Water

Alberta Environment and Sustainable Resource Development

Peace River Basin Flood Mitigation Feasibility Study

Volume 1 of 2

Prepared by:

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Project Number:

60334569

Date:

July, 2015

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July 13, 2015

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Dear Ms. Ziober:

Project No: **60334569**

Regarding: Peace River Basin Flood Mitigation Feasibility Study

We are pleased to present the final report for the above-mentioned project.

The main body of the report is Volume 1 and the Appendices are Volume 2.

If you have any questions or require additional information, please contact me.

Sincerely,
AECOM Canada Ltd.

Ahtesham Shirazi, M.Eng., P.Eng
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AS:sw
Encl.

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Revision #	Revised By	Date	Issue / Revision Description
0		May 29, 2015	Draft
1	CM	July 03, 2015	2nd Draft (Just the changes highlighted)
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AECOM Signatures

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July 13, 2015

Executive Summary

Purpose

The purpose of this study was to conduct a flood mitigation feasibility study for the areas within the Peace River Basin in Alberta that have historically been flooded and are likely to be impacted by future flooding. A water management plan was included and consists of recommending flood mitigation alternatives for flood affected areas, and evaluating the alternatives in terms of cost and benefit to the community.

Stakeholder Consultation

Stakeholder engagement was included as a major part of the study process to identify communities within the Peace River Basin, at risk of flooding and gather local knowledge on historic and current flooding issues and their impacts. The project team contacted both government and non-government stakeholders, which include municipal districts and counties, cities, towns, villages and hamlets, and Mighty Peace Watershed Alliance. Stakeholder meetings were held within the time period of November 2014 to February 2015. Internal stakeholders, including government departments and agencies, were contacted during the stakeholder consultation process. A stakeholder consultation memorandum was prepared and submitted to Alberta Environment and Sustainable Resource Development (AESRD) in February, 2015. The memorandum provided relevant flood related issues and information provided by the various external and internal stakeholders. Additionally, existing studies and available data pertaining to flood issues were reviewed, compiled and included in the memorandum for each community. The compilation of issues and identified flood risks presented in the stakeholder memorandum are considered as a basis for flood mitigation alternatives adopted in the feasibility study.

Water Management Facilities

An overview of the water management facilities within the Peace River Basin was completed in February, 2015. The information presented in the Water Management Facilities memorandum has been included in this feasibility study, as water management facilities will impact flooding within the Peace River Basin. Information presented in the memorandum was compiled through the stakeholder consultation meetings, as well as through literature reviews.

Water Supply

An overview of communities' water supply sources within the Peace River Basin was completed in March, 2015. The information presented in the Water Supply memorandum has been included in this feasibility study, as it illustrates which communities' water supply sources have been impacted by flood in the past. Information presented in the memorandum was compiled through correspondence with communities, municipalities and water treatment plant personnel.

Analysis by Community

Flood risks were assigned to communities based on the severity of historical flooding, as well as the impact on local residents, infrastructure and property damage. The flood impact information was also obtained from the stakeholder consultation process. For the purposes of this study AECOM classified the following ten communities within the Peace River Basin as being at high flood risk.

- Town of Falher
- Town of Manning
- Town of Peace River

- Town of Sexsmith
- Hamlet of Fort Vermilion
- Hamlet of Watino
- Fox Lake 162 Reserve (First Nation)
- John d'Or Prairie 215 Reserve (First Nation)
- Paddle Prairie Métis Settlement
- Wyandie West (Métis Coop)

Additionally, four communities have been classified as moderate flood risk. These communities are:

- Village of Donnelly
- Village of Girouxville
- Village of Rycroft
- Hamlet of La Crete / Buffalo Head Prairie

The remaining communities have been classified as being either low flood risk or no flood risk.

Development of Flood Mitigation Alternatives

Structural mitigation alternatives, such as diversion channels, flash flood ditches and dikes, were developed for all communities classified as high flood risk and for moderate flood risk communities where non-structural methods were not seen to present an effective alternative. In some cases, there were previously completed flood mitigation studies or designs for structural mitigation alternatives which were evaluated and revised, where necessary, for this study.

Water Management Plan

A summary of all recommended flood mitigation alternatives are compiled as the proposed Water Management Plan for the Peace River Basin. The Water Management Plan is presented as a table which provides recommendations to each individual community which has been categorized as high, moderate or low flood risk.

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1. Introduction

1.1 Background

In October 2014, the Resilience and Mitigation (RAM) branch of Alberta Environment and Sustainable Resource Development (AESRD) retained AECOM Canada Ltd. (AECOM) to conduct a water management study, mainly focusing on flood and drought issues in the Peace River Basin within Alberta. The study is named as the Peace River Basin Flood Mitigation Feasibility Study (PRBFMFS). AECOM submitted three technical memorandums: stakeholder consultation including compilation of issues, water management and water supply for the Peace River Basin. This report presents a summary of these memorandums and flood mitigation alternatives including conceptual designs for high, moderate and low risks communities.

1.2 Study Area

The Peace River Basin is located in the northwestern portion of Alberta. The headwaters of the basin are located in British Columbia (BC) and the mouth of the river is located at Lake Athabasca in northeastern Alberta. Of the total river basin, approximately 54,400 km^2 is located in BC, 205,560 km^2 is located in Alberta and a smaller portion is located in Northwest Territories. The largest part of the Peace River Basin is located in Alberta and is the largest river basin within the Province. Figure 1-1 shows the boundaries of the Peace River Basin.

In 2010, the Alberta Biodiversity Monitoring Institute (ABMI) estimated that approximately 15% of the Peace River Basin within Alberta is classified as Human Footprint area whereof most occurs in the Upper Peace and Smoky/Wapiti River sub-basins. Agriculture is the leading contributor to the Human Footprint and it plays a critical role of the economy in the river basin. Other activities include forestry, mining, and oil and gas extraction.

Only a few communities are located along the banks of the major rivers within the basin and most communities are scattered throughout the western part of the basin. The largest communities in the basin are the City of Grande Prairie and the Town of Peace River.

The Peace River Basin located within Alberta is divided into seven Municipal Districts (M.D.), nine Counties and three Improvement Districts (I.D.) as shown in Table 1-1 below and Figure 1-2.

Table 1-1: Municipalities, Counties and Improvement Districts in Alberta's Peace River Basin

Municipality	Basin Area (km^2)	Percentage of Alberta Peace River Basin
Birch Hills County	2,908	1%
M.D. of Big Lakes	2,555	1%
Regional Municipality of Wood Buffalo	14,290	7%
Yellowhead County	85	<<1%
County of Grande Prairie No.1	6,113	3%
M.D. of Greenview No.16	30,907	15%
M.D. of Opportunity No.17	20,818	10%
Saddle Hills County No.20	5,877	3%
Clear Hills County No.21	13,551	7%
County of Northern Lights No.22	12,704	6%
Mackenzie County No.23	37,614	18%

Municipality	Basin Area (km^2)	Percentage of Alberta Peace River Basin
M.D. of Smoky River No.130	2,746	1%
Northern Sunrise County No.131	21,039	10%
M.D. of Spirit River No.133	691	<1%
M.D. of Peace No.135	965	<1%
M.D. of Fairview No.136	1,430	<1%
I.D. No. 12 Jasper	775	<1%
I.D. No. 24 Wood Buffalo	25,798	13%
I.D. No. 25 Willmore Wilderness	3,549	2%

Some of the municipalities in the basin cover relatively small areas and some of these areas are located near the river basin boundary (e.g. M.D. of Big Lakes) where there is a very low risk of significant flooding. Other areas are national and provincial parks (I.D. 12, 24 and 25) and have not been included in this study.

1.3 Purpose

The purpose of the PRBFMFS is to identify communities at risk of flooding within the basin, the causes of flooding, assessment of potential flood damages, mitigation strategies and review of local community mitigation proposal and initiatives. Information has been developed and expanded upon from the technical memorandums which have been submitted as task deliverables during the course of the study.

1.4 Scope

The basic approach that AECOM has taken for the PRBFMFS can be summarised in the form of seven tasks, which are summarized below.

1.4.1 Task 1 – Project Start-Up and Project Management

The project commenced with a start-up meeting between AECOM and AESRD. The items covered at the start-up meeting were:

- AECOM key team members and AESRD Project Management team members were identified
- Communication protocols were defined
- Stakeholders to be consulted during the study were confirmed
- Scope of work for the project were reviewed and updated as required
- Tentative key dates were set
- AECOM will submit a list of digital base features and topographic data that AECOM will require for developing base maps of the river basin, to be used during the stakeholder consultation process.

After the scope of work was reviewed and the list of stakeholders was confirmed at the project start-up meeting, AECOM submitted the following to AESRD:

- **Work Plan:** The work plan was developed after the scope of work and the stakeholders were confirmed at the project start-up meeting.

- **Schedule:** The schedule with start and end dates was prepared based on the scope of work, confirmed stakeholders and the confirmation of key dates at the start-up meeting.
- **Status Reports:** AECOM submitted status reports to AESRD on a monthly basis. The status reports included:
  - An overall summary of the project progress
  - Services completed during the past reporting period
  - Itemized list of remaining deliverables, including progress to date
  - Issues and concerns that may affect scheduled deliverables, project schedule or any other aspect of the project
- **Progress Meetings:** AECOM met monthly with AESRD during the course of the study. At the monthly meetings, AECOM's PM arranged, coordinated and chaired monthly progress meetings and produced meeting minutes.

1.4.2 Task 2 – Data Collection

1.4.2.1 Base Features Data

For the initial mapping of the river basin, to be used for the subsequent locating of flooding and other surface water issues in the river basin, AECOM acquired the following data sets in digital form suitable for GIS (Geographic Information System):

- Boundaries of M.D.s, Counties, I.D.s, towns, cities, provincial parks, national parks, wilderness areas and protected areas
- Locations of villages, hamlets and other localities
- Highways, roads and other access features
- Rivers, lakes and wetlands as polygons
- Other streams as lines
- Topography as spot elevation data, such as Lidar data
- Flood hazard mapping cross-section data
- Other spatial data required during the study

1.4.2.2 Spatial Data

In addition to the base features used for the base mapping of the river basin and mapping of issues, AECOM acquired the following spatial data:

- Locations of existing Alberta Transportation (AT) **Bridge File stream crossings** and related information such as crossing dimensions and design discharge from the AT Hydrotechnical Information System (HIS)
- Locations of **existing AESRD projects**, such as flood control and erosion control projects and related information such as drop structures, channel dimensions and design discharge
- Existing **floodway and flood fringe** delineations, from AESRD
- Topographical data from AltaLIS

This information was used to identify which areas are serviced by existing drainage projects.

1.4.2.3 Reports

AECOM requested copies of all reports available from AESRD and AT related to flooding, high water marks, flood mitigation, erosion and water supply within the Peace River Basin. AECOM reviewed these reports and extracted and compiled the information directly related to the problems at hand. The extracted information was compiled into summary documents for use as background references by the AECOM team and AESRD Project Manager during the study.

1.4.3 Task 3 – Stakeholder Consultation

All municipalities within the river basin have been addressed during this study. Within those municipalities, there is one city, 14 towns, 9 villages and 39 hamlets.

AECOM has arranged to meet with all stakeholders shortly after the project start-up meeting. The purpose of the consultation process was to identify what the issues are in the river basin. The stakeholders that were initially identified by the project team are:

Communities:	Town of Peace River Paddle Prairie Métis Settlement Fort Vermilion Town of Manning City of Grande Prairie Hamlet of Watino
Counties/M.D.s:	M.D. of Peace No. 135 M.D. Fairview No. 136 Birch Hills County Clear Hills County No.21 County of Northern Lights No.22 Northern Sunrise County No.131
First Nations:	Beaver Ranch No. 163 IR (Tallcree First Nation) John D'Or Prairie No. 215 IR (Little Red River Cree Nation) Fox Lake No. 163 IR (Little Red River Cree Nation)
Ministries:	Ministry Tourism Parks and Recreation Ministry of Alberta Transportation Ministry of Aboriginal Relations Ministry of Agriculture Alberta Environment and Sustainable Resource Development
Other:	Mighty Peace River Watershed Alliance

During the project start-up meeting, the stakeholder list was confirmed and during the project additional stakeholders were identified.

Meetings with each stakeholder were arranged to be as efficient as possible, maximizing time on the ground and minimizing travel. The meetings provided the opportunity for the project team to share an overview of the project, its goals and timeline, as well as to learn about specific flooding and water supply issues, challenges and opportunities from each stakeholder.

Stakeholder meetings included members of AECOM's stakeholder team, an ASERD liaison officer, stakeholder liaison, and engineering groups. The stakeholder team member facilitated meetings and the engineering team members located and plotted the issues identified during the meeting in ArcGIS software while projecting the information onto a screen.

During the meetings, AECOM collected information about:

- communities at risk of flooding
- historic flood damages
- developing erosion
- local community mitigation proposals and initiatives
- water supplies

Notes from each meeting and a final report summarising stakeholder conversations and documenting the input received were prepared. The notes and report also informed the project team moving forward.

Following the initial phase of consultation, additional meetings/conferences were held with stakeholders whose complex or challenging issues require more significant conversation. Two way communications between the project team and stakeholders were encouraged to illustrate an open and collaborative process.

The deliverable for the **Stakeholder Consultation** task was:

- One memorandum summarising erosion and flood issues including identified local flood mitigation proposals and initiatives of communities and a compilation of issues of flood affected communities in the study area

1.4.4 Task 4 – Compilation of Issues

During the stakeholder consultation process, the identified issues in the river basin were located and documented in general. During the compilation task, the identified issues were categorised as high, moderate and low risks category for the purpose of this study.

All information collected for each issue were compiled and summarised in Table A-1 in Appendix A. Each issue has a map ID which corresponds to the location on various figures. These compiled issues formed the basis for all future work by the AECOM team on the study and provided the available information and damages, to be used by sub-groups within the AECOM team. Separate groups focussed on water supply issues, flooding from major streams, local flooding, erosion, etc.

1.4.5 Task 5 – Water Management Facilities

In the past, water management facilities such as drainage and erosion control projects were designed and constructed by Alberta Agriculture and then by Alberta Environment after that department was created in the late 1960s. Since then, numerous water management facilities have been constructed in the Peace River region to improve the conditions for agriculture and to stabilise eroding flow paths.

Many water management facilities that were designed and constructed by AESRD in the past have since been turned over to other ministries and municipalities. That has resulted in separate inventories of facilities by different levels of governments and led to an incomplete picture of what water management facilities exist within the river basin and how they are inter-related from a flow pattern point of view. This is of particular importance when these facilities are located within one sub-basin but in different jurisdictions.

During this task, AECOM identified and mapped existing water management facilities in the different municipalities that information was available for and recorded any reported issues with the facilities such as flooding or water supply shortages.

The deliverables for the **Water Management Facilities** task consisted of:

- One technical memorandum summarising existing water management facilities in the river basin that information was available for, including the key information for each facility and an overview map showing the location of each identified facility

1.4.6 Task 6 – Water Supplies

Reliable water supplies are of prime importance to all communities. During this task, AECOM identified the types of water supply used by each community and where the supply is located. Available information about the capacity of the water supplies, the size of the dependent population and the estimated future population size was collected. The deliverables for the **Water Supplies** task consisted of:

- One technical memorandum summarising the type of water supply used by each community and any issues regarding the water supply as reported by the community

1.4.7 Task 7 – Flooding and Flood Mitigation

1.4.7.1 Types of Flooding

River flooding is taken to be flooding caused by a river or stream overtopping its banks and flooding adjacent developed lands.

Local flooding is taken to be flooding caused by snowmelt and rainwater accumulating in low-lying areas and flooding developed lands. This type of flooding is very common and is typically due to clearing of land, which results in increased runoff, and due to man-made alterations of the topography without adequate consideration for natural drainage paths.

1.4.7.2 Types of Flood Mitigation

Flood mitigation can be in the form of non-structural or structural form. Non-structural flood mitigation typically consists of restoring wetlands, re-establishing forested areas, land buyouts, emergency preparedness plans and temporary mitigation measures such as sand bagging. Structural flood mitigation involves the construction of structures of different types. The challenge in addressing flood protection issues is to understand surface water management events in which magnitude and duration of the occurrence depends on ever-changing watershed characteristics.

Non-structural flood mitigation alternatives are appealing from environmental, cost and maintenance point of views. However, non-structural flood mitigation alternatives often have no significant benefits unless it is done on a large scale where cleared and drained lands are restored to natural conditions. Given the enormous amount of time and effort that the farmers and homesteaders of the Peace River Region have invested in the clearing and drainage of their lands to turn them into productive cultivated fields, it is unlikely that any suggestion of turning large areas of agricultural land back into forests and wetland would find any support from the population at large.

AECOM has given preference, wherever possible, to non-structural surface water management methods. This method will avoid incompatible land uses within flood-prone areas and ensure that the land developments does not alter natural drainage patterns and water storage. One such type of non-structural flood mitigation is the delineation of flood hazard areas, using flood hazard mapping studies, and restricting the development within flood prone areas.

Structural flood mitigation consists of either protecting designated areas with dikes, storing flood peaks in reservoirs or diverting flood flows around the affected areas to ensure that flood-prone areas are reasonably safe from inundation due to future flood events.

The construction of dams to store flood peaks and the construction of diversion channels are very costly undertakings and can only be justified when the risk of flooding is significant and the impact to people, damages to property and cost of flood repair are high and recurring. A review of the Peace River Basin characteristics, historical records, existing studies and current federal, provincial and municipal management practices will be conducted to gain an understanding of required flood protection in the study area.

1.4.7.3 Flood Hazard Mapping

AESRD took over the responsibility for the flood hazard mapping in Alberta from the Government of Canada in 1989. Since then, mapping has been conducted under the Flood Damage Reduction Program (FDRP) guidelines as were used while the program was managed by the Government of Canada. Under the FDRP, the Provinces had the choice of the event that should be used as the design flood event and the Government of Alberta selected the 1% (1:100 year) flood as the design event.

Under the FDRP, the floodway is defined as the portion of the flow where the depth of water is greater than 1 m or the flow velocity is greater than 1 m/s. These criteria are based on the conditions under which an average person can wade through flowing water without being swept away. The flood fringe is defined as the portion of the flooded area where the depth of water is less than 1 m or the flow velocity is less than 1 m/s.

As a result of the recurrence of large and very costly floods in Canada during the past few years, the federal government has undertaken a re-assessment of what should be used as the design event. Recent indicators are that the federal government may be recommending the 2% (50-year) flood be used for the floodway delineation and the 0.29% (350-year) flood be used for the flood fringe delineation. This was one of the recommendations by MMM Group to Public Safety Canada under the National Floodplain Management Framework completed in 2014.

In some localities, the extent of river flooding has been estimated and mapped under AESRD's flood hazard mapping program. Existing flood hazard mappings in the river basin have been published by AESRD for:

- Bear River at the City of Grande Prairie and Hamlet of Wedgewood (completed in 2007)
- Peace River at Fort Vermilion (completed in 2000)
- Notikewin River at Town of Manning (completed in 2000)

Additionally, a flood risk mapping study was conducted for the Smoky River at the Hamlet of Watino:

- Watino Flood Risk Mapping Study – Northwest Hydraulics Consultants (1996)

A flood frequency analysis study was also conducted for the Notikewin River at the Town of Manning by the Water Resources Management Services - Technical Services Division (Hydrology Branch):

- Flood Frequency Analysis Notikewin River at Manning Floodplain Study (1991)

A review of the published flood hazard mapping shows that some properties in the flood mapped communities are located within the floodway or flood fringe:

- At Watino – parts of the Hamlet are within the floodway and flood fringe
- At City of Grande Prairie – no part of the town is within the floodway and the flood fringe
- At Fort Vermilion – floodway and flood fringe are close to some townsite properties and River Road
- At Town of Manning – parts of the town are within both the floodway and the flood fringe

During the Study, AECOM met with AESRD River Forecasting to determine if additional flood hazard mapping studies are currently in progress and which flood hazard mapping studies are currently planned to be undertaken in the river basin.

Mackenzie County indicated that flood hazard mapping along tributaries of Peace River is lacking and expressed concerns. Without flood mapping, the County has difficulties enforcing controls on developments along the tributaries. It is recommended to develop flood hazard mapping in Mackenzie County, which will result in restricting the development within the flood prone areas. This would be considered a non-structural mitigation measure.

River flooding affected developed areas that were identified during stakeholder consultations will be discussed with AESRD to determine if flood-prone areas should be included in future flood hazard mapping studies.

1.4.7.4 Mitigation of Stream Flooding

The areas impacted by stream flooding have been assessed to identify the most appropriate flood mitigation alternative for each identified issue. AECOM has conducted flood frequency analysis and updated the 1:00 year peak flow in rivers where new streamflow records were available and determined how frequently the flooding has occurred in the past. The 1:100 year peak flow was used for designing structural flood mitigation alternatives.

The process of flooding from streams and rivers is very similar. The only difference is that flooding from rivers is more extensive than along smaller streams. For communities along rivers, flood hazard mapping is usually prepared, but only in the vicinity of the community. The flood mitigation approach is the same for both rivers and streams. For larger communities, such as the Town of Peace River, flood protection dikes are often constructed to protect the community from flooding and prevent costly flood damages.

