

City of Leduc Stormwater Master Plan

Final Report

City of Leduc

60683843

August 2024



AECOM Canada Ltd. 101 – 18817 Stony Plain Road NW Edmonton, AB T5S 0C2 Canada

T: 780.486.7000 F: 780.669.5782 www.aecom.com

Ryan Graham Infrastructure Manager City of Leduc #1 Alexandra Park Leduc AB T9E 4C4 August 30, 2024

Project # 60683843

Subject: City of Leduc Stormwater Master Plan - Final Report

Dear Ryan:

AECOM Canada Ltd. is pleased to submit our final report for the Stormwater Master Plan. If you have any comments or questions, please contact the undersigned.

Sincerely,

AECOM Canada Ltd.

Kristin St. Louis, P.Eng. Senior Water Resources Engineer Kristin.StLouis@aecom.com

Encl.

Sean Frank, P.Eng. Water Resources Engineer Sean.Frank@aecom.com

Statement of Qualifications and Limitations

The attached Report (the "Report") has been prepared by AECOM Canada Ltd. ("AECOM") for the benefit of the Client ("Client") in accordance with the agreement between AECOM and Client, including the scope of work detailed therein (the "Agreement").

The information, data, recommendations and conclusions contained in the Report (collectively, the "Information"):

- is subject to the scope, schedule, and other constraints and limitations in the Agreement and the qualifications contained in the Report (the "Limitations");
- represents AECOM's professional judgement in light of the Limitations and industry standards for the preparation of similar reports;
- may be based on information provided to AECOM which has not been independently verified;
- has not been updated since the date of issuance of the Report and its accuracy is limited to the time period and circumstances in which it was collected, processed, made or issued;
- must be read as a whole and sections thereof should not be read out of such context;
- was prepared for the specific purposes described in the Report and the Agreement; and
- in the case of subsurface, environmental or geotechnical conditions, may be based on limited testing and on the assumption that such conditions are uniform and not variable either geographically or over time.

AECOM shall be entitled to rely upon the accuracy and completeness of information that was provided to it and has no obligation to update such information. AECOM accepts no responsibility for any events or circumstances that may have occurred since the date on which the Report was prepared and, in the case of subsurface, environmental or geotechnical conditions, is not responsible for any variability in such conditions, geographically or over time.

AECOM agrees that the Report represents its professional judgement as described above and that the Information has been prepared for the specific purpose and use described in the Report and the Agreement, but AECOM makes no other representations, or any guarantees or warranties whatsoever, whether express or implied, with respect to the Report, the Information or any part thereof.

Without in any way limiting the generality of the foregoing, any estimates or opinions regarding probable construction costs or construction schedule provided by AECOM represent AECOM's professional judgement in light of its experience and the knowledge and information available to it at the time of preparation. Since AECOM has no control over market or economic conditions, prices for construction labour, equipment or materials or bidding procedures, AECOM, its directors, officers and employees are not able to, nor do they, make any representations, warranties or guarantees whatsoever, whether express or implied, with respect to such estimates or opinions, or their variance from actual construction costs or schedules, and accept no responsibility for any loss or damage arising therefrom or in any way related thereto. Persons relying on such estimates or opinions do so at their own risk.

Except (1) as agreed to in writing by AECOM and Client; (2) as required by-law; or (3) to the extent used by governmental reviewing agencies for the purpose of obtaining permits or approvals, the Report and the Information may be used and relied upon only by Client.

AECOM accepts no responsibility, and denies any liability whatsoever, to parties other than Client who may obtain access to the Report or the Information for any injury, loss or damage suffered by such parties arising from their use of, reliance upon, or decisions or actions based on the Report or any of the Information ("improper use of the Report"), except to the extent those parties have obtained the prior written consent of AECOM to use and rely upon the Report and the Information. Any injury, loss or damages arising from improper use of the Report shall be borne by the party making such use.

This Statement of Qualifications and Limitations is attached to and forms part of the Report and any use of the Report is subject to the terms hereof.

AECOM: 2015-04-13 © 2009-2015 AECOM Canada Ltd. All Rights Reserved.

Quality Information

Prepared by	Checked by	
Btoitsky		
1 - 0 C 0 0 0 0 0 0 0		

Brend	lan Tı	roitsky	M.E	ng.,	E.I	.Т.
Water	Res	ources				

Sean Frank, P.Eng. Water Resources Engineer

Approved by

Kristin St. Louis, P.Eng. Senior Water Resources Engineer

Revision History

Rev #	Revision Date	Revised By:	Revision Description
0	September 2023	BT/SF/KS	DRAFT REPORT
1	February 2024	BT/SF/KS	Draft 2 Report
2	April 2024	BT/SF/KS	Final Draft Report
3	August 2024	KS	Authenticated Report

Distribution List

# Hard Copies	PDF Required	Association / Company Name
0	✓	City of Leduc
0	✓	AECOM Canada Ltd.

City of Leduc

City of Leduc Stormwater Master Plan Final Report

Prepared for:

City of Leduc #1 Alexandra Park Leduc AB T9E 4C4 Canada

Prepared by:

AECOM Canada Ltd. 101 – 18817 Stony Plain Road NW Edmonton, AB T5S 0C2 Canada

T: 780.486.7000 F: 780.669.5782 www.aecom.com

Ref: 60683843

AECOM

Executive Summary

The City identified the need for a plan to guide stormwater management, to address existing drainage and allow for the orderly development of new areas. AECOM Canada Ltd. (AECOM) was retained by the City to develop a Citywide stormwater master plan (SWMP) to identify any current stormwater infrastructure deficiencies and constraints and guide the implementation of stormwater system improvements. The goal of the study was to identify and prioritize areas of concern, capital improvements, and stormwater operations costs for the City.

As part of the comprehensive SWMP, elements of the natural environment were also considered, including a mitigation strategy for Telford Lake water quality, review of climate change impacts to stormwater management, and the overall performance of Deer Creek.

Existing Drainage System

The City of Leduc is located within both the Whitemud Creek and Blackmud Creek watersheds. The City is generally bisected in the north-south direction by sub-basins that convey runoff eventually west to Whitemud Creek or east to Blackmud Creek. The current City boundary encompasses 3,568 ha. The drainage area is 4,325 ha, which includes upstream areas that flow through the City system; 54% of the drainage area is within the Blackmud Creek basin and 46% is in the Whitemud Creek basin.

The City operates 32 stormwater management facilities that consist of both dry and wet ponds, as well as 4 stormwater lift stations.

The minor system in Leduc is comprised of 133 km of storm sewer mains and 4,476 manholes and catch basins. The pipes range in diameter from 2,100 mm to as small as 100 mm for gravity operated pipes and 65 mm for force mains. The minor system in Leduc is well established in newer neighbourhoods, with extensive underground pipe systems and CBs to receive water from the surface. Flow will typically discharge into a stormwater management facility and then outflow at a controlled rate through the minor system to a receiving waterbody.

In older neighbourhoods, due to the difference in development standards over time, the neighbourhoods were developed with limited or no minor system. Where there are gaps in the minor system, runoff must instead be entirely conveyed overland by ditches and roadways. In flatter regions, such as Willow Park, this lack of minor system can lead to increased surface ponding duration, which consequently can decrease the lifespan of the roadways.

Design Criteria and Standards

The current standards for the stormwater management system are provided in the City of Leduc Engineering Design Standards, November 2022, which reference the EPCOR Design and Construction Standards Volume 3 Drainage dated February 2022.

The City of Leduc Engineering Design Standards specify IDF data from the Edmonton Municipal Airport – IDF period 1914 – 1955. Based on this design rainfall data, the minor system is to be designed to convey a 1 in 5 year rainfall event. The major (overland) drainage system is to be designed to convey/store the 1 in 100 year rainfall event.

Allowable discharge rates for the City were estimated as part of the Blackmud/Whitemud Creek Surface Water Management Study dated July 17, 2013. The report recommended a maximum release rate of 3.0 L/s/ha should be adopted for future development areas discharging to both Blackmud and Whitemud Creeks. As this applies to

all areas of the City, a discharge rate of 3.0 L/s/ha should be utilized for all new developments. Existing stormwater management facilities, as well as areas with previously approved ASPs may discharge at the existing / approved rate, however, opportunities for reducing peak flow discharges were assessed. Telford Lake is considered an adequate outlet and restriction of discharge is not required.

In existing developed areas, the minor and major systems were assessed to determine locations that do not meet the design criteria outlined in the Engineering Standards. This created a baseline for areas within the existing development for further assessment. In locations without a defined major or minor drainage system, it was not practical to develop drainage improvements to meet standards that would only provide minimal benefit to the public, as there have been no reported incidents of flooding. Therefore, during the system assessment, the model was utilized to determine the location of ponding that exceeds the standards, and then the actual risk of flooding both to within the lot limit as well as risk to damage to property.

Hydraulic System Assessment

AECOM developed a City-wide stormwater model utilizing Infoworks ICM hydraulic modelling program. The program allows for 1D and 2D hydraulic modelling of the minor and major system with interaction between them to allow for an accurately visualized depiction of the function of the stormwater management system. The physical aspects of the model were built from the City's GIS. Field surveys were used to fill in data gaps, as well as to verify data at critical locations.

The system assessment showed that the minor system is suitably sized for most areas of the City, with 85% of pipes operating with little to no surcharge during a 1 in 5 year rainfall event, and only 5% of MHs are surcharged to a level at or above ground. Local flooding is generally driven by limited capacity along select storm trunks. In some areas the limited trunk capacity is compounded by limited inlet capacity to the storm sewer system, and undefined major system flow pathways, which results in high levels of ponding. No properties are noted as being vulnerable to flooding from the City's system during this event.

During higher return period events, such as the 100 year 4 hour, the minor system is strained further in older areas with limited major system capacity; this is most noticeable along the 50th Street main and the South Park main. These two areas are relatively flat and have comparably poor access to creeks or major ditches, which reduces the ability of the major system to store and convey flow. The areas contributing to the 50th Street main and the South Park main have seen further urbanization since their installation and in general have fewer SWMFs than would typically be installed under current design standards.

Table ES-1 summarizes the noted hydraulic deficiencies within the system and the recommended improvements. The deficiencies and improvements are discussed in detail in Section 4.3. Improvements were split into Recommended (R) upgrades and Considered (C) upgrades based on the feasibility of construction and benefit of the upgrades.

Table ES-1: Hydraulic Deficiency and Improvement Summary

Improvement No.	Community	Description of Deficiency	Improvement Description
R-1	Corinthia Park	Minor system capacity for large rainfall events & low points in the major system	Surge Pond + Inlet/Outlet Structure
R-2	South Park	Minor system capacity of the existing 1,350 mm diameter trunk along CP Rail	41b Street Local Sewer Upgrade
R-3	Linsford	Minor system capacity of the existing 1,050 mm diameter trunk along 50 th Street	Proposed Dry Pond Dry Pond Inlet - 47 Avenue south Alley Dry Pond Outlet - 51 Street
R-4	65th Ave	Blocked drainage across 65 th Avenue and minor system capacity of downstream system	Sparrow Drive and 65 Ave Sewer Upgrade & New CP Rail Culvert
R-5	Willow Park	Lack of minor system drainage within Willow Park	New Main along 54 Street, from 55 Ave to 57 Ave
R-6	Willow Park	Lack of minor system drainage within Willow Park	New Main along 52 Street, from 52 Ave to 56 Ave
R-7	Willow Park	Minor system capacity of the existing 1,050 mm diameter trunk along 50 th Street and lack of minor system drainage within Willow Park	New Main along 51 Street, from 52 Ave to 54 Ave
R-8	Lakeside Estates	Catchment area contributing to West Point Lake and the capacity of the existing 600 mm diameter sewer along Grant MacEwan Blvd	Lakeside Estates Swale – William Bradbury Place to Black Gold Drive
R-9	Caledonia Park	Minor system capacity along South Park Drive from 43b Avenue to Black Gold Drive.	Caledonia Park Swale - 37 Ave, 41 Street to 42 Street Swale
C-1	South Park / South Telford	Minor system capacity of the existing 1,350 mm diameter trunk along CP Rail	Twin Main along CP Rail from Rollyview Road to Telford Lake
C-2	50th Street / Willow Park	Minor system capacity of the existing 1,050 mm diameter trunk along 50 th Street	Twin 50 Street Sewer from 54 Avenue to 60 Avenue, and across QEII
C-3	Leduc Estates	Capacity of the existing 600 mm diameter sewer along Grant MacEwan Blvd	Grant MacEwan Drive, Black Gold Drive to Deer Creek & Orifice Upgrade

Ref: 60683843 RPT-2024-08-30-Leduc SWMP-Final-60683843.Docx

The Fire Hall on 50th Street was noted to have ponding at the front entrance that would inhibit traffic during large rainfall events. Improvement options were assessed; however, the ponding is primarily due to insufficient capacity of the existing trunk along CP Rail, and therefore minor system upgrades provided little benefit. Therefore, it is recommended that the risk of ponding be identified in the City's Emergency Response Plan, and alternate emergency access routes from the rear doors of the Fire Hall be planned should ponding depths on 50th Street restrict access to and from the front doors.

Future System Assessment

The stormwater management system was also assessed with full build-out of the currently in development ASP areas within the City boundary. The model was developed with major trunks and stormwater management facilities restricting discharge rates to the downstream system based on development standards and previously accepted rates as per the ASPs.

The main finding of the future system assessment was that based on the progression of development and anticipated discharge locations, the existing stormwater management system is not impacted by future development. Future development areas should continue to be designed with stormwater management facilities, while following the restrictions as outlined in the Guidelines for Stormwater Management Facility Design within the Primary Bird Hazard Area in the Vicinity of the Edmonton Internation Airport document.

Deer Creek Assessment

Deer Creek was assessed hydraulically and from a geomorphological perspective. Hydraulically, it is not anticipated that the creek will spill to adjacent communities during a 100 year event.

The creek was found to have moderate to high erodibility with many debris jams present along the entire water course especially in areas with forest cover. This has led to bank slumping and bank undercutting widespread throughout the study area, with particular areas of concern the Creekside Ravines subdivision and the residential properties on Ameena Drive, where significant bank undercutting and slumping close to the residential properties was observed.

The geomorphological assessment indicated that all assessed reaches had frequent instability and downstream reaches are widening. There is evidence from historical air photos that meander belts are being formed and abandoned.

Implementation for improvements to Deer Creek are as follows:

- Implement a development setback from Deer Creek (as well as other named and unnamed creeks within the boundary of the City of Leduc) based on a minimum distance for the property line from top of bank or 15 m. If a more accurate setback is desired, the developer can utilize a qualified fluvial morphologist to complete a meander belt assessment utilizing the mapping approach.
- Multiway setbacks are recommended to be determined by a geotechnical assessment to determine the minimum setback from the top of bank.
- Implement an erosion protection and rehabilitation plan for Deer Creek within existing development areas. Areas with undercutting and slumping should be identified, and the areas should be repaired and/or armoured as soon as possible to protect from further creek migration towards residential areas.
- Conduct an erosion threshold assessment to determine the critical hydraulic conditions at which erosion will theoretically entrain bed or bank material.

Telford Lake Assessment

Telford Lake was assessed to determine the concentration of chlorides within the lake, the condition of the outfalls within the lake, sedimentation that has occurred in Telford Lake via bathymetric survey, and the discharge from the existing snow storage site located directly north of Telford Lake.

Chloride Concentrations

The long-term chloride exposure guideline from the *Canadian Water Quality Guidelines for the Protection of Aquatic Life: Chloride* fact sheet is 120 mg/L (CCME, 2011). However, this guideline is based on aquatic species whose range does not extend to Alberta. A search of the Fisheries and Wildlife Management Information System (FWMIS) database was conducted on June 6, 2023 to identify what aquatic species are present in Telford Lake as well as downstream (Saunders Lake and Blackmud Creek).

It is recommended that Alberta Environment and Protected Areas be consulted about raising the chloride guideline for Telford Lake to 598 mg/L. This corresponds to the long-term chloride exposure limits for fathead minnow, which are shown to be present in Telford Lake and downstream locations. All sampled chloride concentrations were below this value. The highest concentration was recorded at the weir outlet from the lake on the west end at 180 mg/L, and the lowest concentration recorded was 110 mg/L, at the outfall downstream of the existing snow storage facility.

Outfall Assessment

AECOM conducted a visual stormwater outfall assessment in September, 2022 of the 12 storm outfalls to Telford Lake (including the outfall from Telford Lake discharging east). The outfalls generally provide stormwater servicing for residential and undeveloped areas around Telford Lake. Outfalls were constructed between 1973 and 2019, with pipe sizes ranging from 375 mm to 1350 mm in diameter, and various materials including concrete, corrugated metal, PVC and HDPE. Based on the assessment, AECOM recommends the following specific actions for the City's consideration:

- Four outfalls were showing signs of advanced stages of deterioration, and it is recommended that the City
 complete a geotechnical assessment to determine the extent of voiding and risk of instability to the respective
 systems.
- The outfall into the old gravel pits from Lions Park on the north side of Telford Lake could not be located. It is recommended to locate this outfall; if covered with debris or sediment deposition, it will not function as intended.
- Two outfalls into the west bay of Telford Lake, from 46 Street were found to have sandbags. It is recommended that it be confirmed if the sandbags are intended to function as a weir. If not, then add these outfalls to a cleaning program.
- Review the need for hydraulic channel improvements at the outfall into the Lions Park pond. If current vegetation conditions are determined to impact hydraulic function, add the outfall to a cleaning program.
- Perform CCTV on the 1200 mm CMP outfall into the west by of Telford Lake from 46 Street to determine the
 extent of corrosion and consider relining the asset.
- Perform water quality sampling to identify the need for oil-grit separators.
- Nine outfalls are recommended to be added to a cleaning program.
- Six outfalls are recommended to be added to a rehabilitation work program.

Sedimentation Assessment

A bathymetric survey of Telford Lake was conducted in October 2023 by Challenger Geomatics to determine areas where significant sedimentation is occurring in Telford Lake. It was determined that sediment levels in the lake may be as much as 1.6 million m³, with an average of 0.4 m of vegetation above it. This is causing shallow water depths, with some areas having less than 1 m depth of water.

It is recommended that dredging of the lake be undertaken as a targeted effort to support the proposed paddling race course. There is an estimated 500,000 m³ of sediment that would need to be removed to support the course, with an estimated cost of \$25 million. Preliminary engineering and environmental studies would need to be completed, with an estimated cost of \$300,000. The dredging program could be implemented over a 10 year period, and the City-owned land at the Telford Lake outlet could be considered as an area for sediment management.

Snow Storage Discharge to Telford Lake

The previous studies conducted by ISL Engineering were reviewed. Based on the studies, in the spring chloride concentrations discharged from the existing snow storage facility exceed chloride concentrations, but as dilution occurs through rainwater, the chloride concentrations drop to acceptable limits. The existing snow storage facility discharges by gravity through a Stormceptor to Telford Lake. It is recommended to assess the feasibility of upgrading the pond within the existing snow storage facility that can hold the meltwater and rainwater until sufficient dilution of chlorides occurs.

Based on the high concentrations tested during spring near the existing snow storage facility, it is recommended to conduct additional Telford Lake sampling. The program should start in Spring 2024, and throughout the season sample at various times near the outlets to determine the chloride concentration when snow melt is at its greatest.

Stormwater Quality

The primary purpose of stormwater management facilities is to collect the runoff generated by developments and control the outflow to the receiving watercourse to allowable discharge rates. However, a secondary purpose is to provide water quality enhancement. Alberta Environment requires that a minimum of 80% of sediments with a particle size of 75 µm or greater be removed from stormwater runoff.

The City should continue its current practices regarding stormwater management facility construction in new development areas. Stormwater management facilities should be designed to retain stormwater runoff such that it can be discharged to the downstream system at 3 L/s/ha, as per the Blackmud/Whitemud Study. The placement of future stormwater management facilities should consider the restrictions as outlined in the Guidelines for Stormwater Management Facility Design within the Primary Bird Hazard Area in the Vicinity of the Edmonton Internation Airport document.

Stormceptors should be implemented at areas of existing development that do not have upstream water quality enhancement via stormwater management facilities. Stormceptors have been recommended at 3 strategic existing discharge locations to Telford Lake.

LID in future development areas should be implemented on an opportunistic basis during the design stages of future communities. LID can provide stormwater management for the smaller more frequent rainfall events and reduce sediment deposition to the downstream system. The placement of LID features should also consider the Primary Bird Hazard Area, as some LID features can attract nesting birds.

During rehabilitation projects in existing development areas, LID should be considered strategically as space limitations and contributing catchment areas generally govern the application of LID. It is recommended to assess potential locations for LID during road rehabilitation and community redevelopment projects and implement as appropriate.

Condition Assessment

A condition assessment of the sewer infrastructure was performed to help identify critical infrastructure. The assessment included a desktop study based on data from the City's GIS database and the hydraulic model. The assessment includes a risk-based approach generally based on National Association of Sewer Service Companies (NASSCO) Pipeline Assessment Certification Program (PACP), with assets carrying the greatest risk considered to be critical infrastructure.

Risk categories are labelled as Level 1-5, with Level 5 assets having the highest relative risk within the system. It was found that 77% of the storm sewer assets have a Level 1 (low) rating, with less than 1% of assets at a Level 5.

The areas with the highest risk are as follows:

- the storm sewer parallel to CP Rail from approximately 43 Avenue to the Telford Lake outfall,
- the storm sewer along Grant MacEwan Boulevard from Black Gold Drive to Deer Creek, and
- The QEII crossing along Black Gold Drive north of Corinthia.

This should increase the priority the future upgrades (C-1 and C-3), as well as flag an additional upgrade for the QEII crossing along Black Gold Drive. It is understood that upgrading the crossing under QEII is not currently feasible. However, is recommended to re-assess whether an upgrade opportunity is available in the future.

Based on the assessment, recommendations include the following:

- Consider implementing an inspection program to obtain data on storm sewer structural and maintenance condition, starting with the higher risk storm assets. This will help identify whether proactive repairs and/or intervention are required, or confirm whether the asset is in reasonable condition and its likelihood of failure rating can be lowered accordingly.
- Consider regularly updating this assessment as data is collected and information changes. This will help continuously concentrate asset management resources on the most high risk and critical infrastructure.
- Review critical storm infrastructure against critical sanitary infrastructure, to identify any overlap between systems and whether inspection and rehabilitation programs can be synergized.

Public Consultation

The public consultation plan has been developed in consultation with the City and will include the following:

- Development of a brochure mailer that includes general stormwater management information that could be provided via mail or directly to residents at public events.
- Development of a website that includes more detailed information on stormwater management within the City.

The overall goal is to provide residents with easily accessible information on the stormwater management system. It is recommended to treat the website as a living document and update with new information becomes available that would be applicable for the website.

Final Report

Improvements and Cost Summary

Table ES-2 summarizes the proposed improvements, as well as the implementation priority. Suggested timings for implementation are indicated below; however, the hydraulic improvements are recommended to be coordinated with road restoration projects where possible.

The Willow Park upgrades are identified for immediate implementation to coordinate with the current neighbourhood renewal.

For the C-1 and C-3 projects, they have been identified as having both risks to flooding and condition risks. Due to the high costs of these projects, it has been recommended that they are included in the long term capital plan. However, the condition of these assets should be re-reviewed on an ongoing basis. If condition is found to be deteriorating, the timing of implementation may need to be accelerated.

Table ES-2: Proposed Implementation Plan & Cost Summary

No.	Neighbourhood	Description Summary	Upgrade	Cost to City (\$)
		Immediate		
-	Telford Lake	Geotechnical Assessment of Outfalls	Outfalls 298, 873, 3040 and 3507	\$100,000
R-5	Willow Park	New Main along 54 Street, from 55 Ave to 57 Ave	305 m of 600 mm New Storm Sewer	\$699,000
R-6	Willow Park	New Main along 52 Street, from 52 Ave to 56 Ave	410 m of 600 mm New Storm Sewer	\$1,069,000
R-7	Willow Park	New Main along 51 Street, from 52 Ave to 54 Ave	235 m of 1050 mm New Storm Sewer	\$881,000
-	Deer Creek	Erosion Assessment of Deer Creek	Site specific studies for erosion	\$30,000
	Deer Creek	Formalize standards for approvals, including development setbacks	-	n/a
	-	Short Term (<10 years	s)	
R-8	Lakeside Estates	Lakeside Estates Swale – William Bradbury Place to Black Gold Drive	45 m Swale through PUL	\$118,000
R-9	Caledonia	Caledonia Park Swale - 37 Ave, 41 Street to 42 Street Swale	75 m Swale through PUL	\$87,000
D-1	Telford Lake	Dredging Study	Telford Lake	\$300,000
S-1,2,3	Telford Lake	Stormceptors	George Liggins Park, South Telford, South Park	\$1,300,000
		Medium/Long Term Recommended Impro	vements (10-25 years)	
R-1	Corinthia Dry Pond	Surge Pond + Inlet/Outlet Structure	1,500 m ³ Dry Pond and Inlets/Outlets	\$316,000
R-2	South Park	Local Improvements (41B Street, from Black Gold Drive to 43b Ave)	50 m of 600 mm Storm Sewer Upsizing	\$376,000
R-3	Linsford	Proposed Dry Pond in Linsford Park School	13,000 m ³ Dual-use Dry Pond and Inlet/Outlets	\$4,665,000
R-3	Linsford	Storm Sewer Upgrade downstream of Dry Pond (46 Ave, from 51 Street to 50 Street)	100 m of 1050 mm Storm Sewer Upsizing	\$747,000

No.	Neighbourhood	Description Summary	Upgrade	Cost to City (\$)
R-3	Linsford	Back Alley Storm Sewer	270 m of 600 mm New Storm Sewer	\$643,000
R-4	65th Ave	Sparrow Drive and 65 Ave Sewer Upgrade & New CP Rail Culvert	190 m of 600 mm New Storm Sewer, 30 m of 600 mm Culvert	\$871,000
		Medium/Long Term Considered Improve	ments (10-25+ years)	
C-1	South Park	Twin Main along CP Rail from Rollyview Road to Telford Lake	1500 m of 1350 mm Storm Sewer Twinning	\$10,356,000
C-2	50th Street/ Willow Park	Twin 50 Street Sewer from 54 Avenue to 60 Avenue, and across QEII	1400 m of 1200 mm Storm Sewer Twinning	\$9,191,000
C-3	Leduc Estates	Grant MacEwan Storm Upgrade, Black Gold Drive to Deer Creek & Orifice Upgrade	560 m of 1050 mm Storm Sewer Upsizing	\$4,682,000
TOTAL	(Hydraulic & Opera	ational Upgrades)		\$36,431,000

Dredging options for Telford Lake were considered. Based on the estimated sediment loading, dredging the entire lake would cost an estimated \$80-100 million. It is recommended that targeted dredging efforts be undertaken, to include the west bay of the lake, as well as the area required support for the paddling race course proposed in the Telford Lake Master Plan. This would involve removal of approximately 515,000 m³ of sediment, which is approximately 30% of the total lake sediment levels. The cost for a reduced program would be in the range of \$25 million. If the sediment exceeds contamination guidelines and requires disposal at a landfill, the costs would be expected to double. It is recommended that a sampling program be undertaken in advance to confirm contaminant levels.

Finally, based on the results of the erosion assessment of Deer Creek, funds will likely be required to provide erosion mitigation within the Creek. Prior to the study, it is difficult to quantify the required funds but it is recommended to carry a minimum \$500,000 for erosion mitigation measures.

Ref: 60683843 RPT-2024-08-30-Leduc SWMP-Final-60683843.Docx

AECOM Figure: ES.1

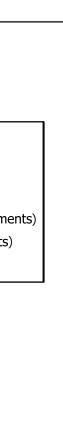
<u>Legend</u>

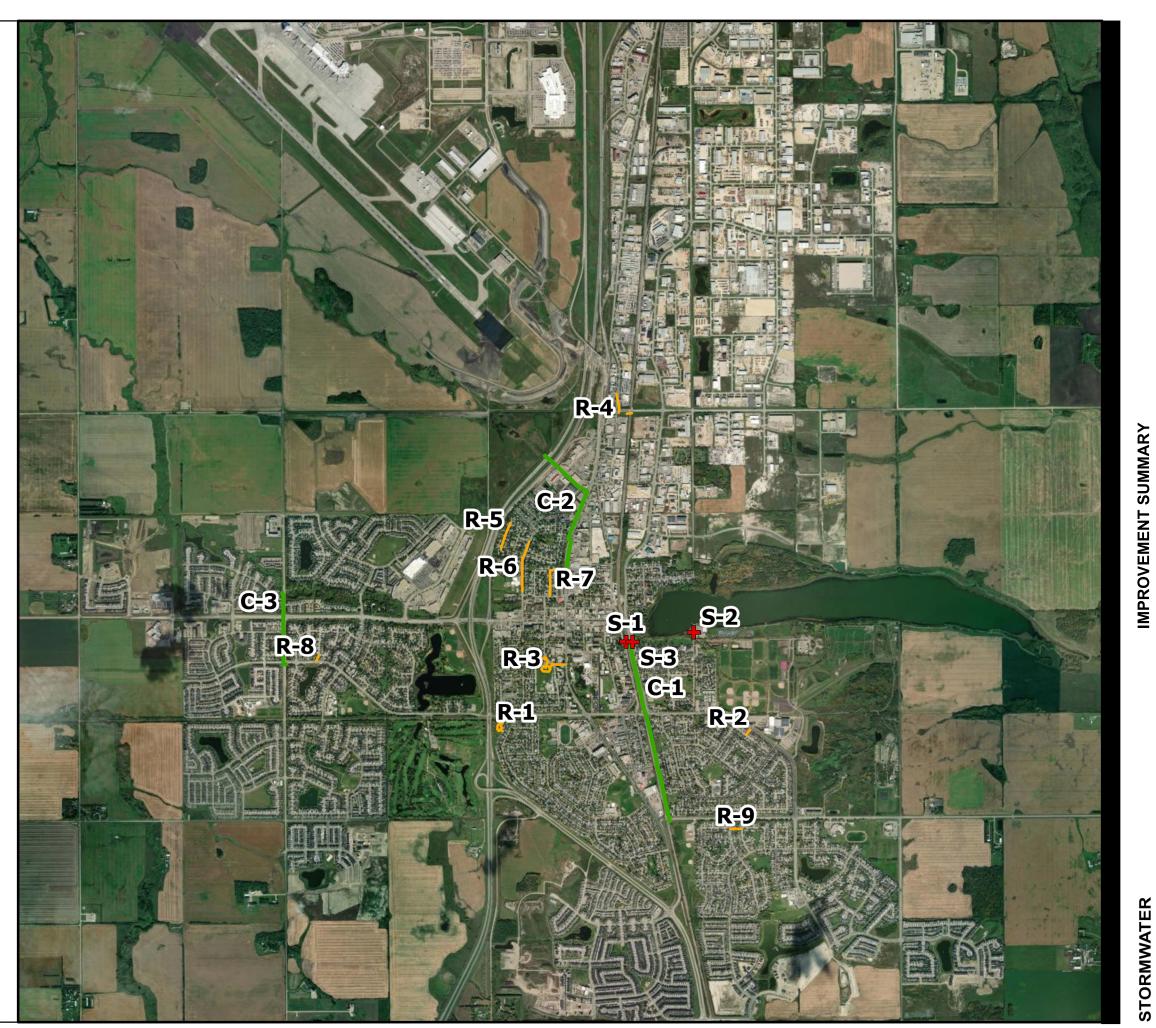
<u>Improvements</u>

Recommended Upgrade (R improvements)

Long Term Upgrade (C improvements)

Stormceptors





1,500 2,000 Meters Final Report

Table of Contents

1.	Intr	oduction	1
	1.1 1.2 1.3 1.4	Background Study Area Scope of Work Data Collection and Review 1.4.1 Previous Studies 1.4.2 Other References 1.4.3 Survey	
2.	Exis	sting Drainage System	9
	2.1	Sub-Basins and System Outlets	g
	2.2	Stormwater Management Facilities	
	2.3	Lift Stations & Forcemains	
	2.4	Minor Drainage System	17
	2.5	Major Drainage System	
3.	Des	sign Criteria and Standards	21
	3.1	Development Staging and Land Use	
	3.2	Current Level of Service Standards	
	3.3	Rainfall Events	
	3.4	Discharge Rates	
	3.5	Other Design Criteria	
	3.6	Cost/Benefit & Tolerance	
	3.7	Review of Relevant Legislation and Regulations	
4.	Hyd	draulic System Assessment	30
	4.1	Model Development	30
		4.1.1 Field Survey and GIS Update	
		4.1.2 Model Parameters and Calibration	30
	4.2	Existing System Hydraulic Analysis	
		4.2.1 Minor System Analysis	
		4.2.2 Major System Analysis – Surface Flooding	
	4.0	4.2.3 Major System Analysis – Stormwater Management Facilities	
	4.3	Existing System Hydraulic Deficiencies and Improvements	
		4.3.1.1 South Park/Caledonia Improvements	
		4.3.1.2 South Park/Caledonia Improvements Assessment	
		4.3.2 Fire Hall – Alexandra Park	43
		4.3.2.1 Fire Hall Improvements	
		4.3.2.2 Fire Hall Improvements Assessment	
		4.3.3 Alexandra Park / Linsford Park	
		4.3.3.2 Linsford Park School Improvement	
		4.3.3.3 George Liggins Park Deficiency	

