THE COUNTY OF VERMILION RIVER IN THE PROVINCE OF ALBERTA

BYLAW 14-25

A BYLAW FOR THE ADOPTION OF THE COUNTY OF VERMILION RIVER FUNCTIONAL 'BLACKFOOT/DEVONIA FUNCTIONAL STORMWATER DRAINAGE PLAN– JUNE 2014'

The County of Vermilion River ("The County") in the Province of Alberta, wishes to adopt a plan for a specific area of the County for future Stormwater drainage improvements in accordance with Section 7 of the Municipal Government Act, Chapter M-26, as amended.

WHEREAS, the Council of the County of Vermilion River has done public consultation on February 18th, 2014 for the plan attached as 'Schedule A' and wishes to use it as the foundation for any offsite levy bylaw that may be introduced

NOW THEREFORE, the Council of the County of Vermilion River, in the Province of Alberta, duly assembled, hereby approves the Blackfoot/Devonia Functional Stormwater Drainage Plan - June 2014 as attached as 'Schedule A'.

SHOULD any provision of this Bylaw be determined to be invalid, then such provisions shall be severed and the remaining bylaw shall be maintained.

THIS Bylaw shall come into force and effect upon receiving third and final reading and having been signed by the Reeve and Chief Administrative Officer.

Read a first time this 24th day of June, 2014

Read a second time this 24th day of June, 2014

Read a third time and finally passed, this 24th day of June, 2014

SIGNED by the Reeve and Chief Administrative Officer this 24th day of June, 2014

SEVERED

Reeve

SEVERED

Chief Administrative Officer

County of Vermillion River

Blackfoot & Devonia
Functional Stormwater Drainage Plan

Final Report

Date: July 21, 2014
Prepared for: County of Vermillion River
Prepared by: Sameng Inc.
Project No: 1152

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July 2, 2014 File: 1152

Mr. Roger Garnett, C.E.T.
Manager, Planning and Development
County of Vermilion River
Box 69, 4912 – 50 Avenue
Kitscoty, AB T0B 2P0

Dear Roger:

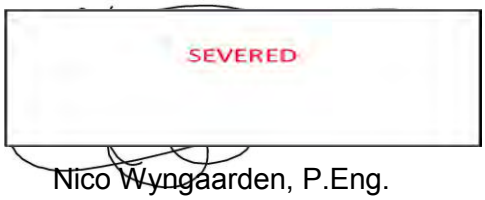
Blackfoot/Devonia Functional Stormwater Drainage Plan

Here are 15 copies of our final report 'Blackfoot/Devonia Functional Stormwater Drainage Plan' along with a DVD containing an electronic copy of the report in PDF format as well as all our study data.

On behalf of the project team, thank you for the assistance, guidance and support you have provided over the course of this project. We have been privileged to undertake the Blackfoot/Devonia functional stormwater drainage plan.

I trust that this is in order. If you have any questions, or wish to discuss any aspect of our study, please contact me.

Sincerely,



Nico Wyngaarden, P.Eng.
Senior Project Engineer

Attach.

Executive Summary

In 2011, Clifton Associates Ltd. completed a Master Stormwater Management Plan (the Master Plan) for the County of Vermilion River (the County), incorporating the area surrounding the City of Lloydminster where most of the development activity has been happening, and is expected to continue. The County has now retained Sameng Inc. to complete a functional stormwater drainage plan for the Blackfoot and Devonia Drainage Basins.

The overall objective of the study is to develop a clear, applicable and sustainable functional stormwater drainage plan for the Blackfoot and Devonia Basins, as extensions to the Master Plan, to meet the stormwater servicing needs of those Basins.

Basin boundaries were provided by the County and confirmed by Sameng. An area of approximately 13.8 km^2 (1378 ha) originally identified as being in the Blackfoot Basin is actually within the Stretton Creek Basin. Similarly, for the Devonia Basin, the original boundaries included an area which was determined to be part of a drainage basin identified as the Blackfoot Creek Sub-basin, which drains directly into Blackfoot Creek.

Using the Water Survey Canada hydrometric stations Stretton Creek near Marwayne and Big Gully Creek near Maidstone, a pre-development release rate of1.65 l/s/ha is recommended for the Blackfoot and Devonia Basins, which reflects the agricultural nature of, and the large storage capacities of the wetlands within, the basins.

Two public Open Houses were held to meet with landowners, developers and other stakeholders. The first Open House was held on June 25, 2013, at the start of the study, to gather information and allow the public, developers and other stakeholders to provide input to the development of the functional drainage plan. The second Open House was held on February 18, 2014 to introduce the conceptual functional drainage plan and to obtain feedback from the public, developers and other stakeholders. Flooding of the Blackfoot Wetland at the outlet to the Blackfoot Basin, and flooding around Devonia Lake and downstream impacts were the primary water-related issues identified at the Open Houses.

To determine the pre- and post-development runoff flows from the basin, an EPA SWMM model was created and used to determine the existing and future runoff and storage parameters in the Blackfoot and Devonia Basins. The rainfall events used to obtain the pre- and post-development flows were the City of Edmonton design storms, based on the 1:100-year 24-hour Huff Distribution and the 1:100 year 4-hour Chicago Distribution. From these two rainfall events, the highest peaks occurred from the 24-hour storm and, therefore, this event was used to develop the stormwater management scenarios.

The functional stormwater drainage plan for the Blackfoot Basin proposes the Blackfoot East Drainage Channel which drains into the Blackfoot Wetland and the Blackfoot West Drainage Channel, which drains into the Blackfoot East Drainage Channel just upstream from the Blackfoot Wetland. The total estimated cost for the Blackfoot East Drainage Channel is approximately $1,316,000 and for the Blackfoot West Drainage Channel approximately $1,226,000.

The functional stormwater drainage plan for the Devonia Basin includes the existing

Central Devonia Drainage Channel and proposes the Devonia East and Devonia West Drainage Channels. The total estimated cost for the Devonia East Drainage Channel is approximately $1,509,000 and for the Devonia West Drainage Channel approximately $359,000. Provided the Central Devonia Drainage Channel has been maintained to its original design standards, this channel provides proper drainage to the Hamlet of Blackfoot and the surrounding lands and no additional works are required.

As development is from east to west, from the City of Lloydminster, the priority for implementation is:

1. Devonia East Drainage Channel
2. Central Devonia Drainage Channel
3. Devonia West Drainage Channel.

Flooding issues around Devonia Lake and downstream impacts should be addressed prior to implementing the Devonia Basin functional stormwater drainage plan.

Major development within the Blackfoot Basin is not anticipated in the foreseeable future. This provides the County with some lead time to address the flooding concerns around the Blackfoot Wetland.

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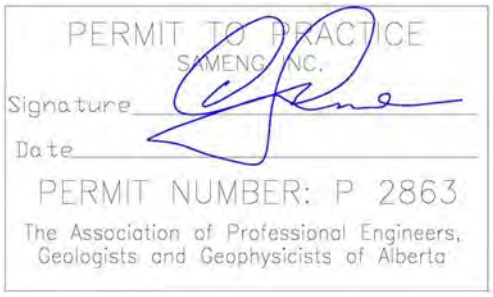
CORPORATE AUTHORIZATION

This document entitled ***"Blackfoot/Devonia Functional Stormwater Drainage Plan"*** was prepared by Sameng Inc. for the account of the County of Vermilion River. The material in it reflects Sameng's best judgment in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibilities of such parties. Sameng Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

	
July 21, 2014 Signature/Date	July 21, 2014 Signature/Date
PROFESSIONAL SEAL	COMPANY PERMIT

1.0 Introduction

1.1 Background

In 2011, Clifton Associates Ltd. completed a Master Stormwater Management Plan (the Master Plan) for the County of Vermilion River (the County). The Master Plan included the area surrounding the City of Lloydminster where most of the development activity has been happening, and is expected to continue. It included two basins: the Northwest Basin and the Blackfoot Basin. A functional stormwater drainage plan was completed for the Northwest Basin by GENIVAR Inc., in 2012.

The County has now retained Sameng Inc. (Sameng) to develop functional stormwater drainage plans, as extensions to the Master Plan, to meet the stormwater servicing needs of the Blackfoot and Devonia Drainage Basins located west of the City of Lloydminster, as shown in Figure 1 and Figure 2. The basin identified as the Blackfoot Basin in the Master Plan, is now named the Devonia Basin. The Blackfoot Basin for the current study was not specifically addressed in the Master Plan.

The Blackfoot Basin is located contiguous to the north end of the Devonia Basin, north of the Hamlet of Blackfoot, and drains north into Big Gully Creek via a large wetland area located primarily on Section 05-051-01 W4M. Big Gully Creek drains into the North Saskatchewan River.

For the purpose of this study, the County has identified the wetland area on Section 05 as the terminus of the Blackfoot Basin. Accordingly, for the purpose of this study, the wetland area will be identified as the Blackfoot Wetland.

The Blackfoot Basin is primarily agricultural land but includes extensive resource development (oil and gas) and is characterized by rill drainage patterns and wetland areas of various sizes.

The Devonia Basin is traversed by the Yellowhead Highway, and drains south into Devonia Lake. Devonia Lake drains into Blackfoot Creek, which is a tributary of the Battle River. The Battle River drains into the North Saskatchewan River.

1.2 Project Objectives

The overall objective of this study is to develop a clear, applicable and sustainable stormwater management plan for each of the Blackfoot and Devonia Basins. Specific objectives include:

- Identify the Blackfoot and Devonia Drainage Basins and the important physical, hydrological, and meteorological parameters that govern the quantity of runoff in the basins.
- Identify the existing drainage features and the interconnections; including channels, wetlands and hydraulic structures (culverts, bridges, etc.).
- Identify existing problems, issues and weaknesses in the drainage system including flooding, inadequate conveyance capacity and environmental issues.
- Identify and review development impacts with respect to:

  - Existing area structure plans;
  - Highway No. 16;
  - Devonia Lake; and
  - Wetlands, including the Blackfoot Wetland.

- Using the EPA Storm Water Management Modeling (SWMM) program, develop a computer model that adequately predicts flow volumes and rates along all significant flow channels. The model will be capable of analyzing the impacts of development and mitigation measures.
- Provide guidelines for future developments including stormwater plan requirements, design parameters and protection of aquatic features.
- Include cost estimates and requirements for regulatory approvals.

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2.0 Existing Conditions

2.1 Land Use

Land use within the Blackfoot and Devonia Drainage basins is primarily agricultural, as shown in Figure 1 and Figure 2. With the increase in population due to the oil and gas industry, more and more country residential and light industrial subdivisions are being developed. Of primary concern for the County, at this time, is the rapid development in and around the Hamlet of Blackfoot and along the Yellowhead Highway (Highway 16).

2.2 Basin Boundaries

Figure 1 and Figure 2 show the Blackfoot and Devonia Basin boundaries as provided by the County. They also show the revised basin boundaries, as determined for the purposes of this stormwater management plan.

2.3 Environmental Considerations

These basins contain several large areas that would be considered wetlands under the new Alberta Wetland Policy. The goal of the Alberta Wetland Policy is to conserve, restore, protect and manage Alberta's wetlands to sustain the benefits they provide to the environment, society and economy.

The County of Vermillion River is a 'wetlands mitigation agent' for the area within the county, and plans should be made in coordination with the County's Alternative Land Use Strategies (ALUS) department to ensure that significant wetlands are preserved and enhanced wherever possible.

Devonia Lake is an important waterbody in this area, and design considerations should be made to ensure the level of siltation into the lake is not increased by any drainage improvements in the Devonia Basin.