Flood protection dikes are often not economically viable alternatives to mitigate occasional flooding from smaller streams due to high construction and maintenance costs. In those cases, non-structural mitigation alternatives may include rezoning land usage and raising, flood-proofing or relocating buildings.

AECOM has assessed the unique conditions at each site where communities are flooded and has proposed flood mitigation alternatives.

1.4.7.5 Mitigation of Local Flooding

Local flooding is relatively common throughout the Peace River Basin and has been reported in nearly all Counties and M.D.s that AECOM has been in contact with during the study.

AECOM has estimated the drainage basin and the magnitude of flood flows for high or moderate flood risk locations. The potentially flooded area has been estimated based on available spatial data and information provided by the municipalities.

For the locations where local flooding occurs, AECOM has proposed mitigation works if the flooding risk is high or moderate whenever sufficient information was available.
When proposing to increase the size of existing culverts, AECOM has assessed if the downstream system can handle the increased flow rate without causing damage to land or property. If damages are likely to occur, AECOM has proposed additional work downstream of the culvert crossing.

When proposing new drainage channels, AECOM has designed the proposed drainage channel for the permissible (non-eroding) flow velocity for the soil type at the site, estimated from existing soil mapping. Where the slope of the land is steeper than the channel profile slope required for the permissible channel flow velocity, erosion protection such as riprap has been proposed.

Gabion step-drop structures are commonly used for flood control and drainage projects in the Peace Region when the required rock fill material is available at an economical in-place cost. This type of structure was used for the Ksituan Drainage project in Saddle Hills County, a few years ago, and has many benefits such as:

- A flexible structure that does not crack due to frost heave
- Construction can be done by unskilled labour
- Maintenance cost is low
- The structure blends into the landscape when vegetation establishes itself in the structure

1.4.7.6 Local Community Mitigation Proposals and Initiatives

All local community mitigation proposals and initiatives, including Alberta Community Resilience Programme (ACRP) funding applications, obtained during the stakeholder consultation process have been reviewed by AECOM. The high level review included identifying the local community mitigation proposal in this report and providing a summary of the mitigation.

1.4.7.7 Geotechnical Aspects

The geotechnical aspects of any proposed flood mitigations and local community proposal and mitigations have been assessed based on available data. Potential geotechnical issues of concerns at the sites have been identified for future reference.

1.4.7.8 Environmental Aspects

A desktop environmental review has been completed for each proposed flood mitigation and local community proposal and mitigations. The review identifies environmental issues of concern, potential historical resources and regulatory requirements.

1.4.7.9 Stakeholder Aspects

For each flood mitigation scheme, the required Right-Of-Way (ROW) area has been estimated. The ROW includes the estimated physical footprint of the proposed mitigation scheme plus a buffer zone outside the estimated footprint. The width of the buffer has been determined on a case by case basis and is dependent on the site conditions.

1.4.7.10 Cost Estimates

A conceptual level cost estimate has been prepared for each proposed flood mitigation scheme that has been identified as part of this study. The cost estimates include a capital cost contingency but do not include the following:

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

1.4.8 Task 8 – Project Report

The project report has been developed from the technical memorandums prepared as task deliverables during the course of the study. The technical memorandums prepared during the study are summary documents which have been expanded on for the project report.

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Filename: P:\60334569\900-WORK\920-929 (GIS-GRAPHICS)\MAIN REPORT FIGURES\FIGURE 1-1 STUDY AREA OVERVIEW.MXD

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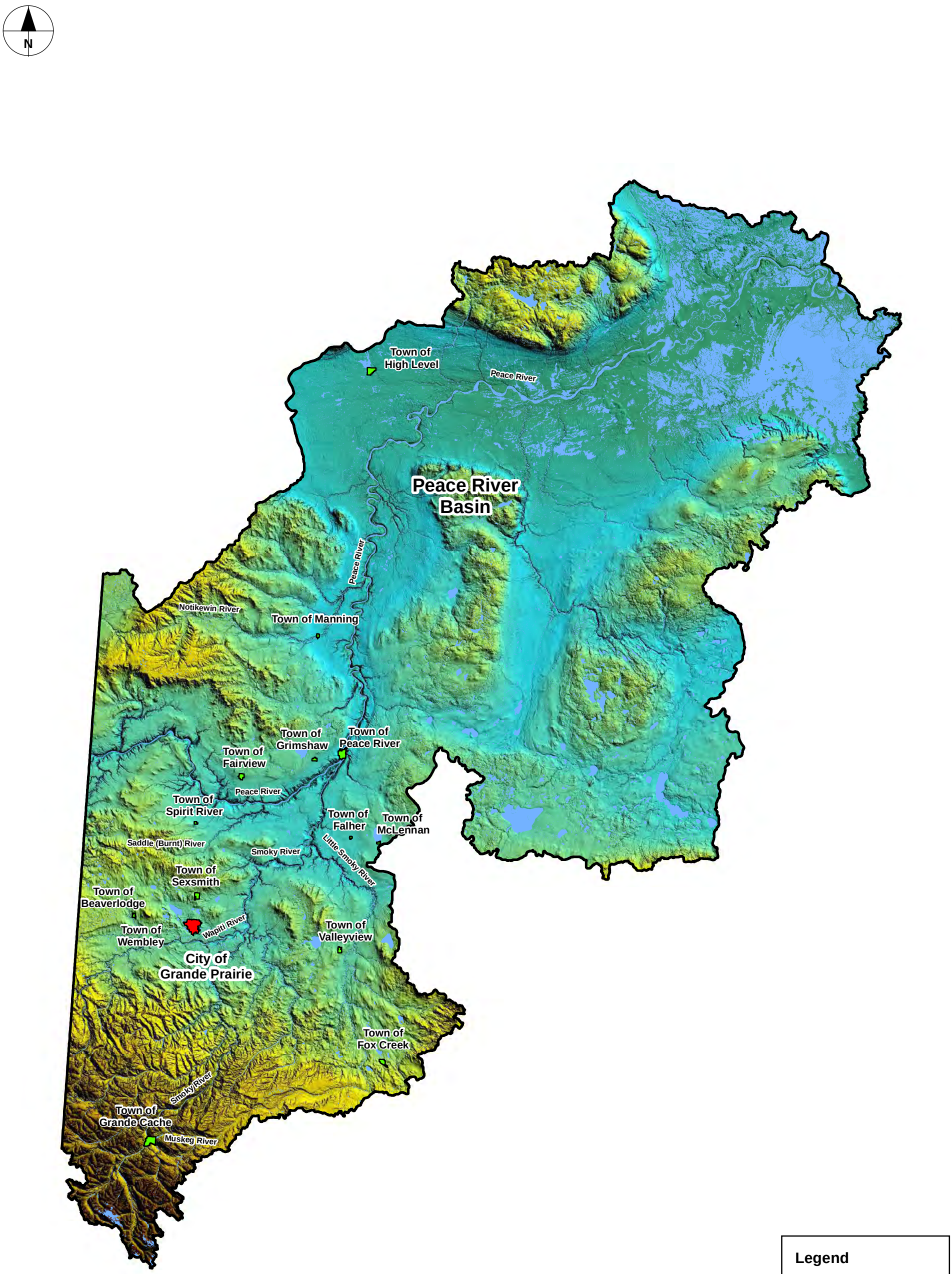

Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

Study Area Overview
River Basins

AECOM

Figure: 1-1

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Filename: P:\60334569\900-WORK\920-929 (GIS-GRAPHICS)\MAIN REPORT FIGURES\FIGURE 1-2 STUDY AREA OVERVIEW MUNCIPALITIES.MXD

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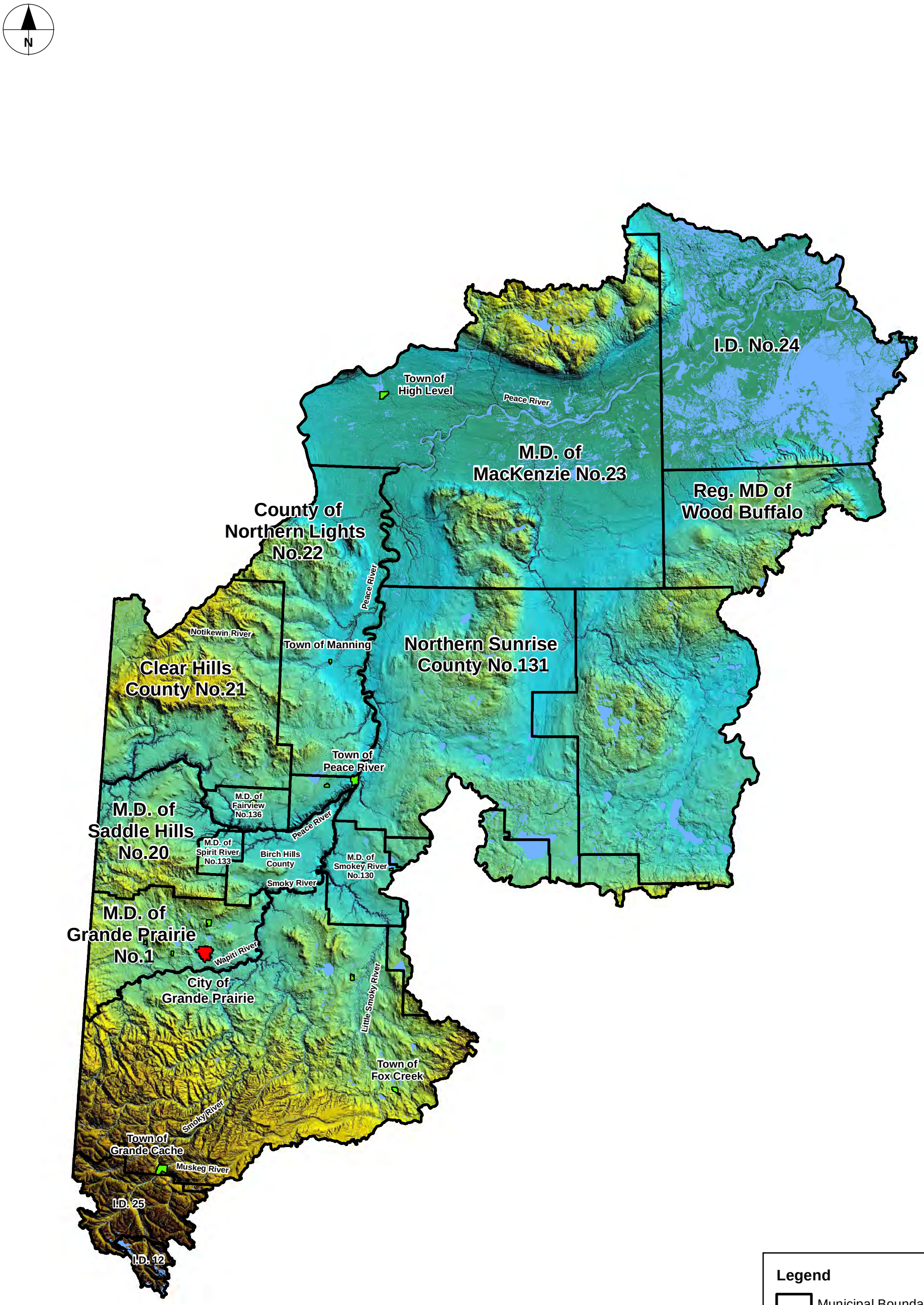


Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

Study Area Overview
Municipalities

AECOM

Figure: 1-2

2. Stakeholder Consultation and Compilation of Issues

2.1 Stakeholder Engagement Process

Stakeholder engagement process was used as a key part of the study in the PRBFMFS, which includes a variety of face-to face and conference call communication approaches to reach out to and engage all flood affected communities and external stakeholder agencies. This report presents the findings of the stakeholder consultations for the PRBFMFS. The findings presented include input received from direct and indirect consultation meetings as well as written questionnaire submissions received during the consultation period.

AECOM engineers and its sub-consultant Twenty/20 Communication together with ASERD liaison officer was involved in the stakeholder consultation process. The study team lead by Twenty/20 Communication developed a plan to:

- Inform stakeholders in advance by sending a questionnaire about the required information so that they can provide valuable feedback during the consultation meetings; and
- Obtain input from the stakeholder meetings during the initial stage of the study process and to compile the issues which would be used for decision making during the flood mitigation process.

Stakeholder engagement was included as part of the process to identify communities in the study area at risk of flooding and gather local knowledge about historic flooding issues and impacts. It will examine the cause of flooding and assess potential flood damages and mitigation plans, as well as assess water supplies to communities.

2.1.1 Stakeholder Identification

The Stakeholder Engagement and Communication Plan include mechanisms to reach out to and engage a wide range of stakeholders whom may be interested in or are affected by flooding in the Peace River Basin. Twenty/20 Communications, together with AECOM, developed a stakeholder list, which includes:

Government Stakeholders, including:

- Municipal Districts, Cities, Towns, Villages and Hamlets
- Provincial Government
- AESRD
- Alberta Transportation
- Alberta Emergency Management Agency
- Ministry of Agriculture
- First Nations and Métis
- Federal Government
- Parks Canada

Non-government stakeholders, such as:

- Mighty Peace River Alliance
- Trout Unlimited
- Ducks Unlimited
- CN Rail
- ATCO Gas

2.1.2 Stakeholder Engagement Plan

The stakeholder engagement strategy involves face-to-face meetings with municipalities, First Nation reserves and Métis settlements in the Peace River Basin which have experienced or are at risk of flooding. In addition, meetings or phone calls were arranged with relevant Government of Alberta and Government of Canada departments, and appropriate industry representatives who can provide information on flood areas to support the study.

The stakeholder engagement plan has been specifically developed to address the key principles – study objectives, comprehensive, inclusive and evidence based flood affected areas which provide substantive guidance to AECOM in the terms of reference for the PRBFMFS. The plan is also designed to ensure that the stakeholders within the basin are provided with the opportunity to contribute focused feedback on key outputs such as flood mitigations identified by AECOM for the study later.

Those municipalities that were deemed to be a high and moderate flood risk were considered a priority. A road trip to the Peace region was coordinated to facilitate dialogue and allow for water resource engineers to instantly map flood areas following stakeholder direction and using GIS technology. Stakeholder outreach began with introductory phone calls to introduce the project and identify the appropriate contact person within each municipality. These calls were followed by an explanatory email which included a questionnaire and a request to schedule a meeting.

The first Stakeholder Road Trip took place on November 26 – 28, 2014; the second on January 15 and 16, 2015.

A total of 11 communities were consulted in November, in addition to the Mighty Peace Watershed Alliance and Mackenzie Municipal Services Agency. A phone meeting was also held with the Town of Grande Cache. Seven municipalities were consulted during the January road trip, including a follow-up meeting with the M.D. of Greenview to obtain detailed information on the Métis coops within its boundary. Three communities were consulted with in February via conference calls and webinars. Meetings were also held with Alberta Transportation to discuss the impacts of flooding on infrastructure and the Alberta Emergency Management Agency (AEMA) to gather insight into potential flooding on First Nations reserves in the basin. The meeting with AEMA provided direction to assist in identification of the appropriate Aboriginal sites that may require additional dialogue. Minutes of all stakeholder meetings are provided in Appendix B.

November 2014

- Town of Grande Cache
- Mighty Peace Watershed Alliance
- M.D. of Greenview No.16
- Town of Valleyview
- Town of Sexsmith
- City of Grande Prairie
- County of Grande Prairie No.1
- Saddle Hills County No.20
- Village of Rycroft
- Town of Peace River
- Northern Sunrise County No.131
- M.D. of Peace No.135
- Mackenzie Municipal Services Agency
- County of Northern Lights No.22

January 2015
- M.D. of Smoky River No.130
- Town of Falher
- Girouxville
- Donnelly
- M.D. of Spirit River No.133
- M.D. of Greenview No.16
- Birch Hills County
- Alberta Transportation
- Alberta Emergency Management Agency

February 2015
- Fort Vermilion
- La Crete
- Mackenzie County No.23

Through the telephone outreach campaign, several municipalities indicated they experience no flooding issues and therefore no meetings will be necessary. These include: Town of Beaverlodge, Village of Hythe, Town of Fox Creek, Town of McLennan, Village of Nampa, Town of Spirit River, Town of Grimshaw, Village of Berwyn, M.D. of Fairview No.136, Town of Fairview and Yellowhead County. M.D. 124 Lesser Slave River indicated the geographic area of this municipal district situated within the Peace River Basin does not have residents and therefore a meeting is also not required.

2.2 Internal Stakeholders

Internal stakeholders are considered those groups, within the government or affiliated to the government, which have an interest in flood and water management-related activities within the Peace River Basin. This group includes Alberta government ministries such as: Peace River Watershed Alliance, Alberta Transportation (AT), Alberta Environment & Sustainable Resources (AESRD), and Alberta Emergency Management Agency (AEMA).

A list of all internal stakeholders can be found in Table 2-1 below.

Table 2-1: List of Internal Stakeholders

Internal Stakeholders	
Government Departments and Agencies	**Status**
Alberta Agriculture Food & Rural Development - Water Division	Meeting not necessary
Alberta Culture - Historical Resources Management	Meeting not necessary
Alberta Emergency Management Agency (AEMA) - 3	Meeting held
Alberta Environment & Sustainable Resource Development (AESRD)	Meeting held
Alberta Infrastructure	Meeting not held
Alberta Transportation (AT) - 6	Meeting held
Mighty Peace Watershed Alliance - 7	Meeting held
Parks Canada - 8	Contacted and reply received

2.3 External Stakeholders

External stakeholders are those groups that are directly affected by flooding within the Peace River Basin. This group includes municipal districts, counties, cities, towns, villages and hamlets.

A list of all external stakeholders can be found in Table 2-2 below.

Table 2-2: List of External Stakeholders

External Stakeholders	
Municipalities	**Status**
Birch Hills County	Meeting held
Mackenzie Municipal Services Agency	Meeting held
M.D. of Big Lakes	Contacted and reply received
Regional Municipality of Wood Buffalo	Meeting held
Yellowhead County	Contacted and reply received
County of Grande Prairie No. 1	Meeting held
M.D. of Greenview No. 16	Meeting held
M.D. of Opportunity No. 17	No response received
M.D. of Saddle Hills No. 20	Meeting held
M.D. of Clear Hills No. 21	No response received
M.D. of Northern Lights No. 22	Meeting held
M.D. of Mackenzie No. 23	Meeting held
M.D. of Lesser Slave River No. 124	Contacted and reply received
M.D. of Smoky River No. 130	Meeting held
Northern Sunrise County No.131	Meeting held
M.D. of Spirit River No. 133	Meeting held
M.D. of Peace No. 135	Meeting held
M.D. of Fairview No. 136	Contacted and reply received
Improvement District 12 Jasper National Park	Not included in study
Improvement District 24 Wood buffalo	Not included in study
Improvement District 25 Wilmore Wilderness	Not included in study
City	**Status**
City of Grand Prairie	Meeting held
Towns	**Status**
Town of Beaverlodge	Contacted and reply received
Town of Fairview	Contacted and reply received
Town of Falher	Meeting held
Town of Fox Creek	Contacted and reply received
Town of Grande Cache	Meeting held
Town of Grimshaw	Contacted and reply received
Town of High Level	No response received
Town of Manning	Contacted and reply received
Town of McLennan	Contacted and reply received
Town of Peace River	Meeting held
Town of Rainbow Lake	No response received
Town of Sexsmith	Meeting held

External Stakeholders	
Town of Spirit River	Contacted and reply received
Town of Valleyview	Meeting held
Town of Wembley	Contacted and reply received
Villages	**Status**
Village of Berwyn	Contacted and reply received
Village of Donnelly	Meeting held
Village of Girouxville	Meeting held
Village of Hines Creek	No response received
Village of Hythe	Contacted and reply received
Village of Nampa	Contacted and reply received
Village of Rycroft	Meeting held
Hamlets	**Status**
Hamlet of Clairmont	Information obtained from M.D. Meeting
Hamlet of Deadwood	Information obtained from M.D. Meeting
Hamlet of Dixonville	Information obtained from M.D. Meeting
Hamlet of Eaglesham	Information obtained from M.D. Meeting
Hamlet of Fort Chipewyan	Meeting not held
Hamlet of Fort Vermilion	Contacted and reply received
Hamlet of Guy	Information obtained from M.D. Meeting
Hamlet of Jean Cote	Information obtained from M.D. Meeting
Hamlet of Marie Reine	Information obtained from M.D. Meeting
Hamlet of Notikewin	Information obtained from M.D. Meeting
Hamlet Reno	Information obtained from M.D. Meeting
Hamlet of St. Isidore	Information obtained from M.D. Meeting
Hamlet of Tangent	Information obtained from M.D. Meeting
Hamlet of Wabasca-Desmarais	Information obtained from M.D. Meeting
Hamlet of Wanham	Information obtained from M.D. Meeting
Hamlet of Watino	Information obtained from M.D. Meeting
Locality	**Status**
Locality of Bonanza	Information obtained from M.D. Meeting
Associations	**Status**
Alberta WaterSMART Solutions Ltd.	Contacted and reply received
ATCO	Contacted and reply received
CN	Contacted and reply received
Ducks Unlimited	Contacted and reply received
Mighty Peace Watershed Alliance	Meeting held
Trout Unlimited	Meeting not held

2.3.1 First Nations and Métis

This group of stakeholders includes First Nations and Métis Settlements. A list of these stakeholders can be found in Table 2-3 below.