		4.3.3.4 George Liggins Park Improvement	
		4.3.3.5 Civic Centre Deficiency	
		4.3.3.6 Alexandra Park / Linsford Park Improvements Assessr 4.3.4 Willow Park	
		4.3.4 Willow Park	
		4.3.4.2 Willow Park Improvements Assessment	
		4.3.5 65 Avenue (at CP Rail)	
		4.3.5.1 65 Avenue (at CP Rail) Improvements	
		4.3.6 Lakeside Estates	
		4.3.6.1 Lakeside Estates Improvements	
		4.3.6.2 Lakeside Estates Improvements Assessment	
		4.3.7 North Industrial Area	
		4.3.7.1 North Industrial Area Improvements	
		4.3.8 Corinthia	
		4.3.8.1 Corinthia Improvements	
		4.3.8.2 Corinthia Improvements Assessment	
		4.3.9 50 Street Sewer	
		4.3.9.1 50 Street Improvements	
		4.3.9.2 50 Street Improvements Assessment	
	4.4	Improvements Summary	52
	4.5	Improved System Assessment	
	4.6	Future System Assessment	
	_	•	
	4.7	IDF Analysis	
		4.7.1 EPCOR/City of Leduc IDF Sensitivity	
		4.7.1.1 IDF Results Discussion	
	4.0	4.7.2 Impact of Climate Change	
	4.8	EMRB Comparison	
		4.8.1 Rainfall Data	
		4.8.2 Flood Hazard	80
5.	Dee	er Creek Assessment	81
	5.1	Deer Creek Hydraulic Analysis	81
	5.2	Geomorphological Assessment	
	0.2	5.2.1 Geomorphological Assessment – Key Findings	
		5.2.2 Geomorphological Assessment – Recommendations	
	5.3	Policy Recommendation	
	5.5	1 olicy Necommendation	
6.	Telf	ford Lake Assessment	87
	6.1	Telford Lake Sampling Program	87
	0	6.1.1 Site Specific Chloride Guideline Assessment	
		6.1.2 Sampling Program Conclusion	
		6.1.3 Sampling Program Recommendations	
	6.2	Telford Lake Outfall Assessment	
	6.3	Telford Lake Sedimentation Assessment	
	6.4	Snow Storage Site Discharge to Telford Lake	98
7.	Sto	rmwater Quality	99
	7.1	Stormwater Management Facilities	QC
		7.1.1 Wetlands	

		7.1.2 Wet Ponds	
	7.2	Low Impact Development (LID)	
	7.3	Telford Lake Water Quality	
8.	Con	dition Assessment	105
	8.1	Condition Assessment Conclusions and Recommendations	105
9.	Pub	lic Consultation	109
10.	Cos	t Estimates	110
	10.1	Funding Mechanisms	110
	10.2	Cost Estimates – Hydraulic Improvements	
	10.3	Cost Estimates – Operational Improvements	
	10.4	Stormwater Flat Rate Assessment	111
11.	Rec	ommended Staging and Implementation Plan	113
	11.1	Hydraulic Improvements	113
	11.2	Deer Creek Improvements	113
	11.3	Telford Lake	114
		11.3.1 Chloride Concentrations	
		11.3.2 Outfall Assessment.	
		11.3.3 Sedimentation Assessment	
	11.4	Stormwater Quality	
	11.5	Condition Assessment	
	11.6	Improvement and Cost Summary	
Fig	ures		
•		udy Area	
_		ighbourhood Map	
•		e Survey Locations	
_		sin Area Map	
•		ormwater Management Facilitiesisting Lift Stations and Forcemains	
-		isting Minor Drainage System	
-		ajor Overland Drainage Routes	
-		isting Minor System Assessment – 5 Year 4 Hour Rainfall Event	
-		isting Major System Assessment – 100 Year 4 Hour Rainfall Event (Figure 1 of 3)	
_		isting Major System Assessment – 100 Year 4 Hour Rainfall Event (Figure 2 of 3)	
Figure	e 4.4. Ex	isting Major System Assessment – 100 Year 4 Hour Rainfall Event (Figure 3 of 3)	37
_	•	stem Improvements	
_		commended Upgrades Assessment – 5 Year 4 Hour Rainfall Event	
Figure	e 4.7: Re	commended Upgrades Assessment - 100 year 4 Hour Rainfall Event (Figure 1 of 3)	60

Figure 4.8: Recommended Upgrades Assessment - 100 year 4 Hour Rainfall Event (Figure 2 of 3)	61
Figure 4.9: Recommended Upgrades Assessment - 100 year 4 Hour Rainfall Event (Figure 3 of 3)	62
Figure 4.10. Long Term Upgrades Assessment – 5 Year 4 Hour Rainfall Event	63
Figure 4.11: Long Term Upgrades Assessment - 100 year 4 Hour Rainfall Event (Figure 1 of 3)	64
Figure 4.12: Long Term Upgrades Assessment - 100 year 4 Hour Rainfall Event (Figure 2 of 3)	65
Figure 4.13: Long Term Upgrades Assessment - 100 year 4 Hour Rainfall Event (Figure 3 of 3)	66
Figure 4.14. Future Development Stormwater Management System	69
Figure 4.15. Future Minor System Results – 5 Year 4 Hour Rainfall Event	70
Figure 4.16: Future Major System Results - 100 year 4 Hour Rainfall Event (Figure 1 of 3)	71
Figure 4.17: Future Major System Results - 100 year 4 Hour Rainfall Event (Figure 2 of 3)	72
Figure 4.18: Future Major System Results - 100 year 4 Hour Rainfall Event (Figure 3 of 3)	73
Figure 5.1: Deer Creek Hydraulic Analysis – 100 Year 4 Hour Rainfall Event	83
Figure 6.1. Telford Lake Sampling Program – Sample Location Plan	90
Figure 6.2. Telford Lake Outfall Condition Assessment	92
Figure 6.3. Telford Lake Sedimentation Assessment – Plan View	96
Figure 6.4. Telford Lake Sedimentation Assessment - Profiles	97
Figure 7.1. Proposed Stormceptor Locations	104
Figure 8.1. Storm Sewer Critical Infrastructure Map	108
Tables Table 2.1: Existing System Drainage Basins	10
Table 2.2: Existing Stormwater Management Facilities	12
Table 2.3: Existing Lift Station Summary	15
Table 2.4: Existing Forcemain Summary	15
Table 3.1: Development Staging and Land Use	21
Table 3.2: Recommended IDF Data – Intensity Table – EPCOR Drainage Standards February 2022	23
Table 3.3: Recommended IDF Data – IDF Parameters – EPCOR Drainage Standards February 2022	
Table 3.4: Future ASP Accepted Discharge Rates	
Table 3.5 Summary of Provincial Permitting Legislation	
Table 3.6: Summary of Federal Legislation	
Table 4.1: Existing Minor Drainage System Assessment	
Table 4.2: Existing Stormwater Management Facility Results	
Table 4.3: South Park/Caledonia Surface Ponding Assessment	
Table 4.4: Fire Hall Surface Ponding Assessment	
Table 4.5: Alexandra Park / Linsford Park Surface Ponding Assessment	
Table 4.6: Willow Park Surface Ponding Assessment	
Table 4.7: Lakeside Estates Surface Ponding Assessment	
Table 4.8: Corinthia Surface Ponding Assessment	
Table 4.9: 50 Street Surface Ponding Assessment	
Table 4.10: Improvements Summary	
Table 4.11: System Improvements Assessment – Structures near HWL	
Table 4.13: Future Minor Drainage System Assessment	
Table 4.14: Improved System Assessment – Stormwater Management Facility Assessment	
Table 4.16: Estimated Future ASP Runoff Volume & SWMF Sizing	
Table 4.17: EPCOR IDF Total Depth Comparison	
rable in the Electrical population in the second se	

City of Leduc

City of Leduc Stormwater Master Plan Final Report

Table 4.18: EPCOR IDF Intensity Comparison	
Table 4.19: Existing Minor Drainage System IDF Comparison – 100 Year 4 Hour Rainfall Event	77
Table 4.20: Impact of IDF Selection – 100 Year 24 Hour Events – SWMFs	78
Table 4.21: Region IDF Data – Storage System Design	79
Table 4.22: Region IDF Data – Major Conveyance System Design	80
Table 4.23: Region IDF Data – Minor System Conveyance Design	80
Table 5.1: Deer Creek Flow Rates	81
Table 6.1: Chloride Concentration in Lakes in the Region	8888
Table 7.1: Proposed Stormceptors	103
Table 8.1: Summary of Storm Sewer Assets by Relative Risk	105
Table 10.1 Cost Estimate Summary: Hydraulic Improvements	110
Table 10.2: Cost Estimate Summary: Stormceptors	111
Table 10.3 Stormwater Flat Rate Assessment	112
Table 10.3 Stormwater Flat Rate Assessment	
Table 10.3 Stormwater Flat Rate Assessment	117
	117
Table 11.1: Implementation Plan Summary	
Table 11.1: Implementation Plan Summary	75
Table 11.1: Implementation Plan Summary Images Image 4.1. 5 Year 4 Hour IDF Comparison	75 75
Images Image 4.1. 5 Year 4 Hour IDF Comparison	75 75
Images Image 4.1. 5 Year 4 Hour IDF Comparison	75 76 76 76
Images Image 4.1. 5 Year 4 Hour IDF Comparison	75 76 76 76
Images Image 4.1. 5 Year 4 Hour IDF Comparison	75 76 76 76 101
Images Image 4.1. 5 Year 4 Hour IDF Comparison	

Appendices

Appendix A	Manhole Survey Diagrams
Appendix B	Model Setup and Calibration – Supplementary Letter
Appendix C	Hydraulic Assessment Figures
Appendix D	IDF Assessment Figures
Appendix E	Climate Change Assessment – Supplementary Letter
Appendix F	Deer Creek Cross Sections
Appendix G	Geomorphological Assessment
Appendix H	Telford Lake Sampling Program
Appendix I	Outfall Condition Assessment
Appendix J	Minor System Condition Assessment
Appendix K	Communications Documentation
Appendix L	Cost Estimates

List of Acronyms

ASP Area Structure Plan

CB Catch Basin

CCTV Closed-Circuit Television

CoE City of Edmonton

EIA Edmonton International Airport

EMRB Edmonton Metropolitan Region Board

FWMIS Fish and Wildlife Management Information System

GIS Geographic Information System
HDPE High-Density Polyethylene

HGL Hydraulic Gradeline HWL High Water Level

IDF Intensity-Duration-Frequency

LC₁₀ Lethal Concentration with 10% mortality

LID Low Impact Development

LiDAR Light Detection and Ranging surface topography

MH Manhole

NASSCO National Association of Sewer Service Companies

NWL Normal Water Level

PACP Pipeline Assessment Certification Program

PVC Polyvinyl Chloride

SWMF Stormwater Management Facility

SWMP Stormwater Master Plan TSS Total Suspended Solids

List of Units

ha hectares
hr hour
km kilometres
L litres
m metres

m³ cubic metres
mg milligrams
mm millimetres
s seconds
yr year

1. Introduction

1.1 Background

The City of Leduc (the City) is located in the Edmonton Metropolitan Area and is one of the fastest growing communities in Alberta. The City's 2023 population is 36,060 based on municipal census. It is located to the south of the City of Edmonton, bordered by Leduc County and the Edmonton International Airport (EIA), and is bisected by the Queen Elizabeth II Highway (QE II). The study area is shown on Figure 1.1.

The City has not experienced substantial flooding due to stormwater, however, has experienced minor flooding occurrences. In July 2022, a localized area experienced a near 100 year, 1 hour rainfall event that caused flooding along 54 Avenue as well as in the Corinthia neighbourhood, including an overflow of the Corinthia Dry Pond. In many of the older development areas within the City, there is no minor drainage system, and some locations do not have a defined major drainage path. Therefore, it is imperative to understand and identify flood risks within the City, such that appropriate mitigation measures can be implemented.

The City identified the need for a plan to guide stormwater management, to address existing drainage and allow for the orderly development of new areas. AECOM Canada Ltd. (AECOM) was retained by the City to develop a Citywide stormwater master plan (SWMP) to identify any current stormwater infrastructure deficiencies and constraints and guide the implementation of stormwater system improvements. The goal of the study is to identify and prioritize areas of concern, capital improvements, and stormwater operations costs for the City.

To accomplish this, AECOM has utilized Infoworks stormwater modelling software to develop a 2D model of the entire stormwater collection system, as well as completed field and desktop assessments to identify existing areas at risk.

As part of the comprehensive SWMP, elements of the natural environment were also considered, including a mitigation strategy for Telford Lake water quality, review of climate change impacts to stormwater management, and the overall performance of Deer Creek.

1.2 Study Area

The study area generally consists of the area within the current City boundary, which includes 2,660 ha of existing development and 1,665 ha of future development area for a total of 4,325 ha. The City currently operates a stormwater management system that consists of approximately 6 kilometres (km) of culverts, 4,476 manholes, 42 km of ditches, 133 km of sewer main line, 4 storm lift stations, multiple weirs/control structures, an engineered snow storage site, the Leduc Reservoir, and 32 stormwater management facilities (SWMFs) both wet and dry.

The City is located within two distinct watersheds, the Whitemud Creek Watershed and Blackmud Creek Watershed, both of which eventually drain to the North Saskatchewan River. The City is bisected north to south by the division between the Whitemud and Blackmud Creek watersheds, as further described in Section 2.

The City is divided into neighborhoods which are referred to throughout this study. Figure 1.2 shows the neighbourhood map.

1.3 Scope of Work

The overall objective of this study was to develop the stormwater servicing concept for the City. This included a review of the existing system and the development of a roadmap for system improvements to address any existing system deficiencies and support future development. The scope of work included the following:

- Collect and review all relevant data for the project
- Review existing flow monitoring data and rainfall data
- Review past flooding incidents with City Operations staff
- Field reconnaissance
- Review existing legislation, regulations, and guidelines
- Develop and calibrate 2D stormwater model using Infoworks
- Assess existing stormwater system
- Recommend existing system improvements
- Assess future stormwater system
- Intensity Duration Frequency (IDF) data comparison to EPCOR design rainfall events and sensitivity analysis
- Impact of climate change and comparison to current IDF data
- Develop Design Criteria
- Assess Willow Park Neighbourhood
- Telford Lake Water Quality Improvement Strategy
- Assess Deer Creek
- Assess Stormwater Outfall Conditions
- Review Low Impact Development (LID)
- Condition Assessment
- Identify Critical Infrastructure
- Future System Improvements
- Cost Estimates & Implementation Plan
- Public Consultation and Communication including presentation to Council
- Develop Stormwater Master Report

1.4 Data Collection and Review

Relevant data was collected and reviewed, including existing reports, survey and topographic data, record information and as-built data, servicing standards, and flow monitoring data.

The following data was utilized for the development of the hydraulic model:

- City of Leduc Cadastral Data, dated April 4, 2022.
- LIDAR and Contour Data dated March 2021.
- City of Leduc infrastructure GIS shapefiles including ASP outlines, bridges, land use bylaw, parcels, ponds, service laterals, storm facilities, storm mains, storm points, streams, and street layouts.
- As-built drawings from all stormwater management facilities.
- Rainfall data from the Fire House rain gauge and Robinson rain gauge for the 2021 rainfall season.
- Leduc City rain gauge rainfall data from 2018 to 2022.
- Flow monitoring data from 2021 rainfall season, including May 19, July 22, Aug 23, and September 22 events.

1.4.1 Previous Studies

Relevant reports reviewed as part of the study include:

 Blackmud/Whitemud Creek Surface Water Management Group – Blackmud/Whitemud Creek Surface Water Management Study – July 2017 – Associated Engineering

This study included a hydrologic, hydraulic, and environmental analyses of the Blackmud and Whitemud Creek Basins to develop a stormwater management strategy to accommodate future development within the basin. Key information utilized from this report include:

- The recommendation for a maximum release rate of 3.0 L/s/ha within the Blackmud and Whitemud basins (with some exceptions).
- The delineation of the Blackmud and Whitemud basin boundaries, which bisects the City of Leduc in the north-south direction.
- Estimation of upstream area and flow rate estimate within Deer Creek during the 5 year and 100 year rainfall events.
- 2. City of Leduc Creekside Phase 1 Storm Water Management Facility Report April 27, 2022 V3 Companies of Canada

This report provides a description of the Creekside stormwater management facility (SWMF) design, storage and release characteristics.

 City of Leduc – Off-Site Storm and Water Servicing – Stormwater Storage Modeling Update – August 12, 2021 – ISL Engineering

This memo provided a description of the modelling conduced and expected performance of the expanded on-site storage option of the Camwood development in Corinthia Park and assessed whether flow paths required additional upgrading.

4. City of Leduc – Deer Creek 1:100 Years Floodplain Analysis in SE ¼ Sec 33-49-25-W4 – 2004 – Challenger Engineering.

This report presents the 1:100 year floodplain of Deer Creek within the Deer Valley subdivision and includes recommendations for development setback from the creek and maximum slope requirements.

5. City of Leduc – Biophysical Assessment Leduc West Area Structure Plan – July 2013, Bruce Thompson & Associates Inc.

This report identified significant and sensitive environmental components within the Leduc West ASP area prior to the development of the ASP and to make recommendations on the sustainability of the site. The report included areas that should be set aside as Environmental reserve and provided recommendations for preserving or enhancing ecologically significant features.

6. City of Leduc - Overland Drainage Study, November 18, 2010 - Urban Systems Ltd.

This study reviewed the overland drainage for the area shared between the City of Leduc and Leduc County on the East side of the City that drains to Saunders Lake with the goal of identifying potential drainage and erosion issues.

City of Leduc – Stormwater Management Facility Vulnerability Assessment Revised – September 2017 – Associated Engineering.

This study included a desktop assessment that identified potential risks and impacts on the City's stormwater management facilities during the 100 year 24 hour rainfall event. During this study, a comprehensive investigation of the City's stormwater management facilities physical parameters was compiled which included design volumes, water elevations, volumetric release rates, and inlet/outlet information. The report identified ponds that did not meet current design criteria as well as provided conceptual improvement opportunities.

8. Indus Development Corp. – Master Drainage Plan for Leduc Residential Subdivision Scenic Acres – December 2003 – T. Fenton Consulting Ltd.

This report included the preliminary storm drainage plan for the Scenic Acres (SW19) development area which is now the Robinson neighbourhood. The report included runoff estimation, and provided a plan for the proposed stormwater management facility.

9. City of Leduc - Leduc Business Park Drainage System Assessment - January 12, 2007 - Stantec

This report assessed the existing storm drainage system in the southwest portion of the Leduc Business Park. The purpose of the study was to determine the allowable discharge rate for the proposed development in Farm Air Stages 4 and 5. The report concluded that the storm sewer had a capacity between a 2 and 5 year return frequency, and the existing pond had a storage capacity between a 25 and 100 year return frequency. The report also recommended that the allowable discharge rate from the development be limited to 0.2 m³/s.

10. City of Leduc – SWMP Vulnerabilities Civic Centre Wet Pond Coupled 1D-2D Modelling – August 2018 – Associated Engineering

The study included the development of a 2D model of the Linsford Park are within the City of Leduc to further assess the likelihood of system flooding within these areas as a result of the 2017 Vulnerability Study.

11. City of Leduc – Telford Lake Master Plan – March 2010 – ISL Engineering and Land Services

The Telford Lake Master Plan included a strategy for the long term development and management of Telford Lake and the lands that surround it. The report provided conceptual level development plans that were developed to maintain five key objectives including environmental protection, multiway and trails, recreational open space and facilities, paddling venue, and land acquisition requirements.

A 2000 m eight-lane paddling course has been included in the Master Plan, with the proposed location identified. To accommodate this, the lake would need to be dredged to a depth of 3 m at this location.

12. City of Leduc – 2021 Snow Storage Sites Monitoring Report – Trace Associates – January 10, 2022

The study included a sampling program for the Engineered Snow Storage Site and Temporary Snow Storage Site, measuring the chloride concentrations throughout the year upstream and downstream of the snow storage sites.

City of Leduc – Telford Lake Dredging and Lagoon Reclamation Preliminary Engineering Report – Daltam Consulting – March 4, 1987

The study examined the feasibility, scheduling and costs for dredging Telford Lake. As appendices to this report, a groundwater investigation, geological investigation and environmental considerations were included.

City of Leduc

City of Leduc Stormwater Master Plan Final Report

1.4.2 Other References

CCME, 2011. Canadian Council of Ministers of the Environment, 2011. Canadian water quality guidelines for the protection of aquatic life: Chloride fact sheet. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

1.4.3 Survey

McElhanney Ltd. was subcontracted to complete a survey of missing infrastructure from the City's GIS stormwater database. They provided survey of approximately 85 manholes and 91 culverts. This information was utilized to update the City's database as well as fill in any missing information regarding pipe or culvert diameter, inverts and locations.

Figure 1.3 shows the locations that McElhanney provided survey which was updated in the City's database. **Appendix A** provides a summary of the survey data provided for the manholes. Additional culverts were added based on a combination of a 2019 orthophoto, LiDAR data, Google Streetview, and site visits.

Surveyed cross sections of Deer Creek were completed by AECOM staff in June 2023. Additional survey at key topographic locations throughout the City was also conducted by AECOM staff in June 2023, December 2023, and January 2024 to confirm risk levels to properties, as discussed in Section 4.

ANSI B 279.4mm x 431.8mm

Approved:

Checked:



STUDY AREA

CITY OF LEDUC

Project No.: 60683843



CITY OF LEDUC Project No.: 60683843



ANSI B 279.4mm x 431.8mm

Approved:

Checked:

Project Management Initials:

Last saved by: BRENDAN TROITSKY (2024-04-19) Last Plotted: 2024-04-25 Filename: C:\60683843 - LEDUC STORM\ARCGIS\FIGURES



SITE SURVEY LOCATIONS

STORMWATER MASTER PLAN

CITY OF LEDUC

Project No.: 60683843

2. Existing Drainage System

The existing stormwater management system includes a minor system, which consists of the underground pipe network, and the major system, comprised of the overland road drainage, major ditches, creeks, and stormwater management facilities. Some regions of Leduc, such as large portions of the northern industrial area, do not have a minor system and rely entirely on the ditch and culvert network. Conversely, other regions of Leduc, such as the downtown area, lack a well-defined major system due to differing design standards at the time of development. As part of the existing system assessment, shortcomings of the minor system, the major system, and the interface between these two classes of systems are identified.

The following sections include a summary of the main features of the Leduc stormwater management system including:

- Drainage Sub-Basins and System outlets.
- Stormwater Management Systems.
- Lift Stations and Forcemains.
- Minor Drainage System.
- Major Drainage System.

This section includes a description of the drainage features as they currently exist (2023). Assessment results and recommendations for the stormwater management system are included in Section 4.

2.1 Sub-Basins and System Outlets

The City of Leduc is located within both the Whitemud Creek and Blackmud Creek watersheds. The City is generally bisected in the north-south direction by sub-basins that convey runoff eventually west to Whitemud Creek or east to Blackmud Creek. Within the City, there are 10 major outlets from the system to downstream drainage basins, as shown on Figure 2.1.

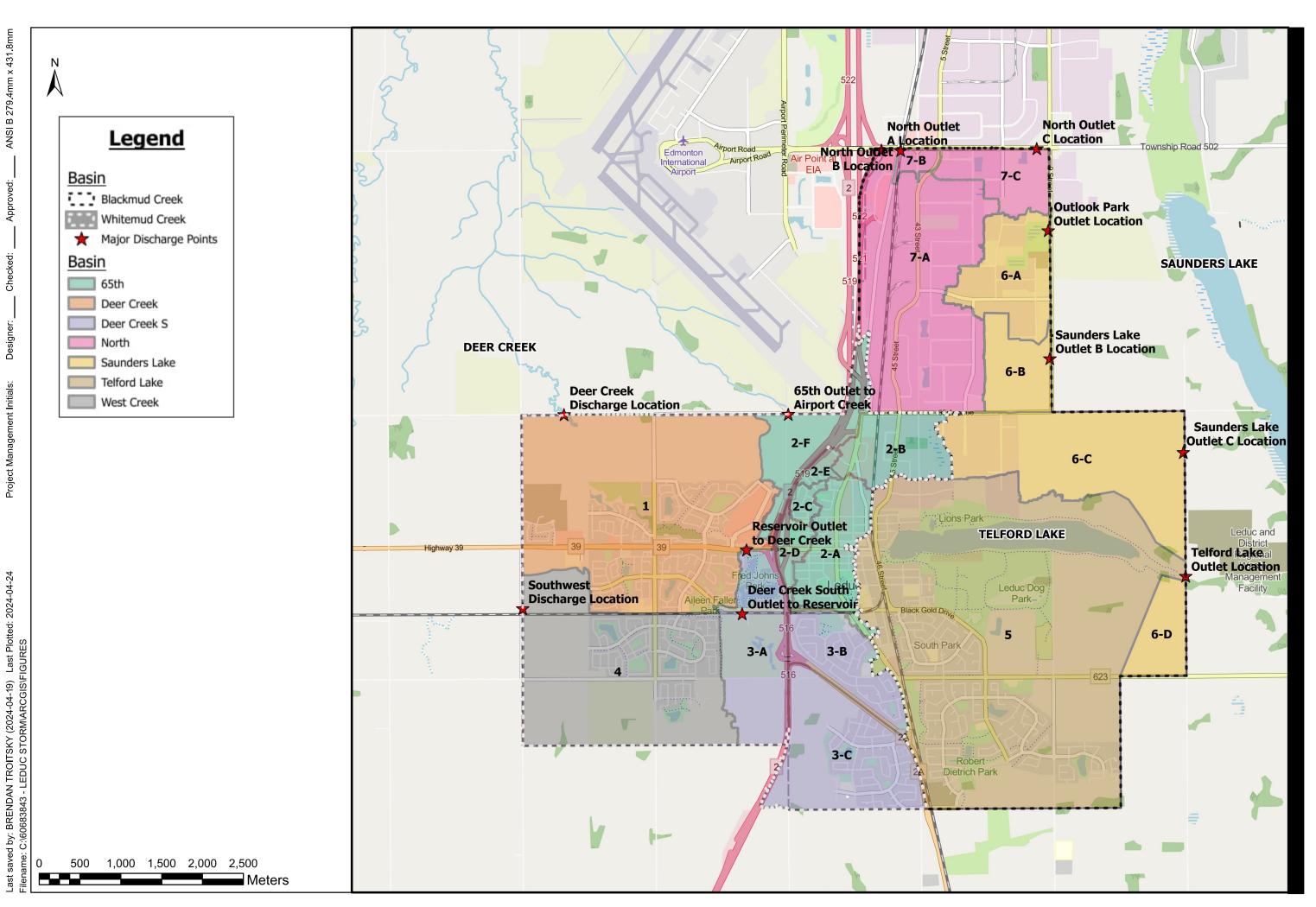
Deer Creek, a tributary of Whitemud Creek, is the primary receiving body to the west. There is also an unnamed southwest creek, and the unnamed creek that flows through the EIA, that are both also tributaries of Whitemud Creek.

Telford Lake is the primary receiving body for the eastern portion of the Leduc. Telford Lake discharges east through an unnamed creek to Saunders Lake, which outlets to Blackmud Creek. Portions of Leduc drain directly to Saunders Lake, with the north industrial areas draining north directly to Blackmud Creek.

Table 2.1 provides a summary of the existing drainage basins and their area within the current City corporate limits.

Table 2.1: Existing System Drainage Basins

Basin Number	Receiving Waterbody	Whitemud/Blackmud Basin	Contributing Area (ha)	Percentage of Overall Area
1	Deer Creek	Whitemud	658	15%
2	65 th Avenue/Unnamed Creek Through EIA	Whitemud	377	9%
3	Deer Creek South/Leduc Reservoir	Whitemud	505	12%
4	Unnamed Southwest Creek	Whitemud	443	10%
		Sub-Total Whitemud	1,983	46%
5	Telford Lake	Blackmud	1,217	28%
6	Saunders Lake	Blackmud	602	14%
7	North Ditch System	Blackmud	523	12%
		Sub-Total Blackmud	2,342	54%
		TOTAL	4,325	100%



BASIN AREA MAP

Project No.: 60683843 **CITY OF LEDUC**

2.2 Stormwater Management Facilities

The City operates 32 stormwater management facilities that consist of both dry and wet ponds. Dry ponds are normally dry, and may have a dual-purpose for both stormwater management during wet weather conditions and for recreation all other times. Wet ponds have a permanent pool and are dedicated stormwater management facilities, with water levels increasing during rainfall events. During the Stormwater Management Facility Vulnerability Assessment (Revised) Study, dated September 2017, a detailed inventory of stormwater management facilities was conducted and is presented in that report. A summary of the facilities is shown in Table 2.2. The existing stormwater management facilities are shown on Figure 2.2.

Through development of a system model the basin areas for each stormwater management facility were reviewed, and three stormwater management facilities were found to have contributing areas that significantly diverged from the listed values in the 2017 Vulnerability Assessment:

- West Point Lake Wet Pond, also known as Leduc Estates, has a listed contributing area of 33.95 ha, but is estimated to have a total upstream catchment area of 64.82 ha.
- Solar Cittee Wet Pond South, also known as NW Commercial #3, had a listed catchment area of 3.85 ha, but the total upstream catchment area was estimated to be 57.6 ha, alongside additional controlled discharge from other SWMFs.
- Solar Cittee Wet Pond North, also known as NW Commercial #2, had a listed catchment area of 2.57 ha, but the total upstream catchment area was estimated to be 12.7 ha, and it may also receive overflow volume from Solar Cittee Wet Pond South.

The above noted difference in contributing area has an impact on the runoff stored and discharged from the stormwater management facilities. However, due to interconnections within the existing stormwater management system including upstream and downstream ponds, orifices, etc.; the impact of the change in catchment area varies between the three ponds. This assessment and resulting risks to the system is discussed in detail in Section 4.

The contributing areas for these three ponds have been updated in Table 2.2.

Table 2.2: Existing Stormwater Management Facilities

Basin (-)	SWMF Name (-)	Volume (m³)	Surface Area (at NWL) (ha)	Bottom Elevation (m)	Normal Water Elevation (m)	High Water Elevation (m)	Contributing Area (ha)	Freeboard Elevation (m)
1	Bridgeport Wet Pond	48,800	2.97	712.0	717.5	719.50	87.11	719.80
	Deer Valley Wet Pond	28,386	1.04	711.2	714.2	715.70	35.79	716.30
	West Haven Estates Wet Pond (Alan Griffiths Park)	37,570	0.78	715.0	717.0	718.96	32.74	719.50
	West Haven Park Wet Pond (Audrey Griffiths Park)	36,485	0.67	714.5	717	719.00	25.78	719.50
	West Point Lake Wet Pond	23,000	1.61	716.9	719.4	720.64	64.82	720.94
	Woodbend 1	46,250	3.51	709.0	711.5	714.70	36.2	714.00
	Woodbend 2	35,800	0.56	709	711.5	713.50	14.2	716.50
2	Leduc Civic Centre Wet Pond	9,910	0.88	723.29	726.03	726.95	42.47	727.25
3	Corinthia Dry Pond (Kinsmen Park)	37,578	3.84	730.1	-	732.43	4.72	732.73

Basin (-)	SWMF Name (-)	Volume (m³)	Surface Area (at NWL) (ha)	(m)	Normal Water Elevation (m)	High Water Elevation (m)	(ha)	Elevation (m)
	Southfork Wet Pond (McHardy Park)	107,000	4.24	731.5	732.1	734.50	122.53	734.70
4	Blackstone	55,730	3.33	719.12	722.0	724.40	52.5	725.00
	Suntree Wet Pond (J.T. Atkinson Park)	36,600	2.41	713.75	716.5	718.25	58.2	718.75
	Windrose Wet Pond (William Glanville Park)	55,900	3.04	719.12	721.62	723.19	57.75	724.04
5	Coady Lake Wet Pond	40,628	1.93	734.87	736.09	737.62	53.1	737.92
	Leduc Recreation Centre Wet Pond	21,449	1.78	731.31	732.87	733.78	18.15	734.08
	Lions Park Dry Pond	13,740	1.23	727.63	-	729.70	20.7	730.00
	Robinson Wet Pond (Ruddy Park)	54,891	3.43	739.4	742	744.0	57.4	744.60
	Tribute Dry Pond (Elks Community Park)	17,100	1.33	736.41	-	738.2	11.23	740.00
	Tribute Wet Pond (Robert Dittrich Park)	37,669	9.85	734.4	733.6	737.9	169.11	740.00
6	Harvest Industrial Park 1	17,270	1.62	725.7	729	730.4	16.1	731.00
	Harvest Industrial Park 2	3,800	0.46	725.4	729	730.38	51.3	731.00
	Leduc BP 7 Wet Pond (Outlook Park)	122,319	3.96	716.5	719	723	100.54	723.50
	Leduc BP Stage 3 Wet Pond	40,000	2.43	720.0	722.1	722.9	52.95	723.20
	Telford Industrial Park Wet Pond	32,750	2.46	727.55	729.15	731.1	42.27	731.45
7	Leduc BP #1 Wet Pond	28,061	1.63	715.5	718.5	719.75	28.02	720.00
	Leduc BP #2 Dry Pond	20,000	1.24	719	-	721.5	32.42	721.90
	Leduc BP Stage 4A Wet Pond	40,500	3.45	721	723.5	725	72.76	725.30
	Leduc BP Stage 5A Wet Pond	40,833	3.52	722.3	725	726.3	28.75	726.55
	Saurabh Park Wet Pond	47,910	2.64	713.05	714.5	717.5	45.78	718.00
	NW Commercial #1 Dry Pond	16,900	0.94	720.2	-	723	43.3	723.35
	Solar Cittee Wet Pond South (NW Commercial #2)	8,339	0.86	719.9	720	721.85	57.6	722.03
	Solar Cittee Wet Pond North (NW Commercial #3)	1,910	0.27	720.92	721	722.13	12.7	722.50

Note: a " - " in the NWL elevation indicates the facility is a dry pond and therefore the normal water level is considered at the bottom of the facility.

ANSI B 279.4mm x 431.8mm

Approved:

Checked:

Designer:

Project Management Initials:



EXISTING STORMWATER MANAGEMENT FACILITIES PLAN VIEW

Project No.: 60683843 CITY OF LEDUC

2.3 Lift Stations & Forcemains

The City operates 4 stormwater lift stations as follows:

- Blackstone Lift Station
- Outlook Park Lift Station
- Woodbend Lift Station
- Civic Centre (Alexandra) Lift Station

Table 2.3 and Table 2.4 summarize the design information for the lift stations and their associated forcemains, which can both be seen in Figure 2.3. Note that the Blackstone and Woodbend lift stations are temporary and are to be removed upon completion of their respective development.

