MPE Engineering Ltd.

Final Report for:

ROCKY VIEW COUNTY

SPRINGBANK MASTER DRAINAGE PLAN

Date: April 26, 2016
Project #: 2285-057-00

Proud of Our Past… Building the Future

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April 26, 2016

Attention: **Rick Wiljamaa**
Engineering Services Manager Infrastructure & Operations

Dear Rick:

Re: Rocky View County – Springbank Master Drainage Plan
Final Draft Report

MPE Engineering Ltd. herein submits the Springbank Master Drainage Plan Final Report as requested by Rocky View County.

This report contains our findings and recommendations in regards to stormwater servicing for future development areas in Springbank. This plan also provides prospective developers additional requirements and considerations for managing stormwater runoff within the Springbank Region.

Yours truly,

MPE ENGINEERING LTD.

David Seeliger, P.Eng.
Project Manager

DS/sb
Enclosure

CORPORATE AUTHORIZATION

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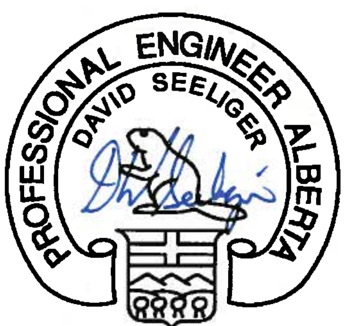

April 26, 2016

David Seeliger, P.Eng.

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The Association of Professional Engineers and Geoscientists of Alberta

Professional Seal

Corporate Permit

EXECUTIVE SUMMARY

The purpose of a Master Drainage Plan (MDP) is to recommend requirements to manage stormwater runoff from future development growth and to identify works to address existing drainage issues within the study area. This includes identifying potential constraints to development and providing guidelines to developers and the municipality to decrease the likelihood of flooding and damage to infrastructure and streams due to the increase in runoff from development.

Rocky View County (RVC), in association with the local community, completed the *Central Springbank Area Structure Plan* in 2001, which set the overall framework for future development in the region. In 2004, Westhoff Engineering Ltd. finalized their *Report of Drainage Strategies for Springbank*, which provided an overview of stormwater management strategies for the region. MPE Engineering Ltd. (MPE) has been retained to update the MDP to provide RVC with a basis for sustainable and organized growth within the Springbank study area. This MDP provides policy and implementation strategies to ensure the responsible and sustainable development of future growth.

The study area for the MDP is bounded by the Bow River to the north and the Elbow River to the south, the City of Calgary to the east and Range Road 34 and 40 to the west. Several catchments have been delineated, with four flowing north to the Bow River and five flowing south towards the Elbow River. Both the Elbow and Bow Rivers are important water courses supporting many uses, including irrigation for crops and golf courses, stock watering, terrestrial wildlife, native flora and aquatic ecosystems, resource extraction, recreational activities as well as one of the most significant: raw water supply for the City of Calgary via the Glenmore Reservoir and Rocky View County and the City of Cagary via the Bearspaw reservoir. The protection of these two important natural resources is imperative for the sustainable growth and development of not only Springbank, but all downstream municipalities.

Development within Springbank has generally been speckled throughout the region and has been slowly growing westward toward Highway 22, or Cowboy Trail. The region has been developed by quarter section with country residential acreages, ranging from 0.8 to 1.6 hectares each (two to four acres). Stormwater infrastructure development in the area has mainly consisted of rural stormwater management strategies such as road ditches, culverts, grassed swales and stormwater ponds.

The Springbank area continues to be a point of major development interest which is expected to be under continued infrastructure pressure as large scale developments consider establishing in the area. Practical and cost-effective solutions to enable the orderly planning and construction of stormwater infrastructure is necessary for responsible growth in the region. Future development in Springbank will remain as mainly country residential acreages, with some commercial and industrial development along the Highway 1 corridor. The new lake community called Harmony is currently being constructed northwest of the study area and will be comprised of higher density single family residential lots along with multi-family residential, mixed-use, and commercial development adjacent to Springbank Airport and the golf course. Another multi-land use community, Bingham Crossing, has also been approved for development by RVC. This development is in very close proximity to the TransCanada Highway and, among many other residential and commercial adventures, is intended to satisfy a long time need for seniors' housing in Springbank.

Development of stormwater management systems for subdivisions in Springbank in the last ten years has been guided by the Westhoff Engineering Ltd. *Report on Drainage Strategies for Springbank*, 2004, which provided a broader perspective on stormwater policy in Springbank, and recommended the following:

- Unit Area Release Rates (UARRs) were estimated for different return periods by using frequency analysis methods for different catchments in Springbank. A UARR of 1.71 L/s/ha was recommended for a 1:100 year design storm event.
- Flow monitoring was also recommended at strategic locations due to limited data producing a degree of uncertainty.
- Conservation easements should be put in place along all existing drainage courses. BMPs should be included in RVC's *Servicing Standards*.

RVC wishes to expand on the 2004 report to create an overall MDP. The following outlines various principles and/or conditions that have changed since 2004:

- Significant development has occurred in Springbank.
- Various engineering and planning documents have been submitted on previous and proposed developments. This includes various SWMPs submitted as a part of conceptual schemes. *The Springbank Context Study* (MPE, 2013) also identifies that some conceptual schemes do not include a SWMP.

- Numerous problem areas related to stormwater drainage and conveyance have been identified by RVC.
- Recent standards and guidelines suggest that stormwater modelling should analyze the following principles:
    - *RVC Current Standards*: Standards related to meeting pre-development discharges where downstream conveyance right-of-ways (ROWs) have not been secured.
    - *Volume Controls*: Numerous municipalities are establishing volume control targets. Recently, volume control targets for land development have been established to reduce erosion and riparian degradation of streams. These aim to control post-development runoff volumes to closely mimic pre-development conditions. Volume controls are also used to improve water quality of stormwater discharges into our streams and rivers.
    - *Emerging Low Impact Development (LID) Techniques*: Techniques such as rain gardens, thicker topsoil and water re-use are being adapted for widespread use in Alberta.
    - *Continuous Simulation Modelling*: The majority of the currently approved SWMPs use the hydrological model SWMHYMO exclusively to calculate the required stormwater pond storage volumes. Continuous modelling such as XPSWMM or PCSWMM should also be completed to determine peak flows to confirm required stormwater pond active storage volumes.

The MDP provides overall direction for development within the study area. Stormwater Catchment Drainage Plans (CDPs) are recommended to determine works and infrastructure upgrades and improvements for each local catchment area within the MDP. These would be prepared by RVC in accordance with this MDP. The CDPs will also include plans to reduce erosion and sedimentation potential by adopting sensitive grading and minimal ground disturbance.

Stormwater Management Policies for Springbank

All proposed development and redevelopment shall prepare a Stormwater Management Plan which addresses the following:

1. All new development should be restricted from building within the 1:100 year floodplain such as the Bow or Elbow Rivers and their local tributaries.

2. New residences to be built on serviced and developed subdivision lots should be built above the 1:100 year flood elevations within proximity to stormwater ponds and defined drainage routes, i.e. the lowest building opening should be at least 0.3 m higher than the 1:100 year flood elevation or safe overland spill elevations.
3. Stormwater management BMPs, LID practices and wet ponds/constructed wetlands are to be adequately sized to restrict discharges to meet the maximum 1 in 100 year flow rate of 1.71 L/s/ha or lower where downstream constraints exist.
4. A volume control target of 45 mm or lower to meet the Stream Erosion Index less than 2 will be required for all major developments that releases into or passes through a natural stream.
5. Discharges from proposed major developments shall demonstrate that the Stream Erosion Index is 2 or lower, using the SEI calculator provided by the County.
6. The flow discharging from the development shall not exceed 10% more than the flow threshold where the pre-development flow intersects the flow threshold line on a flow duration curve.
7. Stormwater management requirements for minor developments has been reduced due to the minimal impacts these developments have on the receiving stream and the practicalities of proving effective infrastructure to meet the more stringent requirements and associated planning efforts expected for major developments.
8. YYC precipitation data shall be increased by 11 percent when undertaking water balance modelling using approved models WBSCC and PCSWMM.
9. Provide downstream ROW until an adequate outlet is provided. An adequate outlet includes a drainage path with a defined channel to a point where there are no measurable downstream impacts.
10. LID practices and stormwater management practices should be adequately sized. The potential influence on groundwater mounding and base flow discharges to downstream facilities or natural wetlands should be adequately investigated.
11. Stormwater re-use co-ops should be considered for developments occurring in proximity to each other, as opposed to lot-based reuse systems. Irrigation systems could be beneficial for multiple lots and even multiple developers.

Integration of LID Practices

The most applicable LID practices for Springbank are:

1. The use of absorbent landscaping to help decrease runoff and recharge aquifers.
2. Rainwater harvesting to use on lawns to help reduce peak flow runoff and increase infiltration.
3. The use of grassed swale and bio swales for flow conveyance.
4. Bioretention areas to provide water quality treatment, decrease peak flows and encourage groundwater infiltration.

Management of Natural Wetlands

Natural wetlands that are to be retained within the development areas should be managed by:

1. Being integrated into the development water balance in a manner to maintain the wetlands pre-development hydrological regime, including volume and hydro period.
2. Directing adequately treated stormwater runoff to maintain retained wetlands and using these facilities for a component of detention storage only during significant flood events such as a 1 in 100 year event or in emergency situations subject to the approval of the approving authority.

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1.0 INTRODUCTION

1.1 Overview

Springbank within Rocky View County (RVC or the County) is a semi-rural area that is developing mainly into country residential acreage developments, with higher density residential and industrial land development being proposed with increasing frequency. The 11,273 ha study area is illustrated on ***Figure 1.1***, and is generally bounded by the Bow River to the north, Elbow River to the south, the City of Calgary to the east and Range Road 34 and 40 to the west.

A report titled, '*A Report on Drainage Strategies for Springbank*' (Westhoff, 2004) has been serving as the Master Drainage Plan (MDP) for new development for Springbank. Increasing land development and past stormwater management practices have led to the creation of numerous local and regional stormwater drainage issues. *The Springbank Context Study* (MPE, 2013) identified the need to resolve existing drainage issues and to update policies for the area. The County retained MPE Engineering Ltd. (MPE) to develop the updated MDP which provides additional policies and guidance for future development within existing development and the environmental constraints.

1.2 Study Scope

The major tasks included in this project were as follows:

- Review all existing local and regional stormwater management reports and conceptual schemes that have been completed for area developments.
- Environmental assessment of wetlands and riparian areas.
- Inspect and identify the condition and maintenance needs of the culvert crossings of major drainage routes.
- Develop a base map identifying existing drainage infrastructure (storm ponds, storm sewers, drainage ditches and major culverts) and drainage corridors.
- Identify and evaluate the main drainage routes in Springbank for constraints such as channel capacity, culvert capacity and potential flooding issues.
- Evaluate the stormwater "hot spots" from the *Springbank Context Study* for causes and prioritize the solutions.

- Hydraulic modelling to size infrastructure requirements related to flood management, water quality improvements and water reuse.
- Identify proposed storage locations, drainage path alignments and typical cross-sections to facilitate safe passage of the design storm event.
- Develop general policies related to stormwater management for a typical development.
- Establish a framework for developing catchment drainage plans (CDPs) for individual catchments within the study area. The CDP should outline mitigation measures for drainage issues and drainage infrastructure requirements for future development.

1.3 Objective

The objective of the overall Master Drainage Plan is to provide a review of the issues, opportunities and constraints within the study area, and develop policy recommendations for existing and future development. Catchment Drainage Studies are recommended for the individual or groups of catchments that are contained within the MDP study area. These catchment drainage studies will identify the existing drainage constraints, and determine infrastructure improvements, and associated costs to resolve existing drainage constraints. The plan will also identify potential stormwater management facilities, and conveyance routes for servicing land to be developed. Acreage assessments or improvement taxes may also be developed where regional infrastructure is proposed. Ultimately, this will provide RVC with a comprehensive group of documents for the purpose of planning the future growth of Springbank with respect to the stormwater management.

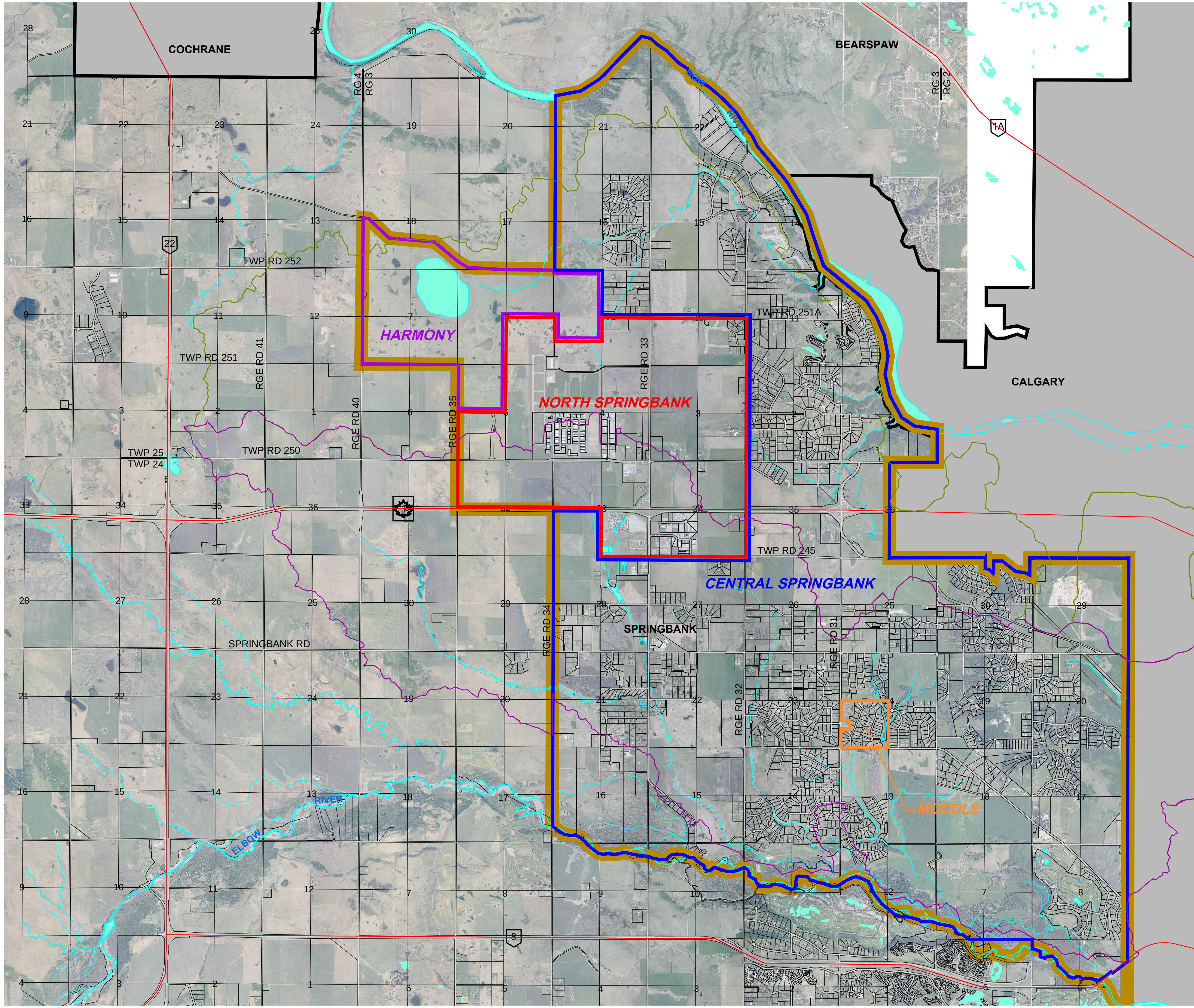
In general, the MDP aims to aid the County in meeting the following objectives:

- Implementation of new stormwater policies and practices, such as development volume controls to minimize impacts from development.
- Establish improved, consistent stormwater policy for the Springbank area.
- Identify new and emerging stormwater policies and practices to mitigate impacts to County infrastructure, existing watercourses, wetlands and downstream rivers.

1.4 Previous Studies and Planning Documents

The following documents provide an overview of planning framework and physical, environmental and natural characteristics of the Springbank region with further details given in Section 3:

- *Central Springbank Area Structure Plan*, M.D. of Rocky View No. 44, adopted October 2, 2001. This ASP is a key planning document used to establish a land use planning framework, development strategy for transportation and utilities.
- *Central Springbank Area Structure Plan – Sub Basin Study*, prepared by Westhoff Engineering Ltd. for M.D. of Rocky View No. 44, March 2000. This study involved assessing the area from the standpoint of water quantity, water quality, stormwater management plans and features, and biophysical properties.
- *North Springbank Area Structure Plan*, M.D. Rocky View No. 44, adopted May 4, 1999. This ASP establishes consistent planning principles and directions for a specified area of the Springbank municipality. This planning document guides proposals for subdivision and development by establishing a framework of land use and development policies to guide and manage development in the vicinity of the Springbank Airport.
- *Elbow River Basin Water Management Plan*, prepared by Elbow River Watershed Partnership, revised January 16, 2009 (M.D of Rocky View No. 44 Council endorsed January 13, 2009). This is a guidance document and planning tool pertaining to water management plan objectives, outcomes, physical characteristics of the Elbow River watershed, measurable impacts on water quality and recommendations for implementation.
- *Report on Drainage Strategies for Springbank*, Westhoff Engineering Ltd., 2004. The objective of this study was to define stormwater management goals and constraints. Also, the study is to formulate solutions and management strategies, and describe appropriate best management practices (BMPs) and their implementation.
- *Bow River Watershed Management Plan,* Bow River Basin Council, 2008. This contains reach-specific water quality objectives, targets, warning levels and baseline water quality data, and serves as a decision support tool.
- *Bow River Phosphorus Management Plan,* AEP, 2014. This is a strategic plan to address sources of phosphorus in the middle reach of the Bow River between Bearspaw and Bassano Dams. The contributing parties worked to define the issue, establish goals, and recommend strategies and actions to manage phosphorus in the Bow River.

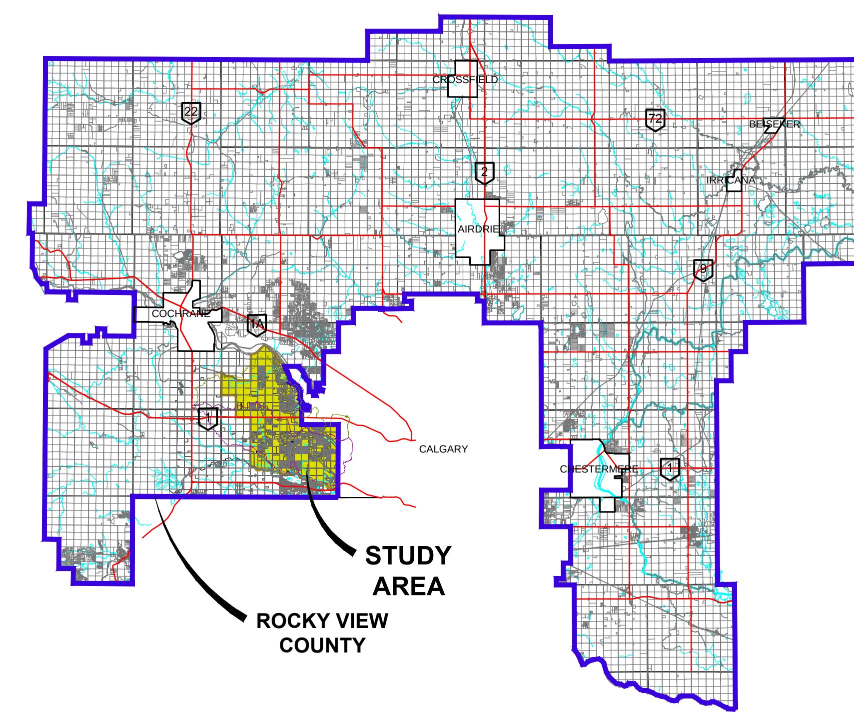


Area Name	Area (ha)	Area (acres)	Approximate Elevation Range (m)
Central Springbank ASP	8903	22 000	1088 - 1284
Harmony CS	708	1749	1182 - 1194
North Springbank ASP	1598	3948	1180 - 1212
Moddle ASP	64	152	1158 - 1180
Total	**11 273**	**27 849**	**1088-1284**
ASP = Area Structure Plan			
CS = Conceptual Scheme			

NOTES:

1. BASE MAPPING FROM ROCKY VIEW COUNTY (JANUARY 2013).

LOCATION PLAN



LEGEND:

- CENTRAL SPRINGBANK AREA STRUCTURE PLAN
- NORTH SPRINGBANK AREA STRUCTURE PLAN
- MODDLE AREA STRUCTURE PLAN
- HARMONY CONCEPTUAL SCHEME
- CATCHMENT TO ELBOW RIVER
- CATCHMENT TO BOW RIVER
- STUDY AREA

ROCKY VIEW COUNTY
Cultivating Communities

MPE Engineering Ltd.

SPRINGBANK MASTER DRAINAGE PLAN
STUDY AREA

DATE: APRIL 2016 | SCALE: 1:75 000
JOB: 2285-057-00 | FIGURE: 1.1

2.0 CONCEPTUAL FRAMEWORK AND GUIDING DOCUMENTS

2.1 Development Design Standards

Development in Springbank mainly consists of country residential subdivisions that have been built-out one quarter section at a time by different developers. As such, the *2013 Springbank Context Study* has identified inconsistencies between design standards for the Conceptual Schemes submitted to RVC Council for approval. One of the objectives of this report is to develop stormwater policies to which all new development must comply.

The proposed updated 2016 ASP will define future development types, which may or may not reflect the typical land uses as in the past. Compared to the already approved Conceptual Schemes, future approved Conceptual Schemes may consist of higher density developments.

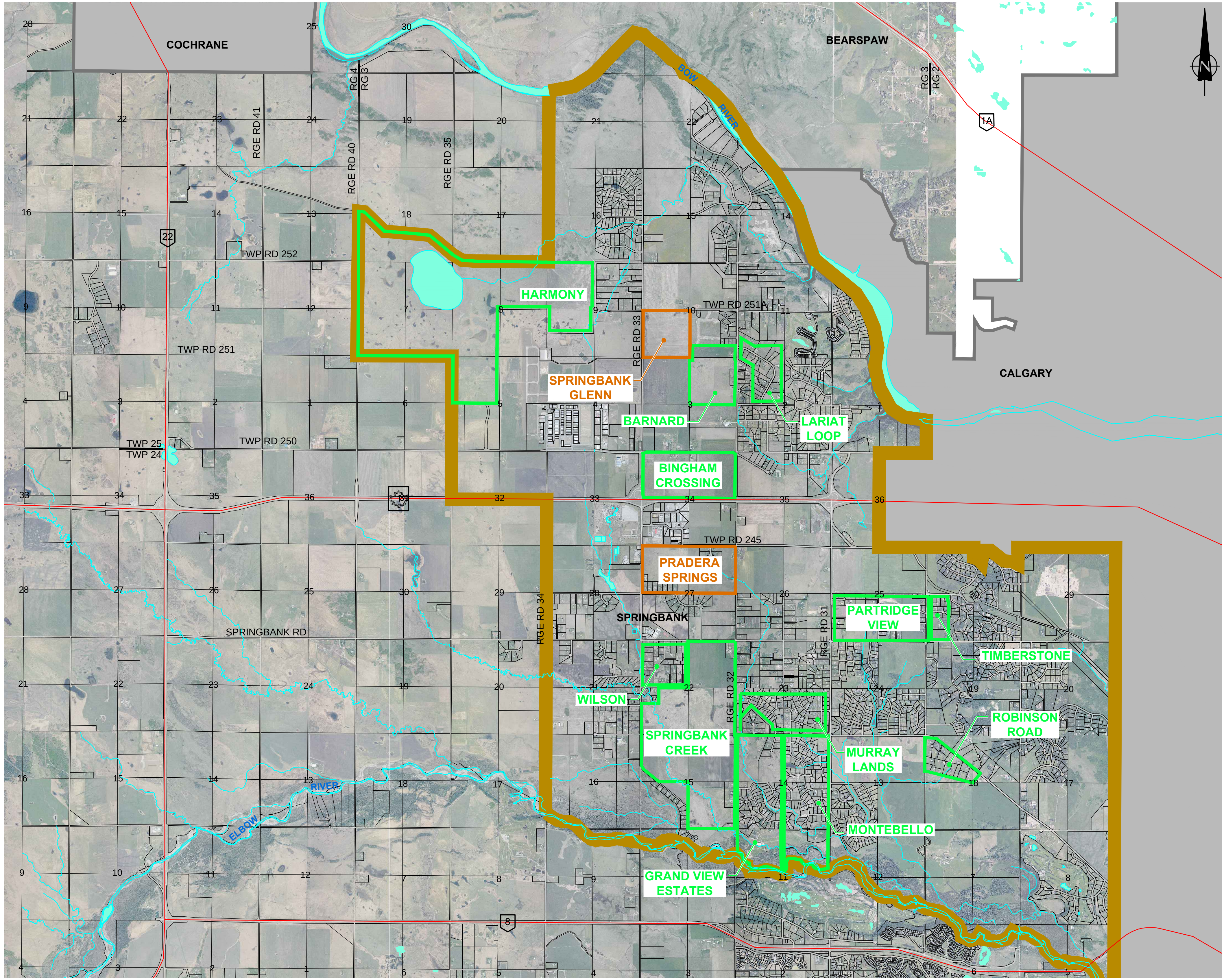
For the purpose of this report, future development in Springbank accommodates a range of land use types and provides policies that will minimize adverse impacts to the receiving stream.

2.1.1 Existing and Proposed Stormwater Management Systems

There are a number of existing developments with stormwater management facilities in Springbank. Existing major developments with stormwater management facilities consisting of one or more stormwater ponds are:

- Grand View Estates
- Windhorse Manor Estates
- Sterling Springs
- Morning Vistas
- Swift Creek
- Other country residential developments with or without conceptual schemes

The locations of these developments are depicted on ***Figure 2.1***. It appears they have been developed around the same time and have similar stormwater management plans in place, consisting of overland drainage leading to a series of stormwater wet ponds. The stormwater ponds were designed for a release rate of 1.71 L/s/ha, adhering to the Westhoff (2004) recommendation.



Conceptual Scheme	Area (ha)	Area (acres)	Approximate Elevation (m)
Barnard CS	81	199	1195
Bingham Crossing CS	120	296	1200
Grand View Estates CS	185	457	1150
Harmony CS	708	1749	1190
Lariat Loop CS	75	185	1175
Montebello CS	188	464	1150
Murray Lands CS	117	276	1170
Partridge View CS	129	320	1200
Robinson Road CS	34	84	1200
Springbank Creek CS	376	928	1150
Timberstone CS	32	80	1230
Wilson CS	65	160	1170
Total	**2110**	**5198**	N/A

NOTES:

1. BASE MAPPING FROM ROCKY VIEW COUNTY (JANUARY 2013).

LEGEND:

- PROPOSED CONCEPTUAL SCHEME
- ADOPTED CONCEPTUAL SCHEME
- STUDY AREA

ROCKY VIEW COUNTY
Cultivating Communities

MPE Engineering Ltd.

SPRINGBANK MASTER DRAINAGE PLAN
CONCEPTUAL SCHEMES

DATE: APRIL 2016	SCALE: 1:75 000
JOB: 2285-057-00	FIGURE: 2.1

2.2 Alberta Environment and Parks Approvals

Alberta Environment and Parks (AEP) approvals are required for all new stormwater management systems to be built in Alberta. Stormwater management is regulated provincially under both the *Environmental Protection and Enhancement Act* and the *Water Act* and federally by the *Navigable Waters Protection Act*, *Fisheries Act*, and the *Canadian Environmental Assessment Act*. The developer is responsible to ensure that all designs and approvals are done in accordance with applicable regulatory agency guidelines. Any new outfall to an existing water body or drainage course also requires approval under the *Water Act*. All new development within the catchment would be expected to adhere to policies in place for the protection of these natural water bodies and reduction of downstream impacts.

Any future stormwater management facilities such as stormwater ponds and constructed wetlands and underground culvert outfalls within the study area would need to be authorized and regulated by AEP under the *Water Act* and *Environmental Protection and Enhancement Act* (EPEA). Prior consultation with AEP is required for future subdivision proposals within the study area if any storm outfalls, stormwater management ponds or stormwater treatment system are to be constructed.

Furthermore, Alberta's *Water Act* requires that an approval be obtained before undertaking a construction activity in a wetland.

2.2.1 Springbank Area Structure Plans

Springbank currently contains three Area Structure Plans (ASPs): the Moddle ASP (adopted in 1998), the North Springbank ASP (adopted in 1999) and the Central Springbank ASP (adopted in 2001). The 2016 ASP is expected to consolidate the three ASP areas.