Table 2-3: List of External Stakeholders - First Nations and Métis

Aboriginals	
First Nations	**Status**
Beaver	Information received from Pat Kennedy (AEMA)
Big Stone Cree	Information received from Pat Kennedy (AEMA)
Dene Tha'	Information received from Pat Kennedy (AEMA)
Duncans	Information received from Pat Kennedy (AEMA)
Horse Lake	Information received from Pat Kennedy (AEMA)
Little Red River Cree	Information received from Pat Kennedy (AEMA)
Loon River Cree	Information received from Pat Kennedy (AEMA)
Lubicon	Information received from Pat Kennedy (AEMA)
Mikisew Cree	Information received from Pat Kennedy (AEMA)
Muskeg River	Information received from Pat Kennedy (AEMA)
Peerless	Information received from Pat Kennedy (AEMA)
Smith's Landing	Information received from Pat Kennedy (AEMA)
Sousa Creek	Information received from Pat Kennedy (AEMA)
Sturgeon Lake Cree	Information received from Pat Kennedy (AEMA)
Tall Cree	Information received from Pat Kennedy (AEMA)
Trout	Information received from Pat Kennedy (AEMA)
Trout Lake	Information received from Pat Kennedy (AEMA)
Whitefish Lake First Nation (Atikameg)	No Response
Woodland Cree	Information received from Pat Kennedy (AEMA)
Métis Settlements	**Status**
Wyandie East (no status)	Information received from Pat Kennedy (AEMA)
Wyandie West (no status)	Information received from Pat Kennedy (AEMA)
Paddle Prairie	Meeting held

3. Water Management Facilities

3.1 Major Dams Affecting Peace River Basin

The Peace River Basin is highly affected by the construction of the William Andrew Cecil (WAC) Bennett Dam, the Peace Canyon Dam and may further be affected by the recently approved Site C Dam which is located upstream of the study area in British Columbia. These dams have altered the flow and characteristics of the Peace River. The level of the Peace River varied seasonally high flow in the spring and low flow in the winter prior to the construction of these dams. However, additions of these dams have dampened these high and low flows in the river to ensure peak power generation during the winter months when power demands are high. These changes in water levels can alter many aspects of the ecosystem, such as the quantity of habitat, the movements of fish and animals, and the period to which the river remains frozen. Two existing dams and one proposed dam in the Peace River within British Columbia are briefly described below.

3.1.1 Bennett Dam, Williston Reservoir

The Bennett Dam and was constructed in 1961/1968. They are located on the Peace River approximately 168 kilometres upstream of the Alberta border. The dam is 183 m high and stores about 39,500 million cubic meters of water in the Williston Reservoir. It is one of the world's highest earth fill dams and Williston Reservoir is the biggest reservoir in BC. The reservoir can store 1.5 times the average annual flow of the Peace River. The reservoir spill and the Shrum Generating Station water flow directly downstream to the Dinosaur Reservoir. The Bennett Dam is a power generating dam owned and operated by BC Hydro.

3.1.2 Peace Canyon Dam, Dinosaur Reservoir

The concrete Peace Canyon Dam is located approximately 20 kilometres downstream of the Bennett Dam near the town of Hudson Hope. The 61 m high concrete dam impounds about 49 million cubic meters of live storage in the Dinosaur Reservoir. The water discharged from the Bennett Dam operation flows directly into the reservoir. The Peace Canyon Dam has a minimal effect on the flow of the Peace River. The Peace Canyon Dam and Dinosaur Reservoir is owned and operated by BC Hydro.

3.1.3 Proposed Site C Dam

The recently approved Site C Clean Energy Project is a third major dam and hydroelectric generating station on the Peace River in northeast British Columbia. The proposed dam will be constructed approximately 85 km downstream of the Peace Canyon dam, or approximately 7 km southwest of Fort St. John. The earth-fill dam height will be approximately 60 m and the dam will impound approximately 165 million cubic meters of water.

The downstream effect of Site C Dam depends upon the permitted operating release from the Dam. The presence of Site C Dam will increase the total reservoir capacity of the three dams by 0.4 percent with a total coverage catchment area by 19.5%. It is possible that that the summer flow peak will be more flattened and winter flow will increase however the BC Hydro has assumed there will be negligible incremental changes in the existing flow regime of the Peace River. Upon completion of the project, the Site C Dam will be owned and operated by BC Hydro.

The above mentioned dams in the Peace River within British Columbia may have the following major hydrological impact and issues in the Peace River Basin in Alberta:

- Peak spring flows have decreased and occur later;
- Summer flows have decreased and thus changing river flow regime resulting drying up delta lakes;
- Winter flows have increased eliminating major ice jam flooding;
- Tributary flows have become more valuable to maintain summer flows;
- Formation of new sandbars and riparian habitat;
- Channel narrowing and loss of fish habitat;
- Traditional way-of-life impacted.

3.2 Water Management Infrastructure in Alberta

Water management facilities in the Peace River Basin in Alberta are located in cities, towns, and hamlets within the boundaries of municipal districts (M.D.s) or improvement districts (I.D.s) and are presented in the following sections.

3.2.1 Birch Hills County

Birch Hills County is located in the Central Peace River Region, bordered by the Peace River to the north and the Smoky River to the east. The hamlets located within the county are Eaglesham, Peoria, Tangent, Wanham, and Watino. A number of drainages/canals have been identified within the county; details of the structures have not been received. Most of these canals are connected to creeks and ultimately flow to the Saddle River, a few canals flow through creeks to the Smoky River. The identified water facilities are: Podruzny Line 4 Drainage; Podruzny Line 2; Podruzny Line 4 Drainage; Podruzny Line 1 Drainage; Vixen Drainage; Reiger Line A; Reiger Line B; Reiger Line C; Fox Creek Drainage; Coote Lake Drainage; Four Mile Creek; Boreen Drainage; North Tangent Drainage; Bouchard Line 2; Bouchard Line 1; Poohkay Drainage and Morgan Drainage and location of facilities are presented in Figure 3-1.

Bridges and culverts in the area that were flooded in the past are listed below:

- The bridge culvert BF 75700 has flooding issues every spring due to runoff. The culvert is under Highway 733. The length of the culvert is approximately 81 m and its height is 3.9 m.
- The low level crossing bridge BF73541 over Saddle (Burnt) River has an erosion problem in its abutments due to spring runoff. The bridge was removed in 2009 and replaced with a low level crossing. The length of the structure is 53.4 m.

3.2.1.1 Hamlet of Watino

Watino was established on the bank of the Smoky River, downstream from its confluence with Little Smoky River. It was flooded in June 1972, July 1982, June 1990 and May 2011. The major cause of flooding the infrastructures in the area was the early spring rainfall and snowmelt. Additional information regarding water infrastructures was gathered from the hamlets to understand water management issues in the area.

3.2.2 County of Grande Prairie No.1

The County of Grande Prairie No. 1 is located northwest of Alberta. The Wapiti River flows from the northwest to the southeast of the area. The County of Grand Prairie contains one City: Grande Prairie; three towns: Beaverlodge, Sexsmith, and Wembley; one village: Hythe; and several hamlets. The following identified water management facilities are briefly explained below. Figure 3-2 illustrates the locations of these structures.

- **Kleskun Hills Drainage:** It was constructed in 1956 and the downstream end was extended in 1979. The drainage was initially constructed for agricultural land drainage purpose. The project consists of 9.5 km of drainage channel with 6 precast concrete drops, 2 gabion basket drops, 2 wooden drops, 3 concrete grade control structures, and 3 large gabion chute structures. The drainage is connected to the existing creek and ultimately flows to the Wapiti River. In 2000, a portion of the creek about 3.2 km in length and parallel to Highway #43 was reconstructed due to twinning of the Highway.
- **Clairmont Stormwater Management Facilities:** There is an ongoing study of Clairmont Stormwater Management Facilities in Clairmont Lake watershed. The catchment area of the lake comprises of 5,500 ha. The ultimate plan of the county is to develop the regional stormwater management in the area.
- The BF 74228 Bridge on the Wapiti River is a major bridge to the City of Grande Prairie and it connects to Highway 40. The bridge was constructed in 1972 having a maximum span of 61 m and a deck height of 20.4 m. The area was flooded in 1988, 1997, and 2011.

3.2.2.1 City of Grande Prairie

The City of Grande Prairie is located in the southeast corner of the County of Grande Prairie and the water management facilities identified within the city are listed below.

- **Bear Lake Reservoir:** A dam on Bear River was constructed approximately in 1948 to create a water supply reservoir and was reconstructed in 1975–76 by AESRD. The main purpose of the dam is for recreation.
- **Bear River Erosion Control:** The Bear River was heavily eroded during 1963 and 1965 floods. As a result, the City implemented major erosion mitigation project from 1965 to1967. River bank protection using riprap and gabion have been constructed on most of the bridge crossings upstream and downstream of the Grand Prairie Dam.
- Two ditches were dug, one along 89 Avenue from Highway 40 and another from Resources Road to allow overland discharge to the creeks. Both ditches are used to divert overland drainage from roads.

3.2.3 M.D. of Greenview No.16

The M.D. of Greenview No.16 lies in the northwest corner of Alberta. The major river within the M.D. is Wapiti River and the three major towns within the M.D. are Town of Fox Creek, Grand Cache and Valleyview. The identified water management facilities owned by Alberta Environment are Swan Lake, Losegun Lake Weir, South Two Lakes Warming Pond and two minor water management structures. The following identified facilities are briefly explained below. Figure 3-2 shows the locations of these structures.

- **Swan Lake Weir:** The Swan Lake weir was built in 1988 for the Fish & Wildlife (F&W) section of Alberta Environment Sustainable Resource Development (AESRD). The weir was constructed as an outlet control for the lake. The structure is owned by AESRD and Alberta Conservation Association (ACA) has been maintaining this structure.
- **Losegun Lake Weir:** The Losegun Lake is located north of Fox Creek. The weir was constructed in 1956/57 to maintain water level of the lake.

- **South Two Lakes Warming Pond:** The South Two Lakes warming pond was constructed in 1994/1995. The project is owned by the Fish & Wildlife section under AESRD. The project consists of a retention pond, a berm, and an outlet weir in a small creek that feeds South Two Lakes. The project aimed to enhance the rainbow trout spawning ground by increasing the temperature of the water flowing into the lakes by 5 degrees Celsius. The project is usually inspected every year.

Bridges and culverts in the area that were flooded in the past are listed below.

- The bridge BF78884 culvert under New Fish Creek, Range Road 223 was flooded due to a high water level. There are 6 barrels of 1200 mm diameter culverts that are 28 m long.
- In July 2011, bridge BF 73701 on TWP 725 over a tributary to Clouston Creek was flooded. The span of the bridge is 10 m and the deck height is 3 m.
- The Bridge BF76067 over Asplund Creek along TWP 683 was flooded in July 2011. The maximum span of the bridge is 8.5 m and the deck height is 5.50 m.
- The major bridge BF73837 W was flooded in July 2011. The bridge is on Highway 43 on the Waskahigan River. The bridge span is 36.60 m and its deck height is 12.2 m.
- The bridge BF81175 culvert under Valleyview Creek TWP 710A road was flooded. It was built in 1988. The culvert size is 2.1 m in diameter.

3.2.3.1 Town of Grande Cache

Grande Cache is a small town located in the northern corner of Alberta's Rockies. It is located northeast of the confluence of Sulphur River (on the south) and Smoky River (on the west). The area has very few flooding issues.

- Bridge BF 76474 on Highway 40, over the Smoky River is a major bridge to the Town of Grand Cache. The bridge is at risk of flooding. The approximate bridge span and the deck height are 76.20 m and 7.00 m, respectively. The bridge was washed out in 1970.

3.2.4 Saddle Hills County No.20

Saddle Hills is located northeast of the Peace River and the BC border. The hamlet of Woking is located within the county area. The identified water infrastructures are: Mulligan Creek Drainage; Ksituan Drainage; Lannga Flood Drainage; Fourth Creek Drainage; Hamelin Creek Drainage; Letersky Drainage; Deep Drainage; Whitburn Drainage; Deep Creek Drainage; Bryan Canyon Drainage; East Bonanza Drainage; Stefanyk Flood Control; and South Snewood Erosion Control own by Saddle Hills County. The Moonshine Lake (Dam/inlet/outlet) facility is owned by AESRD. The locations of the facilities are presented in Figure 3-3.

Ksituan Drainage: The drainage is located on Blueberry Creek, approximately 25 kilometres northwest of the Town of Spirit River.

It is one of the major drainage systems in the area. In 1963, significant flooding and erosion occurred along Blueberry Creek due to the extreme spring runoff. The catchment area of the drainage system is approximately 61.7 km^2.

The project was formed in two phases for drainage improvement and erosion mitigation: Phase I was constructed in 1966 and Phase II was constructed in 1972. Phase I consists of an approximately 8 km long main channel with five wood chute drop structures, three bridges (BF 76103 on Highway 680, BF 75808 on Range Road 74 and BF 74637 on Range Road 73), two culvert crossings (BF 76263 on Range Road 80 and BF 76262 on Range Road 75), two farm crossings and approximately 19 ditch inlets. Phase II consists of a channel with two road culvert crossings (on Range Road 80/Highway 680 and Range Road 75) and one farm crossing.

Maintenance and upgrades were carried out in 1981 and in 1983. In 1983, approximately 2.35 km of channel was reconstructed due to channel slumping that resulted from heavy rainfall. In 2004, Alberta Transportation Saddle Hills County decided to upgrade the size of the culvert under Range Road 80 (BF 76263). In 2006, the drainage system and culverts capacity was assessed and suggested culvert upgrades under Range Road 80/Highway 680 and Range Road 75 to two 1800 mm diameter culverts to serve 1:10 years flow. They also suggested upgrading the farm crossing culverts.

In 2008, due to the deterioration of most of the wood drop structures and the channel, an alternative drainage system design was studied. The study found the existing channel and road crossings to be undersized and in need of upgrades.

Erosive flow velocities exceeding 0.9 m/s were calculated to occur along the existing channel during the 1:10-year designed flood discharge. The assessment indicated that flooding of some areas along the channel would occur and recommended a number of alternatives to reduce the erosion and flooding in the area. The recommended design would accommodate a discharge of 20 m^3/s in the system.

Rehabilitation/reconstruction started in 2009/2010. The work package included: approximately 5.0 km of channel rehabilitation with drop structures from station 3+690 to station 8+698, replacement of bridge BF 75808 and BF 74637 and replacement of one farm crossing (BF 86248).

In 2011, the system was rehabilitated; the work included approximately 3.5 km of channel with 13 drop structures from station 0+000 to station 2+219 and station 2+422 to station 3+690, and 0+950 to 1+1020. It also includes the replacement of BF 76262, BF 76263 and farm crossings BF 86249 and 86250. In June 30/July1, 2011, the area was severely hit by a storm.

The following water structures were flooded or affected by flooding.

- The bridge BF76915 culverts under Highway #2 were flooded in 2011. There are two 1.00 m diameter culverts of 36.6 m long.
- The bridge BF81946 culvert on Saddle River was washed out in a rainfall in 2011. There is a 1.80 m diameter culvert of 24.0 m in length.
- The bridge BF 74198 culvert was washed out in June30/July1, 2011, rainfall. There are two 1.80 m diameter culverts of 62.2 m length. The bridge culvert was replaced in 2014.
- In July 30/July 1, 2011, rainfall severely scoured the bridge pier over Hamlin Creek. The span of the bridge is 41.4 m and height is approximately 6.4 m.

3.2.5 M.D. of Clear Hills County No.21

Clear Hills County No.21 is located northeast of the BC border and Peace River and comprises Village of Hines Creek, and the Hamlets of Cleardale and Hamlets of Worsley. A few water infrastructures information have been identified in the area so far. The identified water facilities are presented in Figure 3-4.

3.2.6 M.D. of Mackenzie No.23

The M.D. of Mackenzie No.23 is located in the northwest corner of Alberta. It comprises a Town of High Level and two hamlets, Fort Vermilion and La Crete. The water infrastructure Hutch Lake Dam/Spillway has been identified. The identified water facilities are presented in Figure 3-5.

- **Hutch Lake Dam:** The Hutch Lake Dam was constructed in 1987 and is owned by AESRD. It is one of the major dam structures within the Peace River Basin. The dam is located approximately 30 km northwest of the Town of High Level. The main purpose of the dam is recreational. The structure is an earth-fill dam approximately 9.0 m high with 6.0 m of crest. The structure also consists of a concrete fixed weir spillway with a low level outlet.

3.2.6.1 Hamlet of Fort Vermilion

Fort Vermilion is located along the bank of the Peace River. It is identified as a high risk area for flooding. The flood map of the area was prepared in 2000. The AESRD, 2000 study indicated that the area was flooded in 1934, 1963, 1964, and 1990. The highest flood was in 1934 due to ice jam. The study indicated that a number of infrastructures including the airport would be flooded if the 1934 flood event reoccurred. The River Road of approximately 3.5 km stretch just upstream of the airport is within the flood fringe area and the road is being flooded frequently due to water level rise in the river mainly caused by operation of dams in BC. Identification of the water management infrastructures has been updated to include all information provided by the stakeholders.

3.2.7 M.D. of Smoky River No.130

The M.D. of Smoky River lies in the northwest portion of Alberta. The major communities located in the M.D. are Village of Donnelly, Village of Girouxville, Town of Falher and Town or McLennan. The major water facility identified in the area is Winagami Canal and is presented in Figure 3-1.

- **The Winagami Canal:** The canal starts at Winagami Lake and is aligned from east to west. The canal passes the Town of McLennan, the Village of Donnelly, the Town of Falher and the Village of Girouxville. It discharges into Winagami and Kimiwan Lake, Rat Lake and finally into Hunting Creek. The canal was built in 1950 and is 34 km long with 19 drop structures, 4 Sheet Pile Weirs with Stop-logs, three bridges, and 36 culvert crossings. Additionally, the canal receives drainage flows from approximately 159 culverts inlets including Desilets Drainage Project (ditch) and drainage flows from McLennan, Donnelly, Falher and Girouxville. The canal used to flood in every sever rainfall.

  There are control gates in place at the outlet to Kimiwan Lake. Water from the lake can overflow the control gates and flow back into the canal when the lake level rises. However, no flooding was reported at the Town of McLennan. The canal discharges through a 1500 mm culvert, which crosses Township Road 782, into Hunting Creek and relieves drainage flows from the canal. Desilets Drainage also drains into the Winagami Canal east of the Town of Falher .The canal used to flood in severe rainfalls; the area was severely flooded in June 2011 and August 2013.

  A control weir was installed in the canal directly upstream of the Village of Girouxville in 2003. Water reservoirs servicing Girouxville may be recharged when the water level in the canal rises above the top of the weir. Runoff due to spring snowmelt in 2003 flooded approximately 6 homes in Girouxville before the weir was installed.

A preliminary assessment of the canal was made in 2006 by AECOM to complete detailed designs of repairs and the cost estimate was approximately $7 million. The condition of all structures was assessed and a rehabilitation program was developed and spanned over several years with an estimated completion date of 2010. Furthermore, AECOM assessed the hydrology for the project and concluded that not all current inflows and outflows appear to have been accounted for in the current canal system and indicates that the canal may be undersized. This was most likely due to the compounding incremental changes that have occurred in the project area since the canal was built. Capacity issues may be exacerbated as more future changes to in and outflows to the canal are made and may result in increased frequency and severity of flooding.

Bridge decks (Slims and Doran Bridge crossings) on Peavine Creek flooded in April 2007, June 2011, and April 2013. Cost for repairs to Doran Bridge resulted in $65,000. A bridge culvert at the most upstream end of Peavine Creek and two bridge culverts on Township Road 722 crossing Range Road 212 and Highway 49 flooded farmlands north of Township Road 722 between Range Roads 210 and 213 in April, 2013.

The Hamlet of Guy is located upstream of Chaibos Drainage Project (ditch) which contributed to flood damage of Wolf Honey store on June 24, 2011 due to spring snowmelt. Additionally, a lift station was damaged and streets experienced minor manholes flooding.

- **Peavine Creek Drainage:** The Peavine Creek Drainage Project was constructed in 1960 to improve drainage of low lying farmland east of Highway 49 and south of Donnelly. The major canal rehabilitation was done in 1982 which included widening and lowering approximately 5.7 km of channel from the Peavine Creek confluence to approximately 3 km east of Highway 49.

  Flooding along the creek had been an issue since 1920. The area experiences frequent flooding. The recent flood history shows the area was flooded in 1996, 1997, and 2003.

  The measured instantaneous peak runoff flow was approximately 85 m^3/s during the spring 2003. It flooded approximately 500 ha of farm lands and overtopped Township Road 772 and Range Road 212. The flooding around the drainage and the creek problem are primary water management concerns for the M.D.