Table 2.3: Existing Lift Station Summary

Lift Station Name (-)	Location Description (-)	Pump Capacity Descriptions (-)	Pump Start (m)	Pump Stop (m)	Notes (-)
Blackstone Pond Outlet (Temporary)	Outlet to the northwest of Blackstone SWMF	118 L/s at 3.79 m	722.51	722.0	Discharge is downstream of SWMF orifice
Outlook Park Lift Station	Lift station between constructed Outlook Park SWMF and natural wetland to the north	200 L/s	719.3	719.0	
Woodbend Lift Station	Outlet to the northeast of Woodbend SWMF	92 L/s	713.3	711.5	Discharges to secondary Woodbend SWMF
Civic Centre (Alexandra) Lift Station (Temporary)	Lift station to the higher elevation south pond at the Civic Centre	100 L/s	726.0	725.0	Flow recirculation between upper and lower ponds
Leduc Business Park Proposed Lift Station	Future Lift station to Telford Lake	TBD – Future Lift Station			

Table 2.4: Existing Forcemain Summary

Forcemain No. (-)	Lift Station (-)	Discharge Location (-)	Diameter (mm)	Length (m)	Material (-)
1	Blackstone Pond Outlet	Outfall ditch to West Creek	300	9	PVC
2	Outlook Park Lift Station	Northern Natural Wetland		131	PVC
3	Woodbend Lift Station	Outfall Ditch to Deer Creek	300	53	HDPE
4	Civic Centre (Alexandra) Lift Station	South Pond	200	106	PVC
5	Leduc Business Park Proposed lift Station	Telford Lake	TBD – Future Forcemain		cemain

ANSI B 279.4mm x 431.8mm

Approved:

Checked:

Designer:

Project Management Initials:



EXISTING LIFT STATION AND FORCEMAINS

STORMWATER MASTER PLAN

Project No.: 60683843 CITY OF LEDUC

City of Leduc Stormwater Master Plan Final Report

2.4 Minor Drainage System

The minor drainage system is defined as the underground piped storm sewer system. The minor system in Leduc is comprised of 133 km of storm sewer mains and 4,476 manholes (MHs) and catch basins (CBs). The pipes range in diameter from 2,100 mm to as small as 100 mm for gravity operated pipes and 65 mm for force mains. The minor system in Leduc is well established in newer neighbourhoods, with extensive underground pipe systems and CBs to receive water from the surface. Flow will typically discharge into a SWMF and then outflow at a controlled rate through the minor system to a receiving waterbody, such as Deer Creek or Telford Lake, as detailed in Section 2.1.

In older neighbourhoods, due to the difference in development standards over time, the neighbourhoods were developed with limited or no minor systems. The existing minor drainage system is shown on Figure 2.4. Where there are gaps in the minor system, runoff must instead be entirely conveyed overland by ditches and roadways. In flatter regions, such as Willow Park, this lack of minor system can lead to increased surface ponding duration, which consequently can decrease the lifespan of the roadways.

CITY OF LEDUC Project No.: 60683843

MINOR SYSTEM EXISTING INFRASTRUCTURE

Legend

Conduit Diameter

375 to 425 mm

450 to 525 mm

750 to 825 mm

1050 mm

1200 mm

1500 mm

2000 mm or Greater



- 300 mm or Smaller

600 mm

675 to 725 mm

900 mm

1350 mm

1800 mm





1,000 1,500 2,000 2,500

■ Meters

2.5 Major Drainage System

The major drainage system includes overland flow including roadways, ditches and creeks. In Leduc, the major overland flow routes are comprised primarily of creeks in the west and ditches in the east. An overview of the major overland drainage routes can be seen in Figure 2.5.

West of QEII, the primary overland drainage route is Deer Creek. Deer Creek flows into the City from the south, collecting flow from Southfork, passing through the Leduc Golf and Country Club, and entering the Leduc Reservoir. Flow is controlled at the reservoir by a weir at the north end. Deer Creek flows north and west through existing development north of 50 Avenue. Northwest of Deer Valley, the creek flows through undeveloped land, and crosses 65 Avenue with a bridge crossing. North of 65 Avenue (City limits) Deer Creek continues to flow northwest through the EIA and Leduc County before merging with Whitemud Creek near Highway 19.

An unnamed southwest creek collects flow from Suntree, Blackstone, and Windrose. This creek merges with Whitemud Creek west of the City near Highway 39. This overland flow path will also be crucial for the future development of Brightwell and Banks of Crystal Creek.

Overland drainage from the northern industrial areas tends to flow north via ditches alongside QEII or using the existing roadway ditch and culvert system throughout the industrial district. These flows discharge into existing ditches to the north of Airport Road, and flow north, eventually entering Blackmud Creek. Regions along the eastern section of the City, from Outlook Park south to Telford Industrial Park, flow to the east along existing major drainage channels towards Saunders Lake.

Areas around and to the south of Telford Lake utilize existing ditches and culverts to flow into Telford Lake, which outlets through a weir controlled structure into an unnamed creek that discharges east into Saunders Lake.

ANSI B 279.4mm x 431.8mm

MAJOR OVERLAND DRAINAGE ROUTES STORMWATER MANAGEMENT SYSTEM

Project No.: 60683843 STORMWATER MASTER PLAN CITY OF LEDUC

500 1,000 1,500 2,000 2,500 Meters



3. Design Criteria and Standards

3.1 Development Staging and Land Use

The current City boundary encompasses 3,568 ha. Within the City boundary, there is a mixture of existing residential, commercial, industrial, and institutional development and undeveloped area. The neighborhoods range from fully developed, fully developed with opportunity for infill development, partially developed with additional area to be developed in the near future, and undeveloped future communities.

Table 3.1 provides the existing and full development land use within the current City Boundary and the percent imperviousness used for the assessment. The stormwater management system will be assessed in the existing development condition and the fully developed condition. Note that in Table 3.1, Urban Services areas for existing development primarily include municipal spaces, government buildings, and stormwater management facilities. Although some schools are zoned under either Urban Services or Green Space, they have been separated out into Institutional for the purposes of this study. The roadways number listed includes the entire roadway right of way, as zoning boundaries only extend to the property line and is estimated for ASPs, which generally only include proposed arterial roadways at this time.

Table 3.1: Development Staging and Land Use

Land Use (-)	Existing Development (ha)	Full Development (ha)	Percent Impervious (%)
Single Family Residential	650	1,032	55
Multi-Family/High Density Residential	59	94	65
Commercial	196	303	70 (neighbourhood) 90 (large commercial)
Industrial	586	1,190	60
Institutional	62	98	10 (green spaces) 100 (other, inc. buildings)
Urban Services	93	220	10 (green spaces) 100 (other, inc. buildings)
Undeveloped	1,812	62	10
Recreational/Green Space	340	467	10
Roadways	527	859	100
Total	4,325	4,325	

3.2 Current Level of Service Standards

The current standards pertaining to the stormwater management system are summarized below, as provided in the City of Leduc Engineering Design Standards, November 2022, which reference the EPCOR Design and Construction Standards Volume 3 Drainage dated February 2022.

The minor system will be designed to convey the 5 year rainfall event. Minor system design criteria include:

- Sewers are to be designed such that they have sufficient capacity to convey the 5 year rainfall event without surcharge.
- Catch basin inlet designed with a maximum ponding depth of 150 mm, with no flooding to private property.

City of Leduc Stormwater Master Plan Final Report

Roadways designed such that there is no curb overtopping. Collector roads should be designed such that there
is the width of 1 lane remaining for vehicle travel. Arterial roads should be designed with 1 lane each direction
remaining for vehicle travel.

The major (overland) drainage system will be designed to convey/store the 100 year rainfall event. Major system design criteria include:

- Sewers will be allowed to surcharge during the 100 year rainfall event utilizing roadways and major system drainage paths to convey the surcharged stormwater.
- Ponds will be designed to store excess stormwater relieving discharge to the downstream system. Ponds should be assessed for the 100 year (4 and 24 hour), as well as the 1978 event, or a rainfall depth of 120 mm over the contributing catchment to the pond.
- Pond drawdown should occur as follows:
 - Storage for the 5 year event available within 24 hours
 - Storage for the 25 year event available within 48 hours
 - o 90% of the drawdown to the normal water level to occur within 96 hours.
- Depth of flow on roadways shall be less than 300 mm, with a freeboard to adjacent buildings of 300 mm where possible (minimum of 150 mm).
- Depth of flow not to exceed 150 mm above the crown of the roadway.

These criteria are recommended to apply to any future development. For upgrades to the existing system, achieving these criteria may not be feasible, and tolerances are recommended to be considered as discussed in Section 3.6.

3.3 Rainfall Events

The City of Leduc Engineering Design Standards, November 2022, replaces the rainfall Intensity Duration Frequency (IDF) data in the February 2022 EPCOR Design and Construction Standards with IDF data from the Edmonton Municipal Airport – IDF period 1914 – 1955.

Section 4.7.1 Includes a comparison of the current City of Leduc Standard rainfall events to the various events that EPCOR has utilized in recent years. As seen in Section 4.7.1, the 2022 EPCOR IDF is relatively similar to the current City of Leduc standard with the 100 year 24 hour rainfall depth within 1% total rainfall depth, and the 100 year 4 hour peak intensity within 7% (8.8 mm/hour higher than current Leduc standard). It is recommended to utilize the EPCOR IDF data for the system analysis and recommended system improvements. The 2022 EPCOR event is slightly more conservative than the current Leduc standards, and is based on data from 11 rain gauges throughout Edmonton with data from a period of 1984 to 2020. Table 3.2 and Table 3.3 show the recommended intensity and IDF parameters, respectively.

Table 3.2: Recommended IDF Data – Intensity Table – EPCOR Drainage Standards February 2022

Minutes	Hours	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr	200 yr
5	0.083	67.84	91.53	109.85	135	155.14	178.49	204.34
10	0.167	449.99	69.66	85.06	105.86	122.13	141.26	163.92
15	0.25	40.29	57.01	70.2	87.96	101.8	118.2	138.24
20	0.333	34.09	48.65	60.18	75.74	87.89	102.34	120.32
25	0.417	29.75	42.68	52.93	66.8	77.7	90.68	107
30	0.5	26.52	38.17	47.41	59.95	69.88	81.7	96.68
35	0.583	24	34.62	43.05	54.52	63.66	74.56	88.41
40	0.667	21.99	31.76	39.51	50.09	58.59	68.71	81.63
45	0.75	20.33	29.4	36.57	46.41	54.36	63.83	75.93
50	0.833	18.93	27.4	34.09	43.29	50.77	59.69	71.09
55	0.917	17.75	25.69	31.96	40.61	47.69	56.12	66.91
60	1	16.72	24.21	30.12	38.28	45.01	53.02	63.25
120	2	10.28	14.86	18.4	23.44	27.82	33.03	39.6
180	3	7.68	11.07	13.65	17.38	20.76	24.75	29.73
240	4	6.23	8.96	11	14	16.8	20.09	24.17
360	6	4.64	6.63	8.09	10.29	12.43	14.93	17.97
720	12	2.78	3.94	4.76	6.04	7.38	8.93	10.76
1440	24	1.67	2.34	2.79	3.53	4.36	5.32	6.41

Table 3.3: Recommended IDF Data – IDF Parameters – EPCOR Drainage Standards February 2022

Rate = a*(t+c) ^b	IDF Parameters										
Parameters	2 yr	2 yr 5 yr 10 yr 25 yr 50 yr 100 yr 200 yr									
a (t in min)	370.26	587.05	798.4	1044.56	1145.99	1290.08	1554.16				
b	-0.74	-0.76	-0.78	-0.78	-0.77	-0.75	-0.75				
c (min)	4.83	6.56	7.83	8.70	8.63	8.76	9.73				

The system will be assessed during the 5 year and 100 year rainfall events, to compare both the minor and major system performance to the Design Standards.

Both the 4 hour Chicago distribution and 24 hour Huff distribution will be evaluated. The 4 hour duration events have a higher peak rainfall intensity, and often govern conveyance system designs. The 24 hour duration events have a higher rainfall volumes, and often govern storage systems.

3.4 Discharge Rates

Discharge rates for the City of Leduc were estimated as part of the Blackmud/Whitemud Creek Surface Water Management Study dated July 17, 2013. The report recommended a maximum release rate of 3.0 L/s/ha should be adopted for future development areas discharging to both Blackmud and Whitemud Creeks. As this applies to all areas of the City, a discharge rate of 3.0 L/s/ha should be utilized for new developments where legacy discharge rates have not been previously accepted by the City.

The City currently operates a number of stormwater management facilities, that attenuate the peak flows discharged to the downstream system. The SWMFs have been designed with unit discharge rates that vary from 0.5 L/s/ha to 15.3 L/s/ha, including some SWMFs that are discharged without orifice restriction. In addition, the stormwater from the downtown area conveyed through the culverts crossing the QEII is discharged unrestricted to the downstream system. It is assumed that existing development is grandfathered in, however, opportunities for reducing the peak flow discharges will be assessed. Telford Lake is considered an adequate outlet and restriction of discharge is not required.

Some neighborhoods within the City have previously accepted Area Structure Plans (APSs) for future neighborhoods with discharge rates greater than 3 L/s/ha. Table 3.4 summarizes the previously accepted rates which should be maintained and were included in the model.

Table 3.4: Future ASP Accepted Discharge Rates

SWMF	Allowable Discharge Rate (L/s/ha)	Contributing Catchment Area (ha)	Peak Discharge Rate (L/s)	Notes
65 th Avenue	3	196.5	590	Assumed 3.0 L/s/ha allowable discharge rate
Banks of Crystal Creek	3	114.2	343	Assumed 3.0 L/s/ha allowable discharge rate
Blackstone	3.5	45.4	159	Calculated release rate from 2014 Stantec Neighbourhood Design Report
Brightwell	3	66.5	200	Assumed 3.0 L/s/ha allowable discharge rate
Deer Valley / Creekside	3	14.2	42	Assumed 3.0 L/s/ha allowable discharge rate
East Telford Lake	3	398.3	1195	Assumed 3.0 L/s/ha allowable discharge rate
Eaton & Emery	3	65.7	197	Assumed 3.0 L/s/ha allowable discharge rate
Grayson	1.9	49.7	94	1.9 L/s/ha as per flow rate for Deer Valley (from 2023 Arcadis NW33 Neighbourhood Design Brief)
Harvest Industrial Park	3	94.1	282	Assumed 3.0 L/s/ha allowable discharge rate
Lakeside	3	55.0	165	Assumed 3.0 L/s/ha allowable discharge rate
North Leduc Industrial Park	3	135.4	406	Assumed 3.0 L/s/ha allowable discharge rate
Robinson	3	31.7	95	Assumed 3.0 L/s/ha allowable discharge rate
Sawridge Business Park	3	23.5	71	Assumed 3.0 L/s/ha allowable discharge rate
Rollyview	3	65.4	196	3.0 L/s/ha allowable discharge rate as per 2024 Rollyview ASP

SWMF	Allowable Discharge Rate (L/s/ha)	Contributing Catchment Area (ha)	Peak Discharge Rate (L/s)	Notes
Southeast Leduc	3	66.7	200	Assumed 3.0 L/s/ha allowable discharge rate
Southfork	3	84.9	255	Assumed 3.0 L/s/ha allowable discharge rate
Suntree	3	0.9	3	Assumed 3.0 L/s/ha allowable discharge rate
West Area (South and Central)	3	191.7	575	Assumed 3.0 L/s/ha allowable discharge rate

3.5 Other Design Criteria

The following additional design criteria were applied to the stormwater management system:

- Minimum pipe diameter of 300 mm. Catch basin lead minimum diameter of 250 mm.
- Manning's n:
 - o 0.013 for Polyvinyl Chloride (PVC), concrete, and other new smooth walled pipes
 - 0.024 for Corrugated Steel Pipe (CSP) pipes and culverts
 - 0.013 for roadway and other impervious surfaces
 - 0.04 for vegetated and other pervious areas
- Stormwater full flow velocity to be within 0.9-1.0 m/s. A minimum pipe velocity of 0.6 m/s should be maintained during a 1:5 year rainfall event.
- Generally, a maximum velocity of 3.0 m/s should be maintained, however, this can be exceeded with engineering control of scour.
- Catchbasin inlet spacing a maximum of 150 m.
- For pipes that service greater than 30 ha, the pipe capacity is to be designed for the calculated peak flow rate multiplied by 1.25.
- SWMF drawdown of 90% of total storage above NWL within 96 hours.
- SWMFs should be designed with an overflow that guides runoff to ditches and away from property.
- Where possible, stormwater management systems should be designed to utilize gravity. Lift stations should be avoided and only utilized when a gravity option is unavailable. Lift stations require City approval prior to construction.
- Stormwater management facilities should be designed with a minimum freeboard of 0.3 m.
- A stormwater management report with City approval is required for all new and redevelopment.

3.6 Cost/Benefit & Tolerance

In existing developed areas, the minor and major systems were assessed based on the criteria in the above-described section to determine locations that do not meet the design criteria. This creates a baseline for areas within the existing development for further assessment. In locations without a defined major or minor drainage system, it may not be practical to develop drainage improvements to meet standards that would only provide minimal benefit to the public, as there have been no reported incidents of flooding. In addition, with a retrofit design, it may be more practical to increase the level of service of the minor system where the major system cannot be feasibly improved, and vice versa.

City of Leduc Stormwater Master Plan Final Report

Therefore, during the system assessment, the model was utilized to determine the location of ponding that exceeds the standards, and then the actual risk of flooding both to within the lot limit as well as risk to damage to property. This was accomplished by identifying the depth of ponding, with the following categories:

- Less than 0.15 m
- 0.15 m to 0.3 m
- 0.3 m to 0.5 m
- 0.5 m to 1.0 m
- Greater than 1.0 m

The areas of surface ponding were identified based on the modelling results and include all land use areas within the City. As the risk of property damage is low within areas such as parks and roadways, the assessment was refined to determine the risk of flooding with the following definitions:

- Lots with flooding: includes all lots where the extent of ponding reached to within the property line with a depth of greater than 0.15 m.
- Flooding to property: includes all lots where the extent of ponding reaches the actual home/business as outlined by the City's GIS layer, to a depth of greater than 0.15 m.

Properties that were identified to have simulated high water levels near homes were field surveyed to confirm the ground elevation at both the property line and the building outline. This approach was used to confirm ground elevations in the model compared to modelled hydraulic grade lines (ponding elevations) to confirm the simulated risk to property.

Proposed upgrades were identified to address flood risks, as detailed in Section 4.3. Each upgrade was assessed to determine the number of properties that are at risk of flooding, and the consequence of that risk. For example, an institutional development such as a hospital or a school would be considered as a higher priority upgrade than a single family residential lot. Upgrades were re-reviewed based on the cost-benefit and may not be recommended for implementation should the cost of upgrades provides limited benefit (high cost to benefit ratio).

Time of inundation was considered when proposing upgrades. Areas which flood and do not have a drainage outlet, or where flooding draws down over an extended period of time will require an upgrade. If areas are identified to have ponding in exceedance of the design standards, and the exceedance is for a short period of time and draw down with the rainfall event or shortly thereafter, the upgrade priority may be reduced.

Each upgrade was assessed for feasibility and timing with other projects. For example, if a community is planned for rehabilitation, this would provide an appropriate timeline for improvements that have lower priority.

3.7 Review of Relevant Legislation and Regulations

Stormwater systems are governed through various legislation. Table 3.5 and Table 3.6 include a summary of the pertinent Provincial and Federal legislation, respectively.

Table 3.5 Summary of Provincial Permitting Legislation

Name	Summary	Project Applicability
Environmental Protection and Enhancement Act and Regulations	The Environmental Protection and Enhancement Act is the primary act in Alberta through which regulatory requirements for air, water, land, and biodiversity are managed. The Act supports and promotes the protection, enhancement and wise use of the environment by designating proposed activities for which an approval or registration is required. The Act and its regulations provide the legislative framework for all approved municipal waterworks and wastewater systems in Alberta. The Act regulates the construction and operation of designated municipal wastewater systems, along with municipal waterworks and storm drainage systems.	Potential – for any waterworks, wastewater, and storm drainage system.
Water Act, Water (Ministerial) Regulation, and Codes of Practice	The Water Act manages Alberta's water resources. The Act governs activities affecting waterbodies in Alberta (including wetlands and watercourses). The Act is applicable when a shoreline, surface water, and/or groundwater resource may be affected. An approval under the Water Act is required to alter flow levels of water; change the location of water; change the direction of water flow, cause the siltation of water; cause erosion of bed or shore of any waterbody; or any effect on the aquatic environment (in drainages, watercourses and wetlands). In addition, the Act covers dam and canal safety.	If any flow of water is altered, building a dam, crossing or affecting a water body, and discharge of water.
Public Lands Act	The intent of the <i>Public Lands Act</i> is to govern lands that are designated as public land. It does not include privately owned land, National Parks, First Nations reserve, or Provincial Parks. Under the Act, the Crown can claim ownership of the bed and shore of permanent and naturally occurring bodies of water, rivers, stream, watercourses, and lakes.	If infrastructure will be located on Crown land
Historical Resources Act	The intent of the <i>Historical Resources Act</i> is to preserve and study historic resources (archaeological, historic and paleontological sites and features) within Alberta.	If excavation will occur.
Weed Control Act and Weed Control Regulation	The Weed Control Act protects stakeholders from economic and invasive losses caused by weeds. Some weed species exhibit extreme growth habits, which can have consequences for line of sight at intersections, wildlife control along roadways, culvert and outfall maintenance, agricultural production, livestock forage quality, and many others. The Act prescribes activities that must be undertaken should a noxious or restricted weed be encountered. Each Municipality is responsible for enforcing the Act.	If there may be spread or introduction of weeds.
Soil Conservation Act	The Soil Conservation Act describes the requirement for landholder to prevent soil loss or deterioration from taking place or stop loss or deterioration from continuing.	If soil loss may occur.
Wildlife Act and Wildlife Regulation	AEP administers the <i>Wildlife Act</i> , which influences and controls human activities that may have adverse effects on wildlife or wildlife habitats on both Crown and privately-owned land. Section 36(1) of the <i>Wildlife Act</i> states that a person shall not willfully molest, disturb or destroy a house, nest or den of prescribed wildlife or beaver dam in prescribed areas and prescribed times. This applies to nests and dens of endangered wildlife, migratory birds, snakes (except prairie rattlesnakes), bats, and prairie rattlesnake hibernacula. Additionally, Section 36(1) also applies to beaver dens on land that is not privately owned as well as houses, nests, and dens of all wildlife in a wildlife sanctuary and nests of game birds in game bird sanctuaries.	If a wildlife house, nest, or den could be affected.

Table 3.6: Summary of Federal Legislation

Name	Summary	Project Applicability
Species at Risk Act	The Species At Risk Act (SARA) contains several prohibitions to protect species listed on Schedule 1 of SARA. Under Sections 32 and 33 of SARA, it is an offence to: kill, harm, harass, capture or take an individual of a species listed as extirpated, endangered or threatened under SARA possess, collect, buy, sell or trade an individual (or any part or derivative of such an individual) of a species listed as extirpated, endangered or threatened under SARA damage or destroy the residence of one or more individuals of a listed endangered, threatened or extirpated species if a recovery strategy has recommended its reintroduction into the wild in Canada SARA also contains provisions that prohibit the destruction of any part of the critical habitat of listed aquatic species (Section 58(1)). Critical habitat is: the habitat necessary for the survival or recovery of the species identified and described in the recovery strategy or action plan for that species	If species at risk are present.
Migratory Birds Convention Act, 1994 and Migratory Birds Regulations, 2022	The Migratory Birds Convention Act, 1994 (MBCA) aims to protect migratory birds, their nests, and their eggs. Birds protected by the MBCA include waterfowl (such as ducks, geese, and swans), insectivorous birds (such as wrens, robins, shrikes, and woodpeckers), and some nongame birds (such as herons and gulls). The MBCA is applicable to all lands and waterbodies in Canada and applies to all activities associated with organizations, industries, and individuals. To protect migratory birds, the MBCA provides general nesting periods based on geographic location. The general nesting period covers the majority of species covered under the MBCA, however, it may not be accurate for species that can breed at any time during optimal conditions (e.g., crossbill species), or species that may nest earlier or later. It is important to note that this period may not include those nesting periods for species not covered under the MBCA but are covered under Alberta's Wildlife Act (see below).	If work occurs within the migratory bird breeding season or nests could be affected.
Fisheries Act	The Fisheries Act provides a legal basis for conserving and protecting fish and fish habitat. The fish and fish habitat protection provisions of the Fisheries Act provide a holistic approach to conserving and protecting fish and fish habitat, supported by policies and programs that provide for the long-term sustainability of freshwater and marine resources. The fish and fish habitat protection provisions of the Fisheries Act include: a prohibition against causing the death of fish, by means other than fishing (Section 34.4) a prohibition against causing the harmful alteration, disruption or destruction (HADD) of fish habitat (Section 35) a framework of considerations to guide the Minister's decision-making functions (Section 34.1) ministerial powers to ensure the free passage of fish or the protection of fish or fish habitat with respect to existing obstructions (Section 34.3) Fisheries and Oceans Canada (DFO) has developed Measures to Protect Fish and Fish Habitat (Government of Canada 2021a) for compliance with the fish and fish habitat protection provisions of the Fisheries Act by incorporating measures to avoid: causing the death of fish harmful alteration, disruption or destruction (HADD) of fish habitat in the work, undertaking or activity	disruption, or destruction of fish habitat could occur.

City of Leduc Stormwater Master Plan Final Report

Name	Summary	Project Applicability
Canadian Navigable Waters Act	for travel or transport, whether or not the water is on the list of scheduled waters of the CNWA.	
	As per the CNWA, navigable water means a body of water, including a canal or any other body of water created or altered as a result of the construction of any work, that is used by vessels, in full or in part, for any part of the year as a means of transport or travel for commercial or recreational purposes, or as a means of transport or travel for Indigenous peoples of Canada exercising rights recognized and affirmed by section 35 of the Constitution Act, 1982. The definition of navigable water does not include artificial irrigation channels or drainage ditches. The CNWA includes protections for navigation on all navigable waters in	
	Canada. Scheduled navigable waters are listed on a Schedule to the CNWA so that any works in those waterways that may interfere with navigation can receive extra oversight.	

4. Hydraulic System Assessment

4.1 Model Development

4.1.1 Field Survey and GIS Update

GIS data was provided by the City of Leduc in 2022. In order to supplement missing data for several important sections of storm sewer, survey data was collected by McElhanney in August 2022. This survey data was used to update missing parameters such as pipe inverts and diameters. The data updated to reflect surveyed elevations and sizes was flagged as such in the updated GIS files. Other sections of the storm system were updated by interpolating pipe profiles and using listed pipe grades when available.

Manhole rim elevations were taken from the GIS or as-built drawings if available, or obtained from surface LiDAR if no data was provided.

Culverts were initially added to the GIS using a combination of a 2021 Orthophoto, Google Streetview, and site visits conducted by AECOM staff. During model calibration, regions with simulated trapped flow were further investigated and additional culverts were added. The majority of these culverts were not surveyed, and the invert elevations were estimated from the LiDAR data. Approximately 400 culverts were added across the City, and while it is not anticipated that this is a conclusive set, during calibration it was found that there was no significant artificial flow detention that would have suggested key culverts missing from the model.

4.1.2 Model Parameters and Calibration

AECOM developed a City-wide stormwater model utilizing Infoworks ICM hydraulic modelling program. The program allows for 1D and 2D hydraulic modelling of the minor and major system with interaction between them to allow for an accurately visualized depiction of the function of the stormwater management system.

As part of the study, the 1D model was developed and calibrated utilizing rainfall events and flow monitoring data from 2021 for the minor system. The 2D model was then developed and calibrated utilizing a flooding event that occurred in July 2022.

Detailed model calibration parameters and the calibration procedures and results are provided in **Appendix B**.

4.2 Existing System Hydraulic Analysis

The following sections summarize the existing system hydraulic analysis and subsequent system deficiencies and recommended improvements for the existing stormwater management system.

In general, Sections 4.2.1 to 4.2.3 provide an overall look at the performance of the minor and major stormwater systems to develop a baseline of flooding extents, ponding depths, surcharging manholes, and pipes that are overutilized within the entire system. This assessment includes all system components but is utilized to determine the overall benefit the proposed upgrades are making on the system.

Section 4.3 looks specifically at system deficiencies causing lots and properties to be at risk within specific neighborhoods; and the proposed system improvements (if recommended) to mitigate the ponding.

Section 10 provides cost estimates and the resulting cost-benefit based on the benefitting lots and properties for each of the proposed upgrades.

4.2.1 Minor System Analysis

The minor drainage system was evaluated to determine the system performance during both the 5 year and 100 year rainfall events. The minor system was evaluated based on the following parameters:

- Pipe Capacity: Used to identify locations where pipe flow exceeds the pipe capacity
- Hydraulic Grade Line: Used to identify potential surcharge and flooding locations

The pipe capacity utilization was calculated by taking the ratio of peak flow in the pipe to the theoretical Manning's full pipe flow. Figures 4.1, 4.3, and 4.4 show color coding of the pipe capacity utilization. The capacity utilization was categorized into three ratings as follows.

- Blue: Peak flow to Manning's capacity ratio is less than 1.2
- Yellow: Peak flow to Manning's capacity ratio is between 1.2 and 2.0
- Red: Peak flow to Manning's capacity ratio is greater than 2.0

The magnitude of surcharging in the storm sewer was identified by the hydraulic grade line (HGL) elevation. Figures 4.6, 4.8, and 4.9 show color coding of the manhole surcharging levels. The surcharging is categorized into the following criteria:

- Green: HGL depth greater than 1 m below ground.
- Orange: HGL depth within 1 m of ground elevation
- Red: HGL depth above ground elevation

Table 4.1 summarizes the minor system assessment as a percentage of pipes and manholes that fall into each of these categories.

The assessment was conducted to provide an overall depiction of the performance of the stormwater system to provide a baseline for the benefit of the proposed system improvements. Some pipes that are shown as overutilized or manholes with high HGL are caused by restrictions from SWMFs or downstream segments, and when the downstream system regains capacity is available the system will flow at higher rates than would normally be present.

Table 4.1: Existing Minor Drainage System Assessment

	5 Year 4 Hour		5 Year 24 Hour		100 Yea	r 4 Hour	100 Year 24 hour		
Description	No.	%	No.	%	No.	%	No.	%	
Pipes Utilization Ratio 0 – 1.2	3817	85.0	4249	94.6	2928	65.2	3992	88.8	
Pipes Utilization Ratio 1.2 – 2	415	9.2	72	1.6	1012	22.5	255	5.7	
Pipes Utilization Ratio >2	261	5.8	172	3.8	553	12.3	246	5.5	
HGL Depth >2.5	1025	25.3	1360	33.6	384	9.5	930	23.0	
HGL Depth 2.5 m – 1 m	2386	58.9	2471	61.0	1248	30.8	2302	56.9	
HGL Depth < 1 m	437	10.8	125	3.1	1185	29.3	503	12.4	
HGL Above Ground	200	4.9	92	2.3	1228	30.4	312	7.7	

City of Leduc Stormwater Master Plan Final Report

The minor system is suitably sized for most regions of the City, with 85% of pipes having a capacity utilization rate below 1.2 in the 5 year 4 hour rainfall event, and only 5% of MHs have a HGL above ground. Local flooding is generally driven by high hydraulic grade lines along specific mains, which in some areas also combines with limited inlet capacity and major system flow pathways to result in high levels of ponding. For areas with high HGLs during the 5 year 4 hour event the ponding is still typically minor, with no properties noted as being vulnerable to flooding from the City's system during this event.

During higher return period events, such as the 100 year 4 hour, the minor system is strained further in older areas with limited major system capacity; this is most noticeable along the 50th Street main and the South Park main. These two areas are relatively flat and have comparably poor access to creeks or major ditches, which reduces the ability of the major system to store and convey flow. They have also seen further urbanization since their installation and in general have fewer SWMFs than would typically be installed under current design standards.

Section 4.3 discusses the hydraulic deficiencies and proposed improvements.

AECOM Figure: 4.1

Legend

Lot Lines

Flow Capacity Ratio

--- < 1.2

1.2 - 2.0

Node Hydraulic Gradeline

- > 1 m Below Surface
- Within 1 m of Surface
- Above Surface



1,000 1,500 2,000 2,500 Meters

City of Leduc Stormwater Master Plan Final Report

4.2.2 Major System Analysis – Surface Flooding

For the City of Leduc, the 100 year 4 hour event is generally the governing event for surface flooding, with the exception of a few locations that are governed by large volumes in the stormwater management facilities during the 100 year 24 hour rainfall event (discussed in Section 4.2.3).

Figure 4.2 through Figure 4.4 show the results of the major drainage system assessment including the surface flooding for the 100 year 4 hour rainfall event. Results for the 5 year, 4 hour and 24 hour, as well as the 100 year 24 hour events are included in **Appendix C**.

Many locations within the model show surface ponding; however, it does not present a risk to property. Instances of ponding caused by hydraulic deficiencies were investigated and are discussed in Section 4.3.

.

