THE COUNTY OF VERMILION RIVER IN THE PROVINCE OF ALBERTA

BYLAW 12-13

A BYLAW FOR THE ADOPTION OF THE COUNTY OF VERMILION RIVER FUNCTIONAL 'STORMWATER DRAINAGE PLAN – NORTHWEST DRAINAGE BASIN – JUNE 2012'

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 May 15th, 2012 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 Functional Stormwater Drainage Plan – Northwest Drainage Plan June 2012 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 12th day of June, 2012

Read a second time this 12th day of June, 2012

Read a third time and finally passed, this 12th day of June, 2012

SIGNED by the Reeve and Chief Administrative Officer this 12 day of June, 2012

SEVERED

Reeve

SEVERED

Chief Administrative Officer

BYLAW 12-13

SCHEDULE 'A'

COUNTY OF VERMILION RIVER

Functional Stormwater Drainage Plan

Northwest Drainage Basin

111-24637-00

Building | Urban Infrastructure | Transportation | Industrial | Power | Environment

GENIVAR

JUNE 2012

GENIVAR

IMPORTANT NOTICE

This report was prepared exclusively for the County of Vermilion River by GENIVAR Inc. The quality of information, conclusions and estimates contained herein is consistent with the level of effort provided by GENIVAR and are based on: i) information available at the time of preparation, ii) data supplied by outside sources, and iii) the assumptions, conditions and qualifications set forth in this report. This report is intended to be used by the County of Vermilion River only, subject to the terms and conditions of its contract with GENIVAR. Any other use of, or reliance on, this report by any third party is at that party's sole risk.

Prepared by :

PROFESSIONAL ENGINEER ALBERTA
PIM VAN DER GIESSEN
LICENSED TO PRACTICE
JUNE 05 2012

Pim van der Giessen, P.Eng., P.E.

Reviewed by:

Mat Langford, M.Eng. P.Eng.

PERMIT TO PRACTICE
GENIVAR Inc.
PERMIT NUMBER: P07641
The Association of Professional Engineers, Geologists and Geophysicists of Alberta

Approved by :

Janis L. Fong, P. Eng.

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GENIVAR

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EXECUTIVE SUMMARY

The County of Vermilion River (the County) has retained GENIVAR Inc. (GENIVAR) to complete a detailed Functional Stormwater Drainage Plan for the Northwest Drainage Basin (the basin) located west of the City of Lloydminster, Alberta. The extents of the drainage basin are defined by the *County of Vermilion River Master Stormwater Management Plan*, produced by Clifton Associates in 2011.

The basin extends from Township Roads 494 to 504 and from Range Road 15 to 75 Avenue covering a total approximate area of 2,679 hectares. The basin is divided into northern and southern sections by Highway 16, which runs west to east through the basin. The land uses within the basin are primarily agricultural in nature but also include the residential subdivision of Deerfoot Estates, the industrial subdivisions of Reinhart, Wist and County Energy Park and the Rolling Greens Golf Course.

The overall goal of the study is to develop a drainage planning strategy throughout the basin that is clearly understood by the public, developers, and the County administration. The strategy goals are to be functional, cost effective, and prioritized based on the rate of development and the availability of funding for stormwater improvements.

This document finalizes the overall study and prioritizes the preliminary planning for drainage channels and improvements throughout the basin. The Functional Stormwater Plan presented herein uses the four concepts developed in the *Master Stormwater Management Plan* as a starting point. In conjunction with other stormwater reports, the functional plan presented by Clifton Associates has been further developed, taking into account site visits completed by GENIVAR personnel, as well as information obtained through the public consultation process with the County and interested stakeholders.

Current issues related to stormwater management within the basin stem largely from the low topographic relief and relative impermeability of the soils in this region. Currently there is a lack of well defined drainage channels and stormwater retention facilities, which lends itself to a situation where there is inefficient shedding of stormwater, which results in intermittent flooding, specifically during spring snow-melt and heavy rainfall events. There are stringent release rate criteria based on agreements in place with the City of Lloydminster. For sites south of the CN Rail, a release rate of 2.5 L/s/ha is acceptable. For sites north of the CN Rail, a release rate of 0.75 L/s/ha is acceptable, based on the Northwest Drainage Ditch License as identified by the *Master Stormwater Management Plan*.

The stormwater concepts were then simulated, using the program PC-SWMM, for scenarios that included the existing conditions only and the existing conditions plus the improvements recommended by GENIVAR. Taking into account policy and implementation constraints, the stormwater infrastructure improvements were prioritized. This information was presented at a second stakeholder meeting, and a final simulation was run incorporating both public and County input.

Additionally, preliminary costs for each conceptual alignment were developed and are summarized in Table I below.

Table I: Summary of Concept and Ditch Alignment Approximate Total Cost

Alignment	Total Cost
North Concept Alignment*	$482,600 or $535,384
North Central Concept Alignment	$416,694
Central Concept Alignment	$255,588
South Concept Alignment	$1,894,781
Northwest Drainage Ditch Alignment	$37,800

**Note: two costs associated with this alignment to reflect two options*

The above cost estimates include modifications to storm culverts and new drainage channels. However, several assumptions were made in deriving these costs which are identified in further detail within this report. It should be noted that these estimates do not include an assessment of the infrastructure condition, age, or land purchase price, and that they impose a generalization of culvert and ditch grading. A 25% engineering and contingency factor is also included in these estimates. However, further analysis is required if an interim solution that does not implement all of the recommended improvements is selected.

The Functional Stormwater Drainage Plan outlines how these concept alignment improvements and maintenance policies will proceed hand in hand with development, and includes information on possible sources of financing, as well as an implementation strategy that can be used for planning budgets for stormwater improvements.

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1. INTRODUCTION

1.1 Background

The County of Vermilion River (the County) has retained GENIVAR Inc. (GENIVAR) to complete a detailed Functional Stormwater Drainage Plan for the Northwest Drainage Basin (the basin) located west of the City of Lloydminster, Alberta. The extents of the drainage basin are defined by the *County of Vermilion River Master Stormwater Management Plan*, produced by Clifton Associates in 2011. The basin extends from Township Road 494 to 504 and from Range Road 15 to 75 Avenue covering a total approximate area of 2,679 hectares. The basin is divided into northern and southern sections by Highway 16, which runs west to east through the basin. The current land uses within the basin are primarily agricultural in nature but include the residential subdivision of Deerfoot Estates and the industrial subdivisions of Reinhart, Wist as well as the County Energy Park, and the Rolling Greens Golf Course. A site plan of the basin is included as Figure 1 in Appendix A.

Current issues related to stormwater management within the basin stem largely from the low topographic relief and relative impermeability of the soils in this region. Currently there is a lack of well defined drainage channels and stormwater retention facilities, which lends itself to a situation where there is inefficient shedding of stormwater. This in turn results in intermittent flooding during spring snow-melt and heavy rainfall events. There are stringent release rate criteria in the basin. For sites south of the CN Rail, a release rate of 2.5 L/s/ha is acceptable. For sites north of the CN Rail, a release rate of 0.75 L/s/ha is acceptable, based on the Northwest Drainage Ditch License as identified by the *Master Stormwater Management Plan*.

There is a drive for additional industrial, commercial and residential development throughout this basin along the western border of the City of Lloydminster. These types of developments are typically less able to accommodate seasonal flooding than bare land or agriculture, and as such it is important that stormwater is managed proactively through the planning and development of the basin. Flooding recognized in recent wet years has contributed to the need to develop a functional plan to manage stormwater within the basin in the future.

1.2 Study Goals

The overall goal of the study is to develop a drainage planning strategy throughout the basin that is clearly understood by the public, developers, and County administration. The strategy goals are to be functional, cost effective, and prioritized based on the rate of development and the availability of funding for stormwater improvements.

This document finalizes the overall study and prioritizes the preliminary planning for drainage channels and improvements throughout the basin. The Functional Stormwater Plan presented herein uses the concept developed in the *County of Vermilion River Master Stormwater Management Plan* (2011) by Clifton Associates as a starting point. In conjunction with other stormwater reports, the concept plan presented by Clifton Associates has been further developed, taking into account site visits completed by GENIVAR personnel, as well as information obtained through the public consultation process with interested stakeholders.

The functional plan is intended to be comprehensive in nature and should provide recommended solutions to improve stormwater conveyance through the basin. A detailed analysis of stormwater routing, and detention/retention using modelling software was conducted. This model simulated existing and proposed conditions based on public and County staff input.

1.3 Methodology

To initiate the project and to familiarize GENIVAR with the basin, all background reports, studies, record drawings, aerial photography and topographic information from the basin were collected and reviewed. Additionally, GENIVAR personnel were accompanied by County staff throughout the drainage basin to identify and photograph identified areas of concern. The assessment of these areas included evaluating soil conditions, evidence of flooding, stormwater infrastructure condition as well as stormwater on vegetation influences. GENIVAR personnel also performed a broader survey of stormwater features throughout the basin.

The 2011 *Master Stormwater Management Plan* consists of a review of multiple drainage basins to identify the existing conditions, but does not provide specific details relating to the resolution of the identified stormwater concerns for each basin. The development of the concept for the Northwest Drainage Basin presented in the Clifton report did utilize a public engagement process. However, this Functional Study has incorporated input from two additional public consultation sessions in order to further refine the concept previously presented. As such, additional stakeholder consultation meetings were held to further identify areas of concern within the basin and to collect information on the attendees' opinions on the previous concept plan. Utilizing the previous concept plan presented in the 2011 *Master Stormwater Management Plan* as a starting point, and incorporating stakeholder input, site assessments and additional analyses, GENIVAR has developed the current functional plan presented herein.

The stormwater concepts presented in this report were simulated utilizing PC-SWMM for a scenario which included the existing conditions only, and for a scenario which incorporated the existing conditions as well as the improvements recommended by GENIVAR. Taking into account policy and implementation constraints the stormwater infrastructure improvements were prioritized. This information was presented at a second stakeholder meeting, and a final simulation which incorporated both public and County input was run.

2. BACKGROUND INFORMATION COLLECTION

The data collection stage for this project provides the basis for the development of the stormwater concept plans as well as for subsequent modelling and analysis of the storm drainage system. The completion of this phase of the project included the review of previous reports, studies and record drawings, two site visits (a field inspection and a topographic survey) as well as two stakeholder consultation meetings.

2.1 Previous Reports and Studies

The development of the Functional Stormwater Drainage Plan for the Northwest Drainage Basin is largely a basin-specific refinement of the broader scale *Master Stormwater Management Plan* that was prepared for the County of Vermilion River. There have been numerous previous studies regarding stormwater management within or relating to this basin that have been reviewed by GENIVAR prior to the development of this study. These previous studies include:

- County of Vermilion River Master Stormwater Management Plan (2011, Clifton Associates Ltd.)
- County of Vermilion River Master Stormwater Management Plan Technical Report (2010, Clifton Associates, Ltd.)
- City of Lloydminster West Lloydminster Drainage Plan (2004, Associated Engineering)
- Land Use Bylaw, Bylaw No. 07-13 (2009, County of Vermilion River)
- Municipal Development Plan, Bylaw No. 07-14 (2009, County of Vermilion River)
- Rural Industrial District Bylaw, Bylaw No. 10-28 (2010, County of Vermilion River)
- Bylaw Respecting the Control and Management of the Surface and Stormwater Management Utility, Bylaw No. 11-16 (2011, County of Vermilion River)
- County of Vermilion River and City of Lloydminster Intermunicipal Development Plan (2008, Matrix Planning, G.T. Hofmann and Associates)
- Final Design of Durness Drainage Improvements (2011, Clifton Associates Ltd.)
- Update to Wist Water Management Plan (2005, Sameng Inc.)
- Proposed Rural-Residential Subdivision Development SW1/4 6-50-01-W4M (1999, AGRA Earth and Environmental Ltd.) (letter)
- Letter Report – Conceptual Drainage Assessment for Proposed Rural-Residential Subdivision Development SW1/4 6-50-01-W4M (1999, AGRA Earth and Environmental Ltd.) (letter)
- County Energy Park (4 plans)
- Northwest Lloydminster Water Management Project Preliminary Engineering Report (2001, Sameng, Inc.)
- Northwest Lloydminster Water Management Project Preliminary Engineering Report (2002, Sameng, Inc.)
- Northwest Lloydminster Water Management Project (2004, Sameng Inc.) (3 plans)
- Big Gully Stormwater Master Plan (2006, Sameng Inc.)
- Blackfoot Devonia Water Management Preliminary Engineering Report (2004, Sameng Inc.)
- Stormwater Management Plan for Proposed Rural Residential Subdivision SE 1/4 24-50-1-W4M (2004, amec)(letter)

- Deerfoot Estates Stormwater Assessment (Sameng, Inc.)
- Grasslands Area Structure Plan (AEGIA, 2006)
- Stormwater Management Plan for Proposed Subdivision SW 19-49 R1 W4M (2006, Sameng Inc.) (letter)
- Reinhart Industrial Park Revised Stormwater Management Plan (2004, Sameng Inc.)
- Blackfoot Subdivision Stormwater Management Plan (2006, Sameng, Inc.)
- Storm Water Management Plan Jack Hill Subdivision (2002, Sameng Inc.)

