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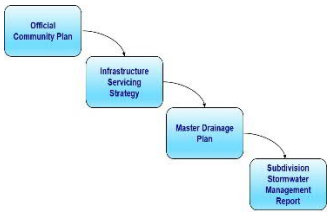
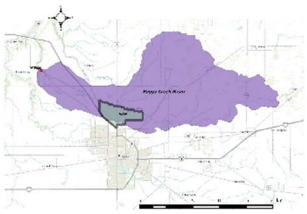
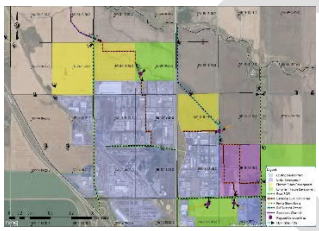
REPORT

RM of Sherwood No. 159

Sherwood Industrial Park
Master Drainage Plan







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Executive Summary

1 SUMMARY

The Rural Municipality of Sherwood (RM) has experienced significant growth over the past several years and this has put pressure on land development in some areas, for example the Sherwood Industrial Park (SIP). SIP has been designated as an area for light and heavy industry and as growth proceeds, land in this area is being transformed from agricultural fields to sites that are largely occupied by buildings and parking lots. The pattern of growth also complicates matters in that agricultural land that is still farmed lies between the main drainage outlet, Boggy Creek, and SIP. To date, there has been no overall stormwater management plan for this region and this has led to drainage disputes among land owners. It is generally recognized that stormwater management must be addressed in a different manner than in the past and that new approaches to stormwater management are required to balance the different land uses within the area.

Effective and cost-efficient stormwater management is necessary for orderly municipal growth. As land becomes less permeable with the placement of buildings and parking lots over it, more runoff is generated. For agricultural land in this region, there is often no runoff seen after the spring melt and so many drainage paths, which convey the spring runoff, dry out and can be farmed. However, with the transformation to more impervious surfaces these pathways could see runoff in the summertime, which could compromise the ability to grow crops along them. Therefore, it is important for the RM to identify and control these pathways so that drainage to SIP to Boggy Creek can occur without negatively affecting downstream landowners.

This Master Stormwater Drainage Plan (MDP) discusses key aspects of the planning, analysis, design and construction of future stormwater management systems in SIP. The Plan is intended to assist RM staff, community developers and landowners planning to develop lands within SIP. By following the recommendations of this plan, it is expected that the rate of growth in this region will not outpace the collective ability to protect the natural environment from the potentially harmful effects of stormwater runoff.

2 RECOMMENDATIONS

The SIP-MDP is conceptual and is intended to form a strategic plan to guide the planning and design of drainage development in the Plan Area. The key recommendations of the SIP-MDP are summarized in this section.

Stormwater Management:

- The RM should work with WSA to develop a flood hazard map for Boggy Creek. This map will provide a delineation of the floodway and flood fringe for the creek within the Project Area. No development should occur within the floodway and development within the flood fringe should be discouraged.

- Until a flood hazard map is available, WSA must be consulted for determining appropriate safe building elevations within the Plan Area.
- The City of Regina should be consulted for stormwater management requirements for the southern portion of the Project Area that drains into Wascana Creek.
- Developers should be responsible for designing and installing appropriate stormwater management infrastructure that adheres to requirements set out by the RM and WSA.
- Developers should work with the RM and WSA to ensure that land control is in place that provides a drainage outlet from any development to an Adequate Point of Discharge.
- For existing developed areas, the RM should work towards improving internal stormwater conveyance systems and to provide regional stormwater detention facilities (see Section 4.5) to service these areas so that a pre-development flow rate is discharged to Boggy Creek.

Watershed Risks:

- The RM should encourage Best Management Practices, as outlined in WSA's Stormwater Guidelines (EPB 322) to reduce the amounts of pollutants entering Boggy Creek.
- The RM should work with The Wascana and Upper Qu'Appelle Watersheds Association Taking Responsibility (WUQWATR) group and developers to protect riparian areas and improve water quality in the Boggy Creek watershed.
- The RM should encourage the submission of a sediment control procedure as part of a building permit application.
- A geotechnical engineer should be consulted where excavations are to occur, such as for stormwater detention facilities, deep ditches, or underground sewer pipes. Maps of existing and abandoned wells should be made available to developers so that there is no intrusion in an aquifer by accidently disturbing one of these features.

Existing Drainage:

- Figure 3-4 shows the main drainage basins within the project area and flow paths to Boggy Creek, based in LIDAR provided by the RM.
- In Section 3.2, the pre-development Unit Area Release Rate (UARR) was determined to be 4.3 L/s/ha. This release rate should be used to determine storage requirements within developed areas and for sizing regional drainage conveyance infrastructure.

- Drainage infrastructure should be planned to minimize disruption of agricultural activities.

Future Development:

- Each new subdivision should establish land control from the point(s) where stormwater runoff leaves the subdivision to an Adequate Point of Discharge.

- The RM should work with developers and land owners to establish the required land controls to drain existing and planned developments to an Adequate Point of Discharge.

- Each new subdivision should be required to provide enough storage for a 100-year, 24-hour storm event with a release rate for 4.3 L/s/ha.

- The RM should work with developers and land owners to optimize the number of stormwater detention facilities in the plan area. The RM should aim to have a regional stormwater management storage facility service development in a way that balances the ability to service as many landowners as is practicable with the ability to coordinate construction among multiple developers.

- For regional infrastructure that is required to implement the SIP-MDP, the following prioritization of activities is recommended:
    1. Establish a drainage route with land control from every developed lot in the Plan Area to an Adequate Point of Discharge.
    2. Complete designs of regional drainage channels.
    3. Complete designs for detention ponds
    4. Plan construction of regional drainage channels that is matches budgeting allocations.
    5. Plan construction of regional detention ponds that is matches budgeting allocations

Subdivision Stormwater Management Plans:

- For each proposed subdivision in the Plan Area, a Subdivision Stormwater Management Report (SSWMR) should be prepared for each development phase of a subdivision. It should include a detailed hydrologic and hydraulic analysis for each development phase.
- Stormwater detention facilities should be designed in accordance to the City of Regina's Development Standards Manual (Section 5.13 for wet ponds and Section 5.14 for dry ponds).
- A Pond Report should be prepared for all stormwater management storage facilities that will be turned over by a developer to the RM for on-going operations and maintenance.

RM Policies for Stormwater Management:

- Developers/builders should submit a sediment control procedure as part of a building permit application
- Define riparian area
- Bylaws for runoff quality

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1 Introduction

1.1 SCOPE OF WORK

The Rural Municipality of Sherwood No. 159 (RM) retained Associated Engineering (AE) to develop a Master Drainage Plan (MDP) for the Sherwood Industrial Park (SIP) that would provide guidance and recommendations for development of stormwater infrastructure in this region and that supports the pattern growth identified in the RM's Official Community Plan (OCP). As stated in the proposal letter for this project, the goal of the MDP is for it to be used to design infrastructure and develop policies that will:

- Best manage the routing of stormwater runoff in a manner that protects public safety and that mitigates property damage that could be caused by flooding.
- Protect natural watercourses and riparian areas.
- Protect existing wetlands and other environmentally sensitive areas.
- Provide guidance for those wanting to develop lands within the SIP region.

To fulfill the goals for the project, the following tasks were undertaken:

- Assemble topographical information from existing DEM and LIDAR sources.
- Use the topographical information to delineate existing catchments within the Project Area.
- Established a pre-development Unit-Area Runoff Rate (UARR) for the Project Area.
- Establish post-development runoff rates for the Project Area.
- Calculate the required storage volumes for the sub-regions within the Project Area.
- Overlay existing and planned road networks for the project area to look at aligning drainage ditches with roadway corridors.
- Identify major system drainage courses to Boggy Creek that will convey the 100-year storm event.
- Identify potential sites for regional stormwater detention.
- Determine if additional stormwater storage is needed at the local or sub-division level.
- Consult with the RM and WSA to establish a procedure for setting the safe building elevations in the Project Area.
- Consult with the RM for establishing the flooding level-of-service for roadways in the Project Area.
- Consult with the RM for the need to establish development policies and/or bylaws for the Project Area pertaining to stormwater management.
- Produce a report that details the stormwater management plan (at a conceptual level) for Sherwood Industrial Park.
- Work with the RM to communicate the stormwater management plan to stakeholders.

1.2 BACKGROUND

The 2181 ha Planning Area for SIP-MDP is in the north-central region of the RM, as shown in Figure 1-1 (see Appendix A for figures). With the exception of 171 ha on the southern part of SIP, almost the entire Planning Area lies within the Effective Drainage Area (EDA) of the Boggy Creek drainage basin

(see Figure 1-2). The southern part drains into the City of Regina and eventually makes its way to Wascana Creek. The 2181 ha Planning Area represents roughly 34 quarter-sections of the RM.