AECOM Figure: 4.2

EXISTING MAJOR SYSTEM ASSESSMENT 100 YEAR 4 HOUR RAINFALL EVENT (FIGURE 1 OF 3)

Project No.: 60683843

CITY OF LEDUC

STORMWATER MASTER PLAN

<u>Legend</u>

Lot Lines

Node Hydraulic Gradeline

> 1 m Below Surface Within 1 m of Surface

Flooding

Flow Capacity Ratio

→ <1.2

>2.0

Surface Ponding Depth

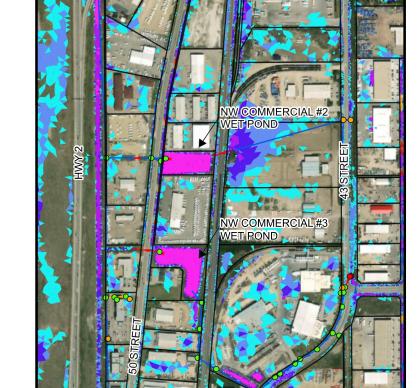
< 0.15 m

0.15 - 0.30 m 0.30 - 0.50 m

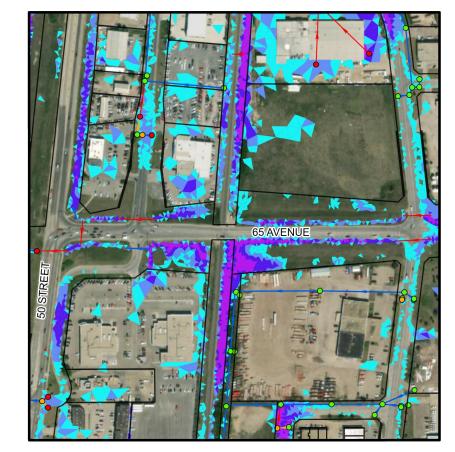
0.50 - 1.00 m >1.00 m

Benefit Analysis

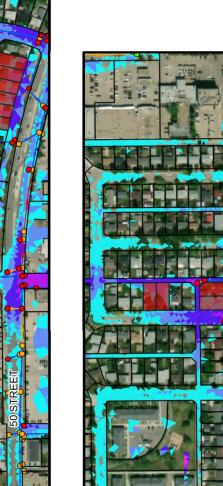
Modelled HWL Near Home

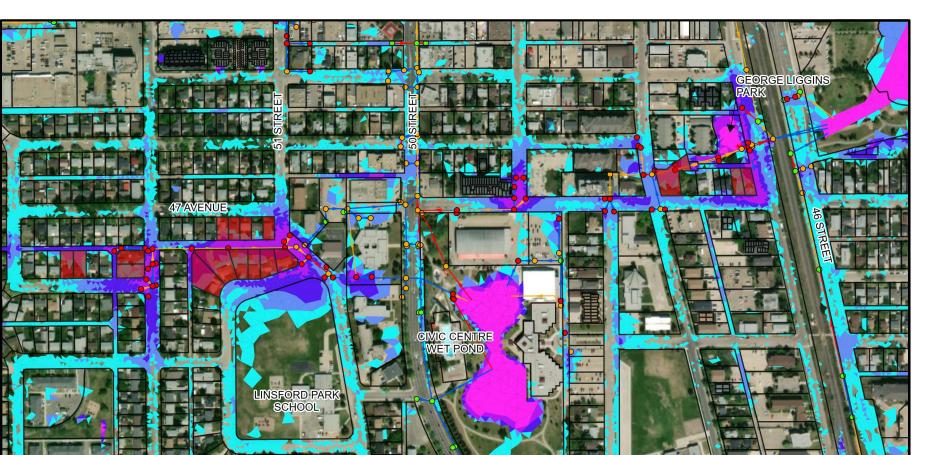


NORTH INDUSTRIAL



65TH AVENUE





DOWNTOWN

WILLOW PARK

CITY OF LEDUC

EXISTING MAJOR SYSTEM ANALYSIS 100 YEAR 4 HOUR RAINFALL EVENT

(FIGURE 2 OF 3)

100 200 300 400 500 Meters Project No.: 60683843

<u>Legend</u> Lot Lines Node Hydraulic Gradeline > 1 m Below Surface Within 1 m of Surface

Flooding Flow Capacity Ratio <1.2 **---** 1.2 - 2.0 >2.0 Surface Ponding Depth < 0.15 m 0.15 - 0.30 m

0.30 - 0.50 m 0.50 - 1.00 m >1.00 m Benefit Analysis

Modelled HWL Near Home



Project No.: 60683843 CITY OF LEDUC

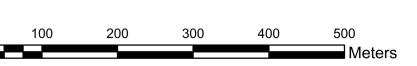














SOUTH PARK

4.2.3 Major System Analysis – Stormwater Management Facilities

The SWMFs were assessed for both the 100 year 4 hour and 24 hour rainfall events. Generally, the 100 year 24 hour is the governing event for the SWMFs because of the higher rainfall volume that occurs in the longer duration event. In Leduc, many SWMFs were governed by the high intensity of the 100 year 4 hour event which resulted in higher water surface levels including Deer Valley, Leduc Business Park Stage 5A, and the Civic Centre Wet Pond. Figures 4.2 through 4.4 show the modelling results for the 100 year 4 hour event. **Appendix C** shows results for all modelled rainfall events.

The water surface elevations of each SWMF are provided in Table 4.2, with water surface elevations that exceed the design high water level highlighted in yellow, and water surface elevations that exceed the freeboard elevation highlighted in red.

The SWMFs identified as having HGLs above the designed Freeboard elevation are listed below, along with a description of the cause of this result.

West Point Lake:

There is limited capacity in the sewer system downstream of West Point Lake due to a combination of hydraulic constraints in the storm sewer flowing north along Grant MacEwan Blvd and an undersized control orifice at the SWMF outlet. More developed area appears to drain to this SWMF than had been assumed in previous studies.

Leduc Civic Centre:

This SWMF is undersized relative to the contributing area. The downstream storm main going North along 50th Street is also undersized, which further increases water levels in the downstream pipe system and Civic Centre pond.

Leduc Business Park #1 & Saurabh Park:

The increased high water level is due to higher imperviousness within the catchment area during the modelling process than current development, as the pond is surrounded by Industrial or Large Commercial zoned lots, despite several large contributing lots being undeveloped or primarily grassed, which effectively makes the current loading to these ponds in the model equivalent to the ultimate design conditions. The outlet conditions are also heavily impacted by the Airport Road crossing to the east of Saurabh Park; the existing crossing has an invert above Saurabh Park's NWL, compared to the ultimate buildout pipe at a much lower elevation. This outlet condition results in reduced outflow and higher water levels in Saurabh Park SMWF, which also increases the water level upstream at Leduc Business Park #1. Effectively, the results shown for these two ponds are based on loading equivalent to the ultimate buildout imperviousness, but with the existing downstream infrastructure that is not capable of handling the ultimate loading condition. When modelled using the ultimate buildout conditions, including the upgraded outlet of Saurabh Park, the HWL was reduced to below the design HWL in both ponds. So, while these two ponds each have listed high water levels greater than the listed freeboard elevations, they were not listed as requiring improvements.

Solar Cittee North:

This pond is significantly undersized relative to its contribution area, as well as receiving some inflow from the already overloaded Solar Cittee South pond.

Solar Cittee South:

This pond is significantly undersized relative to its contribution area. Its inlet is a 1500 mm concrete pipe and outlets via a 284 mm orifice, despite its limited storage capacity of 8,339 m³. As a result this pond is anticipated to consistently flood during major events,

In general, many of the ponds that have a high water level between the designed high water level and the freeboard elevation are within a few centimeters of the designed high water level. Therefore, the difference is likely due to the model simulation compared to how it was designed, and are not of concern.

City of Leduc Stormwater Master Plan Final Report

The discharge rates for the stormwater management facilities range from 0.53 to 15.3 L/s/ha. Notably high discharge rates include:

Leduc Civic Center:

 Maximum calculated discharge rate of 8.83 L/s/ha is due to the pond stage being well above the design HWL and the outlet not being orifice controlled. Discharge is limited by the downstream storm main capacity.

Coady Lake:

Maximum calculated discharge rate of 8.83 L/s/ha as the pond is not orifice controlled, meaning there is a higher discharge rate at this location during the 100 year events.

Lions Park:

 Maximum calculated discharge rate of 15.32 L/s/ha as it is not orifice controlled and has a relatively small catchment area. This pond discharges directly to Telford Lake, which is an adequate receiving waterbody, and will mitigate the peak flow rates.

Leduc Stage 5A:

 Maximum calculated discharge rate of 10.78 L/s/ha as this pond is not orifice controlled. This SWMF discharges to other downstream facilities, including Leduc Stage 4A.

While discharge rates from these ponds are high, they are not causing issues downstream and have been previously accepted. Therefore, improvements are not recommended at this time.

•

Table 4.2: Existing Stormwater Management Facility Results

			Normal		Top of	Listed	Existing System –100 Year 4 Hour Event			Existing System –100 Year 24 Ho Event		
Basin (-)	SWMF Name (-)	Design Volume (m³)	Water Elevation (m)	Design High Water Elevation (m)	Freeboard Elevation (m)	Contributing Area (ha)	HGL (m)	Discharge Flow (m³/s)	Discharge Rate (L/s/ha)	HGL (m)	Discharge Flow (m³/s)	Discharge Rate (L/s/ha)
	Bridgeport Wet Pond	48,800	717.50	719.50	719.8 (berm overflow)	87.11	719.36	0.47	5.40	719.58	0.516	5.92
	Deer Valley Wet Pond	28,386	714.20	715.70	716.30	35.79	715.72	0.04	1.12	715.70	0.04	1.12
	West Haven Estates Wet Pond (Alan Griffiths Park)	37,570	717.00	718.96	719.50	32.74	718.77	0.22	6.72	718.90	0.22	6.72
1	West Haven Park Wet Pond (Audrey Griffiths Park)	36,485	717.00	719.00	719.50	25.78	718.77	0.12	4.65	718.91	0.12	4.65
	West Point Lake Wet Pond	23,000	719.40	720.64	720.94	64.82	721.28	0.20	3.12	721.55	0.21	3.18
	Woodbend 1	35,800	711.50	713.50	714.00	65.67	713.54	0.09	1.40	713.61	0.09	1.40
	Woodbend 2	12,750	714.00	716.00	716.50	65.67	715.14	0.21	3.20	714.97	0.18	2.74
2	Leduc Civic Centre Wet Pond	9,910	726.03	726.95	727.25	42.47	728.04	0.4	9.42	727.84	0.38	8.83
_	Corinthia Dry Pond (Kinsmen Park)	37,578	-	732.43	732.73	115.7	732.05	0.40	3.46	731.82	0.37	3.20
3	Southfork Wet Pond (McHardy Park)	107,000	732.10	734.50	734.70	122.53	734.10	0.09	0.73	734.40	0.13	1.06
	Blackstone	55,730	-	724.40	725.00	65.97	722.96	0.12	1.82	723.44	0.12	1.82
4	Suntree Wet Pond (J.T. Atkinson Park)	36,600	716.50	718.25	718.75	58.2	717.93	0.02	0.34	718.25	0.02	0.34
	Windrose Wet Pond (William Glanville Park)	55,900	721.62	723.19	724.04	57.75	723.23	0.22	3.81	723.44	0.24	4.16
	Coady Lake Wet Pond	40,628	736.09	737.62	737.92	53.1	737.24	0.41	7.72	737.39	0.48	9.04
	Leduc Recreation Centre Wet Pond	21,449	732.87	733.78	734.08	18.15	733.38	0.08	4.41	733.41	0.09	4.96
5	Lions Park	13,740	-	729.70	730.00	32.63	729.34	0.41	12.57	729.64	0.48	15.32
5	Robinson Wet Pond (Ruddy Park)	54,891	742.00	744.00	744.60	57.4	742.88	0.04	0.70	743.16	0.04	0.70
	Tribute Dry Pond (Elks Community Park)	17,100	-	738.20	740.00	11.23	737.46	0	_**	737.53	0	-**
	Tribute Wet Pond (Robert Dittrich Park)	37,669	736.60	739.50	740.00	169.11	738.18	0.29	1.71	738.34	0.29	1.71
	Harvest Industrial Park 1	17,270	729.00	730.40	731.00	60.07	730.31	0.30	5.04	730.46	0.14	2.33
	Harvest Industrial Park 2	3,800	729.00	730.38	731.00	75.99	730.32	0.03	0.39	730.47	0.04	0.53
6	Leduc BP 7 Wet Pond (Outlook Park)	122,319	719.00	723.00	723.50	100.54	720.97	0.2	1.99	721.86	0.2	1.99
	Leduc BP Stage 3 Wet Pond	40,000	722.10	722.90	723.80	52.95	723.18	0.10	1.89	723.29	0.10	1.89
	Telford Industrial Park Wet Pond	32,750	729.15	731.10	731.45	42.27	730.70	0.18	4.26	730.87	0.21	4.97
	Leduc BP #1 Wet Pond	28,061	718.50	719.75	720.00	28.02	720.11	0.12	4.28	720.13	0.12	4.28
	Leduc BP #2 Dry Pond	20,000	-	721.40	721.90	32.42	721.80	-***	-	721.84	_***	-
	Leduc BP Stage 4A Wet Pond	40,500	723.50	725.00	725.30	72.76	724.70	0.39	5.29	725.31	0.49	6.73
_	Leduc BP Stage 5A Wet Pond	40,833	725.00	726.30	726.55	28.75	725.56	0.31	10.61	725.57	0.31	10.78
7	Saurabh Park Wet Pond	47,910	714.50	717.50	718.00	45.78	718.07	0.22	4.72	718.08	0.22	4.74
	NW Commercial #1	16,900	-	723.00	723.35	22.5	722.30	0.06	2.67	722.32	0.06	2.67
	Solar Cittee Wet Pond North (NW Commercial #2)	1,910	720.92	721.02	722.50	12.7	722.63	_***	-	723.14	_***	-
	Solar Cittee Wet Pond South (NW Commercial #3)	8,339	718.03	721.83	722.03	57.6	723.39	_***	-	723.47	_***	-

AECOM 40

^{*} Yellow highlighting indicates HWL above the designed high water level but within the freeboard, red highlighting indicates HWL above top of freeboard.

** Tribute Dry ponds providing 100% storage, and therefore no discharge rate back to Campbell Road

*** Leduc BP #2 Dry Pond outflows via ditch and a meaningful discharge rate could not be determined

*** Solar Cittee Wet Ponds (NW Commercial #2 & #3) outflow via ditch and emergency berm and a meaningful discharge rate could not be determined

4.3 Existing System Hydraulic Deficiencies and Improvements

This section provides a discussion on the system deficiencies observed based on the hydraulic performance of the major and minor stormwater collection systems, as well as the associated proposed system improvements.

In general, it was found that most deficiencies for the conveyance system (minor underground piped system and major overland ditch and culvert system) were during the 4 hour rainfall events, which have higher peak flow rates due to the high intensity of the rainfall. Deficiencies related to stormwater management facilities were noted in both 4 hour and 24 hour rainfall events, as in some cases the minor system was causing a backup of water, and in some cases the volume during the 24 hour rainfall event exceeded the storage capacity. Figures 4.2 through 4.4 show the existing system ponding during the 100 year 4 hour rainfall event. **Appendix C** shows the results figures of all modelled rainfall events.

System deficiencies and improvements were addressed by area and are summarized in the following sub-sections. Figure 4.5 shows a schematic representation of the proposed improvements.

4.3.1 South Park/Caledonia

South Park has several areas where the simulated surface ponding exceeds depth requirements and reaches adjacent lots. The surface ponding areas are primarily caused by capacity limitations in the downstream trunk system, namely the 1,350 mm storm trunk that flows north to Telford Lake along the CP Rail tracks and the east edge of 46 Street. This storm trunk was found to have insufficient capacity to convey the 5 year peak flow rate. This trunk has an average slope of approximately 0.39%, which equates to a full flow capacity of approximately 3.38 m³/s, which is less than the modelled peak flow rate during both the 5 year 4 hour rainfall event (4.26 m³/s) and 100 year 4 hour rainfall event (4.75 m³/s). Due to the lack of a major drainage system in this area, all stormwater must pass through the minor drainage system. An estimation of potential maximum flowrate for the 100 year 4 hour rainfall was performed for this section of storm main, and with increased pipe capacity the simulated flowrates is over 8 m³/s, indicating the 100 year 4 hour rainfall event flowrate is severely limited by the available pipe capacity.

An additional area along South Park Drive at Black Gold Drive is showing ponding with risk to adjacent properties. The ponding is caused by insufficient pipe capacity in the segment along South Park Drive from 43b Avenue to Black Gold Drive.

4.3.1.1 South Park/Caledonia Improvements

To alleviate the flooding, increased capacity is required along the CP Rail sewer, labelled as C-1 on Figure 4.5. This could be accomplished by upgrading the storm trunk from Rollyview Road (HWY 623) along CP Rail and north along 46 Street to the outlet at Telford Lake. The proposed future upgrade includes twinning the existing main, although upsizing to increase capacity would also provide relief upstream. The approximate length of upgrade is 1,500 m. The decision to twin vs. replace will depend on the condition of the existing trunk and space availability for twinning within the City's right of way.

However, due to the extent of the required upgrade, constraints and high costs, it is assumed that if completed, it would be completed in the long term scenario and is recommended as a potential future upgrade (Upgrade C-1).

As an alternate to the proposed improvement C-1, smaller strategic improvements within South Park were considered; however none of the options were found to be effective solutions:

- Construction of berms along Rollyview Road between the CP rail tracks and approximately 44 Street. The goal of the berms would be to contain the ponding observed on Rollyview Road within the roadway preventing encroachment on the properties to the north. The required berm height would be 1.25 m for 250 to 450 m length along Rollyview Road, depending on the desired extents of protection. The preliminary assessment indicated a berm at this location would be effective at containing water in the road right of way; however, it would trap water at the back of lots to the north.
- Instead of a berm, construction of an oversized ditch was considered on the north side of Rollyview Road along the existing path that would temporarily store stormwater until capacity of the downstream sewer is available. A preliminary assessment showed a 1 m deep, 300 m long ditch filed up quickly in a rainfall event and provided minimal benefit to alleviating surface ponding.
- An overflow relief pond within Railroad Park adjacent to the sewer adjacent to CP Rail was evaluated. The pond would surcharge during large rainfall events and hold stormwater until capacity in the sewer adjacent to CP Rail. A 4 m deep pond was assessed, with a storage volume of approximately 18,000 m³. The inlet would be designed as an overflow which would convey water to the pond during larger stormwater events (> 2 year), and the outlet would be configured with a flap gate that would prevent backflow into the pond when surcharged. Similar to the storage ditch, this proposed pond filled up quickly during the rainfall event and did not provide sufficient surge relief to the trunk sewer.

To address local surface ponding issues, two small upgrades are recommended:

- Construction of a swale from the corner of 41 Street and 37 Avenue (In Caldeonia Park) that would convey ponded surface water to 42 Street. The swale would be approximately 70 m in length. This upgrade was found to be effective at reducing surface ponding and corresponding risk to properties in the local area, and is recommended as upgrade R-9.
- A small capacity upgrade is recommended on 41b Street connecting the laterals from 43b Avenue to Black Gold Drive (Upgrade R-2). The proposed upgrade includes upsizing the existing 375 mm pipe to 600 mm. The length of upgrade is 50 m.

4.3.1.2 South Park/Caledonia Improvements Assessment

Table 4.3 shows the locations within South Park that are exceeding 300 mm of surface ponding on the roadway and identifies structure with modelled HWL near the structure during the 100 year 4 hour rainfall event.

Table 4.3: South Park/Caledonia Surface Ponding Assessment

Location Description	Max Depth – Ex. Sys (m)	Est. Structure near HWL – Ex. Sys	Max Depth – R-Impr. (m)	Est. Structure near HWL – R-Impr.	Max Depth – C-Impr. (m)	Est. Structure near HWL – C-Impr.
Along the CP Rail line, from 43 Avenue to 41 Avenue	0.52	2	0.52	2	0.39	0
Along Rollyview Rd between 50 Street and 42 Street	0.51	7	0.51	7	0.51	3
41B Street	0.81	1	0.74	0	0.74	0
41 Street and 37 Avenue	1.00	8	0.77	2	0.77	2
Various other locations including 42 Avenue and 44 Street	0.55	2	0.55	2	0.55	1

4.3.2 Fire Hall – Alexandra Park

There is surface system ponding at the Fire Hall adjacent to 50 Street north of Black Gold Drive, as shown on the South Park callout on Figure 4.4. Ponding is occurring near the Fire Hall and Leduc Community Hospital along 50 Street and into the lot reaching the building footprint of Fire Hall. Ponding depths along the road in front of the Fire Hall reach depths of 0.6 m, which could impede emergency vehicle access. This is caused primarily by the downstream main trunk adjacent to the CP rail tracks being over capacity, resulting in a high HGL that limits discharge from this section of the stormwater system.

4.3.2.1 Fire Hall Improvements

To alleviate the ponding near the Fire Hall, upsizing the existing storm sewer (existing diameters ranging from 450 to 900 mm, increasing as it goes downstream) to a 1,350 mm diameter pipe would be required for 480 m in length from just north of Corinthia Drive to 42 Avenue, then east along 42 Avenue connecting to the main trunk adjacent to the CP Rail tracks.

4.3.2.2 Fire Hall Improvements Assessment

Table 4.4 shows the hydraulic assessment for the proposed upgrade near the Fire Hall.

Table 4.4: Fire Hall Surface Ponding Assessment

Location Description	Max Depth - Ex. Sys (m)	Est. Structure near HWL – Ex. Sys	Max Depth - R-Impr. (m)	Est. Structure near HWL – R-Impr.	Max Depth – C-Impr. (m)	Est. Structure near HWL – C-Impr.
Along 50 Street adjacent to the Leduc Community Hospital and fire hall (south of 42 Avenue)	0.62	0	0.50	0	0.50	0

As seen in Table 4.4, the proposed improvement mostly provides a benefit of reducing the flooding depth along 50 Street and the access to the fire hall. It is also noted that the proposed upgrade is highly dependant on the implementation of the proposed South Park improvement C-1. If improvement C-1 was not completed, the effectiveness is significantly reduced. Therefore, this hydraulic upgrade is not recommended. It is recommended that the risk of ponding be identified in the City's Emergency Response Plan, and alternate emergency access routes from the rear doors of the Fire Hall be planned should ponding depths on 50 Street restrict access to and from the front doors.

4.3.3 Alexandra Park / Linsford Park

The Alexandra Park / Linsford Park and adjacent area has two deficiencies that are generally caused by high surcharge levels in the minor system. One area is north of Linsford Park School, and the other is near George Liggins Park in Alexandra Park. Water levels in the Civic Centre Storm Pond were identified as exceeding the design freeboard elevation, however this high water level is generally contained to the pond and park area. The Civic Centre Storm Pond is not anticipated to put any homes at risk directly, therefore upgrades were not recommended for this SWMF. The surface ponding in Alexandra Park and Linsford Park are shown on Figure 4.3 on the Alexandra/Linsford Park callout.

4.3.3.1 Linsford Park School Deficiency

The storm sewers north of Linsford Park School drain east towards the 50 Street trunk sewer which does not have sufficient capacity to convey peak flow rates. The 50 Street sewer has a Manning's capacity that varies with the pipe slope and diameters; however, the 1050 mm pipe between 47 Avenue and 52 Avenue has an average slope

City of Leduc Stormwater Master Plan Final Report

of approximately 0.10%, and therefore an estimated Manning's capacity of 0.86 m³/s. The estimated peak flow rates in this sewer are 0.98 m³/s during the 5 year 4 hour rainfall event, and 1.35 m³/s during the 100 year 4 hour rainfall event. In addition, some locations were found to have insufficient inlet capacity.

4.3.3.2 Linsford Park School Improvement

To alleviate ponding north of Linsford Park School, it was determined that storage is the most effective solution. There are two potential options for storage.

The first option is the construction of a dry pond in the northern section of the Linsford Park School sports field. To convey the stormwater to the pond an additional 600 mm storm line through the alley south of 47 Avenue is proposed which will also help mitigate ponding on 52 Street and 51 Street. The approximate length of this upgrade is 270 m. The proposed pipe is from 52 Street along 47 Avenue, connecting to the proposed dry pond, which would be regraded to allow for a deeper inlet structure at the pond. The proposed dry pond would have a storage of approximately 13,000 m³. Based on an estimated active storage depth of 1.5 m, the area of the pond would be 11,000 m². Additional piping around the pond to tie back into the existing sewers would be required, at an estimated length of 100 m. The proposed improvement is shown on Figure 4.5 as Upgrade R-3, and the improved hydraulic assessment results are shown on Figure 4.8.

The second option includes underground storage within the vicinity of Linsford Park School. An underground vault could provide additional storage. Similarly, oversized superpipes could provide some relief, however a 3 m diameter oversized pipe would require a length of 1,900 m to provide equivalent storage to the dry pond, which was not considered practical at this stage.

4.3.3.3 George Liggins Park Deficiency

The dry pond in George Liggins Park adjacent to 47 Street and the upstream sewer system drains directly to Telford Lake via a channel to the east of 46 Street at approximately 48 Avenue. There 4 outlets from various sewers within the City's minor system that directly discharge to the channel which is causing the hydraulic grade line within the channel to rise and contribute to ponding issues in George Liggins Park and the upstream sewer system to the west.

The capacity of the existing twin 600 mm diameter sewer on 47 Avenue that discharges to the channel has a slope of 0.67% and a resulting Manning's capacity of 1.0 m³/s. The estimated peak flow rates in this sewer are 2.10 m³/s during the 100 year 4 hour rainfall event, and 0.79 m³/s during the 5 year 4 hour rainfall event. The remaining upstream portion of the sewer to the west of 47 Steet is also comprised of twin 600 mm diameter pipes, but with a flatter slope and estimated Manning's capacity of 0.36 m³/s combined.

4.3.3.4 George Liggins Park Improvement

The upstream storm system is undersized to convey peak flow rates resulting in ponding around George Liggins park. To reduce the ponding at 47 Avenue, approximately 280 m of sewer upgrade, including 140 m of previously twinned pipes, would need increased hydraulic capacity via upsizing or additional twinning.

Improvements to the system downstream of George Liggins Park by twinning/upsizing the outlet to Telford Lake were investigated and found to reduce the hydraulic grade line and ponding by up to 0.15 m. Upgrading the existing twin mains are anticipated to have significant constructability issues, as the existing pipes have less than 0.6 m of cover in some areas and the corridor is already congested with a sanitary trunk and other infrastructure. Sewer upgrades in this area were assessed but provided very limited relief and no reduction to homes at risk.

The ponding within George Liggins Park is highly dependant on the hydraulic grade line within the channel outlet to Telford Lake, which is governed by a combination of the water level of the lake, inflows to the inlet channel, and storm system to the west of the outfall. To reduce ponding elevations in George Liggins Park and the surrounding

City of Leduc Stormwater Master Plan Final Report

lots, the sewer system would need to be isolated from dependency on the water level within Telford Lake, which would require significant upgrades in an area with limited cover that restricts the potential pipe diameter in an already crowded utilities corridor. As no flooding issues in the area have recently been reported and upgrades are considered costly relative to the provided relief.

Upgrades near George Liggins Park were not recommended due to the high cost and minimal anticipated benefit. As shown in Table 4.11, 3 structures were found to have elevations near that of the modelled HWL and the area should be noted as a location with higher ponding risk during large rainfall events.

4.3.3.5 Civic Centre Deficiency

As shown in Table 4.2, the Civic Centre Ponds are anticipated to be at risk of exceeding the designed freeboard elevation by approximately 0.75 m during the 100 year 4 hour event. The maximum HGL in the pond was determined to be 728.04 m during the 100 year 4 hour rainfall event, compared to the design freeboard elevation of 727.25 m.

A topographic survey was conducted surrounding the Civic Centre, which indicated that the HGL was not a risk to the adjacent structures and the pond is not anticipated to spill. The survey indicated that the lowest building elevation adjacent to the pond is at 728.63 m, and the LIDAR indicates that the spill elevation for the berm surround the pond is 728.15 m. Therefore, no upgrades were considered at the Civic Centre pond.

4.3.3.6 Alexandra Park / Linsford Park Improvements Assessment

Table 4.5 summarizes the locations within the Alexandra/Linsford Park area that are exceeding 300 mm of surface ponding on the roadway and identifies the number of structures estimated to be near the HWL during the 100 year 4 hour rainfall event.

Table 4.5: Alexandra Park / Linsford Park Surface Ponding Assessment

Location Description	Max Depth – Ex. Sys (m)	Est. Structure near HWL – Ex. Sys	Max Depth – R-Impr. (m)	Est. Structure near HWL – R-Impr.	Max Depth – C-Impr. (m)	Est. Structure near HWL – C-Impr.
Along 52 Street from 45 Avenue to 47 Avenue (Linsford)	0.60	4	0.54	2	0.54	2
Along 47 Avenue and 46 Avenue, west of 51 Street (Linsford)	0.69	10	0.54	2	0.54	2
Along 47 Avenue, between 49 Street and 47 Street (George Liggins)	0.42	2	0.38	2	0.38	2
Along 47 Street, north of 47 Avenue to 49 Avenue (George Liggins)	0.69	1	0.33	1	0.33	1

4.3.4 Willow Park

Existing system ponding within Willow Park is shown on the Willow Park callout on Figure 4.3. Willow Park currently discharges to two locations. The west half drains towards two culverts that cross QEII at approximately 67 Avenue. The east half generally drains to 50 Street. There is a small swale through Edward Wolfe Park, with a culvert connection back to 52 Street South of 55 Avenue within Willow Park, there is neither a minor nor major stormwater system.

City of Leduc Stormwater Master Plan Final Report

In general, drainage issues within Willow Park are caused by a lack of minor system causing ponding at isolated low areas, the capacity of the sewer on the west side of Edward Wolfe Park, and the capacity of the 50 Street sewer.

4.3.4.1 Willow Park Improvements

Local ponding within Willow Park is largely due to the capacity of the 50 Street sewer as well as local ponding at areas that do not have a minor drainage system. To resolve surface ponding in the east part of Willow Park, downstream conveyance improvements would be required, as discussed in Section 4.3.9 – 50 Street Sewer. Local sewers are proposed at 3 locations including the following:

- A new 600 mm diameter sewer along 54 Street, from 55 Avenue connecting to the existing sewer at 57 Avenue (Upgrade R-5). The length of the proposed sewer is 225 m, with a slope of 0.5%.
- A new 600 mm diameter sewer along 52 Street, from 52 Avenue connecting to the existing sewer at 56 Avenue (Upgrade R-6). The length of the proposed sewer is 410 m, with a slope of 0.3%.
- A new 450 mm diameter sewer along 51 Street, from 52 Avenue connecting to the existing sewer at 54 Avenue (Upgrade R-7). The length of the proposed sewer is 300 m, with a slope of 0.3%. This upgrade includes the replacement of the existing CBs at the low point along 54 Avenue to the east of 51 Street.

These new improvements are recommended to be installed as part of the concurrent road rehabilitation project.

A dry pond in Edward Wolfe Park (north of 56 Avenue and east of 52 Street), was considered to provide relief to adjacent ponding areas. This upgrade was not recommended for implementation due to limited impact; what storage was provided by the pond was quickly filled by the excess flow and high hydraulic grade line in the 50 Street sewer.

4.3.4.2 Willow Park Improvements Assessment

Table 4.6 summarizes the locations within Willow Park that are exceeding 300 mm of surface ponding on the roadway and identifies the number of structures estimated to be near the HWL during the 100 year 4 hour rainfall event pre and post improvement implementation within Willow Park.

Table 4.6: Willow Park Surface Ponding Assessment

Location Description	Max Depth – Ex. Sys (m)	Est. Structure near HWL – Ex. Sys	Max Depth - R-Impr. (m)	Est. Structure near HWL – R-Impr.	Max Depth – C-Impr. (m)	Est. Structure near HWL – C-Impr.
Corner of 54 Street and 55 Avenue	0.62	O ^a	0.33	0	0.33	0
52 Street at 56 Avenue	0.63	0	0.40	0	0.40	0
54 Avenue west of 50 Street	0.73	4 ^b	0.57	3	0.57	3

While no structures are considered to be at risk under the current drainage configuration, the main drainage path is through a single CB and shallow pipe. If the pipe or grate were to become clogged during a rainfall event or freezing conditions, several of the houses in this region could be at risk for flooding.

b Structures that are flagged in this location are seeing back of lot ponding from along 50 Street along the multi-use pathway. The low points in this area, as indicated by 2021 LiDAR, do not appear to have any inlet CBs. High HGLs along the 50 Street main result in decreased CB inflow in the region, with excess runoff eventually flowing and ponding in these trapped areas. During major events the ponding may have the potential to threaten structures between 51 and 50 Street.

4.3.5 65 Avenue (at CP Rail)

Drainage along 65 Avenue is currently being blocked by the crossing of 65 Avenue and the CP rail line resulting in ponding southeast of the crossing. The City's GIS database indicates that there was previously a culvert on the east side of the CP Rail right of way that conveyed flow to the north across 65 Avenue. Site visits were conducted by AECOM and the City and locating the culvert was unsuccessful. It is therefore anticipated that the culvert was buried and no longer functional, causing ponding.

During the 100 year 4 hour event, the drainage is mostly contained within ditches, but the ponding reaches depths of up to 0.76 m, and may reach the adjacent lot to the southeast of the crossing. While no properties are considered to be at risk, it is recommended to restore the previous drainage pattern in this area via culvert installation.

4.3.5.1 65 Avenue (at CP Rail) Improvements

To alleviate the ponding adjacent to the intersection of 65 Avenue and CP Rail, it is proposed to restore the drainage paths in this area via the re-installation of the culvert. It is proposed to install a 600 mm diameter culvert crossing on the south side of 65 Avenue crossing CP Rail conveying stormwater to the west.

A new storm sewer is also proposed that conveys stormwater to the north along the east side of Sparrow Drive, connecting to the existing sewer along Sparrow Drive. This upgrade includes an addition 70 m of 300 mm diameter sewer along Sparrow Drive that requires additional capacity and is proposed to be upsized, as it is undersized for a 5 year 4 hour rainfall event. These upgrades are labelled as Upgrade R-4 on Figure 4.5. The system ponding with this proposed improvement is shown on the 65 Avenue callout on Figure 4.8.