2.2 Rainfall Characteristics

A key component in stormwater planning is the assessment of the local rainfall characteristics. These characteristics are systematically measured over an extended duration of time at rainfall gauging stations and are then statistically analyzed to determine the intensity, duration and frequency of a particular rainfall event. These rainfalls events are then statistically categorized by anticipated return period. In the Province of Alberta, the Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems indicates that the minor system (underground pipes, etc.) should typically be designed to a accommodate a storm of a 5-year return period. The major system (detention facilities, etc.) are to be sized for a storm of a 100-year return period. Generally for a basin-level study, the 100-year storm event is used as the design control.

Environment Canada maintains numerous climate gauging stations across the country, which are a good indication of the rainfall and snowpack characteristics of a region. For example, the closest station to the Northwest Drainage Basin is located at the Lloydminster airport, adjacent to the northeast side of the basin. This climate station is named LLOYDMINSTER A Climate ID: 3013961. This gauging station has complete hourly measurements with records dating back to April 1, 1982. Based on the normalized measurements at this gauging station, the most significant rainfall in the locale is seen during the month of July, averaging 81 mm over the course of the month for the measurement period. The most significant snowfall occurs in the months of December and January (averaging 16.4 and 17.9 cm respectively).

As part of the *Master Stormwater Management Plan* completed by Clifton Associates Ltd., a comprehensive statistical study was undertaken to average rain-gauge data across a broad range in eastern Alberta and western Saskatchewan in the vicinity of the County. An intensity-duration-frequency diagram for the area was developed and is included as Exhibit 1 below. Exhibit 2 depicts the total amount of rainfall generated by each of these storms in a plot of rainfall depth-duration-frequency (I-D-F).

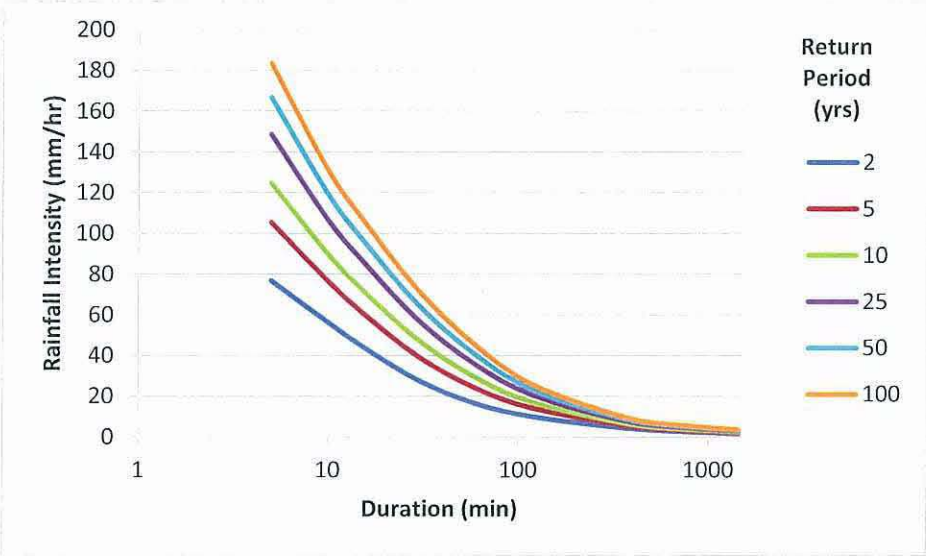


Exhibit 1: Rainfall Intensity-Duration-Frequency for the Northwest Drainage Basin

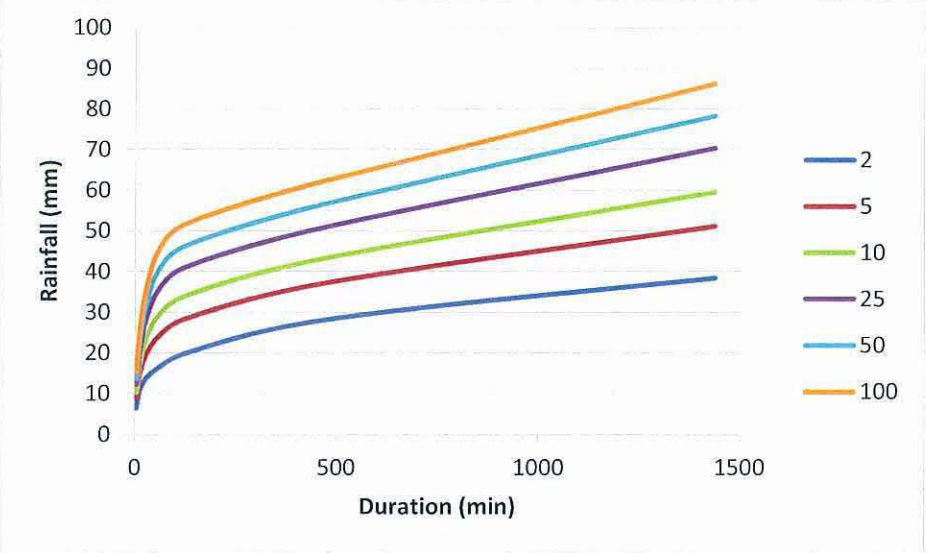


Exhibit 2: Rainfall Depth-Duration-Frequency for the Northwest Drainage Basin

For the return periods that will be evaluated within our study that match the Clifton Associates analysis (5-year and 100-year) the values of rainfall intensity and depth are included as Table 1.

Table 1: Rainfall Depth, Intensity for 5-yr and 100yr Return Periods for Varying Storm Durations

	Duration (min)		5	10	15	30	60	120	360	720	1440
	Duration (hrs)		0.08	0.17	0.25	0.50	1.00	2.00	6.00	12.00	24.00
Return Period	5	Intensity (mm/hr)	105.6	76.8	61.6	39.6	24.1	14.1	5.8	3.4	2.1
		Depth (mm)	8.8	12.8	15.4	19.8	24.1	28.2	35.0	41.1	51.2
	100	Intensity (mm/hr)	183.6	131.4	108.0	72.2	45.2	25.7	9.9	5.7	3.6
		Depth (mm)	15.3	21.9	27.0	36.1	45.2	51.4	59.3	68.4	86.2

2.3 Site Reconnaissance

On November 4, 2011, a team comprising of Jafar Omid, Ph.D., P.Eng. (Geotechnical), Ai Gurung, Ph.D., P.Eng. (Stormwater), and Mat Langford, M.Eng., E.I.T. (Stormwater) from GENIVAR, went to visit the project site to complete a cursory review of its geological and drainage characteristics. Prior to completing the assessment, the team went to the County office in Kitscoty, Alberta and met with Roger Garnett, C.E.T., who showed the group around a portion of the drainage basin. The visit was limited to the northern portion of the project area and also focused on areas near the Northwest Drainage Ditch, which were identified by the County to be the biggest concern in terms of stormwater management. Generally the portion of the basin that was visited was made up of bare-land or agricultural land with the exception of the County Energy Park (industrial), Deerfoot Estates (country residential), the Rolling Greens Golf Course and some commercial/industrial areas adjacent to Highway 16.

First, the team visited County Energy Park. The land in this area was quite flat and the stormwater flows towards the east as the land is sloping eastward. Then the team visited the intersection of the CN Railway and 75 Avenue in the City of Lloydminster, where the outlet of the Northwest Drainage Basin is located. A wetland is located on the north side of the railway (at the NW corner of the intersection of the railway and 75 Avenue) and the stormwater from this wetland flows towards the culvert under the railway, just west of 75 Avenue, which then carries the stormwater southward. Stormwater then flows east through culverts to the outfall located on the east side of 75 Avenue. At this point it joins the City of Lloydminster's stormwater management system which is a large man-made channel directing stormwater eastward. It was observed that the drainage pattern at this location of the site is sloping southward from the north side of the wetland and towards the east from the western portion of the wetland. The area south of the railway drains towards the east and high grasses are prevalent in this area. GENIVAR did not notice any drainage related problems during the site visit, however this area was identified in the *Master Stormwater Management Plan* and by the County as an area of concern. As such, the capacity of the culvert and the underground pipe system were assessed. There was some debris located on the grating of the entrance to the basin's outlet pipe, and the start of an aufeis (culvert icing) formation was observed at this location. It is anticipated that some of the seasonal flooding throughout the basin maybe averted by ensuring that this outlet is free of debris prior to the onset of winter weather conditions. This would help to avoid plugging this major component in the overall drainage system. In the Spring, at the onset of significant melting (mid-late March typically) it is recommended that this inlet as well as the culvert under the railway at this location be checked and de-iced if necessary to allow adequate drainage.

The group also visited sites throughout the northern portion of the drainage basin that were identified by the County to be areas where substantial seasonal flooding or "bottle-necking" of major drainage routes occurs. These included sites that were close to the intersection of the northwest stream course catchment NWSC - 1 and NWSC – 2 (as identified in the *Master Stormwater Management Plan*), and

northwest of the Rolling Green Fairways Golf Course along the main drainage route of the established northwest drainage channel. Other places visited include areas nearby the golf course and Deerfoot Estates, and a country residential subdivision located on NW05-50-01-W4. The drainage system within Deerfoot Estates is located on private property, and drainage easements were not incorporated into the original subdivision design. As such, drainage routes through the subdivision are not well maintained and are generally filled with long grasses and cattails. This reduces the effectiveness of the drainage channels to convey stormwater during heavy rainfall events and may prolong flooding or water retention in the roadside ditches. The County identified that there were some intermittent flooding problems throughout the areas visited. In general, the majority of stormwater issues recognized by the County were limited to the portion of the basin located north of Highway 16.

Based on a geological assessment from the visit, the basin generally has soils of very low permeability which increases stormwater runoff. These soils were identified to be relatively fine grained and are generally fairly silty. The main drainage channel is well vegetated and is supported by long grasses. For the locations seen, there was no indication of erosion issues at the time of the site visit. Though it is not anticipated that the shear stress induced by a storm-driven flow through a channel will exceed the mobilization threshold of silt sized particles, it is important that any new channels constructed for stormwater management in this drainage basin are properly seeded to avoid bed deterioration. Larger culverts that are constructed will likely require armouring (rip-rap or otherwise) to prevent erosion of these fine grain particles.

In addition to the initial site visit, GENIVAR personnel visited the site to do a more comprehensive survey of storm drainage features throughout the drainage basin. GENIVAR completed the survey on December 19 and 20, 2011 and collected information on culvert location, diameter and elevation, the locations and elevations of storm drainage structures (storm ponds, manholes, etc.) as well as drainage channel and roadway cross-sections throughout the basin. Additionally information regarding stormwater management structures within the Reinhart Industrial Subdivision, County Energy Park and on the southern edge of the Wist Industrial Subdivision were identified.

Storm drainage features throughout the site were photographed as part of the site visits. A selection of photographs that were taken throughout the site is included as Appendix B. A legend, identifying the location that each of the photographs was taken is included as Figure 2. Descriptions of each of the photographs are also included in Appendix B.

2.4 Public Consultation

The last component of the data collection and review portion of this study were the public consultation meetings with interested stakeholders.

PUBLIC CONSULTATION MEETING #1

The first meeting was primarily intended as an information gathering forum to allow stakeholders to comment on the previous concept plan presented in the *Master Stormwater Management Plan* and to gather information regarding other potential stormwater concerns.

The public consultation meeting took place on Monday December 5, 2011 from 6:00 - 9:00 pm at the Blackfoot Community Hall in Blackfoot, Alberta (just west of the Northwest Drainage Basin). Advertisement for this public consultation meeting included a newspaper advertisement in the Lloydminster Meridian Booster, a posting on the County website, as well as individual letters addressed to all landowners within and adjacent to the existing drainage basin. A copy of the advertisement and open house invitation letter are included in Appendix C.

The public consultation meeting was facilitated by Pim van der Giessen, P.Eng. and Mathew Langford, M.Eng., P.Eng. from GENIVAR. At the meeting, a short PowerPoint presentation was shown to the attendees introducing the project background, study goals and previous concept plan. Each person in attendance was provided with a survey to complete allowing them to identify any drainage issues that they currently have, or foresee in the future. Additionally, stakeholders were asked to comment on the previous concept plan. Display boards were arranged around the periphery of the room in order to

encourage attendees to circulate to the different areas and interact with GENIVAR / County staff. The display panels included three maps detailing the project area as well as existing and proposed drainage channels from the Clifton Associates concept overlaid on an aerial photograph, existing contours and elevations respectively. Full sized plans detailing the study area were also prepared and pens, pencils, markers and highlighters were provided at each of the tables for attendees to write their comments and suggestions directly on the plans and to discuss their stormwater concerns and ideas with GENIVAR and County personnel. A copy of the presentation, stakeholder surveys, display panels as well as a figure summarizing the input received at this first public meeting is included in Appendix C.

The public consultation meeting was attended by a total of 22 people. A list of the attendees is included in Appendix C. Both County Council and staff members of the County of Vermilion River were present and they actively engaged stakeholders in discussions regarding stormwater management in the Northwest Drainage Basin following the presentation.

One completed survey was received at the public consultation meeting. However, attendees were given the option of submitting their surveys at a later date via email or facsimile. Residents who were unable to attend the meeting were also encouraged to pick a survey up from the County of Vermilion River office following the meeting. Furthermore, many people chose to write their comments directly on the full sized plans as opposed to completing one of the surveys.