Many large and small-scale businesses are located within SIP, some have a long-standing history with the RM, such as Evraz Regina. The company is well known for recycling steel and delivering quality products to the energy, agriculture and transportation sectors. Evraz Regina is one of the largest developments in the RM with many ancillary businesses connected to it. Other businesses within SIP include:

- manufacturing
- metal fabrication
- welding
- farm equipment sales, leasing, and distribution
- construction contractors
- transportation and trucking firms
- asphalt and concrete plants
- chemical, and gas processing facilities
- other heavy, medium and light industrial businesses

The OCP identifies SIP as a key area of growth for the RM and in recent years several new industrial subdivisions have started development including Parker, Lipsett, and DBR and a few are at the concept planning stage including KinWest and Varsteel (see Figure 1-3). This recent growth has brought with it challenges to plan and provide municipal infrastructure for this area, including roadways, water, sewer, and drainage. Within the RM's Infrastructure Servicing Strategy it is stated that:

"The RM of Sherwood has made the Sherwood Industrial Park their most important focus for infrastructure improvements."

Except for the new subdivisions mentioned above, drainage in SIP has been managed by each lot owner with no overall stormwater management plan for the area. As SIP has developed, more pressure has been put on natural drainage paths and municipal ditch systems to convey the additional runoff water that is produced by hardening land surfaces. One noticeable effect has been that many of these drainage paths typically remain wet throughout the summer months whereas in the past they dry out after the spring melt – a direct result of more impervious surfaces. In some cases, this has led to conflicts among land owners where land is no longer usable because it remains constantly wet.

The RM recognizes that continuation of this approach to drainage management poses risks to development in terms of protection of property (private and municipal) and public safety. It will also likely perpetuate conflicts among landowners, as more runoff is directed into natural drainage paths. It is therefore important that the RM develop a Master Drainage Plan (MDP) for the area so that drainage infrastructure can be developed along side land develop in a manner that is socially, environmentally, and economically sustainable for the SIP area. This document outlines this plan.

1.3 ACKNOWLEDGEMENT

Associated Engineering is grateful for the assistance and cooperation given by the RM of Sherwood staff for the provision of input, feedback and background information. We would also like to acknowledge the help provided by staff at the Water Security Agency.

1.4 PREVIOUS REPORTS

The Sherwood Industrial Park Stormwater Management Master Drainage Plan is a progression of work documented in the following reports:

1. R.M. of Sherwood 159 Official Community Plan, Bylaw 16/16, April 2017
2. R.M. of Sherwood 159 Integrated Servicing Strategy, Report No. 151-09572-00, February 2016

The Official Community Plan contains the planned growth pattern for the Sherwood Industrial Park area which guides the drainage planning in terms of land use and the phasing for drainage infrastructure. The Integrated Servicing Strategy provided guidance as to other infrastructure that is planned for development in the Sherwood Industrial Park, most notably roadways with ditch systems.

1.5 GLOSSARY OF TERMS

Adequate Point of Discharge (APD)	A location in the drainage network where downstream flows are contained within recognized drainage courses (e.g. creeks, rivers, or lakes). For most of the Plan Area, the APD is Boggy Creek.
Best Management Practices (BMPs)	A set of practices or treatment methods that reduce the effects of stormwater pollution to meet stormwater management objectives for a given area.
Land Control	In terms of the drainage plan, this refers to having control of the land that is needed to convey runoff water from its source to an Adequate Point of Discharge.
LIDAR	“Laser Imaging, Detection And Ranging” is a surveying method that measures distance from a source to a target by illuminating the target with pulsed laser light and measuring the reflected pulses with a sensor.

Permeability	The measure of the ability of a porous material, such as soil, to allow fluids to pass through it.
Plan Area	The region of the Sherwood Industrial Park for which the Master Drainage Plan applies.
Unit Area Release Rate (UARR)	The maximum flow rate that is permitted to be discharged per unit area. For the Plan Area the unit area is one hectare and the flow rate is in m^3/s.

2 Stormwater Management Philosophy

2.1 INTRODUCTION

The RM has experienced significant growth over the past several years and this has put pressure on land development in some areas, for example SIP. It has been designated as an area for light and heavy industry and as growth proceeds land in this area is being transformed from agricultural fields to sites that are largely occupied by buildings and parking lots. The pattern of growth also complicates matters in that agricultural land that is still farmed lies between the main drainage outlet, Boggy Creek, and SIP. To date, there has been no overall stormwater management plan for this region and this has led to drainage disputes among land owners. It is generally recognized that stormwater management must be addressed in a different manner than in the past and that new approaches to stormwater management are required to balance the different land uses within the area.

Effective and cost-efficient stormwater management is necessary for orderly municipal growth. As land becomes less permeable with the placement of buildings and parking lots over it, more runoff is generated. For agricultural land in this region, there is often no runoff seen after the spring melt and many drainage paths, which convey the spring runoff, dry out and can be farmed. However, with the transformation to more impervious surfaces these pathways could see runoff in the summertime, which could compromise the ability to grow crops along them. Therefore, it is important for the RM to identify and control these pathways so that drainage to SIP to Boggy Creek can occur without negatively affecting downstream landowners. This stormwater plan will identify the major drainage outlets for the SIP and the pathways to these outlets.

In addition to identifying the major drainage pathways and outlets, the release rate of runoff into Boggy Creek must be managed so that the Creek, its riparian areas, and any hydraulic structures that are situated within it are not adversely compromised. This translates into keeping release rates into Boggy Creek to pre-development levels, which requires surface storage to detain runoff. Surface storage facilities often compete for space with other land uses within a development. A holistic approach is needed to balance surface storage on each site with regional storage in a manner that provides the necessary environmental protection while minimizing the financial cost of development. By working with natural systems (such as natural drainage patterns), the development community and the RM will contribute to fiscal sustainability by reducing reliance on engineered solutions.

This Master Stormwater Drainage Plan discusses key aspects of the planning, analysis, design and construction of future stormwater management systems in SIP. The Plan is intended to assist RM staff, community developers and landowners planning to develop lands within SIP. By following the recommendations of this plan, it is expected that the rate of growth in this region will not outpace the collective ability to protect the natural environment from the potentially harmful effects of stormwater runoff.

Management of stormwater can provide numerous opportunities for new development designs that integrates natural topography with landscaped areas. The RM should exercise a degree of flexibility when reviewing development applications to account for these site-specific conditions.

2.2 STORMWATER MANAGEMENT FRAMEWORK

The Master Drainage Plan for SIP was developed using goals from the RM's Official Community Plan to provide guidance for integrating environmental protection and sustainable stormwater management while accommodating projected growth in the study area. The guiding principles are outlined in Table 2-1.

Table 2-1
Stormwater Management Framework

Guiding Principle	OCP Goals
Build and operate the SIP stormwater system in an efficient and effective manner.	1.3.1 (b): *Deliver responsible municipal servicing.* 1.3.3 (b): *Service development areas with cost efficient water, sanitary sewer, transportation, and stormwater drainage requirements.*
Encourage best practices for stormwater management on private sites.	1.3.3 (c): *Ensure proponents provide the required infrastructure.* 1.3.3 (d) *Share cost of services where it has a clear benefit to the RM.*
Provide municipal stormwater infrastructure that maximizes benefits to land development while protecting agricultural and riparian areas.	1.3.3 (e): *Protect, conserve and enhance the natural environment.* 1.3.4 (a): *Retain agricultural land in larger tracts for ease of cultivation minimize land use conflict and create economies of scale.* 1.3.4 (b): *Avoid fragmentation of productive agricultural lands.* 1.3.4 (c): *Require mitigating measures for development proposals that cause unavoidable land use conflicts with agricultural activities and resources or adjacent uses.*
Stakeholder engagement for Master Stormwater Plan.	1.3.3 (g): *Encourage public discussion and involvement in community planning.* 1.3.5 (a): *Encourage dialogue among First Nations and adjacent municipalities.* 1.3.5 (b): *Work with First Nations and adjacent municipalities to ensure land use and development policies are complimentary and compatible.* 1.3.5 (c): *Contribute to inter-municipal land use planning initiatives.* 1.3.5 (f): *Encourage regional thinking in the context of local decision making.* 1.3.5 (j): *Maintain open communication that is mindful of the long-term relationships between First Nations and adjacent municipalities.*

2.3 STORMWATER OBJECTIVES

In order to achieve the above guiding principles, the following key stormwater objectives are established:

Site Planning:

- Encourage built form and site planning that increases the extent of pervious surfaces.
- Minimize flood risk to the community by restricting development within the flood fringe of Boggy Creek.
- Meet runoff release rates that are controlled to pre-development levels.
- Promote on-site storage to reduce the load on municipal stormwater systems.
- Promote the logical sequencing of larger, regional stormwater management storage facilities to encourage orderly growth of developments.