An alternative option would be to replace the original culvert along CP Rail which would convey stormwater to the north crossing 65 Avenue. To avoid the CP Rail Crossing and recently installed billboard, the culvert would need to be shifted to the east and some regrading would be required. A CP Rail crossing may still be required with this option. Based on the City's GIS, the existing pipe that collects the stormwater ends with an inlet structure on the west side of CP Rail. A culvert was assumed crossing CP Rail located just north of that pipe inlet at a low point along the track that was not in the provided GIS layer. The capacity and condition of this culvert would need to be confirmed, as ponding in the ditch on the east side of CP Rail occurs during the 100 year rainfall event, indicating that the culvert may be at capacity.

There is currently work being completed at 65 Avenue and 50 Street as part of the QEII / 65 Avenue Interchange project which has resulted in minor changes to the drainage in the area, however, the drainage directions have remained the same. As the design of this proposed upgrade progresses, the recently completed work along 65 Avenue should be avoided.

4.3.6 Lakeside Estates

The existing surface drainage and ponding depths within Lakeside Estates is shown on Figure 4.4 on the Lakeside Estates callout. Based on the modelling results, West Point Lake stormwater pond is at risk of flooding adjacent properties. During the 100 year 24 hour rainfall event, the high water elevation is reaching 721.51 m which is approximately 0.87 m above the designed high water level of 720.64 m and is above the designed freeboard elevation (720.94 m). This is caused by a few factors including:

- A portion of Leduc Estates, which was not originally designed to be controlled by West Point Lake is routed through the minor system that drains towards Grant MacEwan Blvd and West Point Lake.
- The existing 600 mm diameter CSP sewer along Grant MacEwan Blvd is over capacity. The pipe has a Manning's capacity of 0.18 m³/s (at the average slope of 0.30%). The peak flow rate modelled during the 100 year 24 hour rainfall event was found to be 0.25 m³/s.

City of Leduc Stormwater Master Plan Final Report

The existing 240 mm diameter orifice that controls the discharge from the pond to the downstream is restricting flows causing a rise in HGL within West Point Lake. This is likely caused by the pond and control structure being designed for a catchment area that did not include drainage from Leduc Estates.

There are various locations throughout Lakeside Estates and Leduc Estates that are experiencing localized ponding that exceed 0.3 m of ponding, particularly at low points near the low point and end of a cul-de-sac. In general, these issues are caused by the high hydraulic grade line which is governed by West Pointe Lake until the downstream capacity is restored. The following locations were identified as locations with potential damage to property during the 100 year rainfall event:

- Southwest corner of WM Bradbury Place
- South end of Bonin Place cul-de-sac
- West corner of J Brown Place

There were a few locations that exceed 0.3 m of ponding but were identified as ponding only to within the property line and low risk of property damage during the 100 year event.

4.3.6.1 Lakeside Estates Improvements

To lower the hydraulic grade line within West Pointe Lake, it would be required to replace the existing 600 mm diameter sewer along Grant MacEwan Boulevard with a 1050 mm diameter pipe. The proposed replacement would be from the SWMF outlet structure near Black Gold Drive on Grant MacEwan Boulevard to the outlet to Deer Creek.

The proposed improvement within Lakeside Estates is shown as C-3 on Figure 4.5. It is understood that Grant MacEwan Boulevard was recently upgraded south of 50 Avenue, and therefore additional rehabilitation would not be in the short term. Therefore, the upgrade was assumed to be completed in the long term.

With the upgraded downstream pipe along Grant MacEwan Boulevard, the orifice within the control structure could be increased in diameter to increase the discharge rate to account for the additional contributing area to the SWMF. The additional area includes the sewers from Leduc Estates that drain towards and are controlled by West Point Lake. The orifice is currently appropriately sized to discharge at a flowrate of 3 L/s/ha, so the proposed future improvements would involve increasing the discharge rate, to the rate that West Point Lake was originally designed.

Increasing the capacity of West Point Lake was considered, however the elevations of the HGL and relatively small available active pond depth of just 1.24 m provides limited opportunity for expansion via either regrading or retaining walls. Based on the modelled high water level of 721.51 m, the estimated additional storage volume required to lower the high water level back to the design elevation is at least 21,500 m³, nearly doubling the size of the existing pond. Excavation to reach this volume would encroach on private lots around the perimeter of the ponds and was not pursued further. Given the limited available area and elevation at the SWMF, upgrades to storage would be costly and of limited effectiveness; offsetting the increased discharge from West Point Lake by decreasing the discharge from other ponds contributing to the Deer Creek could result in a net equivalent loading to the basin.

The adjacent lots were surveyed with the lowest elevation at the base of the structure observed to be 721.68 m, which is 0.17 m above the simulated HWL of the pond. Therefore, the risk of flooding adjacent structures is low for a 100 year event.

4.3.6.2 Lakeside Estates Improvements Assessment

Table 4.7 shows the locations that are showing ponding caused by the increased HGL within Lakeside and Leduc Estates, and the subsequent reduction in ponding at structures near modelled high water levels due to the proposed improvements. The areas exceed 300 mm of surface ponding on the roadway and the number of homes estimated to be at risk during the 100 year 4 hour rainfall event are identified.

In this area, the 100 year 4 hour event is governing for the upstream areas while the 100 year 24 hour event is the governing event for the properties surrounding the pond. The highest water levels are presented in Table 4.7.

Table 4.7: Lakeside Estates Surface Ponding Assessment

Location Description	Max Depth – Ex. Sys (m)	Est. Structure near HWL – Ex. Sys	Max Depth – R-8-Impr. (m)	Est. Structure near HWL – R-8-Impr.	Max Depth – C-Impr. (m)	Est. Structure near HWL – C-Impr.
Adjacent to West Point Lake	1.65	n/a (pond)	n/a (pond)	0*	n/a (pond)	n/a (pond)
Southwest corner of WM Bradbury Place	0.62	1	0.52	0	0.50	0
South end of Bonin Place cul-de-sac	0.65	1	0.61	1	0.60	1
West corner of J Brown Place	0.62	2	0.62	2	0.59	2

^{*24} properties have elevations within 0.5 m of modelled pond HWL

4.3.7 North Industrial Area

Existing ponding within the North Industrial area is shown on the North Industrial callout on Figure 4.3. Stormwater management in this area utilizes a ditch and culvert system that generally is sufficient for the 100 year rainfall events with the exception of the Solar Cittee North and South dry ponds. During the 100 year 24 hour rainfall event the modelled high water levels were found to be at 723.14 m and 723.47 m for the north and south ponds, respectively, compared to their designed high water levels of and 722.1 m and 721.9 m.

The high water level in the Solar Cittee ponds is spilling into the ditches on the east side of Sparrow Drive (downstream of the ponds) and there is some ponding reaching adjacent lots, however, the ditches are functioning sufficiently to convey the stormwater without causing risk to adjacent property during the 100 year event.

There is also backup of water and ponding on the east side of the CP rail track (upstream of the north pond) with ponding on the lot to the east of CP Rail. Based on the extent of ponding shown on the North industrial callout upstream (east) of the NW #2 pond, it is anticipated that ponding will be contained adjacent to the CP track on the west edge of the lot, and existing property is not at risk during the 100 year event until capacity becomes available to convey the ponded stormwater through the culvert and the pond.

The high HGL within the ponds is due to a greater contributing catchment area than what the ponds may have been designed for. The 2017 Vulnerability Study lists the contributing areas for the ponds as 2.57 ha and 3.85 ha for the north and south ponds, respectively. During model development, the area that drains to the ponds was estimated at 12.3 ha for the north pond and 57.6 ha for the south pond. There is other upstream stormwater management within the catchment area to the south pond, including the Leduc Business Park 4 storm pond, resulting in some peak flow mitigation upstream. However, the catchment area contributing to the Solar Cittee ponds is causing water to spill over the top of the berm during large rainfall events into downstream ditches.

City of Leduc Stormwater Master Plan Final Report

4.3.7.1 North Industrial Area Improvements

To provide a measurable reduction in hydraulic grade line in the Solar Cittee ponds, the contributing area to the pond would need to be reduced to what was originally designed. However, based on the modelling completed the downstream ditches are generally sufficient to convey the peak flow rates, and the ponding on adjacent lots is limited to encroachment onto the lots and are not shown at risk of property damage. Therefore, no upgrades have been recommended at this time.

If any upgrades are to be made at these ponds the outlet orifice size could be increased but given the lack of anticipated risk this not recommended at this time. The ponds are currently functioning well during smaller rainfall events.

4.3.8 Corinthia

Existing ponding within Corinthia is shown on the Corinthia callout on Figure 4.4. During the 100 year 4 hour rainfall event, the model identifies many instances of roadway ponding that exceeds 300 mm.

Most locations with roadway ponding occur at low points with catchbasins that capture stormwater and is managed by the minor drainage system, but the minor system does not have capacity to convey the peak flow rates. As shown on Figure 4.1, during the 5 year 4 hour rainfall event, the main trunk from the inlet of the Leduc reservoir almost entirely through Corinthia has peak flows over 120% of the theoretical Manning's capacity, with some pipes exceeding 200%. This is causing ponding levels above the surface during the 5 year event. During the 100 year event, the minor system is surcharging and the major system is being utilized to convey the stormwater with ponding in various locations.

In most cases, during the 100 year event, the ponding is contained to within the road right of way as shown on Figure 4.4. In some cases, particularly in the northwest corner of Corinthia and at the inlet and outlet of the Corinthia Dry Pond (Kinsmen Park Pond), the ponding is putting four homes at risk of property damage.

The Corinthia Dry Pond (Kinsmen Park Pond) is showing the water elevation reaching 732.05 m, which is below the design HWL of 732.4 m indicating that the pond is functioning properly. Therefore, the street ponding is due to the upstream pipe capacity that is insufficient for the 100 year 4 hour rainfall event, and is spilling into the pond due to the lack of a defined overland flow route.

4.3.8.1 Corinthia Improvements

To reduce the ponding within Corinthia, additional underground sewers would be required throughout Corinthia. Small, localized upgrades were considered for the minor system, however, these were ineffective at reducing surface ponding without upsizing nearly all the pipes within Corinthia. Table 4.8 shows the estimated homes at risk of property damage.

Based on the high cost of replacing all the sewers few properties at risk of flooding, storm sewer upgrades are not recommended at this time. During future neighbourhood renewal projects, opportunities for storm sewer replacement with upsizing should be considered.

An additional dry pond is recommended in the northwest corner of Corinthia to provide relief to the minor system. The pond would function as a surge pond during large rainfall events and discharge back to the sewers on Black Gold Drive once capacity in the sewer is restored. The available depth for the pond at this location is approximately 1.0 m deep with an area of 1,200 m², providing storage of 1,200 m³. It is identified as improvements R-1.

Due to limited capacity in Corinthia it is recommended that the City consider this area as higher priority for ongoing maintenance, in order to ensure the function of the dry pond and that CBs are clear of clogs.

4.3.8.2 Corinthia Improvements Assessment

Table 4.8 shows the locations within Corinthia that are exceeding 300 mm of surface ponding on the roadway and identifies the structures estimated to be near the HWL during the 100 year 4 hour rainfall event prior to and post implementation of the stormwater management facility.

Table 4.8: Corinthia Surface Ponding Assessment

Location Description	Max Depth – Ex. Sys (m)			Est. Structure near HWL – R-1-Impr.	Max Depth – C-Impr. (m)	Est. Structure near HWL – C-Impr.
Northwest Corner of Camelot Avenue and Alley Behind	0.88	4	0.79	1	0.79	1
Haida Avenue	0.71	1	0.54	1	0.54	1

During the improved system modelling, the pond filled to a depth of 0.45 m and volume of 1,500 m³. It will mitigate peak flows in the downstream sewer to the reservoir which reduces ponding throughout Cornithia and a reduction in homes at risk of damage by 3 houses. This pond primarily acts as a relief pathway for ponding water trapped against the ridge to the northwest of the alleyway.

4.3.9 50 Street Sewer

As discussed in the above sections, many of the ponding issues observed north of 50 Avenue within Alexandria Park, Willow Park, and Linsford Park areas are caused by the shallow slope and limited capacity of the sewers along 50 Street. Since there is not a defined major drainage system, and there is not sufficient area to install a stormwater management facility, the 50 Street sewer acts as the sole outlet. To reduce the ponding in these areas the hydraulic grade line should be lowered to within the pipe during the 100 year 4 hour event.

4.3.9.1 50 Street Improvements

The proposed upgrade includes an increase in hydraulic capacity from along 50 Street 54 Avenue to 60 Avenue, then west along 60 Avenue across the QEII. As the upgrade proceeds north, additional sewers would be tied into the proposed sewer, thus the peak flow rate would increase at the downstream end. The proposed diameter involves twinning the 1200 mm main. The upgrades were optimized to balance the required hydraulic capacity increase while minimizing impacts to the downstream system. Northwest of the QEII where the mains discharge, there are existing ponding concerns, particularly in winter. The peak flow rate crossing the QEII is estimated to be up to 9.5 m³/s. The twin pipe would have a slope similar to the existing storm sewer, at an average of approximately 0.15%.

4.3.9.2 50 Street Improvements Assessment

By increasing the hydraulic capacity of the 50 Street sewer, the overall hydraulic gradeline in the Downtown and Willow Park neighbourhoods would be reduced. Table 4.9 shows the benefit of the proposed 50 Street upgrade.

Table 4.9: 50 Street Surface Ponding Assessment

Location Description	Max Depth – Ex. Sys (m)	Est. Structure near HWL – Ex. System	Max Depth – With C-1 (m)	Est. Structure near HWL – With C-1
54 Avenue and 50 Street	0.76	7	0.68	4
55 Avenue and 51 Street	0.65	4	0.45	1

4.4 Improvements Summary

Table 4.10 shows a summary of the recommended improvements, and the improvements are shown schematically on Table 4.10. Figures 4.7 through 4.9 show the updated surface ponding with the proposed system improvements.

While all proposed improvements are recommended to reduce surface ponding during the 100 year event, it is recognized that some of the improvements are substantial upgrades that may not be completed immediately, especially if road rehabilitation programs are not planned in the area. Therefore, the upgrades have been categorized into 'Recommended' (R improvements) and 'Long Term' (C improvements).

Table 4.10: Improvements Summary

No.	Community	Upgrade Location & Description	Upgrade Length (m)	Pipe Diameter (mm)	Pipe Depth (m)	Number of MHs	Pond Volume (m³)
R-1	Corinthia Park	Surge Pond + Inlet/Outlet Structure	15	300	3	1	1,500
R-2	South Park	41b Street Local Sewer Upgrade	320	600	3	8	-
R-3	Linsford	Proposed Dry Pond	-	-	-	-	13,000
		Dry Pond Inlet - 47 Avenue south Alley	270	600	3	7	-
		Dry Pond Outlet - 51 Street	100	1050	3	2	-
R-4	65th Ave	Sparrow Drive and 65 Ave Sewer Upgrade & New CP Rail Culvert	190	600	1.5	2	-
R-5	Willow Park	New Main along 54 Street, from 55 Ave to 57 Ave	225	600	3	3	-
R-6	Willow Park	New Main along 52 Street, from 52 Ave to 56 Ave	410	600	3	4	-
R-7	Willow Park	New Main along 51 Street, from 52 Ave to 54 Ave	300	450	3	3	-
R-8	Lakeside Estates	Lakeside Estates Swale – William Bradbury Place to Black Gold Drive	45	-	-	-	-
R-9	Caledonia Park	Caledonia Park Swale - 37 Ave, 41 Street to 42 Street Swale	75	-	-	-	-
C-1	South Park / South Telford	Twin Main along CP Rail from Rollyview Road to Telford Lake	1500	1350	5	18	-
C-2	50th Street / Willow Park	Twin 50 Street Sewer from 54 Avenue to 60 Avenue, and across QEII	1400	1200	2	16	-
C-3	Leduc Estates	Grant MacEwan Drive, Black Gold Drive to Deer Creek & Orifice Upgrade	560	1050	5	9	-

In addition to the above improvements, it is recommended to identify the risk of ponding near the Fire Hall in the City's Emergency Response Plan, including identification of alternate emergency access routes from the rear doors of the Fire Hall should ponding depths on 50 Street restrict access to and from the front doors.

As seen in Table 4.10, there are still lots with modelled HWL near the structure. It is recommended that the City provide recommendations for homeowner flood prevention maintenance on the stormwater management website.

City of Leduc

City of Leduc Stormwater Master Plan Final Report

Analysis of the depth of ponding with respect to the sanitary system was also performed to determine sanitary manhole candidates for sealing. Sanitary manholes found to be in areas that experience ponding during the modelled events were identified as regions subject to inflow and are recommended to either have inflow dishes added or sealed covers. Of the 135,931 sanitary MHs identified in the GIS, 1,555 were in 2D cells that had a water depth of at least 0.05 m during the 100 year 4 hour event for existing conditions. Of those manholes, 451 had a 2D water depth of greater than 0.15 m, 416 had a ponding duration equal to at least 4 hours, and 302 had both high ponding depth and long ponding duration. These sanitary manholes have been flagged in GIS and provided to the City, and it is recommended they be investigated for inflow and infiltration.

CITY OF LEDUC

Project No.: 60683843

SYSTEM IMPROVEMENTS RECOMMENDED UPGRADES

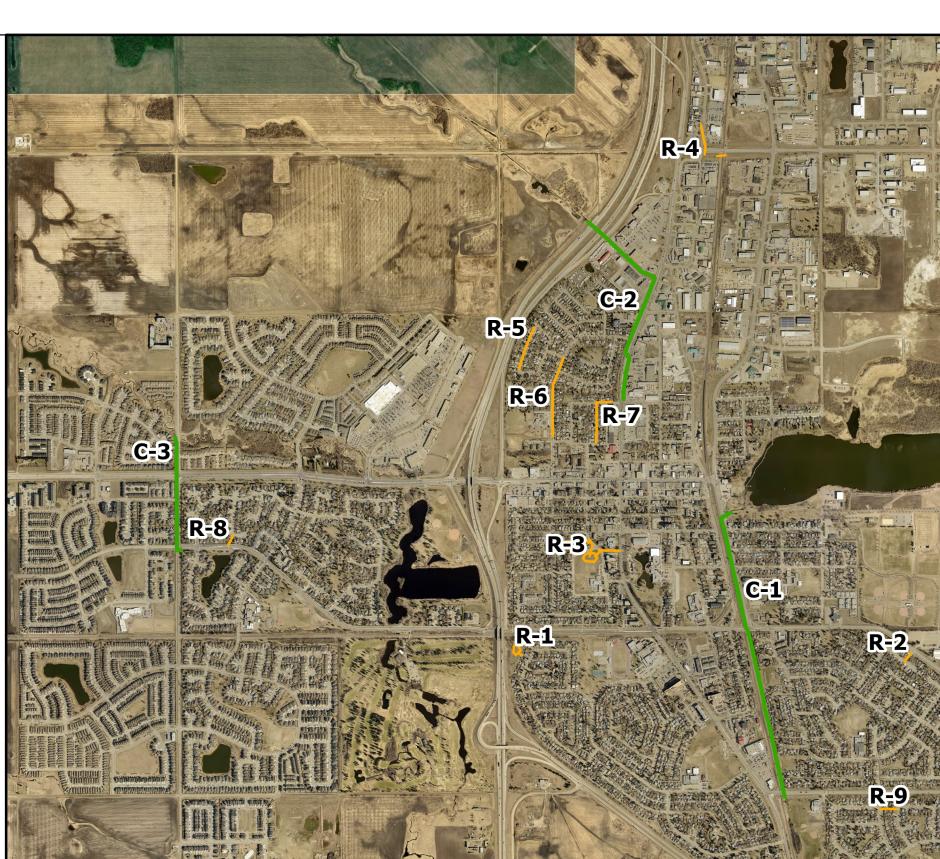
AECOM Figure: 4.5

Legend

<u>Pipes</u> Recommended Upgrade (R improvement) Long Term Upgrade (C improvement)

750 1,000 1,250

Meters



4.5 Improved System Assessment

The proposed system improvements were assessed to determine the overall benefit to the City by comparing the surface ponding area and structures near modelled HWL during governing rainfall events to the existing system. The future improvements were assessed in two stages, with the recommended upgrades (R- Upgrades) and then with the long term upgrades (C-1 through C-3), to help define whether the proposed upgrades provided a sufficient benefit to be implemented.

Table 4.11 and Table 4.12 show the future system assessment comparing the existing system, to with the recommended system upgrades (R- Upgrades), to with the future system improvements (R- plus C- Upgrades). Ponding area during the 100 year event is defined as area with a depth greater than 0.3 m. Stormwater management facilities were excluded from ponding area.

Table 4.11: System Improvements Assessment – Structures near HWL

Neighborhood	Existing System	With Recommended Upgrades	With Future Upgrades	Benefitting Properties
50 Street N Commercial	11	11	5	6
Willow Park	4	3	3	1
Linsford Park	17	7	7	10
Alexandra Park	0	0	0	0
Corinthia	5	2	2	3
South Park	20	13	6	14
East Industrial Park	0	0	0	0
Deer Valley	0	0	0	0
Bridgeport	0	0	0	0
West Haven Estates	0	0	0	0
Lakeside Estates	2	1	1	1
Leduc Estates	2	2	2	0
TOTAL	61	39	26	35

City of Leduc Stormwater Master Plan Final Report

Table 4.12: System Improvements Assessment – Ponding Areas and Depths

		Pondi	ng Area (m²)			Ponding I	Depth (m)	
Neighborhood	Existing System	Recommended Upgrades	Future Upgrades	Reduction	Existing System	Recommended Upgrades	Future Upgrades	Reduction
50 Street N Commercial	39,000	39,000	38,000	1,000	1.14	1.11	1.06	0.08
Willow Park	96,000	91,000	80,000	16,000	0.91	0.90	0.86	0.05
Linsford Park	46,000	41,000	40,000	6,000	0.74	0.69	0.61	0.13
Alexandra Park	73,000	58,000	54,000	19,000	1.24	1.21	1.10	0.14
Corinthia	129,000	126,600	125,000	4,000	0.98	0.98	0.98	0
South Park	93,000	86,000	75,000	18,000	0.98	0.97	0.92	0.06
East Industrial Park	48,000	46,000	46,000	2,000	0.87	0.85	0.84	0.03
Deer Valley	34,000	34,000	32,000	2,000	0.37	0.37	0.37	0
Bridgeport	58,000	58,000	58,000	0	0.67	0.67	0.67	0
West Haven Estates	43,000	43,000	43,000	0	0.37	0.56	0.36	0.01
Lakeside Estates	49,000	49,000	39,000	10,000	0.72	0.72	0.69	0.03
Leduc Estates	20,000	20,000	19,000	1,000	0.67	0.67	0.67	0.01

City of Leduc Stormwater Master Plan Final Report

To determine the benefits of upgrades C-1 (46 Street/CP Rail Upgrade), C-2 (50 Street Upgrade), and C-3 (Grant MacEwan Blvd Upgrade), the neighborhoods were split by their effective contributing catchment area. Specifically, areas north of 50 Avenue and east of the QEII were attributed to C-1, south of 50 Avenue and east of the QEII were attributed to C-2, and areas east of the QEII were attributed C-3. Then the benefitting properties from adjacent future (R) upgrades were subtracted. The benefits of the future upgrades are as follows:

- C-1: Ponding area reduction of 19,000 m², and 7 benefitting structures
- C-2: Ponding area reduction of 21,000 m², and 6 benefitting structures
- C-3: Ponding area reduction of 11,000 m², and 16 benefitting structures

Note that based on the survey completed near the homes adjacent to West Point Lake, the simulated high water level is anticipated to be below the surveyed elevation of the lowest potential point of water entry surveyed at the home. Therefore, the benefit of upgrade C-3 would likely be less than 16 homes.

Table 4.13 shows the future minor drainage system assessment results. Figures 4.6 through 4.9 show the results with future conditions with recommended upgrades. Figures 4.11 through 4.13 show the results with future conditions with both recommended upgrades and considered (future) upgrades. The full set of modelled rainfall events are shown in **Appendix C**.

Table 4.13: Future Minor Drainage System Assessment

	5 Year	5 Year 4 Hour		5 Year 24 Hour		r 4 Hour	100 Year 24 hour		
Description	No.	%	No.	%	No.	%	No.	%	
Pipes Utilization Ratio 0 - 1.2	3907	84.9	4348	94.5	2969	64.5	4078	88.6	
Pipes Utilization Ratio 1.2 – 2	404	8.8	54	1.2	1053	22.9	258	5.6	
Pipes Utilization Ratio >2	290	6.3	199	4.3	579	12.6	265	5.8	
HGL Depth >2.5	1024	24.9	1435	35.0	388	9.5	921	22.4	
HGL Depth 2.5 m – 1 m	1805	44.0	1860	45.3	1059	25.8	1814	44.2	
HGL Depth < 1 m	1070	26.1	727	17.7	1448	35.3	1081	26.3	
HGL Above Ground	206	5.0	83	2.0	1210	29.5	289	7.0	

Table 4.14 shows the existing stormwater management facilities that had highwater levels greater than the design level in the existing development analysis, with the proposed system improvements during the 100 year 24 hour rainfall event.

Table 4.14: Improved System Assessment – Stormwater Management Facility Assessment

			Normal Water		Top of Freeboard	Listed	Future S	ystem –100 Y Event		Future System –100 Year 24 Hour Event		
Basin (-)	SWMF Name (-)	Design Volume (m³)	Water Elevation (m)	Design High Water Elevation (m)	Freeboard Elevation (m)	Contributing Area (ha)	HGL (m)	Discharge Flow (m³/s)	Discharge Rate (L/s/ha)	HGL (m)	Discharge Flow (m³/s)	Discharge Rate (L/s/ha)
	Bridgeport Wet Pond	48,800	717.50	719.50	719.5 (berm overflow)	87.11	719.31	0.47	5.40	718.98	0.39	4.48
1	West Point Lake Wet Pond	23,000	719.40	720.64	720.94	64.82	721.01	0.52	8.02	721.55	0.51	7.87
	Woodbend 1	35,800	711.50	713.50	714.00	65.67	714.26	0.09	1.37	714.88	0.09	1.37
	Woodbend 2	12,750	714.00	716.00	716.50	65.67	715.23	0.24	3.65	715.09	0.22	3.35
2	Leduc Civic Centre Wet Pond	9,910	726.03	726.95	727.25	42.47	727.63	0.38	8.95	727.50	0.34	8.01
	(NEW) Linsford Park Dry Pond	10,200	-	727.88*	728.08	-	727.88	0.07	-	727.55	0.05	-
	Windrose Wet Pond (William Glanville Park)	55,900	721.62	723.19	724.04	57.75	723.16	0.22	3.81	723.33	0.24	4.16
	(NEW) West Corinthia Dry Pond	1,500	-	731.75	731.75 (overflow to existing ditch)	-	731.69	0.13		731.32	0.04	-
6	Harvest Industrial Park 1	17,270	729.00	730.40	731.00	60.07	729.63	0.5	8.32	729.55	0.46	7.66
0	Harvest Industrial Park 2	3,800	729.00	730.38	731.00	75.99	729.64	0.38	5.00	729.57	0.35	4.61
	Leduc BP #1 Wet Pond	28,061	718.50	719.75	720.00	28.02	719.97	0.12	4.28	720.06	0.12	4.28
	Leduc BP #2 Dry Pond	20,000	-	721.40	721.90	32.42	721.76	-	-	721.8	-	-
7	Leduc BP Stage 4A Wet Pond	40,500	723.50	725.00	725.30	72.76	724.8	0.4	5.50	725.19	0.45	6.18
′	Saurabh Park Wet Pond	47,910	714.50	717.50	718.00	45.78	717.79	0.2	4.37	717.97	0.21	4.59
	Solar Cittee Wet Pond North (NW Commercial #2)	1,910	720.92	721.02	722.50	12.7	722.64	_**		723.05	_**	-
	Solar Cittee Wet Pond South (NW Commercial #3)	8,339	718.03	721.83	722.03	57.6	723.32	_**	-	723.38	-**	-

^{*} The design HWL for the proposed Linsford Park Dry Pond is based on the modelled HWL. Note that the HWL will be partially dependent on the improvements (if any) completed in the downstream system, and the design HWL may vary.

^{**} Solar Cittee Wet Ponds (NW Commercial #2 & #3) overflow via ditch and emergency berm under these conditions and as a result a meaningful discharge rate could not be determined

<u>+</u>

Legend

Lot Lines

Flow Capacity Ratio

-- <1.2

1.2 - 2.0

---- >2.0

Node Hydraulic <u>Gradeline</u>

- > 1 m Below Surface
- Within 1 m of Surface
- Flooding

Recommended Upgrade ("R" improvement)



RECOMMENDED UPGRADES ASSESSMENT 5 YEAR 4 HOUR RAINFALL EVENT

AECOM Figure: 4.6

STORMWATER MASTER PLAN
CITY OF LEDUC
Project No.: 60683843

<u>+</u>

Checked:

Surface Ponding Depth

< 0.15 m 0.15 - 0.30 m

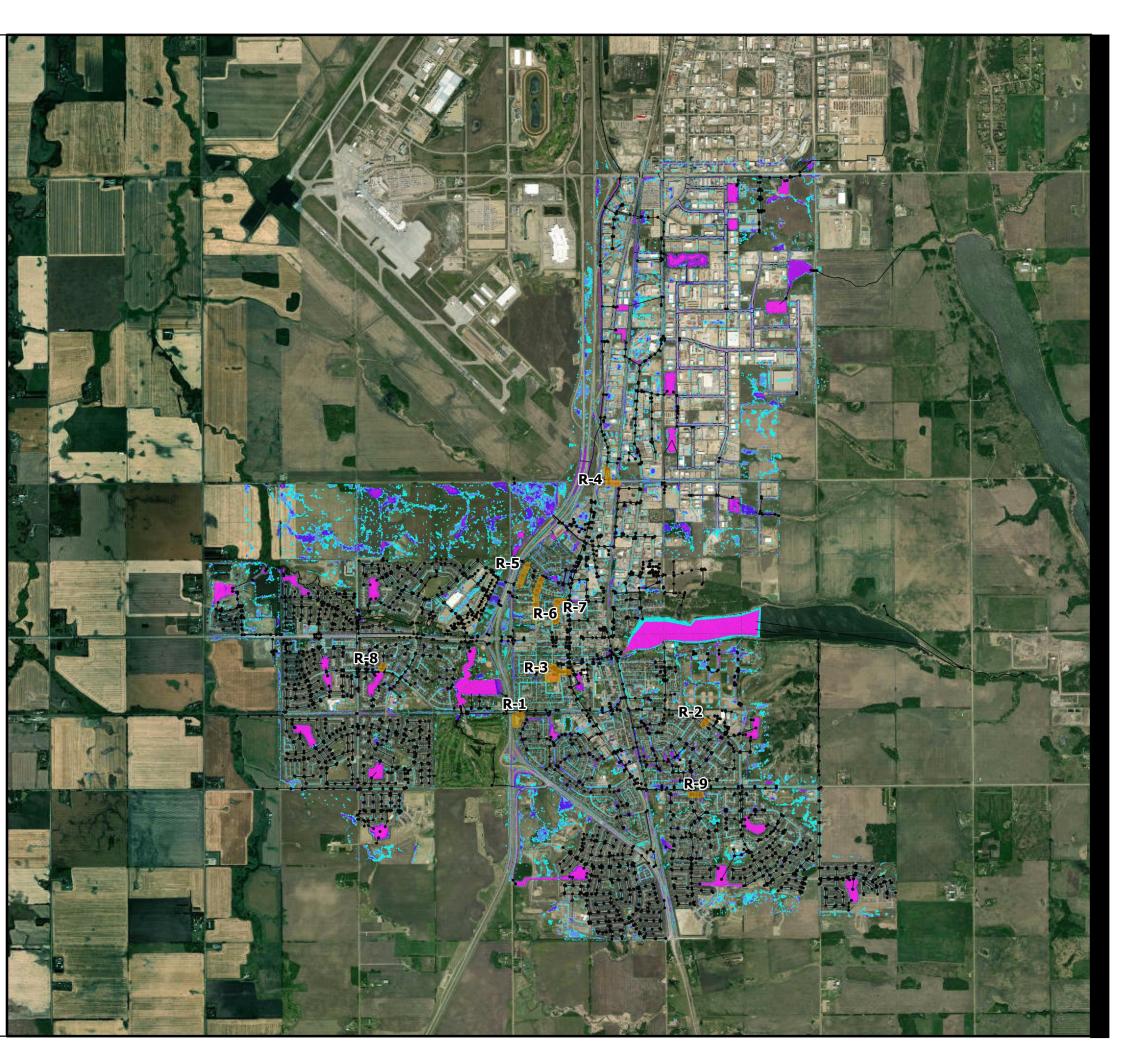
Lot Lines Nodes

Legend

0.31 - 0.50 m 0.51 - 1.00 m

> 1.00 m

Recommended Upgrade ("R" improvement)





RECOMMENDED UPGRADES ASSESSMENT 100 YEAR 4 HOUR RAINFALL EVENT (FIGURE 1 OF 3)

Project No.: 60683843 CITY OF LEDUC

STORMWATER MASTER PLAN

CITY OF LEDUC

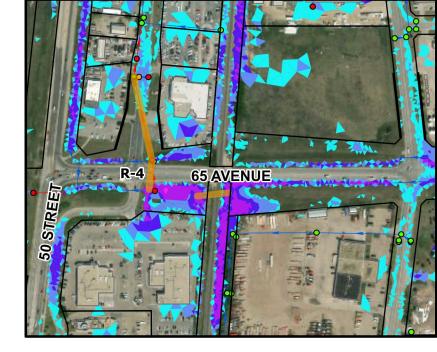
Project No.: 60683843

RECOMMENDED UPGRADES ASSESSMENT 100 YEAR 4 HOUR RAINFALL EVENT (FIGURE 2 OF 3)

<u>Legend</u> Lot Lines Surface Ponding Depth < 0.15 m Node Hydraulic Gradeline > 1 m Below Surface 0.15 - 0.30 m Within 1 m of Surface 0.30 - 0.50 m 0.50 - 1.00 m Flooding Flow Capacity Ratio >1.00 m **→** <1.2 Benefit Analysis ---- 1.2 - 2.0 Modelled HWL Near Home >2.0 HWL Reduced by "R" Improvement Recommended Upgrades ("R" Imp)