Overall, the feedback can be summarized by the following general responses:

- With the relatively rapid development that will be happening within the basin over the next few years, stakeholders understand the importance of functional storm drainage planning.
- There is some concern that stormwater will not be effectively managed by detention facilities as development proceeds.
- The Rolling Greens Golf Course expressed interest in expanding their onsite detention to support their operations. This site is located adjacent to the major northwest drainage channel. Additionally it was expressed that there was a preference to maintain the natural drainage from the east side of the County Energy Park on the north side of the railway.
- The basin boundary defined in the *Master Stormwater Management Plan* needs to be re-evaluated, as there was some dispute to its actual location.
- Changes to the existing drainage channel or culvert sizes were suggested in order to allow additional stormwater runoff to be directed downstream.

PUBLIC CONSULTATION MEETING #2

A second public consultation meeting was held on May 15, 2012 from 6:30 - 9:00 pm at the Blackfoot Community Hall in Blackfoot, Alberta. Advertisement for this public consultation meeting included a newspaper advertisement in the Lloydminster Meridian Booster, a posting on the County website, as well as individual letters addressed to all landowners within and adjacent to the existing drainage basin. A copy of the advertisement and open house invitation letter is included in Appendix C.

The meeting provided the public and County with the results of the model simulation and conclusions as presented in this Functional Drainage Plan. Additional input was gathered to assure that the results were realistic and in touch with actual physical conditions.

Prior to the meeting, the Executive Summary and Recommendations/Conclusions with associated figures were provided to interested stakeholders who were present at the previous stakeholder meeting or who expressed interest during the project.

A presentation summarized the results of the as well as the recommendations and conclusions of the study. The presentation was followed by a question-answer period. After the presentation, GENIVAR and County staff were also available to discuss attendees' concerns on a one on one basis.

The public consultation meeting was facilitated by Pim van der Giessen, P.Eng. and Carolina Correia, M.Eng., E.I.T. from GENIVAR. At the meeting, a short PowerPoint presentation was shown to the attendees introducing the project background, study goals, stormwater model input, and existing with improvements scenarios, proposed drainage plan, and conclusions and recommendations. Display boards were arranged around the periphery of the room in order to encourage attendees to circulate to the different areas and interact with GENIVAR / County staff. The display panels included four maps detailing the project area with Concept alignments by Clifton Associates (Concept A), GENIVAR (Concept B), Conceptual Flood Delineation and the Stakeholder Input Summary from the 1st Stakeholder meeting. Full sized plans detailing the study area were also prepared and pens, pencils, markers and highlighters were provided at each of the tables for attendees to write their comments and suggestions directly on the plans and to discuss their stormwater concerns and ideas with GENIVAR and County personnel. A copy of the presentation, stakeholder surveys, display panels as well as a figure summarizing the input received at this first public meeting is included in Appendix C.

The public consultation meeting was attended by a total of 18 people. A list of the attendees is included in Appendix C. Both County Council and staff members of the County of Vermilion River were present and they actively engaged stakeholders in discussions regarding stormwater management in the Northwest Drainage Basin following the presentation.

No completed surveys were received at the public consultation meeting. However, attendees were given the option of submitting their surveys at a later date via email or facsimile. Residents who were unable to attend the meeting were also encouraged to pick a survey up from the County of Vermilion River office following the meeting. Furthermore, many people chose to write their comments directly on the full sized plans as opposed to completing one of the surveys.

Overall, the feedback can be summarized by the following general responses:

- The proposed conceptual Township Road route runs east to west through the basin about 1 km north of the CN railway. Questions were raised regarding its impact on the stormwater runoff in the study area. GENIVAR responded that the impacts will have to be reviewed with respect to the affected drainage patterns.
- Drainage subarea boundary 2 should be revised as more runoff is directed outside of the NW Drainage Basin limits.
- The berms that were constructed on the Reinhart property adjacent to the County Energy Park will cause stormwater flow to be directed into the County Energy Park.
- Flooding occurs to the property south of the Rolling Greens Golf Course. The limits on the conceptual drainage map reflect flooding impacts.
- A question was raised during the question and answer period if stormwater could be used for fire protection. GENIVAR indicated that stormwater can supplement fire protection but should not be the sole source of fire protection since droughts may cause stormwater in the pond to not be available. An assured water supply will be required that follows fire protection standards and guidelines.
- Several stakeholders stated that the 0.75 L/s/ha criteria for the Northwest Drainage Ditch is very restrictive. GENIVAR responded that the Drainage Ditch license can be revised in a review that would amend the application to Alberta Environment.

3. DESIGN CRITERIA

In order to proceed with a Functional Stormwater Drainage Plan for the Northwest Drainage Basin the following criteria have been developed. The rainfall characteristics identified previously in this report will be utilized as the design basis for stormwater improvements within the Northwest Drainage Basin. The I-D-F parameters outlined in Exhibit 1 will serve as the basis for the rational method described herein.

In developing the basin characteristics GENIVAR utilized a 2011 aerial photograph as well as 2011 topographic information that were provided by the County of Vermilion River.

As identified in the public consultation process, the boundary of the Northwest Drainage Basin required some minor modifications to reflect greater accuracy than in the topographic information that is currently available. As such, some land area was transferred both to and from the adjacent basins in the locations outlined on Figure 3. This figure outlines a total of 5 sections in which there has been modifications made to the basin's boundary.

The reallocation of land area within each of these 5 sections is as outlined herein:

- Section 1 – Reallocation of 37.1 ha of land from the Northwest Drainage Basin to the Blackfoot Drainage Basin.
- Section 2 – Reallocation of 18.13 ha of land from the Northwest Drainage Basin to the Blackfoot Drainage Basin.
- Section 3 - Reallocation of 56.2 ha of land from the Northwest Drainage Basin to the unnamed drainage basin located west of the study area.
- Section 4 - Reallocation of 16.5 ha of land from the Northwest Drainage Basin to the unnamed drainage basin located northeast of the study area.
- Section 5 - Reallocation of 3.2 ha of land from the Northwest Drainage Basin to the unnamed drainage basin located northeast of the study area.

The Northwest Drainage Basin has been further subdivided into a total of 25 smaller sub basins. These basins have been divided based on the 2011 topographic information that was supplied to GENIVAR. Additionally, sub-basins have been developed for each of the existing developments within the drainage basin. The location and extent of each of the sub-basins is depicted on Figure 4. The figure also notes the location of each of the sub-basin outlets, or drainage points, as well as the approximate locations of the high and low points within each sub-basin. The area of each of the sub basins is as outlined in Table 2 below.

Table 2: Sub-Basin Areas within the Northwest Drainage Basin

Sub Basin Name	Area (ha)	Area (km^2)	Sub Basin Name	Area (ha)	Area (km^2)
SUB_BASIN 01	284.45	2.84	SUB_BASIN 14	22.20	0.22
SUB_BASIN 02	85.45	0.85	SUB_BASIN 15	39.03	0.39
SUB_BASIN 03	180.29	1.80	SUB_BASIN 16	181.46	1.81
SUB_BASIN 04	401.21	4.01	SUB_BASIN 17	290.7	2.91
SUB_BASIN 05	93.00	0.93	SUB_BASIN 18	97.94	0.98
SUB_BASIN 06	25.54	0.26	SUB_BASIN 19	93.02	0.93
SUB_BASIN 07	53.80	0.54	SUB_BASIN 20	65.54	0.66
SUB_BASIN 08	11.80	0.12	SUB_BASIN 21	65.86	0.66
SUB_BASIN 09	78.82	0.79	SUB_BASIN 22	155.48	1.55
SUB_BASIN 10	39.99	0.40	SUB_BASIN 23	116.05	1.16
SUB_BASIN 11	30.54	0.31	SUB_BASIN 24	88.37	0.88
SUB_BASIN 12	61.35	0.61	SUB_BASIN 25	133.99	1.34
SUB_BASIN 13	44.40	0.44			

3.1 Development and Land Use

Land use within the Northwest Drainage Basin is one of the key parameters affecting stormwater runoff throughout the basin. As the concept plan and functional drainage plan are designed to guide stormwater management throughout the life of the basin, both the current and future land uses within the basin have been determined herein. The future land uses are as developed per the County of Vermilion River Municipal Development Plan. The current and future land uses throughout the drainage basin are depicted on Figure 5. The definition of each of these land uses, as defined by the Municipal Development Plan, Land Use Bylaw and Intermunicipal Development Plan are as follows:

- M – Industrial Development – The purpose of this District is to allow the development of industries which require large tracts of land and which may not be appropriate to develop within an urban municipality. Permitted uses include: farming, light industry, manufacturing, medium industry, storage, warehousing, as well as buildings and uses that are accessory to permitted uses. For a list of discretionary uses and regulations please refer to the County's *Land Use Bylaw (Bylaw No. 07-13)*.

- B – Business – The purpose of this District is to allow development of extensive land using industrial, warehousing, service, and commercial uses in various locations which have very good accessibility and where the demand for large lots for such uses is increasing. Permitted uses include: agri-tourism, commercial uses, farming, highway maintenance yards, signs, weigh scales and campsites, institutional and public uses, light industry, medium industry, participant recreation facilities, public/quasi public buildings and uses, public utilities, recreational utilities, veterinary services, as well as buildings and uses accessory to permitted uses. For a list of discretionary uses, regulations, and exceptions please reference the County of Vermilion River's *Land Use Bylaw (Bylaw No. 07-13)*.

- B2 – Lloydminster Fringe Business – The purpose of this District is to allow development of extensive land using industrial, warehousing, service, and commercial uses in the vicinity of Highway 16 and very near the City of Lloydminster. For a list of permitted uses, discretionary

uses, regulations and exceptions please reference the County of Vermilion River's *Land Use Bylaw (Bylaw No. 07-13)*.

- CR1 – Country Residential 1, CR2 – Country Residential 2 – The purpose of the CR1 District is to allow for multi-lot country residential development and its permitted uses include Type A one family dwellings as well as buildings and uses accessory to permitted uses. Whereas the purpose of the CR2 District is to allow multi-lot country residential development on large lots where large scale home occupations that would not normally be allowed under the CR1 district may be allowed. For a list of discretionary uses and regulations please reference the County of Vermilion River's *Land Use Bylaw (Bylaw No. 07-13)*.

- A – Agricultural – The purpose of this District is to allow activities associated with primary production and to preserve valuable agricultural land from development that is incompatible with primary production. Permitted uses include: farming, buildings and uses accessory to permitted uses, as well as one family dwellings. For a list of discretionary uses and regulations please reference the County of Vermilion River's *Land Use Bylaw (Bylaw No. 07-13)*.

- A1 – Urban Vicinity Development 1, A2 – Urban Vicinity Development 2 – These districts are defined to be similar to RCI (Rural/Commercial Industrial Area) and the RD (Rural Development Area) in the Intermunicipal *Development Plan*. RCI District areas are intended to provide for the orderly development of rural industrial and compatible commercial uses. Whereas the RD District areas are intended to provide for a wide range of rural uses with on site servicing including, but not limited to continued agricultural uses, recreational uses and compatible country residential uses. For additional information on these Districts please refer to the County of Vermilion River and City of Lloydminster's *Intermunicipal Development Plan*.

- UE – Urban Expansion – The purpose of this District is to protect the immediate vicinity of the City of Lloydminster and the Town of Vermilion and to provide for the orderly and efficient expansion of the City's and the Town's urban uses. The District is located within an area identified in Intermunicipal Development Plans (IDPs) and there may be an Area Structure Plan Bylaw approved to replace this district and regulate development within specific areas. Permitted uses include: bed and breakfast establishments, day homes, farming as well as buildings and uses accessory to permitted uses. For a list of discretionary uses and regulations please reference the County of Vermilion River's *Land Use Bylaw (Bylaw No. 07-13)*.

- MHP – Manufactured Home Park – The purpose of this District is to provide the opportunity for the development of serviced and unserviced mobile homes. Permitted uses include: Type B one family dwellings, recreational uses associated with a manufactured home park, as well as buildings and uses accessory to permitted uses. For a list of discretionary uses and regulations please reference the County of Vermilion River's *Land Use Bylaw (Bylaw No. 07-13)*.

Generally as development proceeds, the portion of the land covered in roadways, parking lots, buildings, etc. increases. This decreases the amount of land that is available for water to permeate into the groundwater table.

The runoff coefficients for the various land uses identified on Figure 5 have been outlined in Table 3 below, as defined in the Functional Concept Plan. The coefficients presented herein are relatively conservative, due to the relatively low permeability of soils in the region. The rational runoff coefficients assigned to each land use and the rainfall data outlined in Section 2.2 were used to determine corresponding Curve Numbers for use in the PC-SWMM modelling. This was done by using the Direct Runoff vs. Rainfall graph shown in Figure C-1, relating direct runoff to rainfall. The calculated Curve Numbers are also shown in Table 3 and were used in the model to calculate runoff using the SWMM Rainfall-runoff algorithm. In the SWMM model, infiltration is calculated using the assigned Curve Numbers for each subcatchment, and effective rainfall intensity is calculated by subtracting the infiltration from the gross rainfall intensity. The effective rainfall intensity, as well as watershed characteristics including flow width, slope and area, are used in the SWMM Rainfall-runoff algorithm to route the rainfall into runoff.

Table 3: Runoff Coefficients based on Land Use

Land Use		Runoff Coefficient	SCS Curve Number
M	Industrial Development	0.75	91
B	Business	0.9	95
B2	Lloydminster Fringe Business	0.75	91
CR1	Country Residential 1	0.35	75
CR2	Country Residential 2	0.35	75
A	Agriculture	0.3	73
A1	Urban Vicinity Development 1	0.55	85
A2	Urban Vicinity Development 2	0.75	91
UE	Urban Expansion	0.8	94
MHP	Manufactured Home Park	0.65	88

3.2 Snow Melt

To analyse and design for the effects of runoff on a storm drainage system, both rainfall and snowmelt may be taken into account.