2.4 Regulatory Requirements

Regulatory requirements may include the following:

- An Approval under the Water Act, from Alberta Environment (ESRD), for any drainage channels required to divert flows to Devonia Lake or Blackfoot Wetland. Any outfall structures required to drain stormwater into Devonia Lake or Blackfoot Wetland fall under the Water Act Code of Practice for Outfall Structures on Waterbodies.
- A letter of authority or an approval to create a harmful alteration, disruption or destruction (HADD) of fish habitat under the Federal Fisheries Act, from DFO, for any outfall structures on Devonia Lake or Blackfoot Wetland.
- An Approval under Section 3 of the Public Lands Act in the form of an easement or a Department License of Occupation (DLO), from Alberta Sustainable Resource Development (Public Lands), for any outfall structures on Devonia Lake or Blackfoot Wetland.
- An Approval under the Navigation Protection Act (NPA), from Transport Canada, for any outfall structures on Devonia Lake or Blackfoot Wetland.
- Registration for new stormwater drainage system outfalls, or an authorization

for new storm drainage treatment facilities or modification of an existing storm drainage treatment facility within existing stormwater systems, under the Wastewater and Storm Drainage Regulation of the Environmental Protection and Enhancement Act, from ESRD.

2.5 Public Consultation

Two public Open Houses were held to meet with landowners, developers and other stakeholders. The first Open House was held on June 25, 2013, at the start of the study, to gather information and allow the public, developers and other stakeholders to provide input to the development of the functional drainage plan. The second Open House was held on February 18, 2014 to introduce the conceptual functional drainage plan and to obtain feedback from the public, developers and other stakeholders.

Approximately 25 to 30 people attended the first Open House, which was facilitated by Nico Wyngaarden, P.Eng., and Nathan Forsyth, P.Eng., from Sameng. Display boards were arranged around the room to encourage attendees to discuss their water management problems and identify the location of their concerns. Attendees were also provided with questionnaires regarding the frequency and severity of water-related problems they experienced. In the Blackfoot Basin flooding and unauthorized drainage appeared to be the primary concerns. In the Devonia Basin, flooding was also a major concern; however, erosion and water quality were also issues. Concern was also expressed regarding the capacity of the Devonia Lake outlet to discharge flood waters.

Approximately 25 to 35 people attend the second Open House, which was facilitated by David Yue, P.Eng., and Nico Wyngaarden, P.Eng., from Sameng. Again, display boards were arranged around the room to illustrate the conceptual functional drainage plans for the Blackfoot and Devonia Basins; and to encourage feedback from the public. Attendees were also provided with questionnaires regarding the frequency and severity of their water-related problems and their perception of the efficacy of the proposed conceptual functional drainage plan. In the Blackfoot Basin flooding and unauthorized drainage were, again, the primary concerns. In one case, unauthorized ditching upstream draining wetlands resulted in a continuous flow across cultivated land and cutting it in two. In the Devonia Basin, most of the concerns expressed were related to the management of Devonia Lake and downstream flooding impacts. Some residents reported that the existing outlet structure of the lake is insufficient to manage lake levels safely. Others expressed concern that the water quality in Devonia Lake may be affected by increased industrial development in the area. The adequacy of the outlets to both the Blackfoot Wetland and Devonia Lake were raised as a major concern.

3.0 Technical Analysis

3.1 General

Runoff from the watershed can be driven by both snowmelt and rainfall. Runoff from snowmelt tends to dominate larger basins and produces longer duration events with large flow volumes. Rainfall events tend to produce flashy peaks, especially on smaller basins. However, flow volumes are normally substantially smaller than the snowmelt events. A regional frequency analysis performed for both snowmelt and rainfall runoff events showed that, for the Devonia and Blackfoot drainage basins, both produce a similar unit runoff. Therefore, given that rainfall data is readily available, rainfall driven runoff was used to determine post-development runoff flows from the watershed, and their impact on the lake's water levels.

3.2 Design Criteria

The development of a functional drainage plan for the Blackfoot and Devonia Basins is based on standard rational method hydrologic and hydrometric parameters that have been used in past studies in this area. The design criterion is to provide drainage features that will provide protection from water-related damage throughout the area and downstream.

As such, the following criteria are considered.

1. Drainage will be collected and controlled by a main stormwater management system, including licensed ditches, and natural and enhanced wetland features.
2. The ditches will be designed to carry peak rainfall events, as well as controlled discharges from wetlands and other stormwater management facilities.
3. Wetlands and constructed wetlands will be enhanced by the addition of control structures, to moderate outflows to a predetermined rate, and maintain normal water levels to promote aquatic biological cycles.

3.3 Basin Delineation

As part of the functional stormwater drainage plan, the drainage area for the Blackfoot Basin had to be defined and the drainage area for the Devonia Basin had to be confirmed. The drainage areas for the Devonia and Blackfoot Basins were delineated using available topographic data – including the County Lidar data and Sameng survey data – Google Earth, and the interpretation of the airphotos of the area.

The original boundaries for the Blackfoot Basin, as provided by the County, included an area of approximately 13.8 km^2 (1378 ha), which was determined to be part of the Stretton Creek Basin, as shown in Figure 1. As this area is not anticipated to be developed in the foreseeable future, and it is not located within the Blackfoot Basin, it was excluded from this study.

The original boundaries for the Devonia Basin, as provided by the County were confirmed with only some minor discrepancies, except in the northwest corner of the basin. There the original boundaries included an area which was determined to be part of a drainage basin identified as the Blackfoot Creek Sub-basin, which drains directly into Blackfoot Creek, as shown in Figure 2.

Blackfoot Basin

Figure 1 shows the drainage area for the Blackfoot Basin to the Blackfoot Wetland. The basin has a total contributing drainage area of approximately 40.7 square kilometres (km^2), or 4070 hectares (ha). The basin was divided into two (2) major sub-basins: Blackfoot East and Blackfoot West.

The Blackfoot East sub-basin has a contributing drainage area of approximately 20.2 km^2 (2018 ha), and extends north from the Hamlet of Blackfoot to the Blackfoot Wetland. The primary watercourse traversing the sub-basin is identified as the Blackfoot East Drainage Channel, which drains directly into the Blackfoot Wetland. Extensive wetlands are located within this sub-basin, which can be enhanced for stormwater management.

The Blackfoot West sub-basin has a contributing drainage area of approximately 20.5 km^2 (2052 ha) and is squeezed between the Stretton Creek Basin and the Blackfoot East sub-basin. The primary watercourse traversing the sub-basin is identified as the Blackfoot West Drainage Channel. It drains into the Blackfoot East Drainage Channel, on Section 32-050-01 W4M, just south of the Blackfoot Wetland. Extensive wetlands are located within this sub-basin as well, which can be enhanced for stormwater management.

On the SW 25-050-02 W4M, near the intersection of Range Road 21 and Township Road 504, the Stretton Creek Basin headwaters are located very close to the Blackfoot West Drainage Channel, as shown in Figure 1. The County has received recurring complaints from the local landowner about flooding, with water going in two different directions, corroborating the location of the drainage divide. Therefore, depending on the relative height of the drainage divide, flows from the Stretton Creek headwaters could be diverted into the Blackfoot West Drainage Channel or vice versa.

Devonia Basin

Figure 2 shows the drainage area for the Devonia Basin. The basin has a total contributing drainage area of approximately 39.9 km^2 (3990 ha). The Devonia Basin was divided into five (5) major sub-basins: Devonia West, Devonia Central, Devonia East, Devonia Southeast and Devonia Lake.

The Devonia West sub-basin has a drainage area of approximately 4.16 km^2 (415.7 ha), with its headwaters in the northwest corner of the Devonia Basin. The primary watercourse traversing the sub-basin is identified as the Devonia West Drainage Channel, which drains into the northwest end of Devonia Lake on the SE 35-049-02 W4M. The Devonia West sub-basin has few wetlands, which are relatively small and may have limited capabilities for stormwater management.

The Devonia Central sub-basin has a drainage area of approximately 8.53 km^2 (852.6 ha). The Hamlet of Blackfoot constitutes its headwaters. The primary watercourse traversing the sub-basin is the existing drainage channel constructed by the County in 2005/06, and is identified as the Devonia Central Drainage Channel. It drains into Devonia Lake on the SE 25-049-02 W4M. Other than the large wetland on the SE 01-050-02 W4M, the Devonia Central sub-basin has virtually no wetlands for stormwater management.

Although Section 06-050-01 W4M is shown in the Devonia Central sub-basin, it appears

to be a 'closed drainage' area with no apparent drainage patterns to Devonia Lake, or north to the Blackfoot Wetland. Therefore, it could also have been included in the Devonia East sub-basin, or the Blackfoot East sub-basin. The Kams Industrial Area, located on the N½ 31-049-01 W4M, appears to be part of this closed drainage area. Currently, the Kams Industrial Area pumps its stormwater west into the Central Devonia Drainage Channel.

The Devonia East sub-basin has a drainage area of approximately 8.07km^2 (807.4 ha), with its headwaters just south of the Kams Industrial Area on the N½ 31-049-01 W4M. The sub-basin has no well-defined drainage patterns, but flows are generally in a due-south direction, draining into Devonia Lake. To provide an outlet to Section 06 and the Kams Industrial Area, the proposed Devonia East Drainage Channel commences at the SE 06 and drains south, across Highway 16 along Range Road 15 and then follows more natural drainage patterns and outlets into Devonia Lake on the SE 18-049-01 W4M. This proposed channel may also provide a drainage outlet to the Kams Industrial Area so they may not have to pump anymore. The Devonia East sub-basin has a number of wetlands, which can be enhanced for stormwater management.

The Devonia Southeast sub-basin is located in the southeast corner of the Devonia Basin and has a drainage area of approximately 3.93 km^2 (393.2 ha). The sub-basin drainage patterns are from the northeast to southwest and drain into a natural watercourse, which was the original, natural outlet for Devonia Lake. As this sub-basin is not anticipated to be developed in the foreseeable future, no stormwater management works are considered, at this time.

The Devonia Lake sub-basin includes Devonia Lake proper, and is located along the southern extreme of the Devonia Basin. It has a drainage area of approximately 15.2 km^2 (1521 ha), oriented in a northwest to southeast alignment. Devonia Lake has a constructed outlet on the NE 24-049-02 W4M, which drains into Blackfoot Creek on the SE 23-049-02 W4M. As this sub-basin is not anticipated to be developed in the foreseeable future, no stormwater management works are considered, at this time.

3.4 Hydrology

Release rates were developed using the Water Survey Canada hydrometric stations Stretton Creek near Marwayne and Big Gully Creek near Maidstone. Their contributing drainage basins are largely agricultural in nature, similar to the Blackfoot and Devonia Basins. Based on the 1:100 year peak instantaneous flow, release rates of 1.65 l/s/ha for Stretton Creek near Marwayne and 0.65 l/s/ha for Big Gully Creek near Maidstone were determined. Although these rates are relatively low, they appear realistic and indicative of the large storage capacities available within the basins. Therefore, a release rate of1.65 l/s/ha is recommended for the Blackfoot and Devonia Basins.

3.5 EPA SWMM Model

To determine the pre- and post-development runoff flows from the basin, an EPA SWMM model was created. The EPA-SWMM is a hydrological modeling system developed by the United States government, to simulate the precipitation-runoff processes of watershed systems. For this study, the program is used to determine the existing and future runoff and storage parameters in the Blackfoot and Devonia Basins.

Imperviousness for industrial, country residential and undeveloped areas is based on the

amount of impermeable surfaces that each type of development includes. An imperviousness of 60% was used for industrial, as this type of development includes high amounts of impervious surfaces, such as roadways, rooftops and parking lots. An imperviousness of 5% was used for country residential developments, given the minimal amount of impervious surfaces over relatively large parcels of land. Undeveloped or natural areas were given an imperviousness of 1%.