Open Space Design:

- Protect wetlands by integrating natural areas into open space systems.
- Promote appropriate riparian management policies and development setbacks.
- Incorporate larger, regional stormwater management storage facilities that are situated to complement parks and open spaces.
- Preserve natural drainage courses and integrate them into the stormwater drainage systems and surrounding developments.

Stormwater Management Storage Facility Design:

- Achieve pre-development release rate targets into Boggy Creek.
- Encourage removal of sediment in stormwater runoff by detaining water so that sediment can settle out.
- Minimize life cycle costs of regional stormwater management storage facilities.
- Contemplate public safety when designing emergency spill routes and landscaping treatments.

These stormwater objectives have been used to guide the development of the SIP Stormwater Management Plan.

2.4 BOGGY CREEK FLOOD FRINGE/FLOODWAY

Water Security Agency (WSA) was contacted to see if there was a Flood Hazard Map available for Boggy Creek to show the extent of the floodway and flood plain for the creek in the Study Area. WSA responded that there was no map available and no near-future plans to develop one. WSA did say that they would provide safe building elevations on a case-by-case basis. It is recommended that the RM work with WSA to develop such a map. In the interim, all proposed development near Boggy Creek should obtain safe building elevations from WSA. It is also recommended that WSA provide the extents of the floodway and flood fringe in the area near the development. The floodway is the portion of the flood hazard area where

the flows are the deepest, fastest and most destructive and is typically set to be the 1:100-year water level. The floodway typically includes the main channel of a stream and a portion of the adjacent overbank area. The flood fringe is the portion of the flood hazard area outside of the floodway. Water in the flood fringe is generally shallower and flows slower than in the floodway.

No development should occur within the floodway of Boggy Creek. Development within the flood fringe may be permitted by the RM, in consultation with WSA, provided that the development is flood-proofed in accordance with provincial and federal requirements. Review of such development applications within the flood fringe of Boggy Creek should be on a case-by-case basis. Stormwater management storage facilities may be located within the flood fringe. The normal water level of wet facilities must be equal to or higher than the 1:100-year design flood elevation so the facilities remain operational during a flood event along Boggy Creek. Similarly, the bottom elevation of a dry pond must be equal to or higher than the 1:100-year design flood elevation. The design of stormwater management storage facilities within the flood fringe must also evaluate the risk of stream movement and, if necessary, implement protective measures.

2.5 STORMWATER BEST MANAGEMENT PRACTICES

Stormwater Best Management Practices are activities or practices that reduce the impacts that stormwater runoff has on the environment. Types of stormwater BMPs include:

- Pollution prevention strategies
- Site control BMPs
- End-of-pipe BMPs

Pollution prevention strategies focus on removing the cause of pollution rather than managing the pollution after it has been created. Pollution prevention strategies include pesticide, herbicide and fertilizer reduction programs, general good housekeeping practices with regards to pollution containment and handling of spills, erosion and sediment control at construction sites, street sweeping and animal waste removal. The most effective pollution prevention strategies include public awareness and education to give a sense of ownership to those who generate pollution and motivate those individuals to reduce or prevent the pollution. Site control BMPs are practices that have traditionally been applied to individual sites to enhance the quality of the stormwater leaving the site. Examples of site control BMPs include filter strips, buffer strips, sand/organic filters and oil/grit separators.

End-of-pipe BMPs are features that receive stormwater from a conveyance system and provide peak flow reduction or quality enhancement prior to discharging to the receiving water body. End-of-pipe BMPs are often the last line of defence after other types of BMPs have been applied. Dry ponds, wet ponds and constructed wetlands are typical end-of-pipe BMPs.

Currently, there are no regulations in the Province of Saskatchewan for treatment of stormwater effluent before it is discharged into a natural water body; however, Water Security Agency has produced BMP guidelines that can be found in the following report:

Water Security Agency, *Stormwater Guidelines*, EPB 322, January 2014.

Consideration of the most appropriate BMPs for a site or development should be based upon the specific soil, vegetation, topography, hydrological conditions and land use. There are many combinations of BMPs that can be implemented to provide peak flow reduction, runoff volume control, total suspended solids (TSS) removal and nutrient removal. A treatment-train type of approach, consisting of multiple BMPs within the contributing catchment, should be considered to reduce peak flows, runoff volume, sediment loads and nutrient loads upstream of the stormwater management storage facilities. Each developer and their design team should determine the BMPs that are appropriate for their specific site and the review by the RM and WSA before implementation.

3 Existing Drainage

3.1 CURRENT DRAINAGE PATTERNS

The plan area lies mainly within the drainage basin for Boggy Creek with exception of the southern tip, which drains southward through the City of Regina to Wascana Creek. Figure 3-1 located in Appendix A, shows the extent of the Boggy Creek Basin for the hydrometric station 05JF006 of that is monitored by Environment Canada. The gross drainage area of this basin is 441.6 km^2 and the effective drainage area is 233.7 km^2. The effective drainage area is defined to be the portion of a drainage basin that would likely contribute runoff (in this case to Boggy Creek) in an average year. The effective drainage area typically excludes sloughs and marshes, along with their drainage areas. As can be seen in Figure 3-1 located in Appendix A, the plan area lies almost entirely within the effective drainage area for the Boggy Creek basin.

As mentioned above, the southern tip of the plan area drains into the City of Regina and eventually ends up discharging into Wascana Creek, as seen in Figure 3-2, located in Appendix A. The section of this area between Pasqua Street and Albert Street (Highway 6) has been accounted for in the City of Regina's Northwest Sector Plan and the City should be consulted if additional development is planned for this area. The portion of the plan area between Albert Street and Winnipeg Street (within N-7-18-19-2) is owned by SaskPower and drains south into the Uplands residential neighbourhood of the City. As with the other area, the City should be consulted if additional development is planned here. The remainder of this section will focus on the portion of the plan area that is within the Boggy Creek Basin.

Figure 3-3 located in Appendix A shows the surface elevations within and surrounding the study area, as represented by color from lower elevations (green) to higher elevations (red). As can be seen in Figure 3-3, there is a ridge in the south region of the project area that splits runoff flow: north of the ridge runoff flows to Boggy Creek; south to Wascana Creek. Elevations within the study area range from a high of 605 m (at the south) to a low of 570 m (at the northwest) and the general flow pattern for the Boggy Creek catchment is from southeast to northwest. This figure was produced using sub-meter Laser Imaging Detection and Ranging (LIDAR) that was supplied by the RM by McElhanney Consulting Services Ltd. It was flown in 2013, has a point density in the 4 to 5 points/m^2 range, a vertical accuracy < 10 cm (RMSE 68% confidence level), and a QL2 Quality Level.

The LIDAR data was processed using a software package called GlobalMapper to determine the flow paths and sub-catchments within the study area. Results of this processing are shown in Figure 3-4 located in Appendix A, with the five main drainage outlets from the plan area that are shown as red triangles. Descriptions of these outlet are as follows in Table 3-1:

Table 3-1
Discharge Locations for SIP Drainage

Map Label	Location	Total Contributing Area (ha)	Adequate Point of Discharge
Outlet 1	NE corner of SW-23-18-19-2	278.14	No. It discharges into NE-22-18-20-2
Outlet 2	NE corner of SW-24-18-20-2	323.85	No. It discharges into Cowessess FN lands
Outlet 3	Middle of NE24-18-19-2	445.36	Yes. It discharges into Boggy Creek
Outlet 4	Between SE-19-19-19-2 and SW-20-18-19-2	108.36	Yes. It discharges into Boggy Creek
Outlet 5	SW corner of SW-21-18-19-2	774.44	Yes. It discharges into Boggy Creek

3.2 PRE-DEVELOPMENT PEAK FLOWS

This section provides the methodology for establishing a Unit Area Release Rate, which is a target to be achieved for post-development runoff in the plan area. It is based on flow rates measured at Environment Canada's hydrometric station 05JF006 on Boggy Creek near its confluence with the Qu'Appelle River and on flood frequency methods used by the WSA. At the conceptual level in this report, municipal stormwater conveyance and storage infrastructure will be sized using the UARR.

Table 3-2 shows the 20 highest peak mean daily flow rates that were recorded at hydrometric station 05JF006 since recording began in 1945. It is interesting to note that seven of these 20 maxima were recorded during the summer season (from May to September), as opposed to spring which is typically the high runoff season for the prairies, including the event of record that was recorded on June 27, 1975. This event was driven by the rainfall event of record that was recorded at the Regina Airport on June 26, 1975, as shown in Figure 3-5 located in Appendix A.