Total runoff volume from spring snowmelt is typically a high number when compared with total rainfall. However, the peak runoff rate from snowmelt is relatively low in comparison to a rainfall event, as snowmelt occurs over a long period of time. A very extreme condition where a snowpack is subjected to a very rapid extreme melt sequence can occur. However, the return period for such an extreme melt coinciding with an extreme rainfall event is much greater than 100 years.

Rainfall events can coincide with a snowmelt event; however, the winter rainfall events that occur during a snowmelt are typically less than the rainfall events represented by the summer IDF curve. Summer rainfall events generally present a higher peak flow than the combined winter/spring rainfall with spring/summer snowmelt. Typically storm management systems are designed to handle peak flow. For this reason, summer rainfall data was used for the modelling and calculations for this study of the Northwest Drainage Basin. Proposed system upgrades and solutions for a 24-hour duration, 100-year rainfall event, as performed for this study, should improve the volume capacity of the system. These improvements will in turn improve the capacity of the system to convey runoff from snowmelt as well.

4. CONCEPT PLAN SUMMARY

There was a previous concept developed as a part of the *Master Stormwater Management Plan* by Clifton Associates Ltd. This previous concept is presented as Figure 6, and will be referred to as Concept A. Within the Clifton report the concept is split into four branches, outlined as the North Concept, the North Central Concept, the Central Concept and the South Concept. It was also noted that these concepts were developed strictly on the basis of stormwater quantity and the best available topographic information at the time. It was recommended that further site surveys, identification of underground utilities as well as public, developer and regulator input be collected to assist in further developing the concept plans.

Prior to providing the final Functional Stormwater Drainage Plan for the Northwest Drainage Plan, GENIVAR proposed a concept plan that incorporated additional survey and refined topographic mapping as well as public input. Similarly to Concept A, major drainage channels were routed around the perimeter of properties in order to maximize the developable property within the drainage basin. The concept plan development also takes into account the natural drainage location of each of the sub basins defined in this study. The concept plan developed by GENIVAR for this drainage basin is included as Figure 7, and will be referred to as Concept B.

Concept B uses the previous plan, Concept A, as a basis and has been refined for three of the four legs of the concept plan. The North, North Central and Central legs of the concept plan have been modified, and the South Concept remains similar to that previously proposed.

4.1 North Concept

As mentioned in the *Master Stormwater Management Plan* the existing Northwest Drainage Ditch has the capacity to service the northeast portion of the basin as well as the Reinhart industrial development. This development, which currently collects and retains runoff in an onsite stormwater management facility, requires pumping to meet the elevation of the drainage ditch on the east side of the development. If this ditch is regraded a higher efficiency and lower maintenance system could be used to drain this storm pond. Based on the improved topographic information that was available for this study, the North Concept plan has been modified to flow south along Range Road 14 to meet with the North Central Concept Plan. This modification was necessary as the drainage route proposed in Concept A along the southern border of the existing Reinhart industrial development would require substantial and potentially costly construction in order for the water to flow from west to east (which is currently partially uphill). The development of the North Concept drainage ditch would allow for future development of properties in the northwest portion of the basin. The North Concept Plan eventually flows into the existing Northwest Drainage Ditch which flows past the Rolling Green Golf Course. As identified in the stakeholder consultation meeting, expanded storage at this property would greatly benefit the operations of the landowner.

4.2 North Central Concept

The North Central Concept presented in Concept B differs from that previously presented as it incorporates the stormwater runoff generated by the Deerfoot Estates country residential subdivision. In this modified concept, the discharge from Deerfoot Estates will be routed north to meet the previous North Central Concept, combining with the flow generated by the future Grasslands development. Currently the storm drainage from the Deerfoot Estates development flows northeast along the natural drainage channel through Section 5 as shown on the Concept B plan. This existing channel may be maintained or upgraded to provide storm drainage to the Grasslands and the Deerfoot Estates developments. However, channel preservation may impact the development potential of this property, which has a future Business zoning under the County's Municipal Development Plan.

Similarly to the North Concept, the North Central Concept will route water to the existing northwest drainage channel, towards the Rolling Greens Golf Course, which has been identified as a water intensive business and which would benefit from a stormwater management facility with increased capacity.

4.3 Central Concept

The Central Concept developed by GENIVAR has a smaller service region than that presented in Concept A. As the storm runoff generated by the Deerfoot Estates Development has been allocated to the North Central Concept, the Central Concept begins along the west side of the County Energy Park and extends east through the same development. The new Reinhart developments have proposed that runoff be directed through the County Energy Park along Production Avenue. The Central Concept presented in Concept B maintains the natural drainage ditch on the north side of the CN Rail track travelling east to Range Road 13, where it is then routed north towards the Rolling Greens Golf Course. From here, the flow will be directed to meet the developed Northwest Drainage Ditch.

4.4 South Concept

As mentioned in the *Master Stormwater Management Plan* the properties located in the southern portion of the basin (south of Highway 16) require stormwater management in the interim until these areas are taken over by the City of Lloydminster. As the natural topography in this area drains generally north and east, drainage channels have been assigned throughout the area to support this natural drainage. As there are no major natural drainage channels located within this portion of the basin, major drainage routes have been conceptualized to coincide with the alignments of the Range Roads and Township Roads in order to maximize the developable property within this portion of the basin. There are two crossings identified in the concept that routes flow north across Highway 16. The location of these proposed crossings has been confirmed with Alberta Transportation to not be in conflict with the planned future upgrades to this roadway. The Wist industrial subdivision, south of Highway 16 has a piped underground stormwater system in which stormwater is collected in an underground pipe which run west-east along the south side of the lots. This underground system is manually pumped into the aboveground drainage ditches as required. A more efficient and lower maintenance system, such as a minor float-controlled stormwater lift station, could improve the reliability of this system. However, this recommendation has not been considered in the modelling completed for this study.

5. FUNCTIONAL STORMWATER PLAN

Following the approval of the Functional Concept Plan for the Northwest Drainage Basin by the County, GENIVAR undertook a stormwater simulation using the modelling program PC-SWMM. Two conditions were considered in development of the Functional Stormwater Plan.

Existing Condition: This baseline simulation is based on the year 2012 land uses, existing stormwater conveyance infrastructure (such as developed and undeveloped channels), retention/detention facilities, and culverts. The results of this simulation will identify "problem areas" and will be the focus for providing recommendations for the ultimate simulation.

Existing Condition with Improvements: This simulation is based on full build-out conditions when all land uses follow developed maximum projections. No time frame is provided in this scenario as it is uncertain when this area will be fully built. Long range planning for this condition should be considered.

Upon analysis of the model, Figure 10 was developed to identify the drainage Sub-Area, existing points of interest, future points of interest and existing possible retention locations. For the purposes of discussion regarding the proposed alignments, the upstream drainage Sub-Area is defined first and is followed by the downstream contributions from other Sub-Areas.

5.1 Overall Basin Plan

5.1.1 Existing Conditions

Current issues related to stormwater management within the Northwest Drainage Basin within the County of Vermilion River stem largely from the low topographic relief and the relative impermeability of the soils in this region. Currently there is a lack of well defined drainage channels and stormwater retention facilities, which lends itself to a situation where there is inefficient shedding of stormwater which results in intermittent flooding, specifically during spring snow-melt and heavy rainfall events. The Northwest Drainage Basin drains east to a single outlet, where it discharges to the City of Lloydminster's storm drainage system. There is a restriction on the peak flow rate of water that is allowed to be discharged from the County of Vermilion River system into the City's system. It is anticipated that flooding can be effectively managed by providing stormwater retention throughout the basin, and releasing this water to the City at a predetermined rate during both wet and dry weather. Based on contractual requirements with the City of Lloydminster, for sites south of the CN Rail, a release rate of 2.5 L/s/ha is acceptable. Stormwater discharge from sites north of the CN Rail are only allowed a retention release rate (0.75 Litres per second per hectare) based on the Northwest drainage ditch license as identified by the County of Vermilion River *Master Stormwater Management Plan*. This release rate is set on the historical precedence set in previous stormwater reports and informal agreements with the City of Lloydminster, where it was noted that downstream flooding in Lloydminster was occurring as a result of stormwater from the Northwest Drainage Ditch. The existing storm pipe at the outfall point limits flow to 0.75 L/s/ha before it enters north of the CN Rail.

At the time of the area survey in November 2011, a picture inventory of existing channels and culverts was completed. Figure 2 presents the location of this picture inventory. Site Photographs in the Appendix A show the stormwater channel or culvert condition of these locations. A review of these photographs indicated areas where high grasses within the existing channels and culverts exist, implying that they are not well maintained. The County of Vermilion River does not have a routine maintenance program in place.

Culvert and road/railroad cross-sections are necessary for input into the model. An inventory indicating the location, size and material of each culvert in the study area is identified as Figure 8. Existing cross sections are presented in Figure 9. These typical cross sections include an existing local road, existing railroad and existing highway cross section. It should be noted that exceptions do exist within the study area, but in general these cross sections will act as berms that reroute runoff.

Section 2.4 within this Functional Drainage Plan identifies the general results obtained from the Stakeholder Meetings regarding stormwater related issues within the Northwest Drainage Basin. Consideration of their input is included in the PC-SWMM model.

5.2 PC-SWMM Model

5.2.1 Introduction

In order to analyse the existing watershed and the plan for future stormwater system improvements, a hydrologic and hydraulic model for the Northwest Drainage Basin was created using PC-SWMM. This model was adapted to simulate the two scenarios presented in Section 5: Existing Conditions and Existing Conditions with Improvements.

A hydrologic and hydraulic model was developed using PC-SWMM software version 4.4.1037 running EPA SWMM model version 5.0.013 - 5.0.022. PC-SWMM is software used to model dynamic rainfall-runoff simulations. PC-SWMM performs hydrologic and hydraulic analysis of a watershed using rainfall and runoff input data. It incorporates geospatial data from CAD and GIS information to represent the physical characteristics of the watershed.

5.2.2 Model Development

MODEL LAYOUT

Subcatchment boundaries and outlets were assigned in the PC-SWMM model as outlined in Section 3 and displayed in Figure 4. The layout of the drainage network was created by establishing a network of drainage system elements along the major drainage paths including channels, ditches, culverts, and retention storage. Watershed and channel mapping developed during the GENIVAR Functional Stormwater Concept Plan was used to create the model of physical components including subwatershed boundaries, outlets, primary drainage channels and cross-sections. Data from the GENIVAR survey completed on December 19 and 20, 2011 was used to establish the location, size and elevation of culverts, the locations and elevations of retention structures, as well as drainage channels and roadway cross-sections at various locations. Berm elevations (elevation at which flooded water would overtop the surface above a culvert or pipe) were also assigned based on the survey data. The overall network was divided at the CN railway into two sub-networks which converge just before the outfall to the City of Lloydminster. Figure 9 and Figure A2 show the general layout that PC-SWMM model follows for the existing storm drainage system outlined in blue, including locations of junctions (nodes connecting channels, ditches and culverts), noted as "J_"; culverts noted as "CA_"; channels and ditches, noted as "C_"; and existing storage facilities, noted as "SU_".

The layout of the existing conditions with improvements model was determined based on the GENIVAR Functional Stormwater Concept Plan. To create this model, the current existing conditions model was modified to account for new channel alignments and potential locations of new infrastructure. This included assigning new points of interest for the existing conditions with improvements model, prefixed by "N_". The general layout of the PC-SWMM model for the future storm drainage system can be seen in Figure 9 and Figure A2 outlined in red.

RAINFALL DATA

The PC-SWMM model was developed to simulate a theoretical 24 hour duration, 1:100 year rainfall event. A total rainfall depth of 86.2 mm for a 1:100 year storm event was determined in the GENIVAR Functional Stormwater Concept Plan and discussed in Section 2.2. The total rainfall depth was fitted to the Modified Chicago distribution to create a synthetic rainfall input for the model.

HYDROLOGIC COMPONENTS

The SWMM 5 model allows for selection between three different models to determine infiltration of rainfall from the pervious area of the subcatchment: Horton infiltration, Green-Ampt infiltration and SCS Curve Number Infiltration. The infiltration model used for this investigation was the SCS Curve Number method. The curve number method assumes that the total infiltration capacity of a soil can be found from the soil's tabulated curve number. During a rainfall event this capacity is depleted as a function of the cumulative rainfall and remaining capacity. The Curve Numbers were determined based on each existing land use can be found in Table C-1 (Appendix D). Curve numbers for each subcatchment were calculated in the PC-SWMM model utilizing the area weighted average of the various land uses within the subcatchment, as displayed in Figure 5. The resulting curve numbers assigned for each subcatchment can be found in Table C-14 (Appendix D).