The Horton method for calculating ground infiltration/loss on pervious areas was used, based on previous models for this area.

A total of 114 sub-basins were considered in the model. The imperviousness value for each sub-basin is the weighted average of the areas designated as industrial, country residential development and/or undeveloped. The same was done for the approved and long-term development conditions.

The rainfall events used to obtain the pre- and post-development flows were the City of Edmonton design storms, based on the 1:100-year 24-hour Huff Distribution and the 1:100 year 4-hour Chicago Distribution. From these two rainfall events, the highest peaks occurred from the 24-hour storm and, therefore, this event was used to develop the stormwater management scenarios.

For the purposes of this study, the following simplifications and assumptions were made.

- Subcatchment areas were treated as having homogenous features in terms of perviousness and slope. All subcatchments were assumed to have a surface grade of 0.5% towards collection points.
- Surface storage nodes were modeled at all locations where wetted areas are apparent from air photos taken during wet years. These storage nodes were assigned volumes proportional to the wetted area, and an assumed average depth of 0.5m.
- In areas where wetted areas were apparent from air photos for dry years, permanent storage nodes were modeled, with volumes proportional to the wetted areas from wet and dry years, and an average depth of 1.0 m.
- Roadside ditches were assumed to conform to County standards for roadside ditch design. Ditch profiles were assumed to have constant slopes between surveyed culverts.
- Profiles and cross sections of established drainage channels away from roads were estimated based on several sources. Surveyed crossings were used to establish profile benchmarks, while cross-sectional data was inferred from air photos and visual inspection. In reaches without available survey information, the channel profiles were assumed to follow the general topography of the surrounding land.
- Where no established drainage channels or ditches are present, drainage was assumed to travel overland, as sheet flow, towards apparent collection points.
- Culvert crossings were assumed to be in good condition, so that the performance of each crossing matches the design capacity of the culverts.
- Roadway crossings were assumed to have no overflow provision, so backwater

effects would flood upstream areas only. Farm crossings were assumed to overflow during design events, without restricting the flow in the channel.

- For improved systems, local collection systems were assumed to connect directly to the improved channels or retained wetland areas.

3.6 Snowmelt Simulation

As snowmelt runoff is unpredictable and varies greatly from year to year, a 'worst-case' simulation was developed assuming total saturation of sub-basin low areas. This would simulate the effects of a drainage channel blocked by ice or other debris suddenly becoming clear.

3.7 Airphoto Interpretation

Airphotos are available for this area for several years, which allowed us to investigate the variation in wetland size and composition over the years. Sameng compared what was determined to be the wettest year (2011), and the driest year (1998). Figures 1 and 2 illustrate the wetted areas, for both years.

As can be seen, the variation in wetted area is substantial between the wet and dry years. This variation is largely due to the lack of efficient drainage throughout the area. Most of these wetlands drain primarily through evaporation or absorption into groundwater.

Due to this variation, the amount of land available in any given year is subject to the annual variations in temperature and precipitation. A future drainage plan can serve to stabilize these wetlands by providing adequate drainage and control to maintain a relatively constant size and shape from year to year of the wetted areas.

The airphotos were also used, in combination with Google Earth, the County Lidar data and Sameng surveys, to determine the most likely drainage paths in the existing system. Because there are few established drainage routes, and the topography of the land is generally flat, existing drainage paths can be expected to change constantly as the land is tilled, and through natural shifts in the top layer of soil from erosion and settling.

3.8 Using Wetlands for Stormwater Management

For development scenarios, existing wetlands were included to manage both stormwater quantity and quality. The maximum outflow from the wetlands was restricted to the pre-development runoff rate, based on the contributing drainage area.

These wetlands are particularly present in the Blackfoot drainage basin, as seen in Figure 1.

3.9 Constraints

During the course of the study, a number of constraints were identified, which may restrict or affect the stormwater management options available to the County. These include:

- Alberta Environment requirements;
- Land availability;
- Existing developments;
- Existing outlets;
- Topography;

- Major utilities;
- Provincial highways; and
- Railroad tracks.

Of these constraints, the Alberta Environment requirements, land availability, the existing outlets and the area topography are the more critical constraints.

3.10 Land Availability

All the lands within the study basins are privately held. However, as the County is the wetland mitigation agent within for the area within the county, it does have a stake in the development of lands containing wetlands. The county also has road right-of-ways available for ditches. Where drainage infrastructure cannot be built along roadways and existing wetlands, the County may have to secure the lands required for some regional stormwater management facilities.

3.11 Existing Outlets

For the purposes of this study, Devonia Lake is considered a suitable outlet for the Devonia Basin. The terms of reference for this study prescribed the Blackfoot Wetland as the outlet for the Blackfoot Basin.

Concerns have been raised by residents adjacent to these outlet locations, particularly at the Blackfoot Wetland, as flooding is a recurring problem. Additional studies, beyond the scope of this study, are required to resolve these concerns. These studies should be undertaken prior to constructing any major drainage works.

4.0 Conceptual Plan

4.1 General

Sameng developed conceptual drainage plans to present to the County, and gather feedback from consultation with the county, landowners, developers and other stakeholders. As the outlets for the basins have been identified, the purpose of these concept plans was to provide adequate drainage routes to those locations, while controlling discharge from runoff to pre-development rates. The following plans were developed for the drainage of these basins.

4.2 Blackfoot East Drainage Channel

As seen in Figure 3, the plan for drainage of the Blackfoot East Basin is to establish the existing drainage pattern in the basin, and utilize the existing wetlands as gross storage to control discharge.

The existing drainage pattern must be excavated in some areas to allow adequate drainage of the existing wetlands. The mean excavation requirement ranges from 0 to 2.5 meters. The total length of improvements is approximately 9 km.

Flow control structures can be placed along the new channel to establish the normal water level of the wetlands, and control outflows to pre-development rates. The final size of the wetlands can be varied depending on the storage requirement, and the County's preference for wetland establishment for environmental enhancement.

Utilizing wetlands in this basin in particular may be advantageous to the County and developers, due to the relative concentration of low areas within the basin, and the need to control discharge to predevelopment levels. Typically, developers would need to dedicate approximately 6% of the gross developable area to stormwater retention. The enhancement and use of wetlands in the area may reduce that requirement by as much as half.

In addition, the wetlands in this basin appear to be in relatively pristine condition compared to other areas, which makes them ideal candidates for preservation and enhancement.

4.3 Blackfoot West Drainage Channel

As seen in Figure 4, the Blackfoot West Basin can be improved by establishing the drainage between the existing wetlands, and into the existing drainage channel. Approximately 5 km of channel improvements will be required to establish drainage in this area, with a mean excavation depth of about 2 meters below existing ground.

This plan will also utilize existing wetlands as storage. Control structures placed at the wetlands will establish the normal water level, and control drainage to predevelopment rates, based on the relative tributary areas.

Though the existing wetlands in this area are not as concentrated as in the Blackfoot East basin, they would still serve to reduce the necessary storage requirements for developers in the area.

4.4 Devonia East Drainage Channel

The drainage plan for this area, as shown in Figure 5, begins with the installation of a

new culvert across Highway 16, which will serve as the drainage outlet for the area north of the Highway. A new drainage ditch along Range Road 15 will take the flows from this culvert, as well as direct drainage from the Kams industrial development located west of Range Road 15, just south of Highway 16. This area currently uses pumps to empty the stormwater collection system into the Central Devonia Drainage Channel along Range Road 20. The new roadside ditch will drain into an existing wetland at Station 2+500, which can be established and enhanced to provide additional storage capacity.

A new channel will be built to provide an outlet to this wetland, following the natural contours of the land to minimize the required excavation, and to connect to other wetlands to the south. The wetlands to the south may also be enhanced and expanded to provide additional stormwater management and water quality control of flows entering Devonia Lake.

Sameng examined the possibility of extending the roadside ditch all the way to Devonia Lake, but found that a natural rise in the road would make this option unfeasible due to the depth of excavation that would be required.

4.5 Devonia West Drainage Channel

This drainage plan, shown on Figure 6, involves establishing the natural drainage channel through the area from Highway 16 to the northern end of Devonia Lake at Range Road 21.

This improvement requires the excavation of approximately 2.8 km of existing ditch, with a mean excavation depth of about 1 meter required to establish the channel. The natural wetlands along the channel are typically small and of lower apparent quality than other wetlands in the area. Nevertheless, they may be either enhanced or removed, depending on the preference of the County.

4.6 Central Devonia Drainage Channel

The existing Central Devonia channel, shown on Figure 7, provides drainage to the Hamlet of Blackfoot and consists of a drainage channel along the Range Road 20 road allowance. Our analysis indicates that this channel, as originally designed, is sufficient to provide drainage to the hamlet and the surrounding lands. However, confirmation of the channel condition is required.

5.0 Functional Drainage Plan Development

5.1 Analysis of Existing Conditions

The SWMM model was run to simulate the conceptual plans under existing runoff conditions. It was found that the proposed upgrades would allow for complete drainage of most areas within their respective basins, without significant increases in peak runoff or surcharging of the existing wetlands.

The concept improvements would allow management of the existing wetlands to buffer runoff from the tributary areas. The wetlands will experience faster response times for storm events, as runoff will enter and exit the wetlands in a timelier manner. The main benefit of these improvements is the increase in the reliability of the drainage patterns. Currently, the wetland areas vary greatly in size and storage from year to year. During wet years, the wetlands afford very little storage capacity, and therefore do not buffer peak flows, while during dry years, the wetlands may have very little outflow, even during heavy rainfall events.

By controlling the discharge from key wetlands, the county may provide a reliable buffer of peak flows, and mitigate the effects of seasonal variations in flooded areas throughout all of the basins.

Simulations of the predevelopment conditions indicate that lots smaller than 10 hectares may have a peak runoff rate of up to 30 L/s/ha. This peak rate is buffered by the wetlands and natural depressions found throughout the area. Therefore, individual lots should control runoff rates to 30 L/s/ha by means of on-lot storage and maximum outlet sizing. Regional stormwater ponds, including the wetlands retained by the County, should limit discharge to the established peak runoff rate of 1.65 L/s/ha.

5.2 Analysis of Future Conditions

The SWMM model was adjusted to simulate hypothetical future conditions in the Blackfoot and Devonia Basins. For this scenario, the areas within 1 mile of Hwy 16 were to be considered developed for light industrial application, and areas between 1 mile and 2 miles were developed with country residential subdivisions. Areas more than 2 miles from the highway were left undeveloped.

Under this scenario, total runoff from most rainfall events is increased by about 50% for both the Blackfoot and Devonia Basins. Primary wetlands were expanded and controlled in the model to provide arbitrary storage, and to release at rates determined in the pre-development discharge rates.

The channel improvements as sized will be sufficient for full build out of the area, and beyond, as long as developers are required to control peak runoff to predevelopment rates. The volume required in the wetlands will vary depending on the storage requirement placed on individual developers.

Typically, constructed wetlands require about twice as much space as a conventional wet-pond to provide the same amount of live storage volume. In the build-out scenario stated above, Table 5.1 summarizes the approximate amount of land that would be required to be dedicated to stormwater management if wetlands or stormwater ponds were used to control rates to predevelopment levels. These areas are only

approximations based on distances from the highway and railroad, as actual requirements will depend on the composition of development, and the active storage available based on land topography.