  The existing channel capacity is approximately 10.6 m^3/s (1:10 year return period) and culvert capacity is approximately 15.9 m^3/s (1:25 year return period). The MPA drainage study (2012) has recommended a number of alternatives including channel intercepts, hydraulic improvement to the existing system, and improvement of bridge culverts.

3.2.8 Northern Sunrise County No.131

Northern Sunrise County No.131 (formerly M.D. of East Peace No.131) is located northeast of the confluence of Peace River and Smoky River. The county comprises of Village of Nampa, and four hamlets, Cadotte Lakes, Buffalo, Marie Reine, Reno, and St. Isidore. The identified water facilities are presented in Figure 3-1.

MPA Engineering Ltd. completed a hydrologic assessment of water management facilities of the area and identified major issues such as: farmlands flooding due to overland drainage, roadways overtopping due to the limited capacity of culverts and road ditches as well, ditches flow capacity exceeded at multiple locations (2014).

Water management infrastructure is overwhelmed by changes in land use over the years. Clearing and ditching of land has significantly increased the rate at which snow melts, the rate at which runoff is shed from land, and lessens the time period for which these events take place.

3.2.9 M.D. of Spirit River No.133

The M.D. of Spirit River is located in the Peace River Region of northwestern Alberta; the Peace River is north of Birch Hill and the Saddle River is to the south. The Town of Spirit River and the Village of Rycroft are the major communities in the M.D of Spirit River County. Identified water management structures in M.D of Spirit River are: Young Drainage; Spirit River Drainage Ditch No. 2; Spirit River Drainage Ditch No. 1; Prestville Drainage; Spirit River Drainage Ditch No. 3; Brunt Erosion Control; Durda Chute Extension Drainage Ditch; Working Drainage Ditch; McDougal Drainage II Ditch and some minor ditches and locations of these facilities are presented in Figure 3-3.

- **Burnt Erosion Control Project:** The project is located along the south boundary of the Township Road 773 and Range Road 51. About 1.25 km of erosion protection work was completed in 1975. The project comprises with 1.82 m x 1.12 m section of Corrugated Steel Pipe (CSP) and is 12.00 m long. Also, there are two CSP culverts 0.76 m and 0.92 m in diameter 21 m and 24 m long respectively.
- **Spirit River Drainage Ditch No. 1:** It was constructed in 1986 and rehabilitated in 1992. The drainage ditch is approximately 4.4 km long and comprises of 5 meter long gabion drop structures, two ditch inlets and riprap on two culvert crossings.
- **Spirit River Drainage Ditch No. 2:** It was constructed in 1968 and rehabilitated in 1985. The ditch is approximately 2.20 km long and comprises of 72 m long rock drop chute structure, a plywood drop structure and two 1.27 m × 0.78 m arches CSP culvert (crossing) the road.
- **Prestville Drainage Ditch:** It was constructed in 1963 and rehabilitated in 1983. The ditch comprises of timber and plywood chute. The chute is approximately 220 m long and a tributary ditch is 480 m long.
- **Woking Drainage Ditch:** The ditch was constructed in 1967. The ditch is approximately 7.50 km long and comprises of culvert under Range Road 54, Range Road 55 and railroad crossing.
- **McDougal Drainage II Ditch:** It was constructed in 1960 and rehabilitated in 1994/95. The length of the ditch is approximately 2.7 km and consists of gabion drop structures and 2 - 900 mm diameter culverts.

Bridge and culvert in the area that were flooded in the past are listed below:

- The low level bridge culvert #78824 in the Saddle River under Highway 45 used to flood during spring snowmelt due to ice jams and debris blockage in the culvert. The low level structure consists of concrete bed with five barrels of concrete pipes of 1400 mm diameter culverts 17 m long. The each span of the culvert is 17 m. The road level is about 2 m in height. The culvert was severely flooded in March 2014 due to spring snowmelt. Highway 45 was out of service for 7 days. The valley upstream of the low level crossing was flooded.

3.2.9.1 Village of Rycroft

Rycroft is located approximately 64 km north of Grande Prairie and 7 km east of Spirit River. The Village of Rycroft had a few flooding problems in 1990, 1996, 2011, and 2013 due to surface runoff. The 1990 flood was the largest, believed to be higher than a 1:100 year flood. The 1990 flood 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 flooding in the Village was due to insufficient land drainage south of and through the Village of Rycroft and over flooding in the unnamed tributaries that flow through the center of the village. Four drainage systems were identified in the area.

3.2.10 M.D. of Peace No.135

The M.D. of Peace No.135 lies in northwestern Alberta and is surrounded by the Peace River in the southeast, M.D. of Northern Light No.22 in the north and M.D. of Fairview No.136 in the west. The major communities located within the M.D. are the Town of Grimshaw, Town of Peace River, the Village of Berwyn, and the Hamlet of Brownvale. The area has very few flooding issues and the Grimshaw Flood Control Water Management infrastructure in the area is briefly described below. Figure 3-1 shows its location.

- **Grimshaw Flood Control Project:** The project is located to the west and south of the Town of Grimshaw. It was constructed in 1979/80. The ditch is approximately 6.5 km in length and consists of 14 steel sheet piling gabion basin drop structures, one Highway crossing culvert, two secondary crossings, and three farm crossings. The project includes erosion control via the McAllister Creek Erosion Project. The erosion control structures were flooded and damaged in 1997. The steel sheet pile weirs with concrete capped gabion baskets were constructed in 1998. The system is inspected annually to ensure the system is functioning as designed. In 2008, the bottom south side last drop structure failed. It was repaired but it failed again. The drop structure was again repaired in 2010. The Grimshaw Flood Control Project is owned and maintained by AESRD.

3.2.10.1 Town of Peace River

The Town of Peace River is located at the mouth of Pat's Creek. The town has relatively flat terrain. It has a history of flooding incidents, including floods in 1986, 1992, 1997, 2013 and 2014. In previous years; Pat's Creek used to be an open channel through the town but is now channeled through a culvert/pipe under the town.

- **Pats Creek Culvert:** The Town of Peace River pipe system consists of 5.486 m x 4.750 m CSP intake with concrete floor which is connected to elliptical CSP pipe (5.210 m x 3.350 m) that runs all the way under the town to the outlet in the Peace River, located approximately at 100 Avenue and 98 Street, within the town boundary. The outlet consist of concrete box sized 3 x 4 m. The existing system capacity has some constrains in its inlet, pipe crossing and outlet.

  In April 2013, flooding was caused due to pipe debris blocking the intake. The intake was affected by ice blockages, debris, and debris related to beaver dam collapse upstream in Pat's Creek. The trash rack and the pipe require upgrading. Additionally, flooding due to snowmelt and rainfall in June 2013 and April 2014 caused water to back up through manholes, thereby flooding the downtown area. The pipe running under the town has less than half of its capacity to convey the peak flow. The existing pipe capacity is approximately 30 m^3/s.

  The winter flow, especially ice jam, is one of the other major problems in the system. In spring 2014, the outlet was frozen which caused water to back up into the pipe. As a result, water spilled out of a manhole located in downtown and flooded towards a park along the Peace River bank. The dike was opened to release the flood water into the Peace River. When the water level is high in the Peace River, the outlet backs up.

3.2.11 M.D. of Fairview No.136

The M.D. of Fairview No. 136 lies in the northwest part of Alberta. The M.D. is surrounded by the Peace River on the south and west and M.D. of Clear Hills No. 21 in the north and M.D. 135 in the east, respectively. The Town of Fairview and Villages of Bluesky and Whitelaw are located within the county. There are six water facilities identified but detailed information has not yet been received. The water facilities are presented in Figure 3-1.

3.3 Summary

Operation of the existing Bennet and Peace canyon dams together with planned Site C Dam in BC may play an important role of flooding the public facilities and communities along the Peace River, specific to the Town of Mannings and Hamlet of Fort Vermilion which are partly situated within the flood fringe. However, the existing water management facilities in the Peace River Basin within Alberta are helping to reduce flooding issues to some extent. A high level investigation on new water management facilities is recommended to mitigate current flooding issues. Table 3-1 shows the existing water management system in the Peace River Basin.

Table 3-1: Summary of Existing Water Management System

Municipality	Basin Area (km^2)	Water Management Information
Birch Hills County	2,908	Sixteen water management canals/ditches were identified. Detailed information regarding the structures and its impact in community will be gathered.
Regional Municipality of Wood Buffalo	14,290	One water management facility was identified. Additional water management facilities information collections are in progress; the report will be updated when the information is received.
County of Grande Prairie No.1	6,113	Five water management facilities owned by AESRD and M.D. were identified. More information will be gathered from the County and the City of Grand Prairie.
M.D. of Greenview No.16	30,907	Two water management facilities were identified, Seeking for more water management information from the M.D. and the Town of Grande Cache.
Saddle Hills County No.20	5,877	Twenty seven water management facility owned by EASRD and M.D. have been identified. Seeking for detailed information of structures.
M.D. of Clear Hills County No.21	13,551	Fourteen water management structures were identified; detailed information of structures will be gathered from the M.D.
M.D. of Northern Lights No.22	12,704	One water management infrastructure has been identified; additional information from the M.D. has been received recently, the report will be updated onward.
M.D. of Mackenzie No.23	82,600	One provincial facility was identified; more information will be explored if required for future flood mitigation analysis.
M.D. of Smoky River No.130	2,746	Five water management facilities owned by the provincial government and the M.D. have been identified. More information will be gathered from the City of Rycroft.
Northern Sunrise County No.131	21,039	Two water management facilities have been identified; more information about water facility within the county will be gathered.
M.D. of Spirit River No.133	691	Twelve water management facility owned by the M.D. have been identified. Detailed information of structures will be collected from the M.D. Recently received information from the Village of Rycroft will be updated onward.
M.D. of Peace No.135	965	One provincial government owned water infrastructure was identified, and more water management of structures from the M.D. will be gathered.
M.D. of Fairview No.136	1,430	Six water management facilities that were identified; detailed information regarding facilities and detailed information of structures from the M.D. will be gathered.

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 3-1 BIRCH HILLS COUNTY, MDS 130, 131, 135, 136 - WATER MANAGEMENT STRUCTURES.MXD

N

Clear Hills County No.21

George Lake/Weir

Minor Strucuture

Minor Strucuture

Minor Strucuture

Town of Fairview

Minor Strucuture

M.D. of Fairview No.136

Minor Strucuture

Minor Strucuture

Peace River

Figure Eight Lake

Town of Peace River

Grimshaw Flood Control Canal

M.D. of Peace No.135

Northern Sunrise County No.131

Minor Strucuture

Minor Strucuture

North Tangent Drainage

Reiger A

Reiger C

Reiger B

Podruzny 1

Poohkay Drainage

Morgan Drainage

Bouchard Line 2

Bouchard Line 1

Prestville

Spirit River 3

Podruzny 2

Podruzny 4

Vixen Drainage

Coote Lake Drainage

Fox Creek Drainage

Boreen Drainage

Four Mile Creek

Desilets Drainage Project

Control Structure Gate

Winagami Canal

Girouxville Control Structure

Falher Control Structure

Weir Outlet Structure

Brunt Erosion Control

Birch Hills County

Smoky River

M.D. of Smokey River No.130

M.D. of Greenview No.16

Little Smoky River

3,600 0 3,600 7,200 m

NAD 1983 UTM Zone 11N

Legend

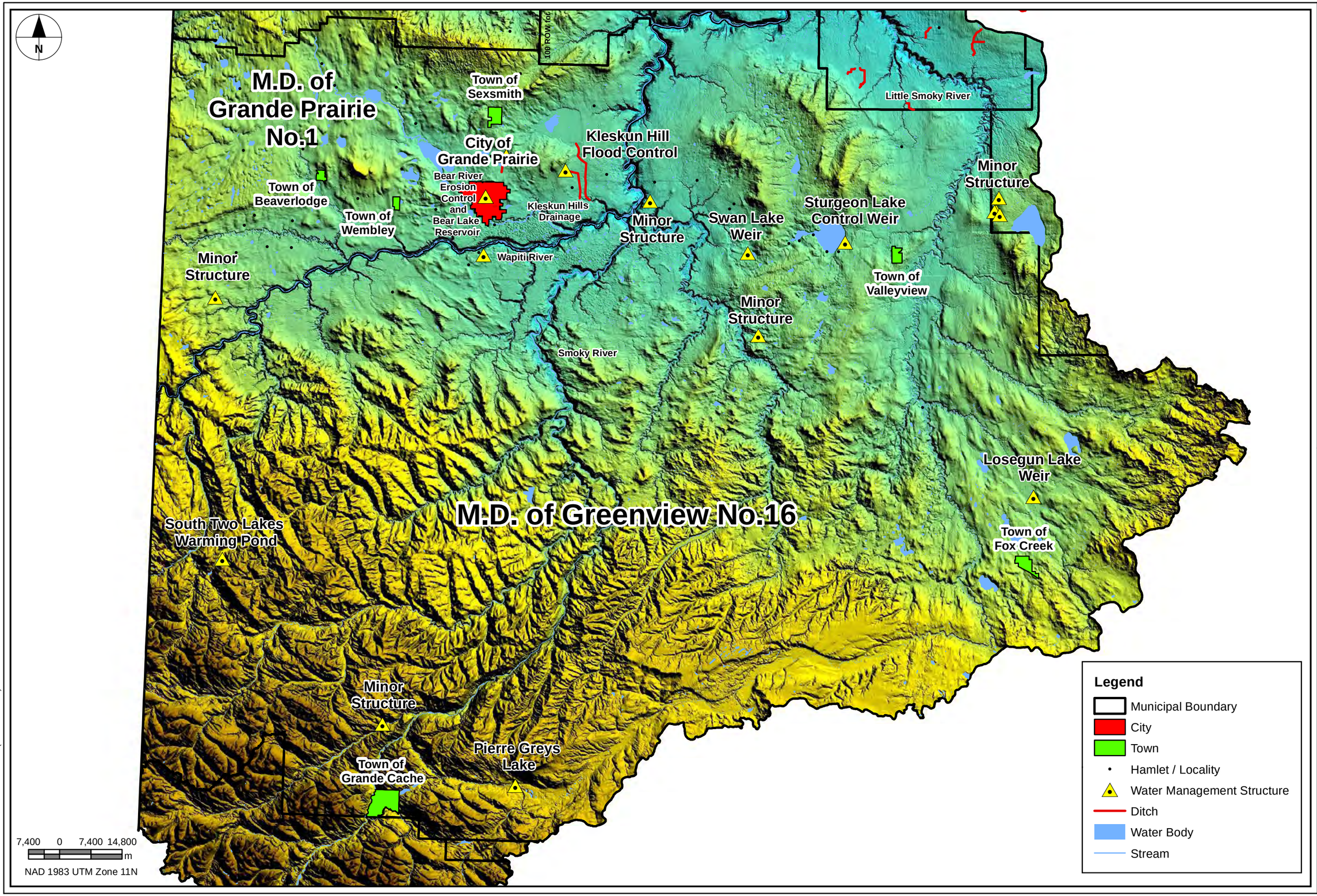
- Municipal Boundary
- Town
- Hamlet / Locality
- Water Management Structure
- Ditch
- Water Body
- Stream

AECOM

Figure: 3-1

Birch Hills County, MD of Peace No. 135, MD of Smoky River No. 130, MD of Fairview No 136 and Northern Sunrise County No. 131 Water Management Structures

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



ANSI B 279.4mm x 431.8mm

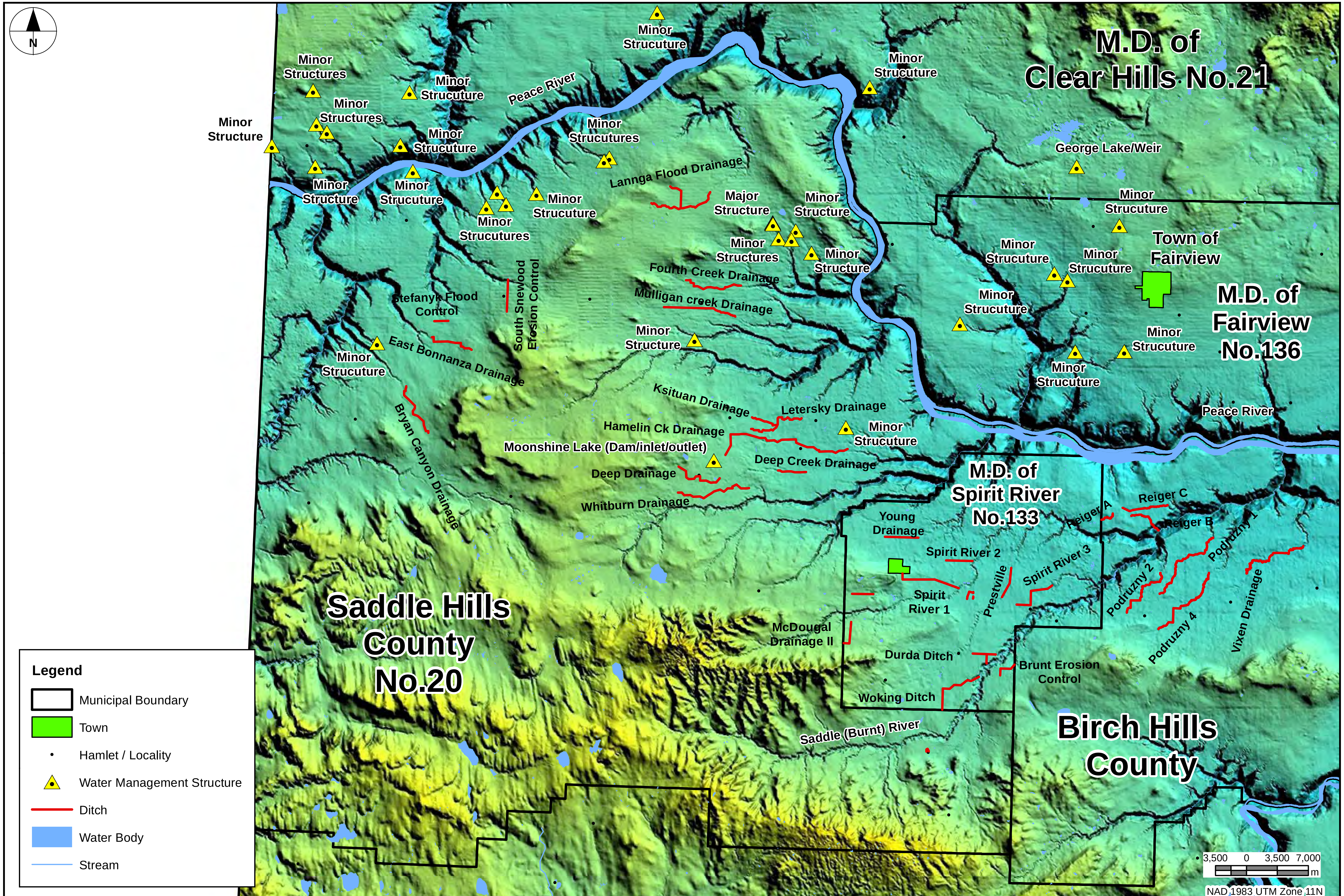
Last saved by: MIREAU LTC (2015-06-02) Last Plotted: 2014-03-18
Filename: P:\60334569\900-WORK\920-929 (GIS-GRAPHICS)\MAIN REPORT FIGURES\FIGURE 3-2 MD OF GREENVIEW NO.16 AND COUNTY OF GRANDE PRAIRIE NO.1 - WATER MANAGEMENT STRUCTURES.MXD