Other hydraulic parameters used in the model were adapted from a similar study performed for the City of Lloydminster, prepared by Associated Engineering, and are shown below (*Associated Engineering, 2004, City of Lloydminster West Lloydminster Drainage "2.3- Hydraulic Parameters").*

Surface Depression Storage:

- Impervious Areas = 2mm
- Pervious Areas = 5mm

Manning's "n":

- Impervious areas= 0.014
- Pervious areas=0.250
- Concrete pipes=0.013
- Corrugated steel pipe (culverts)=0.024
- Grassed ditches= 0.04

Percent impervious (Associated Engineering. 2004. City of Lloydminster West Lloydminster Drainage Pan "2- Design Criteria, Table 2.3: Design Values of Imperviousness for the Design of the Future System") and percent zero impervious (Ed Kluitenberg. August 16, 1994. "Wayne County Rogue Program Office (RPO) Memorandum: Determination of Impervious Area and Directly Connected Impervious Area") values for each subcatchment were also determined through calculating the area weighted averages of values for each land use, and are also shown in Table C-1. Percent zero impervious, alternatively known as percent directly connected impervious area (DCIA) includes only the impervious areas that flow directly to a storm sewer, drain, channel or waterway without flowing over any pervious surfaces

Existing GIS surface data was used to determine the natural direction of runoff within each subcatchment and the longest flow paths directed to the subcatchment outlet were identified. Average subcatchment width was then determined in the PC-SWMM model by dividing the area by the flow path length. The assigned values for each subcatchment are also shown in Table C-14.

HYDRAULIC ROUTING

Hydraulic routing is the process of combining all inflows that enter the upstream end of each conduit in a conveyance network and transporting these flows to the downstream end over each period of time. The resulting flows are affected by such factors as conduit storage, backwater, and pipe surcharging. The SWMM 5 model allows three levels of sophistication to solve the flow routing equations used to calculate gradually varied and unsteady flow within the modelled conduits:

- **Steady Flow Routing**: Uniform and Steady Flow Only
- **Kinematic Wave Routing**: Solves Continuity Equation and Simplified Momentum Equation (Slope of Water Surface must be equal to Slope of Channel)

- **Dynamic Wave Routing**: Solves Complete Equations for Continuity, Momentum and Volume

The hydraulic routing method utilized for this investigation was the Dynamic Wave method. This method was chosen as it is the only one of the routing methods which is capable of representing pressurized pipe flow which occurs when the depth of water in an conduit exceeds the obvert of the pipe, exceeding the full-flow manning equation formula. Dynamic Wave routing can also account for channel storage, surcharging, backwater, entrance/exit losses, and flow reversal.

The Dynamic Routing method solves the complete one-dimensional Saint Venant equations of flow for the entire conveyance network. This method can simulate all gradually-varied flow conditions including backwater effects, pressurized flow, reverse flow and flow splitting, as well as surcharged flow and flooding. Since the Dynamic Routing Method couples the solution of water levels at nodes and flow in conduits, it can be applied to a network layout with multiple downstream outlets and loops.

5.2.3 Assumptions and Model Simplifications/Representations

Once all existing data was incorporated into the PC-SWMM model, various assumptions and alterations were made to further represent the study area:

- While it is recognized that the inlet capacity of the culverts is often reduced as a result of clogging from leaves, branches, grit, snow or trash, the model has assumed that all culvert inlets are free of debris. This assumption was made as culvert clogging is typically a maintenance issue and impractical to simulate in a "high level" watershed study. In order to maintain model integrity and more accurate results, a stormwater infrastructure maintenance program for Fall and Spring is recommended.
- The PC-SWMM model flags points in the system where the capacity of existing infrastructure is exceeded (flooding occurs). If flooding occurs, all flow in excess of the system's capacity at that point would be lost from the model and not accounted for downstream. In order to maintain these flows within the model, weirs were used to simulate overtopping of a berm flow over the surface of the road/railway/driveway). This allowed for all runoff to be contained within the system, as would occur in reality.
- Cross-sections of the channel and ditch system at specific points throughout the drainage area were surveyed. This data was used to assign typical cross-sections to large lengths of conduit. This measurement reflects only one point along the channel section, but the shape of the channel cross section varies along the channel lengths and throughout the drainage basin. The assumption of assigning these typical cross-sections to large sections of the channel simplifies the model, and will likely not have a major effect on the results. Upon analysis and utilizing professional judgement, it can be seen that channel cross-sections are not the major restriction to flow in the area.
- The typical cross-sections assigned to channel and ditches in the model were also expanded laterally outside the surveyed area to reflect natural overbank where the depth of flow exceeded the surveyed cross-section. In many locations the channel cross-sections were expanded at 2% on each side for 50 to 100 m. This is a generalization typically used during studies to account for flow and storage in/over lands adjacent to the channel during extreme flow events. Surface elevations throughout the system will vary but this assumption is appropriate for modelling purposes.
- In the existing conditions with improvements model where proposed infrastructure will connect to the system, the existing invert elevations at the connection location (as interpolated by the SWMM model) were assumed. At other points where new infrastructure was added, invert elevations were assigned at 1.5 m below surface elevations interpolated from GIS surface data.

5.2.4 Criteria for Recommended Solutions

In order to reach conclusions regarding the most appropriate stormwater management solutions for the Northwest Drainage Basin, cost, effectiveness, feasibility and appropriate compliance to standards and regulations must be considered. The primary criteria to propose a solution that meets the requirements of the area are regulated discharge limits, as outlined in Section 5.1, are as follows:

- Discharge from County land into the City of Lloydminster storm channel to be limited to a maximum of 2.5 L/s/ha. Areas South of the CN rail will be regulated by this limit.
- Stormwater discharge from sites North of the CN rail is limited to a maximum of 0.75 L/s/ha based on the Northwest Drainage Ditch license and previous stormwater studies.

When considering solutions for improving the current system and planning to account for future development, these regulations should be met. Proposed improvements to the system based on the existing land uses may aim to provide retention to meet these regulations. As further development occurs, it is assumed that these criteria will be met by each landowner for a newly developed site as directed by the Alberta Stormwater Management Guidelines. If storage is proposed to retain runoff and discharge at a the regulated rate and when new developments are implemented meeting the required limitations, the channel system will only need to account for discharge at the regulated limit since all excess runoff will be contained. As such, the 2.5L/s/ha limit at the outlet will be met.

Appropriate solutions will meet the outlined discharge limits, and should also aim to remediate major localized flooding at various locations of interest. Suggested conduit improvements will be suggested to account for flow in the system without overtopping. Implementation criteria must also be considered, such as available space for storage facilities, minimum cover above culverts, and potential to widen or deepen a channel.

The proposed solution will consist of an ultimate improvement scenario, where discharge regulations are met and all improvements to the system are implemented. However, it is recognized that due to the large capital cost to implement all suggested improvements, it is likely that an interim solution will be proposed. Selected combinations of improvements can be modelled and analysed in the future.

5.2.5 PC-SWMM Model Results

ANALYSIS OF EXISTING CONDITIONS

The PC-SWMM analysis of the existing conditions model demonstrated that the present system cannot accommodate runoff from a 1:100 year storm without surcharging and flooding in numerous areas. The analysis demonstrated that various infrastructure located along the major drainage channel does not have the capacity to convey runoff from a 1:100 year storm, causing surcharging behind culverts and in many cases, overtopping of berms and/or roads. As well, the capacity of many ditches and channels was exceeded, indicating flooding, as demonstrated by water levels exceeding the elevation of the ditch/channel banks in various locations.

It was apparent from the SWMM model results that insufficient culvert capacity was the main cause of flooding and surcharging. However, even if all of the culverts in the system were sized to accommodate all runoff and convey it to the outlet, the discharge limit of 2.5 L/s/ha would be exceeded at the outfall to the City of Lloydminster. As shown in Table C-2 (Appendix D), a maximum flow of 14.1 m^3/s at the outfall was calculated using PC-SWMM. According to the discharge limit, however, the maximum discharge from the Northwest Drainage Basin shall be restricted to no greater than 4.2 m^3/s based on a total area of 27,686 ha. This result indicates that even with updates to infrastructure to prevent flooding upstream, there is still a need for stormwater retention within the system to meet the discharge limit to the City of Lloydminster.

DESIGN INFORMATION FOR PROPOSED IMPROVEMENTS

The PC-SWMM analysis provides the appropriate information to quantify and select potential upgrades to the existing system in order to account for runoff from a 1:100 year storm without flooding or overtopping of roadways

The SWMM model can also be used to calculate required storage at an outlet point that accounts for a calculated volume and flow to the storage facility from a specified area, in order for it to be released at a pre-determined rate. The pre-determined release rate can be set to the limits described in Section 5 to calculate the storage required for an area to meet these discharge limits. This information was used to suggest required retention volumes for the existing conditions with improvements scenario.

5.2.6 Proposed Improvements

The proposed improvements for the Northwest Drainage Basin are prioritized to meet the release rates and provide stormwater retention. They provide new conceptual alignment routes, as well as opportunities for retention areas and recommendations for upgrading the size of storm drain rather than modifying existing channelization. The simulation model assumes that all improvements are completed. It should be noted that this is likely impractical as the cost would be prohibitive and growth in the area is not rapid enough to develop the infrastructure to an ultimate build-out scenario in the short term. Careful consideration of upgrades is recommended as the model developed considers the ultimate developed condition. Various hypothetical scenarios can be simulated since the PC-SWMM model is operational and using the model is strongly encouraged to identify the impacts of piecemeal improvements.

In simulating the existing condition for the Northwest Drainage Basin area it was found that in many cases the runoff rate for each subcatchment exceeded either the 0.75 L/s/ha or 2.5 L/s/ha limitation. Maintaining a pre-development versus post-development match will not work based on this criteria. Our recommendation to reduce stormwater impact downstream is to follow a policy that developing properties be restricted to an outlet release rate of either 0.75 L/s/ha for properties that drain toward the Northwest Drainage Ditch or 2.5 L/s/ha for all other properties located within Northwest Drainage Basin. This can be done by providing retention at various locations throughout the drainage basin, which are sized to retain flow and release at a maximum rate to satisfy this limit. Table 4 below provides a summary of results identifying the drainage Sub-Area number, retention release rate, existing stormwater retention provided, and required retention volume based on existing land use. It is noted that runoff from Sub-Area 5 is accounted for in the drainage of sub-area 2.

Table 4: Stormwater Retention Summary

Subcatchment I.D.	Max Allowable Retention Release (L/s/ha)	Max. Allowable Retention Release (L/s)	Retention Provided (cu. meter)	Retention Required (cu. meter)
1	2.5	711.13	0	112,256
2	2.5	445.55	0	115,878
3	2.5	450.73	0	89,332
4	2.5	1038.95	0	130,763
5	2.5	232.52	0	See S2
6	2.5	63.86	0	18,558
7	2.5	134.51	1860*	38,114
8	2.5	29.51	0	5,896
9	0.75	59.11	0	63,982
10	0.75	29.99	0	30,279
11	0.75	22.90	0	23,900
12	2.5	153.39	Dead Storage	27,727
13	0.75	33.34	Dead Storage	22,655
14	0.75	16.69	Dead Storage	18,164
15	0.75	23.14	Dead Storage	23,525
16	0.75	87.52	0	56,428
17	0.75	218.00	0	147,448
18	0.75	73.45	0	160,468
19	0.75	69.77	0	49,033
20	0.75	49.16	Dead Storage	30,452
21	0.75	49.39	Dead Storage	50,052
22	0.75	116.61	0	156,139
23	0.75	87.04	Dead Storage	53,084
24	0.75	66.27	0	50,748
25	0.75	100.49	0	71,369

**Volume retained by northwest pond (Reference: WIST report)*
***Required storage to account for runoff from both S2 and S5*

In some cases, stormwater retention is already provided, however, adequate information was not available at the time of this report to determine the existing holding capacity. As a result, these basins were defined as "Dead Storage" and not included within the simulation model. This is a conservative approach as it assumes more runoff enters the system than if a volume of available storage was assumed. It should be noted that the outlet storage locations are suggested at the outlet of each subcatchment once the new channel alignments have been implemented. The locations were chosen based on ease of modelling and calculation. Further analysis can be performed for fewer, more, or different storage locations. For example, in lieu of constructing a new pond at a drainage Sub-Area outlet, a storage pond slightly downstream of a subcatchment outlet could account for the required

retention volume for that subcatchment. In this case any conduit connecting the outlet and the storage pond may have to be upgraded.

This study shows drainage Sub-Area boundaries that are owned by several landowners. As the Sub-Areas develop and these boundaries are further subdivided, retention volume will be required based on land area and the release rate identified from Table 4 for their associated drainage Sub-Area.

Stormwater ponding and potential flooding generally occurs upstream of culverts as culverts limit the flow through them. The existing channels as simulated in the model for improved conditions were not modified in depth, width or slope since flooding is usually a result of undersized culverts, not channel geometry. Table 5 provides a summary of results identifying the culvert number (as identified in Figure 10), existing size and material type, and proposed improvement. Proposed culverts in new locations are identified with an "N" prefix instead of the "A" prefix with the same information.

Table 5: Stormwater Culvert Modification Summary

Culvert I.D.	Existing Diam. (mm)	Existing Material	Min. Required Diameter of 1 circular culvert (mm)	Proposed Culvert Size with material (mm)
A3	600	CSP	753	3 x 600 CSP
A11	600	CSP	711	3 x 600 CSP
A12	525	CSP	610	3 x 600 CSP
A18	525	CSP	1138	3 x 700 CSP
A19	600	CSP	854	2 x 700 CSP
N2	N/A	N/A	531	1 x 600 CSP
N6	N/A	N/A	1035	3 x 800 CSP
N21	N/A	N/A	768	2 x 600 CSP

The summary result is approximate and additional detailed design will be required to fine tune the upgrades. As noted previously, the results assume that all suggested improvements to the system have been implemented. This is an ultimate condition and the results shown will not be appropriate should only some of the improvements be implemented. Several general assumptions may cause an error to the actual flow condition at each culvert. The field survey conducted is sufficient for a macroscopic study but not for a detailed design based on existing conditions for each particular point of interest.