The Moddle ASP (MASP) addresses development on the SW 24-24-02 W5M which is surrounded by the Central Springbank ASP (CSASP). The MASP facilitated the redesignation and development of 152 acres of land into a country residential community which has been built out.

The North Springbank Area Structure Plan (NSASP) covers 4,350 acres. The NSASP boundaries extend as far as Range Road 32 to the east, Range Road 35 to the west, Township Road 251A to the north and

Township Road 245 to the south.

CSASP is approximately 22,000 acres in size. The boundaries extend to the Bow River in the north, the Elbow River to the south, The City of Calgary to the east, and one mile west of Range Road 33 to the west. The TransCanada Highway bisects the CSASP area and Highway 8 touches its southeastern corner.

2.2.2 Drainage Strategies for Springbank (Westhoff, 2004)

The Report on Drainage Strategies for Springbank has been used as a guide for determining the unit area release rate for discharge from new development. The Springbank Unit Area Release Rates (UARRs) proposed in this report are summarized in ***Table 2.1***. The two following tables have been taken from this report. This MDP does not intend to update these UARRs and it is proposed that they continue to use these targets for runoff release rates.

Table 2.1: Unit Area Release Rates for Springbank (Westhoff, 2004)

	Unit Area Release Rate (L/s/ha)					
Return Period	1:2	1:5	1:10	1:20	1:50	1:100
Average	0.581	0.947	1.152	1.328	1.546	1.714
Standard Deviation	0.197	0.206	0.188	0.161	0.122	0.092

It is noted that the report also estimated peak flows generated from each catchment shown in ***Table 2.2*** based on the above unit area release rate. It is likely that actual flow rates within many of the catchments will be lower due to the size and slope of the catchment, existing levels of developments and therefore should only be considered as guideline when sizing drainage infrastructure.

Table 2.2: Estimated Pre-development Discharge Rate for Springbank Subcatchments

Subcatchment	Effective Area (Ha)	1:2 (m^3/s)	1:5 (m^3/s)	1:10 (m^3/s)	1:20 (m^3/s)	1:50 (m^3/s)	1:100 (m^3/s)
Draining to Bow River							
B1	3,417.7	1.986	3.237	3.937	4.539	5.284	5.858
B2	1,039.6	0.604	0.985	1.198	1.381	1.607	1.782
B3	207.3	0.120	0.196	0.239	0.275	0.320	0.355
B4	231.2	0.134	0.219	0.266	0.307	0.357	0.396
B5	1,097.6	0.638	1.039	1.264	1.458	1.697	1.881
Draining to Elbow River							
E1	253.7	0.147	0.240	0.292	0.337	0.392	0.435
E2	680.0	0.395	0.644	0.783	0.903	1.051	1.166
E3	285.3	0.166	0.270	0.329	0.379	0.441	0.489
E4	3,706.2	2.153	3.510	4.270	4.922	5.730	6.352
Cullen Creek	2,266.0	1.317	2.146	2.610	3.009	3.503	3.884
Springbank Creek	3,631.2	2.110	3.439	4.183	4.822	5.614	6.224

2.2.3 Elbow River Basin Water Management Plan (Elbow River Watershed Partnership, 2008)

This document contains guidance for water management plan objectives, outcomes, physical characteristics, measurable impacts on water quality and recommendations for implementation, within the Elbow River watershed.

Desired outcomes to be achieved with the implementation of this management plan are:

- Provide a safe and secure drinking water supply,
- Provide a safe habitat for aquatic ecosystems,
- Provide reliable water supplies of high quality for sustainable growth and development, and
- Integrated and committed stewardship of the river and watershed.

The document suggests the adoption of water quality objectives for all jurisdictions and stakeholders for the Elbow River and its tributaries.

2.2.4 Bow River Phosphorus Management Plan (AEP, 2014)

The Bow River Phosphorus Management Plan (BRPMP) is a multi-stakeholder voluntary and collaborative strategic plan to address sources of phosphorus in the middle reach of the Bow River between Bearspaw and Bassano Dams. Objectives of the BRPMP are to manage the phosphorus and promote policies to reduce point and non-point sources of phosphorus entering the Bow River. The plan provided a list of priority objectives and strategies related to stormwater as summarized below:

- Improve the understanding and change behaviour to reduce phosphorus entering the Bow River through public education programs,
- An average of 300 mm absorbent landscaping shall be implemented at all single-family residential development in order to promote infiltration at the lot level,
- Increase knowledge about phosphorus sources within the planning area, phosphorus management practices monitoring and evaluating water quality, and conducting research and fill data gaps,
- Reduce phosphorus loading through best management practices for both urban and rural sources,
- Reduce the movement of phosphorus to the river by disallowing further net loss of wetlands and maintaining and improving riparian areas,
- Remove excess phosphorus from water before it reaches the river by establishing regional watershed targets.

2.2.5 Rocky View County Servicing Standards (2013)

This document describes in detail the design specification for all municipal infrastructure to be constructed in RVC. Some of the requirements identified in these standards include:

- Minimize the transference of drainage issues from one location to another.
- To not burden downstream properties with decreased water quality, increased flow rates and/or volumes resulting from development of upstream properties.
- Ensure that downstream properties do not restrict or redirect upstream runoff that would have otherwise naturally flowed through their site.
- Control stormwater to eliminate inconvenience and adverse effects both on the development site and off-site lands as a result of runoff from more frequent but less intense storms.
- Control of stormwater runoff to prevent damage to property, physical injury and loss of life which may occur during or after a very infrequent or extreme (1:100 year) storm event.
- Runoff water quality shall not be less than pre-development.

- Further information on the stormwater guidelines for developers and engineers can be found in Section 700 of the Rocky View County Servicing Standards.

2.3 Relevant Reference Documents and Policies

2.3.1 Nose Creek Watershed Management Plan (Palliser Environmental Services, 2007)

High rates and volumes of stormwater discharge, due largely to urban growth and country residential developments, are affecting the health of Nose Creek, West Nose Creek and their tributaries. Typical land development practices can generate five to 20 times more runoff compared to pre-development conditions. Runoff volume control targets are necessary to preserve the natural hydrological runoff volume. Pre-development volumes represent approximately 2% of total precipitation for West Nose Creek and Nose Creek.

The recommendations in the Nose Creek Watershed Water Management Plan are summarized here:

- A maximum allowable release rate of 0.99 L/s/ha on West Nose Creek and 1.257 L/s/ha on Nose Creek, respectively.
- To meet the maximum allowable discharge volume for country residential developments and low density industrial, commercial and institutional developments, ultimate runoff volume control targets of 11 mm on Nose Creek main stem and 17 mm on West Nose Creek will be implemented in a staged approach.

2.3.2 Pine Creek Drainage Study

The Pine Creek Drainage Study (AMEC, 2007) assessed the impacts of urbanization in the Pine Creek watershed including flooding, stream stability, runoff volume and water quality. The findings of the impact assessment were used to develop a strategy for managing urban stormwater runoff.

Hydrologic modelling was carried out and compared undeveloped to developed conditions (under various development scenarios), showing how a traditional end-of-pipe stormwater management approach would not address the issue of increases in small, frequent runoff events.

The study recommended a combination of traditional end-of-line treatment and source controls to meet peak flow and volumetric runoff targets, with additional structural and non-structural BMPs to meet water quality criteria. Based on hydraulic and flood hazard modelling, the study also recommended minimum setback requirements to meet ecological and community safety objectives for Pine Creek.

The overall recommendations from this study were:

- 1:100 year unit area release rate 1 L/s
- 17 mm volume control target
- Annual removal of 85% TSS (50 microns or larger)

See the *City of Calgary Water Resources Interim Stormwater Targets* (March 2014) for more details.

2.3.3 City of Calgary Interim Stormwater Targets 2014

In March 2014, the City of Calgary released recommended Interim stormwater targets, including runoff volume targets for watersheds entering the City's rivers and reservoir. ***Table 2.3*** below outlines targets for these specific catchments related primarily to water quality and are considered applicable for Springbank.

Table 2.3: Runoff Rate and Volume Targets for New Development Industry Bulletin City of Calgary Water Resources (March 2014)

Watershed	Runoff Rate Target	Runoff Volume Target	Water Quality Targets
Bow River Watershed	**Off-site Discharge:** net-zero increase over pre-development conditions as per 1999 Provincial Stormwater Management Guidelines. Confirm the unit area discharge rate with Water Resources.	**Off-site Discharge:** 40 mm average annual runoff volume, as per the lower limit of the 10-20% imperviousness target as per the 2009 Municipal Development Plan.	**Off-site Discharge**: 85% TSS removal for particles ≥ 50 microns, as per the *2011 Stormwater Management & Design Manual*, Section 7.4. **Internal Drainage System:** 85% TSS removal for particles ≥ 50 microns for private sites ≥0.4 ha.
Elbow River Watershed, upstream of Glenmore Reservoir	**Off-site Discharge:** net-zero increase over pre-development conditions as per 1999 Provincial Stormwater Management Guidelines. Confirm the unit area discharge rate with Water Resources.	**Off-site Discharge:** 40 mm average annual runoff volume, as per the lower limit of the 10-20% imperviousness target as per the 2009 Municipal Development Plan.	**Off-site Discharge:** net-zero increase in average annual TSS loadings or 90% TSS removal for particles ≥ 50 microns, whichever is lower. **Internal Drainage System:** 90% TSS removal for particles ≥ 50 microns for private sites ≥0.4 ha.

3.0 STUDY AREA

3.1 Introduction

The 11,273 ha study area consists of land within the County, west of the City of Calgary. It is bounded by the Bow River to the north, the Elbow River to the south, City of Calgary to the east, and extends as far as Range Road 40 to the west. Approximately 40% of the catchment area drains to the Bow River and 60% to the Elbow River. The TransCanada Highway bisects the study area from west to east and straddles the general catchment divided between the Bow and Elbow Rivers.

The catchments are mainly agricultural flat lands in the upper catchment, transitioning into steeper grades toward the river. The tops of the catchment have gentle slopes, while the bottoms of the catchments observe steep coulees where runoff collects before discharging to the river. The catchments closer to Calgary are generally steeper, more undulating, and more developed than the catchments on the western portion of the study area.

3.2 Nature of the Problem

Springbank has experienced significant growth over the past two decades. During this time, stormwater management practices have been mainly focused on controlling peak release rates from onsite stormwater runoff, with little focus on the downstream impacts of altering drainage routes, increasing runoff frequency and volumes. The low impervious area of typical developments and the dry climate during much of this time did not highlight the potential issues of using rudimentary or nonexistent stormwater techniques. The wetter conditions since 2005 have highlighted the many drainage issues, such as elevated groundwater levels and regional flooding along main drainage routes. Emerging problems will become more evident as more development occurs upstream and runoff becomes more frequent with higher flows. This will lead to an increased likelihood of erosion and riparian degradation. Water quality from runoff entering the major rivers is compromised as well. The need for strengthened stormwater management policies is thus apparent.

3.3 Development History

The population of Springbank was 5,930 in 2006, representing 17% of RVC's total population. This population is mainly concentrated in the study area, and the remaining area is largely undeveloped agricultural land. North Springbank has grown by 9.1% from 2006 to 2013 (RVC, 2014).

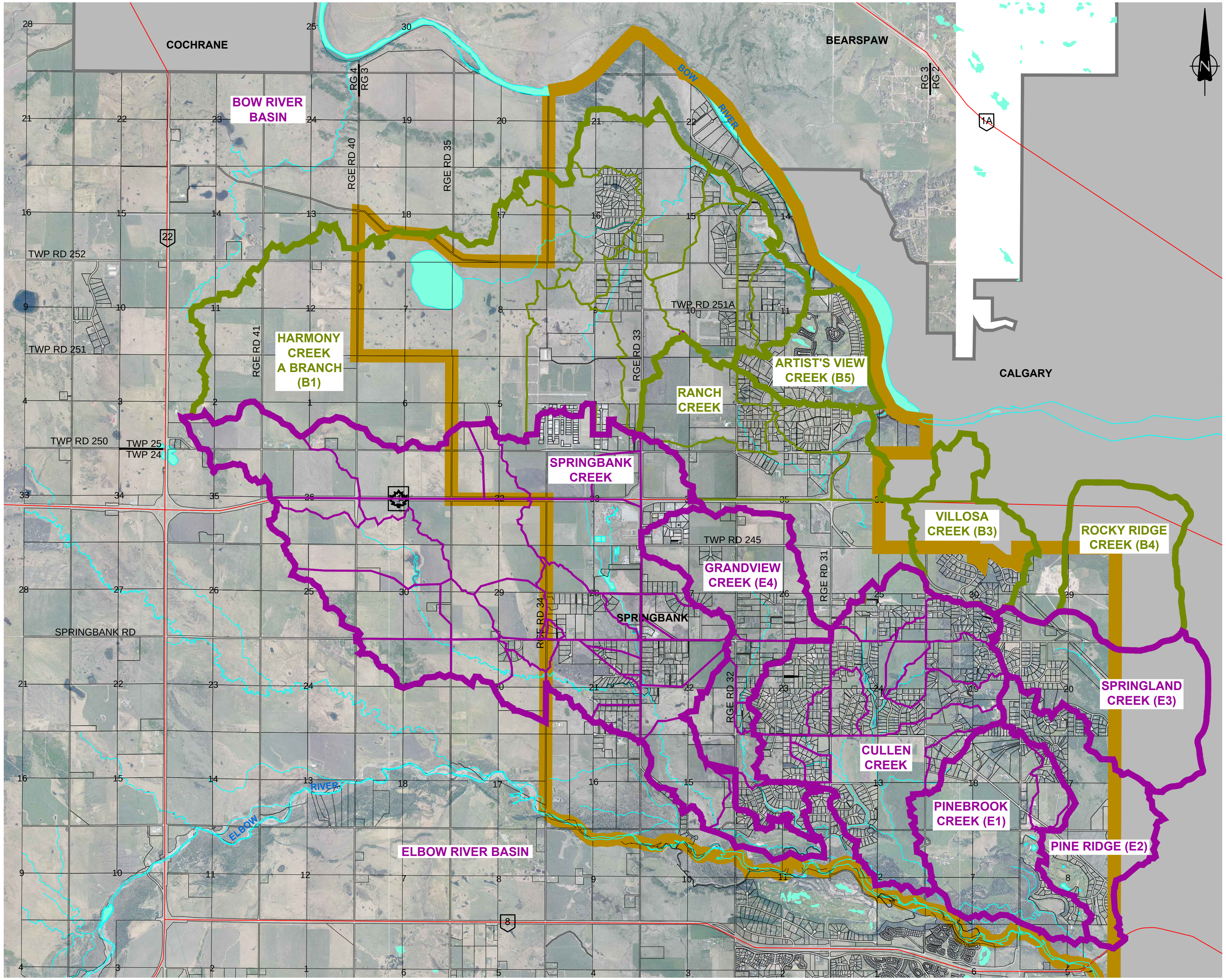
The Central Springbank and North Springbank Area Structure Plans are out of date and are planned to be updated in 2016. This MDP will serve as a guiding document when developing the new ASPs.

Future growth in Springbank will be based on the currently adopted Conceptual Schemes (CSs). Adopted CSs within the study area encompass 5,198 acres of land, which is approximately 19% of the study area. Each adopted CS supports country residential development with the exception of the Harmony CS and the Bingham Crossing CS involving higher density residential, commercial and industrial developments. In addition to the adopted CSs, there is also the proposed CS of North Springbank Gate which has not been approved by Council at the time of this study. The adopted CSs represent large development areas spread out throughout the study area. These CSs are represented on ***Figure 3.1***.

On average, 38 residential permits were issued each year in Springbank between 2004 and 2008. At this current absorption rate for country residential units, the adopted and proposed CS areas will not build-out for a very long period of time (>100 years). As stated in the *County Plan* (RVC 2013), an alternative would be to encourage focused growth on one concentrated area to achieve full build-out. From a cost-effective infrastructure and engineering perspective, it makes sense to prioritize by focussing new development in current planned areas and to consider phasing.

3.3.1 Rural Residential Development

Rural residential development has mainly consisted of country residential homes, where the average lot size varies between two and four acres. Development has occurred by developing a portion at a time, as developers purchase and build out the land. Development in the region is expected to continue to grow in the same density and land use that is currently in place. Land use is expected to transition from country acreages to commercial land use approaching the highway and the existing industrial area around the Springbank Airport.



Catchment	Area (ha)
To Bow River	
Artist's View Creek	302
Harmony Creek A Branch	3533
Ranch Creek	1118
Rocky Ridge Creek	509
Villosa Creek	404
To Elbow River	
Cullen Creek	1377
Grandview Creek	779
Pine Ridge	511
Pinebrook Creek	700
Springbank Creek	3409
Springland Creek	676
Villosa Creek	404

LEGEND:

- CATCHMENT AREA TO BOW RIVER
- SPRINGBANK SUB-BASIN TO BOW RIVER
- CATCHMENT AREA TO ELBOW RIVER
- SPRINGBANK SUB-BASIN TO ELBOW RIVER
- STUDY AREA

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SPRINGBANK MASTER DRAINAGE PLAN CATCHMENT AREAS	DATE: APRIL 2016	SCALE: 1:75 000
	JOB: 2285-057-00	FIGURE: 3.1

3.3.2 Springbank Airport

The Springbank Airport is located west of Range Road 33, north of Highway 1 and south of the Harmony development. The airport is located on the drainage divide of two subcatchments, Springbank Creek (which drains to the Elbow River) and Harmony Creek (which drains to the Bow River).

Since flooding and erosion have been reported to be critical downstream issues along several reaches of Springbank Creek, the stormwater collected within the southern portion of the airport is routed through a detention facility before discharging south through a 1,200 mm culvert. Currently, all runoff from the Northlands drainage system is conveyed through Harmony Creek through privately owned lands. The discharge from the north portion of the airport lands has been restricted to the capacity of a 600 mm culvert across Rocky Range View, which is 350 L/s or 0.85 L/s/ha. Volume controls were not considered as part of this design study.

3.3.3 Harmony Development

Harmony is to provide a hub of development unique to Springbank, ranging from single family residential homes to a commercial corridor and golf course. A large lake system has been designed within this community providing raw water storage for water being directed from the Bow River, as well as to treat and hold stormwater runoff from the development and upstream contributing catchment. The lake will be used as a water source for irrigation for the development, and provide a raw water supply for the on-site water treatment plant. The outfall for the first stage of Harmony Lake is via an existing drainage route flowing northeast to the Bow River. The ultimate outlet would be a pipe leading directly to the Bow River.

3.3.4 Bingham Crossing Development

The Bingham Crossing development is located north of Highway 1 and encompasses 55.25 ha of land. Most of the site drains to the Elbow River via Springbank Creek. A small portion (19%) of the site drains north toward the Bow River. The south travels under a culvert under Highway 1, then enters municipal ditches in the Springbank Creek catchment. An offsite catchment of 8.8 ha flows through this development.

The proposed site use is to be low density retail centre with a seniors' facility. An open space concept has been applied to the design. Parks and a municipal storm pond are also included in the design.

Rainwater harvesting and stormwater reuse for irrigation are two measures proposed to promote evapotranspiration and reduce runoff rates and volumes.

The proposed revisions to the ASPs could affect the type of developments that are approved in the future. The ASP process may result in a more diverse land use across Springbank, like the Harmony and Bingham Crossing developments, rather than the predominantly country residential development of the past.

3.4 Catchment Characteristics

3.4.1 Major Catchment Areas

The Springbank study area is divided (approximately 40/60) between the Elbow and Bow River Basins. The northern portion (5,866 ha) is located in the Bow Basin, and the southern portion (7,856 ha) flows generally south to the Elbow River. These two catchments are further divided into nine sub-catchments as originally identified in the *Report on Drainage Strategies for Springbank* (Westhoff, 2004). For this MDP, the study area has been delineated into 12 sub-catchments using ArcGIS digital mapping DEM using +15m LiDAR (see ***Figure 3.1***).

Most of the catchments drain directly in or upstream of the City of Calgary's main raw water drinking supply reservoirs. The Elbow River basin is a source catchment for the Glenmore Reservoir, while a significant portion of the Bow River catchments drain directly into the Bearspaw Reservoir.

3.4.2 Soil

Soils in Springbank consist mainly of medium to fine grained lake sediments of the Calgary formation as shown in ***Figure 3.2***. These soils are typically susceptible to erosion and rill erosion on steep slopes. This is especially evident at the bottom of catchments along the Bow River, in areas where surface runoff usually collects in deep, narrow draws (Westhoff, 2004).

3.4.3 Stream Profiles and Erosion

Stream profiles have been assessed and ranked into categories according to their potential to erode. Erosion factors include:

- Extent of upstream development
- Stream slope
- Level of and potential to meander
- Soil type

Three criteria have been developed to aid in determining the erosion potential for each stream (***Table 3.1***). Major streams in the Springbank catchment were assessed for their erosion potential giving *High*, *Medium* and *Low* risk rating based on creek slope, soil type and the level of catchment build-out/impervious area as shown on ***Table 3.2***.

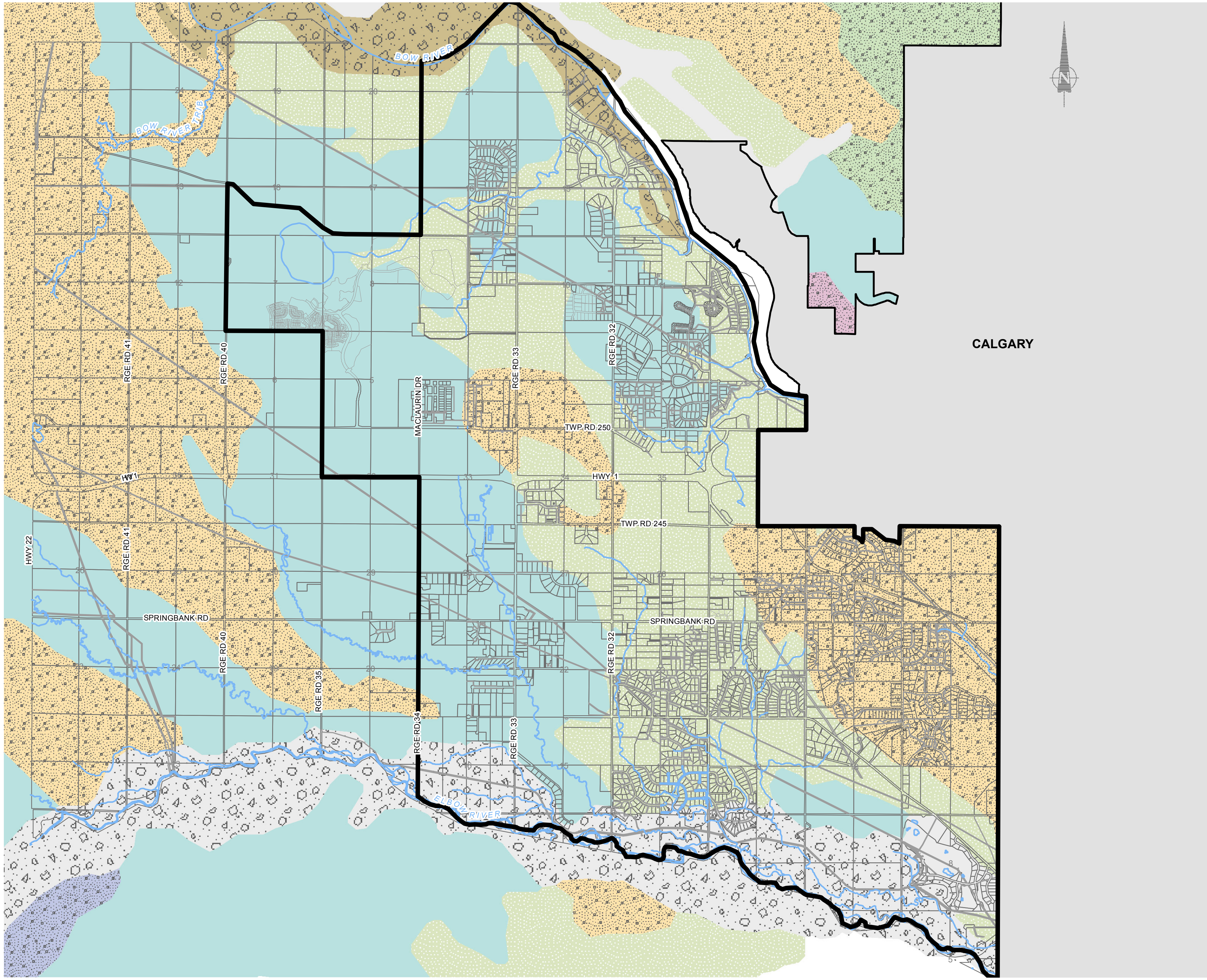
Table 3.1: Evaluation Criteria for Stream Erosion (SE) Potential

Risk	**Low (SE<4)**	**Medium (4 < SE < 7)**	**High (SE>7)**
Soil Type	Medium Textured	Moderately Textured	Fine Textured
Percent Slope	0 – 0.5	0.5 – 2.0	>2.0
% Impervious Area	0 - 2	2 - 5	>5

The score for each criterion was summed to obtain the overall risk of erosion, on a scale of 3 to 9, with 3 being a stream with very low erosion potential and 9 being very high erosion potential under existing development conditions. If future development does not adequately manage stormwater, particularly the runoff volume, then all streams would have a high risk rating.

Table 3.2: Streams and Erosion Risk

Sub-Catchment	Creek Slope (%)	Soil Type	Catchment Built-out (ha) / Impervious Area (%)	Risk of Stream Erosion
Artist's View Creek (B5)	3.6 – 7.2	Fine textured water-laid sediments	78 / 8	9
Cullen Creek	0.4 - 1.2	Moderately fine textured water-laid sediments	58 / 8	7
Grandview Creek (E4)	1.0 - 2.0	Moderately fine textured water-laid sediments	35 / 4	6
Harmony Creek A Branch (B1)	0.5 - 1.3	Moderately fine textured water-laid sediments	10 / 1	5
Pine Ridge (E2)	2.0 – 6.0	Medium textured till	36 / 3	6
Pinebrook Creek (E1)	0.3 – 2.0	Medium textured till	18 / 2	4
Ranch Creek	0.1 - 2.1	Moderately fine textured water-laid sediments	20 / 2	5
Rocky Ridge Creek (B4)	1.0 – 3.6	Medium textured till	2 / 0	4
Springbank Creek	0.3 – 1.1	Fine textured water-laid sediments	12 / 2	4
Springland Creek (E3)	0.8 - 1.8	Medium textured till	25 / 3	5
Villosa Creek (B3)	2.9 - 3.7	Medium textured till	52 / 5	6



LEGEND

- COARSE TEXTURED MATERIAL (UNDIFFERENTIATED)
- GRAVELS OR GRAVELY COARSE TEXTURED MATERIAL (COBBLY/STONY)
- MODERATELY COARSE SEDIMENTS DEPOSITED BY WIND OR WATER
- GRAVELLY AND STONY MEDIUM TEXTURED TILL
- MEDIUM TEXTURED OVER GRAVEL OR GRAVELLY COARSE (INCLUDES COBBLY AND STONY VARIATIONS)
- MEDIUM TEXTURED TILL
- MEDIUM TEXTURED
- MODERATELY FINE TEXTURED SEDIMENTS DEPOSITED BY WATER
- FINE TEXTURED WATER-LAID SEDIMENTS
- UNDIFFERENTIATED
- STUDY AREA

*Source: Agricultural Regions of Alberta Soil Inventory Database (AGRASID)

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SPRINGBANK CREEK
SOILS - PARENT MATERIAL

DATE: APRIL 2016	SCALE: 1:75,000
JOB: 2285-057	FIGURE: 3.2

3.5 Drainage Infrastructure Assessment

Field reconnaissance visits of the main drainage infrastructure were conducted in May 2014. The culverts crossing public county roads and regional highways were of main focus. Criteria observed were:

- Upstream end,
- Downstream conditions,
- Culvert condition, size and
- Intended direction of flow.