AECOM

Figure: 3-2

MD of Greenview No.16 and MD of Grande Priarie No.1
Water Management Structures

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



AECOM

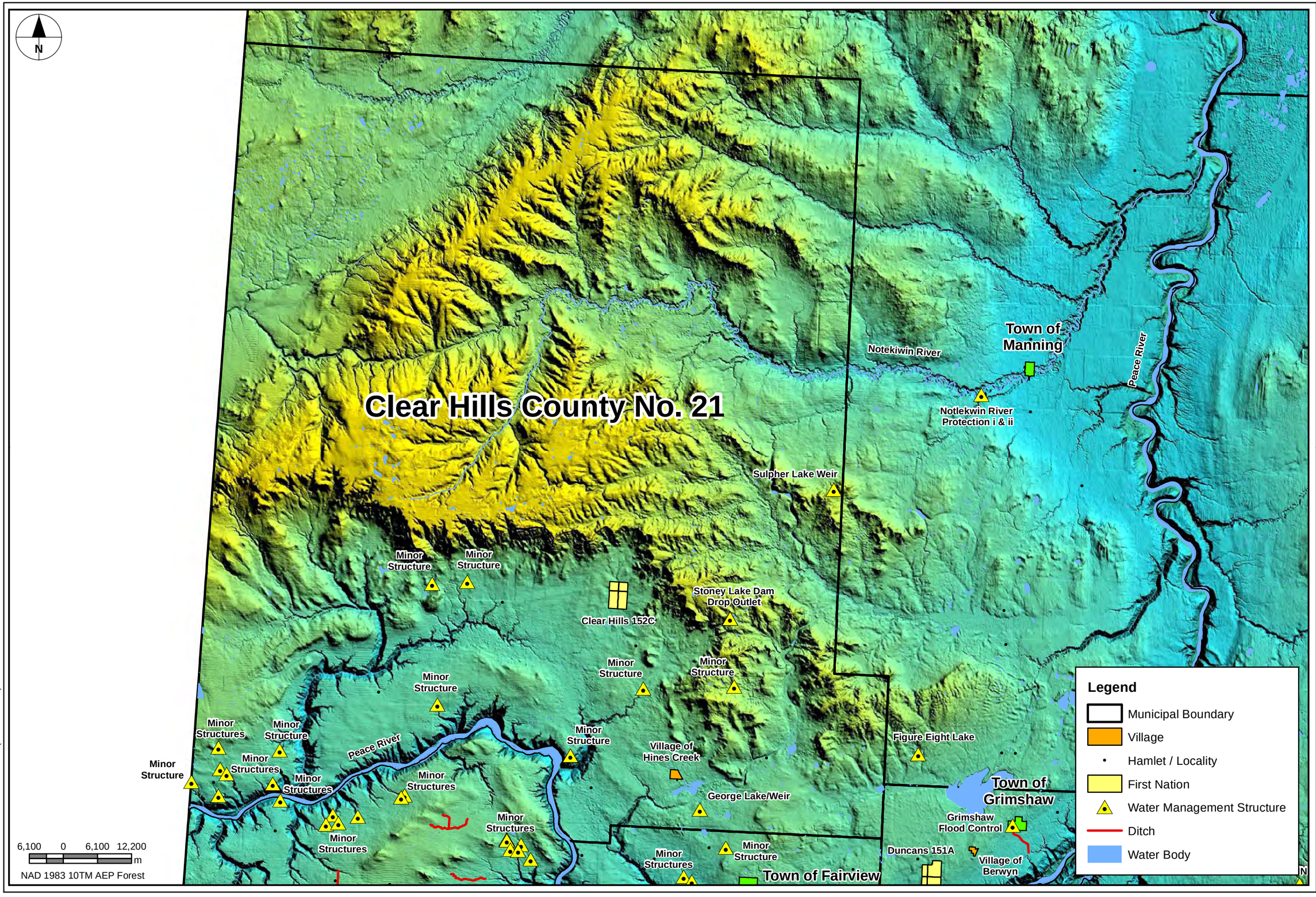
Figure: 3-3

Saddle Hills County No. 20
MD of Spirit River No. 133
Water Management Structures

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 3-3 SADDLE HILLS 20 MD AND SPIRIT RIVER 133 - WATER MANAGEMENT STRUCTURES.MXD



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 3-4 CLEAR HILLS COUNTY NO.21 - WATER MANAGEMENT STRUCTURES.MXD

ANSI B 279.4mm x 431.8mm

AECOM

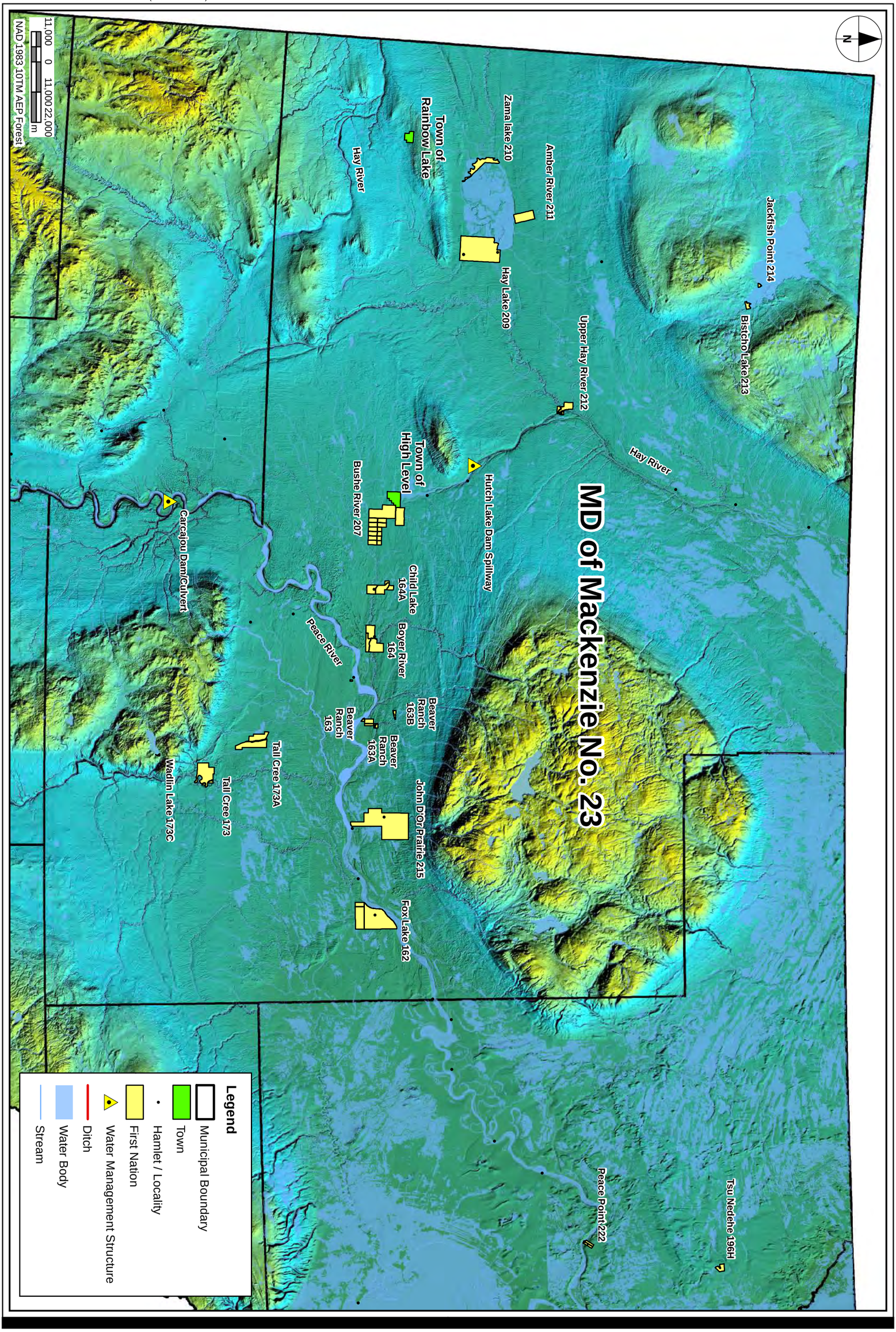
Figure: 3-4

Clear Hills County No.21
Water Management Structures

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

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 3-5 MD OF MACKENZIE NO.23 - WATER MANAGEMENT STRUCTURES.MXD

ANSI B 279.4mm x 431.8mm



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

MD of Mackenzie No.23
Water Management Structures

AECOM

Figure: 3-5

4. Water Supply

4.1 Communities' Water Sources Affected due to Past Flooding

The following section contains communities' water sources that could have potentially been impacted due to the past floods in the Peace River Basin (PRB) and are shown on Figure 4-1. Communities outside the flood hazards area that depend on water supply from the flood affected communities were also considered. Communities with high to medium flooding risk were considered in this report as there are a total of approximately 3000 wells within the Peace River Basin. Rural communities that are dependent on private wells, surface water, or have water trucked in beyond the flood hazard area were not investigated further in this study. All information about the communities was obtained by correspondence with communities, municipalities, and water treatment plant (WTP) personnel.

4.1.1 County of Grande Prairie No.1

Aquatera Utilities Inc. owns and operates a WTP in the City of Grande Prairie, as shown on Figure 4-2, and provides municipal water supply to the City of Grande Prairie, County of Grande Prairie – for the Hamlet of Clairmont, the Hamlet of Wedgewood as well as east and west rural subdivisions, and the Town of Sexsmith from the Wapiti River. Other areas in the county get their water supply primarily from groundwater wells. As such, there have been water supply restrictions due to drought in the past. It was reported that the clay conditions within the county both promotes drought during low precipitation periods and flooding during high precipitation periods.

The existing WTP is located in its current place as a result of flooding in 1982, and as such, the WTP is built so that flooding will not be a concern.

The river intake, pump house and sedimentation ponds are located adjacent to the Wapiti River. The intake facilities have experienced flooding in the past, once in 1982 and again in 1990.

The Town of Sexsmith is also serviced by municipal wells. Two municipal wells, as shown on Figure 4-3, have a potential to be affected during annual flooding. The Town experiences annual flooding along 106 Street due to snowmelt. Additionally, a creek running at a flat slope (0.1%) through Town floods the southeast part of Town adjacent to the CN rail line.

4.1.2 Town of Fairview

The Town of Fairview owns and operates a WTP as shown on Figure 4-1 and also supplies water to the Fairview Rural Co-op and the municipal District of Fairview for the Hamlet of Bluesky. The drinking water source is the Peace River. The emergency overflow at the Fairview WTP experienced flooding approximately 20 years ago. Since then there has been no flooding issues for the Water Supply for the Town.

4.1.3 Town of Falher, Villages of Donnelly and Girouxville, and Hamlets of Guy and Jean Cote

The Smoky River Regional Water Management Commission (SRRWMC) provides a municipal water supply to the Town of Falher, the Villages of Donnelly and Girouxville and the Municipal District of Smoky River – for the Hamlets of Guy and Jean Cote, from the Little Smoky River, which is a tributary to the Smoky River. The SRRWMC WTP as shown on Figure 4-1 gets its water from the Little Smoky River, which is a tributary to the Smoky River. Water from the river is pumped to a water reservoir and then to the WTP. Since its construction in 2006, the river intake has reportedly been flooded three times; however, the WTP itself has not been subject to flooding.

The Little Smoky River is a reliable source of water for the plant, however the infrastructure constructed in 2006 has made diverting the water from the river difficult. The intake has been damaged due to log jams, siltation due to high flows, and as a result needs to be cleaned out annually.

4.1.4 Town of Manning

The Town of Manning and Northern Lights County own and operate the Northern Lights/Manning Regional Waterworks System. The regional Waterworks system consists of two water treatment plants: one for the Town of Manning as shown on Figure 4-4 and one for the surrounding areas located in the Locality of Keg River as shown on Figure 4-1. From previous communication, it has been noted that both flood and drought are potential issues for the intake for the Town of Manning, which is located on Notikewin River. The water supply has not been interrupted due to intake flooding as the water reservoir has a large capacity.

4.1.5 Village of Rycroft

The WTP and river intake for the Village of Rycroft are located northwest of the Village itself as shown on Figure 4-1. The WTP gets its water supply from the reservoir which also supplies raw water to the Spirit River WTP. The river intake at the WTP for Rycroft was damaged by flooding in June/July of 2011, due to a heavy rainfall event. However, this flooding did not interrupt service.

4.2 Communities' Water Sources Potentially at Risk of Future Flooding

4.2.1 City of Grand Prairie

The City of Grand Prairie is serviced by a WTP located close to the Bear River and also one municipal well as shown on Figure 4-2. The municipal well is within the 1:100 year flood fringe and therefore has a potential to be affected during 100-year flooding event. The municipal well is located approximately 1 km south of 68 Avenue and 700 m east of Canfor Hauling Road.

4.2.2 Hamlet of Fort Vermilion

The Hamlet of Fort Vermilion issues a flood watch nearly every spring which extends to the WTP for Fort Vermilion. However, the WTP itself has reported no flooding or any flooding related issues for the water supply for the Town. The river intake and the WTP are located on the south side of the Peace River as shown on Figure 4-5. Additionally, the Fort Vermilion WTP supplies water to other nearby rural communities by a truck-fill station.

The Hamlet of Fort Vermilion is also serviced by multiple municipal wells. Two municipal wells as shown on Figure 4-5, are within the 1:100 year flood fringe and therefore have a potential to be affected during 1:100 year flood. Six additional municipal wells located south of the Peace River have a potential to be affected if the Peace River overtop its banks.

4.2.3 Hamlet of La Crete

The Hamlet of La Crete WTP obtains their water supply from surface runoff, located south of the Hamlet as shown Figure 4-6. No flooding issues have been reported at the WTP or with its supply infrastructure. The Hamlet is also serviced by four groundwater wells located approximately 11 km west of the Hamlet and on the east side of the Peace River. The wells were not accessible due to reported flooding in June 2001. The primary cause of flooding was heavy rainfall.

4.2.4 Hamlet of Watino

The Hamlet of Watino draws its water from the Smoky River via multiple wells. Eight domestic wells as shown on Figure 4-7, are within the 1:100 year flood way/ flood fringe and therefore have a potential to be affected during the 1:100 year flood.

4.3 Groundwater Wells at Risk of Future Flooding

Alberta Water Well Information data was obtained from the Alberta Environment and Sustainable Resource Development and was compiled into a database by AECOM. This data contains information from water well records including: well identification, latitude, longitude, elevation, drilling date, static water level (meters below ground surface), date static water level measured, well purpose, recommended pump rate (liters per minute), lithology, perforation length, screen length, and other comments extracted from the well logs.

The database was exported into ArcGIS shape files that are geographically referenced in the Peace River Basin. Geological data from the Alberta Geological was used to project a three dimensional subsurface throughout the perforated and screened intervals obtained from the database and geological units were determined and/or assigned in the perforated and screened intervals.

High water marks with high to medium risk flooding potential were identified and geographically referenced. Water wells within these zones could be affected during a flooding event. Figures 4-2 to 4-7 illustrate the water wells in high and medium flood risk areas that could be potentially impacted by a flooding event.

Table 4-1 lists the wells that are in the high to medium risk flooding zone along with the river they are near.

Table 4-1: Water Wells within the High to Medium Risk Flooding Zone

River	Number of Wells
Peace River	57
Notikewin River	7
Boyer River	3
Bear River	8
Smoky River	31
Unnamed Stream (near Sexsmith)	7
Unnamed Stream (near Rycroft)	1

Water wells can be affected in three ways during a flood event. These are summarized below:

- Damage and or total destruction of the wellhead and any associated structures (pump shack) by the force of the flood waters or by debris in the flood waters.
- Flood waters travelling down the well due to poor sealing of the well or down the well annulus (the hole outside of the well casing caused by the drilling of the borehole) due to poor or compromised sealing of the annulus.
- Flood waters infiltrating down through a surficial sand aquifer (an aquifer that consists of sand and gravel from surface to the depth the well[s] are completed) and impacting wells completed in that aquifer.

Of the three possible ways of impact to water wells, the third is the most damaging as it impacts the aquifer as a whole and will be widespread versus local impact at specific well locations (i.e. the whole aquifer is contaminated rather than just a specific well). Of the wells listed in Table 4-1, 78 wells are completed in surficial aquifers.

4.4 Communities' Water Sources Unaffected by Past Flooding

4.4.1 M.D. of Opportunity No.17

The Municipal District of Opportunity owns and operates the Wabasca-Desmarais Regional Waterworks System to provide a municipal water supply to the Hamlets of Wabasca and Desmarais. The source of water for the WTP is North Wabasca Lake. Wabasca and Desmarais have adequate water supply for the plant, with Desmarais also supplying potable water to Bigstone Cree Nation.

The M.D. of Opportunity also owns and operates the WTP at the Hamlet of Red Earth Creek to treat surface water from Red Earth Creek, or Peerless Lake in case of emergency. The Red Earth Creek water supply system also provides bulk treated water to potable water haulers. The WTP used to serve the Locality of Loon Lake to the east of Red Earth Creek, but it is our understanding that Loon Lake now has a separate WTP.

The M.D. of Opportunity also owns and operates WTP's at the Hamlet of Peerless Lake, Sandy Lake and Trout Lake and treat surface water from Peerless Lake, Sand Lake and Trout Lake respectively.

The WTPs for Wabasca, Desmarais, and Sandy Lake have all reported no flooding issues at their water supply facilities. Sandy Lake WTP is unable to produce potable water due to turbidity and therefore have an inadequate water supply for the community. The Red Earth Creek WTP and intake have not experienced any flooding issues, as they are located on high elevation.

4.4.2 Saddle Hills County No.20

Saddle Hills County owns and operates a WTP to treat surface water from an unnamed watercourse for a municipal water supply for the Hamlet of Woking. The Woking WTP and intake have not experienced any flooding issues.

Saddle Hills County also owns and operates a WTP at the Locality of Whitburn and gets its water from surface runoff. There have been no reported flooding issues with the WTP or the water source for this administration site.

Another WTP is being planned in the Locality of Bonanza, within the county. The area where the Bonanza site is planned to be constructed is prone to flooding. However, the county is intending to use the flooding as a water source by diverting water to dugouts. The Bonanza site will likely form water Co-ops which will serve neighbouring communities, including Bay Tree.

4.4.3 Town of Beaverlodge

The Town of Beaverlodge owns and operates a WTP to treat surface water from the Beaverlodge River for a municipal water supply.

Through communications with the Town, it is understood that the Town generally has not experienced any flooding issues. Therefore, it is likely that the WTP for the Town has also not experienced any flooding issues.

4.4.4 Town of High Level

The Town of High Level obtains their water supply from Footner Lake, located north of the Town. The Town also provides a municipal water supply to the Footner Lake Forest Site. No flooding issues have been reported at the WTP or with its supply infrastructure.

4.4.5 Town of Peace River

The Town of Peace River has two WTP's: one located at Shaftsbury and other on 103rd Street. Both WTP's get their water supply from intakes located on the Peace River, which is therefore considered the main source of water for the jurisdiction. The Town of Peace River WTPs supplies two water co-ops: Shaftesbury and Pats Creek. The river intakes and the WTPs that supply the Town of Peace River reported that there have been no flooding issues at any of the water supply facilities. However, the Town did report that turbidity and low water levels in the Peace River have been a cause of water supply issues for the jurisdiction, limiting the available water supply.

4.4.6 Town of Valleyview

The Town of Valleyview owns and operates a WTP to treat surface water from Little Smoky River. The WTP is located southeast of the Town.

The WTP and the river intake have not experienced any noted flooding. The WTP at Valleyview does not directly supply water to any other communities, but does sell treated water in limited quantities to a rural water system in the Municipal District of Greenview.

4.4.7 Town of Spirit River

The Town of Spirit River gets its water supply from a coulee tributary to the Spirit River and the Village of Rycroft from the Spirit River, which is collected into a water reservoir, located south of the Town. This reservoir supplies water to the Town of Spirit River and the Village of Rycroft. There have been no noted flooding issues at the WTP. However, drought has been as issue in the past, and the Town had to ration their water supply.

4.4.8 Village of Hines Creek

The Village of Hines Creek WTP obtains their water supply from Jack Creek, located approximately 2 km north of the WTP. The WTP and the river intake have not experienced any noted flooding. The WTP at Hines Creek does not supply water to any other communities.

4.4.9 Village of Nampa

The Village of Nampa owned and operated a WTP to treat surface water from the Heart River until early 2010. NEW Water Ltd. is a collaborative partnership between Northern Sunrise County, the Village of Nampa, and Woodland Cree First Nation to supply water on a regional basis. The drinking water source is the Peace River. The system includes a raw water transmission line, raw water reservoir, water treatment plant and regional transmission lines. The WTP for the community has not experienced any flooding issues.

4.4.10 Hamlet of Eaglesham

Birch Hills County owns and operates a WTP in the Hamlet of Eaglesham, to treat surface water from Fox Creek and provides water to the Hamlets of Eaglesham, Tangent and Wanham using a regional water supply system. The source of water for the WTP is spring runoff from Fox Creek, an intermittent creek where water only flows during spring melt. Water is stored in a reservoir which has 3.5 years of storage capacity. From communications with the stakeholder, it was reported that there are no flooding or drought issues for the area.

4.4.11 Paddle Prairie Métis Settlement, Fox Lake 162 and John D'Or Prairie First Nations Reserve

The Paddle Prairie Métis Settlement, Fox Lake 162 & John D'Or Prairie Indian Reserve own and operate a WTP to treat surface water from Boyer River, Peace River and Lawrence River respectively. No flooding issues have been reported at the WTP or with its supply infrastructure. The approximate locations of WTP's are shown on Figures 4-8 and 4-9.

4.5 Groundwater Wells and Aquifers in the Study Area

4.5.1 Methodology

Data on the water wells with the study area was obtained from the Alberta Environment and Sustainable Resource Development Water Well Information database. The data was imported into ArcGIS with relevant information from water well records including: well identification, latitude, longitude, elevation, drilling date, static water level (meters below ground surface), date static water level measured, well purpose, recommended pump rate (liters per minute), lithology, perforation length, screen length, and other comments extracted from the well logs.

The database was compiled to establish groundwater topography. Well data was not used in the Rocky Mountain deformation belt due to the highly variable geologic structure would present invalid and inconsistent groundwater yield results. Well data that looked to be inaccurate or could affect the quality of the model was removed.

The complied database was outputted into ArcGIS shapefiles that are geographically referenced in the Peace River and Slave Basins. Geological data from the Alberta Geological Survey (Barnes 1977, Borneuf 1972, Borneuf 1979, Borneuf 1980, Borneuf 1981, Borneuf and Pretula 1980, Ceroici 1979, Hackbarth 1977, Ozoray 1980, Ozoray 1982, Ozoray et al. 1980, Ozoray and Lyviak 1980, Tokarsky 1972a, Tokarsky 1972b, Tokarsky 1972c, Tokarsky 1976, Tokarsky 1977, and Vogwill 1978) was used to project a three dimensional subsurface throughout the perforated and screened intervals obtained from the database and geological units that were determined and/or assigned in the perforated and screened intervals.