Table 5.1: Stormwater Storage Requirements for Future Development

Basin	Approximate Developed Area	Area Required for Wetland Storage	Area Required for Pond Storage
Blackfoot East	450 ha.	62 ha.	30 ha.
Blackfoot West	320 ha	45 ha.	20 ha.
Devonia East	551 ha.	76 ha.	37 ha.
Devonia Center	580 ha	85 ha	40 ha.
Devonia West	260 ha	37 ha.	17 ha.

As the lands in the study area develop further, additional storage will be required. In particular, lands with no downstream natural wetland will have to provide full stormwater management within the development, as they will not be able to rely on the wetlands for storage.

The existing wetlands may be sufficient to provide adequate storage for the present and near-future development in the area. However, until these wetlands are managed by operable control structures, and the drainage improvements are installed to allow this management, the potential storage of these wetlands cannot be relied on for any additional development. The size and configuration of the ultimate wetlands should be established as part of the County's wetland management program.

5.3 Control Structures and Crossings

The drainage plans below include managing natural and constructed wetlands and storm ponds to control flow and manage water quality. Various types of control structures may be used in this type of application, depending on the need. Crossings at roadways and pipelines are also considered.

Weir Structures

A weir structure is a barrier placed inside an open channel to block flows. Upstream of the weir, water levels rise to lowest opening of the barrier (the crest) before flowing over the weir. Weirs may be designed with variable widths, shapes, and alignments to control the rate at which water will flow through the channel. Typically, the rate of flow over the weir increases as the upstream level rises. Weirs manage water quality by allowing sediment to settle behind the weir, allowing only the cleaner water at the top over the structure.

Stop-Logs

Stop logs are a special type of weir composed of wooden beams, or other materials, placed in slots in a concrete or metal structure in the channel. This structure acts as a weir under normal conditions, but has the advantage in that the beams may be removed from the structure with relative ease, allowing the upstream water level to be drawn down

as required. These structures are often used in irrigation channels, where the requirement for water retention and/or diversion varies seasonally.

Orifice Structures

An orifice is a hole in a concrete or metal barrier through which water can flow. Orifices are typically used in combination with weirs to manage normal and high water levels upstream of the control structure. Orifices are used when a constant flow rate independent of upstream water levels is desired. The main drawback with orifices is that they may become blocked fairly easily if not protected.

Control Pipes

Flows may be controlled by using a specific size of pipe in an outlet. The size of the pipe will restrict flows to its maximum capacity. This type of control system is usually less consistent in performance, and is generally not used where management of flow rates and water levels are critical.

Road Crossings

For channels of this size, road crossings are usually constructed with buried pipes (culverts) in line with the channel. The size of pipe is selected to allow peak flows in the channel to cross the road without restrictions that could cause flooding upstream of the crossing, or overtopping of the road crossing the channel. The crossings considered below are all assuming circular, corrugated steel culverts, or in some cases, two such culverts placed side by side. Culverts may come in other shapes and materials depending on specific requirements.

The culvert sizes stated here are of sufficient size to pass 1.65L/s/ha based on the upstream catchment area. As the flows in these channels will be managed, it is assumed that this flow rate will occur frequently, but will not be exceeded under 100-year frequency. These sizes, therefore, apply to all types of crossings, including temporary and farm crossings.

5.4 Blackfoot East Drainage Channel

As seen in Figure 3, the improved drainage channel begins east of Range Road 15. The existing wetland there may be retained or drained, as needed by the County. As this area is not likely to develop soon, the wetland should remain as-is for the present time, with the opportunity to drain or enhance as future development may require.

The channel will drain across Range Road 15 through a 750 mm diameter culvert to replace the existing 300 mm diameter culvert. The channel will then drain into an existing wetland complex. This wetland is a permanent water feature and should be retained as much as possible. A new control structure located at the north end of the retained wetland will maintain a normal water level of 664.0 m and regulate discharge from the wetland to 2600 L/s. This wetland could be expanded and enhanced to provide storage for most of the basin upstream of this area.

The natural drainage path from this wetland will be improved by trenching to a grade of 0.03% to convey a peak flow rate of at least 2600 L/s. Two (2) 1050 mm diameter culverts will be required at the crossing of Township Road 503A to accommodate flows from the wetland.

A second wetland complex is to be established south of Township Road 504. This wetland is currently seasonal, but can be improved to maintain a constant water level. A new control structure at Township Road 504 will maintain a water level of 663.8 m and control discharge from the wetland to 2900 L/s. This wetland and the one upstream may be designed to work in series in order to achieve other objectives set by the County's wetland policy managers. Future design considerations may include aquatic environment optimization, educational and recreational reserve, and wildlife preservation.

The new control structure will discharge through Township Road 504 via two (2) 1050mm diameter pipes into the existing drainage channel. This channel appears to have an average slope of 0.26%, which will be sufficient to convey future flows. However the condition of the existing channel should be confirmed by physical survey.

The existing channel currently crosses Range Road 15 through a 600mm diameter culvert at an elevation of 657.65 m. This crossing will need to be replaced by two (2) 1200mm diameter culverts to convey the design flows. The existing 800mm diameter culvert at Township Road 510 will also need to be replaced by two (2) 1500 mm diameter pipes to convey the design flows.

One or two farm crossings may be required along the channel on the E½ 30-050-01 W4M to provide the landowner access to his cultivated land on both sides of the channel. Developments in this area will need to provide their own stormwater management to control runoff to predevelopment rates.

As an alternative to the required culvert upgrades outlined here, the County may decide to limit discharge from the wetlands to less than 1.65 l/s/ha by retaining more live storage in those wetlands. The existing culverts at Range Road 15 and Township Road 510 may be adequate if discharge from the second wetland is restricted to less than 600 L/s, or 0.33L/s/ha.

5.5 Blackfoot West Drainage Channel

As seen in Figure 4, the Blackfoot West Channel follows the existing drainage patterns through several existing wetlands. The current condition of this channel is anticipated to be poor, based on reports of poor drainage in the area. The topography of the southern portion of the Blackfoot West basin is very flat, and may present challenges for local drainage. The drainage channel improvements presented in Figure 4 will serve mainly to provide suitable drainage for the wetlands in the basin.

The existing wetlands (both permanent and seasonal) in this basin should be preserved and converted into stormwater management facilities. The proposed drainage channel will be constructed to connect these facilities in series by the most direct alignment. A slope of at least 0.1% should be maintained at the upstream reach of the channel to ensure adequate flow.

The wetland south of the road alignment for Township Road 504 may be controlled by means of a 1050 mm diameter culvert Figure 8 shows a more detailed view of this location, as well as the recommended alignment of the channel improvements, which avoids unnecessary crossings of wellsite access roads, and connects the existing wetland areas in series. A more direct alignment (running directly north along the section boundary) would require additional trenching and fill of low areas, which is not recommended.

The topography around the upper reach of this channel is very flat, with many areas having little or no positive drainage. This flat topography makes this region a good location for constructed and enhanced wetlands. A large area south of the Township Road 504 alignment may be converted to a wetland complex for the purposes of wetland compensation. Control structures may be placed in individual cells of the wetland to manage water retention and water quality. The complex will be controlled overall by a control structure at the Township Road 504 alignment. The lowest portion of the complex will be held to a normal water level of 664.0 m and discharge at a peak flow rate of 1400 L/s.

A second wetland complex north of Township Road 504 will be managed by a control structure holding the normal water level to 662.9 m and discharging at a rate of 1800 L/s. Local drainage plans in this basin should drain into these wetland complexes.

Downstream of the second wetland complex, the existing natural drainage channel appears to have sufficient capacity to convey the controlled flows. There is an existing access road between the NW and SW quarters of Section 36-50-2 that the existing channel crosses. This crossing is currently served by a 900mm diameter culvert, which must be replaced by a 1200mm diameter pipe. The existing 750 mm diameter crossing at Range Road 20 should be replaced by a 1350 mm diameter crossing, and the 1000 mm diameter crossing at Range Road 15 should be upgraded to a 1500 mm diameter crossing. Farm and access crossings between Range Road 20 and Range Road 15 should use 1500mm diameter pipes or equivalent.

Downstream of Range Road 15 the Blackfoot West Channel discharges into the Blackfoot East Channel. This confluence should be upgraded with erosion protection.

5.6 Devonia East Drainage Channel

The Devonia East Channel, shown in Figure 5, provides drainage to the area east and north of the Hamlet of Blackfoot. This area drains to a large wetland area north of Highway 16. This wetland area does not appear to have any active drainage, so a new culvert should be installed under Highway 16.

Since this wetland area is prone to flooding, a regional wet pond should be developed at the site, both to provide fill for development of the remainder of the site, and to manage drainage sub-basins north of the Highway. A new 900mm diameter culvert across the Highway will be sufficient to provide effective drainage, but an orifice/weir type control structure is recommended to manage water levels in the pond, and control the peak flow rate to 350 L/s.

An improved roadside ditch would be constructed along Range Road 15 to drain the new culvert, and collect drainage from the existing Kams industrial development immediately west of the roadway. This development currently pumps a large portion of their runoff towards the Central Devonia Drainage Channel. A drainage channel within closer proximity would benefit this development and future developments in the area. The access roads crossing this ditch may be crossed adequately with 675 mm diameter culverts along the road. However, 900mm diameter culverts are recommended to avoid flooding due to potential blockages in any one culvert.

The drainage channel would run along the west side of Range Road 15 for approximately 2.0 km. The existing 500mm diameter culvert across the road at this point

would be replaced by a new 1050 mm diameter culvert. The channel will discharge into an existing wetland complex that should be retained and enhanced to provide additional regional storage for the area. This wetland complex would be managed by a control structure. The normal water level of the wetland would be established at 668.28m, and the discharge from the wetland would be controlled to 1500 L/s.

The existing wetland complex currently has poor outflow. A new channel with an average slope of 0.32% will be constructed from the wetland to Township Road 494. The existing 600mm diameter culvert crossing the road will be replaced by a lower 1200mm diameter culvert.

South of Township Road 494, there is a natural drainage path that will be enhanced and lowered by approximately 1 m below the existing profile. Existing crossings at access roads and Range Road 15 will be replaced by 1200mm diameter culverts at the new ditch invert.

A new channel outlet into Devonia Lake will be required. This outlet will need to be designed and constructed in accordance with provincial Environmental policies regarding changes to the shores of permanent waterbodies.

5.7 Devonia West Drainage Channel

The Devonia West Drainage Channel, shown on Figure 6, will start at the existing crossing at Highway 16. This crossing does not need to be upgraded, as long as developments north of the Highway control discharge to 1.65 L/s/ha. South of the Highway, there are no defined drainage channels, and flows currently travel overland via various routes. A drainage channel across this land may be incorporated into the local drainage system as the land develops.

The 300mm diameter culvert at Township Road 500 should be replaced with a 750 mm diameter culvert with an invert elevation no higher than 674.9m.

The natural watercourse from this point, downstream, will be deepened and expanded to provide the necessary drainage capacity. With no established wetlands along this course, individual developers will need to control runoff to 1.65L/s/ha in individual stormwater management facilities that discharge into the main channel.

The channel crosses Range Road 21 twice at existing crossings. The culverts at these crossings should be upgraded to, at least, 900mm diameter pipes to pass the design flows without restriction.

This channel discharges into the flood basin of Devonia Lake. Though this basin is often dry and the flow path into the main body of the lake appears to be shifting, the outlet is considered to be adequate, as the flood basin can be considered to be part of the Lake. As this outlet is to the flood basin, but not the shore of the lake, an outlet agreement may not be required with Alberta Environment and Sustainable Resource Development.

5.8 Additional Considerations

Although the Central Devonia Channel is designed to convey flows under ultimate development, the condition of the channel has not been verified. If the channel is not maintained, flooding may result. The channel should be inspected periodically, to ensure compliance with its original design parameters.