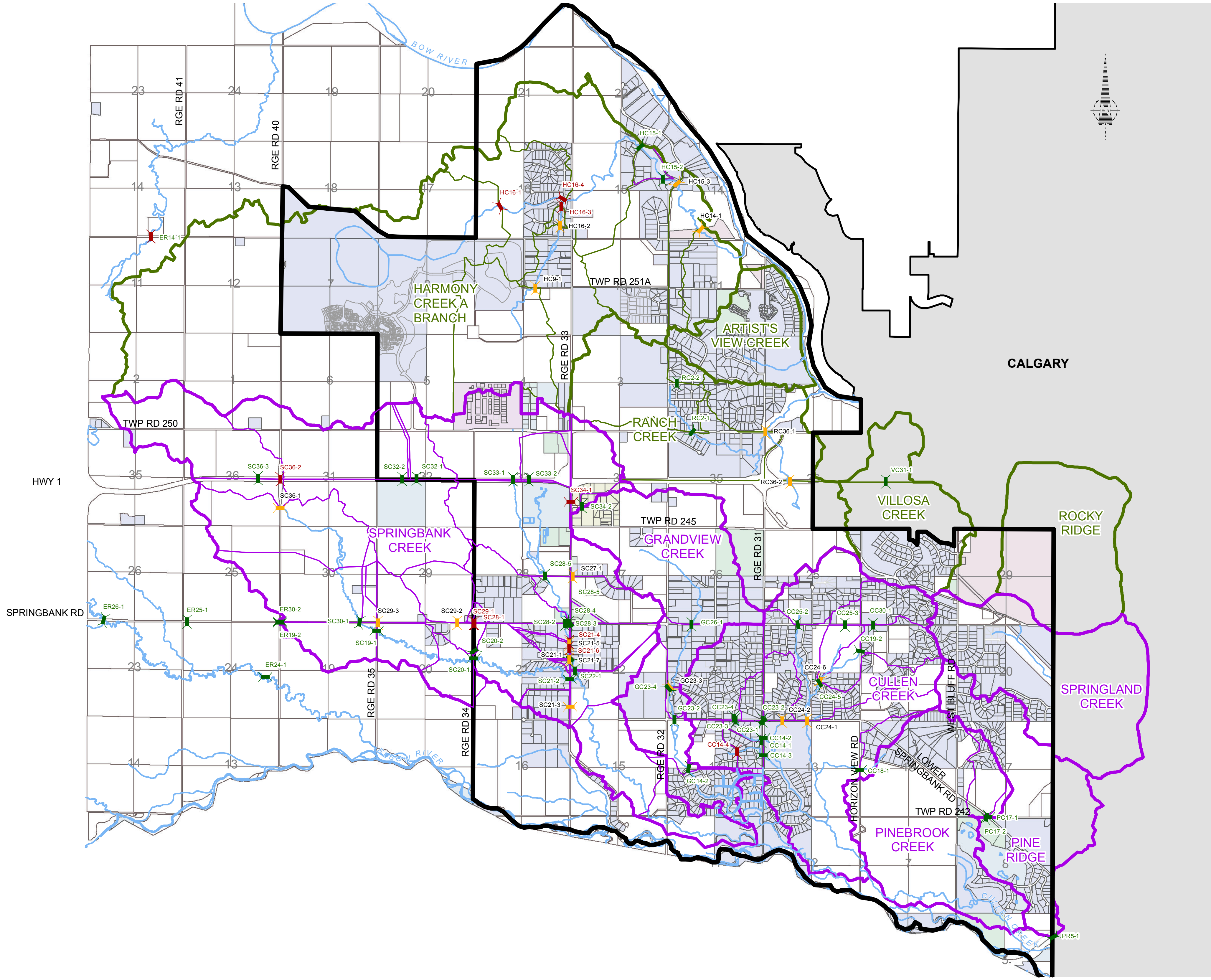
ArcGIS was used to delineate the catchment(s) areas draining to each culvert. The drainage areas in conjunction with the calculated culvert capacity were used to assess the actual runoff release rate from the minor catchment. It was found that most culverts have a capacity higher than the 1:100 yr unit area release rate of 1.71 L/s/ha recommended for Springbank and calculated using streamflow frequency analysis (Westhoff, 2004), however this high level of analysis did not consider backwater effects from adjacent downstream culverts. Pre-development hydrological estimates based on streamflow of large catchments tend to underestimate peak flow.

Figure 3.3 depicts the locations of culverts and existing sizes. They are colour coded according to their level of service. Red culverts depict those with a level of service less than the 1:100 UARR of 1.71 L/s/ha, yellow culverts are those between 2 and 4 L/s/ha and green culverts are those that can accommodate a UARR greater than 4 L/s/ha.

Table 3.3: Culverts and Level of Service

Level of Service (L/s/ha)	Number of Culverts
<2 (Red)	11
>2 (Yellow)	13
>4 (Green)	42

Additional work should be done to identify and prioritize culvert upgrades to meet the 1.71 L/s/ha release rate. This could be done as part of a catchment drainage plan.



LEGEND

CULVERT ASSESSMENT: LEVEL OF SERVICE

- > 4 L/S/HA
- 2-4 L/S/HA
- < 2 L/S/HA
- CATCHMENTS TO ELBOW RIVER
- CATCHMENTS TO BOW RIVER
- STUDY AREA

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SPRINGBANK MASTER DRAINAGE PLAN CULVERT ASSESSMENT	DATE: APRIL 2016	SCALE: 1:75,000
	JOB: 2285-057	FIGURE: 3.3

4.0 OPPORTUNITIES, CONSTRAINTS AND DESIGN CONSIDERATIONS

Present and future drainage requirements for Springbank will be described in order to develop the basis for the development of optimal drainage systems. This will give guidance to the County and developers on what level of stormwater servicing is required for each subcatchment in the region. Regional and local constraints for the study area are identified and considered in this section and will provide guidance for detailed stormwater planning for developing areas. This is particularly relevant to Springbank, where new development is ongoing, but also established neighbourhoods are in need of retrofitted infrastructure to alleviate existing stormwater issues.

Individual drainage concerns are often symptoms of regional issues. If the regional “main trunk” issues can be remediated, often the local drainage issues will ease as well. Therefore, the focus will be on the main drainage courses in the Springbank area.

An understanding of the opportunities and constraints will help shape the strategies considered to manage stormwater. This includes design consideration and criteria used to size the infrastructure. A summary of the key opportunities and constraints is given in ***Table 4.1***.

Table 4.1: Opportunities and Constraints for Stormwater Management

OPPORTUNITIES	CONSTRAINTS
• Adequately managing land development runoff flow volume and timing • Stormwater reuse • LID practices • Natural wetland and stream protection • Directing treated stormwater to natural wetlands to maintain pre-development hydrological regime	• Springbank hydrological characteristics • Soils and hydrogeological conditions • Natural wetlands • Roads and conveyance limitations • Private properties, need to obtain ROW and land acquisition • Servicing costs • River WQ guidelines • ESRD reuse policy • Maintain pre-development hydrology • Source water protection • Providing an adequate outlet • Potential licensing requirements for evaporative losses

4.1 Springbank Hydrological Response Characteristics

4.1.1 Precipitation Characteristics

Typically most stormwater studies within the study area have been using the Calgary International Airport (YYC) rainfall data for hydrological and water balance analyses. Average precipitation in the Calgary region typically increases in a westerly direction towards the mountains. As the study area is located west of Calgary, it should experience higher average precipitation. A comparison between weather stations in the Springbank Airport and YYC indicates average precipitation is approximately 11% higher at the Springbank Airport. This higher precipitation would imply that catchment runoff volumes should be higher for both pre-development and post-development conditions considering similar soil characteristics, than for catchments that more closely resemble the YYC average precipitation.

A comparison of daily maximum precipitation shown in ***Figure 4.1*** and ***Figure 4.2*** indicates that apart from 2005, YYC tends to have similar or higher daily maximums over the comparative period of record. This would indicate that future urban development is less likely to be impacted using the YYC Intensity Duration Frequency and continuous data set to control maximum release rates. The three day cumulative annual maximum give similar results to the daily maximums, however the 30 day or monthly cumulative annual maximum is higher for Springbank Airport as shown in ***Figure 4.3***. This would be expected, reflecting the higher average annual totals at Springbank.

Figure 4.1: Annual Daily Maximum Precipitation at Calgary and Springbank Airports

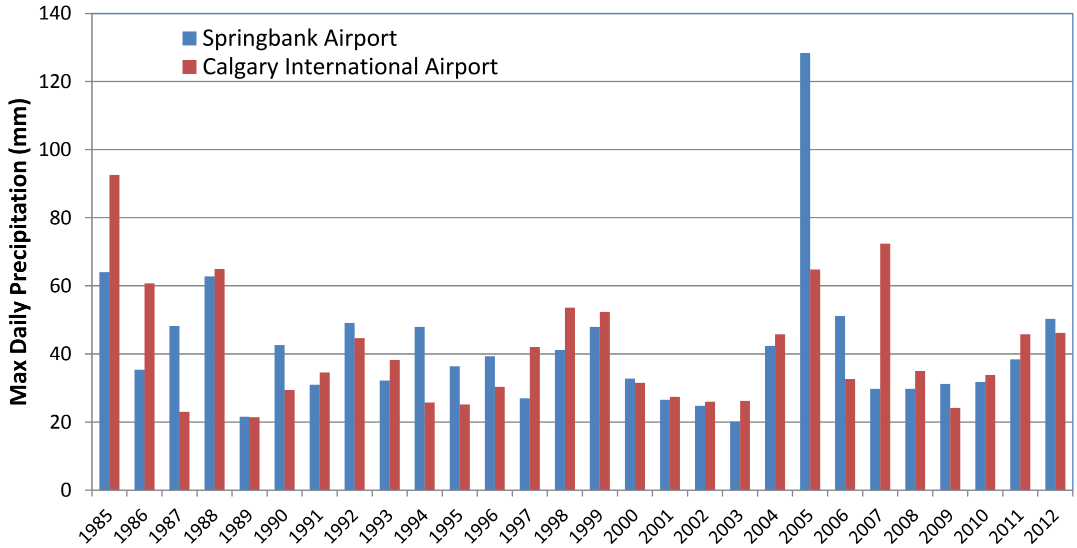


Figure 4.2: Ranked Annual Maximum Daily Precipitation

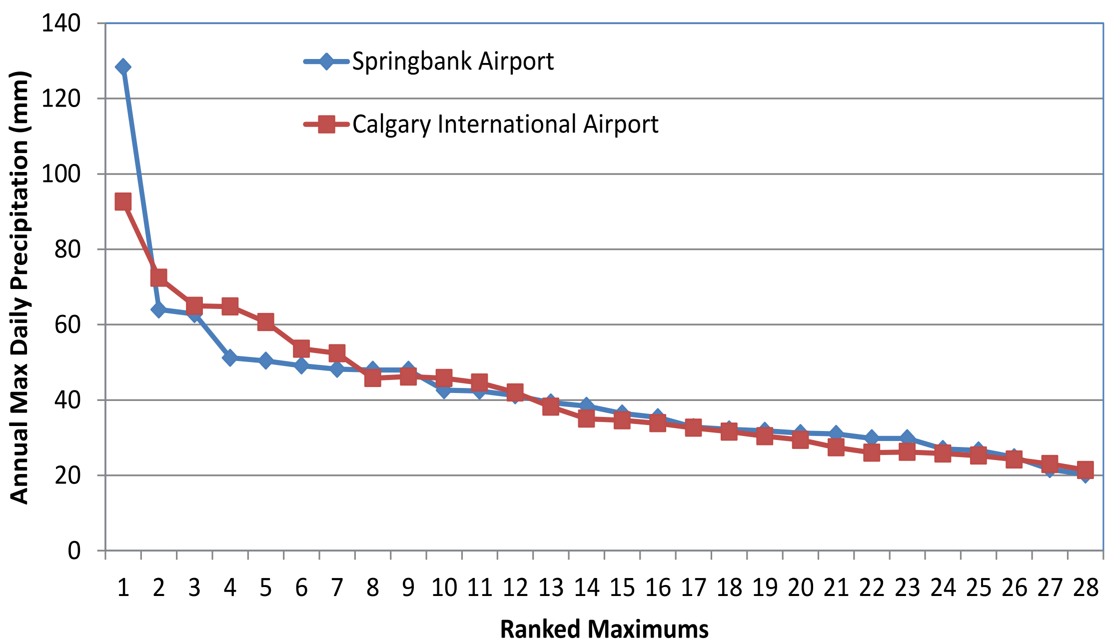
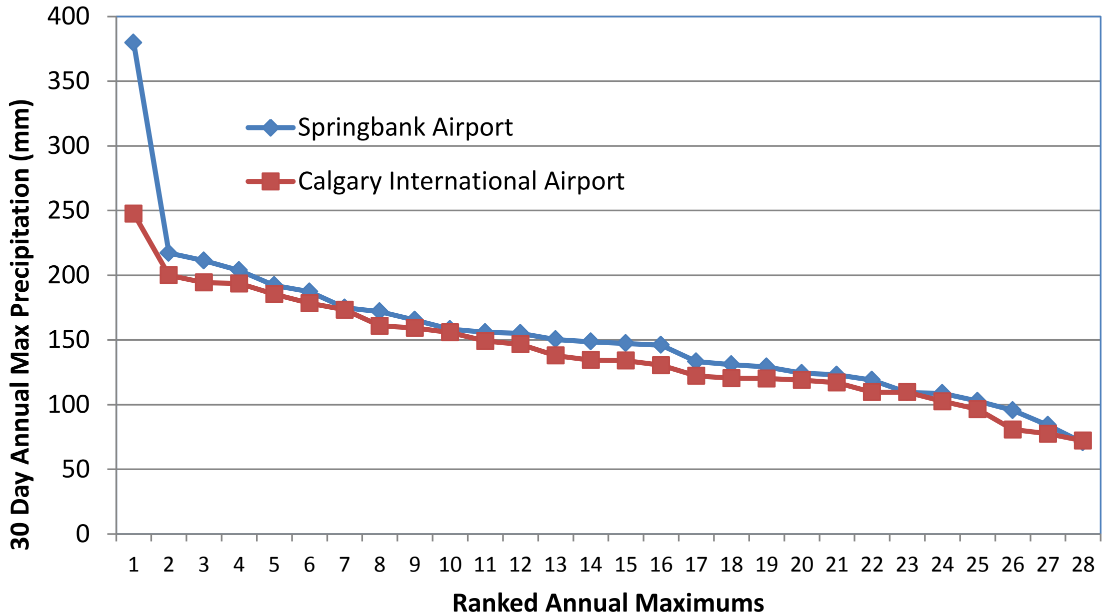


Figure 4.3: Ranked Annual Maximum 30 Day Precipitation



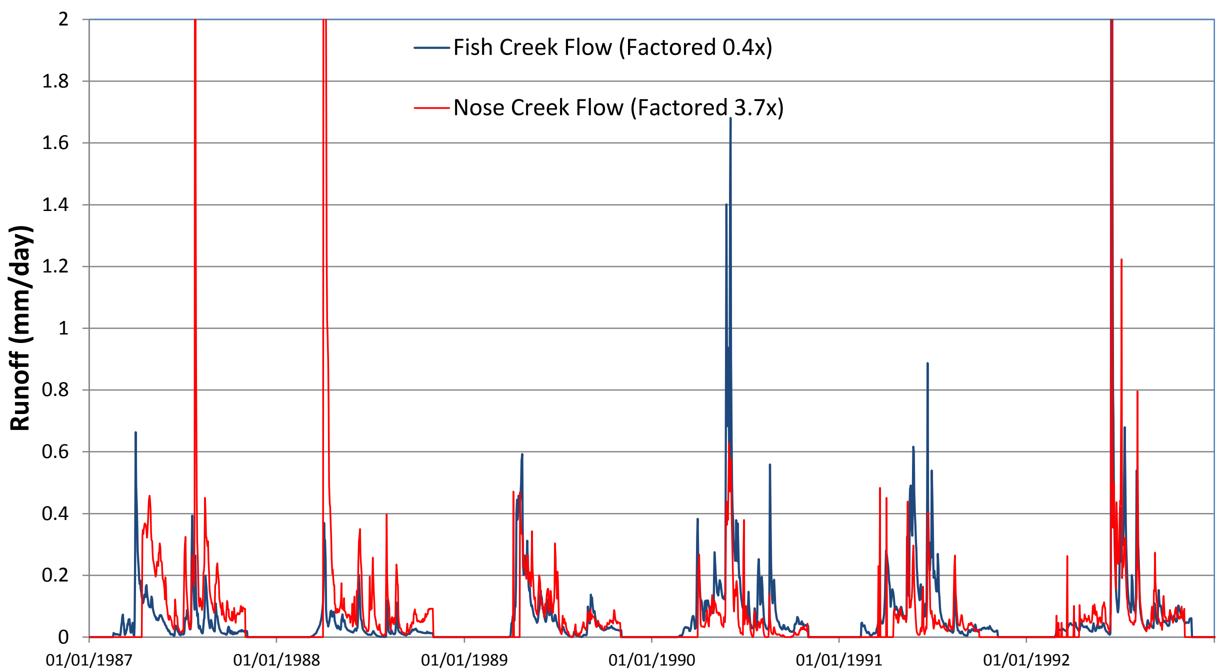
4.1.2 Runoff Characteristics

Understanding the pre-development runoff characteristics generated from Springbank catchments is important in setting policies and requirements for managing runoff from development so that it does not result in significant downstream impacts to property, infrastructure and water courses. Very limited stream flow gauging data exists for the Springbank region so any analysis would need to use adjacent streamflow data. The closest stream gauges, West Nose Creek and Fish Creek at Priddis, exhibit very different average runoff volumes over the comparative years of record being 9 mm and 75 mm, respectively. The City of Calgary *Total Loading Phase 1 Study* indicates that pre-development average runoff volumes range from 6 mm to 30 mm across the City of Calgary with the Springbank MDP boundary with the City representing the highest runoff. The values have been interpolated from limited gauged data and therefore exhibit significant uncertainty.

Considering the above, it would be reasonable to expect that the pre-development runoff could be in the range of 30 to 40 mm per year across the study area with some areas exhibiting higher or lower runoff due to soil characteristics. The 2004 Westhoff study recommended that a stream gauge program be implemented for Springbank. Although significant period of time (greater than ten years) would be required to confirm pre-development runoff volumes, the data collected would enable calibration of hydrological models to refine pre-development hydrological characteristics to measure the performance of future development stormwater LIDs and BMPs.

The daily stream flow data was factored to achieve an average pre-development runoff volume of 30 mm in order to compare similarities of the Fish Creek Station (ID: 05BK001) factored down by 0.4 and Nose Creek Stations (IDs: 05BH003 and 05BH904) factored up by 3.7 as shown in ***Figure 4.4***. The graph shows that even though there are yearly differences, potentially related to precipitation variability between the catchments, the comparison indicates a reasonable correlation and can be useful for model calibration and flow duration curve analysis.

Figure 4.4: Fish Creek vs. Nose Creek Runoff



4.1.3 Flow Duration Characteristics

Flow duration curves have been in use since the early 20th century as a simple way to understand the hydrological characteristics, or 'flow behavior' of streams. Despite their inherent simplicity, flow duration can be difficult to interpret. The flow duration curve is a cumulative frequency curve of flow, which represents the percentage of time that a particular flow rate is equaled or exceeded.

A time series of stream flow shows how stream flow changes from day to day. For example, by examining gauged flow records in Fish Creek (as shown in ***Figure 4.4)***, we can determine how much flow occurred on any given day and observe daily and long-term trends, such as higher stream flows in spring months and lower stream flows in winter months. Individual flow peaks can also be identified with a flow time series.

Time series are an effective tool to communicate stream flow behavior; however they do not answer all questions. For example, a time series does not indicate the proportion of time where flows are high, low, or zero. To gain a deeper understanding of a stream's flow behavior and to make informed decisions based on that behavior, flow duration curves are useful.

Flow duration curves were calculated from the factored stream flow time series for Fish Creek and West Nose Creek as shown in ***Figure 4.5***. The flows duration curves are fairly similar for percentile exceedances more than 0.1% which could be considered around a 2 year event flow. Above this value, Fish Creek is somewhat higher which is reflective of this catchment being more responsive to rainfall than Nose Creek. If the streamflow time series for Fish Creek is extended to represent the typical 50 year period use for water balance modelling, the flow duration curve shows a general increase in flow and average annual runoff of close to 40 mm, (which is the upper range of expected runoff from the Springbank area; refer to ***Figure 4.6***). The time series needed to be scaled down by 0.32 to the original gauged flow to achieve a 30 mm average annual runoff volume.

Although flood event magnitude cannot be directly calculated from percentile exceedance values shown in ***Figure 4.5***, a 1:2 and 1:5 year average daily peak flow would roughly correlate to a 0.1% and 0.05% percentile exceedance, respectively.

Figure 4.5: Fish Creek vs. Nose Creek Flow Duration Curve

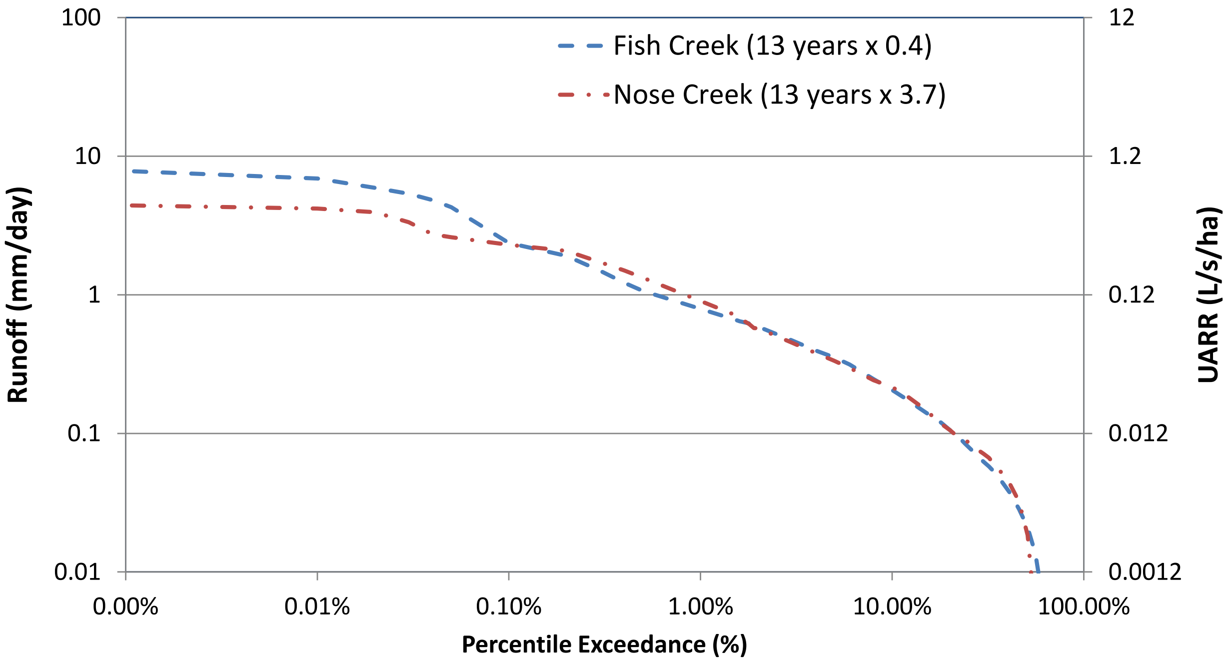
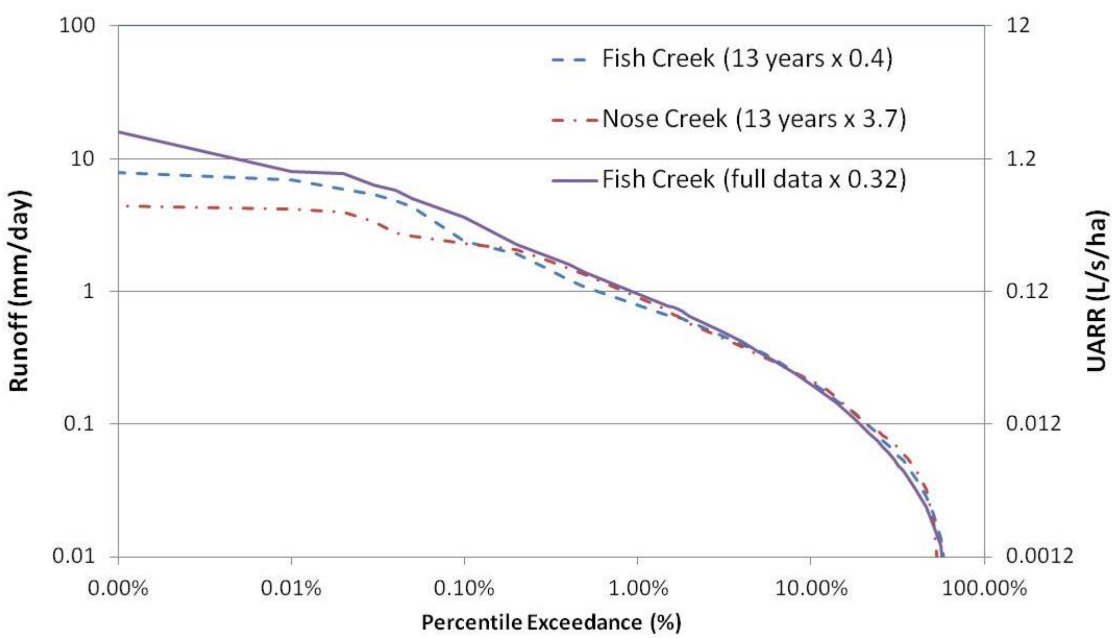


Figure 4.6: Fish Creek and Nose Creek Adjusted Flow Duration Curves



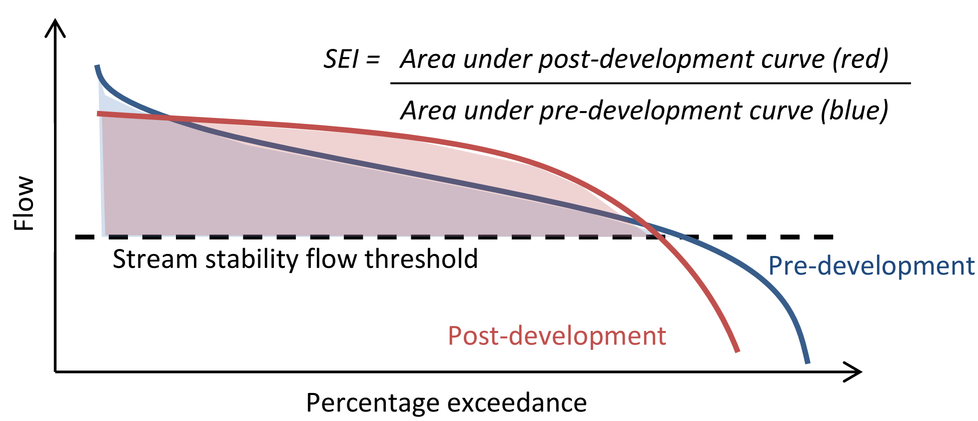
4.1.4 Stream Erosion Assessment

The construction of roads, buildings, paved walkways and parking lots results in increased runoff in developed catchments. Additional runoff and higher peak flows can increase erosion in streams that are connected to developed and developing catchments.

A number of methods have been developed to track increased erosion potential in streams affected by development. Such methods include the Stream Erosion Index (SEI) method and the Western Washington Procedures. The City of Calgary currently recommends an adapted version of the Western Washington Procedures. A comparison of these two methods, provided in ***Appendix C***, resulted in a modified version of the SEI being recommended as the preferred approach to managing stream health in the Springbank area. This modification involves not permitting the post-development flow to exceed 10 % above the pre-development flow at the flow threshold (50% of the 1:2 year flow) being 0.15 L/s/ha or 1.3mm/day.

The SEI is a measure of hydrologic change and is the ratio of pre-development to post-development flows exceeding the receiving stream's stability threshold. In most cases the assumed stability threshold is 50% of the 1:2 year flow in the stream. The SEI is the ratio of the area under the pre-and post-development flow duration curves above the stream's stability threshold, as shown in ***Figure 4.7***. Where the SEI approach is used, it is common to set an objective of managing flows to achieve an SEI 2 or less.

Figure 4.7: Stream Erosion Index Method



The equation below described the SEI calculations (from Dotto, et. al., 2014).

$$SEI = \frac{\sum(Q_{post} - Q_2/2)}{\sum(Q_{pre} - Q_2/2)}$$

Where, Q_{post} is the flow after development has taken place, Q2 is the 2 year flood flow rate, and Q_{pre} is the flow prior to development.