Table 3-2
Top 20 Mean Daily Flow Rates at 05JF006

Rank	Year	Month	Day	Flow rate (m^3/s)
1	1975	6	27	56.6
2	1956	4	15	41.6
3	1971	4	11	39.6
4	1974	4	19	36.5
5	1996	4	11	35.5
6	1982	4	16	26.2
7	2011	4	13	24.3
8	1955	5	3	24.1
9	1976	4	2	22.5
10	1951	6	8	20.0
11	1969	4	10	19.6
12	2014	7	1	16.5
13	2005	4	3	16.1
14	1979	4	21	15.4
15	2013	4	30	13.4
16	1960	6	26	13.2
17	1999	3	28	13.0
18	1947	4	13	11.9
19	2000	7	11	11.8
20	1991	7	2	11.4

Table 3-3 shows the expected return frequencies of peak mean daily flows for 05JF006 that were provided by the WSA. These return periods are annual and include both spring and summer events.

Table 3-3
Return Frequencies at 05JF006 Provided by Water Security Agency

Return Period (in years)	Peak Mean Daily Flow Rate (m^3/s)
1:2	5.5
1:5	14.5
1:10	22.5
1:25	34.0
1:50	45.0
1:100	56.0
1:200	67.0
1:500	82.0

The effects of land development on spring runoff is different than its effects on summer runoff. For spring events, impervious surfaces are usually clear of snow before the main snow melt and so they don't have a major impact on runoff. Also, snow typically melts one or two weeks earlier on developed land than in the surrounding open areas and this tends to spread out the runoff and may modestly reduce peak flows.[1]
The summer events have a more pronounced effect on runoff from post-developed land. For many summer rainfall events, typically up to a frequency of a 1:5-year storm, very little runoff may be seen with the rainfall being held on the land until evaporated or infiltrated. However, as the land is converted to impervious surfaces more rainfall is directed to runoff and this will be seen in downstream water courses. The Cunnane Plotting Method was used to determine the return periods for mean daily peak flow rates at hydrometric station 05JF006 from May 1 to September 30 (the summer season). The results are shown in Table 3-4 along with the annual mean daily peak flow rates from Table 3-3.

Table 3-4
Return Frequencies at 05JF006 for Annual and Summer Periods

Return Period (in years)	Mean Daily Peak Flow Rate (m^3/s) Annual	Mean Daily Peak Flow Rate (m^3/s) Summer
1:2	5.5	0.3
1:5	14.5	2.0
1:10	22.5	11.0
1:25	34.0	20.0
1:50	45.0	25.0
1:100	56.0	56.0

[1] Ray Pentland, Report to RM of Edenwold on Flood Damage Reduction, January 2014.

To determine the UARR for the plan area, the first step is to determine the runoff from the plan area that contributes to the overall Boggy Creek basin at hydrometric station 05JF006. This was done using a procedure to estimate flow rates at an ungauged site, developed by the Water Security Agency[2], and by noting that then entire plan area is within the effective drainage area of the 05JF006 basin. Using this method, the runoff rates for the plan area were calculated and are shown in Table 3-5.

Table 3-5
Return Frequencies for the 05JF006 and Plan Area Basins

Peak Mean Daily Flow Rate (m^3/s)				
	05JF006 Basin		Plan Area Basin	
Return Period	Annual	Summer	Annual	Summer
2-Year	5.5	0.3	1.0	0.1
5-Year	14.5	2.0	2.6	0.4
10-Year	22.5	11.0	4.0	2.0
25-Year	34.0	20.0	6.1	3.6
50-Year	45.0	25.0	8.1	4.5
100-Year	56.0	56.0	8.8	8.8

The UARR for the Plan Area is obtained by dividing the above flow rates by 2010 ha (the size of the Plan Area that drains to Boggy Creek). Table 3-6 shows the UARR in different units. For planning purposes, the municipal stormwater conveyance and detention infrastructure will be sized using the 1:100-year UARR of 4.3 L/s/ha, which is consistent with the City of Regina's standards for sizing the major stormwater system and detention facilities[3].

Table 3-6
Return Frequencies for the 05JF006 and Plan Area Basins

Plan Area Pre-Development Runoff Release						
	Annual			Summer		
Return Period	m^3/s	L/s/ha	24-hr depth (mm)	m^3/s	L/s/ha	24-hr depth (mm)
2-Year	1.0	0.5	4	0.1	0.0	0
5-Year	2.6	1.3	11	0.4	0.2	2
10-Year	4.1	2.0	17	2.0	1.0	8
25-Year	6.2	3.0	26	3.6	1.8	15
50-Year	8.1	4.0	35	4.5	2.2	19
100-Year	8.8	4.3	37	8.8	4.3	37

[2] Magnitude and Frequency of Peak Flows and Volumes in Saskatchewan, Sask Water, 1993.
[3] Development Standards Manual, City of Regina, 2010.

The UARR of 4.3 L/s/ha for the Plan Area is higher than that developed for the Global Transportation Hub[4], which is 3.16 L/s/ha, that drains into Cottonwood Creek and for the City of Regina's Southeast Sector[5], which is 3.3 L/s/ha, that drains into Chuka Creek. The reason for this is that the entire Plan Area lies within the effective drainage area for the Boggy Creek basin whereas for the other two sites it was assumed that they contained the same proportion of ineffective drainage area as the overall basins, which translates into less runoff.

Using the UARR value of 4.3 L/s/ha, the target discharge rates for the five outlets described in Section 3.1 are provided in Table 3-7.

Table 3-7
Target Discharge Rates for Outlets

Outlet	Basin Area (ha)	Peak Mean Daily Flow Rate (m^3/s)
Outlet 1	278.14	1.20
Outlet 2	323.85	1.39
Outlet 3	445.36	1.92
Outlet 4	108.36	0.47
Outlet 5	774.44	3.33

3.3 GROUNDWATER CONDITIONS

The Study Area for the SIP Master Drainage Plan lies on top of two aquifers – the Regina Aquifer and the Condie Aquifer, as shown in Figure 3-6. As stated in the OCP:

Precautions to ensure the long-term sustainability of the aquifers and high-quality water is required. Management of the environment, aquifers, and source water is important to our community.

The RM promotes responsible growth and sustainability to protect, conserve, and enhance the aquifers, ground and source water, recharge areas, and significant environmental areas.

In the region of the Study Area, the Condie Aquifer lies above the Regina Aquifer and with the Condie categorized as "Extreme Sensitivity" and the Regina as "High Sensitivity". The Master Drainage Plan is focused on surface water runoff and its controlled conveyance to an Adequate Point of Discharge, which in most cases is Boggy Creek – a surface water feature. However, it is recognized that there is potential for surface water to be directed to the groundwater system if consideration is not given to proper design and construction methods of drainage-related infrastructure. Sections 7.6 and 7.7 of the OCP outline the responsibilities of developers when considering development over Extreme and High Sensitivity Aquifer areas.

[4] Design Report: Global Transportation Hub Drainage Channel, Clifton Associates, 2010.
[5] Southeast Serviceability Study – Final Report, AECOM, 2012

A geotechnical engineer should be consulted where excavations are to occur, such as for stormwater detention facilities, deep ditches, or underground sewer pipes. Maps of existing and abandoned wells should be made available to developers so that there is no intrusion in an aquifer by accidently disturbing one of these features.

3.4 WATERSHED RISKS

The natural topography of the study area poses both opportunities and constraints to development. The natural low areas (sloughs and minor wetlands) may be viewed as opportunities for innovative stormwater management or unique open space amenities. Alternatively, these areas may be viewed as requiring engineered fill to enable the greatest development potential. The high points or drainage divides will likely influence development staging. The natural drainage channels may pose a challenge to planning road networks but may create a linear open space system that serves as a public amenity. Natural drainage channels could also play a role in the stormwater management system as the emergency spill routes.

In the past, stormwater runoff was regarded as a relatively minor source of pollution. However, studies have shown that there can be significant pollution within stormwater flows. Common pollutants found in urban stormwater include:

- Suspended solids (typically caused by eroded soil)
- Nutrients (particularly phosphorus and nitrogen)
- Organic contaminants
- Trace metals
- Microorganisms and pathogens
- Road salt

It is generally accepted that the implementation of stormwater BMPs will reduce the impact that stormwater runoff has on the environment. Refer to Section 2 of this document for more information on stormwater BMPs.

Agricultural lands within the Study Area may also contribute polluted runoff. Nutrient levels within runoff may be elevated due to fertilization of the agricultural lands. The nutrient levels may also contribute to algal outbreaks or excessive aquatic growth in downstream water bodies and in stormwater detention ponds that retain a permanent water level (wet ponds). The design of wet pond storage facilities that are downstream of agricultural lands should consider the mitigation of high nutrient load potential in the stormwater runoff.