Increased development may have impacts on the hydrology of the region, including alteration of the groundwater table, and increase in surface water storage. A study of these impacts is beyond the scope of this plan, however, the County should be aware of potential impacts of development. It is recommended that this be done as part of ongoing municipal development plans and area structure plans for the region.

6.0 Financing and Implementation Strategy

6.1 Current County Legislation

The County of Vermilion River Municipal Development Plan (MDP) (Bylaw No. 07-14) provides the overall direction for development within the County. The goal of the MDP is to encourage environmentally sound, sustainable economic development, while conserving and enhancing the County's rural character. For transportation and utilities, the County provides policies which encourage compatible, economic and efficient service and utility related development. The County encourages the location of transportation and utility lines and facilities in a manner which:

- encourages the integration of transportation routes and utility lines within defined corridors;
- discourages the creation of fragmented parcels of land between rights-of-way; and
- minimizes the impacts on recreational, historical or wildlife resource areas.

To assist the County in financing transportation and utility infrastructure to encourage and accommodate compatible, economic and efficient service and utility related development, the County passed Bylaw 12-04 to provide for off-site levies. Schedule 'A' identifies the development areas which are subject to off-site levies and Schedule 'B' identifies the rates. The stormwater off-site infrastructure charges are:

- Basin 1 (Northwest Basin) - $2197.00/net developable hectare;
- Basin 2 (Blackfoot Basin) - $66.00/net developable hectare; and
- Outside drainage basins – no levy.

6.2 Cost Estimates

The costs of the proposed channel improvements were estimated based on the quantities for channel improvements and culvert and control structure installation.

These estimates do not include the cost to acquire land for easements that may be necessary for channels outside of roadways, and does not include the costs to establish wetland areas as recommended in the previous section. It is recommended that the costs for wetland improvements be covered under the County's wetland compensation program, as the primary purpose for those wetlands.

Table 6.1 summarizes the construction costs for the channel improvements identified.

Table 6.1 Cost Estimate Summary (thousands)

Channel	Channel Improvement	Crossings and Control Structures	Engineering /Contingency & Mobilization.	**Total**
Blackfoot East	$ 414	$ 310	$ 592	**$ 1,316**
Blackfoot West	$ 244	$ 428	$ 554	**$1,226**
Devonia East	$ 510	$ 327	$ 672	**$1,509**
Devonia West	$ 107	$ 54	$ 198	**$ 359**
Total	**$ 1,061**	**$ 1,333**	**$ 2,016**	**$ 4,410**

6.3 Improvement Implementation and Prioritization

Current development within the Blackfoot and Devonia Basins is along Highway No. 16, going from east to west and within 1 mile north and south of the highway. This trend is anticipated to continue. Accordingly, construction of the Devonia East Drainage Channel is the first priority at a total estimated cost of approximately $1,509,000. The benefitting area and the cost per net developable hectare are detailed in Table 6.2. Table 6.2 also shows the proposed stormwater levy for the net developable area, which is the sum of the current levy plus the levy required to construct the Devonia East Drainage Channel.

Table 6.2: Devonia East Drainage Channel Cost Per Benefitting Hectare

Location	Developable Area (ha)				Basin*	Stormwater Levy	
	Gross	wetland #	Wetland	Net		Current	Proposed
SW 05-050-01 W4M	32.4	NW Basin	8.1	17.0	1	$2,197.00	$6,461.73
NW 32-049-01 W4M	64.8		0	45.4	1	$2,197.00	$6,461.73
SW 32-049-01 W4M	64.8		0	45.4	1	$2,197.00	$6,461.73
NE 31-049-01 W4M	64.8		0	45.4	2	$66.00	$4,330.73
SE 31-049-01 W4M	64.8	SD320	12.8	36.4	2	$66.00	$4,330.73
SE 06-050-01 W4M	64.8	SD322/323/324	20.9	30.7	2	$66.00	$4,330.73
NE 06-050-01 W4M	64.8		0	45.4	outside	$0.00	$4,264.73
SW 06-050-01 W4M	64.8		0	45.4	2	$66.00	$4,330.73
NW 06-050-01 W4M	64.8	SD325	3.5	42.9	outside	$0.00	$4,264.73
Total	550.8			353.8			
Estimated Cost	$1,509,000			$4,264.73			

* as per Off-site Levies Bylaw (Bylaw 12-04)

The second priority is the existing Central Devonia Drainage Channel. As designed, this channel provides proper drainage to the Hamlet of Blackfoot and the surrounding lands. Table 6.3 shows the benefitting area and the cost per net developable hectare for the Central Devonia Drainage Channel. As no works are proposed for the Central Devonia Drainage Channel, no additional levies are necessary. However, should rehabilitation works be required to return the channel to its original design standards, those costs could be recouped in an off-site levy and added to the current levies.

The third priority is the Devonia West Drainage Channel at a total estimated cost of approximately $359,000. The benefitting area, the cost per net developable hectare and the proposed stormwater levy for the net developable area are detailed in Table 6.4.

As noted above, complaints have been received by the County and at the second Open House regarding the efficacy of the existing outlet to Devonia Lake. These complaints should be investigated and addressed by the County prior to undertaking any additional stormwater works that drain into Devonia Lake. The cost of the investigations and any improvements implemented could then be recouped through additional levies on the benefitting lands.

As no major developments are anticipated, for the foreseeable future, within the headwaters of the Blackfoot East and Blackfoot West drainage channels, no stormwater levies are suggested, at this time.

Table 6.3: Central Devonia Drainage Channel Cost Per Benefitting Hectare

Location	Developable Area (ha)				Basin*	Stormwater Levy	
	Gross	Wetland #	Wetland	Net		Current	Proposed
NE01-050-02 W4M	64.8		0	45.36	2	$66.00	$66.00
SE 01-050-02 W4M	64.8	SD121	20.7	30.87	2	$66.00	$66.00
NE 36-049-02 W4M	64.8	SD120	3.9	42.63	2	$66.00	$66.00
SE 36-049-02 W4M	64.8	SD111	6	41.16	2	$66.00	$66.00
NW 31-049-01 W4M	64.8		0	45.36	2	$66.00	$66.00
SW 31-049-01 W4M	64.8	SD321	9	39.06	2	$66.00	$66.00
Total	388.8			244.44			
Estimated Cost	$0			$0.00			

* as per Off-site Levies Bylaw (Bylaw 12-04)

Table 6.4: Devonia West Drainage Channel Cost Per Benefitting Hectare

Location	Developable Area (ha)				Basin*	Stormwater Levy	
	Gross	Wetland #	Wetland	Net		Current	Proposed
SW 01-050-02 W4M	64.8		0	45.36	outside	$0.00	$2,021.16
NW 36-049-02 W4M	64.8		0	45.36	outside	$0.00	$2,021.16
NE 02-050-02 W4M	64.8	SD115/116	2	43.96	outside	$0.00	$2,021.16
SE 02-050-02 W4M	64.8	SD12/113	3.4	42.98	outside	$0.00	$2,021.16
Total	259.2			177.66			
Estimated Cost	$359,080			$2,021.16			

* as per Off-site Levies Bylaw (Bylaw 12-04

7.0 Conclusions and Recommendations

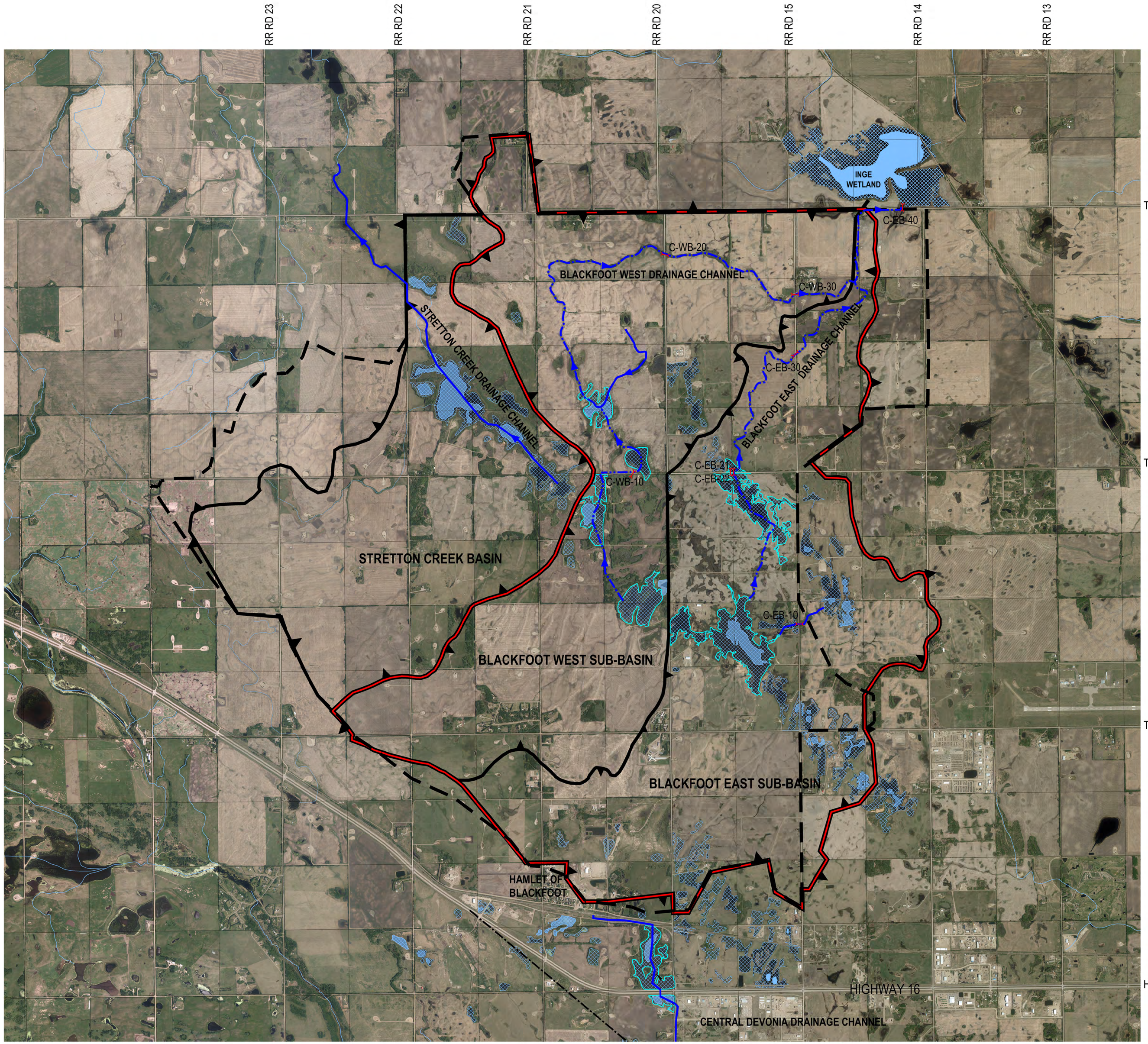
7.1 Conclusions

1. The Blackfoot and Devonia Basin boundaries were confirmed as shown on Figures 1 and 2, respectively. An area of approximately 13.8 km^2 (1378 ha) originally identified as being in the Blackfoot Basin is actually within the Stretton Creek basin.
2. A predevelopment peak runoff rate of 1.65 l/s/ha was determined to be the most appropriate approximation for the Blackfoot and Devonia Basins.
3. The EPA SWMM model was used to determine the pre- development runoff flows from the basins. Local peak runoff rates for 100-year events were found to be up to 30 L/s/ha for local runoff, and 1.7 L/s/ha for basin runoff in both the Blackfoot and Devonia Basins.
4. Devonia Lake is the outlet for the Devonia Basin and the Blackfoot Wetland is the outlet for the Blackfoot Basin. Additional studies are required to resolve flooding issues around Devonia Lake and the Blackfoot Wetland.
5. For the Blackfoot Basin, the Blackfoot East and Blackfoot West drainage channels are required to provide proper drainage for future development.
6. For the Devonia Basin, the existing Central Devonia and the Devonia East and Devonia West drainage channels are required to provide proper drainage for future development.