Geological units that were assigned in screened and perforated areas using ArcGIS made it possible to determine the geological source that the water is coming from (assuming that the same water conditions are the same as when last recorded). After determining where the groundwater was coming from in the individual lithologies, the recommended pump rates were applied to those unique selections. These unique sections include the local surficial sediments and bedrock units.

Potential aquifers were limited by areas of interest in selected populated areas. These populated areas of interest included are as follows.

- Town of Manning
- Hamlet of Watino
- Hamlet of Fort Vermilion
- Buffalo Head Prairie, Mackenzie County No.23 (South of La Crete)
- Town of Peace River
- Town of Sexsmith
- Town of Falher
- Village of Rycroft

Surficial sediments are divided into two categories, upper surficial and lower surficial. The upper surficial boundary is defined from the surface of the earth to 100 meters below the ground surface (mBGS). The lower surficial sediments are defined from 100 mBGS to the top of the bedrock. The top of the bedrock is defined from shapefiles derived from the Alberta Geological Survey (Pawlowicz and Fenton 2004, and Atkinson and Lyster 2010).

Search areas for bedrock aquifers in the area of interest were extended to approximately 50 km from the populated areas of interest to the nearest aquifer, where bedrock geology data could be obtained. There were no populated areas of interest selected within the Slave Basin. Lithologies with a majority of sandstone within the formation were used to define potential aquifers. This limited the potential aquifers to the Upper Wapiti, Lower Wapiti, and Dunvegan Formations. These formations were also limited by available data. The majority of the subsurface mapping of the Wapiti Formation is not divided into Upper and Lower Wapiti, therefore the Wapiti Formation had to be modeled as one formation. The Dunvegan Formation was limited by the lack of water wells drilled in the formation. Only a few water wells could be determined to have water coming from the Dunvegan Formation, therefore it could not be modeled.

The Paskapoo, Grand Rapids, and McMurray Formations could be potential aquifers, but the formation locations are too far from the populated areas of interest, therefore bedrock aquifers in the Peace River Basin are limited. The aquifers are also limited due to the majority of bedrock in the Peace River Basin being composed of mudstone. Mudstone inhibits groundwater flow, therefore making a poor aquifer. A table of formations is shown in Figure 4-10, which identifies the relative age of the geological formations.

The top of the Fort St. John Group, only below the Dunvegan Formation, was modeled to provide a base for the Dunvegan Formation; the Fort St. John Group was modeled only to provide a base for the Dunvegan Formation. The Fort St. John Group is mainly composed of mudstone (Prior et al. 2013a) and, therefore, a poor aquifer.

4.5.2 Results

Figure 4-11 presents the location of the wells that are screened within each geological unit (upper and lower surficial sediments, and combined Wapiti Formation). Figures 4-12, 4-13, 4-14, and 4-15 present the groundwater topography for each aquifer unit. Generally, the groundwater topography should mimic the topography for the upper surficial sediments, and show shallow gradients in the lower surficial sediments and in the bedrock aquifers. Areas near river and creeks which display an up-gradient “V” shape indicate groundwater discharge into the river.

It is important to identify these areas during a flood event, areas of groundwater discharge will not have any capacity to absorb the flood water, and this would increase the magnitude of the flood event in these areas.

Figure 4-12 presents the static groundwater water elevation in the upper surficial sediments. Figure 4-13 presents a close up of the area around Grand Prairie where there is a high concentration of water wells in the upper surficial sediments.

Groundwater discharge along the Peace River is observed along most of its river course with the exception of a short section west of Fairview and the section of the river around Fort Vermillion and Buffalo Head Prairie. This indicates there will be little to no damping of the magnitude of a flood event by the soil absorbing some of the flood water

The Smoky River and the Little Smoky River upstream (south) of Watino are groundwater discharge locations as is the portion at the Smoky River east of Grand Prairie (Figure 4-12). Downstream of Watino, however, they lose water to the groundwater.

The Notikewin River nearing Manning experiences groundwater discharge from the mouth to the nearby British Columbia border where the river turns to the south. The groundwater from the upper surficial sediments would likely have no effect on high-water upstream from this point on the Notikewin River.

The Spirit River, which goes through the Town of Rycroft, does not appear to have significant groundwater discharge to it.

The lower portion (northeast trending) of the Saddle (Burnt) River also does not appear to have significant groundwater discharge; however, the east-west portion north of Sexsmith (See Figure 4-13) does.

Other rivers in the study area that appear to have significant groundwater discharge are:

- the Wapiti River south of Grande Prairie
- the Simonelte River, and
- the Meikle River

The lower surficial sediments (Figure 4-14) show that the majority of the Peace River is a gaining stream, (groundwater is discharging to the River) where data is available or where lower surficial sediments are present. This is due to the Peace River following the thalweg at the pre-glacial Notikewin Buried Valley and down-cutting into the pre-glacial gravels in the buried valley. Areas of interest where no data is available or there are lower surficial sediments are Watino, Falher, Fort Vermillion, Buffalo Head Prairie, Sexsmith, and Rycroft. Upstream from the town of Peace River is a thick section of lower surficial sediments. The rivers affected by the lower surficial sediment aquifers are the Peace River from the west and the Smoky River from the south.

The only bedrock unit with a potential aquifer in the nearby vicinity of the selected areas of interest is the Wapiti aquifer (Figure 4-15). The Wapiti aquifer, composed of the Upper and Lower Wapiti Formations, extends south of Rycroft and Watino and is nearly centred underneath the town of Sexsmith. The Wapiti aquifer is too deep to be an affect during flood events.

4.5.3 Groundwater Quality

The groundwater quality is summarized into tables by lithology, which includes the upper surficial sediments, upper Wapiti, lower Wapiti, and the Dunvegan Formations (See Tables 4-2, 4-3, 4-5 and 4-6 below). The upper surficial sediments included are 100 mBGS and higher. Data was not available for the lower surficial sediments. The groundwater chemistry is expected to be unique in each separate paleo-valley. All groundwater quality data was obtained from HCL Consultants, 2004. Since their report was completed, the geological formations have reassigned lithology names in the study area. The Horseshoe Canyon Formation correlates with the Upper Wapiti Formation. The Oldman and Foremost Formations correlate with the Lower Wapiti Formation.

Table 4-2: Surficial Aquifers (upper 100 meters) – Groundwater Quality

Constituent	Number of Analyses	Range for Study Area (mg/L)				
		Guideline [1]	Minimum	Maximum	Mean	Median
Total Dissolved Solids	3,770	500	16	15,712	1,084	728
Sodium	3,108	200	0.1	4,410	141	46
Sulfate	3,760	500	0.3	7,625	411	170
Chloride	3,411	250	0.1	2,178	30	7
Nitrate + Nitrite (as N)	3,024	2	0.001	513	4.1	0.3

**Data table from (Hydrogeological Consultants Ltd, 2004)*
Data Defined to bedrock or top 100 meters of surficial sediments.
[1]Canadian Drinking Water Guidelines

Table 4-3: Upper Wapiti Aquifer - Groundwater Quality

Constituent	Number of Analyses	Range for Study Area (mg/L)				
		Guideline [1]	Minimum	Maximum	Mean	Median
Total Dissolved Solids	901	500	13	5,084	1,227	1,133
Sodium	794	200	0.5	2,280	426	417
Sulfate	820	500	0.6	2,440	295	170
Chloride	761	250	0.8	586	10.4	7
Fluoride	807	1.5	0.05	6.9	0.96	0.63

**Data table from (Hydrogeological Consultants Ltd, 2004)*
Correlated with Horseshow Canyon Formation in HCL Report
1Canadian Drinking Water Guidelines

Table 4-4: Aquifer in the Upper part of the Lower Wapiti Formation - Groundwater Quality

Constituent	Number of Analyses	Range for Study Area (mg/L)				
		Guideline [1]	Minimum	Maximum	Mean	Median
Total Dissolved Solids	435	500	17	4,026	1,125	1049
Sodium	398	200	9	1308	413	395
Sulfate	395	500	1	2000	210	90
Chloride	405	250	1	98	16	12
Fluoride	407	1.5	0.06	7.9	1.3	0.93

**Data table from (Hydrogeological Consultants Ltd, 2004)*
Correlated with Horseshow Canyon Formation in HCL Report
[1]Canadian Drinking Water Guidelines

Table 4-5: Aquifer in the Lower part of the Lower Wapiti Formation - Groundwater Quality

Constituent	Number of Analyses	Range for Study Area (mg/L)				
		Guideline [1]	Minimum	Maximum	Mean	Median
Total Dissolved Solids	807	500	3	4,869	935	870
Sodium	737	200	1	8,188	350	339
Sulfate	746	500	1	2,931	168	85
Chloride	727	250	0.6	1,250	19	8
Fluoride	739	1.5	0.04	6.78	1.1	0.57

**Data table from (Hydrogeological Consultants Ltd, 2004)*
Correlated with Horseshow Canyon Formation in HCL Report
[1]Canadian Drinking Water Guidelines

Table 4-6: Dunvegan Aquifer - Groundwater Quality

Constituent	Number of Analyses	Range for Study Area (mg/L)				
		Guideline [1]	Minimum	Maximum	Mean	Median
Total Dissolved Solids	357	500	122	7,836	1,199	941
Sodium	296	200	3	1,733	183	90
Sulfate	356	500	0.2	4,075	474	327
Chloride	266	250	1	472	36	6
Fluoride	248	1.5	0.06	1.7	0.36	0.33

**Data table from (Hydrogeological Consultants Ltd, 2004)*
Correlated with Horseshow Canyon Formation in HCL Report
[1]Canadian Drinking Water Guidelines

In general, the groundwater in the upper surficial aquifers is high for total dissolved solids while the bedrock aquifers are high for total dissolved solids and sodium.

4.5.4 Spring Areas

Spring areas were identified by data obtained from the Alberta Geological Survey (Stewart 2014 and Stewart 2009). Locations of the springs are seen in Figure 4-16. As springs represent groundwater discharge location, areas with springs will allow little damping of a flood event though absorption of the flood waters by the soil. Springs are noted near Manning, Peace River and close to Sexsmith.

4.6 Summary Table of Communities' Water Sources and Locations

Information in Table 4-7 was obtained through stakeholder consultation, correspondence by phone or e-mail with communities, municipalities, and water treatment plant personnel.

Table 4-7: Water Sources, Water Treatment Plants, and River Intake Locations

Location	Type	Water Source	Water Source Delivery Type	Longitude	Latitude	Notes
Grande Prairie	City	Wapiti River	WTP	-118.80	55.13	Coordinates / location is approximate and obtained from the City of Grande Prairie
Saddle Hill County	County	Runoff and Surface Water	WTP	-119.18	55.84	Location is approximate, based on ¼ Section Another WTP is planned to be constructed for the County in Bonanza. ATS location is NW 10-80-12-W6
Beaverlodge	Town	Beaverlodge River	WTP	-119.45	55.19	-
Fairview	Town	Peace River	WTP	-118.39	56.07	Coordinates / location are approximate and obtained from the Town of Fairview. Address: 10813 111th Street
High Level	Town	Footner Lake	WTP	-117.13	58.52	Coordinates / location is approximate and obtained from the Town of High Level
Manning	Town	Notikewin River	WTP	-117.64	56.93	Coordinates / location is approximate and obtained from the County of Northern Lights
Peace River (Shaftsbury)	Town	Peace River	WTP	-117.34	56.20	Coordinates / location is approximate and obtained from the Town of Peace River
Peace River (103rd Street)	Town	Peace River	WTP	-117.28	56.22	Coordinates / location is approximate and obtained from the Town of Peace River
Spirit River	Town	Tributary to Spirit River/Reservoir	WTP	-118.84	55.77	Gets second priority for pumping from the reservoir which has resulted in rationing of water. ATS location is SE 22-78-06-W6
Valleyview	Town	Little Smoky River	WTP	-117.27	55.06	Coordinates / location is approximate and obtained from the Town of Valleyview
Hines Creek	Village	Jack Creek	WTP	-118.60	56.25	Coordinates / location are approximate and obtained from the Village of Hines Creek. Address: 315 11th Street
Nampa	Village	Peace River	WTP	-117.13	56.04	Address: 10105 97th Street
Rycroft	Village	Spirit River/Reservoir	WTP	-118.71	55.76	Rycroft is the first priority for pumping from the Reservoir. Second Priority is Spirit River.
Desmarais	Hamlet	South Wabiskaw Lake	WTP	-113.75	55.94	-
Eaglesham	Hamlet	Fox Creek/Reservoir	WTP	-117.88	55.79	Location approximate
Fort Chipewyan	Hamlet	Lake Athabasca	WTP	-111.12	58.72	Located just east of the Peace River Basin boundary.
Fort Vermilion	Hamlet	Peace River	WTP	-116.00	58.18	-
Le Crete	Hamlet	Peace River	WTP	-116.41	58.18	-
Peerless Lake	Hamlet	Peerless Lake	WTP	-114.58	56.67	-
Red Earth Creek	Hamlet	Red Earth Creek	WTP	-115.32	56.54	-
Sandy Lake	Hamlet	Sandy Lake	WTP	-113.42	55.82	-
Trout Lake	Hamlet	Trout Lake	WTP	-114.56	56.50	-
Wabasca	Hamlet	North Wabiskaw Lake	WTP	-113.75	55.94	-
Woking	Hamlet	Unnamed Watercourse	WTP	-	-	Coordinates / location are approximate and obtained from the Hamlet of Woking. ATS location is NE 9-79-8-W6

Location	Type	Water Source	Water Source Delivery Type	Longitude	Latitude	Notes
Fox lake 162	First Nation Reserve	Peace River	WTP	-114.56	58.48	Location approximate
John D'or Prairie	First Nation Reserve	Lawrence River	WTP	-115.13	58.48	Location approximate
Paddle Prairie Métis Settlement	Métis	Boyer River	WTP	-117.48	57.95	Location approximate
Smoky River Regional Water Commission	Various	Little Smoky River	WTP	-117.29	55.55	The commission operates the water treatment plant and sells the treated water to Falher, Donnelly, Girouxville, Guy, Jean Cote and the Smoky River Water Co-ops. Location is approximate, based on ¼ Section

Last saved by: MIREAULTC (2015-06-01) Last Plotted: 2014-03-18
Filename: P:\60334569\900-WORK\920-929 (GIS-GRAPHICS)\MAIN REPORT FIGURES\FIGURE 4-1 WATER TREATMENT PLANTS AND RIVER INTAKES - STUDY AREA OVERVIEW.MXD

ANSI B 279.4mm x 431.8mm

N

Peace River Basin

Town of High Level
Hamlet of Fort Vermilion
John D'or Prairie
Fox Lake
Hamlet of La Crete
Paddle Prairie
Peace River
Notikewin River
Town of Manning
Peerless Lake
Red Earth Creek
Loon Lake
Town of Peace River
Town of Fairview
Village of Rycroft
Hamlet of Eaglesham
Town of Spirit River
Hamlet of Woking
Smoky River
Little Smoky River
Town of Sexsmith
Town of Beaverlodge
Town of Valleyview
Wapiti River
City of Grande Prairie
Desmarais
Sandy Lake
Muskeg River

25 0 25 50
km

NAD 1983 10TM AEP Forest

Legend

- River Basin
- City
- Town
- Village
- Hamlet / Locality
- Water treatment plant
- River intakes
- Water Body
- Stream

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

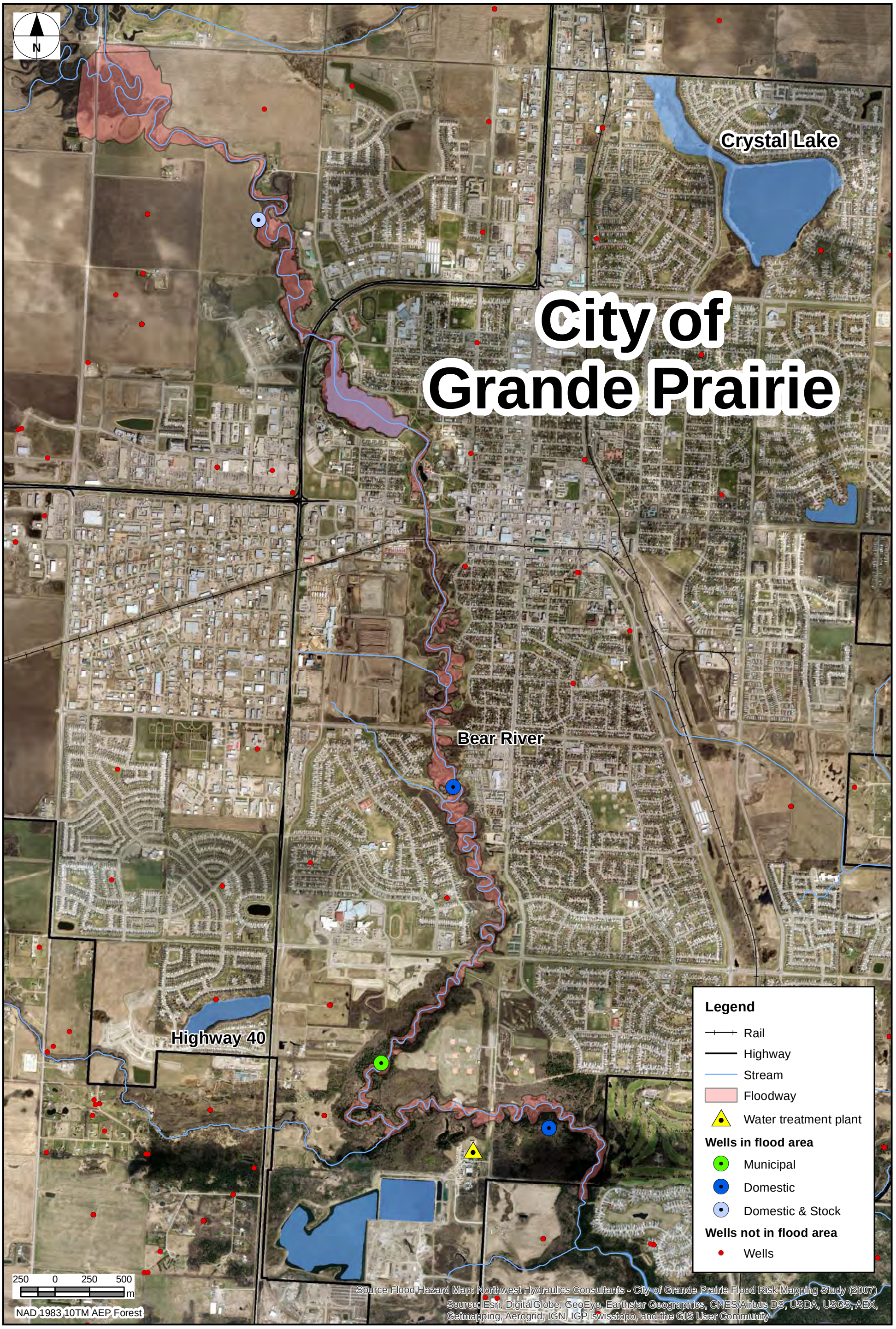
Water Treatment Plants and River Intakes

AECOM

Figure: 4-1

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 4-2 CITY OF GRANDE PRAIRIE - WATER SUPPLY.MXD

ANSI B 279.4mm x 431.8mm



Peace River Basin
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City of Grande Prairie
Water Supply

AECOM

Figure: 4-2

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 4-3 TOWN OF SEXSMITH - WATER SUPPLY.MXD