To help facilitate development, GENIVAR has summarized the conceptual flooding delineation limits for the existing conditions in Figure 12. The purpose of this figure is to show the impacts of stormwater for the peak 100 year, 24-hour storm adjacent to the existing storm channels within the Northwest Drainage Basin. These limits are derived from the outcome of the existing conditions model produced by this Functional Stormwater Drainage Plan and therefore, any assumptions that were made with this model apply to these boundaries. Additional topographic survey will be required to identify the final location of this boundary. For purposes of this study, understanding which sub-basins are impacted will be a helpful tool for those who want to develop within or adjacent to the delineation. Figure 12 also summarizes the discharge release rate permitted for each drainage sub-basin. This figure was used and provided to Stakeholders and the County at the second open house.

Currently, the County of Vermilion River does not have a routine maintenance program in place. GENIVAR would like to propose a maintenance program to keep culvert opening and channels clear of debris and high vegetative growth during the fall and spring. In the fall, the maintenance program should include the following: cutting down grasses in existing channels, remove debris on upstream culvert trash racks, inspect culvert condition, review evidence of excessive bank erosion and mark headwalls or pipe

ends for snow plow operators. In the Spring, an inspection and de-icing of the culverts should be completed as needed.

As the lands within the Northwest Drainage Basin develop and provide modified stormwater infrastructure or follow the stormwater policies identified, a reduction of stormwater flows will occur. GENIVAR suggests that the PC-SWMM model be updated every 2-5 years to reflect the modified conditions. The model will function as a tool to help facilitate development and encourage better use of land.

5.2.7 Criteria for Cost Estimation

In order to determine the approximate costs for the concepts presented, a few assumptions are noted:

- The condition or age of the existing stormwater infrastructure has not been analyzed since a CCTV inspection of each culvert was not conducted. For purposes of this study, an assumption that the stormwater infrastructure was in full working order was assumed.
- No consideration of land purchases was considered with this estimate.
- This Functional Drainage Plan is macroscopic in nature and the design detail for each culvert including the actual length, inverts and road cover are approximate. An average length for road crossings of 8 m and depth of cover from top of road center to pipe obvert of 450 mm was assumed for proposed generation of culvert recommendation.
- A typical cross section for proposed channelization, Figure 11, was used as a general assumption for newly constructed channel dimensions with an approximate length shown.
- The costs for each drainage Sub-Area retention are left to the landowners as a cost to develop their land.
- A 25% engineering and contingency was added to the cost estimate.

5.3 North Concept Alignment

The first concept consists of drainage Sub-Areas of 24 and 25 which drain to Point A14 or Point N2 and combine with the North Central Concept Alignment. Existing and future zoning for Sub-Areas 24 and 25 is Agricultural. The alignment follows the Range Road 14 alignment with drainage swales that convey stormwater runoff southward toward the existing main conveyance channel that ultimately drains eastward toward the Northwest Drainage Basin outlet. A typical suggested channel cross-section is provided as Figure 11. Runoff for areas in excess of a release rate of 0.75 L/s/ha should be contained by retention storage in each Sub-Area to alleviate downstream impacts. The stormwater model simulation reflects retention for both drainage Sub-Areas 24 and 25 with the volume recommend in Table 4.

Drainage Sub-Area 24 is approximately 88.37 hectares of mixed agriculture, and undeveloped forest or land. Stormwater runoff is directed southeasterly toward Range Road 14 and a retention basin at the southeast corner of this section is recommended to contain runoff in excess of the 0.75 L/s/ha. No culvert exists and any overflow will overtop the adjacent road.

Drainage Sub-Area 25 is composed of agriculture and several existing buildings on 133.99 hectares of land. Runoff is directed southwesterly toward Range Road 14 and a retention basin at the southwest corner of this section is recommended to contain excess runoff. No culvert exists and any overflow will overtop the adjacent road.

The North Concept Alignment including the construction of a new channel on the east side along Range Road 14 can end at Point N2 or Point A14. The approximate length of channel to Point N2 is 2,432 meters and is 2,700 meters to Point A14. The end point is dependent on the outcome of development within Drainage Sub-Area 17. An explanation of the combination of the North Concept and North Central Concept are provided with the North Central Alignment section below. The approximate total cost for ditch grading, access crossings, etc., is **$482,600** or **$535,384** for endpoints, Point N2 and A14, respectively. Tables 6 and 7 summarize the cost for each scenario.

Table 6: Cost Summary - North Concept Alignment to Point N2

Description	Unit	Quantity	Unit Rate	Amount
Channel Construction (incl. topsoil stripping, channel excavation, topsoil replacement, hydro seeding)	LS	1	$386,080	$386,080
25% Engineering and Contingency				$95,520
Total Concept Cost				**$482,600**

Table 7: Cost Summary - North Concept Alignment to Point A14

Description	Unit	Quantity	Unit Rate	Amount
Channel Construction (incl. topsoil stripping, channel excavation, topsoil replacement, hydro seeding)	LS	1	$428,307	$428,307
25% Engineering and Contingency				$107,077
Total Concept Cost				**$535,384**

5.4 North Central Concept Alignments

Drainage Sub-Areas 13 and 17 drain to Point A14 or Point N2 and combine with the North Concept Alignment. Existing zoning for these Sub-Areas is Agricultural or Country Residential. Future zoning identifies that these Sub-Areas can develop as additional Country Residential, Business or remain agricultural. There are two alignment scenarios for the North Central Plan which either follows a natural stream course or travels along section lines within Sub-Area 17. Both alternatives ultimately travel toward the existing main conveyance channel that drains eastward toward the Northwest Drainage Basin outlet. The new section line channel cross-section is provided as Figure 11. Runoff for areas in excess of a release rate of 0.75 L/s/ha should be contained in each Sub-Area to alleviate downstream impacts. The stormwater model simulation reflects retention for both drainage Sub-Areas.

Drainage Sub-Area 13 (Deerfoot Estates) is approximately 44.4 hectares of Country Residential One land use including some existing homes and agricultural areas. Based on the zoning bylaw, the agricultural area can be redeveloped as a Country Residential One District. Stormwater runoff is directed easterly along a natural stream course. At Point A15, either the stormwater runoff can be directed along the natural stream course or directed northward along the section line in Drainage Sub-Area 17. For the existing model simulation flow rates in excess of the 0.75 L/s/ha are released downstream of the site. For the agricultural portion that has not been developed, a retention pond can still be constructed to reduce the effects downstream. For purposes of the model, retention for this development was not considered.

Drainage Sub-Area 17 is composed of agriculture, small naturally ponded areas, forested areas and a few buildings on 290.7 hectares of land. Portions of the area can remain agriculture or be developed into business as per the zoning code. Runoff is directed southeasterly toward the natural stream course or Range Road 14. The stream course currently drains into a low area identified as SU10 which is used by a farmer to irrigate nearby lands. The model does not consider this basin to have defined retention but an enlargement of this retention is recommended to reduce the effects of downstream runoff. Also, naturally ponded areas in the northwest portion could be enlarged to provide storage to maintain a 0.75 L/s/ha release rate. The total retention required prior to release for the North Central Concept is identified in Table 4. Two scenarios are identified within this Sub-Area (Grasslands development) which can either direct flow from Point A15 along the natural stream course or divert it along section lines to either Point A14 or N2. When this property is developed in the future, both options should be explored as GENIVAR's simulation took both into account. At Point A14, an existing 525 mm diameter pipe conveys runoff under Range Road 14.

For the future scenario at Point N2, relocation of the North Concept Alignment and North Central Alignment combined concepts was simulated. This scenario was considered if the development in drainage Sub-Area 17 follows the natural stream course as shown, or follows the perimeter along section lines. There is no cost to using the natural stream course, however, development adjacent to it would be inefficient for usable land. From Point N2, a stormwater pipe to cross under the road was considered and the size identified in Table 5. From the outfall point east of the road, the cross section as identified in Figure 11 was considered to connect with the existing Northwest Drainage Ditch. The total approximate cost for fully completing the North Concept Alignment along the natural course is **$0** however there is an estimated cost of **$416,694** if section lines are followed. A breakdown of approximate costs for the Section Line Alignment (approximate length = 2,084 meters) is detailed below in Table 8.

Table 8: Cost Summary - North Central Section Line Concept Alignment

Description	Unit	Quantity	Unit Rate	Amount
Channel Construction (incl. topsoil stripping, channel excavation, topsoil replacement, hydro seeding)	LS	1	$330,835	$330,835
Install 600 mm CSP Culvert (incl. material, delivery and install) at Point N2	LS	1	$2,520	$2,520
25% Engineering and Contingency				$83,339
Total Concept Cost				**$416,694**

Although no cost is associated to the alignment along the natural course, less usable land would be available to develop. A cost for this consideration is not available due to many unknown factors.

5.5 Central Concept Alignment

The third plan consists of drainage Sub-Areas of 9, 10, 11, 14, and 15 which drain to Point A26 and combine with the Northwest Drainage Ditch. The existing development in this area is a mix of industrial, commercial business, agriculture with existing buildings, and road networks. Future zoning will include expansion of business and urban expansion districts. Where development has not occurred, runoff for areas in excess of a release rate of 0.75 L/s/ha should be retained to alleviate downstream impact. The stormwater model simulation reflects retention for undeveloped drainage Sub-Areas. Several opportunities exist to provide retention for existing properties that have not retained stormwater to the maximum release rate.

Drainage Sub-Area 9 is composed of agriculture and several existing buildings on 78.82 hectares of land. A future expectation is that this area will develop into a Business District as it is adjacent to Highway 16. To date, plans are underway to develop portions of this land that do take stormwater retention into account. For purposes of this study, it was assumed that stormwater runoff will be directed northeasterly toward an existing culvert under the CN Rail and a retention basin at the northeast corner of this section will be utilized to contain runoff in excess of the 0.75 L/s/ha. For the simulation, no modification to the pipe under the CN Rail was considered assuming that all other suggested culvert upgrades and retention storage suggestions are implemented.

The current use of drainage Sub-Area 10 is existing industry on approximately 39.99 hectares of land. Some parcels of land are unused but overall, the zoning will remain industrial. Stormwater runoff is directed northeasterly toward an existing stormwater pipe system under the CN Rail. As the northeast corner is undeveloped a retention basin is recommended to contain runoff in excess of the 0.75 L/s/ha. For the existing with improvements simulation, retention of the volume identified in Table 4 before it crosses under the railway was considered.

Drainage Sub-Area 11 is approximately 30.54 hectares of agricultural land that will ultimately be developed as part of the urban expansion district. For purposes of this study, it was assumed that stormwater runoff will be directed northeast to a retention basin located at the northeast corner of this

section to contain runoff in excess of the 0.75 L/s/ha. The retained volume for Sub-Area 11 is provided in Table 4.

Drainage Sub-Area 14 is approximately 22.20 hectares of agricultural land. Future zoning identifies this area as business district. Runoff from drainage Sub-Area 9 is combined with Sub-Area 14 and directed north, ultimately travelling across the road into drainage Sub-Area 15 as shown on Figure 10. A retention basin along the eastern boundary is recommended to contain runoff in excess of the 0.75 L/s/ha. There is no stormwater pipe under Range Road 14 but two culverts are proposed for the future condition to release runoff to Sub-Area 15.

The current use of drainage Sub-Area 15 is existing industry on approximately 39.03 hectares of land. Production Avenue, an east-west road, dissects this Sub-Area into north and south parcels of land with runoff directed easterly along this road to the southeast corner at Point A17. Runoff from Sub-Areas 9 and 14 are also conveyed along the sides of the road. This area appears to be developed to its full extent and matches the future zoning Industry classification. Existing retention within this area was considered but for purposes of the model, it was not accounted for. At Point SU1 where there is undeveloped land a retention basin is recommended to contain runoff in excess of the 0.75 L/s/ha. Table 4 identifies the volume recommended. Additional runoff from a pipe crossing under the CN Rail at this corner, Point A17, conveys flow from drainage Sub-Area 10.

A conveyance channel in the undeveloped land between Points A17 and A26 was simulated in the model with the cross section presented in Figure 10. The alignment of this channel follows on the north side of the CN Rail for 0.5 kilometres until it reaches Range Road 13, where it is then redirected north until it reaches the southwest corner of the Rolling Greens Golf Course. At point A26, conveyance flow combines with the Northwest Drainage Ditch. During the public stakeholder meeting, a recommendation was provided to offer stormwater retention for the Golf Course. Stormwater runoff from upstream flows at Point SU8 can be a source of water to irrigate the Golf Course. The retention volume was considered dead storage within the model simulation as indicated in Table 4.