7.2 Recommendations

1. The County should manage the stormwater from existing and future developments within the Study Basins, for both quality and quantity, prior to discharge into Devonia Lake and the Blackfoot Wetland.
2. Discharge into regional stormwater management facilities and managed wetlands should be restricted to a peak rate of 30L/s/ha.
3. Discharge from regional stormwater management facilities and managed wetlands should be restricted to 1.65 L/s/ha.
4. The County should implement the Blackfoot East and Blackfoot West Drainage Channels to manage the stormwater from existing and future developments within the Blackfoot Basin.
5. The County should continue to use the Central Devonia Drainage Channel, and implement the Devonia East and Devonia West Drainage Channels to manage the stormwater from existing and future developments within the Devonia Basin.
6. The County should address the flooding concerns around Devonia Lake and downstream impacts prior to implementing the Devonia Basin functional stormwater drainage plan.
7. The County should address the flooding concerns around the Blackfoot Wetland prior to implementing the Blackfoot Basin functional stormwater drainage plan.

Figures



LEGEND

- MAJOR BASIN BOUNDARY
- SUB-BASIN BOUNDARY
- STUDY AREA BOUNDARY
- MAJOR DRAINAGE PATHS
- MAJOR DRAINAGE PATHS IMPROVED
- PROPOSED DRAINAGE PATHS
- HIGHWAY 16 REALIGNMENT
- WETLANDS (REGULATED)
- WETLANDS (WET YEAR)
- WETLANDS (DRY YEAR)
- HIGHWAY 16 REALIGNMENT

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Client:

County of VERMILION River

DATE:

April 21, 2014

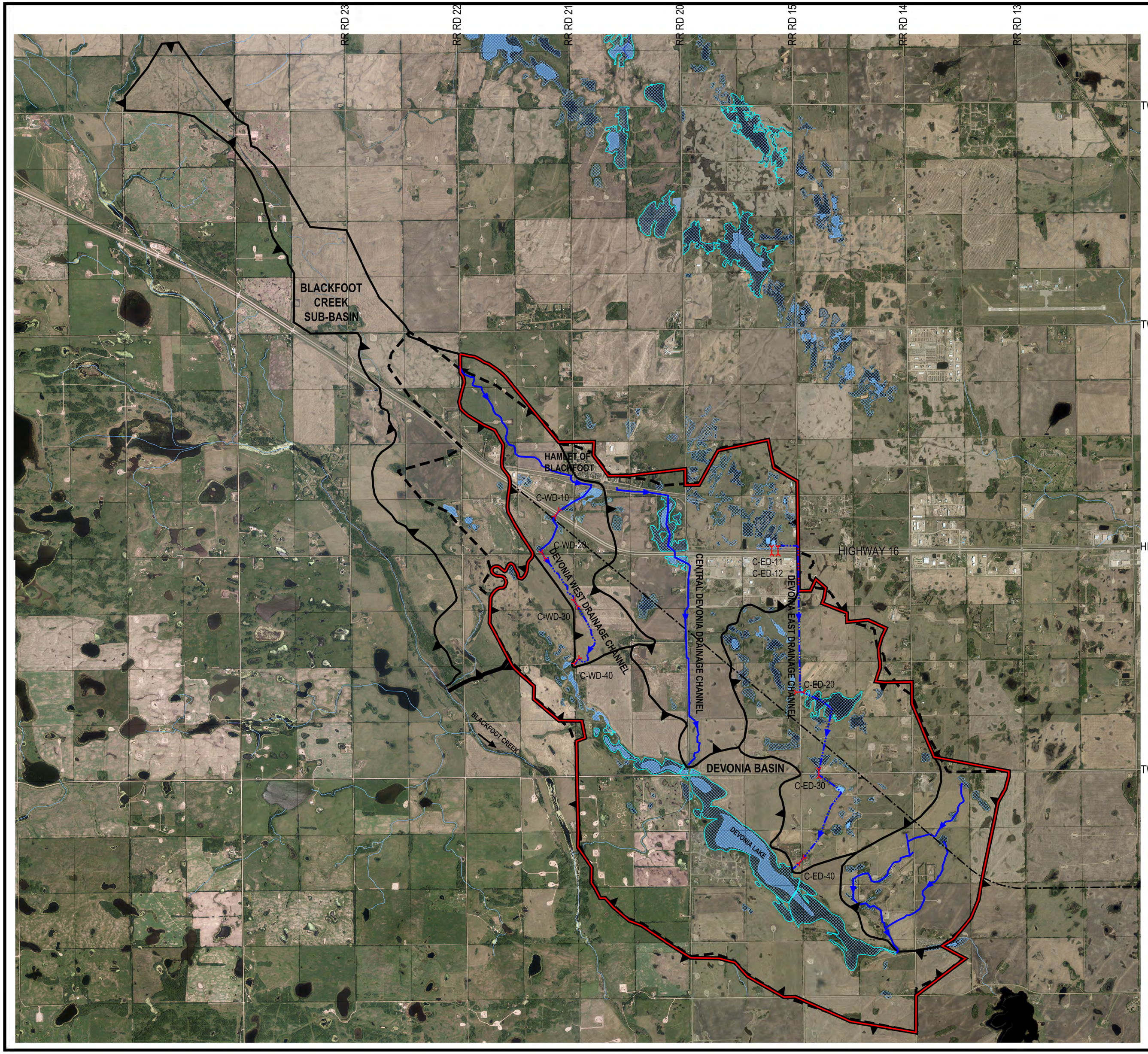
Project:

Blackfoot and Devonia Basins Functional stormwater Drainage plan

Title:

BLACKFOOT BASIN

Scale:	Figure:
NTS	**1**



LEGEND

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- MAJOR DRAINAGE PATHS IMPROVED
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- WETLANDS (REGULATED)
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Project:

Blackfoot and Devonia Basins Functional stormwater Drainage plan

Title:

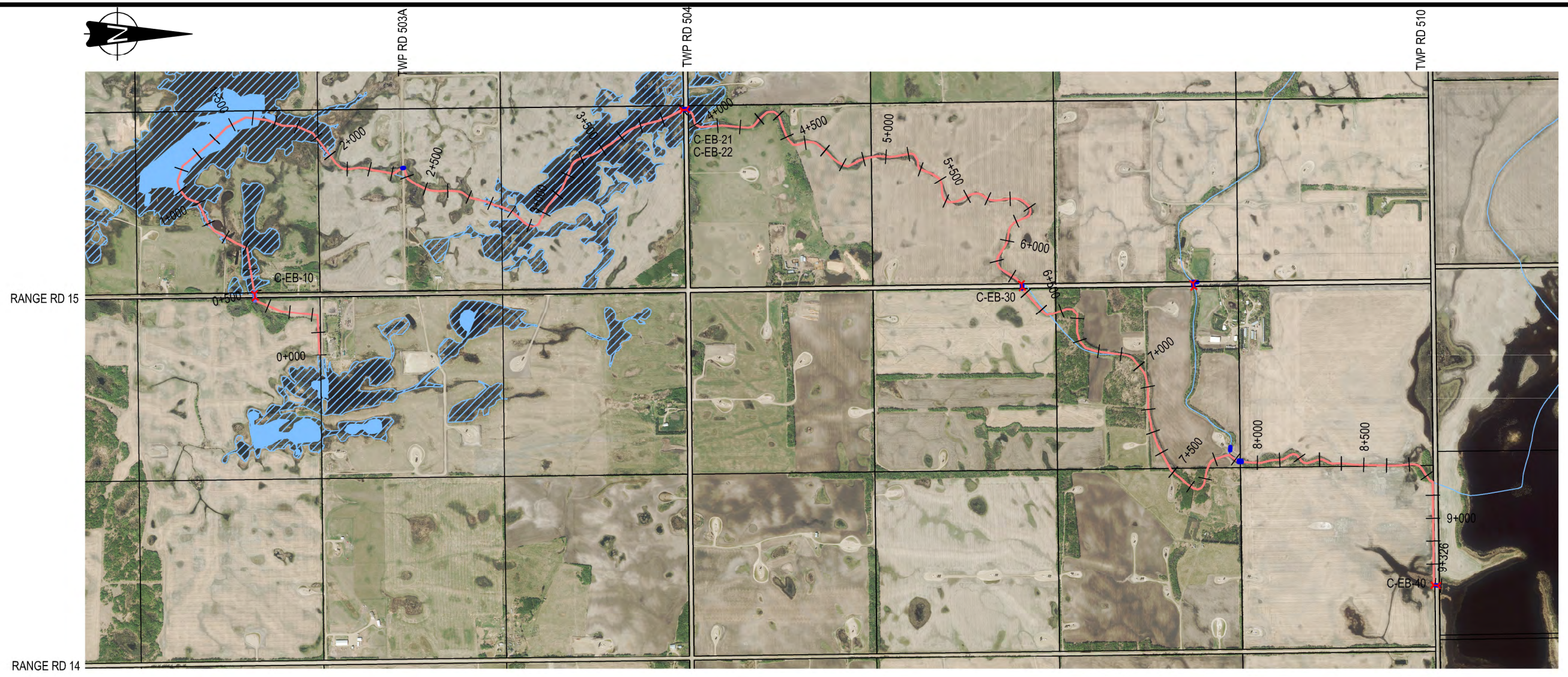
DEVONIA BASIN

Scale:

NTS

Figure:

2

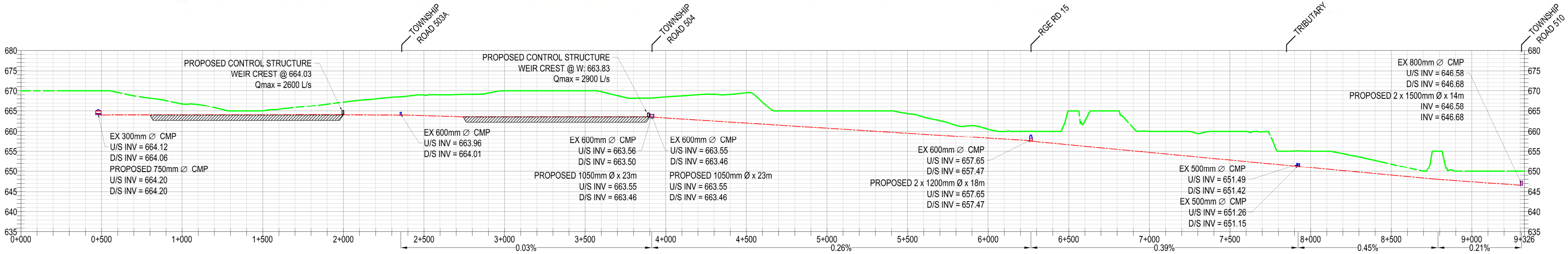


LEGEND

- EXISTING COUNTY LIDAR DATA
- EXISTING EDGE OF ROAD
- EXISTING BOTTOM OF DRAINAGE CHANNEL
- PROPOSED BOTTOM OF DRAINAGE CHANNEL
- EXISTING DRAINAGE COURSE
- ALIGNMENT

PLAN PROFILE

- EXISTING CULVERT
- PROPOSED CULVERT
- WETLAND CONTROL STRUCTURE
- WETLAND AREA DRY YEAR
- WETLAND AREA WET YEAR
- CONTROLLED WETLAND