Long Term Upgrade ("C" Imp)

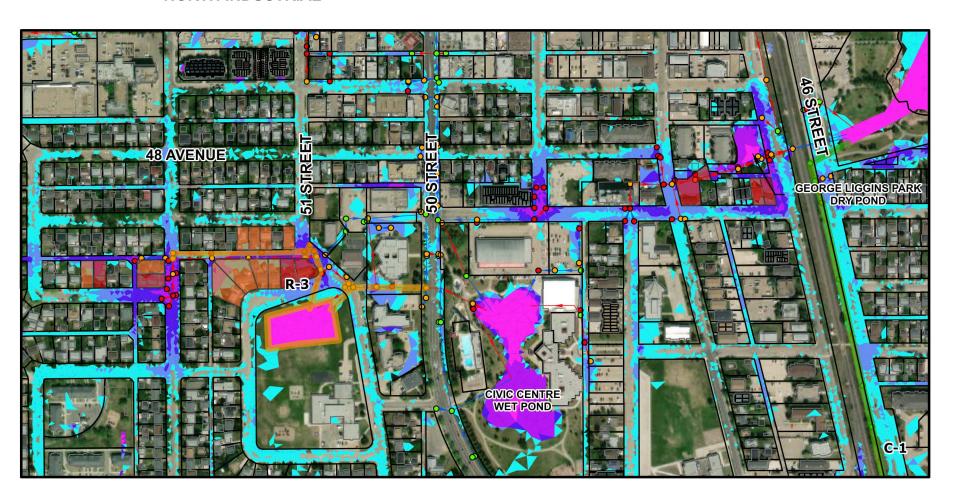




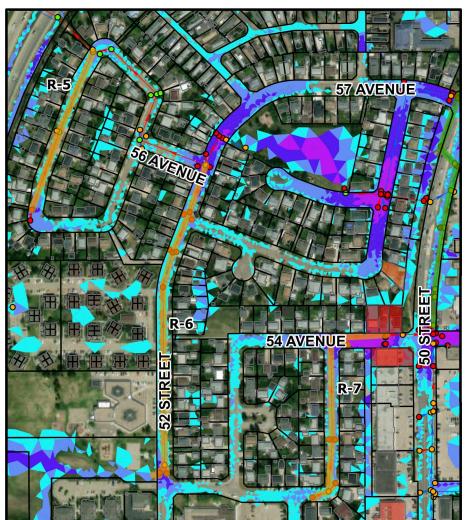
65TH AVENUE



NORTH INDUSTRIAL

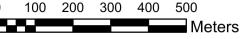


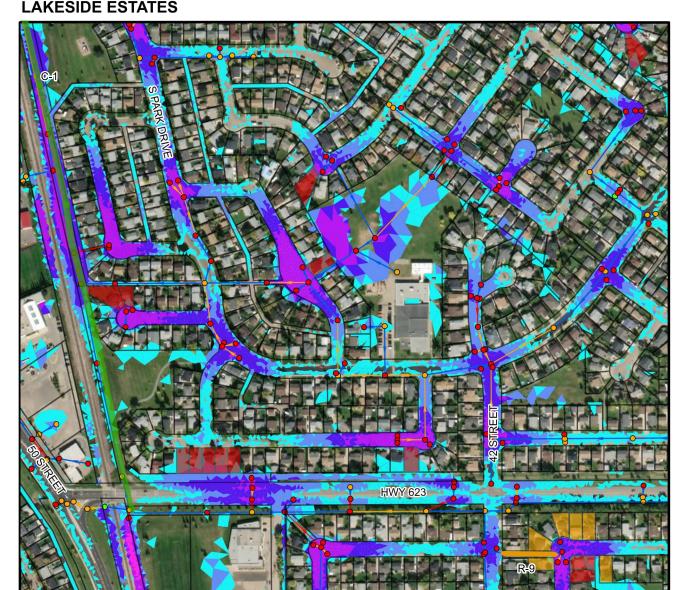
DOWNTOWN



WILLOW PARK

100 200 300 400 500 Meters





SOUTH PARK

CORINTHIA

300 400 500 200 Meters

CITY OF LEDUC

Project No.: 60683843

RECOMMENDED UPGRADES ASSESSMENT 100 YEAR 4 HOUR RAINFALL EVENT (FIGURE 3 OF 3)

LEDUC RESERVOIR

 \pm

AECOM Figure: 4.10

<u>Legend</u>

Lot Lines

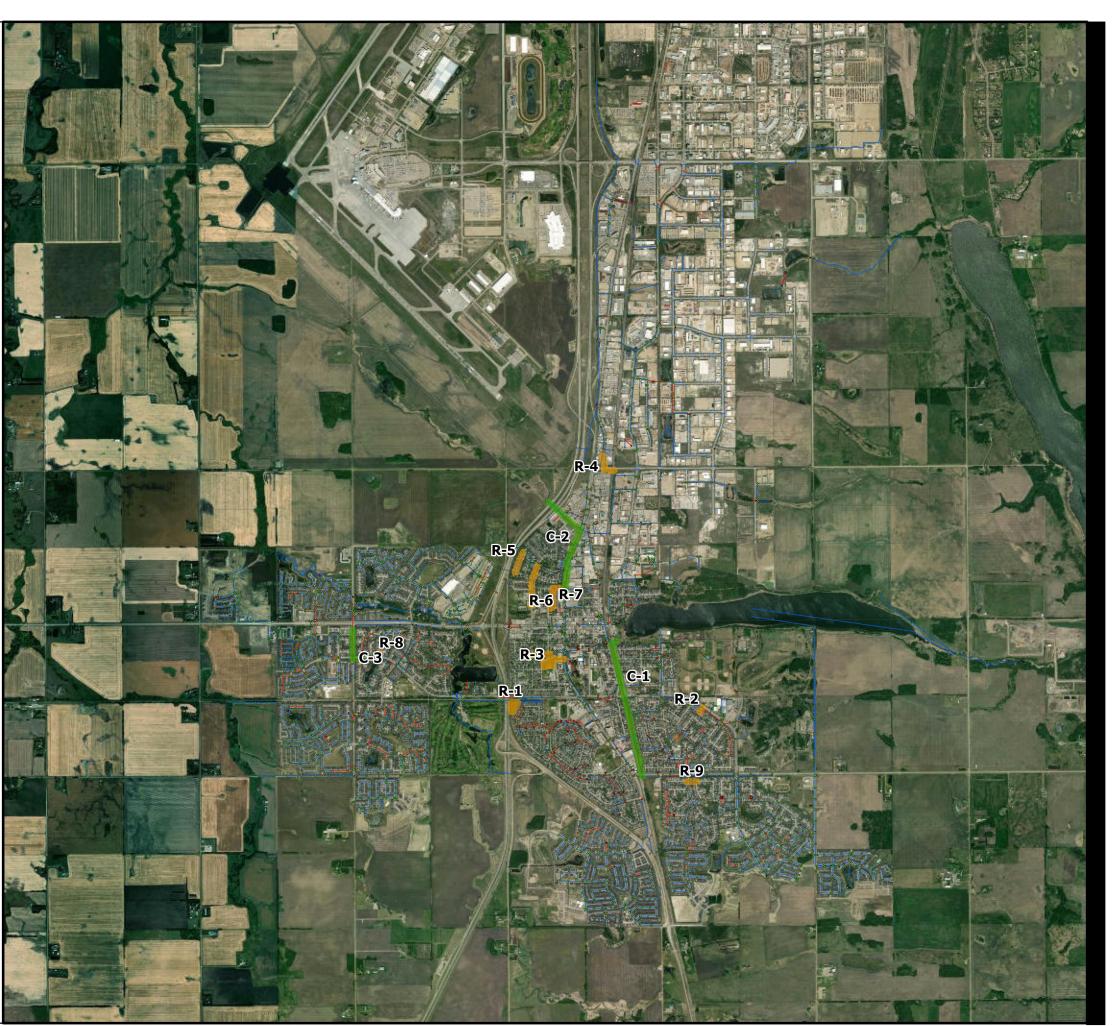
Flow Capacity Ratio

<1.2

1.2 - 2.0 >2.0

Node Hydraulic Gradeline

- > 1 m Below Surface
- Within 1 m of Surface
- Flooding
- Recommended Upgrade ("R" Improvement)
 - Long Term Upgrade ("C" Improvement)



LONG TERM UPGRADES ASSESSMENT 5 YEAR 4 HOUR RAINFALL EVENT

STORMWATER MASTER PLAN
CITY OF LEDUC
Project No.: 60683843

Legend

Lot Lines

Nodes Pipes

Surface Ponding Depth

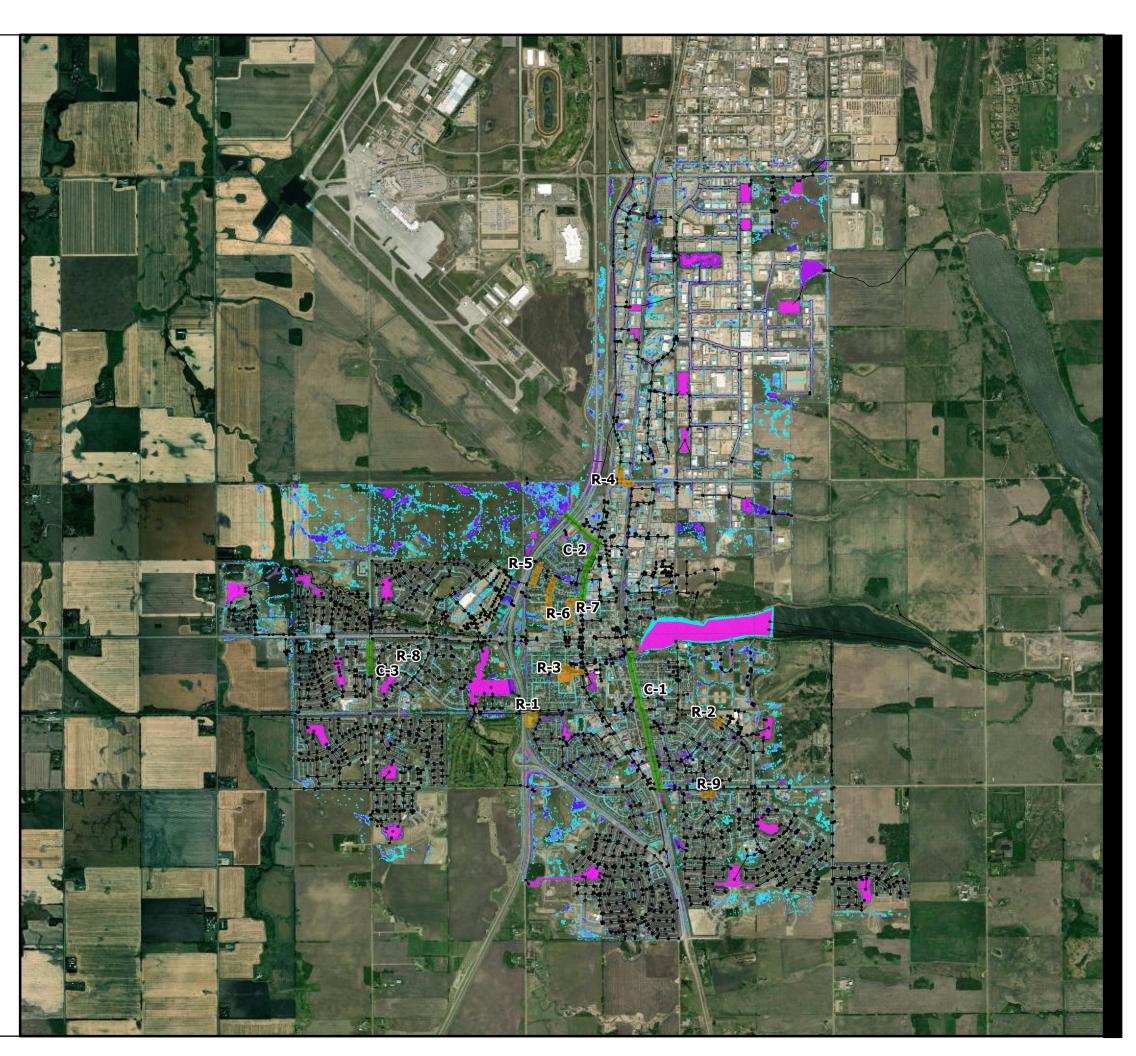
< 0.15 m 0.15 - 0.30 m

0.31 - 0.50 m 0.51 - 1.00 m

> 1.00 m

Recommended Upgrade ("R" Improvement)

Long Term Upgrade ("C" Improvement)





CITY OF LEDUC Project No.: 60683843

AECOM Figure: 4.11

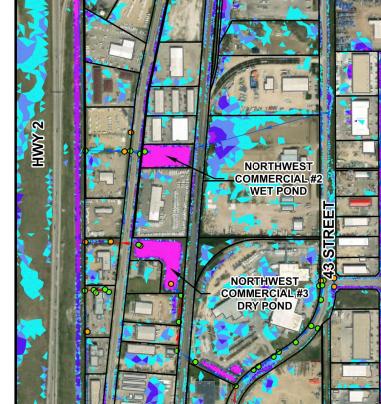
CITY OF LEDUC

Project No.: 60683843

LONG TERM UPGRADES ASSESSMENT 100 YEAR 4 HOUR RAINFALL EVENT (FIGURE 2 OF 3)

AECOM

<u>Legend</u> Lot Lines Surface Ponding Depth < 0.15 m Node Hydraulic Gradeline > 1 m Below Surface 0.15 - 0.30 m Within 1 m of Surface 0.30 - 0.50 m Flooding 0.50 - 1.00 m Flow Capacity Ratio >1.00 m **→** <1.2 Benefit Analysis ---- 1.2 - 2.0 Modelled HWL Near Home >2.0 HWL Reduced by "R" Improvement Recommended Upgrades ("R" Imp) HWL Reduced by "C" Improvement Long Term Upgrade ("C" Imp)

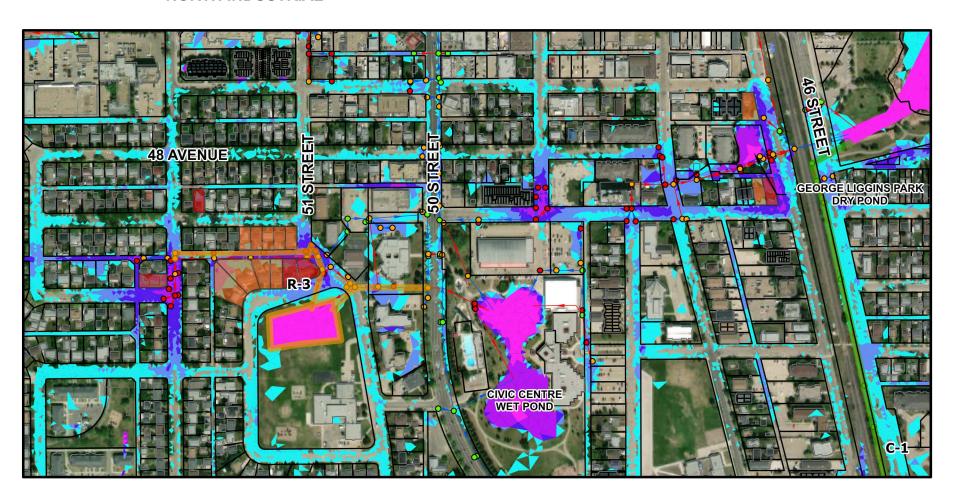


R-4 65 AVENUE

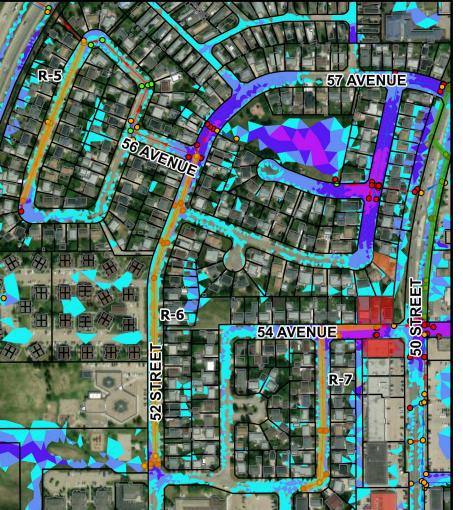
65TH AVENUE



NORTH INDUSTRIAL

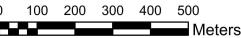


DOWNTOWN



WILLOW PARK

100 200 300 400 500 Meters





LONG TERM UPGRADES ASSESSMENT 100 YEAR 4 HOUR RAINFALL EVENT (FIGURE 3 OF 3)

Project No.: 60683843 CITY OF LEDUC

4.6 Future System Assessment

The Future stormwater management system was modelled by adding future ASP areas in their fully developed condition, and determining their impact on the stormwater system. Since overland flow paths are likely to change from the existing condition, future ASP areas were added to the model utilizing 1D catchment areas draining to the minor system, which were then routed to the proposed SWMF, and then discharged from the modelled SWMF at the calculated allowable discharge rate.

Figure 4.14 shows the Future stormwater management system, with the assessment of the system displayed in Figures 4.15 through 4.18.

Similar to the existing development assessment, the minor system, the stormwater management facilities, and the surface ponding was assessed to determine the stormwater management system performance during the 5 year and 100 year, 4 and 24 hour rainfall events. Most of the future development occurs on the fringe of existing development, and the future SWMFs do not drain through the existing system. Therefore, the future SWMF assessment was geared to determine the SWMF and control structure sizing requirements. Future stormwater pipes were included in the model adequately sized to convey the stormwater to the proposed SWMF. Stormwater collection mains will be designed by developers, and thus were not included in this study.

Table 4.15 shows the future minor drainage system assessment results. Figure 4.15 shows the results of minor system assessment during the 5 year 4 hour rainfall event. The remaining rainfall events are shown in **Appendix C**.

Table 4.15: Future	Minor Drainage	System Assessment
--------------------	-----------------------	--------------------------

	5 Year	5 Year 4 Hour		5 Year 24 Hour		r 4 Hour	100 Year 24 hour		
Description	No.	%	No.	%	No.	%	No.	%	
Pipes Utilization Ratio 0 - 1.2	3890	87.0	4305	94.4	2948	64.6	4040	88.6	
Pipes Utilization Ratio 1.2 – 2	299	6.7	57	1.2	1043	22.9	259	5.7	
Pipes Utilization Ratio >2	283	6.3	200	4.4	571	12.5	263	5.8	
HGL Depth >2.5	1024	24.1	1431	35.1	382	9.4	916	22.5	
HGL Depth 2.5 m – 1 m	1818	44.6	1835	45.1	1057	26	1778	43.7	
HGL Depth < 1 m	1030	25.3	720	17.7	1394	34.2	1062	26.1	
HGL Above Ground	200	4.9	86	2.1	1238	30.4	316	7.8	

As expected, the minor system shows greater utilization during the more intense 4 hour events. The results are very similar to the existing system results, with both pipe utilization and flooding numbers being slightly higher than the existing system. The slight increase in strain on the system is primarily from the buildout of partially completed developments, such as Southfork, Tribute, Robinson, and Woodbend. In general, the anticipated increase in runoff is expected to be mitigated by the SWMFs that are already in place in these neighbourhoods, which is why the calculated increase is very low, on the order of 10 additional nodes with the HGL above ground compared to the existing system.

Table 4.16 shows the SWMFs in the Future development scenario and the estimated sizing requirements. The storage requirement was governed by the 100 year 24 hour rainfall event for these pond designs. Ponds that are existing are showing the additional future calculated runoff volume only, as the developed portions were included as part of the existing 2D modelled surface.

Table 4.16: Estimated Future ASP Runoff Volume & SWMF Sizing

		Percent Impervious	Runoff	Total Required Storage Volume	Discharge
ASP Designation	Area (ha)	(%)	Volume (m³)	(m³)	Rate (L/s)
Blackstone (Future)	45	58.4%	38,200	32,300	Existing Pond
Brightwell	66	59.6%	53,300	44,700	198
Banks of Crystal Creek	130	51.6%	100,300	83,400	390
West Area (South and Central)	96	53.7%	73,200	60,800	288
West Area (North)	48	69.5%	42,900	36,700	144
65th Avenue Area (West)	65	62.9%	56,900	48,500	195
65th Avenue Area (Central and East)	132	69.0%	119,700	102,600	396
North Industrial	1	-	-	-	Existing Ponds
Sawridge Business Park	24	65.9%	21,100	18,100	72
Harvest Industrial Park	46	63.7%	39,400	33,400	138
East Telford Lake (North)	286	65.0%	245,100	208,000	858
East Telford Lake (South)	215	63.0%	180,000	152,200	645
Eaton and Emery	66	74.2%	63,100	54,600	198
Robinson (Future)	32	59.5%	27,300	23,200	Existing Pond
SE Leduc (Future)	67	60.1%	53,700	45,100	Existing Pond
Southfork (Future)	29	58.0%	23,800	20,100	Existing Pond
Saurabh Park (Future)	46	63.5%	38,300	-	Existing Pond
Leduc Recreation Centre (Future)	62	51.9%	42,200	-	Existing Pond

Figures 4.16 through 4.18 show the results of the major system assessment during the 100 year 4 hour rainfall event. **Appendix C** shows all 2D modelling results including the 5 year and 100 year, 4 and 24 hour rainfall events.

FUTURE DEVELOPMENT STORMWATER MANAGEMENT SYSTEM

AECOM Figure: 4.14





2,500

Meters

1,000 1,500 2,000

1,000 1,500 2,000 2,500

Legend

Lot Lines

Flow Capacity Ratio

--- < 1.2

1.2 - 2.0

Node Hydraulic Gradeline

- > 1 m Below Surface
- Within 1 m of Surface
- Above Surface



FUTURE MINOR SYSTEM RESULTS 5 YEAR 4 HOUR RAINFALL EVENT

AECOM Figure: 4.15

Project No.: 60683843 CITY OF LEDUC

AECOM Figure: 4.16

FUTURE MAJOR SYSTEM RESULTS 100 YEAR 4 HOUR RAINFALL EVENT (FIGURE 1 OF 3)

Project No.: 60683843 CITY OF LEDUC

100 200 300 400 500

Meters

Legend

____ Lot Lines

Node Hyraulic Gradeline

O > 1 m Below Surface O Within 1 m of Surface

Flooding

Flow Capacity Ratio

--- < 1.2 **1.2 - 2.0**

> 2.0

Surface Ponding Depth

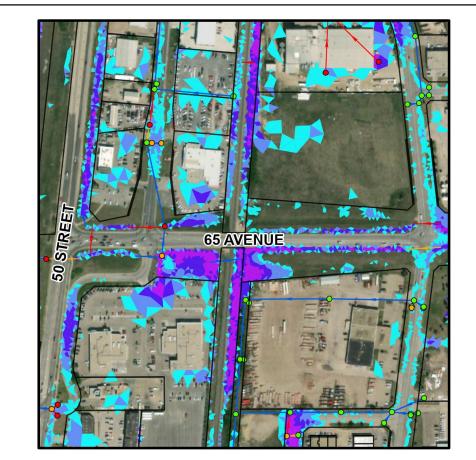
< 0.15 m 0.15 - 0.30 m

0.31 - 0.50 m 0.51 - 1.00 m

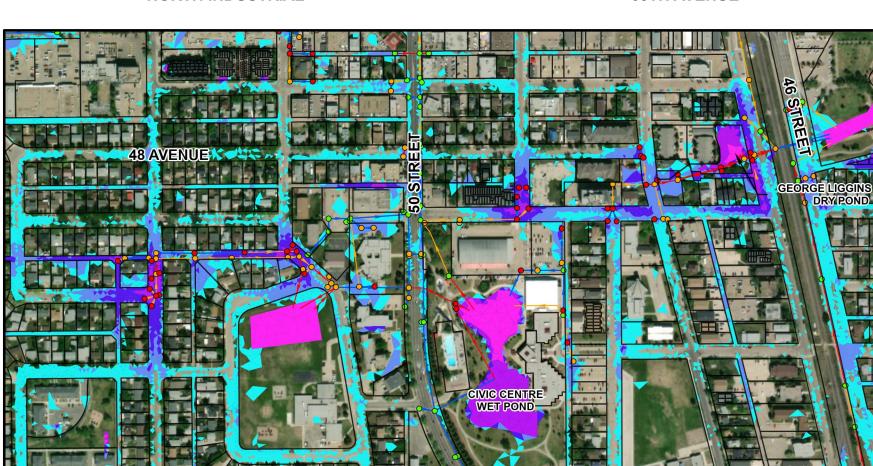
> 1.00 m



NORTH INDUSTRIAL



65TH AVENUE





WILLOW PARK



FUTURE MAJOR SYSTEM RESULTS 100 YEAR 4 HOUR RAINFALL EVENT (FIGURE 2 OF 3)

AECOM

Project No.: 60683843

CITY OF LEDUC

Legend

Node Hyraulic Gradeline O > 1 m Below Surface Within 1 m of Surface

Flow Capacity Ratio

Surface Ponding Depth

____ Lot Lines

Flooding

--- < 1.2 1.2 - 2.0

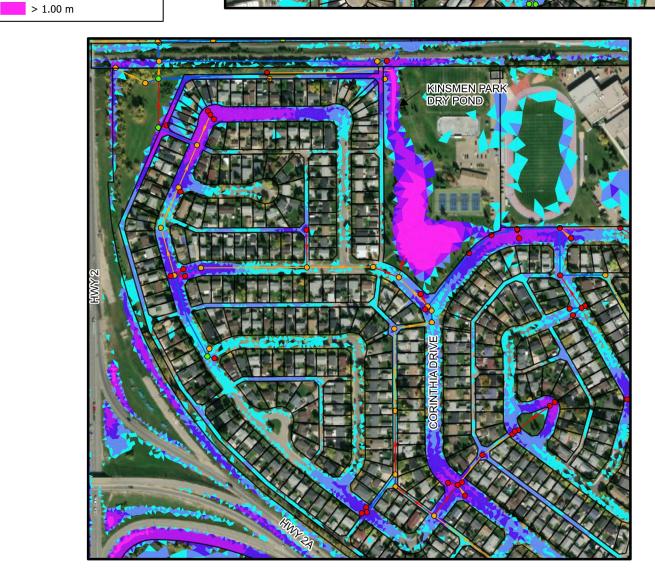
> 2.0

< 0.15 m 0.15 - 0.30 m 0.31 - 0.50 m 0.51 - 1.00 m

LEDUC RESERVOIR



LAKESIDE ESTATES



CORINTHIA



500 Meters

SOUTH PARK

4.7 IDF Analysis

The City of Leduc Design and Construction Standards currently reference rainfall Intensity Duration Frequency (IDF) data from the Edmonton Municipal Airport (Blatchford), with data from 1914-1995. This data was utilized in the City of Edmonton Design and Construction Standards, Volume 3 Drainage dated May 2012.

Over the past decade, the City of Edmonton (and EPCOR) have updated their design standards and design rainfall event. Different municipalities in the surrounding region also reference a variety of different standards. In addition, climate change will impact the frequency and severity of large rainfall events.

The following sections summarize the impact of updating the current City of Leduc design rainfall standard, including a sensitivity analysis when compared to the current EPCOR standards, the impact of climate change, as well as a summary of the discussions with the Edmonton Metropolitan Region Board (EMRB).

4.7.1 EPCOR/City of Leduc IDF Sensitivity

EPCOR has revisited their IDF curve three times since the 2012 IDF curve which is currently referenced in the City of Leduc Standards. In general, the 2015 IDF curve was saw the largest increase in both intensity and total depth of rainfall, and since then the values have decreased to near, but slightly higher, than the original 2012 IDF curve. Table 4.17 and Table 4.18 show a summary of the total depth of rainfall and the peak intensity of the IDF curves, respectively.

Table 4.17: EPCOR IDF Total Depth Comparison

	5 yr - 4 hr Depth (mm)	100 yr - 4 hr Depth (mm)	5 yr - 24 hr Depth (mm)	100 yr - 24 hr Depth (mm)
CoE 2012 (Leduc Standard)	37.1	68.8	69.4	127.0
EPCOR 2015	33.6	90.0	52.8	168.0
EPCOR 2018	34.8	84.4	57.6	139.2
EPCOR 2022	35.8	80.4	56.2	127.7

Table 4.18: EPCOR IDF Intensity Comparison

	5 yr - 4 hr Peak Intensity (mm/h)	100 y - 4 hr Intensity (mm/h)	5 yr - 24 hr Intensity (mm/h)	100 y - 24 hr Intensity (mm/h)
CoE 2012 (Leduc Standard)	68.1	129.0	10.2	18.6
EPCOR 2015	74.1	179.1	7.9	24.8
EPCOR 2018	65.2	143.6	8.4	20.4
EPCOR 2022	67.9	137.8	8.2	18.8

In the 2022 EPCOR IDF, the total depth of the 5 year events has decreased compared to the current City of Leduc Standard, and the total depth of the 100 year events has increased, however the 100 year 24 hour event is currently within 1 mm of the current standard.

As seen in Table 4.18, the peak intensity in the 2015 IDF increased drastically, and has mostly returned to the values currently used by the City of Leduc with the exception of the 100 year 4 hour rainfall event, which is 8.8 mm/hour (approximately 7%) greater than the current City standard.

Images 4.1 through 4.4 show a comparison of the 5 and 100 year Chicago and Huff Distribution rainfall events for the various IDF events.

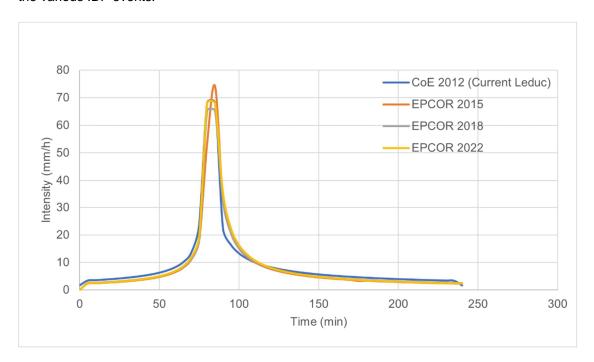


Image 4.1. 5 Year 4 Hour IDF Comparison

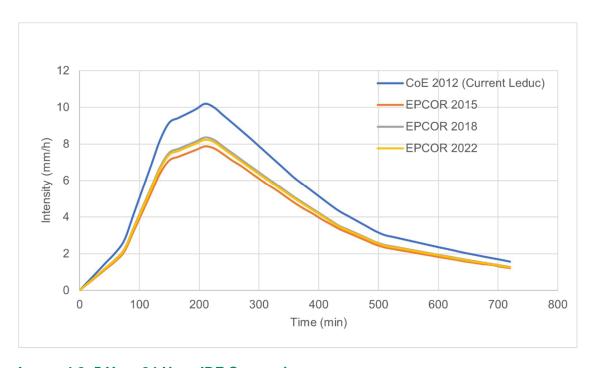


Image 4.2. 5 Year 24 Hour IDF Comparison

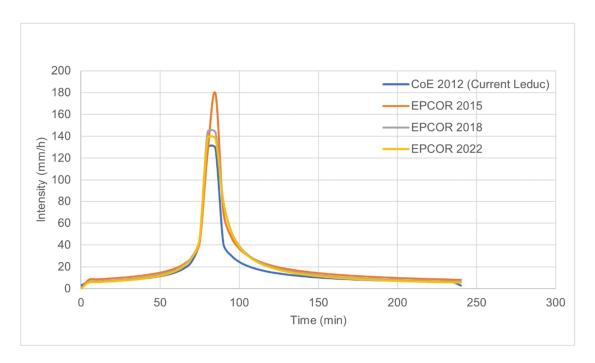


Image 4.3. 100 Year 4 Hour IDF Comparison

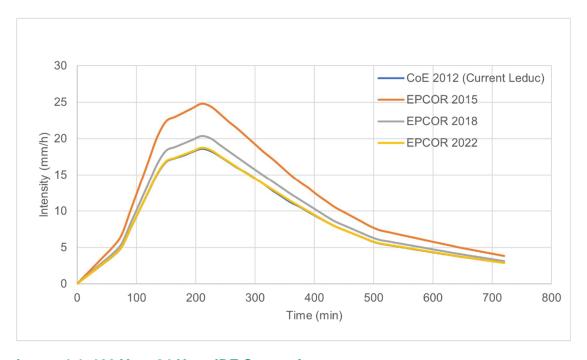


Image 4.4. 100 Year 24 Hour IDF Comparison

As seen in Images 4.1 through 4.4, the rainfall distribution of the events are all quite similar, with the 2015 IDF being higher than the rest of the rainfall distributions. Notably the current City of Leduc 24 hour event (2012 CoE IDF) is higher than all other rainfall events. However, this would not make a considerable impact to system upgrades as the 24 hour event rarely governs improvements for the minor system compared to the 4 hour event.

4.7.1.1 IDF Results Discussion

Table 4.19 shows a comparison of the performance of the minor drainage system during the 100 year 4 hour rainfall event. The increase in intensity in the 100 year 4 hour EPCOR 2022 IDF over the 100 year 4 hour Leduc Standards IDF causes a small increase in ponding. The number of pipes that are within a utilization ratio of less than 1.2 decreases by 2.3% (108 pipes), and the number of pipes above a utilization ratio of 2 increases by 1% (48 pipes). The number of manholes that the HGL is at a depth within the pipe or greater than 2.5 m below ground subsequently increases, and the number of manholes showing flooding (HGL above ground) increases by 5.5% (223 manholes).

Table 4.20 shows the results comparisons for the SWMFs within Leduc comparing the 100 year 4 Chicago distribution rainfall events.

Figures D1 through D4 in **Appendix D** show the existing system results during the 100 year, 4 and 24 hour rainfall events, respectively, comparing the current City of Leduc standards rainfall events to the 2022 EPCOR IDF. As seen on the figures, in general areas that flood when utilizing Leduc standard rainfall events also flood during the EPCOR 2022 rainfall with minor differences in ponding depths and volumes between the events.