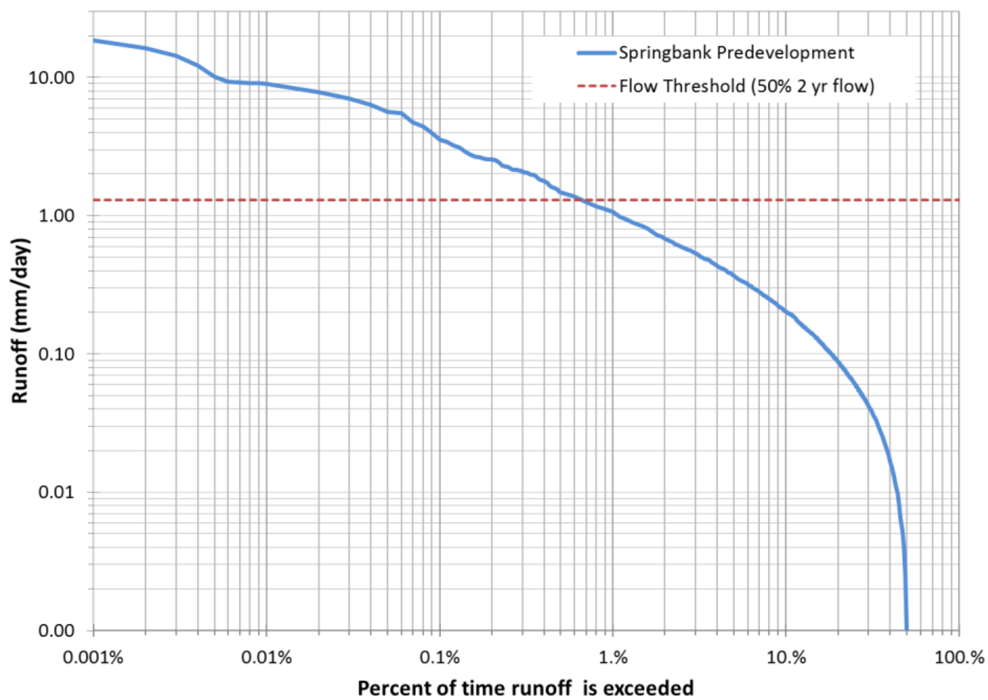
Higher SEI values indicate a greater potential for stream erosion to occur as a result of the development. SEI can be calculated using the following steps:

1. Generate flow time series for pre-development and post-development conditions.
2. Estimate the 2 year flood flow rate for pre-development conditions.
3. Sum all flows greater than 50% of the 2 year flood flow rate (flow threshold) over the duration of the flow time series. The SEI is the ratio of the pre-development to post-development numbers totals.

Studies assessing the effectiveness of SEI to maintain stream health suggest that an SEI target of two represents best practice stormwater management (Dotto, et. al., 2014). To achieve this target, stormwater management practices can be applied to reduce runoff from the developed catchment. Stormwater practices such as infiltration trenches, bioswales and rain gardens work to increase infiltration and reduce stormwater runoff. The SEI can be calculated for different stormwater management scenarios and show their effectiveness in reducing stream erosion potential.

In previous studies in the Pine Creek catchment, southwest Calgary, the 50% of the 2 year flood flow threshold was found to be a suitable metric for assessing stream erosion. In the Springbank area, this criteria equates to approximately 0.15 L/s/ha on a unit area basis or 1.3mm/day. The Springbank flow duration curve (***Figure 4.8***) derived from the Fish Creek flow data is proposed to be used to examine the impact that existing and future development has on flow volumes and the erosion potential within a natural stream.

Figure 4.8: Springbank Flow Duration and Flow Stress Threshold



4.1.5 Source Water Protection

The majority of the Springbank catchment within the study area discharges upstream or into the main water supply reservoirs for the Calgary region on the Bow and Elbow Rivers. Volume control targets and total suspended solid loading requirements are similar to the City of Calgary standards. It is likely that the volume control targets needed for minimizing stream erosion will be lower than the requirements needed for source water protection. However TSS loading limits should also be considered in combination with the volume control targets. Another emerging requirement for managing stormwater from higher risk development types and major transportation ROW involves the capture of accidental spills. Consideration should be given to providing additional measures to mitigate significant source water protection risks.

4.2 Current and Emerging Issues

Increasing the runoff rate and volume can negatively impact the natural drainage paths. Drainage paths have been developed by erosion of natural waterways over a number of years.

Riparian zones provide many environmental benefits to any developable land. A designated drainage corridor allows runoff to reach a stream course in a concentrated fashion and lessens the risk of flooding nearby homes and businesses.

4.2.1 Bow and Elbow River Water Quality Considerations

Total Suspended Solids

Total Suspended Solids in runoff water can lead to increased sediment in streams and ditches, and can have adverse effects on water quality, in addition to the added cost of maintenance to County road ditches. These policies are proposed to avoid high TSS concentrations in discharges from development sites:

- Runoff from commercial and industrial land is to pass through an Oil and Grit Separator or alternative approved device, and 85% TSS removal of particles larger than 50 µm for all years of Calgary International Airport rainfall data.
- 85% TSS removal of particles larger than 50 µm for storm ponds, as determined by continuous modelling of all years of Calgary International Airport rainfall data, factored up by 11%.

Source Water Protection

Pertinent Source Water Protection guidelines are:

- LID practices should be considered for subdivisions to improve downstream water quality as well as meeting the volume control target.
- Wherever possible, natural surface drainage systems should be incorporated within all developments located in Springbank as opposed to underground drainage systems.
- Implementation of absorbent landscaping should be used for irrigation of stormwater reuse purposes.
- The use of fertilizers, pesticides and herbicides (other than to control noxious weeds) shall be discouraged for residences within the study area to improve water quality in the receiving water bodies (Elbow and Bow Rivers).

Phosphorus

- The Bow River has seen an increase in the amount of phosphorus (P) loading in recent years. Sources of P in the Bow River basin include: plant material, soil, animal waste, treated wastewater effluent, fertilizer in runoff water, sediment from eroding riverbanks and dust fall.

Airborne P originates from sources such as industry and vehicle emissions, forest fires, and from wind picking up dust, soil and fertilizers.

4.2.2 Stormwater Management Targets

A number of targets for future development will be required to be met within the Springbank area to minimize the risk of downstream impacts related to:

a) Flood management.
b) Erosion minimization within the receiving stream.
c) Water quality for the receiving environment including retained wetlands, streams and rivers.
d) Where a limited or no outfall exists from the proposed development.

Proposed targets will provide designers with the guidance on the level of stormwater management needed to minimize the risk of adverse downstream impacts from proposed development. The following targets are recommended:

- Providing peak rate control to minimize flood risk based on previous guidance of 1.71 L/s/ha and lower rates in areas where downstream restrictions exist.
- Provide a volume control target of less than 45 mm to achieve water quality improvement for stormwater discharging to receiving streams/water bodies and minimize erosion impacts in existing streams.
- Matching closely to the flow duration curve to minimize downstream erosion impacts and where inadequate outlet currently exists for a development.
    - Stream Erosion index to be less than 2 over pre-developed conditions; refer to Section 4.5 for further discussion.
    - Post-development flow to not exceed 10 % above the pre-development flow at the intersection of the flow threshold and the pre-development on a flow duration curve.

The above requirements may be relaxed where development comprises of larger lots that have an actual impervious area of less than 10% and no internal roads. The minimum requirement in this situation is to direct the impervious area onto undisturbed natural areas or onto an absorbent landscape using an I/P ratio of 0.2 or lower, that is providing a minimum of 5 m^2 of pervious area for every 1 m^2 of impervious area. Roof and paved surface runoff should be spread out over the pervious surfaces and not concentrated into ditches or conveyance swales.

In addition, where a proposed development has an impervious area greater than 10% but less than 20% of the subdivision area the stormwater management system would need to meet the peak rate and volume control target.

4.3 Wetland and Riparian Assessment

Reconnaissance-level field visits were conducted between July 29 and August 11, 2014. A total of 114 wetlands were visited, as well as seven riparian areas and drainage courses. The majority of the surveyed wetlands were mapped previously by RVC. Photographs were taken at each visited wetland site and botanical information sufficient to identify wetland class and dominant wetland vegetation association(s) and physiognomy was collected. The edges of sampled riparian areas were walked on foot and delineated using the track log function handheld GPS units. It is important to note that "edge" in this report does not mean where the current open water channel flows, but rather the extent or width of existing wetland vegetation surrounding the main channel. By walking this edge, it is possible to accurately map the width of the sampled riparian areas.

The classified wetlands and man-made ponds/dugouts (excluding those that are part of drainage course/riparian areas) occupy 242.5 ha (2.3%) of the Springbank MDP study area. Riparian areas occupy 137.3 ha (1.3%), totaling 379.8 ha (3.6%) within the boundaries of the Springbank MDP study area (see ***Figure 4.9***). Semi-permanent/permanent wetlands are the largest wetlands, with an average size of 9.9 ha. These wetlands occupy 129.3 ha (13 wetlands). Semi-permanent tilled, seasonal, temporary and ephemeral wetlands are generally smaller and occupy 93.9 ha (504 wetlands). Man-made dugouts and ponds occupy 17.4 (96 wetlands). Wetlands were typically embedded within a matrix of cultivated fields. As a result, 34% of the wetlands (175 out of 517) were found to be recently tilled. The majority of the tilled wetlands are ephemeral/temporary wetlands. The descriptions of different wetland types are described in the complete assessment in ***Appendix A.***

4.4 Potential Impacts of Stormwater Drainage on Wetlands

Potential impacts of stormwater drainage and management on wetlands in the study area include:

- Increase of surface water runoff due to increase in impervious surfaces.
- Reduction of water due to isolation from the local upland catchment.
- Decrease in water quality entering to the wetland. Contaminants, sediments and nutrients are transported by stormwater. Aquatic and semi-aquatic wildlife and fish habitat might be affected.
- Increase the potential of creation of erosion channels in the wetland.
- Reduction of floodwater storage capacity.
- Altered plant composition and wildlife habitat.

Changes in water regime and water permanence have the greatest potential to alter wetland plant structure and composition and therefore wildlife habitat and populations. Increased water input into wetlands will generally result in reductions in low-prairie, wet-meadow, shallow-marsh, and deep-marsh wetland zones, and increases in open water. Reduction of plant and structural diversity provided by the different wetland zones will result in a more homogeneous environment where wildlife habitats are reduced or lost.

4.4.1 Mitigation Strategies

It may be beneficial to direct stormwater to wetlands and/or potentially incorporate or convert them to engineered natural wetlands. Any discharge would need to be strictly managed so the quantity of water would mimic pre-development conditions. The water quality of the discharges would also need to be adequately treated using LID practices and constructed wetlands. Any modification or impact to existing wetlands needs to be assessed by AEP. According to the new *Alberta Wetland Policy* (Alberta Environment, 2013) and the *Provincial Wetland Restoration/Compensation Guide* (Alberta Environment 2007), mitigation is the process to reduce loss of wetlands by:

- Avoiding impacts to wetlands;
- Minimizing impacts and requiring applicable compensation; and
- Compensating for impacts that cannot be avoided or minimized.

Avoiding impacts on wetlands is the most desirable mitigation strategy, however, when avoidance is not possible, then minimizing impacts is preferred. Mitigation measures to minimize impacts on wetlands should consider the protection, maintenance or enhancement of wetland conditions such as: water quality, flow regime, wetland zonation, plant and wildlife diversity and potential to harbor species at risk.

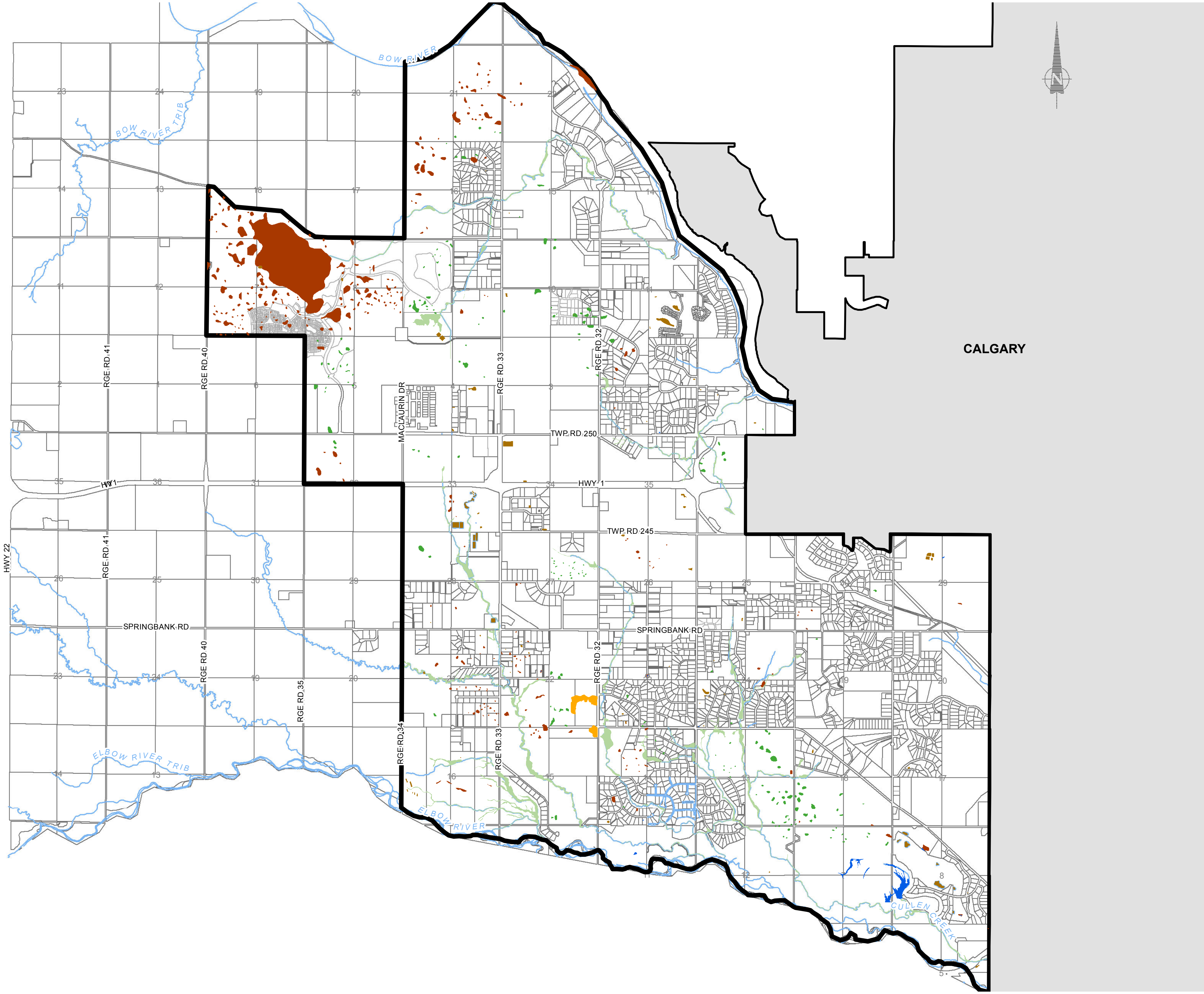
When avoidance and minimization is not possible, then compensation should be taken into consideration. Wetland compensation supports the concept of no further loss of wetland area in the province by restoring wetlands to replace those impacted by development. Wetland restoration is undertaken by wetland restoration agencies (i.e. Ducks Unlimited).

Integration of existing wetlands into future demands will be an important consideration. Historically it is common to fill over wetlands to make way for development. The successfully managed wetland will be dependent on how the existing hydraulic regime can be maintained. The following general guidelines are provided to ensure better integration of wetlands and stormwater management during the land development process:

- A Biophysical Impact Assessment (BIA) should be completed at the Land Use/Outline Plan stage and should identify wetlands to be preserved, wetlands that will be integrated with stormwater concepts and wetlands that will be compensated.
- Preserved wetlands are fully protected in their natural state and are not a part of post-development stormwater management systems, however highly treated stormwater needs to be diverted to the wetlands to ensure their survival post-development.
- A Stormwater Management Report (SWMR) should describe how the preserved wetlands are going to be maintained. Generally, a water balance needs to be conducted on the wetland, with continuous simulation software utilizing 50 years of climate data, to establish the hydroperiod and the average annual pre-development runoff volume the wetland was receiving, as well as to assess potential pre-development discharge rates and volumes. This will provide the basis for evaluating the impacts of post-development discharges and establishing the post-development stormwater volume inputs to the wetlands, to ensure that pre and post-development wetland hydroperiods are matched.

- If natural wetlands are to be integrated with the post-development concept, the SWMR needs to include a description and necessary analysis to show how they are to be included into the post-development stormwater system, with inflow rates, frequency of inundation, vegetation and habitat management plans. Depending on the level of integration and engineering of these wetlands, they may be subject to compensation. Integrating existing wetlands into a post-development stormwater management concept is subject to ESRD approval.

Only highly treated stormwater may be discharged to preserved wetlands; the type and level of treatment and expected inflow water quality should be described in the SWMR report. In addition to treatment provided by wet ponds, a mechanical filter system may need to be considered to ensure adequate level of pollutant and nutrient removal.



LEGEND

- WETLAND - CROPPED BASIN
- WETLAND - EMERGENT VEGETATION
- WETLAND - OPEN WATER
- DUGOUT
- UNDEFINED
- RIPARIAN REGION
- STUDY AREA

ROCKY VIEW COUNTY
Cultivating Communities

MPE Engineering Ltd.

SPRINGBANK CREEK WETLAND AND RIPARIAN ASSESSMENT	DATE: APRIL 2016	SCALE: 1:75,000
	JOB: 2285-057	FIGURE: 4.9

4.5 Stormwater Best Management Practices

To minimize impacts on sensitive wetlands and to achieve the volume and water quality targets from development, three key types of stormwater management practices can be employed:

- Minimize the generation of runoff.
- Retain runoff on-site through evapotranspiration, infiltration and reuse.
- Capture, hold and reuse runoff within a development or regional system.

LID practices are an emerging science in stormwater management and include planning through site design and the application of CDPs. These provide a range of benefits from the retention of incident rainfall and runoff from adjacent impervious surfaces, to the treatment of runoff to improve water quality. More traditional end-of-pipe facilities can also play an important role and include constructed wetlands, wet ponds and detention storage areas.

In addition to hydrologic/hydraulic loading rates, the effectiveness of the various stormwater practices will depend on the level of maintenance and operation compliance that is achieved. In order to identify suitable LID practices for development, a number of factors need to be considered including function (i.e. volume reduction/water quality treatment capabilities), operation and maintenance requirements and location (i.e. on public or private land). The location is important as the owner is typically responsible for the future maintenance and therefore the long-term performance of a facility. The performance of potential stormwater management practices based on an assessment by MPE is summarized in ***Table 4.2***. Further description of individual practices is provided in ***Table 4.3*** and their suitability for the Springbank area is given in ***Table 4.4***.

Some LID practices require more maintenance than others. The County should consider an update applicable to County bylaws to enforce maintenance and upkeep of these systems. The integration of LID at the lot level will require documentation on the maintenance and upkeep of the LID. A self-reporting and auditing system may be an approach where the property owner and RVC share the responsibility, however, this self-reporting is more easily completed on industrial, commercial and multifamily developments than on single family residential lots. For small subdivisions, the most applicable LIDs are absorbent landscaping and rain barrels. These LIDs do not typically require significant maintenance and RVC involvement with these LID installations would be minimal.

Table 4.2: Stormwater BMP Performance Matrix

BMP Practice	Pollutant Removal	Volume Reduction	Peak Flow Reduction	Maintenance Requirements	Operation Requirements	Capital Cost	Suitability on Private Land	Suitability on Public Land
Better Planning Practices	M	M	M	N/A	N/A	L	H	H
Maintain Natural Undisturbed Areas	H	H	H	L	L	L	H	H
Minimize Impervious Area	M	M	M	L	L	L	H	H
Absorbent Landscape	H	H	M	L	L	L	H	M
Bioretention	H	L - M	M - H	H	L	M	M	H
Permeable Pavement	M	L - M	M - H	M - H	L	H	M	M
Green Roof	L	M - H	L - M	M - H	L	H	H	L
Rain Tank & Irrigation	M	M	L	M	H	H	H	L
Rain Tank for Non-potable Use	M	M	L	M	H	H	H	L
Bio Swales	M	L - M	M	M	L	L	L	H
Swales	L	L	L	M	L	L - M	H	L
Stormwater Reuse	M	M - H	M	M	H	M	M	H
Wet Ponds	M	L	H	M	L	H	L	H
Constructed Wetlands	H	L - M	M - H	M - H	L	H	L - M	H
Engineered Natural Wetlands	M	L - M	M - H	M - H	L	M	L - M	H

Notation: L – Low, M – Medium, H – High, N/A – Not Applicable

Table 4.3: Stormwater BMP Description and Discussion

Practice	Description, Key Benefits/Disadvantages
Better Planning Practices	The positioning of the development within the site, the road and lot layout and the arrangement of buildings on a lot can significantly influence the hydrology and water quality performance of a development. In addition to managing the increase in runoff volume, care needs to be taken not to significantly change the hydraulic loading of adjacent wetlands, including significantly reducing or increasing the runoff volume they receive. Best practices should be used to avoid these issues at the planning and the design phase of a development.
Maintain Natural Areas	Natural undisturbed areas generally have a higher infiltration and holding capacity than disturbed areas. They will be most effective where runoff from impervious areas can be directed and evenly distributed over such natural areas provided that the quantity and quality is closely controlled. This is one of the key practices that should be implemented for low impervious development in the watershed.
Minimize Impervious Areas	Reducing imperviousness of a development not only reduces the volume of runoff but also provides more opportunity for the pervious area to absorb runoff from the impervious areas. Developing cluster developments, reducing road widths and reducing building footprint by "building up" are examples.
Absorbent Landscape	Absorbent landscapes use thickened topsoil to provide additional capacity to absorb and hold direct rainfall and distributed runoff from adjacent impervious areas such as paving and roofs. They also promote infiltration and evapotranspiration similar to the original natural areas. Absorbent landscape areas would complement the desire of most property owners to beautify the property. The material for this type of landscape would ideally come from the topsoil stripping process for the building site and may require amendment to achieve the desired properties. Site grading and spreading of surface runoff from impervious areas are important components but the construction and maintenance of these practices is relatively straightforward. It is critical that the absorbent landscape material and subsoil do not become over-compacted during construction or ongoing operation. Absorbent landscaping is considered a practical and reliable LID practice that is ideally suited as a source control practice on private lots.
Bioretention	Bioretention areas are highly engineered soil media that allows stormwater to be filtered in a similar manner to a sand filter for water supply treatment systems. If no underdrain is present below the filtration media, it is typically referred to as a rain garden. Bioretention is typically designed to accept concentrated runoff and therefore is suited to accepting roof and road runoff. As bioretention areas have a higher hydraulic loading, they need higher levels of design input and higher maintenance requirements, especially during construction, as there is more potential for failure than absorbent landscape. This could be due to being undersized, to unsuitable growing media resulting in ponding, to plant selection not matching wetting and drying regime of the soil. These problems can result in owners desiring to remove them due to nuisance issues, which become problematic for long-term performance.
Bio Swales	Bio swales have a similar function to vegetated swales but provide additional treatment capacity through the use of a filtration media and may have an underdrain.
Green Roof	Green roofs involve placing a vegetated growing media layer on a roof to enhance evapotranspiration and reduce runoff volumes. They are especially effective in controlling intense, short-duration storms. They are typically used in higher density commercial and residential settings. Provide minimal water quality benefit in its own right, but can reduce runoff volume to improve efficiency of downstream treatment systems.

Table 4.3: Stormwater BMP Description and Discussion (continued)

Practice	Description, Key Benefits/Disadvantages
Permeable Pavement	Permeable pavements can reduce runoff from hard surfaces by allowing rainfall to infiltrate the surface and be stored in the voids of the underlying pavement from where it percolates further into the ground or evaporates back through the surface. Permeable paving is mostly suited for low traffic areas and requires specialist design, installation and maintenance requirements and is often costly to install and maintain. Using permeable paving (porous concrete and asphalt, pavers) and gravels and reinforced grassed areas for infrequent vehicle and foot traffic areas are means to reduce the impervious surfaces in developments. Suitable construction, operation and maintenance procedures are required for long-term performance.
Rain Barrel & Irrigation	Rain barrels or tanks that store water from impervious surfaces such as roofs can be used for irrigation. The water balance is actively managed either through an automatic system or users/owners that are dedicated to reusing rainwater. These systems require regular maintenance for efficient and continued operation. Considering these issues, it is likely that some of the installations may be prone to neglect or lack of use and therefore may not be fully relied upon for the long-term management of runoff.
Cistern & Non-potable Reuse	Cistern, rain tanks or vaults can be used for non-potable uses such as toilet flushing or other commercial uses. Stored water should be utilized regularly to be an effective LID practice (e.g. toilet flushing).
Vegetated Swales	The main function of vegetated swales is to convey runoff in a manner that allows some infiltration and water quality treatment, while providing flood protection capacity during a significant rainfall event. Slope and vegetation cover are important components to encourage siltation and to minimize erosion. Development in many parts of Springbank currently relies on this type of system to convey runoff from developed areas.
Stormwater Reuse	Stormwater that is captured in wet ponds and other storage facilities can be reused for irrigation of parks, golf courses, toilet flushing in commercial, institutional, residential buildings and for industrial processes. The level of treatment will be dependent on the level of exposure to humans and required quality for the intended use.
Wet Ponds	Wet ponds are traditional end-of-pipe solutions which are primarily used to reduce peak flows and provide water quality treatment, specifically reduction in sediment. They do have some volume control function due to evaporation and possibly infiltration into the underlying soils. An oversized shallow wet pond can function much like an evaporation basin.
Constructed Wetlands	Constructed wetlands provide the key functions of retention, detention, pollutant removal in addition to providing increased habitat, an amenity and a buffer zone to adjacent wetlands and streams. Wetlands and ponds usually provide the last opportunity to minimize development impacts, particularly when there is limited ability to incorporate LID practices within public lands.
Engineered Natural Wetlands	Engineered natural wetlands involve modifying existing wetlands to improve the hydraulic, biological and habitat function and can accept treated stormwater. Natural wetlands located at the bottom or at an intermediate level within an internal drainage area will likely require stormwater surface or subsurface inflows to maintain their hydraulic regime. If an existing wetland is to be part of a post-development stormwater system, it should not require a diversion license from ESRD. If the hydrological regime of a natural wetland is changed, an ESRD license may be required.

4.5.1 On-site Source Control Practices

The effectiveness of the specific on-site LID practices has been assessed against a number of factors as shown in ***Table 4.4***.

Table 4.4: Suitability of Source Control Practices

Site LID	Design / Install Expertise	Maintenance Requirements	Required to be Operated	Nuisance Potential	Difficulty to Relocate	Aesthetic Value
Maintain Natural Areas	L	L	L	L	H	H
Absorbent Landscape	L	L	L	L	L	H
Bioretention	M	M	L	L - M	M	H
Porous Pavement	H	H	L	L - M	M	M
Green Roof	H	M	L	L - M	H	M - H
Rain Barrel & Irrigation	M - L	M	H	H	M	L
Cistern & Non-Potable Reuse	H	M	H	H	H	L

Notation: L – Low, M – Medium, H – High

LID practices have been shown to be effective in controlling the volume of stormwater generated either on its own or in combination with wet ponds/wetlands. Many of the preferred LID practices are mainly located on private lots, which raise questions on their long-term operation and performance. Therefore, consideration should be given to how socially acceptable specific LID practices are and the likelihood that they will remain operational. Consideration is also given to what potential mechanisms or encouragement/incentives can be provided to ensure they remain operational over the longer term. LID practices should be included at the planning stage to better prepare for incorporation into the stormwater design.

4.5.2 Suitability Assessment of Stormwater Management Practices and Facilities

A suitability assessment of the range of stormwater management practices potentially being applied to various types of development within the study area is presented in ***Table 4.5***. The key conclusion is that specific practices are more suited to specific types of development.

Table 4.5: Suitability of Stormwater Practices

BMP Practices	Development Type									Maintenance Primarily by Municipal/Private
	Residential	Multi Residential	Retail/ Commercial	Industrial	Country Residential	Parks & Recreation	Cluster	Small Development	Large Development	
Better Planning Practices	M - H	L	L	L	H	L	H	H	M	P/M
Maintain Natural Areas	M - H	L	L	L	H	H	H	H	M	P/M
Minimize Impervious Area	M	L - M	L	L	M - H	M - H	H	M - H	M	P/M
Absorbent Landscape	M - H	L	L	M	H	H	H	H	H	P
Bioretention	L - M	M	M	M	M	M - H	M - H	M - H	M	P/M
Vegetated Swales	M	L	L	H	H	H	M	H	M	M
Bio Swales	M	L	M	H	H	H	M	H	M	M
Green Roof	L	M	H	M	L	L	L	L	L	P
Permeable Pavement	M	L - M	L - M	L	L	L	L	M	L	P/M
Rain Barrel & Irrigation	H	L	L	L	M	L	M	H	M	P
Cistern & Non-potable Reuse	M - H	H	H	M - H	H	L	M	M - H	M	P
Wet Pond	H	H	H	H	M	M	M	L	H	M
Wetlands	M - H	H	M	M	M - H	H	M - H	L	H	M
Stormwater Reuse	M	H	H	L - M	L	H	M	L - M	H	M

Notation: L – Low, M – Medium, H – High, M – Municipal, P – Private

4.6 Modelling of Stormwater Best Management Practices

It has been estimated that precipitation is approximately 11% higher in Springbank compared to the City of Calgary Airport. The City of Calgary typically recommends a 40 mm volume control target to adequately manage water quality of runoff discharging into the main rivers such as the Bow and Elbow Rivers. In catchments such as Pine Creek, and West Nose Creek, the volume control targets are lower, being 17 mm, in order to minimize stream erosion.