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CLIENT:

County of VERMILION River

DATE:

April 21, 2014

PROJECT:

BLACKFOOT & DEVONIA BASINS FUNCTIONAL STORMWATER DRAINAGE PLAN

TITLE:

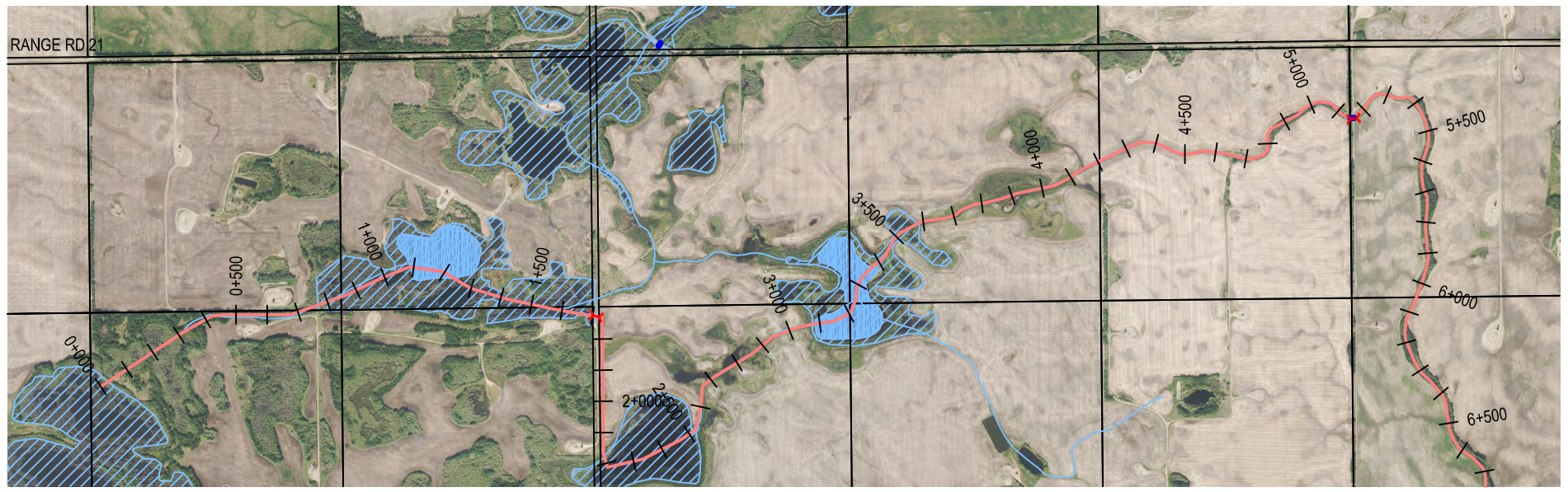
PLAN & PROFILE OF BLACKFOOT EAST DRAINAGE CHANNEL 0+000 TO 9+326

SCALE:

1:20,000

FIGURE:

3

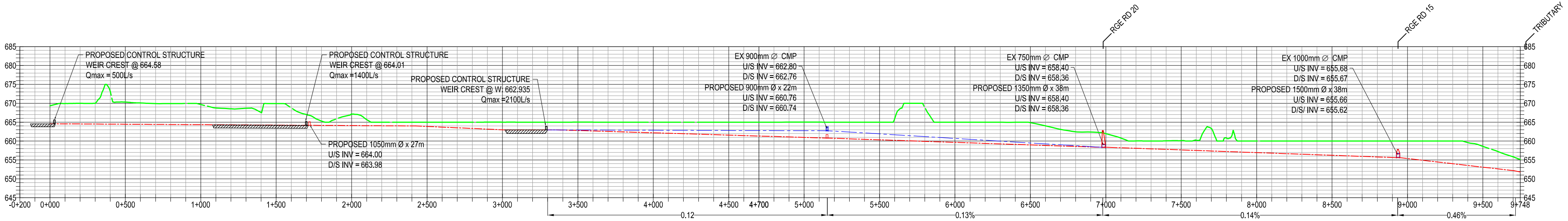


LEGEND

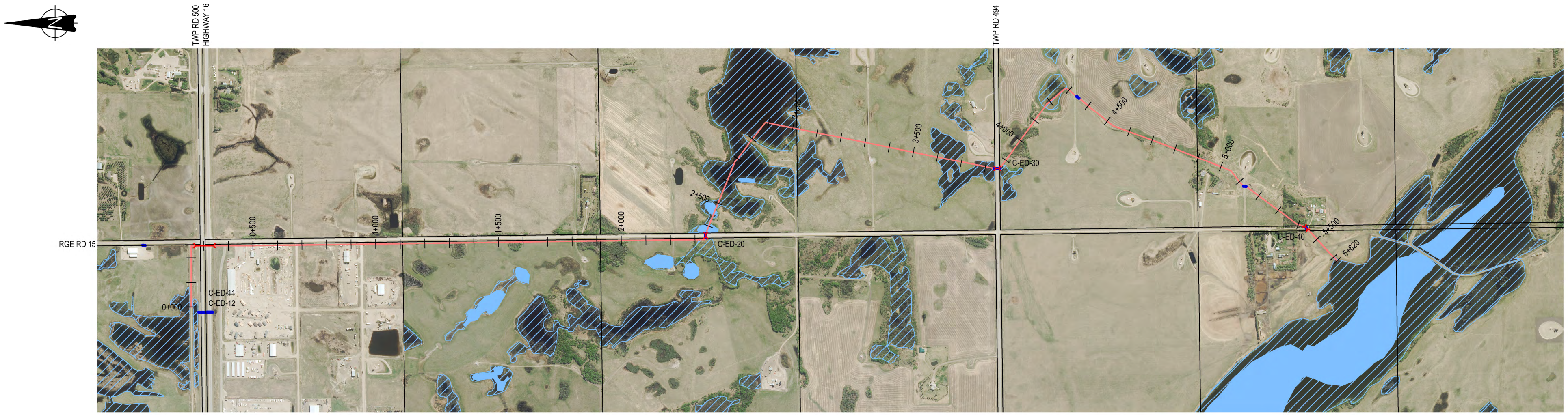
- EXISTING COUNTY LIDAR DATA
- EXISTING EDGE OF ROAD
- EXISTING BOTTOM OF DRAINAGE CHANNEL
- PROPOSED BOTTOM OF DRAINAGE CHANNEL
- EXISTING DRAINAGE COURSE
- ALIGNMENT

PLAN PROFILE

- EXISTING CULVERT
- PROPOSED CULVERT
- WETLAND CONTROL STRUCTURE
- WETLAND AREA DRY YEAR
- WETLAND AREA WET YEAR
- CONTROLLED WETLAND

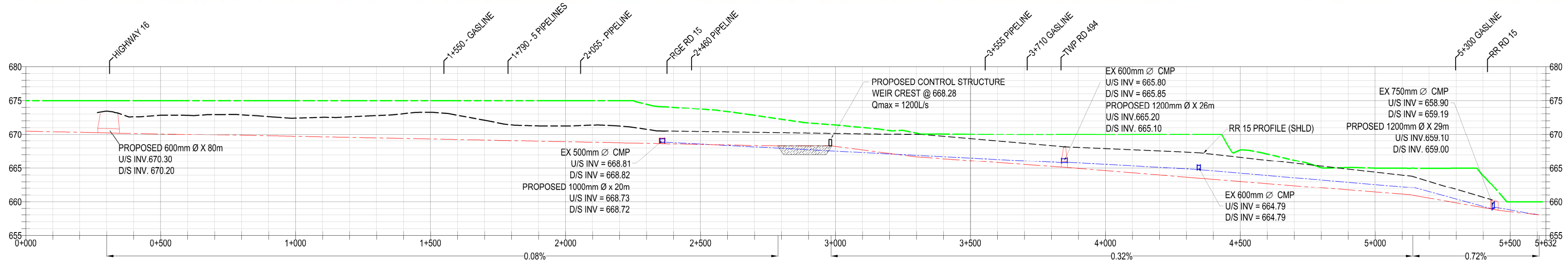


PREPARED BY: sameng inc. better water | better world 1500 Baker Center, 10025-106 Street, Edmonton, Alberta, Canada T5J 1G4 Ph. 780-482-2557 * Fax 780-482-2538	CLIENT: County of VERMILION River	DATE: April 21, 2014	PROJECT: **BLACKFOOT & DEVONIA BASINS FUNCTIONAL STORMWATER DRAINAGE PLAN**	TITLE: **PLAN & PROFILE OF BLACKFOOT WEST DRAINAGE CHANNEL 0+000 TO 9+748** SCALE: **1:20,000** FIGURE: **4**



LEGEND

	PLAN	PROFILE
EXISTING COUNTY LIDAR DATA		
EXISTING EDGE OF ROAD		
EXISTING BOTTOM OF DRAINAGE CHANNEL		
PROPOSED BOTTOM OF DRAINAGE CHANNEL		
EXISTING DRAINAGE COURSE		
ALIGNMENT		
EXISTING CULVERT		
PROPOSED CULVERT		
WETLAND CONTROL STRUCTURE		
WETLAND AREA DRY YEAR		
WETLAND AREA WET YEAR		
CONTROLLED WETLAND		



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County of VERMILION River

DATE:

April 21, 2014

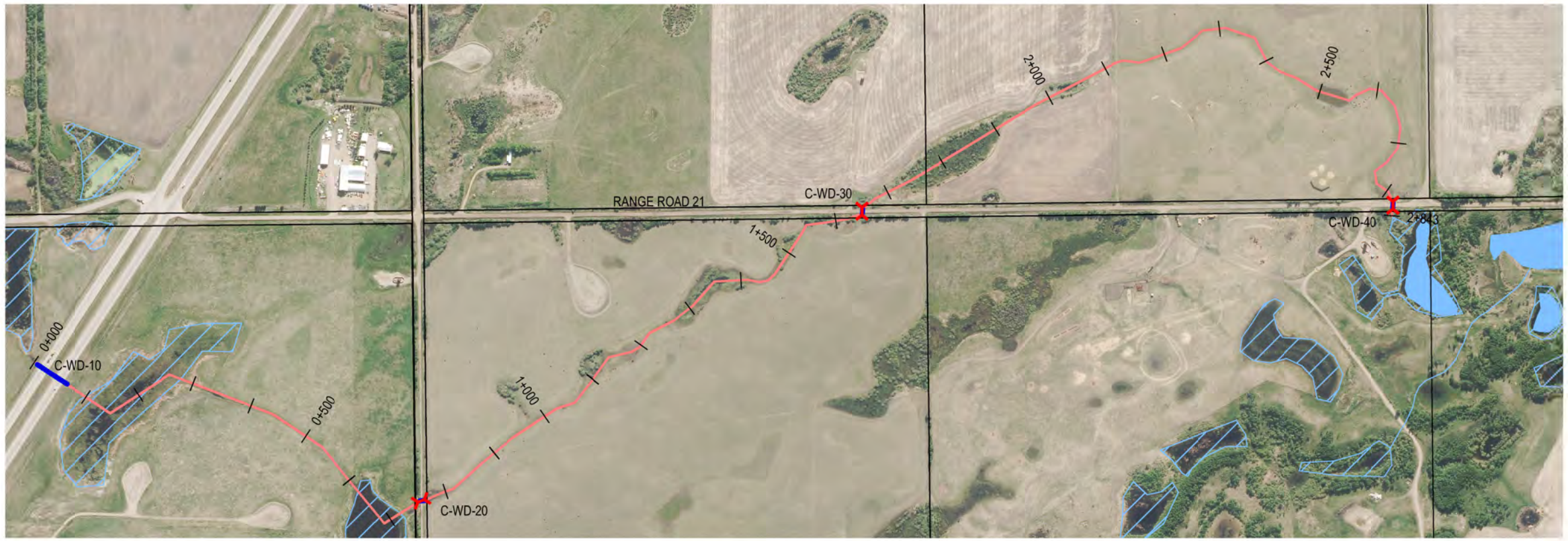
PROJECT:

BLACKFOOT & DEVONIA BASINS FUNCTIONAL STORMWATER DRAINAGE PLAN

TITLE: **PLAN & PROFILE OF DEVONIA EAST DRAINAGE CHANNEL 0+000 TO 5+632**

SCALE: **1:12,500**

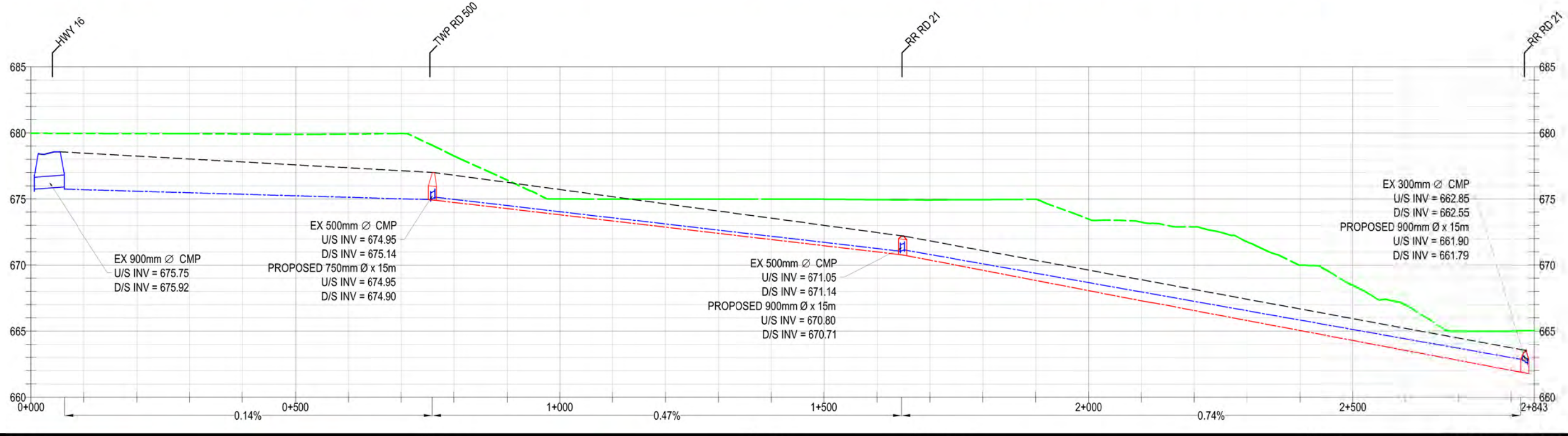
FIGURE: **5**



LEGEND

- EXISTING COUNTY LIDAR DATA
- EXISTING EDGE OF ROAD
- EXISTING BOTTOM OF DRAINAGE CHANNEL
- PROPOSED BOTTOM OF DRAINAGE CHANNEL
- EXISTING DRAINAGE COURSE
- ALIGNMENT
- EXISTING CULVERT
- PROPOSED CULVERT
- WETLAND CONTROL STRUCTURE
- WETLAND AREA DRY YEAR
- WETLAND AREA WET YEAR
- CONTROLLED WETLAND

PLAN PROFILE



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County of VERMILION River

DATE:

April 21, 2014

PROJECT:

BLACKFOOT & DEVONIA BASINS FUNCTIONAL STORMWATER DRAINAGE PLAN

TITLE:

PLAN & PROFILE OF DEVONIA WEST DRAINAGE CHANNEL 0+000 TO 2+843

SCALE:

1:8,000

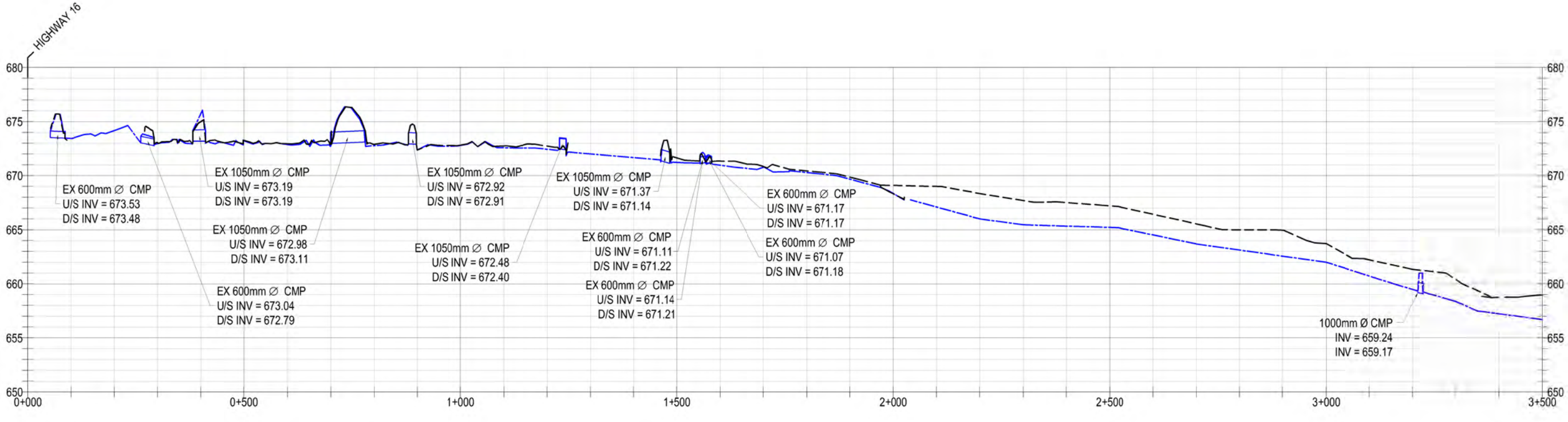
FIGURE:

6

LEGEND

- EXISTING COUNTY LIDAR DATA
- EXISTING EDGE OF ROAD
- EXISTING BOTTOM OF DRAINAGE CHANNEL
- PROPOSED BOTTOM OF DRAINAGE CHANNEL
- EXISTING DRAINAGE COURSE
- ALIGNMENT

	PLAN	PROFILE
EXISTING CULVERT		
PROPOSED CULVERT		
WETLAND CONTROL STRUCTURE		
WETLAND AREA DRY YEAR		
WETLAND AREA WET YEAR		
CONTROLLED WETLAND		



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County of VERMILION River

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April 21, 2014

PROJECT:

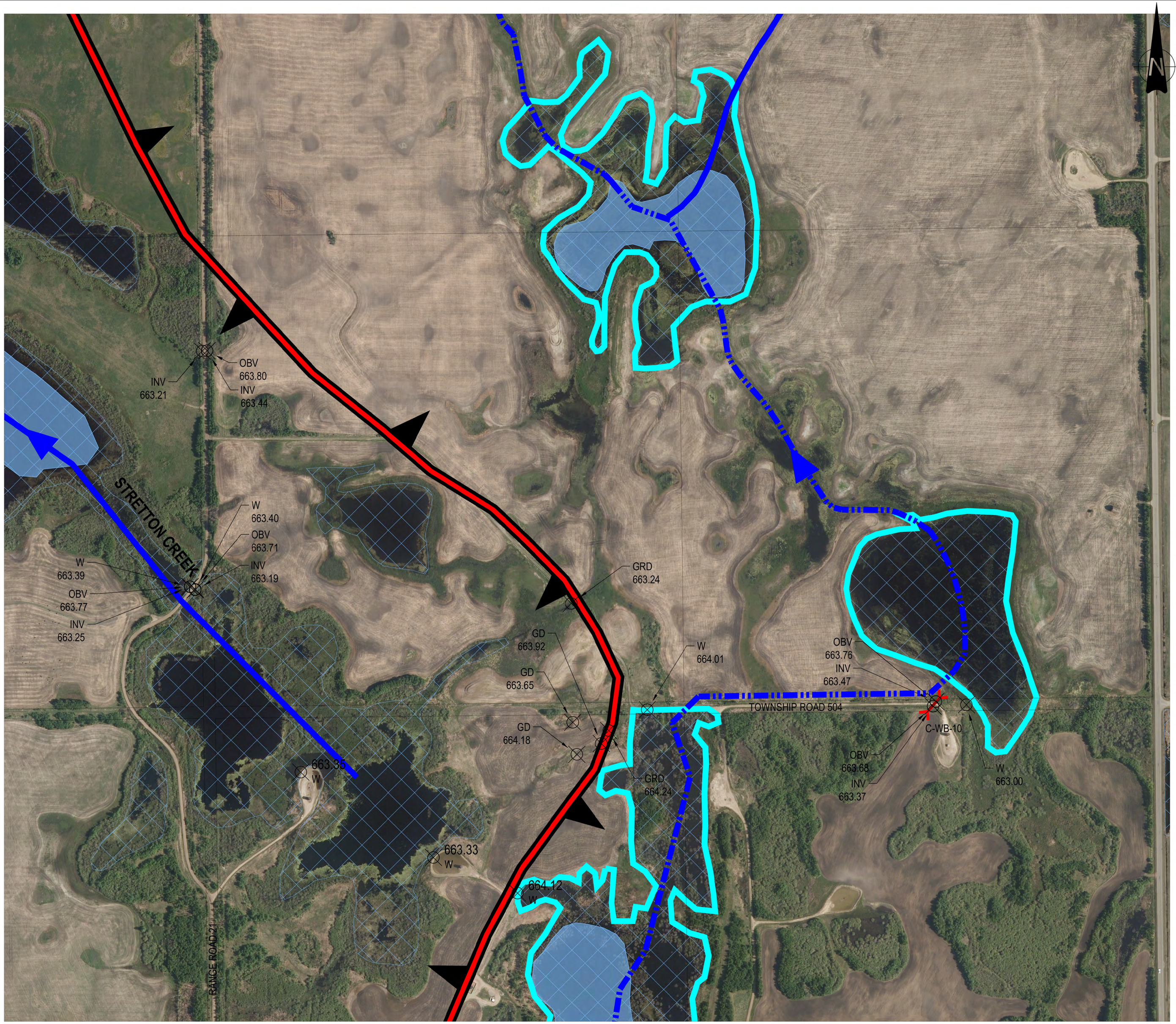
BLACKFOOT & DEVONIA BASINS FUNCTIONAL STORMWATER DRAINAGE PLAN

TITLE:

PLAN & PROFILE OF EXISTING DEVONIA CENTRAL DRAINAGE CHANNEL 0+000 TO 3+500

SCALE: **1:10,000**

FIGURE: **7**



LEGEND

- MAJOR BASIN BOUNDARY
- SUB-BASIN BOUNDARY
- STUDY AREA BOUNDARY
- MAJOR DRAINAGE PATHS
- MAJOR DRAINAGE PATHS IMPROVED
- PROPOSED DRAINAGE PATHS
- WETLANDS (REGULATED)
- WETLANDS (WET YEAR)
- WETLANDS (DRY YEAR)
- EXISTING CULVERT
- SURVEY POINTS

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Client:

County of VERMILION River

DATE:

April 21, 2014

Project:

Blackfoot and Devonia Basins Functional stormwater Drainage plan

Title:

TOWNSHIP ROAD 504 & RANGE ROAD 21 FLOODING CONCERNS

Scale:	Figure:
NTS	**8**