For the purposes of this study, it is not anticipated that updating the IDF would result in major changes to existing system deficiencies or the proposed upgrades, with the exception of the potential for an increased pipe size during the 100 year 4 hour event for some areas. As further discussed in Section 4.8, one of the goals of the Edmonton Metropolitan Board (EMRB) is to unify the IDF curve utilized by the municipalities surrounded by Edmonton. Due to the frequency of recent changes in EPCORs IDF data, it is recommended to continue to monitor EPCORs IDF curve for significant changes, and reassess whether updating the City of Leduc IDF is required. Development plans should continue to utilize the current City of Leduc IDF data.

To provide a conservative estimate of pipe and pond sizing requirements for planning purposes, the 2022 EPCOR IDF curve was utilized for the remainder of this assessment. The model was also run with the current City of Leduc IDF Curve, and it was found that it did not change the results of the assessment discussed in the previous sections.

Table 4.19: Existing Minor Drainage System IDF Comparison – 100 Year 4 Hour Rainfall Event

	EPCOR	2022 IDF	Leduc	Standards IDF
Description	No.	%	No.	%
Pipes Utilization Ratio 0 – 1.2	3206	70.3%	3314	72.6%
Pipes Utilization Ratio 1.2 – 2	882	19.3%	822	18.0%
Pipes Utilization Ratio >2	476	10.4%	428	9.4%
HGL Depth >2.5	383	9.5%	459	11.3%
HGL Depth 2.5 m - 1 m	1249	30.9%	1392	34.4%
HGL Depth < 1 m	1175	29.0%	1181	29.2%
HGL Above Ground	1238	30.6%	1015	25.1%

Table 4.20: Impact of IDF Selection – 100 Year 24 Hour Events – SWMFs

			Normal		Top of	Listed	EPCOR 20	022 IDF –100 \ Event	Year 24 Hour	Current	Current Leduc IDF –100 Year 24 Hour Event		
Basin (-)	SWMF Name (-)	Design Volume (m³)	Water Elevation (m)	Design High Water Elevation (m)	Freeboard Elevation (m)	Contributing Area (ha)	HGL (m)	Discharge Flow (m³/s)	Discharge Rate (L/s/ha)	HGL (m)	Discharge Flow (m³/s)	Discharge Rate (L/s/ha)	
	Bridgeport Wet Pond	48,800	717.50	719.50	719.5 (berm overflow)	87.11	719.58	0.516	5.92	719.48	0.52	5.97	
	Deer Valley Wet Pond	28,386	714.20	715.70	716.30	35.79	715.7	0.04	1.12	715.61	0.04	1.12	
	West Haven Estates Wet Pond (Alan Griffiths Park)	37,570	717.00	718.96	719.50	32.74	718.9	0.22	6.72	718.82	0.21	6.41	
1	West Haven Park Wet Pond (Audrey Griffiths Park)	36,485	717.00	719.00	719.50	25.78	718.91	0.12	4.65	718.81	0.12	4.65	
	West Point Lake Wet Pond	23,000	719.40	720.64	720.94	64.82	721.55	0.21	3.24	721.55	0.21	3.24	
	Woodbend 1	35,800	711.50	713.50	714.00	65.67	713.61	0.09	1.37	713.60	0.09	1.37	
	Woodbend 2	12,750	714.00	716.00	716.50	65.67	714.97	0.18	2.74	715.15	0.25	3.81	
2	Leduc Civic Centre Wet Pond	9,910	726.03	726.95	727.25	42.47	727.84	0.38	8.95	727.72	0.35	8.24	
3	Corinthia Dry Pond (Kinsmen Park)	37,578	-	732.43	732.73	115.7	731.82	0.37	3.20	731.62	0.89	7.69	
3	Southfork Wet Pond (McHardy Park)	107,000	732.10	734.50	734.70	122.53	734.4	0.13	1.06	734.42	0.13	1.06	
	Blackstone	55,730	-	724.40	725.00	65.97	723.44	0.12	1.82	723.23	0.12	1.82	
4	Suntree Wet Pond (J.T. Atkinson Park)	36,600	716.50	718.25	718.75	58.2	718.25	0.02	0.34	718.18	0.04	0.69	
	Windrose Wet Pond (William Glanville Park)	55,900	721.62	723.19	724.04	57.75	723.44	0.24	4.16	723.30	0.19	3.29	
	Coady Lake Wet Pond	40,628	736.09	737.62	737.92	53.1	737.39	0.48	9.04	737.22	0.36	6.78	
	Leduc Recreation Centre Wet Pond	21,449	732.87	733.78	734.08	18.15	733.41	0.09	4.96	733.32	0.09	4.96	
5	Lions Park	13,740	-	729.70	730.00	32.63	729.64	0.48	14.71	729.17	0.30	9.19	
5	Robinson Wet Pond (Ruddy Park)	54,891	742.00	744.00	744.60	57.4	743.16	0.04	0.70	743.09	0.04	0.70	
	Tribute Dry Pond (Elks Community Park)	17,100	-	738.20	740.00	11.23	737.53	0	0.00	737.51	0	0	
	Tribute Wet Pond (Robert Dittrich Park)	37,669	736.60	739.50	740.00	169.11	738.34	0.29	1.71	73832	0.29	1.71	
	Harvest Industrial Park 1	17,270	729.00	730.40	731.00	60.07	730.46	0.14	2.33	729.50	0.13	2.16	
	Harvest Industrial Park 2	3,800	729.00	730.38	731.00	75.99	730.47	0.04	0.53	729.57	0.04	0.53	
6	Leduc BP 7 Wet Pond (Outlook Park)	122,319	719.00	723.00	723.50	100.54	721.86	0.2	1.99	722.37	0.20	1.99	
	Leduc BP Stage 3 Wet Pond	40,000	722.10	722.90	723.80	52.95	723.29	0.10	1.89	723.14	0.10	1.89	
	Telford Industrial Park Wet Pond	32,750	729.15	731.10	731.45	42.27	730.87	0.21	4.97	730.54	0.16	3.79	
	Leduc BP #1 Wet Pond	28,061	718.50	719.75	720.00	28.02	720.13	0.12	4.28	720.07	0.12	4.28	
	Leduc BP #2 Dry Pond	20,000	-	721.40	721.90	32.42	721.84	-	-	721.50	-	-	
	Leduc BP Stage 4A Wet Pond	40,500	723.50	725.00	725.30	72.76	725.31	0.49	6.73	725.17	0.37	5.09	
_	Leduc BP Stage 5A Wet Pond	40,833	725.00	726.30	726.55	28.75	725.57	0.31	10.78	725.58	0.32	11.13	
7	Saurabh Park Wet Pond	47,910	714.50	717.50	718.00	45.78	718.08	0.22	4.81	717.97	0.22	4.81	
	NW Commercial #1	16,900	-	723.00	723.35	22.5	722.32	0.06	2.67	722.16	0.06	2.67	
	Solar Cittee Wet Pond North (NW Commercial #2)	1,910	720.92	721.02	722.50	12.7	723.14	-	-	723.15	-	-	
	Solar Cittee Wet Pond South (NW Commercial #3)	8,339	718.03	721.83	722.03	57.6	723.47	-	-	723.44	-	-	

4.7.2 Impact of Climate Change

The impact of climate change, in general, projects greater variability in extreme weather events, which includes both periods of drought, as well as more frequent larger and more intense rainfall events. Therefore, it is imperative to understand the potential impact to storm infrastructure that can result from larger rainfall event, and make financially feasible decisions to mitigate the potential for increased flood risk.

For informational purposes, **Appendix E** provides an assessment of the potential impact of climate change. For the purposes of this stormwater management plan, it is recommended to continue to work collaboratively with the Edmonton Metropolitan Region Board (EMRB) and continue to monitor changes in the intensity and frequency of extreme rainfall events. Discussion of the current actions and recommendations of the EMRB is provided in Section 4.8.

4.8 EMRB Comparison

One of the goals of the Edmonton Metropolitan Region Board (EMRB) is to plan and build out services in the region in a collaborative, efficient and cost-effective manner. The EMRB has initiated a Stormwater Collaborative group, in which the City of Leduc participates.

The work of the Stormwater Collaborative was ongoing, concurrently to the development of the City of Leduc Stormwater Master Plan. The data and processes being reviewed by the EMRB was compared to the data and processes undertaken in the development of the Stormwater Master Plan. Some of the key comparisons are provided below.

4.8.1 Rainfall Data

One of the key design criteria in stormwater design is the rainfall data used in the assessment. This includes rainfall depths, selection of return periods, and intensity-duration-frequency (IDF) data. The IDF data for the City of Leduc Stormwater Master Plan is based on the detailed in Section 4.5.

The different IDF data in use within the Region is summarized in Table 4.21 through Table 4.23. In general, the IDF data used across municipalities is comparable.

Table 4.21: Region IDF Data – Storage System Design

Storage System Design	Municipalities that Use it	Primary Use	Total Rainfall Depth (mm)	Peak Intensity (mm/hr)
1:100 Year 24 hour design events based on 1914- 1995 Edmonton Municipal Airport	Leduc	Storm Ponds	123.5	18.6
1:100 Year 24 hour - EPCOR 2020 gauge network	EPCOR	Storm Ponds	127.3	18.8
1:100 Year 24 hour - EPCOR 2015 gauge network	St. Albert	Storm Ponds	138.0	20.4
Actual July 10-11, 1978 Edmonton Rainfall Event	Leduc, EPCOR	Storm Ponds	133.5	105.6
Actual July 2 & 3, 2004 Rainfall event	EPCOR	Storm Ponds	135.8	158.4
Actual July 14, 1937 rainfall event	EPCOR	Storm Ponds	154.8	18.5
Actual July 12, 2012 Rainfall Event	EPCOR	Storm Ponds	49.7	110.4

Table 4.22: Region IDF Data – Major Conveyance System Design

Major Conveyance Design	Municipalities that Use it	Primary Use	Total Rainfall Depth (mm)	Peak Intensity (mm/hr)
1:100 Year 4 hour design events based on 1914- 1995 Edmonton Municipal Airport	Leduc	Surface Conveyance	68.8	129.0
1:100 Year 4 hour - EPCOR 2020 gauge network	EPCOR	Surface Conveyance	80.4	137.8
1:100 Year 4 hour - EPCOR 2015 gauge network	St. Albert	Surface Conveyance	84.4	143.6

Table 4.23: Region IDF Data – Minor System Conveyance Design

Minor System Conveyance System (Underground pipe) Designs	Municipalities that Use it	Primary Use	Total Rainfall Depth (mm)	Peak Intensity (mm/hr)
1:5 Year 4 hour design events based on 1914-1995 Edmonton Municipal Airport	Leduc	Underground Pipes	37.1	68.1
1:5 Year 4 hour - EPCOR 2020 gauge network	EPCOR	Underground Pipes	35.8	67.9
1:5 Year 4 hour - EPCOR 2015 gauge network	St. Albert	Underground Pipes	34.8	65.2

4.8.2 Flood Hazard

The EMRB is recommending an approach to determining flood risk that considers the flood hazard, the likelihood of flooding, consequence of flooding, which then weighs into the final flood risk determined. This approach is in line with the approach used for the City of Leduc Stormwater Master Plan.

The EMRB is utilizing flood hazard mapping information from the insurance industry, and Alberta Environment and Parks River Hazard Mapping studies where available. For areas within the City of Leduc municipal boundary, the flood maps provided by the EMRB were compared to the flood mapping simulated through the 2D model, and the results were comparable. The 2D modelling approach utilized for the City of Leduc Stormwater Master Plan allows us to assess the flood risk at a higher level of definition that may not be available to all municipalities within the Region. The model was utilized to further refine our results to specific projected elevations at properties to determine recommended improvements that would not have been possible at the higher level of planning done at the EMRB.

5. Deer Creek Assessment

5.1 Deer Creek Hydraulic Analysis

A hydraulic assessment of Deer Creek was performed by incorporating surveyed cross sections into the Infoworks model between the Leduc Reservoir and crossing at 65 Avenue, and assessing conveyance flow versus capacity within the creek. Eleven creek cross sections and several creek bed points were surveyed to develop the modelled cross section at various sections along the creek. The location and details of the cross sections are shown in **Appendix F**. The creek was found to generally have a u-shaped channel with a typical depth of 0.6 m and a typical width of 3.5 m. This channel profile was relatively consistent across the collected survey data, although side slopes varied from 2:1 (H:V) to approximately 10:1. Therefore, the creek has variability in its hydraulic capacity. Where cross section data was not collected, interpolated cross sections with an estimated typical channel depth were incorporated into the ground elevation obtained from the LiDAR.

Upstream of the Leduc Golf and County Club, hydrographs were estimated for the 5 and 100 year rainfall events based on the findings of the Blackmud/Whitemud Creek Surface Water Management Study (AE, July 2017). The report provided a delineation of the overall Deer Creek catchment area, which was scaled to determine the flow rates for the upstream area. In the 2D model, the catchment was connected to a storage node that represented the furthest downstream waterbody at the Leduc Golf & Country Club, which was then routed through two consecutive sets of culverts before entering the Leduc Reservoir. These culvert connections, along with the storage capacity of the reservoir, mitigate peak flows in Deer Creek before reaching the residential communities downstream.

The hydraulic assessment included an approximation of the flooding extents, high water levels, and peak flow rates observed during the 5 and 100 year, 4 and 24 hour rainfall events. Table 5.1 summarizes the peak flow rates at various critical crossings along Deer Creek compared to the estimated hydraulic capacity at that location. The locations are shown on Figure 5.1. Hydraulic capacity was estimated by the Manning's capacity of the creek based up to the top of bank, assuming a Manning's roughness coefficient of 0.03. This value is considered to be the "Bankful Flow", which typically has a flowrate comparable to the 2 year event. The hydraulic capacity to the creek banks was extremely varied across the creek length. In locations near culverts with well defined cross sections the creek had a high capacity, while meanders with lower slope or location with flow obstructions had reduced capacity. The flood plain of Deer Creek downstream of the reservoir is generally quite well defined, and greatly increases the capacity of the creek during the 100 year events.

The governing rainfall event for Deer Creek is the 100 year 4 hour rainfall event. Figure 5.1 shows the flooding depth extents and water level profile in the creek during the 100 year 4 hour rainfall event.

Table 5.1: Deer Creek Flow Rates

Event	Reservoir Weir Flowrate (m³/s)	Bridgeport Crossing Flowrate (m³/s)	Grant McEwan Blvd Flowrate (m³/s)	65 th Avenue Flowrate (m³/s)
Hydraulic Capacity	-	2.43	2.01	5.10
100 Year 4 Hour	12.40	12.75	12.94	13.55
100 Year 24 Hour	7.17	7.43	9.02	9.35
5 Year 4 Hour	3.30	3.75	4.43	4.47
5 Year 24 Hour	1.37	1.40	1.95	2.10

City of Leduc

City of Leduc Stormwater Master Plan Final Report

The peak flow rate in the creek increases slightly as it progresses further downstream, but the overall peak flow is relatively constant. This is partially due to the peak flow mitigation provided by the reservoir and upstream in-line storage. While there are several discharge points, the peak discharge rates are mostly controlled by stormwater management facilities.

A rechannelling of Deer Creek would provide limited hydraulic benefits for storm system discharges in the urban portion. Improvements could provide more grade to any improved connections from the storm system outfalls at QEII and 65 Avenue. The hydraulic assessment only consisted of summer conditions with dry antecedent conditions, however the QEII and 65 Avenue outfall has been identified as a flat location with ponded surface water, both by the model and by City of Leduc Operations staff. This means that this section of the creek may be more vulnerable to flooding in successive events both because it does not draw down like a typical designed SWMF, and because it is more vulnerable to icing up in the winter. However, as part of future improvements in this area, increased grade along Airport Creek to Deer Creek could result in improved functionality during wet periods and spring melt.

Bridgeport does not have any major flooding issues, but during major events the pond has extremely limited discharge because of the water surface elevation of Deer Creek in the area. The modelled water surface elevation was below the design HWL of the pond for all events, but with future development along Deer Creek potentially increasing the flowrate in the Creek or even restricting the floodplain, it is an area that may need to be re-evaluated in future studies.

Deer Valley has no noted hydraulic improvements, however several properties in the area may be vulnerable to erosion of the creek banks in the future. The closest buildings are approximately 10 m from the main creek channel and less than 2 m above the normal water level, while some private backyard sheds are within 5 m of the creek. Recommendations for setbacks and erosion are provided in the geomorphological assessment in Section 5.2.

Project No.: 60683843

500 200 300 400

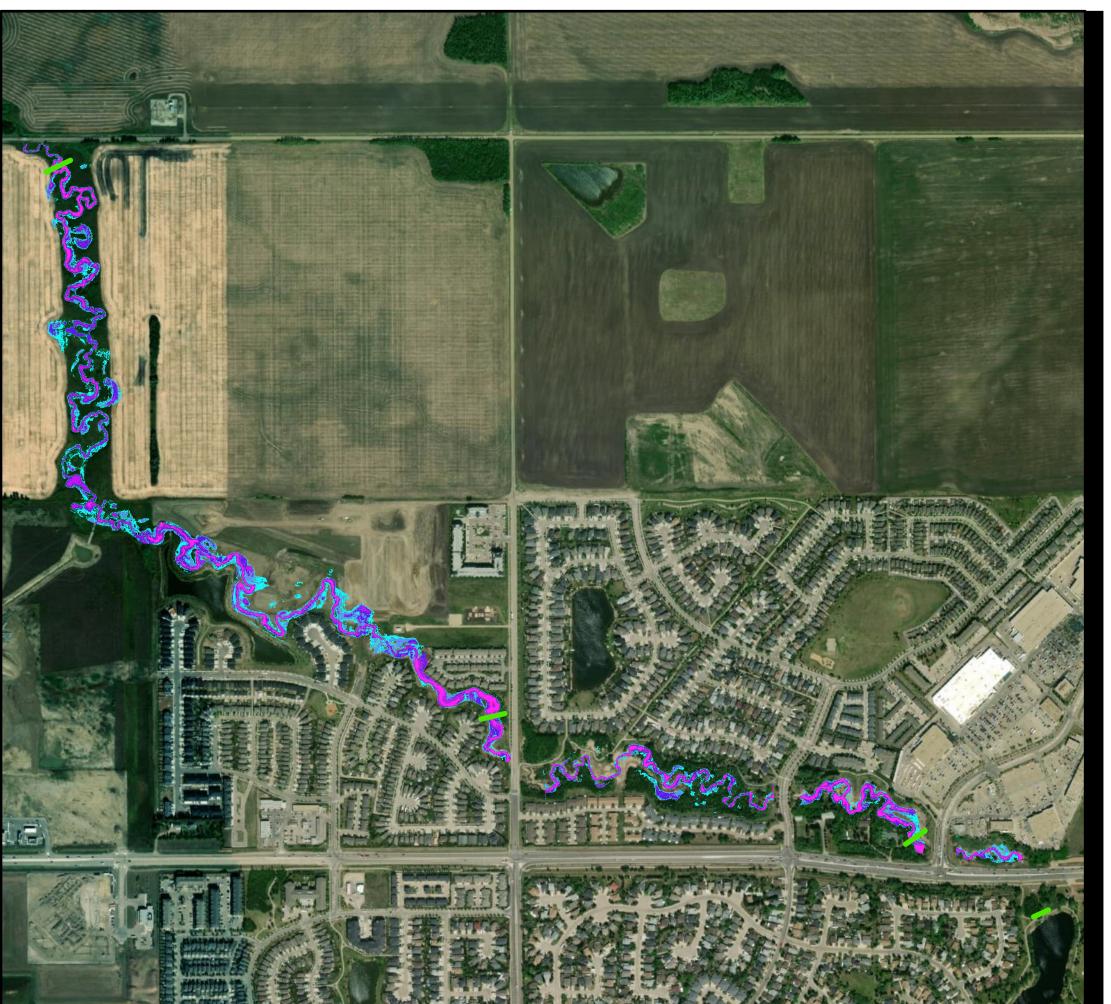
■ Meters

Legend

Depth

0.51 - 1.00 m

> 1.00 m



Hydraulic Capacity Estimation

Cross-Sections

Surface Ponding

< 0.15 m

0.15 - 0.30 m 0.31 - 0.50 m

DEER CREEK HYDRAULIC ANALYSIS 100 YEAR 4 HOUR RAINFALL EVENT

AECOM Figure: 5.1

5.2 Geomorphological Assessment

A fluvial geomorphological assessment was completed for the reaches of Deer Creek west of the QEII. Seven creek reaches were delineated; the reaches are further described and illustrated in the full geomorphological assessment, provided in **Appendix G**.

The seven delineated creek reaches, from upstream to downstream, are generally defined as follows:

- LD-01: from QEII to the Leduc Golf Club,
- LD-02: through the Leduc Golf Club up to Black Gold Drive.
- LD-03: through the Leduc Reservoir, from Black Gold Drive to Hwy 39,
- LD-04: from Hwy 39 to Bridgeport Crossing,
- LD-05: from Bridgeport Crossing to Grant MacEwan Boulevard,
- LD-06: from Grant MacEwan Boulevard through Deer Valley / Creekside, and
- LD-07: from Creekside to 65 Avenue.

A photographic record was completed to document channel dimensions, bank and bed materials, riparian vegetation, valley walls, and floodplain dynamics. Locations of geomorphological importance were photographed and included areas of bank erosion and channel modification. The complete photographic record is appended to the full geomorphological assessment in **Appendix G**.

In the study area, Deer Creek has a meandering channel planform within topographic low and follows a relatively flat topography from an elevation of 733 m near the QEII, to 711 m where the watercourse crosses 65 Avenue over a channel length of approximately 10,330 m.

The key findings and recommendations from the assessment are summarized in the sub-sections below.

5.2.1 Geomorphological Assessment – Key Findings

The fluvial geomorphological assessment concluded the following:

- The creation of impervious paved streets, parking lots and roofs has increased the flow rate of stormwater coming to Deer Creek and has resulted in higher peak flow levels and flood risk (Associated Engineering, 2017).
- All reaches assessed had a "Transitional" RGA rating, indicating the channel morphology is within the range of variance for streams of similar hydrographic characteristics, but evidence of instability is frequent. The dominant process occurring in LD-01 was planimetric form adjustment, while the dominant process occurring in LD-04 to LC-07 was widening. The channel is likely adjusting to the increased runoff from the city center as well as from agricultural activities.
- The higher peak flow issues due to the increased imperious surfaces and entrenched channel banks could have been compounded by the over steepened and slumping banks, leading to the RGA rating of "Transitional" and evidence of erosion displayed throughout Deer Creek.
- The very low topographic changes contribute to overland flooding along the creek.
- The surficial geology has a moderate to high erodibility and is dominated by fines (clay, silt, and sand) along the channel bed, with lesser amounts of gravel to boulder sized fragments in reaches LD-01 and LD-06.
- The riparian zone is largely limited to tall grasses, with lesser amounts of herbaceous vegetation and tree cover. Many debris jams are present along the entire watercourse especially in the area with forest cover.
- All reaches in the Study Area appeared to be entrenched.
- Deer Creek has been impacted by multiple culvert crossings, agricultural activities, and short sections have likely been straightened.

City of Leduc Stormwater Master Plan Final Report

- Bank slumping and bank undercutting are widespread throughout the Study Area. Of particular concern are the Creekside Ravines subdivision and the residential properties off Ameena Drive where significant bank undercutting and slumping close to the residential properties was observed.
- Evidence of sediment aggradation increases in the downstream direction, with aggradation first being noted in LD-05 and increasing in LD-06 and LD-07. There are significant amounts of suspended sediment in the downstream half of LD-07. Sediment is likely sourced from upstream erosion.
- The preliminary meander belt width for the reaches ranges from 26.4 46.9 m, using the empirical meander belt approach. The wider value calculated for LD-04 was applied to all downstream reaches.

5.2.2 Geomorphological Assessment – Recommendations

The Blackmud/ Whitemud Creek Surface Water Management Study (AE, July 2017) recommended lowering Deer Creek to lower the flood levels and allow for adjacent development to discharge by gravity to the creek. This would assist with mitigating the increased flow rates that have developed due to the increased stormwater runoff from the growing urban center (Associated Engineering, 2017). However, lowering Deer Creek within the City boundary would not be feasible, as the downstream reaches on the Edmonton International Airport and within Leduc County would also need to be altered.

As part of future works, it is recommended that an Erosion Assessment be conducted to identify priority high-risk erosion sites for erosion mitigation measures and to identify site constraints. Deer Creek is an actively meandering system, with evidence of abandoned meanders readily apparent in historic aerial photographs. The creek meanders through a narrow corridor with public and private residential properties close to the edge of the corridor. Of particular concern are the Creekside Ravines subdivision and the residential properties off Ameena Drive where significant bank undercutting and slumping close to the residential properties were apparent during the fluvial geomorphic field assessment. At least one failing retaining wall was also observed in this area.

It is also recommended that an Erosion Threshold Assessment be conducted to determine critical hydraulic conditions at which theoretically erosion will be initiated in the channel. An erosion threshold assessment can identify the flow that will theoretically entrain bed or bank material on a reach-scale basis based on numerical models. It can identify how each reach will be impacted by changes in the flow regime (Credit Valley Conservation Authority, 2015). These critical hydraulic conditions will help to establish goals and constraints for the study area and to inform conceptual design options to mitigate erosion.

It is recommended that the meander belt width be refined using the mapping approach, as outlined in the Toronto and Region Conservation Authority (TRCA), 2004. The meander belt is an important planning tool, when compared to a defined setback from top of bank, as it defines the corridor that the watercourse is expected to move across in the future (TRCA 2004). The planform mapping approach is the preferred approach to defining the meander belt wherever the watercourse is unaltered, and its meandering history could be tracked on aerial imagery according to TRCA (2004) and the Credit Valley Conservation Authority (2015) in their guidance documents. In general, once the reach and meander belt axis have been defined the meander belt can be delineated. This is achieved by drawing parallel lines tangential to the outside meanders of a planform for each reach in the study area using its current and historic position and configuration of the planform for the study reach. The distance between the two lines can then be measured and is used to represent the width of the preliminary meander belt. This method also considers any confining valley walls which will limit the extent of the meander belt. To calculate the final meander belt width the 100-year erosion rate should be calculated. The 100-year erosion rate predicts the potential for erosion over the next 100 years. A minimum of 20-30 years of historical data are required to provide a measure of reliability when determining the average annual recession rate extended over 100-years (TRCA, 2004; CVC, 2015). This type of erosion rate calculation is only applicable to natural, unaltered reaches. The final meander belt width will depend on the preliminary meander belt size and whether the flow regime is likely to change in the future. A series of equations are provided in the Meander Belt Width Delineation Procedures document to accurately delineate a final meander belt width (TRCA 2004).

5.3 Policy Recommendation

Based on the above hydrologic and geomorphological assessments, Deer Creek is a meandering creek that varies in peak flow rates throughout the year depending on the quantity of rainfall. As discussed with the City, a clear setback requirement for development is required to prevent potential erosion and flood related issues to properties adjacent to creeks.

For the purposes of setback requirements, it is recommended that developers pursue one of the following options.

Option 1: Property line setbacks shall be determined via an empirical meandering belt assessment that utilizes a 1:2 year rainfall event for the calculation. When determining the erosion potential of the creek, the assessment shall utilize the mapping approach, which assesses the historical movement of the creek and defines the actual movement per year, and utilizes the 100 year erosion potential. The report shall be completed and stamped by a qualified fluvial geomorphologist. Multiway setbacks shall be determined by a geotechnical assessment to determine the minimum distance from top of bank.

Option 2: Property line setbacks will be 15 m from the identified top of bank. Multiway setbacks shall be determined by a geotechnical assessment to determine the minimum distance from top of bank.

This recommendation is indented to be applied to all named and unnamed creeks within the boundary of the City of Leduc.

6. Telford Lake Assessment

A key natural feature of the City's stormwater management system is Telford Lake. Various aspects of the lake were assessed, including water quality, condition of the stormwater outfalls, and sedimentation with the lake.

6.1 Telford Lake Sampling Program

AECOM conducted water sampling within Telford Lake and performed laboratory analysis of the samples with the following goals:

- Determine total suspended solids (TSS) loading within Telford Lake.
- Determine chloride concentrations within Telford Lake.
- Determine whether the chloride concentration is above acceptable concentrations based on the current standard of 120 mg/L, or if Alberta Environment should be consulted about the potential for raising the chloride guideline based on lake specific species of fish.

The following sections include the conclusions and recommendations of the Telford Lake sampling program. The complete Telford Lake sampling program and testing results are provided in **Appendix H**. Sampling locations are shown on Figure 6.1.

6.1.1 Site Specific Chloride Guideline Assessment

The long-term chloride exposure guideline from the Canadian Water Quality Guidelines for the Protection of Aquatic Life: Chloride fact sheet is 120 mg/L (CCME, 2011). However, this guideline is based on two species of freshwater mussel indigenous to Ontario freshwater systems and whose range does not extend to Alberta. A search of the Fisheries and Wildlife Management Information System (FWMIS) database was conducted on June 6, 2023 to identify what aquatic species are present in Telford Lake as well as downstream (Saunders Lake and Blackmud Creek). The results of the FWMIS searches can be found in **Appendix H**. Fathead minnow (Pimephales promelas) is shown to be present in Telford Lake and downstream locations, and has a long-term chloride exposure 33 day lethal concentration with 10% mortality (LC10) of 598 mg/L. All chloride concentrations were below this value. Although no list was found of invertebrate species in Telford Lake, chloride concentrations shown at the time of sampling were below the lethal concentration values presented for invertebrates (excluding the two freshwater mussels are found in Ontario only) that are commonly found in freshwater systems.

6.1.2 Sampling Program Conclusion

Chloride concentrations present in Telford Lake at the time of sampling are relatively consistent surrounding the outfalls at the west and east end of the lake, with upgradient outfall concentrations generally lower than those seen in the lake. Snow was still present at the snow storage facility north of Outfall C at the time of sampling, and the chloride concentrations at the outfall (both upgradient and downgradient) were consistent with the other outfalls surrounding the lake, with the upgradient chloride concentration being lower than the downgradient chloride concentration. This suggests that the chloride load from all of the outfalls into Telford Lake has increased the chloride concentration throughout the lake, with no discernable mixing zones being created. For comparison, the Alberta Water Quality Data Portal was accessed to determine the chloride concentration for other lakes in the region. Table 6.1 presents the results.

Table 6.1: Chloride Concentration in Lakes in the Region

Lake	Sampling Date Range	Chloride Concentration Range (mg/L)	Number of Records
Telford Lake	2023 SWMP	40-180	1
Big Island Lake	Jan 1987	35	1
Twin Island Lake	Jan 1987	30	1
Coal Lake	Aug 1993 to Oct 2016	6 to 26	27
Wizard Lake	Jul 1983 to Sept 2022	3 to 8	37
Long Lake	Jun 1989 to Sept 1991	4 to 8	13
Bittern Lake	Jul 2007	46	1
Cooking Lake	Jul 1987 to Oct 2007	17 to 59	9
Boag Lake	Jul 1987	22	1
Half Moon Lake	Jan 1987 to Feb 1993	9 to 12	20
Bennett Lake	Jul 1987	4	1
Antler Lake	Jan 1987	10	1
Hastings Lake	Jul 1987 to Sept 2022	9 to 47	12

Source: Alberta Water Quality Data Portal

Note that in all cases where a lake has been sampled over a number of years, the lowest concentration is seen in the initial sampling event and the highest concentration in the most recent sampling event.

The data in Table 6.1 shows that a general increase in chloride concentration is occurring in all lakes in the region. However, the concentration seen in Telford Lake is three times the highest concentration seen in other lakes in the region.

Chloride concentrations in Telford Lake at the time of sampling are below the fathead minnows LC₁₀ of 598 mg/L and below the lethal concentrations presented for invertebrates commonly found in freshwater systems. The highest concentration of chloride was found at Outfall O (188 mg/L).

The *Environmental Quality Guidelines for Alberta Surface Waters* (AEP, 2018) states that for long term exposure, a maximum average increase of 5 mg/L from background levels for TSS in clear waters is acceptable. While the difference between upgradient concentrations and downgradient concentrations was greater than 5 mg/L, overall TSS concentrations were relatively consistent between outfalls and between upgradient and downgradient samples, with most concentrations within the same order of magnitude.

The exception to this occurred in one sample at Outfall B (B-2: 256 mg/L), two samples at Outfall D (D-2: 162 mg/L and D-3: 156 mg/L) and the sample collected at Outfall O (O-1: 246 mg/L). TSS concentrations in these samples are one order of magnitude higher than the rest of the samples, however, it is likely that sample collection methods and weather conditions influenced these results. Wind speed started to increase during the sampling of Outfall B and it is possible that sediment from the lake bed was disturbed while trying to anchor the boat in the sample area. Samples from Outfall D and Outfall O were taken with a surface water sample pole. The samples were taken closer to shore during windy conditions; and it is possible that these conditions had an impact on the results. As with chloride concentrations, TSS concentrations throughout the lake suggest no discernable mixing zone being created near the outfalls.

City of Leduc Stormwater Master Plan Final Report

6.1.3 Sampling Program Recommendations

At the time of sampling in 2023, snow was still present at the snow storage site north of Outfall C and surface melting conditions were captured in that area. Surface snow was not present at the other outfalls surrounding the lake. If there is an opportunity to sample the outfalls in the future during the beginning of spring melt, these results could be compared to the previously captured data. Sampling earlier in the year would also potentially mitigate sampling constraints caused by nesting waterfowl and allow more samples to be taken surrounding each outfall to assess chloride and TSS trends within Telford Lake.

It is recommended that Alberta Environment and Protected Areas be consulted about raising the chloride guideline for Telford Lake to the fathead minnow 33 day LC₁₀ concentration of 598 mg/L.

Telford Lake Sampling Program Sample Location Plan

AECOM Figure: 6.1

6.2 Telford Lake Outfall Assessment

AECOM conducted a visual stormwater outfall assessment in September, 2022 of the storm outfalls to Telford Lake (including the outfall from Telford Lake discharging east). **Appendix I** includes a letter report with field inspection reports.