A water balance analysis using the City of Calgary water balance spreadsheet was used to assess the types of LIDs and source control practices required to meet specific targets. The analysis considered a 45mm volume control target for country residential, urban residential and industrial/commercial land uses. YYC daily rainfall/snowmelt was increased by 11% to reflect the higher runoff volumes expected in the Springbank Area. The types of practices required are provided in ***Table 4.6*** below.

Table 4.6: LID Practices and Land Use

Volume Control	Industrial/Commercial	Residential	Country Residential
45 mm	• Absorbent Landscape • Lot Irrigation • Bioretention (ROW/Lot) • Ponds • MR Irrigation	• Absorbent Landscape • Lot Irrigation • Ponds • MR Irrigation	• Absorbent Landscape • Ponds • MR Irrigation

The above water balance model was then tested to determine the average annual runoff volume if YYC precipitation data was used. The analysis indicated that the development would have a reduced annual average runoff volume of approximately 25 mm. This demonstrates that using Springbank precipitation data is an important factor in estimating development runoff in order to minimize downstream impacts.

Increased precipitation at Springbank would also result in higher runoff under predevelopment conditions compared to catchments that experience lower precipitation, assuming other factors are similar. Therefore a recommended higher runoff volume target for 45mm is similar to a 20mm volume control target required by the City of Calgary for natural streams such as Pine Creek.

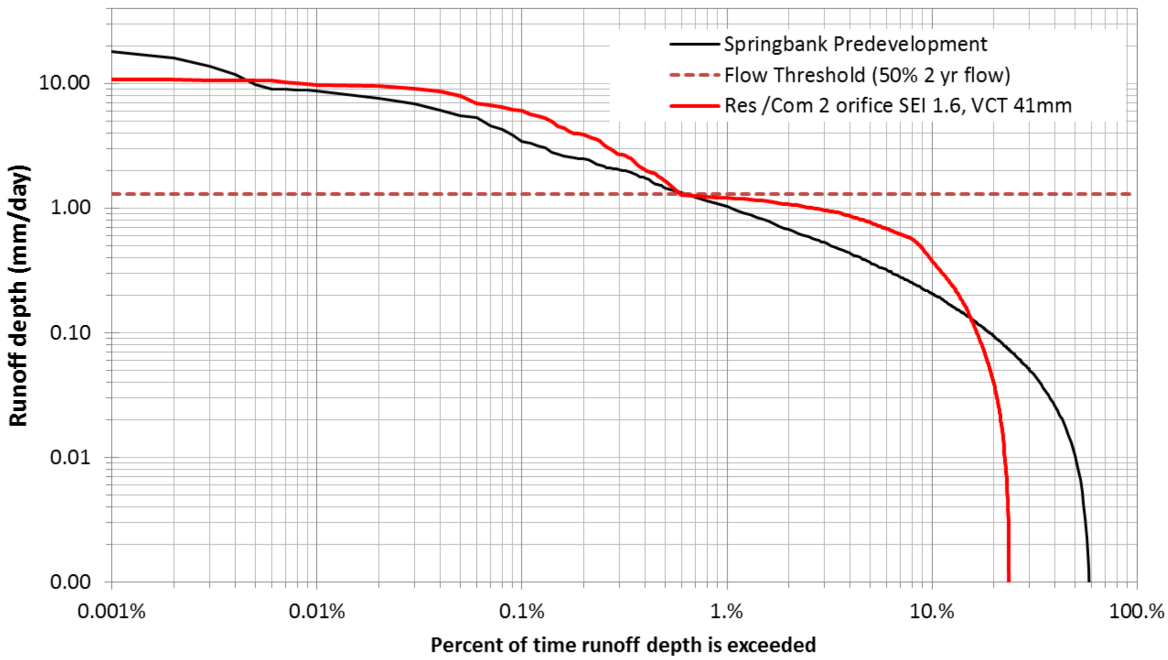
4.6.1 Stormwater Management Requirements to Limit Stream Erosion Impacts

The City of Calgary Water Balance Spreadsheet (WBSCC) was used to assess the level of stormwater volume control target required for a development and the system arrangement in order to minimize downstream erosion impacts. The SEI was used to assess the likely impact of different volume control targets to ensure the SEI remains below 2 (See Section 4.1.4). The analysis indicated that a Volume Control Target of less than 45 mm would need to be used to achieve a SEI below 2 with 30 mm potentially being required where a single orifice outlet control from a pond is being used.

The volume control target that could be adopted is dependent on the setup of the outlet controls and the size of the stormwater pond. An arrangement that permits preferential discharges below the 0.15 L/s/ha release rate will enable a higher portion of the volume to be below the flow stress threshold. This can be achieved by using multiple orifices and using a part of the active storage for the lower smaller orifice. ***Figure 4.10*** includes the flow duration curve from a development with a volume control target of 41 mm which uses a smaller orifice for the lower 1.2 m of active depth in the discharge pond and a larger orifice for the upper 0.8 m of active depth. The SEI of around 1.6 is achieved for this arrangement.

Figure 4.10 shows how the Land Development curve hugs the flow threshold line around the 1 percentile value. This arrangement will require more storage than a single orifice outlet; however a higher volume control target may be permissible under a multiple orifice arrangement. Therefore, the only difference in required practices in meeting the volume control target shown in ***Table 4.6*** and meeting an SEI of less than 2 is the storm pond configuration.

Figure 4.10: Land Development Flow Duration Curve



4.6.2 Runoff Modelling Considerations

Runoff modelling of single event and continuous simulation of various land use types and BMPs and LID practices are required to confirm sizing of the range of practices in order to meet the targets outline in Section 4.1.5 above. Robust local guidance is given for modelling traditional urban development and the sizing of stormwater ponds for rate control. However, there is limited local guidance for conducting continuous simulation analysis and understanding the runoff generated for high percentage of pervious area in developments that are typically found in Springbank. Also the understanding of the water balance of LID practices is still being developed. There needs to be some caution on the methods and assumption used. Some considerations in developing a continuous simulation water balance model include:

a) Impact of reduced infiltration and moisture holding capacity of soils due to construction activities compared with pre-development conditions and reduced infiltration that occurs during winter snowmelt events.
b) Accounting for the influence of higher precipitation compared to the main reference gauge at YYC and the influence this will have on BMP and LID performance. This is particularly critical where the development proposes to match pre-development flow duration curves.

c) Absorbent landscaping (thickened topsoil) should be limited to a maximum effective depth of 300 mm for modelling purposes and an Impervious to Pervious area ratio (I/P ratio) of not greater than 4:1, with a recommended I/P ratio of 3:1. Care needs to be given to how effectively concentrated flows can be dispersed evenly over the absorbent landscape surface as typically assumed. Consideration should be given to the influence of slope on the drainage mechanisms of the soil, as typical water balance models assume the soil profile act like a bath tub. One approach is to model the absorbent landscape as a bioretention area. However, this may still tend to overestimate the actual retention achieved through this practice. Another important consideration is the effective area of absorbent landscaping assumed in the model when impervious area is directed over it, particularly where there are concentrated flows and steeper slopes.

d) There is an inverse correlation between rainfall and evaporation when examining monthly records. That is, higher rainfall periods typically result in lower evaporation. This is due to the higher humidity and cloud cover that is experienced. Therefore, modelling should use actual monthly average evapotranspiration values for each year in the model, divided into a daily time step. Lower evaporation occurs during higher rainfall periods, and using this evapotranspiration data will mimic what is actually occurring.

e) Use the latest available precipitation and temperature input files that have been prepared by the City of Calgary.

f) Use the City of Calgary Irrigation Demand Estimation Tool to estimate irrigation demand and Frequency Analysis Tools in sizing of infrastructure when using continuous simulation analysis.

g) Demonstrate how model assumptions will be implemented in practice, including evenly distributing impervious area on previous surfaces, irrigation of all pervious areas.

h) Subsoil infiltration losses should be carefully considered when conducting water balance modelling. It should generally be assumed that very low to zero deep infiltration losses occur in the Springbank region if detailed supporting evidence is not provided. This implies that losses above normal evapotranspiration should be accounted for when meeting volume control targets and calculating flood storage volumes using continuous event analysis.

5.0 PROPOSED POLICY RECOMMENDATIONS AND PROCEDURES

5.1 Policy Considerations

Individual catchments in Springbank vary from one to another in terms of percentage developed, topography, catchment areas and soil types. There are subcatchments that are mainly agricultural where the drainage paths have not been affected by development, there are those catchments that are approaching being 100% fully developed and there are those catchments that are somewhat developed and have room to grow. These proposed policies will serve as an overall guide for developing these drainage plans within the Springbank study area. Additional policies for individual catchments may be developed in the comprehensive drainage plan proposed for each catchment. The following policies and procedures provide overarching stormwater management guidelines.

Three overarching areas for stormwater management policies for Springbank include:

1. Flood (Peak Flow) Protection and Management
2. Receiving Stream Riparian Areas Water Quality Protection
3. Treating Stormwater as a Resource

Each of these major stormwater management topics will be addressed in further depth below.

5.2 Flood Protection and Stormwater Flow Management

The main goal of stormwater management is to protect existing infrastructure and development from the impacts of flooding. As development occurs, the area of land that rainfall can infiltrate into the ground is reduced, and therefore there is a higher occurrence of runoff. Managing these higher runoff rates by properly sizing stormwater infrastructure such as culverts, swales, channels, ponds and LIDs is crucial to reduce flood damage to properties, and to protect the natural streams and riparian corridors. The approach to stormwater management for existing developments in Springbank will be slightly different than the approach taken toward future development.

5.2.1 Drainage Improvements to Existing Developments

A number of subdivision developments and properties are known to experience a range of stormwater issues due to inadequate stormwater management systems. Many existing developments were originally designed for onsite stormwater management, and ignored the downstream effects of discharging runoff more frequently. To mitigate these existing issues and to avoid future issues resulting from developments already in place, the proposed guidelines for existing developments, redevelopment or retrofit construction works are as follows:

- New residences to be built in serviced and developed subdivision lots should not be built below the 1:100 year flood elevations within proximity to stormwater ponds and defined drainage routes, i.e. the lowest building opening should be at least 0.3 m higher than the 1:100 year flood elevation or safe overland spill elevations.
- No net increase in existing peak flows is allowed in channels, as well as no increase to culvert capacities.
- Existing properties within the 1:100 year flood plain may be permitted to put measures in place to mitigate flood risk, such as building berms, armouring channels at bends and increasing storage in the flood plan areas. These modifications should have negligible impact on runoff volumes and peak flows, particularly in areas that have known flood issues.

5.2.2 Future Developments

Future developments in Springbank must not exacerbate existing stormwater issues. In order to achieve this, it should be demonstrated that peak flows do not increase in the drainage routes. The following guidelines for future development are proposed:

- Peak flows from greenfield development must be managed to allow a net zero increase in peak flows over pre-development conditions, or peak discharge must be less than or equal to the UARR of 1.71 L/s/ha, as established by Westhoff, 2004.
- If downstream constraints are less than 1.71 L/s/ha (i.e. undersized culvert), then the new development could resolve the downstream constraint or adopt the lower release rate in order to not exceed the capacity of the downstream constriction. This will involve hydraulic modelling to confirm the capacity of the downstream culverts. It has been determined for the Springbank that natural runoff often exceeds the 1.71 L/s/ha pre-development UARR set for future development. Also, existing developments that have not been adequately controlled will also increase the release rate. Therefore, modelling is generally required to establish the required culvert sizes. In the absence of a catchment drainage plan, a high level estimate of culvert capacity of downstream culverts is necessary to determine if they exceed the 1.71 L/s/ha.

- All new development should be restricted from building within a defined 1:100 year floodplain such as the Bow or Elbow Rivers and their local tributaries.
- In areas with trapped lows, property minimum building openings should be at least 300 mm above the overland drainage escape route.
- The Developer must include an operations and maintenance plan for the development area, subjected to the approval of the County.

5.3 Water Quality and Stream Protection

- A runoff volume control target of 45 mm or lower shall be required for all development that releases into or passes through a natural stream.
- The timing and runoff volume of discharges from development shall be controlled to achieve a Stream Erosion Index of less than 2 on a unit area basis using a flow threshold of 0.15 L/s/ha (1.3mm/day) and predevelopment runoff as per the SEI spreadsheet calculator provided by the County (refer Section 4.1.4).
- The flow discharging from the development shall not exceed 10% more than the flow threshold where the pre-development flow intersects the flow threshold line on a flow duration curve.
- YYC precipitation data shall be increased by 11 percent when undertaking water balance modelling using approved models WBSCC and SWMM.
- Provide downstream ROW until an adequate outlet is provided. An adequate outlet includes a drainage path with a defined channel to a point where there are no measurable downstream impacts. Consultation with downstream landowners should be completed.

5.4 Stormwater Management Requirements for Minor Developments

Springbank has been undergoing substantial development pressures from a very broad range of development types. These include major development like Harmony and Bingham Crossing to small two to three lot subdivisions on larger acreage properties. Therefore it has been proposed that the above requirements (Sections 5.2 and 5.3) may be relaxed where development comprises of larger lots types and low impervious area, as follows:

Developments with < 10% Impervious Area and no Internal Roads

- The minimum requirement involves directing the impervious area onto undisturbed natural areas or onto an absorbent landscape.
- The natural areas or absorbent Landscape shall using an I/P ratio of 0.2 or lower, that is providing a minimum of 5 m^2 of pervious area for every 1 m^2 of impervious area.
- Roof and paved surface runoff should be spread out over the pervious surfaces and not concentrated into ditches or conveyance swales.

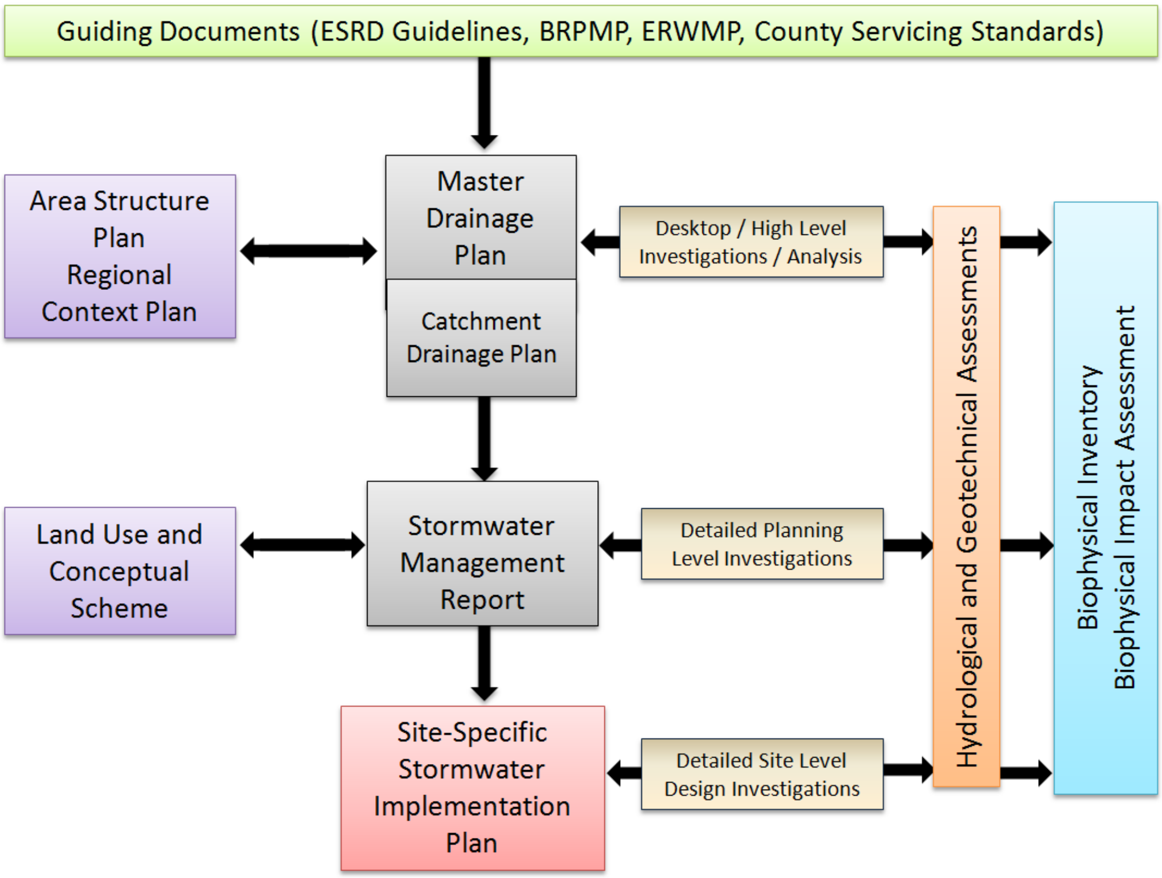
Developments with < 20% Impervious Area with or without Internal Roads

- Peak flows from must be managed to be less than or equal to the UARR of 1.71 L/s/ha.
- A runoff volume control target of 45 mm or lower shall be required for all development that releases into or passes through a natural stream.

5.5 Stormwater Planning and Reporting Procedures

The types of stormwater management studies and how they relate to the various levels of planning that is described in the County Servicing Standards are provided in ***Figure 5.1***.

Figure 5.1: Relationship Between Different Planning Documents



5.6 Catchment Drainage Plans

Develop a 'typical' scope of work and list of requirements for Catchment Drainage Plans. The scope of work may include:

- Analyzing how to eliminate or improve site constraints.
- Verifying constraints through private property.
- Completing flood risk assessment and potential property damage.
- Evaluate impact to wetlands or other sensitive areas, etc.
- Assessment of site constraints.
- Constraints through private property.
- Complete flood risk assessment and flood plain mapping.
- Evaluate impact to wetlands.

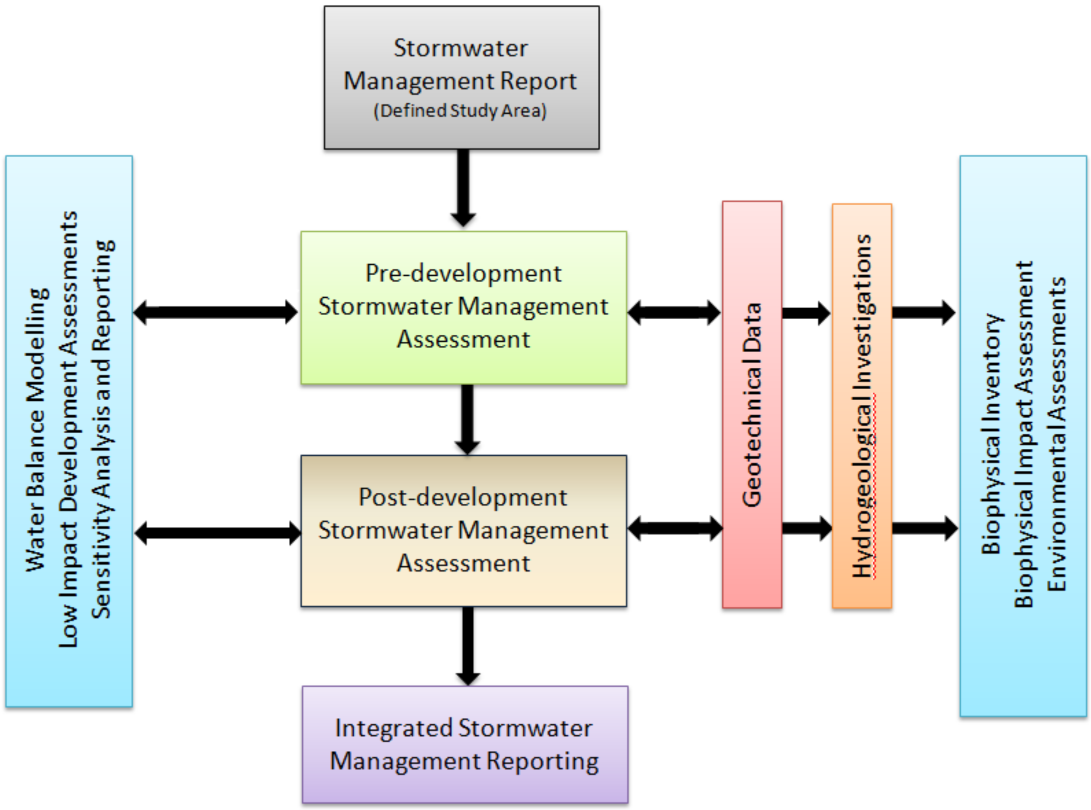
- Hydrological modelling:
    - Single event modelling: 1:100 year 24 hour rainfall.
    - Continuous simulation modelling: Full data set for Calgary International Airport for precipitation including snowfall increased by 11%.
- Floodplain mapping and/or trapped low spill analysis.
- Determine proposed storage locations and drainage path alignments.
- Develop capital expenditure costs for main infrastructure additions or upgrades, including culverts, easements, ROW acquisition, pond construction, LID controls, etc.
- Stream Erosion Analysis of the existing catchment.
- 100 year flood analysis and flood plain mapping.

5.7 Stormwater Management Report

The steps required to develop a plan ensure that stormwater runoff is adequately managed within the development, the broader catchment and the downstream receiving streams to show that sensitive environments and existing infrastructure are protected. It should be demonstrated how stormwater is to be controlled to maintain the hydrological regime of the wetland. The key components for a Stormwater Management Report submission, as shown in ***Figure 5.2***, should include:

- Wetland Management Plan identifying the hydrological regime of existing wetlands, sensitivity and class of the wetland, existing infrastructure constraints and wetland augmentation measures.
- Stormwater Management Assessment of proposed developments including water balance modelling and sensitivity analysis to test robustness of proposed strategy.
- Geotechnical and Hydrogeological Investigation including soil sampling, soil testing, infiltration assessments, identification of confining layers (if any), groundwater monitoring and infiltration impact assessments.

Figure 5.2: Stormwater Management Report Development Process



Similarly, the Site-Specific Stormwater Implementation Plan (SSIP) processes would follow a similar development process to the Stormwater Management Report, however a more detailed level of assessment is needed based on a firmer understanding of the development layout and constraints. The various components of these are discussed in the next sections.

5.8 Wetland Management Plan

A Wetland Management Plan should establish the environmental and hydrological characteristics of a particular wetland based on the following:

Assess Hydrological Characteristics and Environmental Values

- Define direct physical area draining to the wetland.
- Survey of depressions to define height, surface area and storage characteristics.
- Wetland class and historical evidence of water level variations.

- Conduct BIA to define vegetation type and environment significance.
- Typically wetlands would have very low infiltration characteristics but they often involve groundwater discharge/recharge interactions. Groundwater interaction may need to be quantified depending on the conditions of the wetland.

Establish the Pre-development Water Balance

- Develop a water balance model of the undeveloped catchment and depression low point.
- Use typical values to establish runoff from the natural catchment and review water balance of the depression.
- Compare predicted water levels with historical evidence.
- Adjust model parameters to achieve representative performance of wetland.
- Establish water level variations considering a 50 year historical period.
- Conduct a sensitivity analysis of key model parameter to ensure flood level variations are appropriately robust for determining predicted flood levels.
- Use the annual high water elevations from the water balance analysis to determine the statistical 1:100 year flood level.

5.9 Post-development Stormwater Management Assessment

A Post-development Stormwater Management Assessment should be conducted to ensure the volume control target for stormwater discharges released from proposed development within a local watershed is achieved. This would involve:

- Assess the extent and type of development.
- Identify appropriate stormwater control measures at the site, street and subdivision level to control runoff.
- Assess hydrological conditions and likely infiltration rates.
- Water balance modelling analysis.
- Conduct additional field investigation and analysis to define hydrogeological constraints and downstream impacts for areas incorporating infiltration.
- Determine how sensitive retained wetlands are managed and protected.

Undertaking a stormwater management assessment for an area or region should involve the following steps:

1. Define types of land use being proposed.
2. Determine existing development that may need to be taken into account.
3. Determine imperviousness and hydrological parameters.
4. Estimate infiltration parameters based on site soil characteristics (refer to Section 4.5 for further geotechnical and hydrogeological investigations required).
5. Identify suitable stormwater practices for each development type.
6. Prepare suitable daily (1960 to 2010) or sub-daily water balance model which covers a preferred 50 year data period including the 2005 event.
7. Run model and determine if stormwater measures result in target volume controls being met.
8. Adjust model design sizes until target runoff volumes are met.
9. Calibrate model based on best available historic information and carry out sensitivity analysis.
10. Adjust parameters based on hydrogeological investigation outcome.

5.9.1 Geotechnical and Hydrogeological Investigations

A range of geotechnical and hydrogeological investigations should be required following a preliminary assessment of the infiltration rates and potential infiltration impacts, including:

- Geotechnical and hydrogeological desktop assessment.
- Preliminary field investigations.
- Infiltration impact assessment.
- Geotechnical and hydrogeological investigations based on potential impacts and risks.
- Hydrogeological studies to assess the long-term sustainability and downstream impacts considering the direction of groundwater flows.

The procedures outlined below are summarized from *The City of Calgary Low Impact Development Project Module 1 - Geotechnical and Hydrological Considerations* (EBA 2014). This document should be referred to in completing the investigations and analysis described below.

The higher the actual or assumed infiltration rates used for LID practices and facilities, the more reliant the performance of the system is on infiltration capacity to achieve the volume reduction target. An infiltration capacity investigation and monitoring will be required to ensure long-term performance and minimization of unintended downstream impacts. Also, the groundwater impacts from these facilities will need to be understood.

The geotechnical and hydrogeological investigations should involve the following procedures:

Develop Preliminary Site Field Investigations *(Conducted at Stormwater Management Report Level)*

- Take preliminary soil samples (minimum of three per study) to characterize soil horizons and define any confining layers (refer Table 3.1, EBA 2014).
- Conduct infiltration tests on soils at or below the proposed infiltration zone (refer Table 3.3, EBA 2014).
- Identify presence of groundwater, likely recharge areas and seasonal variations for a minimum of one season (monitoring should be continued monthly for a minimum of two years if the development has not proceeded).
- Identify potential for high groundwater to be a restriction on infiltration capacity of the LID practices and stormwater facilities.

Post-development Infiltration Impact Assessment *(Stormwater Management Report Level)*

- Calculate pre-development infiltration volumes for the site or catchment.
- Calculate infiltration volumes from proposed LIDs and facilities based on preliminary assessments.
- Consider external hydrological inputs such as irrigation or septic fields in determining the infiltration impact.
- Determine change in infiltration volume by comparing the pre-development and post-development conditions.
- Use *Geotechnical and Hydrogeological Considerations* (EBA, 2014) to determine calculation methods and procedures.

Hydrogeological Studies to Assess the Long-term Sustainability and Downstream Impacts
(Conducted for Subdivision Stormwater Management Report Level)

Where the Post Development Infiltration Assessment indicates that a measurable change in groundwater elevations may occur resulting in a potential downstream impact the flowing procedures should be followed as identified in EBA (2014):

- Develop a conceptual groundwater model to assess potential for groundwater table influences, flow directions and downstream impacts.
- Assess impacts on downstream development, infrastructure and property.
- Assess potential for rising groundwater table and potential impacts on the infiltration capacity of proposed facilities.
- Maintain established groundwater monitoring program into the post-development period for a minimum of five years or as required by the approving authority.

Refer to *The City of Calgary Low Impact Development Project Module 1- Geotechnical and Hydrological Considerations* (EBA 2014) for additional testing and analysis requirements during the detailed design phase of a development.

5.9.2 Water Balance Modelling Methods and Reporting

A component of developing an overall integrated stormwater management plan is to consider the water resources impacts of the development, specifically:

- Water Balance Modelling Methods.
- Key parameter sensitivity analysis and impact assessment.

The water balance modelling will include the following analysis and reporting requirements based on the analysis outlined in Section 5.5.2 above.

5.9.3 Water Balance Modelling Methods and Requirements

The following approaches and assumptions should be incorporated into the water balance modelling:

- Daily or sub-daily precipitation time series data over 50 years (refer to City of Calgary Data).
- Account for the influence of higher precipitation compared to the main reference gauge at YYC and the influence this will have on BMP and LID practices.
- Evapotranspiration based on actual monthly values.
- Initial sizing of CSPs shall be based on the City of Calgary technical guidance documents.

