La Crete/Buffalo Head Prairie. The purpose was to compile information on existing conditions and to provide commentary on potential permitting requirements associated with possible flood mitigation options. The desktop review consisted of examining a variety of publically available ecological databases and reports. This desktop review does not follow the format of an Environmental Impact Assessment (EIA) due to the limited engineering, hydrological, geotechnical, hydrogeological, and geological information available for the location. This is considered an environmental overview desktop report and is intended as a general guidance document outlining some of the major environmental concerns and regulatory issues associated with potential flood mitigation projects, and their surrounding area.

Various databases were searched to identify environmental factors within the Buffalo Head Prairie Area of Interest (AOI).

5.11.8.1 Wildlife and Species at Risk

Within the 20 km search radius of the Buffalo Head Prairie AOI 36 birds, two mammals, one reptile and two amphibians were listed by AESRD, Alberta *Wildlife Act*, COSEWIC, and/or SARA. In total, there are 41 species with an AESRD general status of “At Risk”, “May be at Risk” or “Sensitive” and six species listed with a SARA status of “Special Concern”, “Threatened” or “Endangered”. These species are listed in Table 26 of Appendix D.

5.11.8.2 Fisheries

The Buffalo Head Prairie AOI includes Steephill Creek which is a Mapped Class C Water Body with a RAP of April 16th to July 15th (AESRD 2015b). There are no records of fish occurring within Steephill Creek.

5.11.8.3 Applicable Legislation

For the Buffalo Head Prairie AOI, there are a number of legislations which may be applicable to the mitigation alternative including:

- *EPEA*
- *Fisheries Act*
- *Migratory Birds Convention Act*
- *Water Act*
- *Alberta Wetland Policy*
- *Public Lands Act*
- *Historical Resources Act*
- *Provincial Parks Act*
- *Wilderness Areas Ecological Reserves, Natural Areas and Heritage Rangelands Act*
- *Alberta Wildlife Act*

See Appendix D for further detail on the Applicable Legislation for the Buffalo Head Prairie AOI.

5.11.8.4 Discussion and Summary

The following environmental elements identified in the Buffalo Head Prairie AOI:

- Boreal Forest Natural Region, Dry Mixedwood Subregion
- HRVs of 1, 4, and 5
- 14 ESAs
- Open water, fen, marsh, and swamp wetlands
- Class C Creek with RAP of April 16 – July 15
- 41 species with AESRD general listing, 6 species with SARA listing
- Migratory Bird Timing Window of April 30 – August 15
- Project submission under EPEA to determine if EIA required

Required permitting and approvals are subject to change based on the final project design. Table 27 in Appendix D summarizes potential considerations which may be required in order for the project to adhere to applicable legislation.

5.11.9 Geotechnical Review of Flood Mitigation Alternatives

5.11.9.1 Introduction

A new flood channel is proposed to reduce runoff due to snowmelt west from Highway 697 to Steephill Creek, which eventually drains into Peace River. This assessment contains a desk study of the surficial geology of the proposed alignment and highlights potential issues. Preliminary recommendations are also provided for channel stability.

5.11.9.2 Methodology

Geological maps of Alberta from the Alberta Geological Survey were consulted to determine surficial geology of the proposed alignment. Water well drilling records in the area were checked however no stratigraphic data was available from them.

5.11.9.3 Subsurface Conditions

The proposed Buffalo Head Prairie Area water diversion alignment runs primarily through organic deposits consisting of bog peat with areas of undifferentiated organic deposits ranging from woody to fibrous peat. The alignment occasionally crosses areas of glaciolacustrine deposits. It is possible that ice-thrust moraine may also be encountered along the alignment. The following sections include expected material for each deposit.

Organic Deposits

Organic deposits contain undifferentiated peat ranging from woody to fibrous peat. The organic material is commonly underlain by fine-grained, poorly drained glaciolacustrine deposits, resulting in high moisture content material. Bog peat is expected to be the primary organic deposit encountered

Bog Peat

Bog peat typically has a fluctuating water table, with sphagnum mosses, heath shrubs and stunted trees. Bog peat occurs where a fluctuation groundwater table is encountered.

Glaciolacustrine Deposits

Glaciolacustrine deposits material deposited within lakes by meltwater from glaciers. Glaciolacustrine deposits are primarily fine-grained sediments of clay in central portion of the lake and alternate layers of silty clay or silt and clay (varved clay) in peripheral zones. These deposits are compressible and very uniform in a horizontal direction.

Ice-Thrust Moraine

Ice-thrust moraine terrain results from glacial transport of originally subglacial material deposited by the glacier more or less intact. The terrain can include till, stratified drift and/or bedrock.