While the natural environment has some ability to mitigate the impacts of small scale development, the cumulative impacts of impervious surfaces and human activities in these developments can produce negative consequences that affect the watershed. It is recommended that the RM work with developers and the Wascana & Upper Qu'Appelle Watersheds Association Taking Responsibility (WUQWATR) group to protect riparian areas and improve water quality in the Boggy Creek watershed. Of primary importance is the Condie Reservoir, which is approximately 5 km downstream of the Study Area. The Condie Reservoir is a constructed lake approximately 64 ha in area that is a fishing spot containing Yellow Perch, Walleye, and Northern Pike.

A critical factor in the protection of the Boggy Creek watershed is proper erosion and sediment control. Proper planning, implementation, inspection and maintenance of erosion and sediment controls is the responsibility of all those who are involved in the development industry (i.e. the RM, land owners, developers, consultants, contractors, builders and owners). It is generally accepted that the best strategy for managing sediment is to minimize erosion at the source. The RM should encourage the submission of a sediment control procedure as part of a building permit application.

3.5 EXISTING LAND USE

The land within the Plan Area can be categorized into three main classifications:

1. Agricultural
2. Developed (Industrial)
3. Under development

These three land categories will be described in more detail in the remainder of this section.

3.5.1 Agricultural

Although the Plan Area has been designated for industrial growth, most of this area is currently agricultural. Section 5 of the Official Community Plan addresses how agricultural land use should be promoted and protected as growth proceeds in the RM. As growth proceeds in the Plan Area, attention should be given to the following statements in Section 5.1.1 of the Official Community Plan:

- 5.5.1 (d) - *Minimize the fragmentation of large agriculture parcels, mitigate impacts between agriculture and non-agricultural uses through setbacks, separation and buffers between agriculture and proposed non-agriculture uses, urban style of uses, aggregate, mineral, and resource development, and resource extraction activities.*

- 5.1.1 (g) - *Reduce the fragmentation of agriculture parcels, consider single parcel rural residential development on residual parcels, sites with a physical or natural severance, and limit subdivisions to contiguous blocks adjacent to property boundaries, adjacent subdivision, and Rural Residential areas.*

Drainage infrastructure for the Plan Area should be planned to minimize disruption of agricultural activities in accordance to the two items mentioned above. Also, it is important to recognize that as land is converted from agricultural to industrial uses, more runoff water will be generated as there is less capacity in the land to infiltrate precipitation. Natural low areas that receive runoff would see not only more runoff volumes but also would see longer periods of runoff, most notably in the summer months. It is important to recognize this as development proceeds and that land controls are in place for those areas that drain through agricultural areas to an Adequate Point of Discharge.

3.5.2 Developed (Industrial)

The Plan Area is an extension of the existing Sherwood Industrial Park that is shown in Figure 1-3 located in Appendix A. Development in this area has occurred since the 1950's and includes Evraz Regina. The company is well known for recycling steel and delivering quality products to the energy, agriculture and transportation sectors. Evraz Regina is one of the largest developments in the RM with many ancillary businesses connected to it. Other businesses within SIP include:

- manufacturing
- metal fabrication
- welding
- farm equipment sales, leasing, and distribution
- construction contractors
- transportation and trucking firms
- asphalt and concrete plants
- chemical, and gas processing facilities
- other heavy, medium and light industrial businesses

The areas identified as "Existing Development" in Figure 1-3 have no drainage plans. These areas tend to be graded to drain to roadside ditches and/or internal swales that convey the water to the edge of the development, typically discharging onto adjacent agricultural land. An important component of the Drainage Plan will be to address the drainage leaving these subdivisions in the following ways:

1. Develop routes to convey water from these locations to an Adequate Point of Discharge.
2. Determine locations for stormwater detention so that runoff from these areas is releases at a pre-development rate.

As part of the Master Drainage Plan work, stormwater runoff routing within existing subdivisions was examined at a high-level to see where runoff is conveyed to the edge of property but there was no detailed assessment of the internal capacity and condition of internal stormwater infrastructure. It is recommended that the RM conduct these assessments as part of the overall drainage improvements within the Plan Area.

3.5.3 Under Development

At the time of issuing the Sherwood Industrial Park, three new industrial subdivisions were under development (see Figure 1-3 located in Appendix A):

- Parker Industrial Subdivision (SE-16-18-19-2)
- Lipsett Industrial Subdivision (SE-18-18-19-2)
- DBR Industrial Subdivision (SE-18-18-19-2)

Unlike the Existing Developed areas (see Section 3.6.2), the subdivisions under development have drainage plans that have been reviewed by the RM and WSA. The Parker subdivision has a ditch and culvert system that conveys runoff to a dry-bottom detention pond that will hold runoff volume from a

1:100-year storm event. The pond discharges into a 600 mm buried pipe that outlets near Boggy Creek in the west ditch of Fleet Street. Both the Lipsett and DBR subdivisions were designed to have on-site storage that will hold 500 m^3/ha (50 mm rainfall depth). The on-site storage discharges into a ditch system that outlets at the northwest corner of the DBR subdivision. The RM is currently working with downstream land owners and WSA to establish land control between this outlet and Boggy Creek (the Adequate Point of Discharge).

4 Future Development

4.1 PROPOSED LAND USE

For the purposes of the SIP Master Drainage Plan (SIP-MDP), a generalized land-use concept was used for the study area that is based on “Schedule B: Future Land Use Plans” from the OCP. This land-use concept assumes that the entire plan area could be developed for industrial purposes. Based on this premise, this chapter provides the details of the SIP-MDP. It should be noted that for lands not yet developed, appropriate approvals are required and that this planning document is not a form of such approval.

4.2 DRAINAGE CATCHMENTS WITHIN THE PLAN AREA

LIDAR data provided by the RM was used to determine the natural drainage catchments for the Plan Area. The catchments are shown in Figure 3-4 located in Appendix A. For planning purposes, the post-development catchments will follow the natural catchments where possible. The rationale for this is that the natural catchments follow the grade of the land and it is assumed that this would be the most cost-effective approach for development of the land (to minimize earthworks). It is recognized that situations could arise where it would be advantageous to re-direct drainage from one catchment to another. Should this be required, the developer must demonstrate the downstream drainage system can handle the re-directed runoff and that there are no negative effects on other landowners.

Most of the undeveloped lands within the SIP-MDP area are owned in quarter-section sizes. Therefore, it is assumed that when land is to be developed, a stormwater management plan will be developed for the quarter section, even if only a portion of the quarter-section is initially developed. This means that runoff leaving each quarter-section must be at pre-development rates.

It will be the responsibility of the developer to provide stormwater management facilities and to size drainage infrastructure that will provide the appropriate level of flood protection to all landowners. Depending on the number of landowners that make use of a stormwater management facility or conveyance channel, the RM may engage the developer to plan such facilities so that the RM will eventually acquire and operate them (see Section 4.8).

Recently, WSA has indicated that all applicants for site development must demonstrate that there is land control from the location of discharge from a development to an adequate point of discharge. The term “Adequate Point of Discharge” (APD) refers to a location in the drainage network where downstream flows are contained within recognized drainage courses (e.g. creeks, rivers, or lakes). For the Plan Area, the APD is Boggy Creek. Land control could include the following:

- Roadside ditches owned by the Municipality or Ministry of Highways provided approval is obtained.
- A drainage easement that is registered on title
- A municipal drainage corridor provided approval is obtained from the RM
- Direct discharge into Boggy Creek provided approval is obtained from WSA

Each applicant for site development must demonstrate that there is land control from every point of discharge from the site to an APD. Each applicant must also demonstrate that there is sufficient capacity in the drainage system from the site to the APD to handle the runoff from that site.

4.3 POST-DEVELOPMENT STORAGE REQUIREMENT

To estimate the size of stormwater management facilities and conveyance structures, that would be required, as post-development Unit-Area Release rate was calculated. A sample of lots from the existing SIP development was examined to determine the fraction of surface cover. Each surface cover type was assigned a Rational Method runoff coefficient for a 100-year event and then the aggregated runoff coefficient for a typical site was determined, as shown in Table 4-1.

Table 4-1
Post-Development Runoff Coefficient for A Site

Surface Cover	Fraction of Area Covered	Runoff Coefficient
Buildings	0.19	0.95
Paved Parking and Approaches	0.16	0.95
Gravel Parking	0.57	0.63
Grass	0.08	0.30
Aggregated Coefficient		**0.72**

It should be noted that in the literature there is a wide range of values for gravel surfaces that correspond to different opinions as to the impermeability of gravel. Based on a review of the literature, the value selected above was chosen to reflect that in parking lots the gravel does become compressed by traffic loads and made more impermeable while at the same time this traffic also generates ruts and depressions that will store rainwater.