- Select suitable model parameters for LID practices, in particular, timing of stormwater reuse for irrigation, clogging factors to account for long-term infiltration performance, effective footprint and base area/storage volumes of vegetative practices like bio swales and bioretention.
- Select effective area for absorbent landscape considering building setback, site slopes and ability to spread flow evenly over an area.
- Where absorbent landscaping are being applied on slopes greater than 5%, consider the area of absorbent landscaping that the roof leaders can effectively be spread over (i.e. a 2 to 3 m width down slope from the roof leader).
- Adopt a model that incorporates interflow (allows moisture in excess of field capacity to drain down slope – such as the bioswale practice in WBSCC or MUSIC).
- Absorbent landscaping should be limited to a maximum effective depth of 300 mm for modelling purposes and have a recommended I/P ratio (ratio of impervious area to pervious absorbent landscape area) of less than 3:1, with a maximum I/P ratio of 4:1.

5.9.4 Water Balance Modelling Sensitivity Analysis

A sensitivity analysis should be conducted to assess the robustness of the design given changes to the key variables being used in the model. Soil infiltration rates and water reuse demands are two key variables subject to the highest potential variability and influence on the performance of the management of stormwater management facilities within the internal drainage area. The following analysis should be considered in preparing a sensitivity analysis report.

1. Sensitivity on Infiltration Rates

- Run 1 – apply 50% reduction to adopted LID infiltration rates.
- Run 2 – apply 30% reduction to adopted LID and stormwater facility infiltration rates (where a pond liner is not being used).
- Run 3 – apply a 200% increase to adopted LID and stormwater facility infiltration rates (where a pond liner is not being used).

2. Sensitivity to Water Reuse Estimates

- Run 1 – apply a 50% reduction to industrial/domestic reuse demands (non-irrigation).
- Run 2 – apply a 100% reduction to industrial/domestic reuse demands (non-irrigation).

- Run 3 – apply a 50% reduction to irrigation demand.
- Run 4 – apply a 50% reduction to industrial/domestic and irrigation demands.

3. Sensitivity Analysis Absorbent Landscaping Parameters

- Run 1 – apply a 30% increase in topsoil compaction and a 30% reduction to topsoil thickness.
- Run 1 – apply a 50% reduction to topsoil and subsoil infiltration.
- Run 2 – apply a 50% reduction to effective area of the absorbent landscape.

5.9.5 Integrated Stormwater Management Reporting

The investigations and analysis conducted in developing an integrated stormwater management plan should be documented in a report with supporting data and analysis. It is envisioned that increasing degrees of detail would be expected for the Catchment Drainage Plan, Stormwater Management Plan and the Subdivision Stormwater Management Report. If underlying assumptions of the higher level document are found to be invalid, a review of the water balance and hydrogeological modelling analysis of the overall study area should be revisited. These reports should include the investigations and analysis supporting development of an internal drainage area or areas. The report should include the following components:

- Wetland Management Plan
- Stormwater Management and Water Balance Assessment
- Geotechnical and Hydrogeological Investigations
- Water Balance Modelling and Reporting

The report would need to demonstrate that the key policies for the Springbank MDP have been addressed and investigations and site-specific analysis conducted to ensure risks and adverse impacts are adequately managed.

6.0 SUMMARY OF RECOMMENDATIONS

Stormwater Management Policies for Springbank

All proposed development and redevelopment should prepare a Stormwater Management Plan which addresses the following:

1. All new development should be restricted from building within a defined 1:100 year floodplain such as the Bow or Elbow Rivers and their local tributaries.
2. New residences to be built in serviced and developed subdivision lots should not be built below the 1:100 year flood elevations within proximity to stormwater ponds and defined drainage routes, i.e. the lowest building opening should be at least 0.3 m higher than the 1:100 year flood elevation or safe overland spill elevations.
3. Stormwater management BMPs, LID practices and wet ponds/constructed wetlands with detention storage to be adequately sized to meet volume controls and restrict discharges to meet the maximum 1 in 100 yr event unit flow rate of 1.71 L/s/ha or lower where downstream constraints exist.
4. A volume control target of 45 mm or lower to achieve an SEI index of 2 or lower is required for all development that releases into or passes through a natural stream.
5. Discharges from a proposed development shall demonstrate that the Stream Erosion Index is 2 or lower, using the SEI calculator provided by the County.
6. The flow discharging from the development shall not exceed 10% more than the flow threshold where the pre-development flow intersects the flow threshold line on a flow duration curve.
7. Stormwater management requirements for minor developments has been reduced due to the minimal impacts of these development have on the receiving stream and the practicalities of proving effective infrastructure to meet the more stringent requirements and associated planning efforts expected for major developments.
8. YYC precipitation data shall be increased by 11 percent when undertaking water balance modelling using approved models which include WBSCC and SWMM based models.
9. Provide downstream ROW until an adequate outlet is provided.
10. LID practices and stormwater management practices should be adequately sized. The potential influence on groundwater mounding and base flow discharges to downstream facilities or natural wetlands should be adequately investigated.

Integration of LID Practices

The most applicable LID practices for Springbank are:

1. The use of absorbent landscaping to help decrease runoff and recharge aquifers.
2. Rainwater harvesting, to use on lawns to help reduce peak flow runoff and increase infiltration.
3. The use of grassed swale and bio swales for flow conveyance.
4. Bioretention areas to provide water quality treatment, decrease peak flows and encourage groundwater infiltration.

Management of Natural Wetlands

Natural wetlands that are to be retained within the development areas should be managed by:

1. Being integrated into the development water balance in a manner to maintain the wetlands pre-development hydrological regime, including volume and hydro period.
2. Only directing adequate treated stormwater runoff into the wetlands using these facilities for a component of detention storage during significant flood events such as a 1 in 100 year event or in emergency situations subject to the approval of the approving authority.

7.0 REFERENCES

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APPENDIX A

Wetland and Riparian Assessment

HAB-TECH environmental

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November 3, 2014

David Seeliger, *P.Eng.*
Senior Water Resources Engineer
MPE Engineering Ltd.
Suite 320, 6715 – 8 Street NE
Calgary, Alberta T2E 7H7

Dear Mr. Seeliger:

Re: Springbank Master Drainage Plan – Wetland Inventory and Assessment

This letter report provides an inventory, classification and mapping of wetlands and riparian areas within the Central Springbank ASP. The report includes an evaluation and identification of areas of sensitivity, relative importance of wetland types, potential impacts of stormwater drainage on wetlands and riparian areas, as well as mitigation strategies.

Thank you for considering HAB-TECH for this work. Please do not hesitate to contact me by email at jvargas@hab-tech-env.com or by phone at 403-239-9726 should you have any questions or concerns.

Sincerely,

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WETLAND INVENTORY AND ASSESSMENT

Wetland Classification and Mapping

Wetlands previously mapped by Rocky View County in the Central Springbank Master Drainage Plan area were classified based on the Steward and Kantrud Wetland Classification System (Steward and Kantrud 1971). This classification system has been adopted by Alberta Environment (2007) and the City of Calgary (2004) for wetland assessment and compensation in the region.

Reconnaissance-level field visits were conducted between July 29th and August 11th 2014. A total of 114 wetland polygons were visited, as well as 7 riparian areas/drainage courses. The majority of the surveyed wetlands were mapped previously by Rocky View County (Figure 1). Photographs were taken at each visited wetland site and botanical information sufficient to identify wetland class and dominant wetland vegetation association(s) and physiognomy was collected. The edges of sampled riparian areas were walked on foot and delineated using the track log function of hand held GPS units. It is important to note that "edge" in this report does not mean where the current open water channel flows, but rather the extent or width of existing wetland vegetation surrounding the main channel. By walking this edge it was possible to accurately map the width of the sampled riparian areas. Notes and photos were taken within the riparian areas with regards to potential for blocking (such as tree falls, destroyed culverts etc.), signs of erosion, and overall native integrity of the riparian areas.

Ground truth information from the field reconnaissance sites was used in combination with visual interpretation of orthophotos (1:10,000 scale – 2012) to classify all the wetlands mapped by the Rock View County for the Springbank MDP study area. Wetland boundaries were not modified and only a few large wetlands were added. Wetland boundary assessment was outside of the scope of this project. It was however noted during field visits and during orthophoto classification that: 1) some wetlands were not mapped, in particular small wetlands; 2) some wetlands were partially mapped (e.g. only the central wetter portion was mapped, but not the surrounding wet-meadow/low-prairie zones); 3) some mapped wetlands were part of a single larger wetland; 4) some areas mapped as wetlands were in fact not wetlands, and; 5) some mapped wetlands were part of larger riparian, or drainage course areas. The latter wetlands were merged as part of the riparian areas in our mapping and area analysis. Such issues should be addressed when specific and more detailed development planning is conducted.

Table 1 summarizes the classifications of the frequency and land area of identified wetland polygons for different wetland classes (either mapped by Rocky View County or identified by visual interpretation of the orthophotos).

Table 1 Classifications and summary of the wetland polygons identified for the Springbank Master Drainage Plan area

Type	Polygons	Min Size (ha)	Max Size (ha)	Average Size (ha)	Total Size (ha)
Ephemeral/Temporary wetland - Class I/II	276	<0.1	2.0	0.1	33.3
Ephemeral/Temporary wetland - Class I/II Tilled	237	<0.1	1.5	0.1	29.5
Seasonal wetland - Class III	337	<0.1	4.1	0.3	87.8
Seasonal wetland - Class III Tilled	94	<0.1	1.3	0.2	21.1
Semi-Permanent wetland - Class IV Tilled	15	0.1	2.0	0.5	6.9
Semi-Permanent/Permanent wetland - Class IV/V	37	0.1	113.5	4.5	165.6
Manmade	93	<0.1	1.4	0.2	15.2
Riparian	-	-	-	-	207.4
Not a Wetland	16	-	-	-	-

Wetland Type Descriptions

The classified wetlands and man-made ponds/dugouts (excluding the ones that are part of drainage course/riparian areas) occupy 359.4 ha (2.3%) of the Springbank MDP area. Riparian areas occupy 207.4 ha (1.4%), totaling 566.8 ha (3.7%) within the boundaries of the Springbank Master Drainage Plan area (Figure 2). Semi-permanent/permanent wetlands are the largest wetlands, with an average size of 4.5 ha. These wetlands occupy 165.6 ha (37 polygons). Semi-permanent tilled, seasonal, temporary and ephemeral wetlands are generally smaller and occupy 178.6 ha (959 polygons). Manmade dugouts and ponds occupy 15.2 ha (93 polygons). Wetlands were typically embedded within a matrix of cultivated fields. As a result 34% of the wetlands (346 out of 1089) were found to be recently tilled. The majority (71.3%) of the tilled wetlands are ephemeral/temporary wetlands. Descriptions of each mapped wetland type are provided below.

Ephemeral/Temporary Wetlands (Class I/II)

Ephemeral wetlands are characterized by low-prairie vegetation occupying the central area of the wetland. Surface water is ordinarily maintained for only a brief period in the early spring before the bottom ice seal disappears. Temporary wetlands are characterized by wet-meadow vegetation found in the deepest portion of the wetland and surface water is only maintained for a few weeks after the spring snowmelt or after heavy rainfall events (Steward and Kantrud 1971).

A total of 513 wetlands within the study area were classified as ephemeral/temporary and comprised 62.8 ha (0.4%) of the area. The ephemeral/temporary wetlands were divided into two groups. The first group included wetlands that have been recently and completely cultivated (Ephemeral/Temporary Wetlands Tilled – Class I/II). A total of 237 ephemeral wetlands covering 29.5 ha were tilled – Class I/II. All these wetlands were dominated by agronomic species, although some had patches of foxtail barley (*Hordeum jubatum*), northern reed grass (*Calamagroastis inexpansa*), smooth brome (*Bromus inermis*), Nuttall's salt-meadow greass (*Puccinellia nuttalliana*) and dandelion (*Taraxacum officinale*) (Photo 1 and 2). Native ecological integrity and functionality of these wetlands is severely compromised by frequent tilling that impedes the development of natural wetland processes and habitat characteristics.

The second group included ephemeral/temporary wetlands that had not been cultivated in recent years. A total of 276 wetlands covering 33.3 ha were classified as Ephemeral/Temporary Wetlands – Class I/II. Such wetlands typically contained the following invasive species: Smooth brome (*Bromus inermis*), timothy (*Phleum pratense*), clover (*Trifolium sp.*), stinkweed (*Thlapsi arvense*), Kentucky bluegrass (*Poa pratensis*), dandelion (*Taraxacum officinale*), Canada thistle (*Cirsium arvense*) and perennial sow thistle (*Sonchus arvensis*). However, in some areas native species like slender wheat grass (*Elymustrachycaulus ssp. trachycaulus*) and fine sedges (*Carex spp.*) were found (Photo 3 and 4). Floristic and structural diversity of these wetlands are significantly limited due to grazing, past tillage and/or non-native plant invasion. As a result these wetlands have low habitat suitability for wildlife species at risk or rare plants. Native ecological integrity of these wetlands is generally low.

Seasonal Wetlands (Class III)

Seasonal wetlands are characterized by shallow-marsh vegetation occurring in the deepest portion of the wetland. Surface water is usually maintained in spring and early summer (Steward and Kantrud 1971).

A total of 431 of the wetlands were classified as seasonal and occupied 108.9 ha (0.7%) of the study area. These wetlands were divided into two groups. The first group included seasonal wetlands that had been recently tilled. Ninety-four wetlands covering 21.1 ha were classified as Seasonal Wetlands Tilled – Class III. These wetlands were dominated by agronomic species and were generally highly degraded, with low native floristic and structural diversity. Shallow-marsh plant species found in the deepest portion of these wetlands were: slough grass (*Bechmannia syzigachne*) and coarse sedges (*Carex spp*) mixed with wet-meadow plant species such as foxtail barley and Nuttall's salt-meadow grass (Photo 5). Some of these wetlands were invaded by non-native species such as smooth brome, and some wetlands were still in the open water stage, and had sparsely distributed patches of cattail (*Typha latifolia*) and bulrush (*Scirpus lacustris*).

The second Class III group included seasonal wetlands that had not been cultivated in recent years. A total of 337 wetlands covering 87.8 ha were classified as Seasonal Wetlands – Class III. These wetlands were characterized by a shallow-marsh zone in the deepest portion of the wetlands dominated by some of the following species: creeping spike-rush (Eleocharis palustris), awned sedge (*Carex atherodes*), water sedge (*C. aquatilis*), slough grass and golden dock (*Rumex maritimus*). Patches of common cattail occurred sporadically (Photo 6). Other wetland species that were frequently observed included: foxtail barley, wire rush (*Juncus balticus*), Nuttall's salt-meadow grass, tickle grass (*Agrostis scabra*) and tufted hairgrass (*Deschampsia caespitosa*). Sparsely distributed wetland species included: wild mint (*Mentha arvensis*), common plantain (*Plantago major*) and bulrush (*Scirpus spp*). Low-prairie and wet-meadow zones of these wetlands were usually invaded by non-native plant species. The ecological integrity for these wetlands were predominantly rated as moderate.

Semi-Permanent/Permanent Wetlands (Class IV/V)

Semi-permanent wetlands are characterized by deep-marsh vegetation in the deepest portion of the wetland. Surface water is maintained throughout spring and summer and sometimes into fall and winter. Permanent wetlands are characterized by a deep-water zone with submerged vegetation in the deepest portion of the wetland and surface water is maintained throughout the year (Steward and Kantrud 1971).

A total of 52 of the wetlands were classified as semi-permanent/permanent and occupied 172.5 ha (1.1%) of the study area. These wetlands were divided into two groups. The first group included semi-permanent wetlands that had been cultivated in dry years. Fifteen wetlands covering 6.9 ha were classified as Semi-permanent Wetland Tilled – Class IV. These wetlands were generally located within cultivated fields, and as a result, litter cover was shallow and sparse, and structural and floristic diversity was limited (Photo 7). These wetlands were characterized by deep marsh vegetation in the deepest portion of the wetland, which was dominated by common cattail, spike rush (*Eleocharis palustris*) and bare soil. The shallow-marsh zone of these wetlands was dominated by slough grass, and foxtail barley. The outer vegetation rings of wet-meadow/low prairie zones were cultivated.

The second group includes semi-permanent/permanent wetlands that had not been cultivated in the deep-marsh and shallow marsh zones. Accurately distinguishing between these permanent and semi-permanent wetlands requires detailed historical air photo analysis, which was outside of the scope of this inventory. Historical air photo analysis is typically conducted at the individual property assessment level of planning. A total of 37 wetlands covering 165.6 ha were classified as Semi-permanent/permanent Wetlands – Class IV/V. The more shallow wetlands were characterized by deep marsh vegetation in the deepest portion of the wetland, which was dominated by common cattail and/or spike rush (Photo 8) Some of these wetlands were characterized by a shallow water or mudflats zone interspersed or surrounded by common cattail, duckweed (*Lemna minor*), and/or bulrushes. In the deeper wetlands, vegetation in the deep-water zone was sparse or absent and dominated by common cattail and bulrushes. Duckweed was also found in patches of standing water. Patches or outer rings of shallow-marsh and wet-meadow vegetation are often present (Photo 9). The shallow-marsh zone, when present, was characterized by the same species described for the shallow-marsh zone of the Seasonal Wetlands – Class III. Common species in the wet-meadow zone were: foxtail barley, Nuttall's salt-meadow grass, brome, fine sedges, and wire rush. The native ecological integrity of these wetlands was generally rated as high.

Dugout/Man-Made Ponds

Even though dugouts and man-made ponds are not wetlands, they were mapped as such by Rockyview County. A total of 93 Dugout/Man-Made Ponds were mapped occupying 15.2 ha (0.1%) of the study area. Some dugouts occurred in upland areas while some were located inside of natural wetlands. Man-made ponds were often wetlands prior to excavation/construction. Some of them supported scattered wetland vegetation such as common cattail, reed canary grass and foxtail barley (Photo 10).

Non-Wetland Polygons

A total of 16 polygons mapped by the County as wetlands are no longer wetlands. These may have been ephemeral to temporal wetlands in the past, however no defined wetland basins or wetland vegetation were observed during the field visits (Photo 11).

Riparian Areas

Riparian areas comprise 207.4 ha (1.4%) of the study area and support a variety of characteristics and species composition that resemble all five wetland classes. Some areas are relatively flat and wide (Photo 12), with vegetation in these areas being similar to a Class II wetland. Other areas are positioned within ravine topography having slightly steeper side slopes, creating a narrower but wetter water channel (Photo 13). These ravine areas have vegetation more similar to a Class III wetland. In yet other types there are natural basins within the drainage course that resemble Class IV (Photo 14) or Class V wetland vegetation (Photo 15).

Several riparian water courses transect the study area, including three in the north connecting to the Bow River, and three in the south connecting to the Elbow River. Each of these riparian areas have two or more tributaries (Figure 2). Notably, the riparian areas that connect to the Elbow River have several large tributaries. Riparian areas are water drainage channels that provide the important function of draining water while preventing flooding and excessive run-off. . As such it is important to keep these areas intact in the context of future development of the area.

All of the riparian areas visited during field surveys were intact with functioning culverts under roads, and no major blockage issues. However, some potential for future blockages were documented in the southeastern part of the study area (Figure 3). In one area there is a steep slope with bare soil adjacent to the river (Photo 16). In years with high water levels, there is potential for erosion and/or mudslides in this area. Some other areas with minor potential for blocking were characterized by abundant tree windfall (Photo 17) and beaver damming activity (Photo 18). These areas were located in the southeast portion of the study area where streams flow through a patch of mature forest. The majority of the other riparian areas flow through open areas within pastures and cultivated fields.

It is noteworthy that because only a sub sample of the riparian areas within the study area was visited, there may be other areas where there is significant potential for blocking/flooding. Depending on future rainfall and water levels, the level of blockage of visited areas may change. It is therefore important that all areas are revisited before and during future development of the study area.

High Ecological Integrity Areas

Riparian areas support unique hydrology, high rare plant and rare plant community potential, topographic diversity, juxtaposed wetland and upland habitats, hiding cover for wildlife movement, and are typically less developed than surrounding uplands. Because of these factors all identified riparian areas mapped within the study area (Figure 2) are considered to be areas of high ecological integrity. There are also two other areas with particularly high overall native ecological integrity mapped in Figure 3. These areas are located in the northern and western portions of the Springbank MDP area and constitute large and diverse complexes of small and large wetlands of several classes.

Relative Importance of Wetland Types

According to Alberta's *Water Act* (Government of Alberta 1996) all wetlands in the province are important from hydrological, ecological and socio-economical perspectives, regardless of class or type. This is reflected in the strict wetland policy that requires an approval and/or license to affect a water body including, dredging, filling, diverting, and drainage. Rocky View County adopted policies in 2010 with the purpose of conserving and managing wetlands and riparian lands. These policies help the County to fulfill its legislative mandate through meeting legal and statutory requirements for the protection of provincial water resources.

The definition of a water body in the *Water Act* is as follows:

"Water body means any location when water flows or is present, whether or not the flow or the presence of water is continuous, intermittent or occurs only during flood, and includes but is not limited to wetlands and aquifers".

The importance of individual wetlands is often measured by applying the concept of wetland functionality (Bond *et al*. 1992, Clairain 2002, Fennessy *et al*. 2004, City of Calgary 2004, Adamus, 2013). Wetland functionality provides the basic knowledge to assess the relative importance of specific wetlands and the impacts of specific proposed developments. Wetland impact assessments are one of the requirements to apply for an approval to disturb a wetland (Alberta Environment 2007) and determine compensation and mitigation activities.

Factors used to measure the relative functional value of wetlands include hydrological, biological/ecological, and socio-economic elements. **Table 2** lists some of the most important factors to take into consideration when assessing the functionality of a wetland.

Assessment of the relative importance of individual wetlands lies outside of the scope of this project and is in fact not applicable to this level of sub-regional planning and wetland classification. There are however some inherent differences in the level of ecological importance of the wetland types mapped in **Figure 2** and described above. These include: 1) regional rarity; 2) wetland native ecological integrity; 3) plant and wildlife biodiversity potential; and 4) size and connectivity.

Table 2. Wetland Functions Overview
Wetland Function
Hydrological Function
Contribute to recharge or discharge of water supply aquifers
Flood protection
Erosion control
Usable surface water
Storage of agricultural run-off
Containment of toxics: surface run-off/discharge flow
Sediment flow stabilization
Biological/Ecological Function
Habitat for migratory birds
Habitat for amphibians and reptiles
Habitat for vertebrate species at risk
Habitat for supporting rare plant species
Habitat for supporting rare plant communities
Support of plant species diversity
Support of vegetation structural diversity
Ecological integrity
Socio-Economical Function
Contribute to visual diversity of landscape
Recreational opportunities
Education and nature interpretation
Accessibility to public
Contribution to crop irrigation
Tourism or other commercial use
Source of domestic or industrial water supply

Regional rarity

Native habitats occurring in short supply (rare) in a regional context are considered to be more significant than abundant habitats in the context of preserving landscape diversity and the plant and animal species that these landscapes support (Noss 1993; Council on Environmental Quality 1993; Noss and Cooperrider 1994). Even though all wetlands are considered uncommon at a regional level, the least common wetlands in the study area in terms of frequency of occurrence are semi-permanent/permanent wetlands (n=52).

Wetland native ecological integrity

Invasion of native habitats by non-indigenous or "introduced" species of plants can result in a loss of native plant species, changes in community structure and function, and alterations in the physical structure of the system (Drake *et al*. 1989; Desserud and Naeth 2010).

Habitat loss (agricultural land clearing and tillage) is the main disturbance factor observed in the Springbank MDP study area. As such, tilled wetlands have a lower ecological integrity than non-tilled wetlands. However, tilled wetlands have the potential to partially recover their native ecological integrity after agricultural activities ceased (Bartzen *et al*. 2010). Moreno-Mateos *et al*. (2012) concluded that after disturbance occurred, wetlands either recover very slowly or move towards alternative states that differ from reference conditions. Such alternative states, even though not pristine, can nonetheless provide important ecosystems services such as water storage, reduction in sedimentation and nutrient loading, plant biodiversity, carbon sequestration (Gleason *et al*. 2011), and wildlife habitat (Begley *et al*. 2012).

Plant and wildlife biodiversity potential

Ecosystems that support a high level of diversity of plant species tend to be structurally diverse and productive (Meffe and Carroll 1997). These areas in turn support a wide variety and abundance of insect and animal forms. Permanent and semi-permanent wetlands generally support a higher number of vegetation zones than seasonal and temporal wetlands. Each vegetation zone contains unique plant communities and structural assemblages providing a variety of habitats for wildlife species. They together have the potential to provide numerous reproductive, forage and cover opportunities or "niches" for survival and reproduction for several wildlife (and plant) species.

Wetland size and connectivity

Large wetlands or wetland complexes offer secure 'core' areas for certain wetland wildlife and plant species. Small wetlands that lack "core" areas are more prone to isolation, non-native plant invasion and fragmentation. In addition, small and isolated wetlands are not able to support all the species and number of individuals that a large multi-zoned wetland does. The largest wetlands in the study area are semi-permanent/permanent wetlands with average sizes of 4.5 ha. The smallest are ephemeral and temporary (Classes I and II).

Potential Impacts of Stormwater Drainage on Wetlands and Riparian Areas

Some of the potential impacts of stormwater drainage and management on wetlands and riparian areas in the study area include:

- Increase of surface water runoff because of impervious surfaces;
- Decrease in water quality entering the wetland. Contaminants, sediments and nutrients are transported by stormwater. Aquatic and semi-aquatic wildlife and fish habitat might be affected;
- Increase in the potential for creation of erosion channels in the wetland;
- Reduction in floodwater storage capacity; and,
- Alteration of native plant community composition and wildlife habitat.

Changes in water regime and water permanence have the greatest potential to alter wetland plant structure and composition and therefore wildlife habitat and populations. Increased water input into wetlands will generally result in reductions in low-prairie, wet-meadow, shallow-marsh, and deep-marsh wetland zones, and increases in open water. Reduction of plant and structural diversity provided by the different wetland zones will result in a more homogeneous environment where wildlife habitats are reduced or lost.

Mitigation Strategies

According to the new Alberta Wetland Policy (Alberta Environment 2013) and the Provincial Wetland Restoration/Compensation Guide (Alberta Environment 2007), mitigation is the process used to reduce loss of wetlands by:

- Avoiding impacts to wetlands;
- Minimizing impacts and requiring applicable compensation; and
- Compensating for impacts that cannot be avoided or minimized.

Avoidance of impacts on wetlands is the most desirable mitigation strategy. However, when avoidance is not possible, then minimization of impacts is preferred. Mitigation measures to minimize impacts on wetlands should consider the protection, maintenance or enhancement of wetland conditions such as: water quality, flow regime, wetland zonation, plant and wildlife diversity and potential to harbor plant and animal species at risk. Implementation of Best Management Practices (BMPs) to control quality and quantity of stormwater should be considered at early design stages. Those BMPs can be Source Control BMPs, Lot-Level BMPs, Stormwater Conveyance System BMPs, and End-of Pipe Systems (Alberta Environment 1999)

When avoidance and minimization is not possible, then compensation should be taken into consideration. Wetland compensation supports the concept of no further loss of wetland area in the province by restoring wetlands to replace the lost ones. Wetland restoration is done by wetland restoration agencies (i.e. Ducks Unlimited).