5.11.9.4 Discussion and Recommendations

Suitability

The presence of peat and organic material will cause problems for the construction of a drainage system along this alignment. Difficulties in mobility of construction equipment are anticipated due to the presence of weak subgrade conditions and relatively shallow groundwater levels. High groundwater levels could potentially result in various difficulties during construction including unstable excavation and difficulties with placement and compaction of fill. The organic material will not be able to be sloped and must be removed down to the underlying glaciolacustrine deposit, depending on the thickness of the organic deposit. The groundwater table is likely to be near surface or fluctuate, which will need to be controlled or drained during construction. Areas of the alignment where glaciolacustrine deposits and ice-thrust moraine are encountered may likely be suitable for construction.

Side Slopes

Till is anticipated to be encountered along the proposed channel alignment. Cut slopes in low to medium plastic clay till or clay soils up to depths of 3 m should be sloped no steeper than 2.5H:1V. If high plastic clay is encountered, cut slopes should be sloped no steeper than 5H:1V. Areas where a high water table is encountered or areas of increased sand content will require the side slopes to be flattened. Plasticity and strength parameters should be confirmed during detailed design stage. An intrusive investigation should be conducted prior to construction to confirm subsurface conditions.

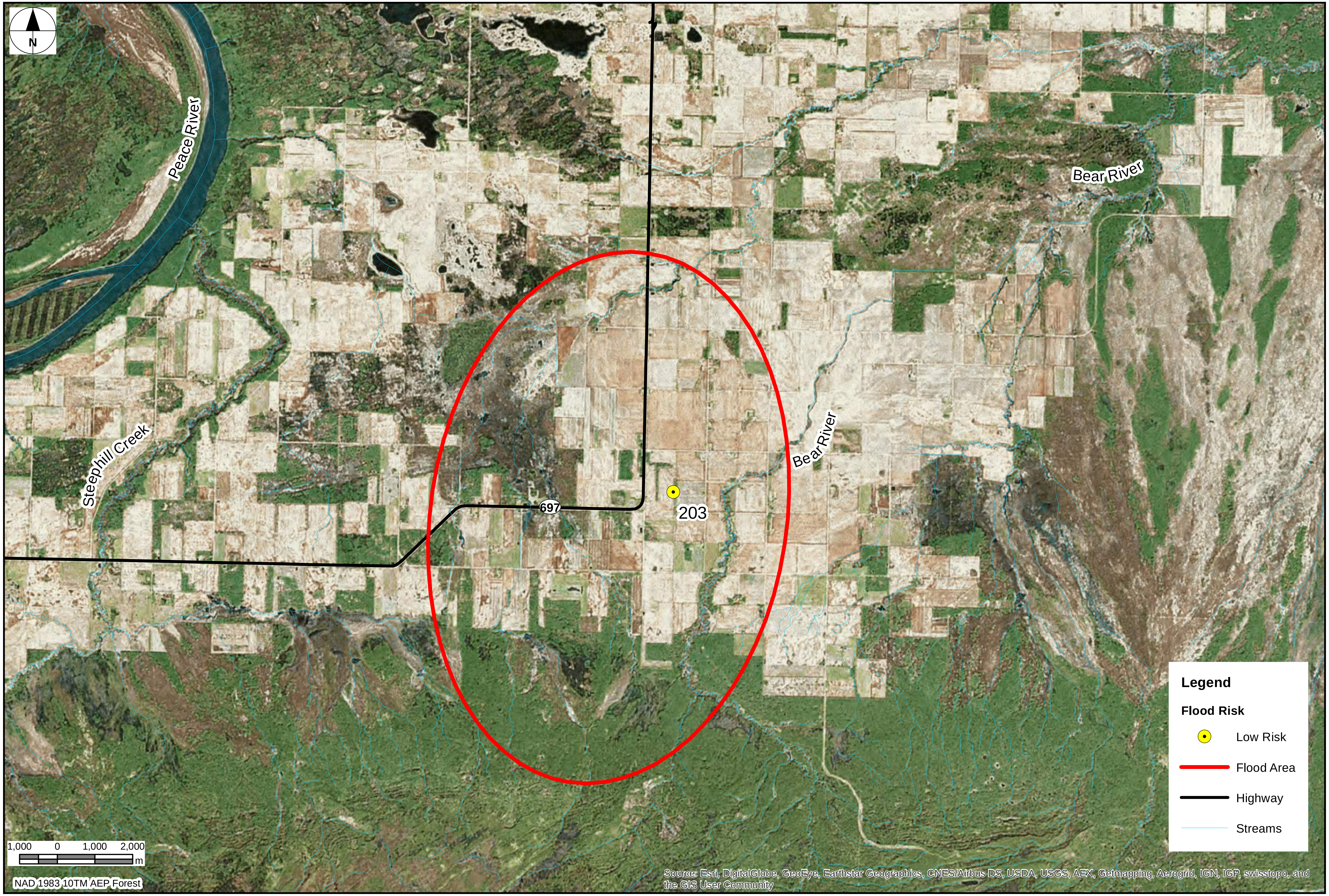
Erosion

All permanent slopes should be provided with some form of erosion protection to minimize potential of scour and erosion of the slope face. Erosion control synthetic mats or rip rap, and/or topsoil and seeding with a native seed mixture should be considered.