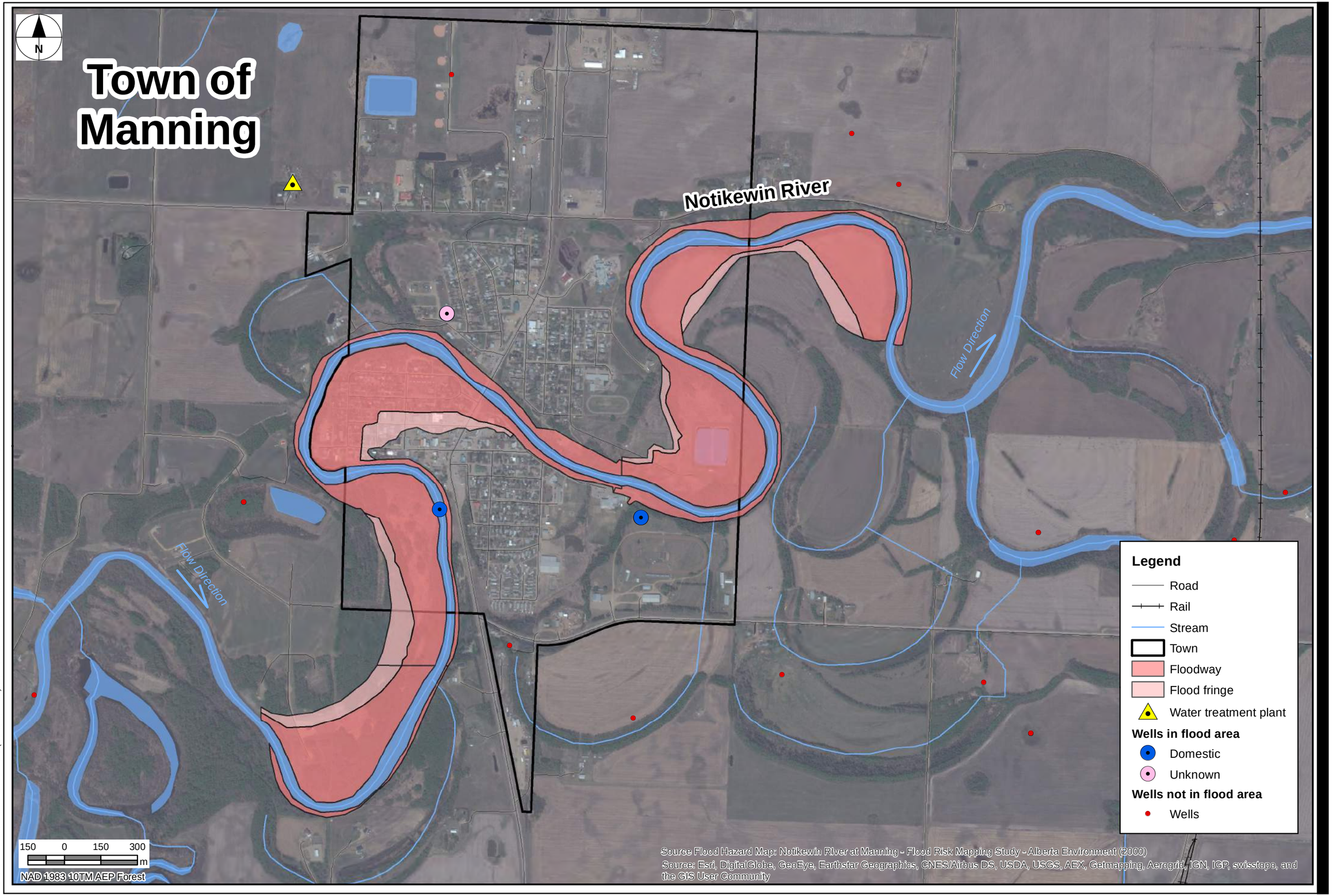
ANSI B 279.4mm x 431.8mm

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

Town of Sexsmith
Water Supply

AECOM

Figure: 4-3



AECOM

Figure: 4-4

Town of Manning
Water Supply

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

ANSI B 279.4mm x 431.8mm

Hamlet of Fort Vermilion

Flow Direction

Peace River

N

400 0 400 800 m

NAD 1983 10TM AEP Forest

Legend

- Road
- Stream

Soil Type

- Eolian Deposits
- Glaciofluvial Deposits
- Floodway
- Stakeholder identified flood area
- Water treatment plant
- River intakes

Wells in flood area

- Municipal
- Domestic
- Domestic & Stock
- Industrial
- Investigation
- Monitoring
- Observation
- Stock
- Unknown

Wells not in flood area

- Wells

Source Flood Hazard Map: Peace River at Fort Vermilion - Flood Risk Mapping Study - Alberta Environment (2000)
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

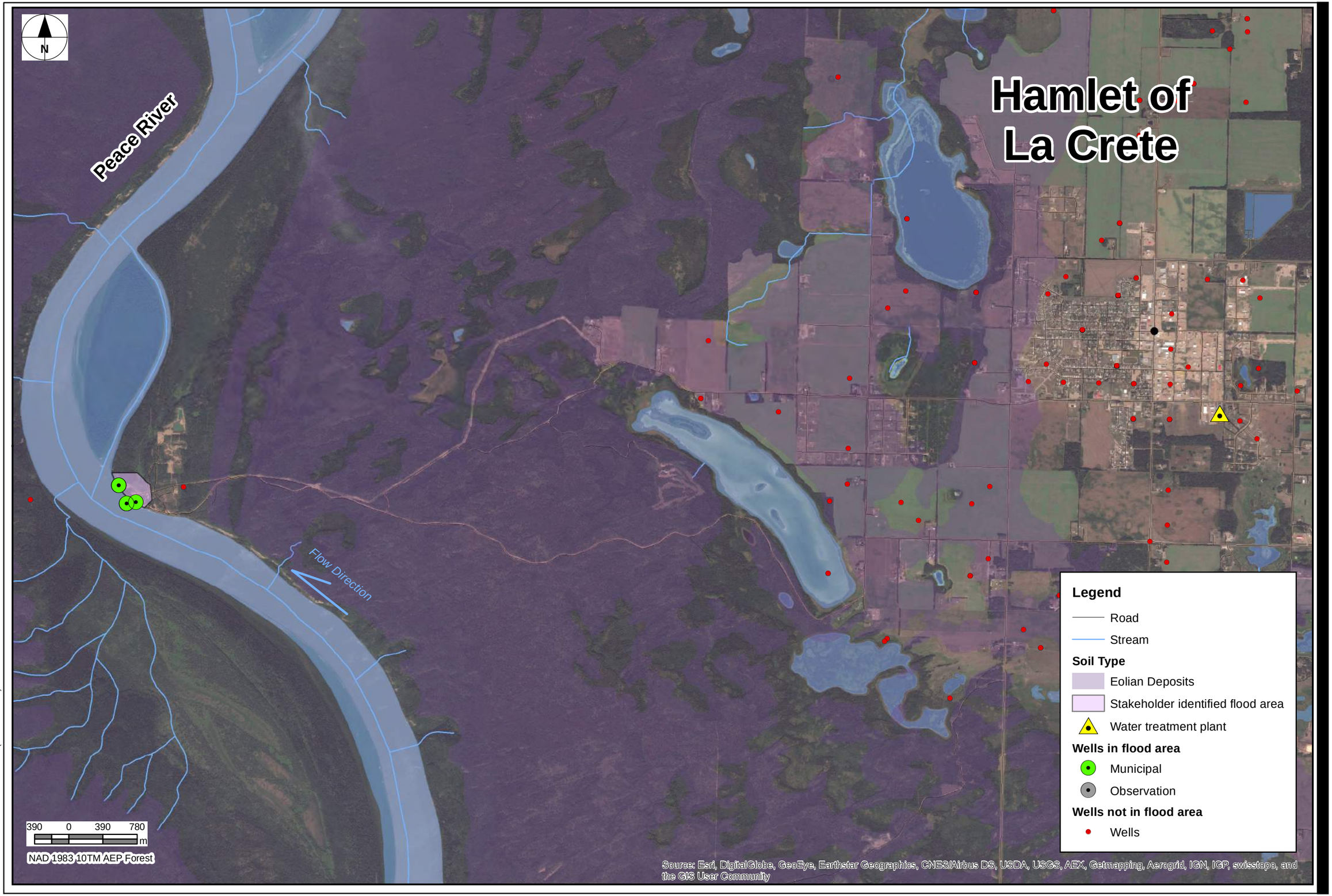
Last saved by: MIREAULTC (2015-06-02) Last Plotted: 2014-03-18
Filename: P:\60334569\900-WORK\920-929 (GIS-GRAPHICS)\MAIN REPORT FIGURES\FIGURE 4-5 HAMLET OF FORT VERMILION - WATER SUPPLY.MXD

AECOM

Figure: 4-5

Hamlet of Fort Vermilion
Water Supply

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



AECOM

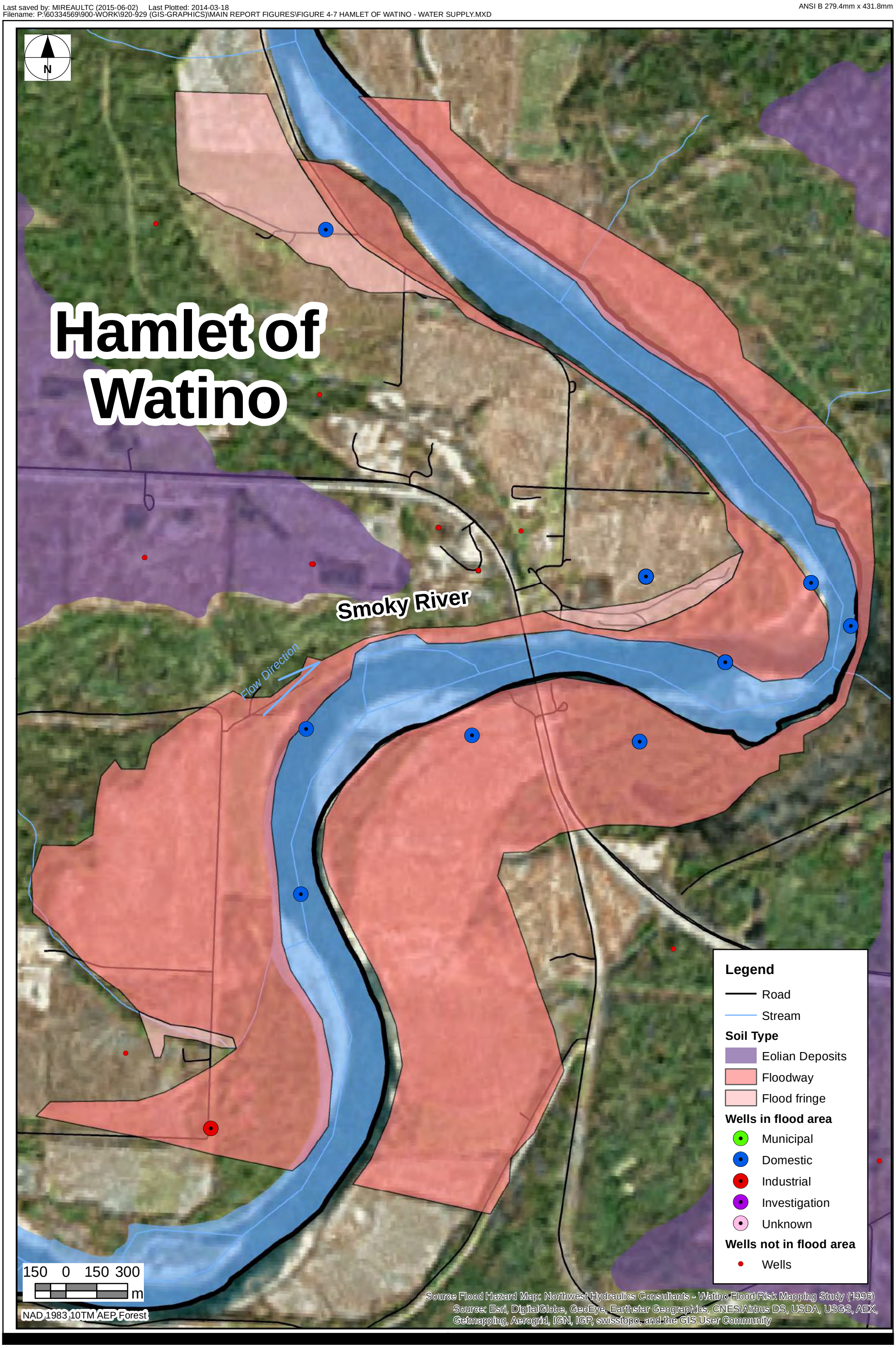
Figure: 4-6

Hamlet of La Crete
Water Supply

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

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 4-7 HAMLET OF WATINO - WATER SUPPLY.MXD

ANSI B 279.4mm x 431.8mm



Peace River Basin
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Project No.: 60334569

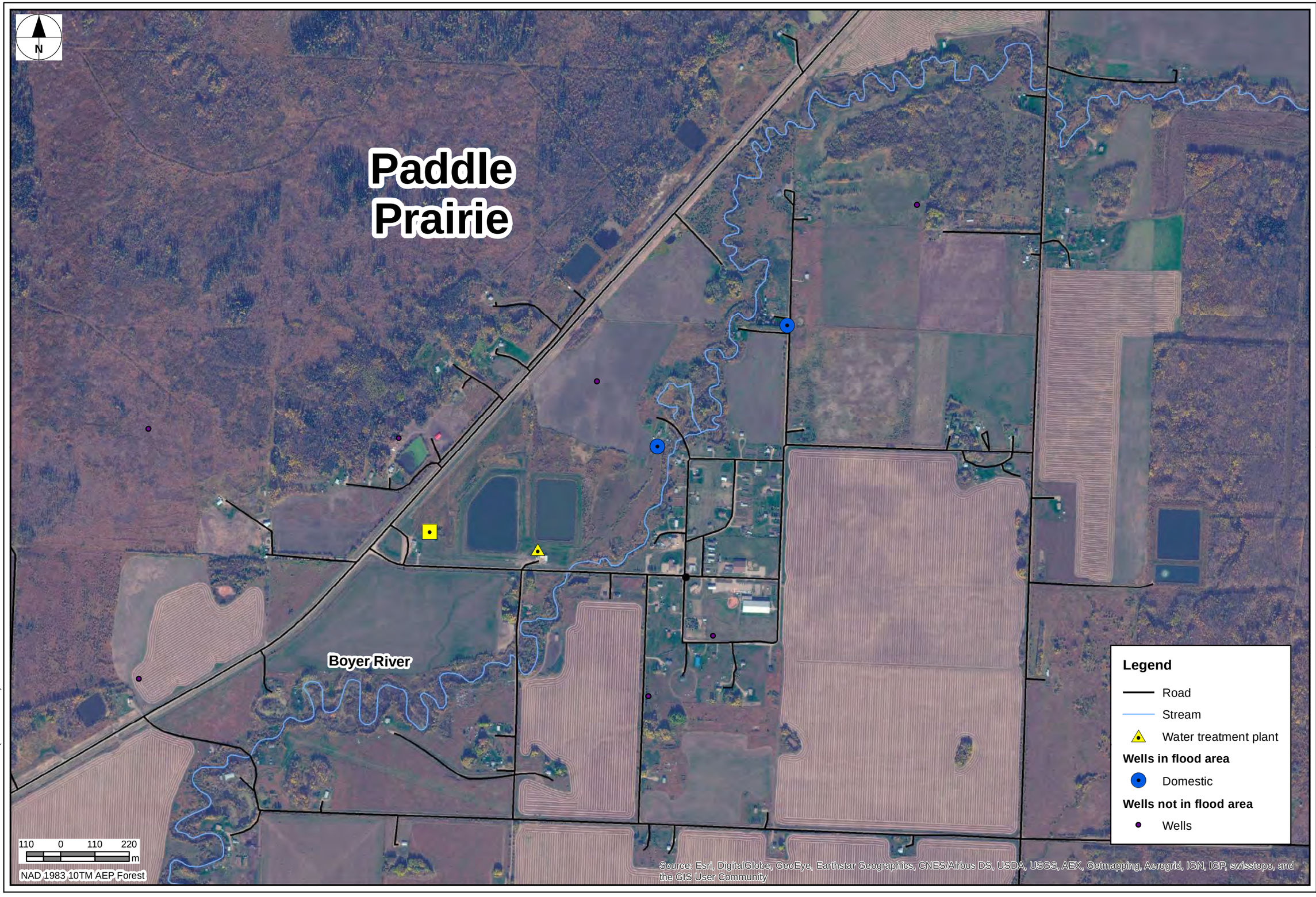
Hamlet of Watino
Water Supply

AECOM

Figure: 4-7

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 4-8 PADDLE PRAIRIE METIS - WATER SUPPLY.MXD



AECOM

Figure: 4-8

Paddle Prairie Metis Settlement
Water Supply

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

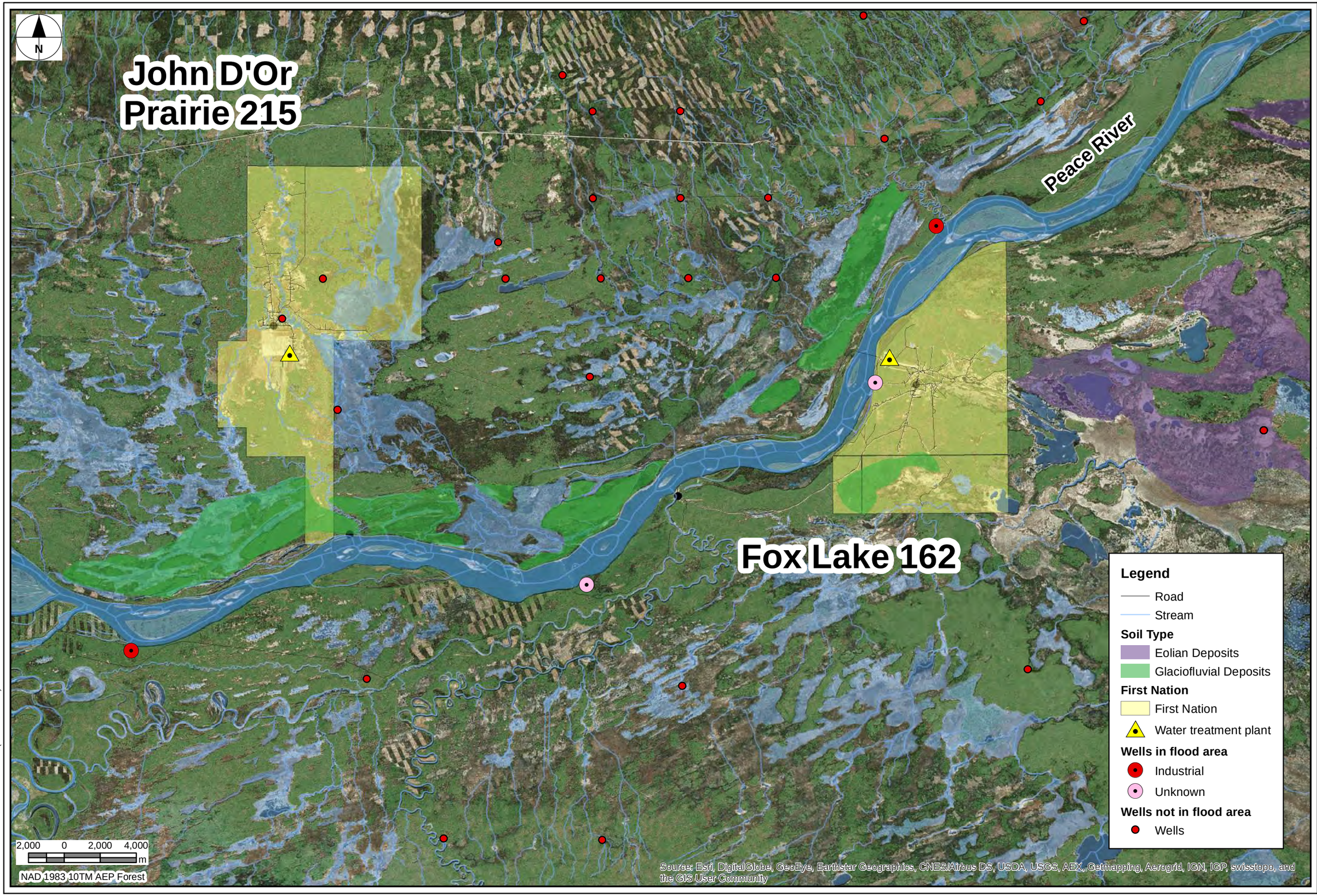


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Figure: 4-9

Fox Lake 162 and John D'Or Prairie 215
Water Supply

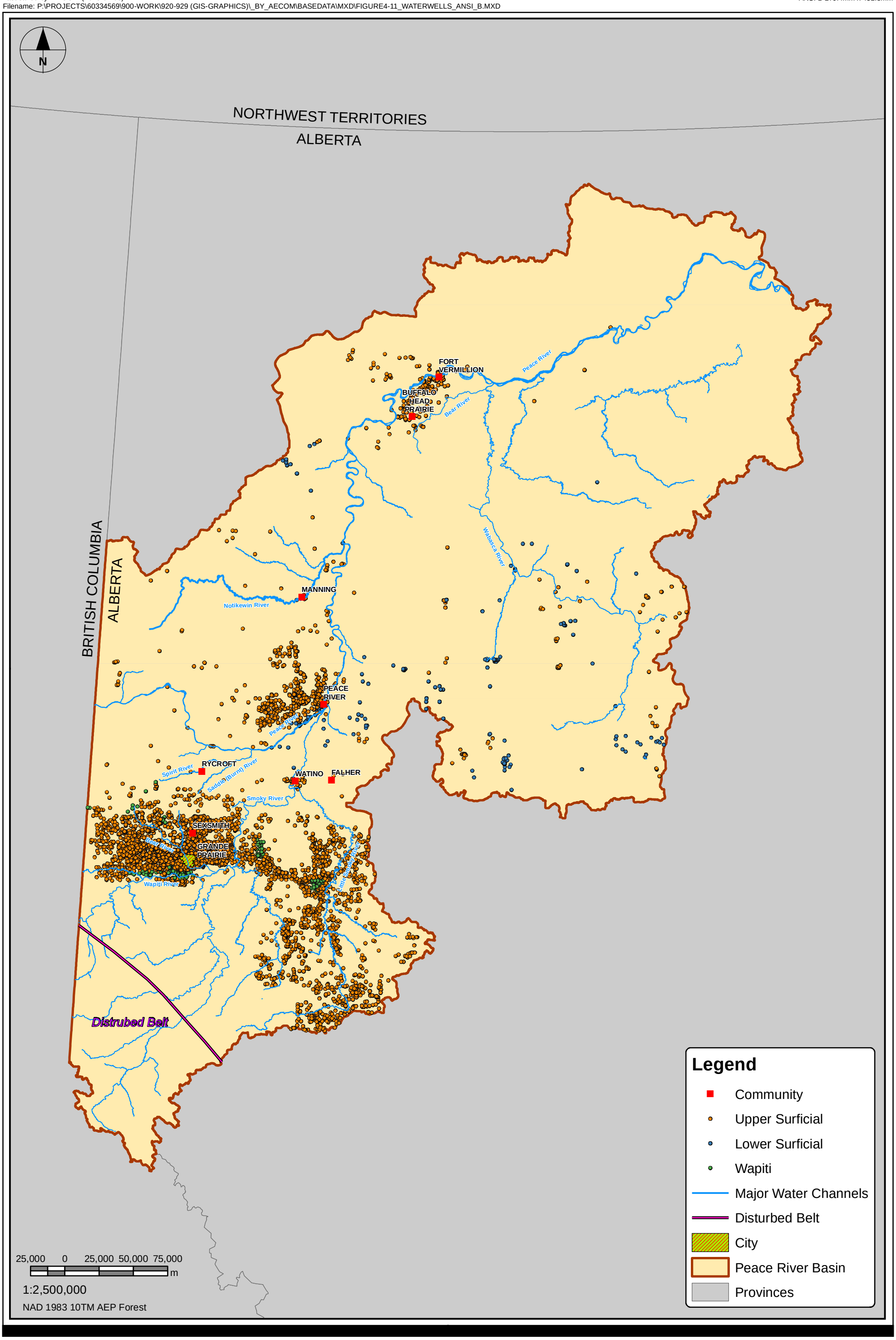
Peace River Basin
Flood Mitigation Feasibility Study
Alberta Environment and Sustainable Resource Development
Project No.: 60334569