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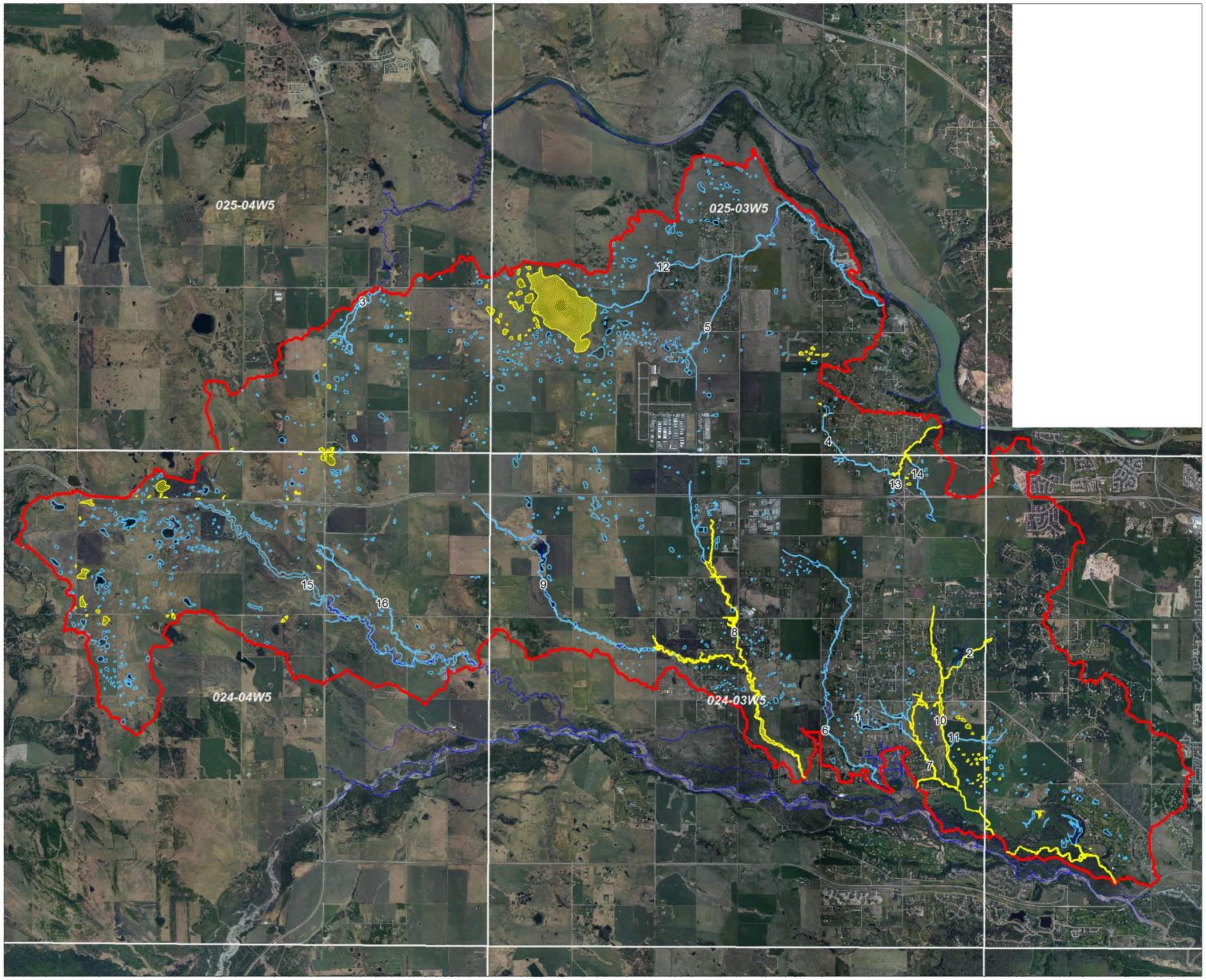
FIGURES

Figure 1. Reconnaissance-level field sites - Central Springbank Area Master Drainage Plan



Legend

- Area Structure Plan
- Watercourses
- Potential Wetlands and Riparian Areas
- Areas Surveyed

0 2.5 5 km.

Scale 1 : 70,000

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Produced by Rich Ashton Oct. 2014
Ref# H-F633_10-14

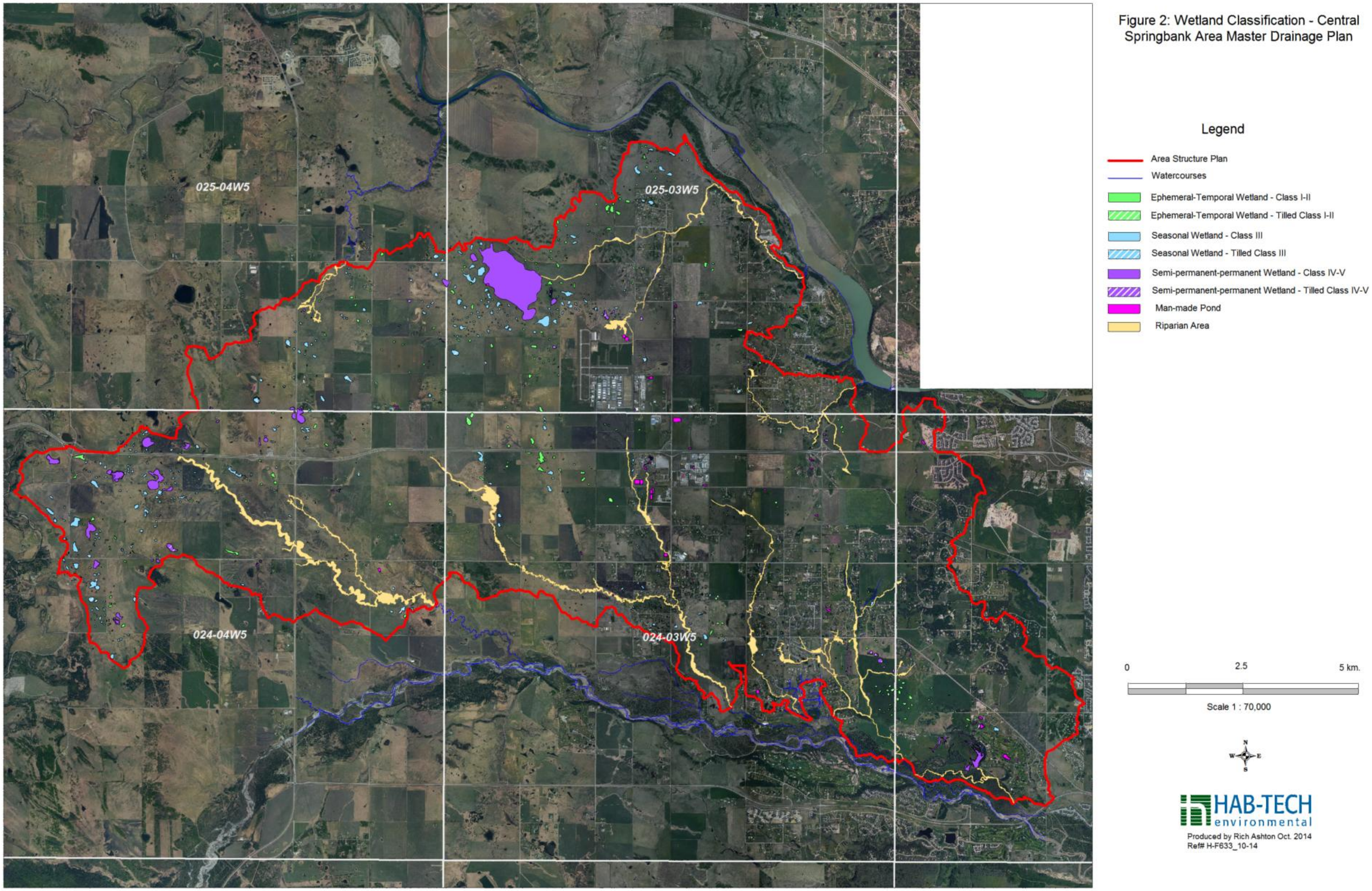

Figure 2: Wetland Classification - Central Springbank Area Master Drainage Plan

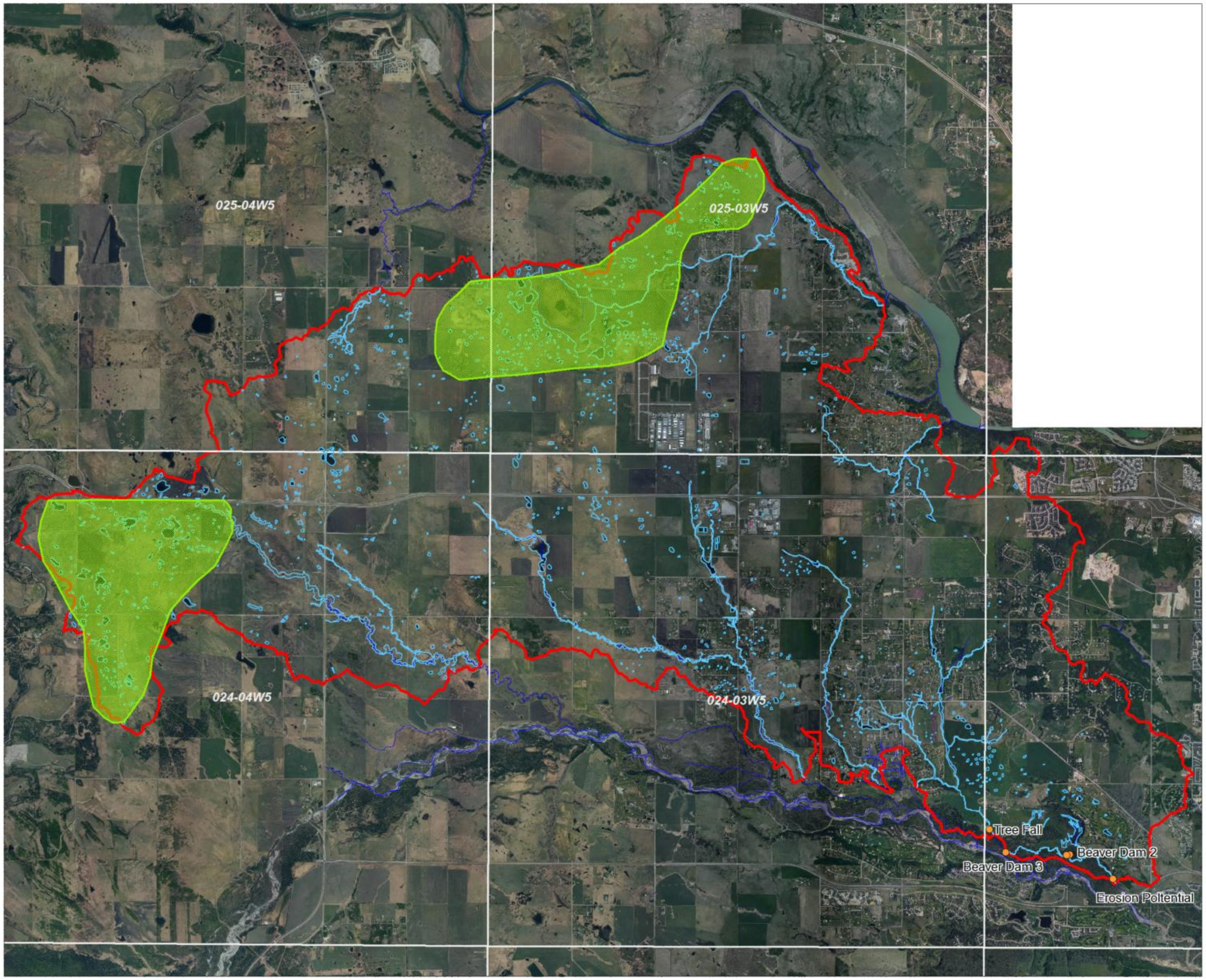

Figure 3: Areas of High Environmental Integrity - Central Springbank Area Master Drainage Plan

Legend

- Area Structure Plan
- Watercourses
- Mapped Wetlands and Riparian Areas
- High Environmental Integrity
- Potential Blockage Locations

0 2.5 5 km.

Scale 1 : 70,000

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SITE PHOTOGRAPHS


Photo 1. Ephemeral wetland class 1 – Tilled


Photo 2. Temporary wetland - Class II Tilled

Photo 3. Ephemeral wetland - Class I

Photo 4. Temporary wetland - Class II

Photo 5. Seasonal wetland - Class III Tilled

Photo 6. Seasonal wetland - Class III

Photo 7. Semi-Permanent wetland - Class IV Tilled

Photo 8. Semi-Permanent wetland - Class IV


Photo 9. Permanent wetland – Class V


Photo 10. Manmade wetland/dugout

Photo 11. Area mapped as a wetland, but no longer is a wetland

Photo 12. Riparian area resembling temporary wetland

Photo 13. Riparian area resembling seasonal wetland

Photo 14. Riparian area resembling semi-permanent wetland

Photo 15. Riparian area resembling permanent wetland

Photo 16. Riparian area with potential for erosion


Photo 17. Riparian area with potential from blocking due to deadfall


Photo 18. Riparian area with minor potential from blocking due to beaver activity

APPENDIX B

Culvert Hydraulic Assessment Summary and Site Photographs

Table B1: Culvert Hydraulic Assessment

Culvert #	Location	Size (mm)	Top of Culvert to Road Shoulder (m)	Intended Direction of Flow	Culvert Condition (Squashed, blocked etc...?)	Upstream Conditions	Downstream Conditions	Culvert Condition Rating	CulvertMaster Computed Inlet Control Q (m^3/s)	Total Drainage area (ha)	Direct Drainage area (ha)	Unit Area Capacity (L/s/ha)	Level of Service (>4 = green,>2 = yellow, <2 = red)
SC-20-2	Rge Rd 34	600	0.4	to the SE	Good Condition	Good capacity, storage in field	meandering stream, good condition	G	0.49	704	37	0.7	R
SC-20-1	Rge Rd 34	1100	0.4	to E	Arched and tapered 11 X 1600	good capacity, storage in field	good, meandering stream + storage	G	1.877	765	765	2.5	Y
SC-28-1	Rge Rd 34 + Springbank Rd	450	0.65	to S	Squashed on south side to 250 mm	partially buried, good ditch slope upstream	good ditch ROW 3.7 m wide	R	0.3018	1.2	1.2	>20	G
SC-29-1	Rge Rd 34 + Springbank Rd	450	0.5	to S	Partially buried , downstream totally buried and badly squashed	good, newly topsoiled, needs seeding	ROW slopes nicely	R	0.134	3.3	3.3	>20	G
SC-29-2	Springbank Rd west of RR34	900	0.85	to S	good condition and capacity	excellent ROW storage	eroded, pooling sitting water in ditch, potential farm flooding	Y	1.68	704	704	2.4	Y
ER-26-1	Springbank Rd east of Hwy22	3000	1.2	to S	good	pooling, good capacity but flat topo, fencing acting as dam	good, fence acting as dam for debris, pooling, but good field storage capacity	G	26.49	2380	2380	11.1	G
ER-25-1	Springbank Rd east RR41	1850	1.2	to S	good	field storage	field	G	8.75	480	480	18.2	G
ER-24-1	Private Rd east of RR 41	2 x 300, 450, 1050	0.5	to E	good improvements and added CSP to south on private road	ponding, meandering northeast to farm buildings, potential flood hazard	ponding and then meandering	G	1.1	3413	553	0.3	R
SC-30-1	West of RR35	1850	1.1	to S	Partially removed and in repair, lots of sediments on south side	forested coulee	storage, sediment	G	8.42	1065	765	7.9	G
SC-19-1	RR35	2400	0.4	to E	good	meandering, storage	storage pond	G	11.56	582.2	122.6	19.9	G
SC-29-3	RR35 + Springbank Rd	450	0.3	to S	south side full of brassy debris, north countersuck 0.5 m	ponding, opening of CSP 0.5 m deeper than grade	good	Y	0.22	2	2	>20.0	G
SC-28-2	RR33 west of Springbank rd	1200	0.5	to S	good	good	ponding, narrowing coulee	G	2.62	845	123.7	3.1	Y
SC-28-3	RR33 + springbank Instersection	1200	0.5	to S	good	good, seems as though sports field will provide storage	ponding, meandering to west	G	2.62	702.6	702.6	3.7	Y
SC-28-4	RR 33 + Springbank Intersection	525	0.5	to SE	good	ponding next to cemetery	outlet ponding, lots of mosquitoes	G	0.34	142.6	142.6	2.4	Y

Culvert #	Location	Size (mm)	Top of Culvert to Road Shoulder (m)	Intended Direction of Flow	Culvert Condition (Squashed, blocked etc...?)	Upstream Conditions	Downstream Conditions	Culvert Condition Rating	CulvertMaster Computed Inlet Control Q (m^3/s)	Total Drainage area (ha)	Direct Drainage area (ha)	Unit Area Capacity (L/s/ha)	Level of Service (>4 = green,>2 = yellow, <2 = red)
RC-36-1	Twp 250 + Callinghorse Rd	Assumed 600	8	to N	uninspected due to inaccessibility	deep wide ROW	deep wide ROW	G	0.72	252	252	2.9	Y
GC-23-3	RR 32 Morning Vista Way	1200	0.5	to S	good	well maintained swale to storm pond	to 23-4	G	2.62	85.1	85.1	>20	G
GC-23-4	RR 32 Morning Vista Way	1200	0.3	to SW	good	23-3	into ditch and piped across RR 32	G	2.2	85.1	85.1	>20	G
CC-24-6	Cullen Creek Estates	450	3	to E	good	deep coulee	into 24-6	G	0.36	128.4	128.4	2.8	Y
CC-24-5	Cullen Creek Estates	1200	3	to S	good	wide coulee	wide ROW	G	3.35	36.2	128.4	>20	G
RC-2-1	Twp 250 + Clover Lane	600, 750	3	to S	good	swale through residential yard not much elevation to home	coulee through farmland	G	1.95	283.3	283.3	6.9	G
RC-2-2	Lariat Loop Hot Spot	400	0.4	to N	good	standing water	standing water, wetland	G	0.162	24.4	24.4	6.6	G
HC-15-1	Springbank Height Dr Loop	2 * 1500	5	to SE	good	big wide ROW	big wide ROW	G	10.9	356.3	356.3	>20	G
HC-15-2	Springbank Height Dr Loop	2 * 1500	1.2	to S	good	big wide ROW	forested coulee	G	11.6	382.2	25.9	>20	G
HC-15-3	Springbank Height Dr Loop	2 * 1500	4	to E	good	House in flood plain very close to coulee		Y	10.9	382.2	0	>20	G
HC-14-1	Two 252 to Gravel Pits	Unknown (assumed 1200)	8	to S	culvert not found	wide and deep canyon	wide and deep canyon	Y	4.84	750.3	368.1	6.5	G
SC-36-1	Hot Spots of Hwy 1 on RR40	900, 1200	0.5	to the E	downstream dammed (E), New CSP (road structure not great)	needs riprap, wetland	meandering stream, good condition	Y	3.3584	300	300	11.2	G
ER-14-1	Twp 252 41092	500	0.3	to N	good	good storage	good, meandering stream + storage	G	0.3124	284	284	1.1	R
HC-9-1	Rocky Range View	600	1	to N	good	nice slope	good ditch ROW 3.7 m wide	G	0.72	324	324	2.2	Y
HC-16-1	Rocky Range no trespassing gates	500	0.3	to E	good	good, natural drainage	ROW slopes nicely	G	0.3124	1879.2	1879.2	0.2	R

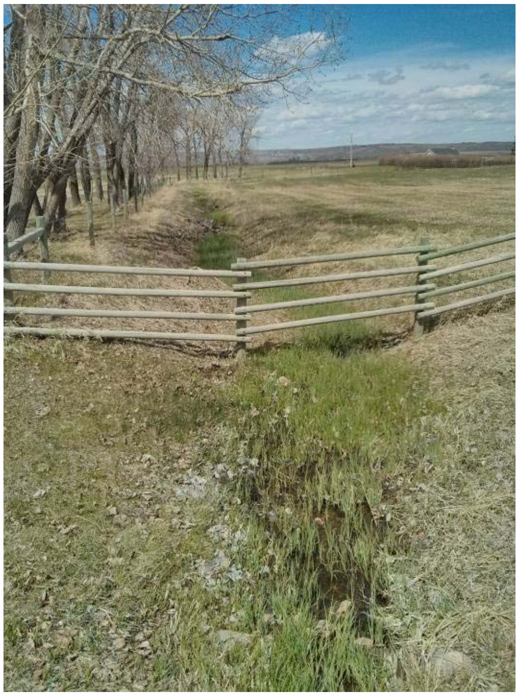
Culvert #	Location	Size (mm)	Top of Culvert to Road Shoulder (m)	Intended Direction of Flow	Culvert Condition (Squashed, blocked etc...?)	Upstream Conditions	Downstream Conditions	Culvert Condition Rating	CulvertMaster Computed Inlet Control Q (m^3/s)	Total Drainage area (ha)	Direct Drainage area (ha)	Unit Area Capacity (L/s/ha)	Level of Service (>4 = green,>2 = yellow, <2 = red)
HC-16-2	Idlewild Estates	450	5	to N	seems to be undersized, perhaps to restrict flow	good	eroded, pooling sitting water in ditch, potential farm flooding	Y	0.7811	324	204	2.4	Y
HC-16-3	Country Lane	600	1	to N	good, damaged ends	large easement	good, fence acting as dam for debris, pooling, but good field storage capacity	Y	0.72	528	5	1.4	R
HC-16-4	Country Lane	1050	0.3	to E	good, low spot not much flow	low area	field	Y	1.627	1879	245	0.9	R
PR-5-1	Hwy 8, Lower springbank Rd	600	8	to S	good	good, wide deep coulee	ponding and then meandering	G	1.965	61	61	>20	G
PC-17-1	Twp 242, Lower Springbank Rd	525	1	to S	good, some debris	good	storage, sediment	G	0.5287	61	61	8.7	G
PC-17-2	twp 242, south of lower Springbank road	600	0.6	to SE	good	soggy	storage pond	G	0.574	61	61	9.4	G
CC-18-1	Horizon View Rd South of springbank	450,900	0.3	to W	good	good meandering stream	good	G	1.4675	41	41	>20	G
CC-24-1	Lower Springbank Road, Cullen Creek	600	3	to S	good	wetland, lots of storage	ponding, narrowing coulee	G	1.23	571	367	2.2	Y
CC-23-1	Lower Springbank RR31 West	425	1	to S	good	stormpond 23-1 upstream	ponding, meandering to west	G	0.3686	28	28	13.2	G
GC-23-2	Lower Springbank Rd South	600	1	to SE	good	CSP 23-1 upstream	road ditch is good, but quite flat	G	0.72	28	28	>20	G
CC-14-3	RR31 Windhorse	750	1.5	to E	good	drains storm pond	good	G	1.433	80.7	80.7	17.8	G
GC-14-2	Grand Arches Drive	900	2	to S		pond, lots of storage	good, nice forested coulee	G	2.37	228.5	143.4	10.4	G
GC-23-3	Lower Springbank Rd RR32	1050	0.3	to S		soggy ROW, water still flows through	ponding and trapped	G	1.627	461	85.1	3.5	Y

Culvert #	Location	Size (mm)	Top of Culvert to Road Shoulder (m)	Intended Direction of Flow	Culvert Condition (Squashed, blocked etc...?)	Upstream Conditions	Downstream Conditions	Culvert Condition Rating	CulvertMaster Computed Inlet Control Q (m^3/s)	Total Drainage area (ha)	Direct Drainage area (ha)	Unit Area Capacity (L/s/ha)	Level of Service (>4 = green,>2 = yellow, <2 = red)
GC-26-1	Springbank Rd East of RR32	1200	1.5	to S	south end squished	ponding coulee, but good	coulee	R	3.87	461	461	8.4	G
CC-25-2	Springbank, Cullen Creek	1200	1.8	to S	good	good	good coulee	G	4.15	123	123	>20	G
CC-25-3	Springbank, Cullen Creek	600	1.2	To S	good	good	good	G	0.35	32	32	10	G
CC-30-1	Springbank, Cullen Creek	1050 Apprx.	>2	To S	Under construction	Under construction	Under construction	G	1	96	96	10.4	G
CC-19-2	Horizon View Rd	450	1.5	to W	good	storm pond outfall	into coulee	G	0.4491	80.7	80.7	5.6	G
SC21-1	RR 33	1250	2	to SE	Good	Stream feeds in, meandering, good condition cs	Feeds into another culvert, 2 additional pipes feed into stream	G	4.58	886.9	20.3	5.16	G
SC21-2	RR33	2250	2	To east	Good	Good condition, clear wide stream	Good condition meandering wide stream	G	12	893.1	128.1	13.44	G
SC22-1	TWP RD 243A	1350, 900	3	to S	Good	Good condition, large storage area, second higher pipe	Good condition, clear meandering stream	G	6.6876	979.8	92.9	6.83	G
SC32-1	Highway 1	900	2	to S	Good	Ditches from both sides lead to culvert, close to grazing land	Did not access	G	1.145	66.3	66.3	17.27	G
SC32-2	Highway 1	Unknown (assumed 900)	Unknown	To S	Not accessed	Not accessed	Not accessed	G	-				
SC33-1	Highway 1	1200	1	to S	Good	Ditches from each side, close to grazing land	Did not access	G	2.2	221.8	221.8	9.9	G
SC21-3	RR 33	200	2.5	to E	Unknown	Completely obscured by reeds, outflow for trapped low	Covered by reeds	Y	0.1176	36.1	36.1	3.26	Y
SC21-4	RR 33 driveway	900	0.5	S	Good, mostly submerged	Ponded windy stream, reeds	Ponded stream, reeds, culvert obscured by reeds	Y	1.45	865.4	20.4	1.68	R

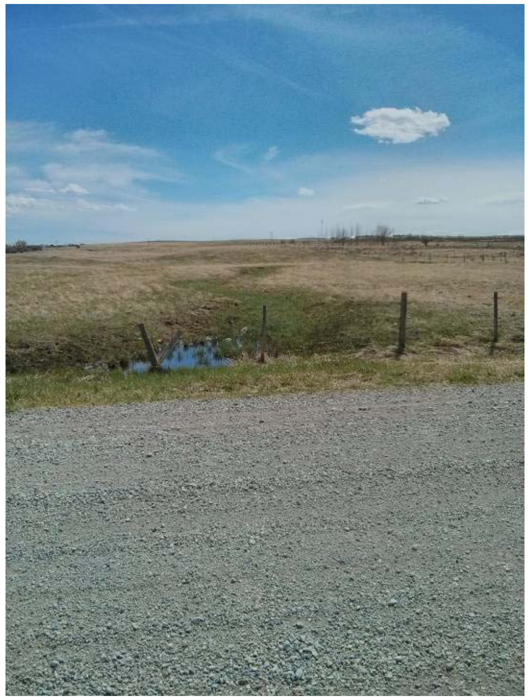
Culvert #	Location	Size (mm)	Top of Culvert to Road Shoulder (m)	Intended Direction of Flow	Culvert Condition (Squashed, blocked etc...?)	Upstream Conditions	Downstream Conditions	Culvert Condition Rating	CulvertMaster Computed Inlet Control Q (m^3/s)	Total Drainage area (ha)	Direct Drainage area (ha)	Unit Area Capacity (L/s/ha)	Level of Service (>4 = green,>2 = yellow, <2 = red)
SC21-5	RR 33 driveway	1350	0.5	S	Size unsure as half submerged. Condition good	Ponded reedy stream	Ponded reedy stream	Y	3.4	865.4	0	3.93	Y
SC21-6	RR 33 driveway	900	0.5	S	Good, ponding	Ponding in reedy stream	Ponding in weedy winding stream	Y	1.45	866.6	1.2	1.67	R
SC21-7	Hillcrest Estates	300	1	N	Obscured by reeds	Ditch leading into culvert	Outflow restricted by vegetation	Y	0.139	2.6	2.6	53.46	G
CC14-1	Windhorse Dr	600	1	N	Good	Reedy ditches	Reedy ditches	G	0.72	0	0	#DIV/0!	
CC14-2	RR 31	750	1.5	E	Good, partially submerged	Reedy ditches, slight ponding		G	1.4326	172.3	17	8.31	G
CC14-4	Windhorse Way	600	1	E	Good	Reedy ditches	Artificial pond. Culvert daylights and another culvert goes under walking path	G	0.72	52.6	52.6	13.69	G
CC23-4	Pond outfall Lower	200	1	S	Good, pond outlet	Pond	Ditch	G	0.1263	0	0	#DIV/0!	
SC36-3	HWY 1	1200, 900	2	S	Good, ditches leading in		Not accessed	G	4.9805	258.3	258.3	19.28	G
SC34-2	Commercial Dr	600	1	SW	Good, half submerged, outlet uncertain, cracks in road indicate it may form a T with driveyway culvert on other side of road	Ponded reedy ditch	Ponded reedy ditch	G	0.72	10.3	10.3	69.90	G
SC34-1	RR33	300	1.5	W	Intact no silt	Ditches and wide field		G	0.139	99.4	89.1	1.40	R
RC36-2	HWY 1	600	1.5		Wingwall detached, concrete. Section of pipe detached and exposed. May be silted.	Ditches	Not accessed	Y	0.72	365.3	365.3	1.97	R
SC33-2	HWY 1	900	1	To S	Good	Ditches and low point leading to culvert	Not accessed	G	-	67.7	67.7	-	-

Culvert #	Location	Size (mm)	Top of Culvert to Road Shoulder (m)	Intended Direction of Flow	Culvert Condition (Squashed, blocked etc...?)	Upstream Conditions	Downstream Conditions	Culvert Condition Rating	CulvertMaster Computed Inlet Control Q (m^3/s)	Total Drainage area (ha)	Direct Drainage area (ha)	Unit Area Capacity (L/s/ha)	Level of Service (>4 = green,>2 = yellow, <2 = red)
SC27-1	Huggard Road	450	0.7	To S	Slight damage, obscured by vegetation	Vegetation overgrown, upstream culverts are blocked by ice, low point is further east on Huggard Road and ponds heavily.	Some vegetation	Y	-	46.4	46.4	-	-