For roadways with the RM, typical right-of-way widths are 25 m and 30 m. The runoff coefficients for these rights-of-way are shown in Table 4-2.

Table 4-2
Runoff Coefficients for Roadways

	Pavement		Shoulder		Ditches		
RoW Width (m)	Fraction of RoW	Runoff Coefficient	Fraction of RoW	Runoff Coefficient	Fraction of RoW	Runoff Coefficient	Aggregate Runoff Coefficient
25	0.34	0.95	0.05	0.65	0.61	0.30	0.54
30	0.29	0.95	0.04	0.65	0.67	0.30	0.50

To limit runoff to the pre-development UARR of 4.3 L/s/ha (see Section 3.2) for developed lands, storage of stormwater runoff will be required. For planning purposes, a high-level estimate of storage requirement is provided below and is based on a developed land-use shown in Table 4-1. The amount of roadway infrastructure within a development is difficult to estimate at a concept level so a runoff coefficient of 0.72 will be assumed for the entire development, which could lead to a slight over-estimate of the amount of storage. The post-development storage is calculated using a 24-hour balance of rainfall for a 100-year event and the pre-development runoff for a one-hectare unit area. This balance is shown in Table 4-3.

Table 4-3
Calculation for Required Storage Volume

Parameter	Calculation	Value
1:100-year, 24 hr Rainfall	Env. Canada - Regina Airport	1212 m^3/day/ha
Post-Development Runoff	0.72 x 1212 m^3/day/ha	873 m^3/day/ha
Pre-Development Release	0.0043 m^3/s/ha x 86400s	372 m^3/day/ha
Required Storage Volume	873 m^3/day/ha – 372 m^3/day/ha	501 m^3/ha

For developed sites, 500 m^3/ha should be needed for stormwater storage. It must be stressed that this is a high-level estimate for planning purposes and that actual storage volumes must be calculated at the design stage and considers the planned land use for that development. For existing developments that do not have a stormwater management facility, this storage volume can be used to determine the size of regional stormwater management facilities that could service these areas. This is addressed in more detail in the next section.

4.4 LAND CONTROL TO ADEQUATE POINT OF DISCHARGE

Figure 4-1 shows the major drainage corridors for the Plan Area. This figure also shows the proposed locations of regional stormwater detention facilities, which are described in more detail in Section 4.5. Most of the drainage routes can be combined with roadside ditches (seen as green in the figure) to convey runoff to Boggy Creek. New subdivision developments have provided (or will need to provide) corridors that connect upstream drainage to downstream corridors (seen as orange in the figure). Figures 4-2 and 4-3

show the pre-development peak mean daily flow rates that shall limit the flow from each quarter section in the planning area. The location of these arrows are approximate reference points; the actual locations would be determined during the design phase of the development.

There are three regions within the Plan Area where land control to an Adequate Point of Discharge is needed but where land control does not presently exist and are shown as blue-black and purple-black lines in Figure 4-1. These are listed below.

NW-16-18-19-2

There is approximately 300 m from the grid road (between NE17 and NE16) where drainage from lands to the west and south is conveyed to an inlet to Boggy Creek and for which there is no land control. There is also a reach from this drainage run, which extends approximately 330 m to the south that conveys runoff from SE16 to this inlet. It is recommended that this drainage run and its south reach be brought under land control so that it becomes a formal drainage outlet for the part of the Plan Area.

SIP East Drainage Channel

Lands currently being developed in SE-18-18-19-2 as well as existing developed lands in NW-18-18-19-2 require land control for drainage to Boggy Creek, which is an Adequate Point of Discharge. Currently, these areas drain through approximately 1.5 km of agricultural lands in NE-18-18-19-2, NW-18-18-19-2, and SW-19-18-19-2 until it reaches the Highway 6 ditch. It is recognized that this natural drainage path would see more summer runoff and likely remain wet for longer periods of time due to the increase of impervious surfaces from the development. The RM is currently in discussion with landowners and is working towards completion of a design for this municipal drainage channel.

Cowessess First Nation Channel

Currently, about 440 ha of the Project Area drains through Cowessess First Nation lands east of Pasqua Street in NE-23-18-20-2, to Boggy Creek. Cowessess First Nation has contacted the RM about its plans to develop its lands and is planning a drainage route that will provide land control to Boggy Creek. It is recommended that the RM work closely with Cowessess First Nation to ensure that this drainage route is designed to have adequate capacity, based on pre-development release rates from upstream lands.

4.5 REGIONAL STORMWATER MANAGEMENT FACILITIES

Four regional stormwater management storage facilities are proposed within the Plan Area. Figure 4-4 shows the proposed locations of the future regional stormwater management storage facilities. The facilities were situated within the drainage catchments based upon the following considerations:

- The facilities are situated adjacent to natural drainage channels such that the facilities are off-line. Ideally, the existing natural channels should be preserved. From a stormwater perspective, the drainage

channels provide a possible outlet from the facilities, an emergency spill route and a conveyance route for the off-site runoff from the undeveloped external areas.

- The facilities are situated outside of the floodway of Boggy Creek. As mentioned in Section 2.4, the floodway for Boggy Creek has not been delineated within the Plan Area; however, the locations of the planned facilities are far enough from the creek that this will not be an issue.

- Where possible, the facilities are situated to service existing developed areas that have no storage capacity.

- Where possible, the facilities are situated on the land that is expected to be developed in the near future.

The regional stormwater management storage facilities may be wet ponds, constructed wetlands, dry ponds or a combination thereof:

- Wet ponds have a permanent body of water, below the Normal Water Level (NWL), which is the primary source of water quality enhancement. The active storage is situated between the NWL and the High-Water Level (HWL) of the pond and allows the pond to handle runoff from the 1:100 year storm event.

- Constructed wetlands are similar to wet ponds. Typically, the criteria used to differentiate between the two are the aquatic vegetation and the proportion of deep (greater than 1 m) and shallow (less than 0.5 m) water areas. Constructed wetlands are dominated by shallow water areas and the aquatic vegetation is found throughout the pond. Wet ponds have greater portions of deep water areas and the vegetation is concentrated along the perimeter of the pond. Constructed wetlands have higher land area requirements than wet ponds.

- Dry ponds do not have a permanent body of water and are only used for quantity control. Water quality enhancement is achieved through the use of sediment forebay(s) or implemented in a downstream wet pond or constructed wetland.

It is anticipated that most of the regional stormwater management storage facilities in the study area will be dry ponds. Volume estimates for the regional ponds is based on the 500 m^3/ha of storage to service the developed areas that have no existing storage capacity. It is assumed that future developments will be required to store 500 m^3/ha within the site boundaries. However, for planned developments that contain proposed pond locations there is likely a cost benefit to both the developer and the RM to expand planned ponds to service new developments. The fewer the ponds, the lower the O&M costs for the RM. The area estimates for the ponds are based on a rectangular footprint with 4H:1V side slopes and a 2 m maximum depth (assuming dry bottom ponds).

4.6 DEVELOPMENT STAGING

It is recognized that installation of infrastructure that is needed to achieve the objectives of the SIP-MDP will require planning and allocation of budget appropriations over several years. Therefore, it is recommended the activities for this infrastructure installation be prioritized as follows:

1. Establish a drainage route with land control from every developed lot in the Plan Area to an adequate point of discharge.
2. Complete designs of regional drainage channels.
3. Complete designs for detention ponds.
4. Plan construction of regional drainage channels that is matches budgeting allocations.
5. Plan construction of regional detention ponds that is matches budgeting allocations.

The first priority is to make sure that proper land control has been obtained for all drainage in the Plan Area (see Section 4.4). This will be an important requirement to fulfill for WSA and will demonstrate that the RM is committed to establishing drainage works that meet WSA regulations. Completion of designs for the regional drainage channels and detention ponds will provide more accurate cost estimates (than the conceptual-level estimates provided in this report) and these estimates will then feed into the planning for construction of the drainage works.

4.7 CONCEPTUAL LEVEL COST ESTIMATE OF CAPITAL PROJECTS

Six capital projects and three advisory services that have been identified for the project area: two drainage channels that will provide land control to an adequate point of discharge; and four regional detention ponds. The costs and proposed schedules for the regional channels and detention ponds are provided in Table 4-4.