Period		Foothills and or Central Plains	Northwest Plains			Northeast Plains		
Quaternary			Sand	Drift	Till / Sand and Gravel	Drift, Sand, Till, Sand and Gravel		
			Sand and Gravel					
Tertiary			Upland Gravels (Clear Hills)					
		Paskapoo						
		Scollard						
CRETACEOUS	UPPER		Upper Wapiti / Lower Wapiti	Wapiti		Wapiti		
		Alberta Group	Smoky Group	Puskwaskau		Lea Park		La Biche
				Badheart / Muskiki / Cardium		Colorado Group	First W.S. / Colorado Shale / Second White Speckled / Belle Fourche / Fish Scale	
				Kaskapau	Pouce Coupe			
			Dunvegan					
			Fort St John Group	Upper Shaftesbury / Lower Shaftesbury	Shaftesbury	Belle Fourche / Fish Scale		
				Westgate			Westgate	
	LOWER			Upper Loon River	Peace River	Paddy / Cadotte / Harmon	Pelican (Viking) / Joli Fou	
				Lower Loon River	Spirit River	Notikewin / Falher / Wilrich	Mannville Group	Grand Rapids / Clearwater
				Bluesky				
			Bullhead		Gething			McMurray
					Cadomin			
Devonian age and older geological units								

Units modeled

Not all known geological units shown.

Derived from Alberta Energy Regulator (AER 2013) and Alberta Geological Survery



Peace River Basin
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Peace River Basin
Well Completion Intervals

AECOM

Figure: 4-11

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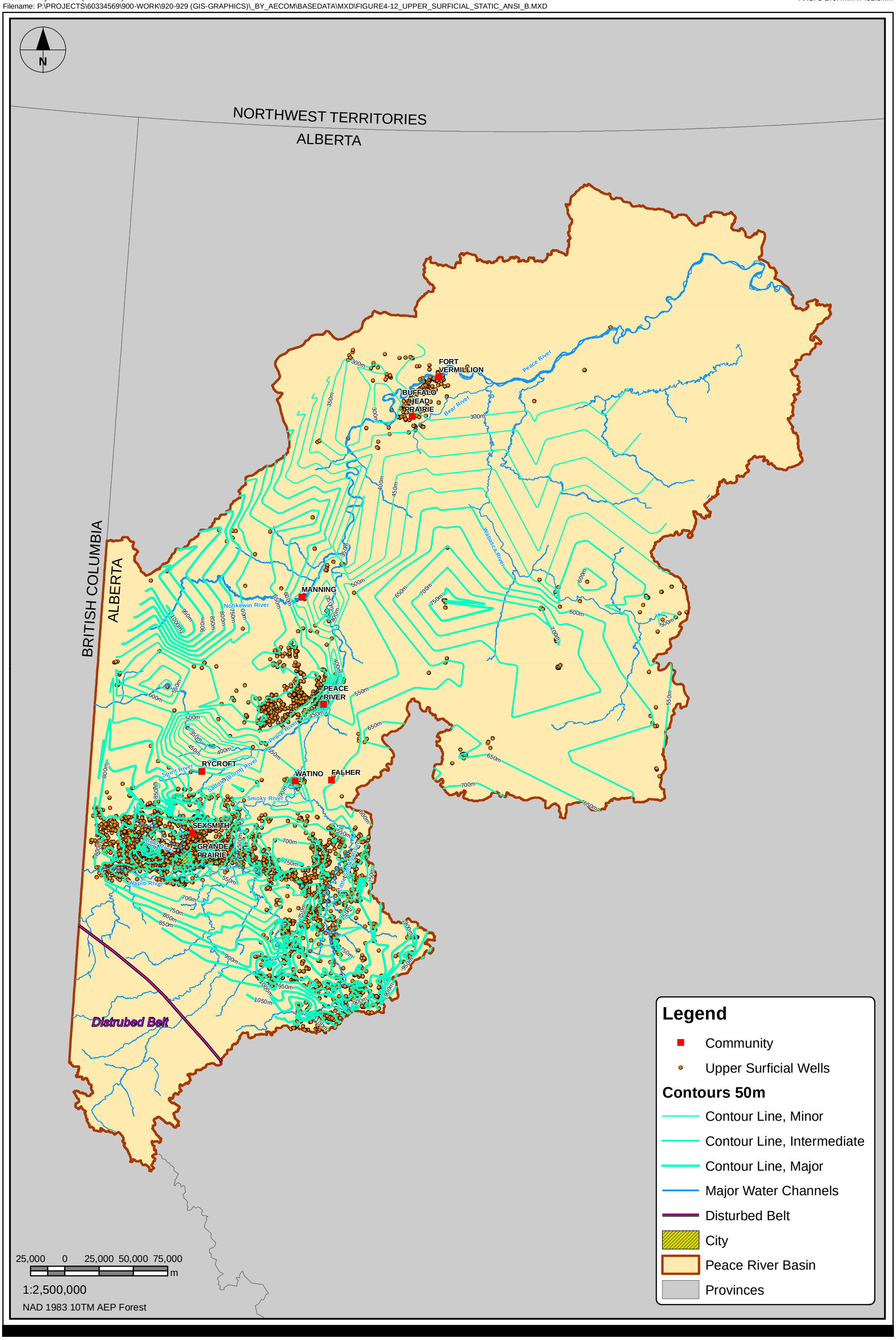
Filename: P:\PROJECTS\60334569\900-WORK\920-929 (GIS-GRAPHICS)_BY_AECOM\BASEDATA\MXD\FIGURE4-12_UPPER_SURFICIAL_STATIC_ANSI_B.MXD
ANSI B 279.4mm x 431.8mm



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

Static Groundwater Elevations Overview
Upper Surficial Sediment Acquifers

AECOM

Figure: 4-12

ANSI B 279.4mm x 431.8mm

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Filename: P:\PROJECTS\60334569\900-WORK\920-929 (GIS-GRAPHICS)_BY_AECOM\BASEDATA\MXD\FIGURE4-13_UPPER_SURFICIAL_STATIC_ANSI_B.MXD

BRITISH COLUMBIA
ALBERTA

Saddle (Burnt) River
Grande Prairie Creek
Bear River
Wapiti River
Wapiti River
Smoky River
Smoky River

SEXSMITH
GRANDE PRAIRIE

5,000 0 5,000 10,000 m
1:350,000
NAD 1983 10TM AEP Forest

Legend

- Community
- Upper Surficial Wells

Contours 50m

- Contour Line, Minor
- Contour Line, Intermediate
- Contour Line, Major
- City
- Peace River Basin
- British Columbia

AECOM

Figure: 4-13

Static Groundwater Elevations
Upper Surficial Sediment Aquifers

Peace River Basin
Flood Mitigation Feasibility Study
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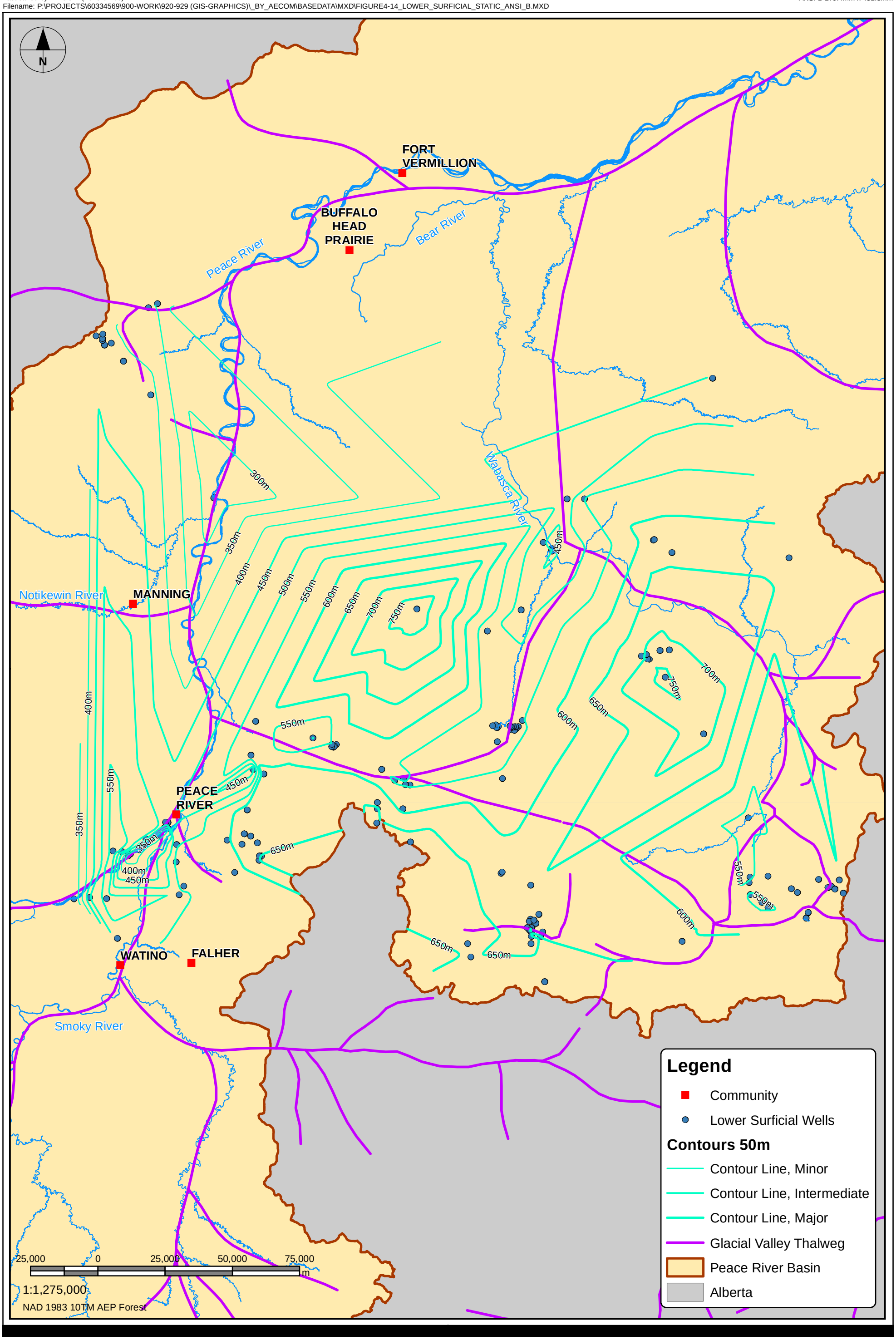
Filename: P:\PROJECTS\60334569\900-WORK\920-929 (GIS-GRAPHICS)_BY_AECOM\BASEDATA\MXD\FIGURE4-14_LOWER_SURFICIAL_STATIC_ANSI_B.MXD
ANSI B 279.4mm x 431.8mm



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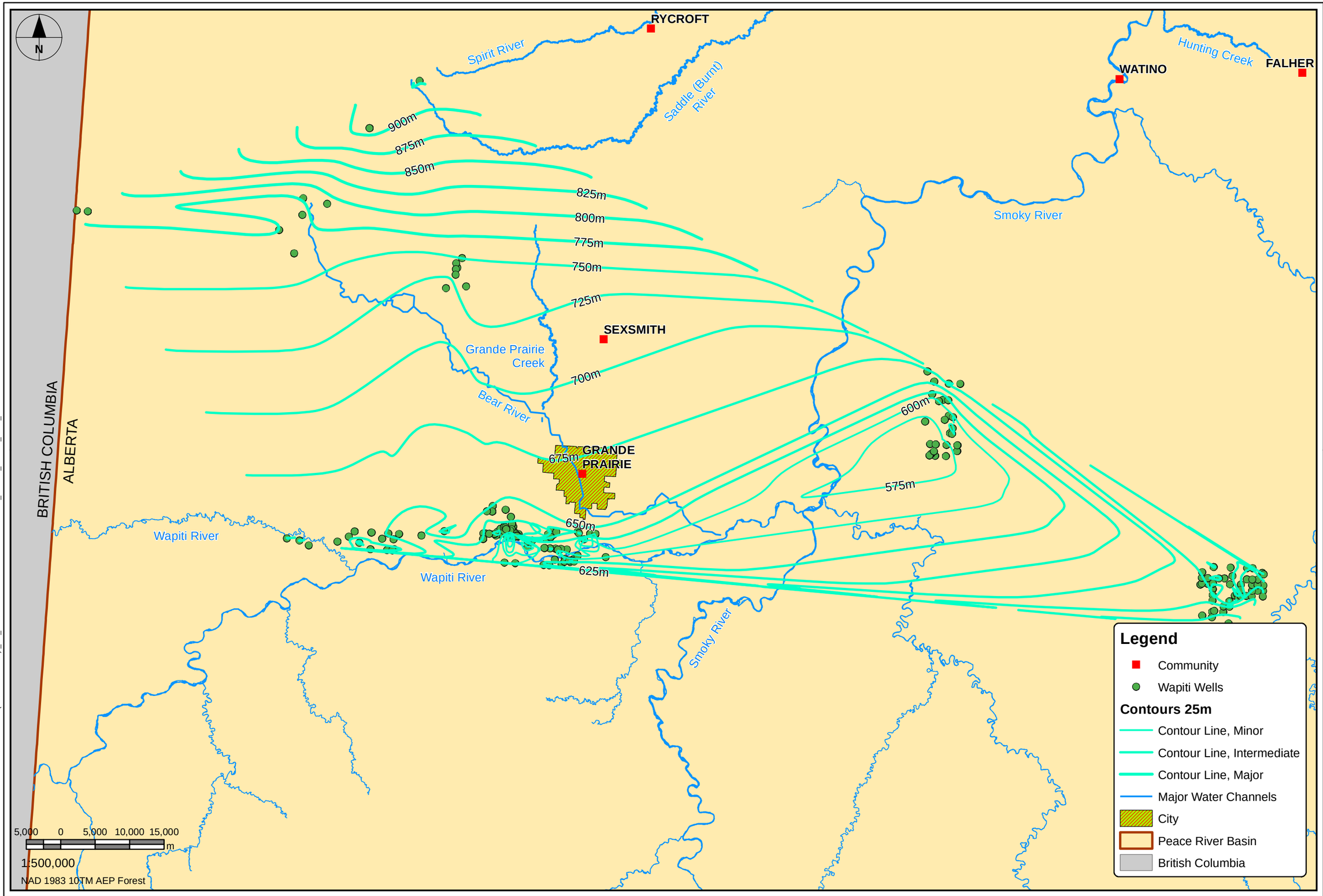
Project No.: 60334569

Static Groundwater Elevations
Lower Surficial Sediment Aquifers

AECOM

Figure: 4-14

ANSI B 279.4mm x 431.8mm



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Filename: P:\PROJECTS\60334569\900-WORK\920-929 (GIS-GRAPHICS)_BY_AECOM\BASEDATA\MXD\FIGURE4-15_WAPITI_STATIC_ANSI_B.MXD

AECOM

Figure: 4-15

Static Groundwater Elevations
Wapiti Formation Aquifer

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

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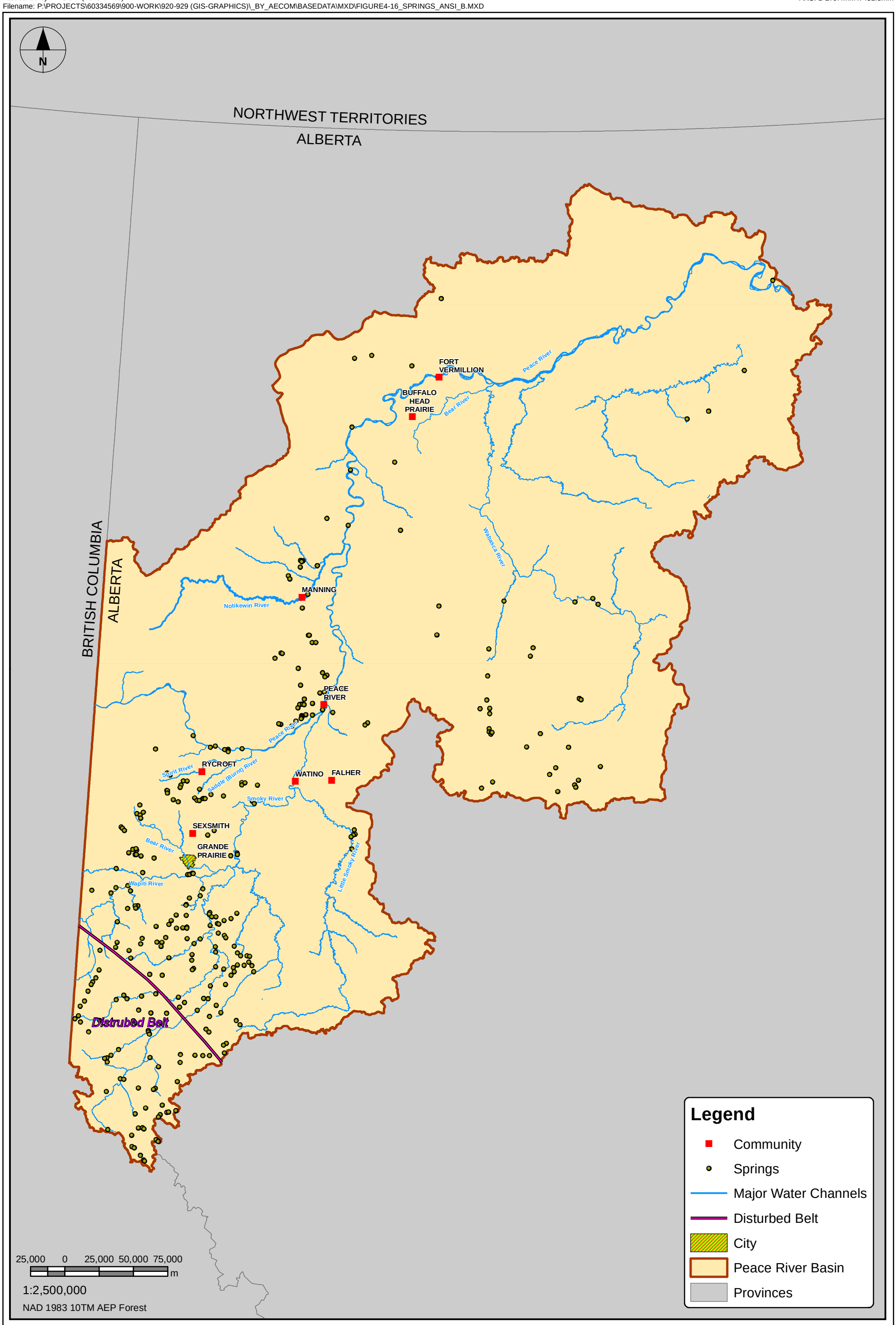
Filename: P:\PROJECTS\60334569\900-WORK\920-929 (GIS-GRAPHICS)_BY_AECOM\BASEDATA\MXD\FIGURE4-16_SPRINGS_ANSI_B.MXD

ANSI B 279.4mm x 431.8mm



Peace River Basin
Flood Mitigation Feasibility Study
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Peace River Basin
Spring Water Wells

AECOM

Figure: 4-16