5.11.10 Conclusions and Recommendations

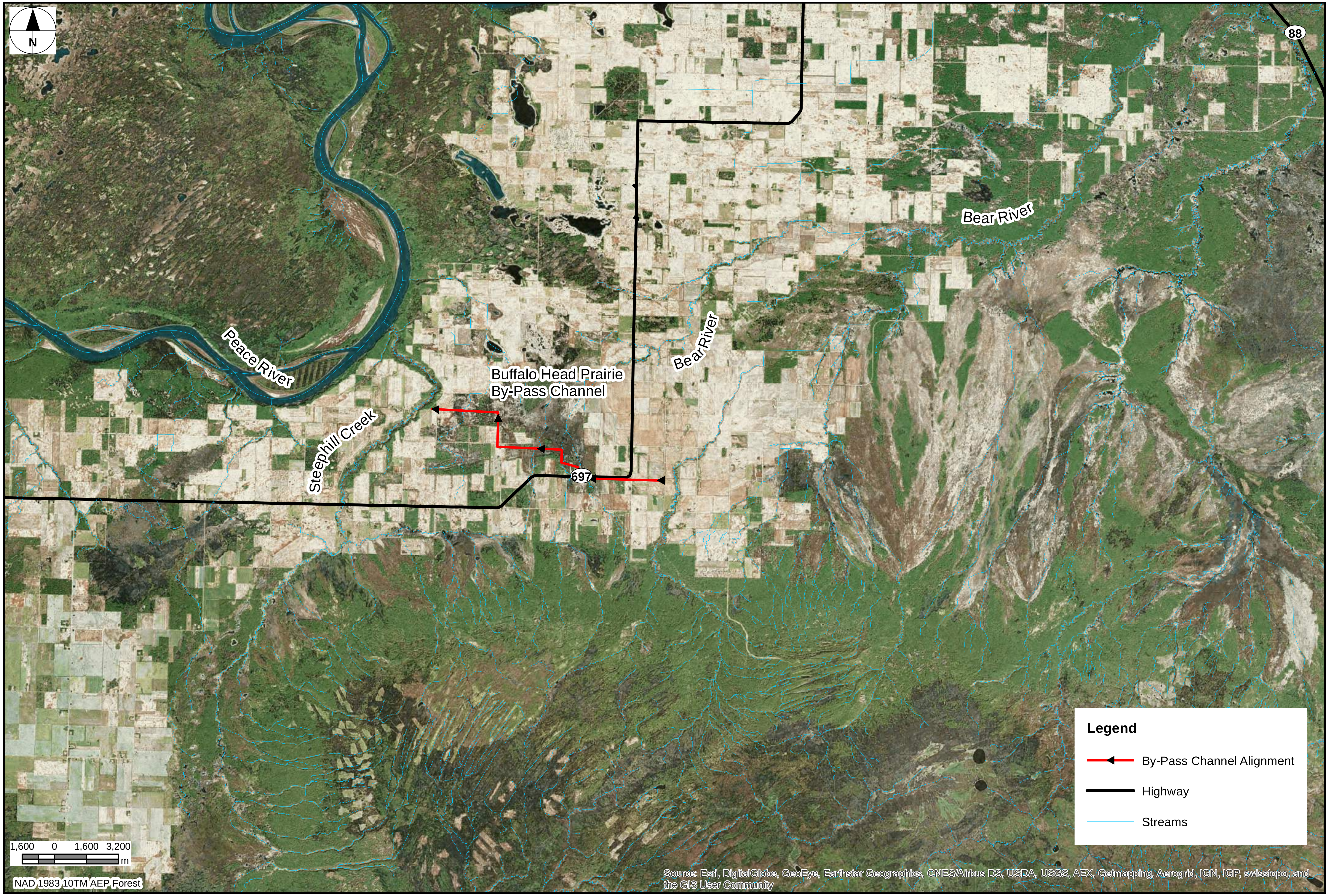
Following a technical review of the information presented in the two reports by DCL, AECOM believes that in order to convey peak discharge as discussed in section 5.11.5, the cross-sectional area of the by-pass channel should be increased. The channel bottom width should be increased to 3.5 m with 3H:1V side slopes which results in a channel depth of 3.0 m (including 0.3 m of freeboard).

Figure: 5-11-1



Buffalo Head Prairie, Mackenzie County
Stakeholder Identified Historical Flood Issue

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569



AECOM

Figure: 5-11-2

Buffalo Head Prairie, Mackenzie County
By-Pass Channel Overview

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569