Table 4-4
Capital Projects Plan

			Budget Allocation for SIP Drainage Works ($)				
Task	**Start Date**	**End Date**	**2019**	**2020**	**2021**	**2022**	**2023**
Annual Total			**176,2500**	**1,629,000**	**947,500**	**550,000**	**212,500**
SIP East Channel	2019-Jan-31	2019-Oct-31					
Design			9000				
Construction			840,000				

			Budget Allocation for SIP Drainage Works ($)				
Task	**Start Date**	**End Date**	**2019**	**2020**	**2021**	**2022**	**2023**
Cowessess Channel	2019-Jan-01	2019-Dec-31					
Advisory Services			1000				
Winnipeg/Inland Drive Upgrade	2019-Jan-01	2019-Dec-31					
Advisory Services			1000				
Evraz Discharge Rate	2019-Jan-01	2019-Dec-31					
Advisory Services			750				
NW16-18-19-2 Channel (RM/CoR)	2019-Jan-01	2020-Nov-15					
Advisory Services			750				
Design				5,000			
Construction				104,000			
West Detention Facility 1	2019-Jan-01	2020-Mar-31					
Design			30,000				
Construction			880,000	880,000			
Central Detention Facility 1	2020-Jan-01	2021-Mar-31					
Design				30,000			
Construction				610,000	610,000		

			Budget Allocation for SIP Drainage Works ($)				
Task	**Start Date**	**End Date**	**2019**	**2020**	**2021**	**2022**	**2023**
Central Detention Facility 2	2021-Jan-01	2022-Mar-31					
Design					25,000		
Construction					312,500	312,500	
Central Detention Facility 3	2022-Jan-01	2023-Mar-31					
Design						25,000	
Construction						212,500	212,500

Notes to the above table:

1. A project has been set up to complete the pre-design and detailed design tasks for the SIP East Drainage Channel and its budget has allocated to the 2018 fiscal year.

2. At the concept-level of cost estimating, no estimates have been provided for land owner engagement (including acquisition of land) or legal survey. These should be estimated as part of the pre-design work for the related infrastructure.

3. It is assumed that the RM will handle the tendering of contracts and no estimate was provided for this item.

4. It is anticipated that works related to the Cowessess Channel, upgrades at Winnipeg Street and Inland Drive, and the Evraz Discharge control will be done by others or combined with other work with the RM. The money allocated to the advisory services is intended to make sure that these works result in improvements that are consistent to the objectives of the SIP-MDP.

The estimate for the construction cost of the SIP East Drainage Channel was taken from the pre-design report for that project. The construction cost for the NW16-18-19-2 Channel was estimated based on a 10 m top-width, 4H:1V side slopes, and a 2 m bottom width. For the four regional detention ponds, it is likely that most of the perimeter will require berms, as opposed to excavation, due to the flat topography in these areas. To estimate the volume of the berms, they were assumed to have a 2 m height, a 3 m flat top and 4H:1V side slopes; resulting in a base width of 19 m. Each pond was assumed to have one outlet structure consisting of a concrete vault with a sump and a CSP culvert that would go through the

berm. The culvert diameter was sized to handle the pre-development release rate for the pond. Cost estimates for the two regional channels and the four regional ponds are provided in Appendix B.

4.8 COST SHARING PHILOSOPHY

It is recognized that multiple land owners and/or developers will need to coordinate the design and construction of the regional stormwater management storage facilities. The RM should aim to have a regional stormwater management storage facility service development in a way that balances the ability to service as many landowners as is practicable with the ability to coordinate construction among multiple developers. In most cases, negotiations will involve at least two land owners or developers and in some cases may also include the RM in cases where upstream development has occurred but no stormwater management facility exists.

Where possible, the regional stormwater management storage facilities should be situated on lands with the highest development potential and that best serves the planned development for the area. Depending on the rate of growth in an area, the construction of a regional stormwater management facility could be staged and designs should account for this possibility. The development of a regional stormwater management storage facility can be handled in one of the following manners:

- A staged facility could be constructed to consist of independent cells that can be fully isolated from each other. The isolated cells will reduce the risk or impact from erosion and eliminate the need to drain down a functioning facility to allow for expansion. This is more applicate to wet ponds and constructed wetlands than to dry pond facilities.

- The first development could construct the facility to its ultimate size and recover the proportionate share of the cost from the future development and costs could be included in the negotiations.

- The first development could construct a smaller single celled facility to service only the first development area. The future development could then expand the original facility to service the ultimate development area. Extra care must be exercised to minimize the impacts on the operation of the drainage system.

- In the situation that the first development is located upstream of the regional stormwater management storage facility, the RM should encourage negotiations between the first and future developments are expected to yield one regional facility at the downstream location. The first development could consider additional on-site stormwater BMPs to potentially reduce its dependence on the downstream regional stormwater management storage facility.

- In the situation that the first development is located upstream of a planned location for a regional stormwater management storage facility and negotiations for construction of the facility at its downstream location are unsuccessful, then the first development could construct its own stormwater management facility. However, the RM should not, in general, encourage this option as it will lead to more O&M responsibilities for the RM by managing more facilities than are required.

In some jurisdictions, temporary evaporation facilities have been considered as an interim solution until a permanent regional facility is constructed. Generally, this practice is not a recommended for the following reasons:

- The RM should not assume responsibility for the operation and maintenance of a temporary facility so that the developer bears the costs to operate and maintain it, thereby encouraging the developer to find an alternative solution. This means the RM must rely on the developer to provide these services to a standard that properly serves the development.

- Evaporation ponds require a large area to function properly. This can place constraints on developers, which in turn could lead to pressure being place the RM to relax conditions related to the sizing and location of these ponds.

- The risk that a temporary facility will become a long-term facility due to market conditions and the pace of future development.

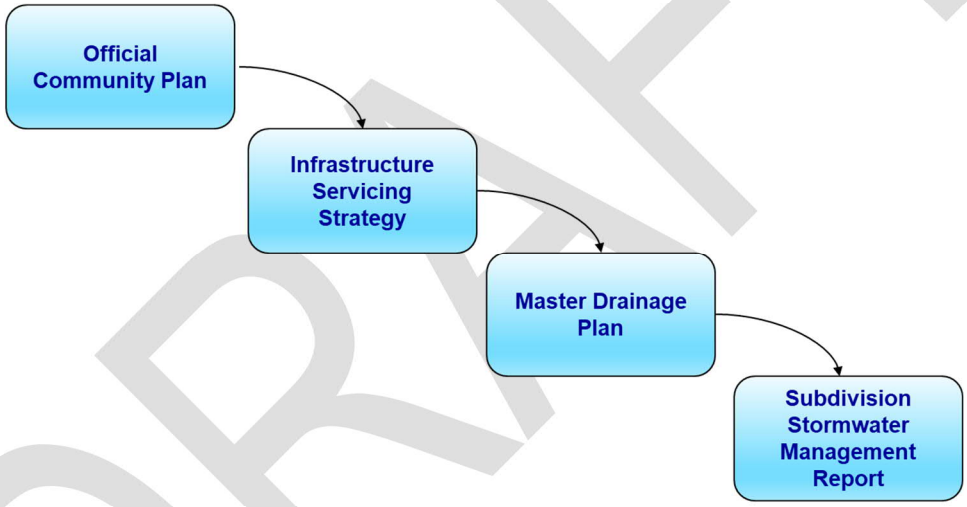
The RM should carefully consider any requests for the use of a temporary evaporation facility.

5 Technical Requirements

5.1 STORMWATER MANAGEMENT PLANS

All development and construction within the Plan Area shall be carried out in accordance with the RM of Sherwood Development Standards Manual (currently in draft form) and all Acts, Bylaws, Guidelines, and Policies that it references. Any development and construction work not addressed within the preceding documents shall be reviewed by the RM of Sherwood and all deviations must have the written approval of RM of Sherwood.

For each proposed subdivision in the Plan Area, a Subdivision Stormwater Management Report (SSWMR) must be prepared for each development phase and correspond to a set of construction drawings. The hierarchy of planning documents is shown below:



The SSWMR should include a detailed hydrologic and hydraulic analysis for each development phase. The SSWMR should be submitted prior to the Final Construction Drawings. The RM should not review the Final Construction Drawings until the SSWMR is approved.

A Pond Report must be prepared for all stormwater management storage facilities that will be turned over to the RM for operations and maintenance. The Pond Report may be a stand-alone document or included in the SSWMR. The Pond Report should include all details relevant to the design, construction and operation of the facility. The Pond Report should also demonstrate that the design objectives from preceding documents including the SMDP. The Pond Report should be submitted concurrent with the Preliminary Construction Drawings. The RM will not review the Final Construction Drawings until the Pond Report is approved.

An Operating and Maintenance (O&M) Manual may be required for each stormwater management storage facility. The need for an O&M Manual will be determined by the RM upon review of the Final Construction Drawings. The O&M Manual, if deemed necessary, should be submitted to the RM prior to the Final Acceptance Certificate application.