HC-14-1 Facing North Downstream



HC-14-1 Facing South Upstream



HC-16-1 Private Road Downstream

HC-16-3 Downstream

HC-16-2 Upstream

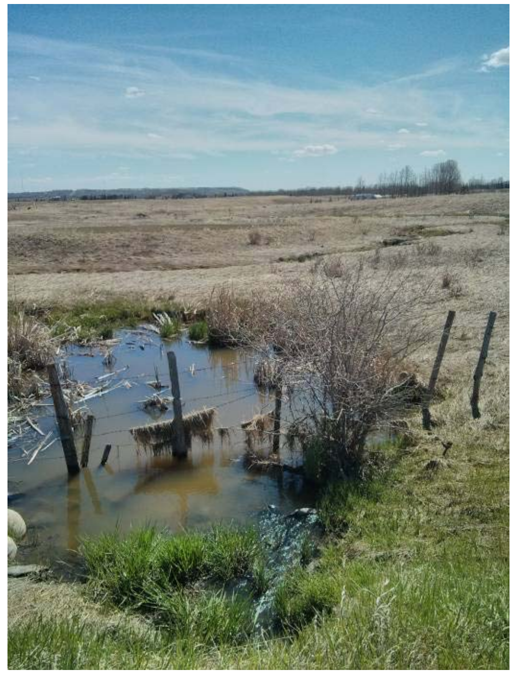
HC-16-2 Downstream

HC-16-4 Downstream with Storage

SC-19-1 Downstream

SC-19-1 Upstream

SC-20-1 Downstream

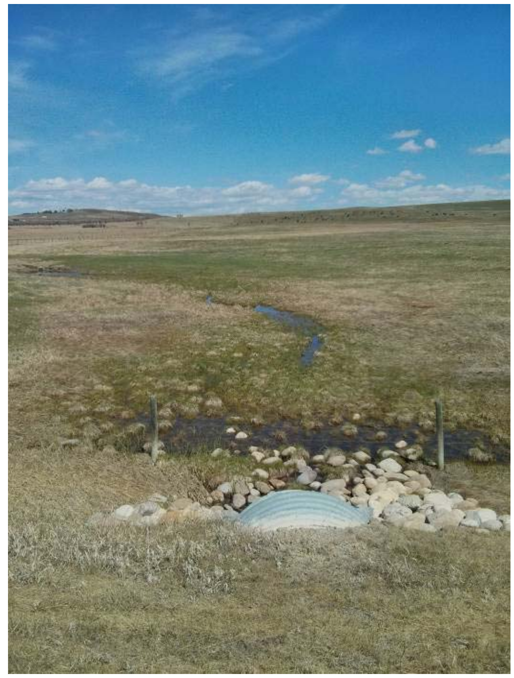


SC-20-1 Upstream

SC-20-2 Downstream

SC-20-2 Upstream

ER-25-1 Upstream



ER-24-1 Downstream

ER-24-1 Upstream

ER-26-1 Downstream

ER-26-1 Upstream

SC-28-1 Downstream

SC-28-1 Upstream

SC-28-4 Upstream Facing South

SC-29-1 Facing North

SC‐29-1 Downstream

SC-29-1 Upstream

SC-29-2 Upstream

SC-29-3 Facing North Upstream

SC-30-1 Downstream

RC-36-1 Facing upstream

RC-36-1 Upstream

GC-14-2 Check Dams

PR-5-1 Upstream

GC-14-2 Upstream

GC-14-2 Downstream

PC-17-1 Upstream

PC-17-1 Downstream

CC-18-1 Upstream

CC-18-1 Downstream

GC-23-3 Upstream

GC-23-3 Downstream

CC-25-2 Upstream

CC-25-2 Downstream

CC-25-3 Upstream

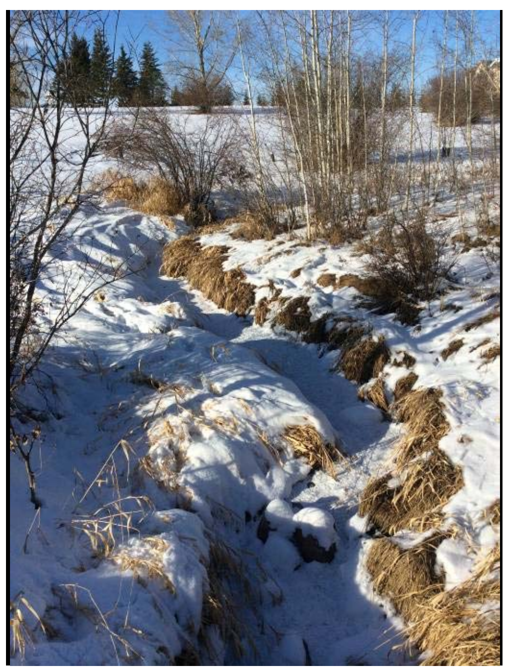
CC-25-3 Downstream

CC-30-1 Upstream

CC-30-1 Downstream

SC-21-1 Upstream

SC-21-1 Upstream



SC-21-1 Downstream

SC-21-1 Downstream

SC-21-2 Upstream

SC21-2 Upstream

SC-21-2 Downstream

SC-22-1 Upstream

SC-22-1 Upstream

SC-22-1 Upstream

SC-22-1 Downstream

SC-22-1 Downstream

SC-32-1 Upstream

SC-32-1 Upstream

SC-32-1 Upstream

SC-33-1 Upstream

SC-33-1 Upstream

SC-33-1 Upstream

SC 33-2 Upstream

SC 27-1 Upstream

SC 27-1 Downstream

APPENDIX C

Technical Memorandum

Comparison of Stream Erosion Index Method to Current City of Calgary Approach

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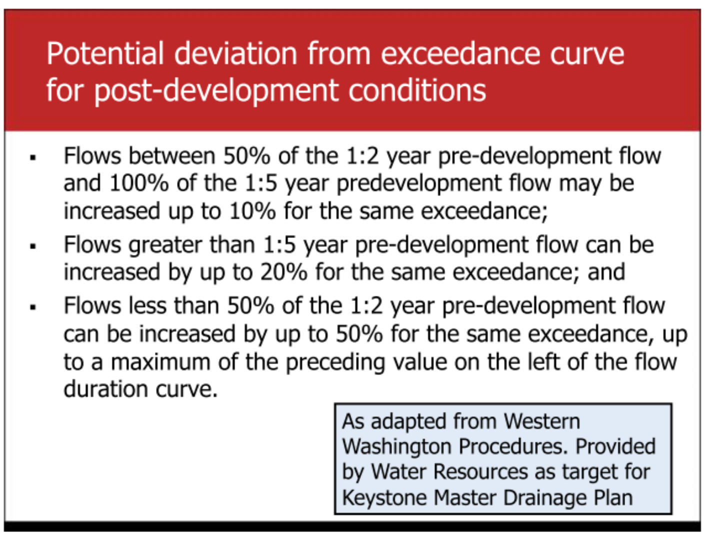
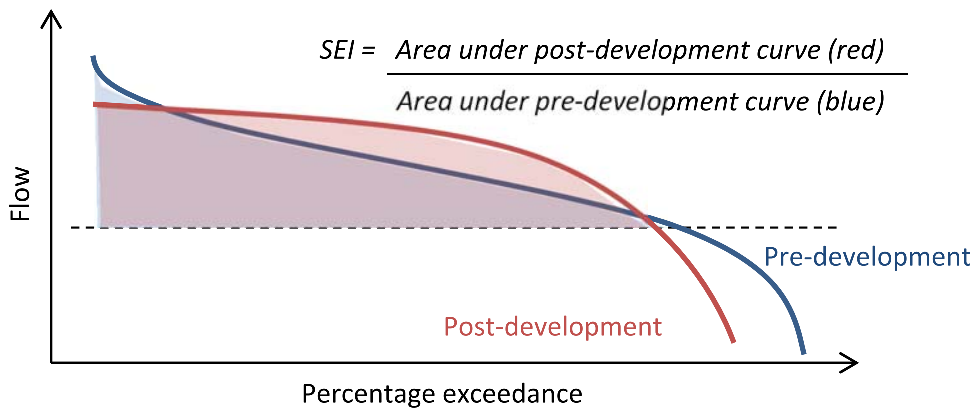
TECHNICAL MEMORANDUM

Comparison of Stream Erosion Index to Current City of Calgary Approach

Development tends to increase the magnitude and durations of flows. One of the objectives of stormwater management is to limit this increase. Stormwater management practices (BMPs, LIDs) can be used to ensure flows are within reasonable limits of pre-development conditions. The City of Calgary has developed an approach to manage hydrologic change that occurs when land is developed. The City of Calgary approach or rule is shown below is based on Western Washington rules (ref: "Stormwater Design Brilliance" presentation by CoC, Bert V'D, March 2015).



Another approach that seeks to manage flows in developing catchment is the Stream Erosion Index (SEI). The SEI is a measure of hydrologic change and is the ratio of pre-development to post-development flows exceeding the receiving stream's stability threshold. In most cases the assumed stability threshold is 50% of the 1:2 year flow in the stream. The SEI is the ratio of the area under the pre-and post-development flow duration curves above the stream's stability threshold, as shown in the figure below. Where the SEI approach is used, it is common to set an objective of managing flows to achieve an SEI 2 or less.



The City of Calgary rule and the SEI approach are two different methods to achieving the same goal of managing hydrologic change in developing catchments. This assessment compares the two measures using model data from the recent Springbank Creek Master Drainage Plan. The objective of this assessment is to explore the similarities and differences between the two methods and determine whether there are any advantages of one method over the other.

The Springbank Creek pre-development flow duration curve is shown in Figure 1. Flows are 0.2 mm/day or greater only 10% of the time (37 days per year) and the median flow (i.e. that occurs 50% of the time, or 183 days per year) is 0.02 mm/day.

Analysis of flood frequency was carried out using pre-development average daily flow data. The 1:2 event average daily flow rate is 1.5 mm/day. Previous analysis by Westhoff Engineering (2004) estimated the 1:2 event instantaneous flow rate to be 0.58 L/s/ha, or 5 mm/day. Applying a peaking factor of 2, this is equivalent an average daily flow rate of 2.5 mm/day for the 1:2 event. The stability threshold assumed in this analysis, 50% of the 1:2 event, is 1.3 mm/day and is shown on Figure 1.

The City of Calgary Rule and SEI equivalent

In Figure 1 the dashed curve shows the maximum allowable increase in flow according the City of Calgary Rule. Flows less than 50% of the 1:2 event are increased by 50%; flows between 50% of the 1:2 event up to the 1:5 event are increased by 10%; and flows greater than the 1:5 event are increased by 20%. The SEI is calculated by estimating the area under each curve above the assumed threshold. An SEI of 1.4 was calculated for Springbank Creek based on the City of Calgary rule assuming the maximum allowable exceedances are permitted. However, it is virtually impossible to meet this allowable distribution and typically a SEI of less than one would result, which is explained further when a comparison is made between a typical development example.

Post-development flows from Example Development

The City of Calgary's Water Balance Spreadsheet (WBSCC) was used to simulate the application of stormwater BMP's including LID practices. The stormwater management system includes a number of LIDs and a storm pond with a typical single orifice control for an actual recent development in Springbank that proposed to meet predevelopment flows. Figure 2 compares the pre- and post-development flow duration curves. The development met peak runoff rate of 1.71 L/s/ha and volume controls of less than 45mm recommended by the MDP, however it produced runoff volumes greater than predevelopment. The analysis estimated a resulting SEI of 3.7 which is substantially greater than a SEI of 2 proposed by the MDP. It also substantially exceeded the City of Calgary rule as shown in Figure 1.

Figure 2 shows that a typical stormwater arrangement cannot meet the fairly restrictive discharge rules recommended by the City or even a SEI of 2 without modifying the approach used to just meet a volume control target. As expected, the volume at the left of the graph (larger less frequent events) and the right of the graph (more frequent events) are always typically lower then the predevelopment estimate. To try and meet the City of Calgary rule, the SEI would need to be less than 1 and volume control below predevelopment using typical design criteria. That is increasing the extent of LID practices and storm ponds so the post development FDC (red line in Figure 2) move to the left or closer to the predevelopment curve around the flow threshold (dotted line).

Figure 1. Springbank Creek pre-development versus CoC rule

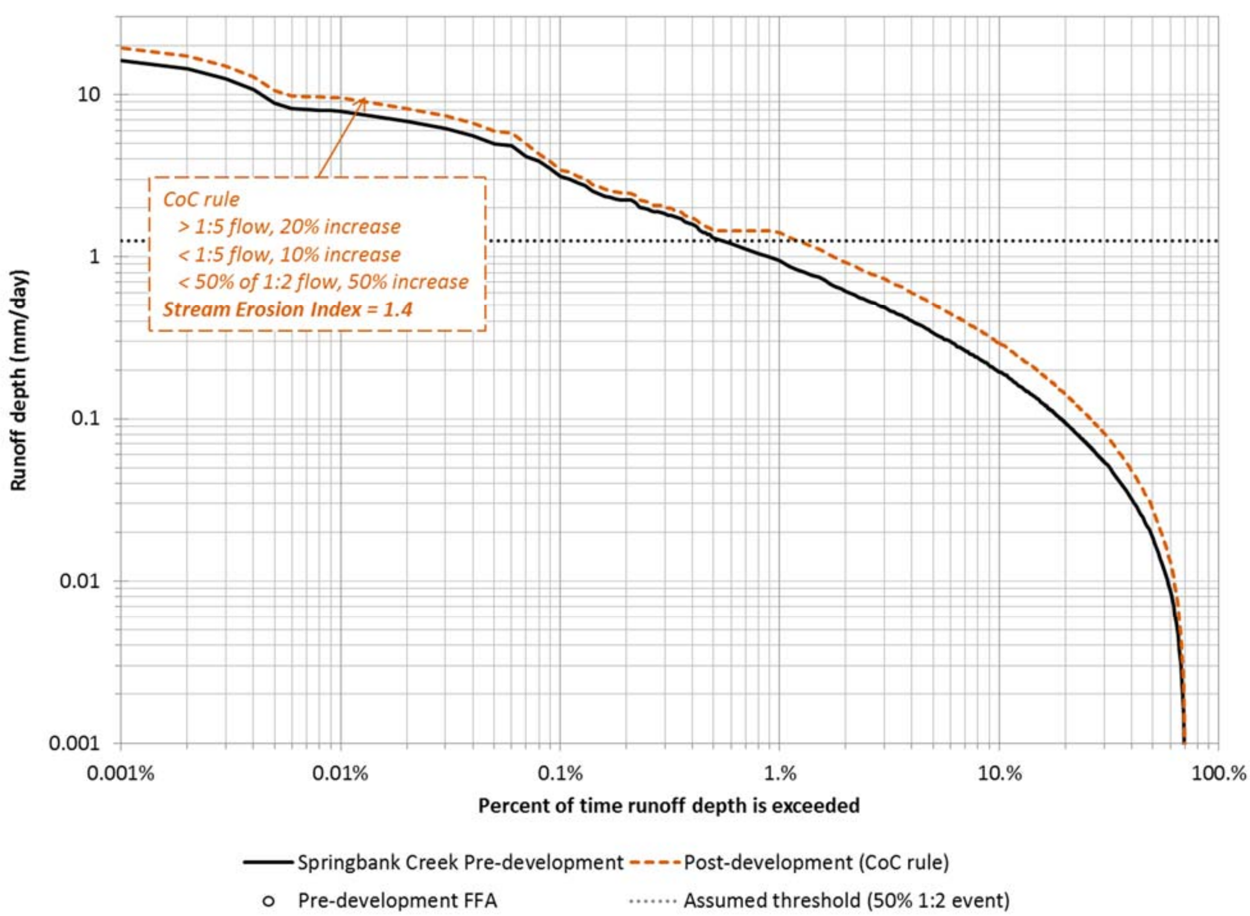
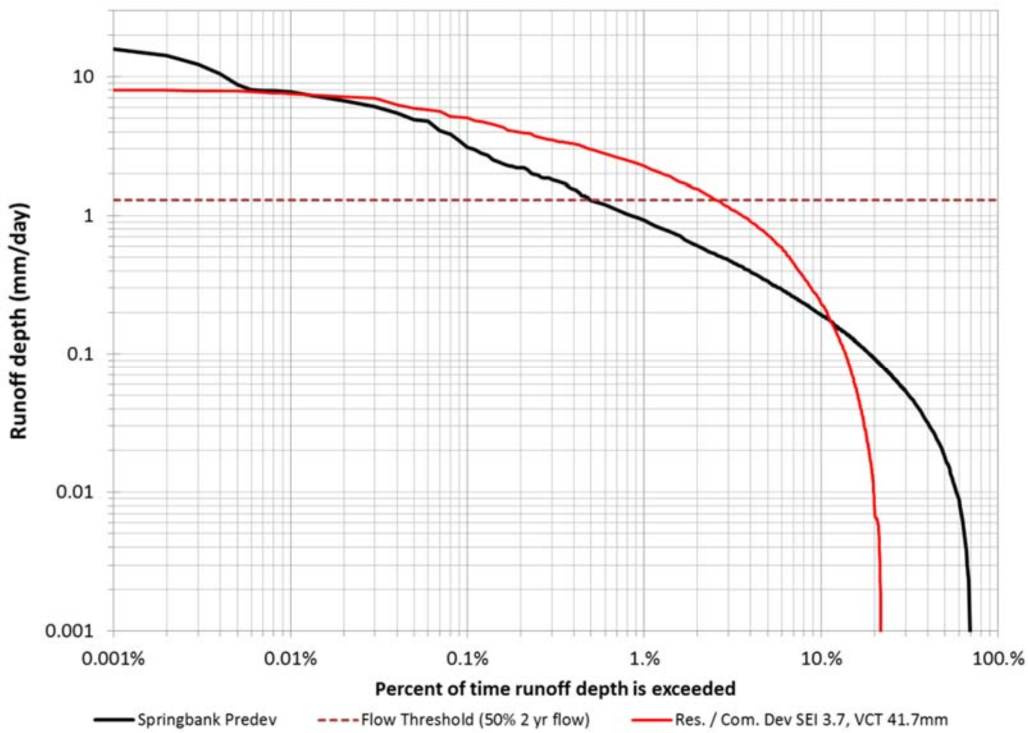


Figure 2. Post Development Residential / Commercial flow duration curves



Another approach would be to use a number of orifices at various levels in the storm pond to obtain a closer match to the predevelopment curve. Figure 3 show the FDC for a development with 2 control orifices for the outlet. While it still does not meet the City of Calgary rule, it provides a solution that is much closer, but it has a SEI of 0.9 and a volume control of 32mm that nearly matches the 30mm predevelopment volume.

A similar approach was then used to determine the volume control target that is required to meet an SEI of 2 as per the draft Springbank MDP recommendation. Figure 4 shows the FDC derived from the development with a stormwater management configuration to achieve an SEI of 2. This development had a volume control target of 41mm which is significantly higher than for the development configuration in Figure 3.

Figure 3. Residential / Commercial (Double Orifice) to nearly meet C of C Policy

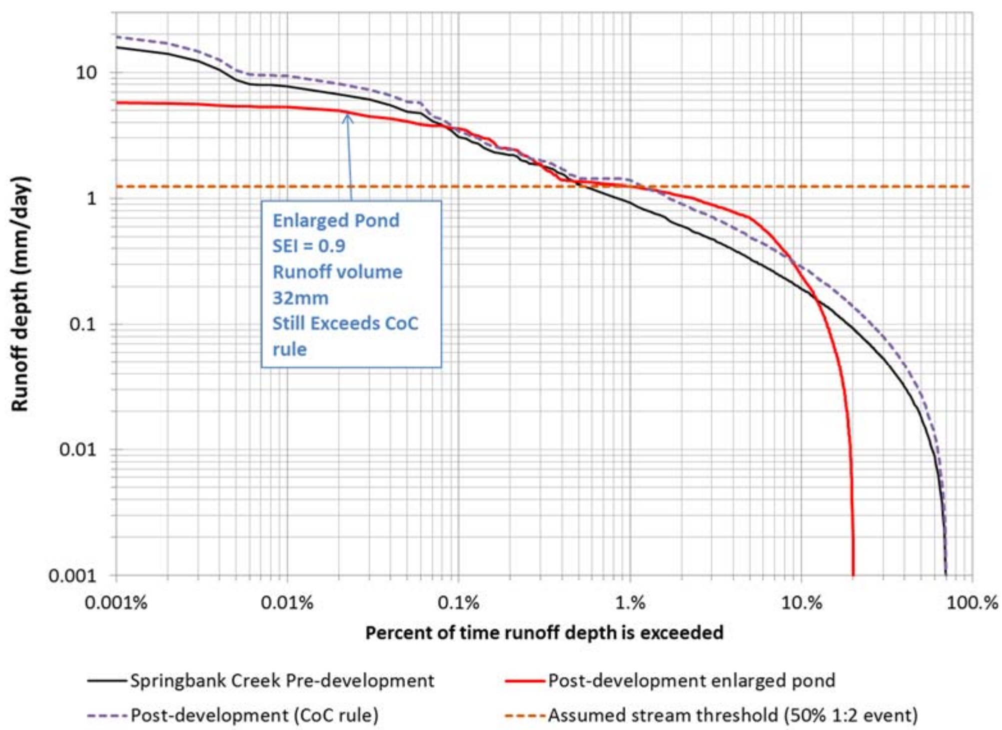
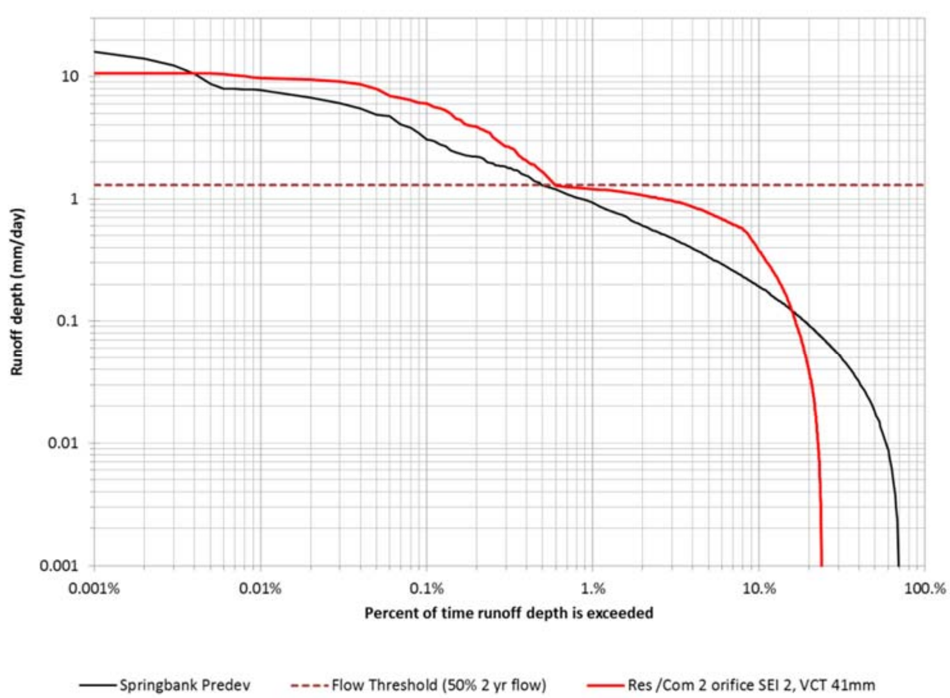


Figure 4. Residential / Commercial (Pond with 2 Orifice) flow duration curves



Discussion

In the case of Springbank or any development area it is difficult to meet City of Calgary rule without reducing flows to below pre-development levels for much of the flow duration curve. There maybe other approaches to achieve a more economical stormwater design that gets close to the City of Calgary rule, however is such an approach suitable for the Springbank MDP policy area?

One limitation of the SEI method is that it can be used in a manner that does not achieve the best outcome for the stream. That is skew the results so the critical flows between 50 percent of the 1 in 2 year flow and the 1 in 5 year flows are substantially increased but still managing to achieve an SEI of 2. While such a possibility has not been tested the single aggregated value of the SEI method could be open to such issues.

Generally the Springbank area does not have widespread erosion issues to date and the majority of streams are well vegetated and not located on steep escarpments with high erosion risks. It is still important not to alter the predevelopment hydrology to the point of creating additional problems. Therefore applying an approach that is not as restrictive as the City of Calgary rule but limiting discharges just above the critical threshold and ensuring an SEI of 2 is being met.

Therefore a recommended approach is to limit the increase in flow between the flow threshold (50% of the 1 in 2 year flow) and the 1 in 2 year flow to no more than 10 percent of the predevelopment flow in addition to limiting the SEI to a maximum of 2. In this way slightly higher volumes can be permitted from future development areas, while limiting increases in flow at the most critical channel forming flow ranges.

If a specific catchment is shown to be highly sensitive to increased volumes, then a more restrictive policy could be developed in specific cases.

APPENDIX D

Example New Development Stormwater Checklist

STORMWATER MANAGEMENT CHECKLIST FOR DEVELOPMENT APPLICATION (PAGE 1) Note: All N/A answers require an explanation at the bottom of this checklist.		YES	NO	N/A
1.0	**General Requirements**			
1.1	Is peak discharge from the development less than or equal to 1.71 L/s/ha, or lower to limit peak discharges to existing downstream constraints?			
1.2	Is the development located outside of a define 1:100 year floodplain such as the Bow or Elbow Rivers and their local tributaries or a known high water mark?			
1.3	Is the minimum opening elevation to buildings and critical infrastructure 300 mm above the overland drainage escape route flood elevation?			
1.4	Has a cost feasibility and sustainability report been prepared?			
1.5	Has an operations and maintenance plan been submitted for the development?			
1.6	Does the development have an adequate outlet?			
1.7	Is the development 5 lots or less and an impervious area less than 4%? Should			
2.0	**Stormwater Planning and Reporting Procedures**			
2.1	Has a continuous water balance model been performed for the development?			
2.2	Has the YYC precipitation data been increased by 11% in the water balance modelling?			
2.3	Is evapotranspiration data based on actual monthly values?			
2.4	Where absorbent landscaping is proposed, is the modelled effective depth 300 mm or lower and a I/P ratio of 3:1 or lower, maximum I/P ratio of 4:1?			
2.5	Has the runoff volume control target of 45 mm on average per year of discharge from the development been achieved?			
2.6	Does the discharge from the development have a Stream Erosion Index of 2 or less using the SEI calculator provided by the County?			
2.7	***Developments with < 10% Impervious Area and no Internal Roads Comply with the following?*** • The minimum requirement involves directing the impervious area onto undisturbed natural areas or onto an absorbent landscape. • The natural areas or absorbent Landscape shall using an I/P ratio of 0.2 or lower, that is providing a minimum of 5 m2 of pervious area for every 1 m2 of impervious area. • Roof and paved surface runoff should be spread out over the pervious surfaces and not concentrated into ditches or conveyance swales.			
2.8	***Developments with < 20% Impervious Area with or without Internal Roads Comply with following?*** • Peak flows from must be managed to be less than or equal to the UARR of 1.71 L/s/ha. • A runoff volume control target of 45 mm or lower shall be required for all development that releases into or passes through a natural stream.			
2.9	Has reduced infiltration and moisture holding capacity of soils due to construction activities and winter snowmelt events been account for?			
2.10	Has the City of Calgary Irrigation Demand Estimation Tool to estimate irrigation demand and Frequency Analysis Tools in sizing of infrastructure been used with the continuous simulation analysis?			
2.11	Has a sensitivity analysis been performed on LID performance in the water balance modelling?			

CHECKLIST FOR DEVELOPMENT APPLICATION (PAGE 2) Note: All N/A answers require an explanation at the bottom of this checklist.		YES	NO	N/A
3.0	**Wetland Management**			
3.1	Does the development site have any existing or proposed wetlands? If no, go to Section 4.0.			
3.2	Has a Wetland Management Plan been submitted?			
3.3	Does the Wetland Management Plan include a Biophysical Impact Assessment?			
3.4	Does the Stormwater Management report describe how the preserved wetlands are to be maintained in their natural state?			
3.5	If the wetlands are to be incorporated into the postdevelopment concept, does the SWMR include a description of how this is to be achieved including: inflow rates, frequency of inundation, vegetation and habitat management plans			
3.6	If wetlands are to be incorporated into the postdevelopment concept, have ESRD approval procedures been followed?			
3.7	If wetlands are to be incorporated into the postdevelopment concept, are compensation wetlands required?			
4.0	**Geotechnical and Hydrogeological Investigations**			
4.1	Have soil samples been taken (to RVC standards) and soil characterization been determined?			
4.2	Have infiltration tests been performed? Have infiltration volumes been identified from the locations of proposed LIDs?			
4.3	Has groundwater monitoring been done for a minimum of one season?			
4.4	Has the impact of irrigation or septic field on infiltration been assessed?			
4.5	If subsoil infiltration losses are <0.1mm/hr, does the water balance analysis adequately account for these infiltration losses?			