The Central Concept Alignment construction of approximately 1,288 meter length of channels, stormwater pipe infrastructure improvements and retention within the Rolling Greens Golf Course at Point A26 was simulated to produce an approximate total cost of **$255,588**. Table 9 summarizes the cost:

Table 9: Cost Summary - Central Concept Alignment

Description	Unit	Quantity	Unit Rate	Amount
Channel Construction (incl. topsoil stripping, channel excavation, topsoil replacement, hydro seeding)	LS	1	$204,470	$204,470
25% Engineering and Contingency				$51,118
Total Concept Cost				**$255,588**

5.6 South Concept Alignment

The South Concept Alignment consists of drainage Sub-Areas 1, 2, 3, 4, 5, 6, 7, 8 and 12 which drain in a northeasterly direction toward the Northwest Drainage Basin Outlet at Point A27. The criteria are different for these drainage Sub-Areas than the previous three concept alignments as the permissible drainage rate is 2.5 L/s/ha instead of 0.75 L/s/ha. There is existing industrial and commercial development adjacent to Highway 16 with agricultural lands through the majority of the surrounding drainage tributary area. One section of land south of the Highway is considered to be a Country Residential District. The future land uses that will envelop most of the land include the highway development special district and business districts. For purposes of proposed drainage channels, they will be conveyed along section lines adjacent to roads and follow the cross-section provided as Figure 11. For undeveloped areas, runoff for areas in excess of a release rate of 2.5 L/s/ha should be contained in each Sub-Area to alleviate downstream impacts. The stormwater model simulation reflects retention for

all the drainage sub-areas with volumes recommend in Table 4. As the Sub-Areas will be subdivided in the future, they shall follow the release rate criteria for their respective areas.

Adjacent to Highway 16, drainage Sub-Area 5 contains some commercial development on approximately 93.00 hectares which follows the commercial zoning classification for existing and future development. Stormwater naturally follows an easterly direction toward Range Road 14. For modeling purposes under the future conditions scenario, a retention pond was included at the eastern boundary to reduce downstream impact. The excess runoff drains southward along Range Road 14 toward drainage Sub-Area 2.

Drainage Sub-Area 2 is primarily agricultural and lies on approximately 85.45 hectares land. Future land use will envelop most of the land with business districts with some agriculture. Existing runoff from Sub-Area 5 is assumed to be conveyed through Sub-Area 2. Stormwater runoff is directed east toward Range Road 14 and a retention basin along the east boundary of this section is considered in the simulation to contain runoff in excess of the 2.5 L/s/ha. Discharge from the basin would then combine with that from Sub-Area 5 and would then travel eastward to point N21. For the future model scenario, a proposed drainage channel was considered to convey flow toward point N6.

Drainage Sub-Area 3 is approximately 180.29 hectares of agricultural land with sparse Country Residential within. Future zoning identifies this area as Business and Urban Expansion District with Country Residential remaining in place for a quarter section of land. Stormwater generally flows northeast to Range Road 13 or along the south side of the Wist Industry Park where it is collected and directed eastward. For the interim condition, a retention basin at the northeast corner is recommended (and modelled) to contain runoff in excess of the 2.5 L/s/ha. For the future scenario, an east-west channel was simulated through the approximate middle of the Sub-Area that collects runoff from the south and from Sub-Area 2 and directs stormwater to Point N6. At this point, stormwater from Sub-Area 1 is combined with the flow and is then conveyed northward along channels to Point N21. The existing culvert at point A19 was determined to be undersized to account for runoff, even when discharge is only released at the 2.5 L/s/ha limit. Table 5 identifies the recommended increased size, assuming all other improvements have also been implemented.

Drainage Sub-Area 6 is approximately 25.54 hectares of agricultural land that is zoned as Business District and Urban Expansion. Runoff naturally flows northward to an existing swale along the south boundary of the Wist Industry Park. A retention basin at Point SU6 is recommended to contain runoff in excess of the 2.5 L/s/ha with a volume presented in Table 4.

The Wist Industrial Park which is developed as a business and industrial district is identified as drainage Sub-Area 7 and contains approximately 53.8 hectares of land. It should be noted that a few parcels of land in this sub-basin are undeveloped. Consideration of retention was provided within the Industrial Park with basins draining into an underground storm pipe along the south boundary. As the underground storm pipe is filled, a pump lifts stormwater to the surface that drains eastward. The pumping rate and retention were input parameters into the simulation.

The 284.45 hectares of agricultural lands that make up drainage Sub-Area 1 drain to the north east. Future zoning identifies this area as an Urban Expansion District. A retention basin at the northeast corner is recommended to contain excess runoff.

Drainage Sub-Area 4 is 401.21 hectares of agricultural and forested lands. Future zoning identifies this area as an Urban Expansion District. The east boundary of Sub-Area 4 is 75 Avenue which is effectively a berm which holds back runoff from entering the City of Lloydminster. Stormwater is routed northward toward Highway 16. In combination with the stormwater from drainage Sub-Areas of 1, 2, 3, 5, 6, 7 and 8 it drains to Point A18. The existing 525 mm diameter culvert is insufficiently sized to accommodate the flow rates and hence, an upgrade is recommended. Retention basins are recommended along the north portion of Sub-Area 4 to contain runoff in excess of the 2.5 L/s/ha.

Drainage Sub-Area 8 is located within the City of Lloydminster and is a full developed commercial center on approximately 11.8 hectares of land which is consistent with the existing and future zoning of urban expansion. Future zoning identifies this area as a Business District. Its runoff is directed northward along

Highway 16 and ultimately reaches Point A18. For purposes of the simulation, existing retention for the site was not considered as it is fully developed. A storage volume requirement is listed for this subcatchment but it was not clear if any retention was provided for the site.

Drainage Sub-Area 12 is approximately 61.35 hectares of mixed use agricultural land and commercial development. Future zoning identifies this area as an Urban Expansion District. Routing of a channel along the south side of the CN Rail was considered with crossings that direct runoff south of Highway 16 at Points N21 and A18. The Northwest Drainage Basin ultimate outfall is located here at Point A27 along the east boundary with the City of Lloydminster. Located here are two existing 1200 mm diameter pipes, that convey stormwater from the South Concept Alignment all of which in total should not convey more than the 2.5 L/s/ha maximum allowed under 75 Avenue into a larger conveyance channel downstream to Lloydminster. For the undeveloped portion of Sub-Area 12, retention should be provided and identified in Table 4.

The South Concept Alignment construction of channels (approximately 9,216 meters in length), stormwater pipe infrastructure improvements and retention including the size upgrades to the storm pipe at Point A27 were calculated to produce an approximate total cost of **$1,894,781**. Table 10 provides a breakdown of costs:

Table 10: Cost Summary - South Concept Alignment

Description	Unit	Quantity	Unit Rate	Amount
Channel Construction (incl. topsoil stripping, channel excavation, topsoil replacement, hydro seeding)	LS	1	$1,463,040	$1,463,040
Install 600 mm CSP Culvert (incl. material, delivery and install) at Point N21	LS	1	$5,040	$5,040
Install 2 x 700 mm CSP Culvert (incl. material, delivery and install) at Point A18	LS	1	$27,675	$27,675
Install 700 mm CSP Culvert (incl. material, delivery and install) at Point A19	LS	1	$7,380	$7,380
Install 2 x 800 mm CSP Culvert (incl. material, delivery and install) at Point N6	LS	1	$12,690	$12,690
25% Engineering and Contingency				$378,956
Total Concept Cost				**$1,894,781**

5.7 Northwest Drainage Ditch Alignment

The Northwest Drainage Ditch alignment currently exists and recommendations regrading the ditch were not considered. The existing ditch widths or depths were not modified for the simulation of existing baseline improvements or for the existing condition with improvements scenario. This is because the channel grades are fairly flat. A limit of 0.75 L/s/ha was registered with Alberta Environment and hence all drainage Sub-Areas that convey flow to this ditch should respect this limitation even though the existing condition as simulated shows excess in most cases. During the public participation process, many people identified reoccurring flooding along the ditch banks. Upgrades as a result of retaining upstream flows within Sub-Area parcels of land, providing retention at key locations along the channel or increasing the size of culverts will help alleviate the existing flooding that is occurring along its banks.

Opportunities exist where there is land or demand available to provide stormwater retention along the ditch alignment and they include Points SU4, SU5, SU7, SU8 and SU9. Currently, retention at Points SU4, and SU5 provide a stormwater source for irrigating water for the Rolling Greens Golf Course. The model does not take into account this retention and considers a time when the basins could be full and overflow runs over. This conservative approach was taken as the information was not available. During

the public stakeholder meeting, a recommendation was provided to offer an additional retention source at point SU8 for the Golf Course. Other strategic locations recommended for stormwater retention are identified as Points SU7 and SU9 which would help alleviate flooding downstream.

The Reinhart Industrial Park which is fully developed as an Industrial District is identified as drainage Sub-Area 21 and encompasses approximately 65.86 hectares. Consideration of retention was provided within the Industrial Park with a large retention basin provided within the development. To drain the retention pond, a pump lifts stormwater to the surface at Point A13. As the information was not available at the time, this retention facility was not considered within the model.

The model as simulated has identified that retention is naturally occurring at Point A2 since the culvert is undersized to accept significant stormwater flow upstream from the northern drainage Sub-Areas. This helps in reducing the release rate before it reaches the Northwest Drainage Basin Outlet at Point A27.

Upgrades to provide retention as well as pipe size upgrades as identified in Table 5 would result in an approximate total cost of **$37,800**. Table 11 provides a breakdown of costs:

Table 11: Cost Summary - Northwest Drainage Ditch Alignment

Description	Unit	Quantity	Unit Rate	Amount
Install 2 x 600 mm CSP Culvert (incl. material, delivery and install) at Point A3	LS	1	$7,560	$7,560
Install 2 x 600 mm CSP Culvert (incl. material, delivery and install) at Point A7	LS	1	$7,560	$7,560
Install 2 x 600 mm CSP Culvert (incl. material, delivery and install) at Point A11	LS	1	$7,560	$7,560
Install 2 x 600 mm CSP Culvert (incl. material, delivery and install) at Point A12	LS	1	$7,560	$7,560
25% Engineering and Contingency				$7,560
Total Concept Cost				**$37,800**

6. FINANCING AND IMPLEMENTATION STRATEGY

6.1 Improvement Prioritization

The PC-SWMM input parameters have been identified in Section 5.2.2. GENIVAR has provided the following list of recommended improvements in order of priority:

- Propose a retention policy whereby new development is limited to 0.75 or 2.5 L/s/ha release rate as identified by the applicable drainage Sub-Area in Figure 12. This will reduce downstream effects over time. As it was determined during the existing simulation model of the entire Northwest Drainage basin that most sites contributed to overall flooding, an overall policy should be implemented. This policy is not quantified for cost as it will be a cost incurred by the landowner when they develop the land.
- Propose a routine maintenance program to keep culvert openings and channels clear of debris and high vegetative growth during the fall and spring. The simulation attempts to mimic existing conditions as much as possible; however, if stormwater infrastructure and channels are impeded by these encumbrances, the model results will not be accurate. A seasonal maintenance program has not been quantified for cost.
- Propose a detailed hydrologic review of existing flooding limits along the Northwest Drainage Ditch alignment. The area has been problematic for years and the issue was raised during the first stakeholder meeting. Figure 12 delineates in concept the probable flooding limits for 100 year storm events as generated by the existing simulation model for the Northwest Drainage Basin. This information would be useful for development purposes for setting finished floor elevations for structures adjacent or within this area.
- Propose four concept alignments and Northwest Drainage Ditch Alignment (identified in Figure 7) improvements to reroute stormwater from current conditions. Controlling flow to channelization will allow for maximum allowable future development. Generally, the alignments follow the routes as identified in the Master Stormwater Management Plan with a few minor modifications. The existing alignment route for the Northwest Drainage Ditch alignment was also simulated. The recommended solution assumes all the improvements are implemented and a cost summary is identified below:

Table 12: Summary of Concept and Ditch Alignment Approximate Total Cost

Alignment	Total Cost
North Concept Alignment	$482,600 or $535,384
North Central Concept Alignment	$416,694
Central Concept Alignment	$255,588
South Concept Alignment	$1,894,781
Northwest Drainage Ditch Alignment	$37,800

These costs are based on 2012 estimates only and include modifications to storm culverts and new drainage channels. Several assumptions apply to these costs that are identified in detail within this report. In general, these costs do not include an assessment of the condition or age of the existing infrastructure, or the land purchase price. Additionally, the ditch grading dimensions and culvert size have been generalized and a 25% engineering and contingency factor has been included.

- Due to the flat nature of the existing stormwater channels, it is recommended that the County maintain the channels as is without modifying depth, width or slope. Flooding generally occurs as

a result of insufficient culvert sizes rather than channel geometry. There are no costs associated with this parameter.

- Provide new stormwater retention locations to reduce existing developments excess runoff. As identified in the first stakeholder meeting, the Rolling Greens Golf Course requested a stormwater source for golf course irrigation.
- Update the PC-SWMM stormwater model information as provided with this Functional Stormwater Drainage Plan to reflect modified development conditions approximately every 2-5 years. With the policies or capital improvements in place, a reduction of stormwater flows will occur that will produce additional land for development.
- Propose culvert modifications to increase stormwater flow through pipes and remove retention ponding upstream. These culvert modifications are for the future scenarios when the retention policy has been implemented for all drainage Sub-Areas. The cost is included within the total presented for each alignment.

6.2 Funding Options and Capital Generation

The construction of a stormwater management system to meet the current and future needs of all stakeholders and residents within the County of Vermilion River's Northwest Drainage Basin is a project of significant scope. There is a large amount of storage and channel improvements required for the project to follow the recommendations as identified with this Functional Stormwater Plan and this may translate to large capital costs.