Detailed engineering drawings for all new development must be submitted to the RM for review and approval. All plans and reports must be designed and prepared by qualified professionals. At a minimum, the preparation of plans and reports require the involvement of a Professional Engineer. All engineering drawings must be sealed by a Professional Engineer registered in the Province of Saskatchewan.

At the time of the issuing of this report, the RM of Sherwood does not have a drainage or stormwater bylaw. The Province of Saskatchewan has guidelines but no regulations for stormwater effluent. In recent years, other jurisdictions, including the cities of Calgary, Edmonton and Lethbridge, have passed bylaws specific to storm drainage. These bylaws generally establish the following:

- Releases to the storm drainage system (including prohibited materials)
- Discharge and detention/retention requirements
- Use and reuse of storm drainage
- Lot grading
- Connections and inspections of the storm drainage system
- Offences and penalties

It is recommended that the RM review these bylaws and consider preparing a similar Drainage Bylaw. The Bylaw could also address concerns regarding the appropriate locations of downspouts, the use of rain barrels and cisterns, accommodation of drainage at property lines, placement of topsoil and landscaping.

Approvals or authorizations for construction of stormwater systems may be required from three jurisdictions: the federal, the provincial and the municipal governments. The developer of a stormwater system is responsible for preparing the necessary applications. Construction of work is not permitted without the required approvals or authorizations in place.

The following federal acts may apply:

- Fisheries Act
- Canadian Environmental Assessment Act
- Aeronautics Act

The following provincial acts and regulations may apply:

- Environmental Management and Protection Act
- Water Security Agency Act
- The Statements of Provincial Interests Regulations
- Stormwater Guidelines EPB 322

5.2 REGIONAL STORMWATER MANAGEMENT FACILITIES

The design and construction of stormwater management storage facilities shall be carried out in accordance with the current edition of City of Regina's Development Standards Manual[6] and the Stormwater Guidelines (EPB 322, 2014). Where design criteria between the province and the City of Regina vary, the more conservative design criteria will govern.

Detailed facility design is described in the following sections of the 2010 edition of the City of Regina's Development Standards Manual:

- Wet ponds - Section 5.13
- Dry ponds - Section 5.14

A constructed wetland are also an option for a stormwater management storage facility; however, there are no specifications for these types of facilities that are provided in the City of Regina's Development Standards Manual. Design guidelines are provided in the Province of Saskatchewan's Stormwater Guidelines EPB 322.

The key design components of stormwater management storage facilities within the study area include:

- All facilities must be designed to provide active storage for a 1:100 year event based on a 24 hour storm (i.e. single event) and/or continuous modelling. For continuous modelling, a statistical analysis is performed on a series of maximum annual pond volumes. The design of the facility must be based on the more conservative of the two results.

- For wet facilities, a minimum pond depth must be provided for water quality enhancement. For the City of Regina, a typical depth of the permanent pond is 2 m.

- A designated continuous emergency overland escape route from all facilities must be provided. Alternatively, additional freeboard and/or a piped emergency escape route may be considered in cases where it is difficult to establish an overland escape route.

- A geotechnical investigation must be undertaken by a qualified geotechnical consultant to address issues related to the design of all stormwater management storage facilities. The geotechnical report should be submitted with the Pond Report.

5.3 RUNOFF QUANTITY AND QUALITY CONTROLS

The design of stormwater management storage facilities and their corresponding drainage systems shall meet the following objective for runoff quantity control:

[6] At the time of completion of this report, the 2010 version of this manual is available; however, a newer version is anticipated to be released soon.

- Maximum allowable release rate to Boggy Creek (of 4.3 L/s/ha) as recommended within Section 3.2 of this report.

As stated above, there are currently no regulations for the water quality of stormwater effluent in the Province of Saskatchewan; however, best practice is to improve the quality of runoff water before it enters a receiving water body. It is recommended that the RM consult with WSA to determine how water quality from stormwater runoff could be improved and what measures can be adopted by land owners and the RM to achieve these improvements.

6 Conclusions and Recommendations

6.1 CONCLUSIONS

The main findings of the SIP-MDP are provided in:

- Table 2-1: Stormwater Management Framework (see Section 2.2). The Stormwater Management Framework consists of the guiding principals that are linked to the RM of Sherwood's Official Community Plan and that are used to guide the development of the SIP-MDP.
- Figure 4-2: Drainage corridors and regional stormwater management facilities. This figure shows the main regional infrastructure components that are required to manage stormwater runoff in the plan area under future growth plans.
- Table 4-4: Capital Projects Plan. This table provides a five-year schedule for capital projects based on conceptual-level costs.

6.2 RECOMMENDATIONS

The SIP-MDP is conceptual and is intended to form a strategic plan to guide the planning and design of drainage development in the Plan Area. The key recommendations of the SIP-MDP are summarized in this section.

Stormwater Management:

- The RM should work with WSA to develop a flood hazard map for Boggy Creek. This map will provide a delineation of the floodway and flood fringe for the creek within the Project Area. No development should occur within the floodway and development within the flood fringe should be discouraged.
- Until a flood hazard map is available, WSA must be consulted for determining appropriate safe building elevations within the Plan Area.
- The City of Regina should be consulted for stormwater management requirements for the southern portion of the Project Area that drains into Wascana Creek.
- Developers should be responsible for designing and installing appropriate stormwater management infrastructure that adheres to requirements set out by the RM and WSA.
- Developers should work with the RM and WSA to ensure that land control is in place that provides a drainage outlet from any development to an Adequate Point of Discharge.

- For existing developed areas, the RM should work towards improving internal stormwater conveyance systems and to provide regional stormwater detention facilities (see Section 4.5) to service these areas so that a pre-development flow rate is discharged to Boggy Creek.

Watershed Risks:

- The RM should encourage Best Management Practices, as outlined in WSA's Stormwater Guidelines (EPB 322) to reduce the amounts of pollutants entering Boggy Creek.
- The RM should work with The Wascana and Upper Qu'Appelle Watersheds Association Taking Responsibility (WUQWATR) group and developers to protect riparian areas and improve water quality in the Boggy Creek watershed.
- The RM should encourage the submission of a sediment control procedure as part of a building permit application.
- A geotechnical engineer should be consulted where excavations are to occur, such as for stormwater detention facilities, deep ditches, or underground sewer pipes. Maps of existing and abandoned wells should be made available to developers so that there is no intrusion in an aquifer by accidently disturbing one of these features.

Existing Drainage:

- Figure 3-4 shows the main drainage basins within the project area and flow paths to Boggy Creek, based in LIDAR provided by the RM.
- In Section 3.2, the pre-development UARR was determined to be 4.3 L/s/ha. This release rate should be used to determine storage requirements within developed areas and for sizing regional drainage conveyance infrastructure.
- Drainage infrastructure should be planned to minimize disruption of agricultural activities.

Future Development:

- Each new subdivision should establish land control from the point(s) where stormwater runoff leaves the subdivision to an Adequate Point of Discharge.
- The RM should work with developers and land owners to establish the required land controls to drain existing and planned developments to an Adequate Point of Discharge.
- Each new subdivision should be required to provide enough storage for a 100-year, 24-hour storm event with a release rate for 4.3 L/s/ha.

- The RM should work with developers and land owners to optimize the number of stormwater detention facilities in the plan area. The RM should aim to have a regional stormwater management storage facility service development in a way that balances the ability to service as many landowners as is practicable with the ability to coordinate construction among multiple developers.

- For regional infrastructure that is required to implement the SIP-MDP, the following prioritization of activities is recommended:
  1. Establish a drainage route with land control from every developed lot in the Plan Area to an Adequate Point of Discharge.
  2. Complete designs of regional drainage channels.
  3. Complete designs for detention ponds.
  4. Plan construction of regional drainage channels that is matches budgeting allocations.
  5. Plan construction of regional detention ponds that is matches budgeting allocations.

Subdivision Stormwater Management Plans:

- For each proposed subdivision in the Plan Area, a Subdivision Stormwater Management Report (SSWMR) should be prepared for each development phase of a subdivision. It should include a detailed hydrologic and hydraulic analysis for each development phase.
- Stormwater detention facilities should be designed in accordance to the City of Regina's Development Standards Manual (Section 5.13 for wet ponds and Section 5.14 for dry ponds).
- A Pond Report should be prepared for all stormwater management storage facilities that will be turned over by a developer to the RM for on-going operations and maintenance.

RM Policies for Stormwater Management:

- Developers/builders should submit a sediment control procedure as part of a building permit application.
- Define riparian area.
- Bylaws for runoff quality.

Certification Page

This report presents our findings regarding the RM of Sherwood No. 159 Sherwood Industrial Park Master Drainage Plan.

Respectfully submitted,

Prepared by:

Reviewed by:

Appendix A - Figures

Appendix B - Cost Estimates