To fund the project, there are various potential sources of government funding available. These include programs such as the Municipal Sustainability Initiative and the Federal Gas Tax Fund. Some select programs that are currently available and that this project may be eligible for are described below. As both Provincial and Federal grant programs are dynamic, it is possible that there will be future announcements regarding new grant programs that this project may be eligible for. Each grant program has specific administrative requirements and budgetary limitations of granting governments directly affect the approval allocation of grant funds. A copy of the Government of Alberta's Municipal Grants Information Booklet for 2011 /12 has been included as Appendix E.

MUNICIPAL SUSTAINABILITY INITIATIVE - CAPITAL PROGRAM (MSI)

The MSI program forms an important part of the Province's commitment to provide long term funding to municipalities to help them improve municipal sustainability and to enable them to meet the demands of growth. Municipalities in Alberta that are eligible to apply for funding under the MSI program include any municipality, Métis settlement and the Townsite of Redwood Meadows Administration Society. Additionally the program allows for projects funded under MSI to be determined by the municipality based on local priorities, as long as they fall within the general criteria set out in the program guidelines.

Each year $50 million of the total allocated MSI is provided in the form of operating funding to municipalities. The operating funding portion of a municipality's allocation includes a base funding amount as well as sustainable investment funding where applicable. The remaining funds in the MSI program are allocated to municipalities for qualifying capital projects. Of the total MSI funding (capital and operating) 48% is allocated based on a per capita basis, 48% is allocated based on education property tax requisitions, and the remaining 4% allocated based on kilometres of local roads. In 2012, municipalities will receive $120,000 in base funding.

Under MSI various storm sewer drainage systems and facilities including storm water ditches and the major relocation of existing storm water ditches, stormwater or waterway flooding containment structures, storm sewer collection lines (includes service lines and catch basins), storm water retention ponds and treatment facilities, as well as outfall storm sewers to the point of discharge or disposal are eligible for funding. Included in the qualifying capital costs that the grant can be used for are engineering and architecture costs, including functional planning, design, and tender preparation and advertising.

Currently, under MSI the total funded amount of each project application must be at least 5% of the municipality's annual MSI capital funding allocation; municipalities are advised of this amount following approval of the provincial budget. If a municipality's annual MSI capital allocation is greater than $20 million, the minimum project threshold is $1 million. However, contributions to qualifying projects carried out by neighbouring municipalities, regional municipally-controlled entities or non-profit organizations as well as eligible costs associated with infrastructure management systems are exempt from this minimum threshold.

FEDERAL GAS TAX FUND (FGTF)

The FGTF is a program that is designated to foster partnerships between the government and municipalities to provide their citizens with safe, sustainable and cost-effective municipal infrastructures. Under this program, financial assistance is provided to municipalities to help fund various types of infrastructure projects that are environmentally sustainable and that work to enhance economic, social, and cultural opportunities and will result in cleaner air, water and/or reduced greenhouse gas emissions.

The FGTF was extended for an additional four years in 2008, which provided an additional $199 million annually to Alberta Municipalities through to fiscal year 2013/14. The grants are provided annually or semi-annually and are subject to the availability of sufficient funds being transferred from the Federal to the Provincial government.

In regards to storm sewer drainage systems and facilities, there are various categories of projects which are eligible for funding under the FGTF. These include storm sewer line replacements or rehabilitations, construction of new storm sewer retention ponds or treatment facilities, the replacement of storm sewer collection lines (includes service lines and catch basins), outfall storm sewers to the point of discharge/disposal and related works as well as the implementation of storm sewer infrastructure management systems. This last category includes the purchase of software and the collection of data, as outlined/defined in the grant's program guidelines. Additionally, storm water projects must be classifiable as separate storm water systems.

Funding is provided to municipalities based on a minimum allocation of $50,000 over the four years of the extended program, and the amount paid in each instalment is based on the 2009 Official Population recorded by Alberta Municipal Affairs. Additionally, it is required that the receiving municipality provide the Provincial government with a Multi-Year Capital Infrastructure plan that substantiates the community's ability to utilize the allocated funds within the program's time period. If the municipality has a large project that requires funding from multiple years, they are able to carry forward the balance of funds not spent in a given year until the end of the program. In order to receive each grant instalment, the municipality must also provide a project profile for each project (preferably before April 1) which contributes to the generation of the current year's Application for Program Acceptance for in the Municipal Grant Management System. Additionally a Statement of Funding and Expenditures for the preceding year should be submitted utilizing the Municipal Grant Management System prior to June 30 of each year.

ALBERTA MUNICIPAL INFRASTRUCTURE PROGRAM (AMIP)

AMIP is available for municipalities who are developing capital municipal infrastructure to maintain or enhance economic, social, cultural and well being while protecting the Alberta Environment. Under this program storm sewer drainage systems and facilities projects such as the implementation of storm sewer infrastructure management systems (including purchasing software and data collection/input), construction of new stormwater ditches and the major relocation of existing stormwater ditches, replacement or rehabilitation of storm sewer collection lines (including service lines and catch basins), the construction of storm sewers, stormwater detention ponds, stormwater treatment facilities, and outfall storm sewers to the point of discharge or disposal as well as other capital projects that are deemed appropriate by Alberta Transportation, are available for funding. It should be noted that the major relocation of existing stormwater ditches does not include routine maintenance or reconditioning of existing ditches.

Grants received under this program will be paid to each eligible municipality in annual increments over the first five years of the program (2005 – 2010), up to their maximum allocation. The municipalities will then have an additional five years in which the project(s) must be completed. There is a minimum allocation of $500,000 over five years for all eligible municipalities excluding summer villages which are subject to a different base allocation. There is no requirement for a municipal finding contribution for projects accepted under this program, however, the municipality will be required to maintain its normalized annual capital expenditure before utilizing the grant funds available. It should also be noted that when a project includes work on a highway that is under provincial jurisdiction a separate agreement with Alberta Transportation for work within the highway right of way is required.

PRAIRIE FARM REHABILITATION ADMINISTRATION (PFRA)

At this time the PFRA does not have any available grants that would apply to this project. However, they do periodically release funding in the form of grants for a wide variety of projects, and it is recommended that the Partners notify the PFRA about this project. The grants released by the PFRA typically have a very short turn around period, and it is advised to make the PFRA aware of this project as they may send notification out to applicable projects as funding becomes available.

GRANT STACKING

Many of the Government of Alberta municipal grant programs allow for "grant stacking opportunities." However, it should be noted that not all programs allow stacking and that certain programs have specific limitations and requirements that must be adhered to. Finally, it is important to note that under some programs that allocate project specific funds, such as the AMWWP, project specific funding should be approved before utilizing funding received under any other programs.

7. CONCLUSIONS

The major current issues related to stormwater management within the Northwest Drainage Basin in the County of Vermilion River stem from the low topographic relief and relative impermeability of the soils in this region. Currently there is a lack of well-defined drainage channels and stormwater retention facilities, which lends itself to a situation where there is inefficient shedding of stormwater and resulting intermittent flooding, specifically during spring snow-melt and heavy rainfall events. The Northwest Drainage Basin discharges to the City of Lloydminster's storm drainage system. There are stringent release rate criteria in the basin. For sites south of the CN Rail, a release rate of 2.5 L/s/ha is acceptable. For sites north of the CN Rail, a release rate of 0.75 L/s/ha is acceptable, based on the Northwest Drainage Ditch License as identified by the *Master Stormwater Management Plan*.

Concept plans that were developed as part of the *Master Stormwater Management Plan* for the County of Vermilion River were revised by GENIVAR based on refined topographic information, public consultation meetings, sub-basin delineation, site visits, a site survey, and detailed stormwater simulation using PC-SWMM software. Figure 13 identifies the concerns raised during the public consultation meeting. Two models were developed that mimicked both the existing conditions and the existing conditions with the recommended improvements installed. It should be noted that in the existing model simulation most existing drainage Sub-Areas exceeded the retention release rates identified above including those that are not developed. Figure 12 identifies the drainage Sub-Areas for the existing condition and maximum allowable release rate. The goal of this Functional Stormwater Drainage Plan is to provide a prioritization of policies or capital improvement options to reduce stormwater flooding. In order of priority, GENIVAR recommends the following:

- Propose a retention policy whereby new development is limited to 0.75 or 2.5 L/s/ha release rate as identified by the applicable drainage Sub-Area in Figure 12. This will reduce downstream effects over time. As it was determined during the existing simulation model of the entire Northwest Drainage basin that most sites contributed to overall flooding, an overall policy should be implemented. This policy is not quantified for cost as it will be a cost incurred by the landowner when they develop the land.

- Propose a routine maintenance program to keep culvert openings and channels clear of debris and high vegetative growth during the fall and spring. The simulation attempts to mimic existing conditions as much as possible; however, if stormwater infrastructure and channels are impeded by these encumbrances, the model results will not be accurate. A seasonal maintenance program has not been quantified for cost.

- Propose a detailed hydrologic review of existing flooding limits along the Northwest Drainage Ditch alignment. The area has been problematic for years and the issue was raised during the first stakeholder meeting. Figure 12 delineates in concept the probable flooding limits for 100 year storm events as generated by the existing simulation model for the Northwest Drainage Basin. This information would be useful for development purposes for setting finished floor elevations for structures adjacent or within this area.

- Propose four concept alignments and Northwest Drainage Ditch Alignment (identified in Figure 7) improvements to reroute stormwater from current conditions. Controlling flow to channelization will allow for maximum allowable future development. Generally, the alignments follow the routes as identified in the Master Stormwater Management Plan with a few minor modifications. The existing alignment route for the Northwest Drainage Ditch alignment was also simulated. The recommended solution assumes all the improvements are implemented and a cost summary is identified below:

Table 13: Summary of Concept and Ditch Alignment Approximate Total Cost

Alignment	Total Cost
North Concept Alignment	$482,600 or $535,384
North Central Concept Alignment	$416,694
Central Concept Alignment	$255,588
South Concept Alignment	$1,894,781
Northwest Drainage Ditch Alignment	$37,800

These costs are based on 2012 estimates only and include modifications to storm culverts and new drainage channels. Several assumptions apply to these costs that are identified in detail within this report. In general, these costs do not include an assessment of the condition or age of the existing infrastructure, or the land purchase price. Additionally, the ditch grading dimensions and culvert size have been generalized and a 25% engineering and contingency factor has been included.

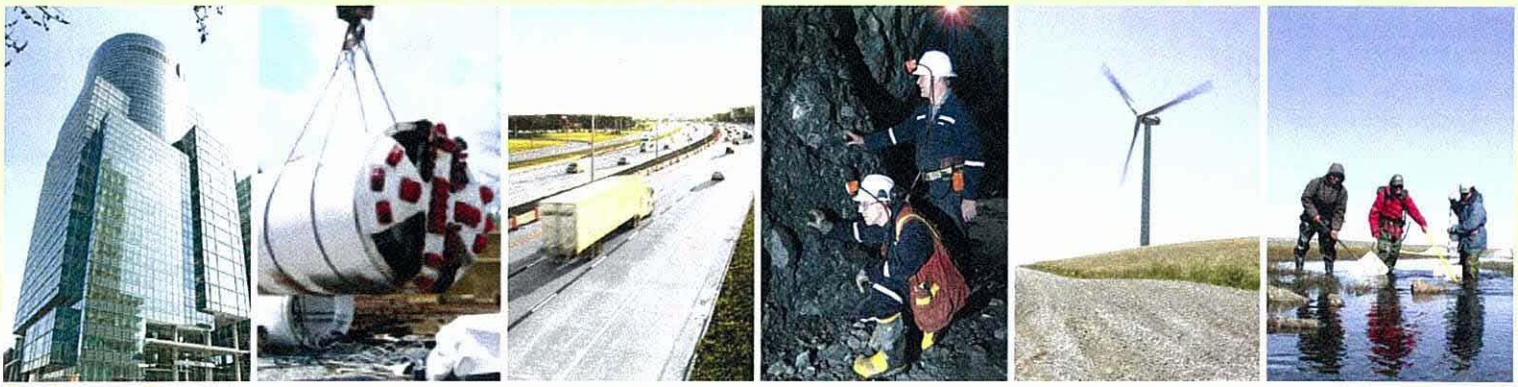
- Due to the flat nature of the existing stormwater channels, it is recommended that the County maintain the channels as is without modifying depth, width or slope. Flooding generally occurs as a result of insufficient culvert sizes rather than channel geometry. There are no costs associated with this parameter.
- Provide new stormwater retention locations to reduce existing developments excess runoff. As identified in the first stakeholder meeting, the Rolling Greens Golf Course requested a stormwater source for golf course irrigation.
- Update the PC-SWMM stormwater model information as provided with this Functional Stormwater Drainage Plan to reflect modified development conditions approximately every 2-5 years. With the policies or capital improvements in place, a reduction of stormwater flows will occur that will produce additional land for development.
- Propose culvert modifications to increase stormwater flow through pipes and remove retention ponding upstream. These culvert modifications are for the future scenarios when the retention policy has been implemented for all drainage Sub-Areas. The cost is included within the total presented for each alignment.

It should be noted that further analysis is required should an interim solution involving less improvements is selected.

The Functional Stormwater Drainage Plan outlines how these improvements and maintenance policies will proceed hand in hand with development, and includes information on possible sources of financing, as well as an implementation strategy that can be used for planning budgets for the stormwater improvements.

8. CLOSURE

This report has been prepared by GENIVAR Inc. based on the best information available at the time for the exclusive use of the County of Vermilion River. Use by third parties, without the express written permission of GENIVAR, is not permitted.



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