The outfalls generally provide stormwater servicing for residential and undeveloped areas around Telford Lake. Assets were constructed between 1973 and 2019, and ranged in construction from flared ends to pipes projecting from embankments. Pipe sizes ranged from 375 mm to 1350 mm in diameter, and materials included concrete, corrugated metal, PVC and HDPE.

There are 12 stormwater outfalls to Telford Lake; however, one outfall could not be field located. Outfall locations are shown on Figure 6.2. The inspection of the remaining 11 outfall assets found that the majority of the system is in moderate condition. Outfalls were given condition grades (CG), as detailed in **Appendix I**, with a condition grade of 1 or 2 indicating acceptable condition, but further long-term monitoring is recommended to watch for deterioration. Outfalls with a grade of 3, 4 and 5 have significant defects that require attention to prevent further deterioration, and therefore these assets are generally recommended for additional cleaning or repair work.

Results of the structural condition assessment can be summarized as follows:

- 3 outfalls are showing signs of advanced stages of deterioration (CG 4&5).
- 5 outfalls are showing signs of moderate stages of deterioration (CG 3).
- 3 outfalls are showing limited to no signs of deterioration (CG 1&2).

Results of the O&M condition assessment can be summarized as follows:

- 1 outfall is showing signs of advanced stages of deterioration (CG 4&5).
- 8 outfalls are showing signs of moderate stages of deterioration (CG 3).
- 2 outfalls are showing limited to no signs of deterioration (CG 1&2).

It is recommended that 8 outfalls be added to a repair program, and 9 outfalls be added to a cleaning program.

Based on the assessment, AECOM recommends the following specific actions for the City's consideration:

- Take immediate action to perform a geotechnical assessment of Outfalls 298, 873, 3040 and 3507 to determine the extent of voiding and risk of instability to the respective systems.
- Locate Outfall 4347; if covered with debris or sediment deposition, it will not function as intended.
- Confirm if the sandbags at Outfalls 285 and 1593 are intended to function as a weir. If not, then add these outfalls to a cleaning program.
- Review the need for hydraulic channel improvements at Outfall 4324. If current vegetation conditions are determined to impact hydraulic function, add the outfall to a cleaning program.
- Perform CCTV on Outfall 1593 to determine the extent of corrosion, and consider relining the asset.
- Perform water quality sampling to identify the need for oil-grit separators.
- Add 9 assets to a cleaning program (assuming Outfalls 285, 1593 and 4324 require cleaning).
- Add 6 assets to a rehabilitation work program (assuming Outfall 1593 requires relining).



TELFORD LAKE OUTFALL CONDITION ASSESSMENT

Project No.: 60683843

6.3 Telford Lake Sedimentation Assessment

Over time, sedimentation levels in Telford Lake are slowly increasing. With buildup of sedimentation, the water levels are subsequently reducing, and the water depth is as shallow as 1 m deep in areas.

As part of the Telford Lake Master Plan (ISL, March 2010), the Telford Lake Training Centre Society was consulted, and the desire to implement a 2000 m paddling race course on the lake was identified. To implement this, the lake would need to be dredged to a minimum water depth of 3 m along the proposed paddling course limits.

A dredging plan was previously developed for the lake (Telford Lake Dredging and Lagoon Reclamation, Preliminary Engineering Report, Daltam Consulting Ltd., March 1987). Based on drilling completed by Alberta Environment in 1980, the sediment levels at the time ranged in depth from 1.5 m to 3.4 m. A portion of the lake was subsequently dredged in the late 1980s; however, dredging operations were limited due to several factors, including debris in the lake. This dredging program targeted an 8.5 ha area on the west portion of the lake.

Bathymetric survey was completed on Telford Lake by Challenger Geomatics in October 2023. A dual-frequency survey was completed, including both high-frequency and low-frequency sonar. High-frequency waves penetrate through the water but are blocked by submerged vegetation and soft sediment. They are useful for identifying vegetation levels within the lake. Low-frequency waves can penetrate through the submerged vegetation and soft sediment but cannot penetrate through consolidated sediment or rock. This provides a surface for the top of sediment within the lake.

Bathymetric data from the Alberta Government Open Data set (*Reference: open.alberta/opendata/gda-dig_2008_0685*) was also reviewed and compared to the survey completed by Challenger as an approximation of the lake bottom.

Figures 6.3 and 6.4 show the high and low frequency surfaces generated through the bathymetric survey, as well as the lake bottom and normal water level.

The surveyed area of Telford Lake is over 90 ha. The bathymetric survey data shows that a significant portion of the lake contains vegetation and soft sediment, which are on average 0.4 m thick. Areas with the highest vegetation levels include the perimeter of the lake, as well as the centre of the lake. This indicates that the centre of the lake has experienced a high buildup of sediment over time. Sediment levels generally lower in the west portion of the lake where previous dredging has occurred.

It is recommended that a dredging program be undertaken to remove the vegetation and buildup of sediment from within the lake. This will help restore the deeper area of the lake and remove excess nutrients accumulated at the lake bottom, in turn improving the overall health of the lake and the water quality.

Prior to dredging, it is recommended that sediment be sampled for contaminants including chlorides, heavy metals and hydrocarbons, at various locations across the lake to gain an understanding of how the sediment will need to be managed once removed. If the sediment is of good quality, it could potentially be dried and utilized for shoreline restoration or as an amendment to topsoil. However, if the sediment is contaminated and exceeds disposal guidelines, it may need to be disposed to landfill, which would significantly increase costs.

Different options are available for sediment sampling, including:

- Grab samples:
 - This could be conducted from a boat using an Ekman dredge
 - o Grab samples are cost-effective; however, they only provide a sample of the surface sediment which may not be representative of the sediment depth as it has built up over time.

City of Leduc

City of Leduc Stormwater Master Plan Final Report

- Column samples:
 - The sediment column could be sampled through a borehole.
 - This would provide a representation of potential contaminants throughout the sediment layer.
 - o For drill rig access, the work could either be done in winter through the ice, or from a barge
 - For drill rigs to access over the ice, preparation of the ice would need to be completed to support the
 equipment. Once ice thicknesses can support a snowmobile, snowmobiles would run over snow along
 the access route to pack down the snow. This thickens the ice below over time by reducing insulating
 properties of the snow. Ice preparation would continue until sufficient thicknesses are reached to
 support the equipment.

Sampling may be an iterative process. If the initial samples show high levels of contamination in certain areas of the lake, additional samples should be considered to delineate these areas to gain a better understanding of contamination extents and associated cost impacts.

There are different dredging options available, including: hydraulic dredging and mechanical dredging. Due to the size and depth of Telford Lake, hydraulic dredging is recommended over mechanical dredging. Based on the available data, total sediment levels are estimated to be in the range of 1.6 million m³. Contractor methods may vary; however, sediment would likely be pumped through siltation bags, with excess water returned to the lake. The sediment could then be spread out to dry.

The City owns two properties south of the lake that could be considered for management of sediment during the dredging program:

- William F. Lede Park
 - located along the south central side of the lake
 - approximately 15 ha available north of the K9 Dog Park
 - site previously contained wastewater lagoons, that were reclaimed with dredged material from Telford Lake during the 1980s dredging program
- NE30-49-24-W4
 - o located at the outlet of Telford Lake
 - approximately 23 ha available without impacting the treed areas
 - currently leased as farmable land

The NE30-49-24-W4 has been suggested for future consideration due to the larger available area, and further proximity from recreational areas in the City. The proposed area is shown on Figure 6.1.

If the City's desire is to complete a full dredging program for the lake, it is recommended that this be staged over a minimum 10 year period, or as needed to support funding constraints. To remove all of the estimated 1.6 million m³ of sediment, it is estimated that costs could be in the range of \$80-\$100 million. If the material is contaminated and disposal to landfill is required, the costs would be expected to double.

Alternatively, the area identified for dredging could be targeted to the west bay and the proposed paddling race course in support of the Telford Lake Master Plan . Based on the proposed 2000 m long course, with 10 x 12.5 m lanes, the area for the paddling course is approximately 25 ha. To achieve a 3 m depth, it would involve removal of approximately 500,000 m³ of sediment, which is approximately 30% of the total lake sediment levels. The west bay is approximately 10 ha, with an average sediment depth of 1.5 m, and an estimated sediment volume of 15,000 m³. The cost for a targeted program would be in the range of \$25 million. As noted above, if the material is contaminated and disposal to landfill is required, the costs would be expected to double. Potential contamination should be confirmed in advance through a sampling program.

City of Leduc

City of Leduc Stormwater Master Plan Final Report

To complete dredging within the lake additional studies would be required, including preliminary engineering plans as well as environmental studies. As part of the Telford Lake Master Plan (ISL, 2010), an estimated cost of \$300,000 was provided for the required studies. To complete the work, permits and approvals would be required, including Water Act, Department of Fisheries and Oceans and Navigable Waters.

If dredging were to occur, future efforts may then be able to be completed under a Code of Practice for Routine Maintenance Dredging for Navigation. This code of practice outlines practices to follow for routine maintenance dredging, which occurs at least once every 10 years. It applies to routine maintenance dredging only and does not apply to new dredging projects or to the expansion of a previously dredged area.

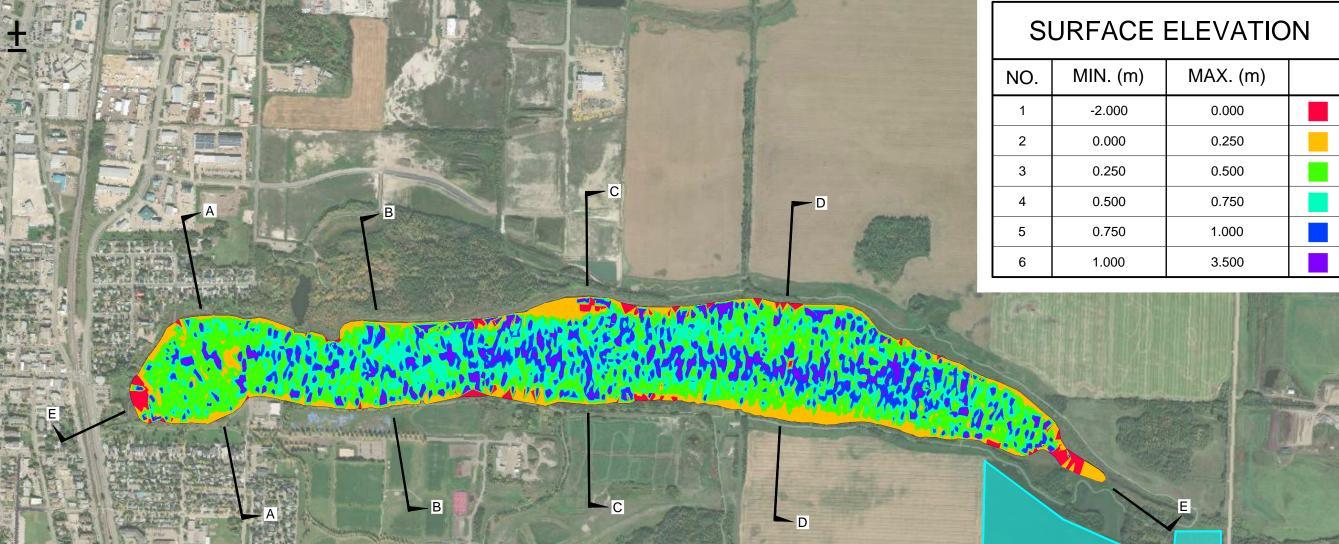


PROPOSED SEDIMENTATION STORAGE LOCATION

312.5

1:12500

625





AECOM

1+700

125

6.4 Snow Storage Site Discharge to Telford Lake

In 2021, Trace Associates conducted water sampling upstream and downstream of the snow storage site located at 4301 56 Avenue. The results of this study were compared to the sampling completed by AECOM within Telford Lake. The following includes a summary of results of the Trace report applicable to the discharge to Telford Lake. The Trace report should be reviewed for a full description of the sampling and conclusions.

- Samples were taken directly at the snow storage site, as well as along the piped discharge to Telford Lake, with one sampling location upstream of the snow storage site and two downstream locations. Samples were taken in March, April and May, 2021. Chloride concentrations were compared to the guideline recommending a maximum chloride concentration of 120 mg/L.
- Chloride concentrations exceeding the guideline were observed both being discharged by the snow pile during melt season as well as upstream and downstream of the snow site.
- Upstream of the snow storage site, chloride concentrations were consistently above the guideline generally above approximately 400 mg/L, but peaked in April at 1,520 mg/L.
- The highest chloride concentration identified was at the snow storage site in March 2021, at 5,180 mg/L.
- As the melting continues and rainfall dilutes the chlorides, the concentration at the snow storage site drops to 1,500 mg/L in March, and then 205 mg/L in May.
- Downstream of the snow storage site, the chloride concentration exceeded the guideline with maximum concentrations in April, but decreasing to approximately 160 mg/L.
- Two additional sites were tested at outfalls to Telford Lake that were not connected to the snow storage site. In April and May, chloride concentrations exceeding the guideline at approximately 200-300 mg/L, but fell to acceptable concentrations in May.

Based on the above, when the snow first begins to melt, chloride concentrations are high, and throughout the year decrease to near the recommended guidelines through dilution. In addition, based on the decreasing concentration of chlorides from the snow pile meltwater, this indicates that the chlorides get being dissolved into the first meltwater.

Compared to the sampling completed by AECOM in May, 2023, the chloride concentrations at were similar to that were observed in May 2021 during the Trace study. This indicates that the chloride concentrations are relatively consistent through the years, and that the existing snow storage facility is a major contributor of the chlorides that are relatively consistent throughout the entire lake.

The snow storage site currently discharges freely through a Stormceptor oil/grit separator; however, no chloride treatment is occurring with the exception of dilution. It is recommended that a study is completed to evaluate options for upgrades to the existing snow storage facility be considered to lower the concentration of the chlorides in the snow meltwater prior to discharge from the existing facility.

As discussed in Section 6.1.3, it is recommended that Alberta Environment and Protected Areas be consulted about raising the chloride guideline for Telford Lake to the flat head minnow 33 day LC₁₀ concentration of 598 mg/L. If this value was accepted, chloride concentrations would be acceptable once sufficient dilution has occurred (typically by May).

7. Stormwater Quality

7.1 Stormwater Management Facilities

The primary purpose of stormwater management facilities is to collect the runoff generated by developments and control the outflow to the receiving watercourse to allowable discharge rates. However, a secondary purpose is to provide water quality enhancement. Alberta Environment requires that a minimum of 80% of sediments with a particle size of 75 µm or greater be removed from stormwater runoff.

Stormwater quality enhancement can be provided by preserving and enhancing existing wetlands, creating wetlands, constructing wet ponds and constructing dry ponds, all listed in decreasing value of contribution to the preservation of natural conditions.

The servicing concept recommends the use of wet ponds for all basins within the study area. However, during preliminary design, alternative facility types can be assessed to determine if they can provide better water quality enhancement or additional cost/benefit. In addition to wet ponds, water quality enhancement can be addressed by using Best Management Practices (BMP's). Several BMP's, such as:

- Oil and Grit Separators locating oil and grit separators at the stormwater outfall allows the removal of sediment and pollutants from the stormwater before entering the receiving waterbody. Oil and grit separators may also be appropriate for the existing stormwater system in the City to provide some quality enhancement, and are discussed further in Section 7.3. It is important to note that regular maintenance of these units is required.
- Vegetative zones in and around a wet pond enhances pollutant removal capabilities.
- Vegetated swales discharge into grassed channels/ditches provides sediment an opportunity to settle out of the stormwater while being conveyed to the receiving waterbody.

The placement of stormwater management facilities should consider the Guidelines for Stormwater Management Facility Design within the Primary Bird Hazard Area in the Vicinity of the Edmonton Internation Airport document. The guideline outlines the areas where the development of wetlands, wet ponds, LID features, and other stormwater management facilities are restricted.

The following sections briefly summarize alternative facility types:

7.1.1 Wetlands

Wetlands provide sediment retention, filtration, and pollution reduction through biological processes and are suitable for drainage areas greater than 5 ha. As wetlands can reduce soluble pollutants, wetlands are generally applicable to residential, commercial, and industrial areas where the nutrient loading is relatively high.

In general, wetlands have been found to lower biological oxygen demand (BOD), TSS, and nitrogen concentrations to 10% to 20% of the level at the inflow point. For total phosphorus, metals, and organic compounds, the removal efficiency varies significantly but is typically between 20% and 90%.

Natural and constructed wetlands are the preferred SWMF (over wet ponds) outside of the development restrictions of the Edmonton International Airport Vicinity Protection Area Regulation.

City of Leduc Stormwater Master Plan Final Report

7.1.2 Wet Ponds

Wet ponds are water bodies that temporarily store stormwater runoff to promote the settlement of suspended pollutants and to restrict discharge to predetermined levels. Wet ponds have two storage zones: a lower permanent storage and an upper active storage. The permanent storage will always exist irrespective of the inflow while the water level in upper storage will fluctuate in response to the inflow volume.

The deep permanent storage is the wet pond's primary water quality enhancement mechanism. Runoff entering the wet pond will slow down and thus induce the settlement of suspended pollutants. Biological processes, such as nitrogen uptake by algae, are established in the permanent storage and help reduce the concentration of soluble contaminants. However, due to the smaller biological contact area, wet ponds are not as efficient as wetlands in reducing these concentrations.

7.1.3 Dry Ponds

The primary purpose of a dry pond is to provide temporary stormwater storage to reduce the peak outflow rate. Dry ponds drain down to a dry condition at the end of the rainfall event. Being primarily designed for temporary and short duration stormwater retention, the dry pond has minimal water quality enhancement capabilities without the inclusion of a small wet pond forebay to trap some of the suspended sediment. The dry pond's very limited ability to reduce the concentration of soluble contaminants limits its application.

7.2 Low Impact Development (LID)

As discussed in Section 3, City standards reference EPCOR design and construction standards, which recently have implemented Low Impact Development (LID) design guidelines in Section 5.0 of Volume 3-02 Stormwater Management and Design Manual. In the design standards, they require that LID is incorporated as a "Best Management Practice (BMP) for stormwater management and should not be viewed as a redundant system, but as a necessary part of the integrated stormwater management system".

For the City of Leduc, LID is recommended to be implemented at strategic locations in addition to the major and minor stormwater infrastructure but is not a requirement for development. It is recommended to continue to collaborate with the EMRB and update recommendations for LID as the technology is developed and implemented throughout the region. Discussions were held with the City regarding implementation of LID features. Due to factors such as limitations in cold climates, neighbourhood aesthetics, as well as increased cost and operational requirements, it is recommended that LID features be implemented on an opportunistic basis, rather than implemented as a requirement at this time.

The placement of stormwater management facilities should consider the Guidelines for Stormwater Management Facility Design within the Primary Bird Hazard Area in the Vicinity of the Edmonton Internation Airport document. The guideline outlines the areas where the development of wetlands, wet ponds, LID features, and other stormwater management facilities are restricted.

Typically, LID features are designed to retain the first 18 mm from the contributing area, which is sufficient for frequent smaller rainfall events. LID provides the following benefits to the stormwater management system.

- Increases the overall percent pervious of developed areas, reducing the stormwater load on downstream drainage systems.
- Provides storage for the first flush of rainfall events, which includes a high sediment load which would be managed by the LID feature.
- Generally positive public perception, as they provide an aesthetic stormwater management solution compared to CBs and tanks.

General design guidelines from EPCOR include the following. Refer to EPCOR Design and Construction Standards for a full list of design requirements.

- LID facilities should be designed to retain and store a minimum of 18 mm of rain from their contributing catchment area. This is roughly equivalent to the 1:2 year rainfall event frequency.
- LID contributing area is designed based on the I/P ratio, where "I" is the impervious area of the contributing drainage area, and P is the surface area of the LID facility. The I/P ration shall not exceed 50:1, should be lower than 10:1 for catchment area with high sediment or winter salt load. 20:1 is a common ration for roads and parking areas.
- Minimum setback of 3.0 m from buildings is recommended. A setback of 1.0 m is acceptable with the inclusion if an impermeable membrane.
- Setbacks from utilities vary by the requirements of the utilities themselves.
- Depth to the seasonally high groundwater elevation below the LID invert shall be no less than 1.0 m.

There are a variety of LID features that can be implemented depending on available space and infrastructure available including:

Bioswales / Enhanced Swales: Open channel surface conveyance could be utilized within the boulevard areas behind the proposed curbing. Small check dams could be incorporated within the bioswale design to detain surface water and to promote infiltration/filtration through the biomedia. A small amount of retention storage could be incorporated within the design to ensure that sufficient water is available for bioswale vegetation throughout the interceding periods between rainfall events.



Image 7.1. Bioswale

Bioretention Cells: Bioretention units could be placed in select areas within the boulevard and planted with either perennial plants/shrubs, trees, or a combination thereof two. Bioretention facilities would provide filtration and attenuate of stormwater runoff, and a subsurface retention area could be incorporated within the design to provide groundwater recharge benefits as well.



Image 7.2. Rain Garden / Bioretention Cell

Soil Filtration Systems (including Structurally Supported Soils): Similar to a bioretention unit, reinforced soil planters fulfill attenuation, filtration, and partial retention functions. Additionally, these units are well-suited for application in compact areas with tight spatial constraints and can be surfaced with sidewalk panels or other impervious finishes without leading to compacted soils

Image 7.3. Box Planter



City of Leduc

City of Leduc Stormwater Master Plan Final Report

Infiltration Gallery: A subsurface gallery located behind the curb of the ROW parallel to the curb that receives runoff through catch basins located in the ROW. The infiltration gallery is comprised of clean stone to detain and infiltrate runoff volume. An overflow pipe is located above the inlet to the gallery and is used as an overflow to the storm sewer network.

Subsurface Chamber or Crate System: Chamber or crate-style systems would receive runoff and attenuate stormwater flows. Such systems are readily adaptable and could be modified to provide partial retention of stormwater.

7.3 Telford Lake Water Quality

The City currently operates three Stormceptors all of which are situated near discharge locations to Telford Lake as shown on Figure 7.1. Locations for additional proposed future Stormceptors are also shown in Figure 7.1, and listed in Table 7.1. In general, they were placed at locations discharging to Telford Lake with catchment area that drains directly to the downstream system without water quality enhancement from stormwater management facilities.

Table 7.1: Proposed Stormceptors

No.	Location	Discharge Body	Pipe Size (mm)	Estimated Untreated Catchment Area (ha)
1	George Liggins Park	Telford Lake	2x 600	20
2	South Telford	Telford Lake	1050	30
3	South Park	Telford Lake	1350	120

For the South Park catchment area it is likely that 2-3 Stormceptors would need to be installed in parallel to capture flows from the entire upstream basin area.



PROPOSED STORMCEPTOR LOCATIONS STORMWATER MANAGEMENT SYSTEM

EXISTING

EXISTING

South Telford

Project No.: 60683843

CITY OF LEDUC



Legend

Stormceptors

1,200 1,500

ANSI B 279.4mm x 431.8mm

0 150 300

8. Condition Assessment

As part of the overall Stormwater Management Plan, a condition assessment of the City of Leduc's existing storm sewer infrastructure was performed to help identify critical infrastructure. This assessment consisted of a desktop study based on data from the City's GIS and hydraulic models. A risk-based approach, generally based on National Association of Sewer Service Companies (NASSCO) Pipeline Assessment Certification Program (PACP) Appendix D – Risk Management in Piping Systems, was then used to identify which sewer assets carry the most potential risk for the City, with assets carrying the greatest risk considered to be critical infrastructure.

The complete condition assessment is included in a supplemental letter, and is provided in **Appendix J**. The following includes a summary of the findings of the study.

8.1 Condition Assessment Conclusions and Recommendations

Risk categories are labelled as Level 1-5, with Level 5 assets having the highest relative risk within the system. Note that, since an objective of the assessment is to show relative risk, an adjustment factor was applied to all assets to better distribute risk scores across the relative risk matrix. Table 8.1 provides a breakdown by risk category.

Table 8.1: Summary of Storm Sewer Assets by Relative Risk

Risk Category	Number of Assets	Percent of System
Level 1 (Low)	1,470	77%
Level 2	306	16%
Level 3	22	1%
Level 4	92	5%
Level 5 (High)	7	> 1%
Total	1,897	

The areas with the highest risk, as shown on Figure 8.1, are:

- The storm sewer parallel to CP Rail from approximately 43 Avenue to the Telford Lake outfall.
- The storm sewer along Grant MacEwan Boulevard from Black Gold Drive to Deer Creek.
- The QEII crossing along Black Gold Drive.

Figure 8.1 summarizes the results of the assessment, with each asset color-coded to reflect its respective risk rating.

A detailed asset-by-asset breakdown of the assessment can be found in **Appendix J**.

For storm sewers parallel to CP Rail and along Grant MacEwan Boulevard correspond to the C-1 and C-3 hydraulic upgrade projects. As noted in Section 11, these upgrades have been identified as long term upgrades due to the high costs. However, the condition of these assets should be re-reviewed on an ongoing basis. If condition is found to be deteriorating, the timing of implementation may need to be accelerated.

Image 8.1 shows the relative risk of each asset plotted on a risk matrix, and Image 8.2 shows the percent of system within each risk category.

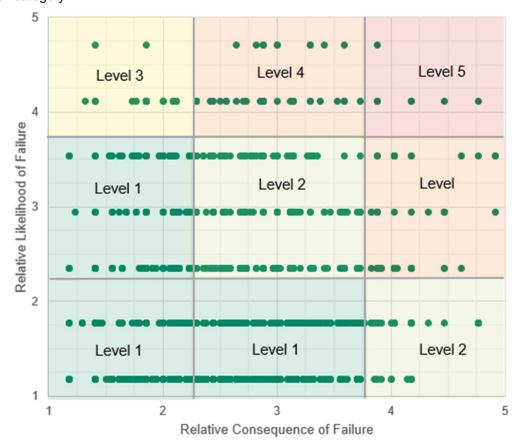


Image 8.1. Distribution of Storm Sewer Assets based on Relative Risk

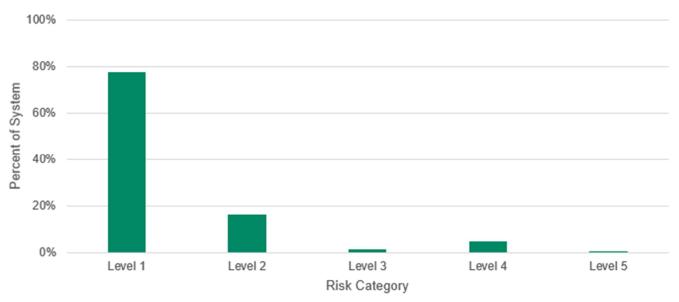


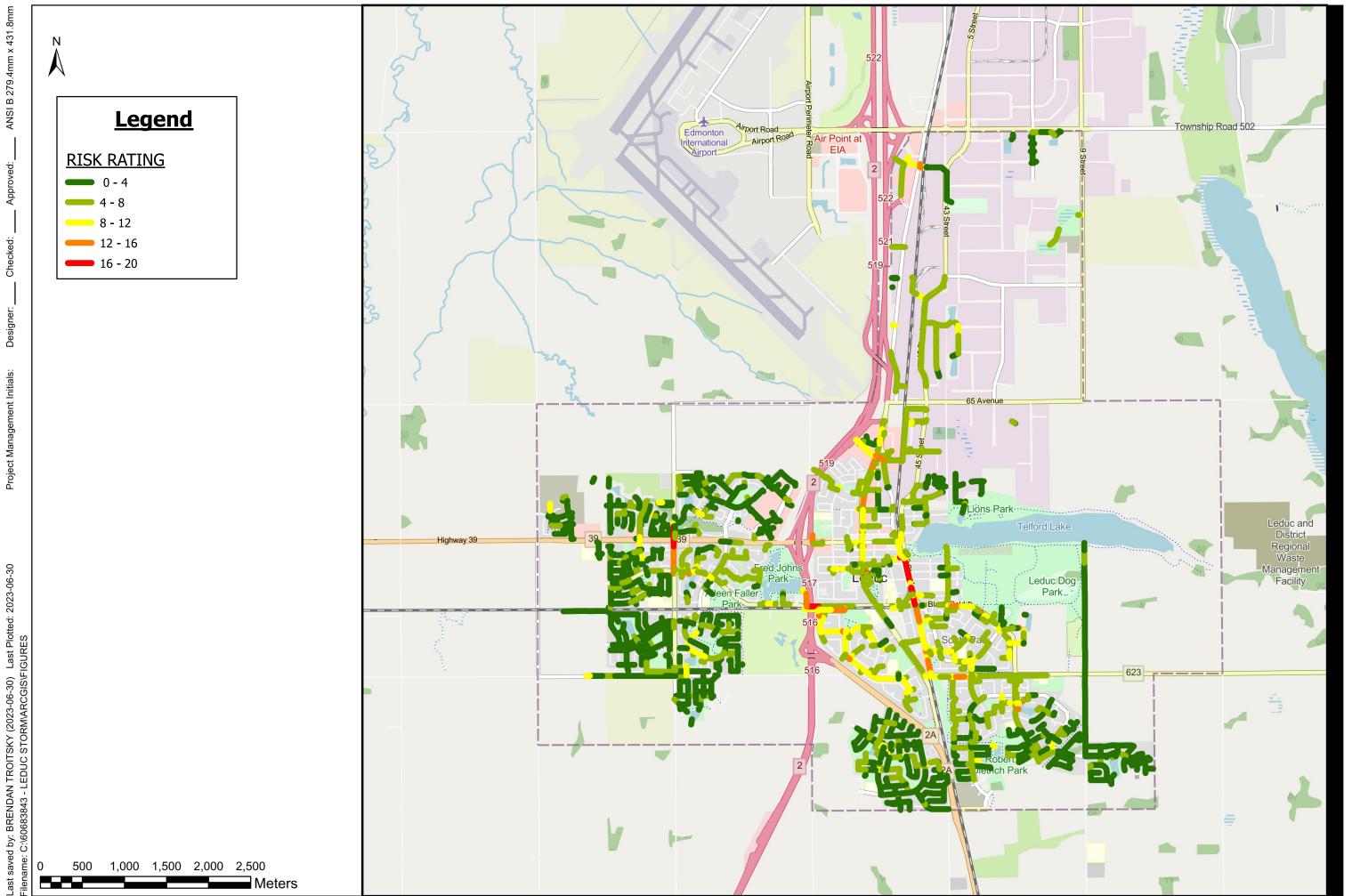
Image 8.2. Percent of System by Risk Category

City of Leduc

City of Leduc Stormwater Master Plan Final Report

Based on the assessment, recommendations include the following:

- Consider implementing an inspection program to obtain data on storm sewer structural and maintenance condition, starting with the higher risk storm assets. This will help identify whether proactive repairs and/or intervention are required, or confirm whether the asset is in reasonable condition and its likelihood of failure rating can be lowered accordingly.
- Consider regularly updating this assessment as data is collected and information changes. This will help continuously concentrate asset management resources on the most high risk and critical infrastructure.
- Review critical storm infrastructure against critical sanitary infrastructure, to identify any overlap between systems and whether inspection and rehabilitation programs can be synergized.



Checked:

Designer:



STORM SEWER CONDITION ASSESSMENT CRITICAL INFRASTRUCTURE (RISK PROFILE) MAP PLAN VIEW

Project No.: 60683843

CITY OF LEDUC

STORMWATER MASTER PLAN

City of Leduc Stormwater Master Plan Final Report

9. Public Consultation

The public consultation plan has been developed in consultation with the City and will include the following:

- Development of a brochure mailer that includes general stormwater management information that could be provided via mail or directly to residents at public events such as a market.
- Development of a website that includes more detailed information on stormwater management within the City.

The overall goal is to provide residents with easily accessible information on the stormwater management system. The brochure and content for the webpage are provided in **Appendix K**. It is recommended to treat the website as a living document and update with new information becomes available that would be applicable for the website.

10. Cost Estimates

The following sections detail the costs for recommended system improvements. Costs were developed in 2023 construction dollars; a detailed breakdown is provided in **Appendix L**.

10.1 Funding Mechanisms

For each of the proposed system improvements and expansions, the associated payment method was reviewed. Typically funding comes from one of three sources:

- City: Improvements required to benefit the existing system to be paid from the City's capital budget.
- Off-Site Levies: Future system expansions, including off-site or downstream improvements to the existing stormwater system to support new development will be paid through off-site levies.
- <u>Developer</u>: New stormwater systems required to service future development will be paid by developers.

10.2 Cost Estimates – Hydraulic Improvements

The total costs for the conceptual hydraulic system improvements are summarized in Table 10.1. Costs for hydraulic system improvements include pipe supply, installation, and restoration costs unless noted otherwise. Cost estimates include a 25% for contingency and 15% for engineering fees. All hydraulic improvements are required to benefit the existing system, and would be paid under the City's capital budget.

Table 10.1 Cost Estimate Summary: Hydraulic Improvements

Number	Neighbourhood	Description Summary	Upgrade	Cost to City (\$)
Recomm	endations			
R-1	Corinthia Park	Proposed Dry Pond south of CP Rail and east of QEII	1,500 m ³ Dry Pond and Inlet/Outlets	\$316,000
R-2	South Park	Local Improvements (41B Street, from Black Gold Drive to 43b Ave)	50 m of 600 mm Storm Sewer Upsizing	\$376,000
R-3	Linsford	Proposed Dry Pond in Linsford Park School	13,000 m ³ Dual-use Dry Pond and Inlet/Outlets	\$4,665,000
R-3	Linsford	Storm Sewer Upgrade downstream of Dry Pond (46 Ave, from 51 Street to 50 Street)	100 m of 1050 mm Storm Sewer Upsizing	\$747,000
R-3	Linsford	Back Alley Storm Sewer	270 m of 600 mm New Storm Sewer	\$643,000
R-4	65th Ave	Sparrow Drive and 65 Ave Sewer Upgrade & New CP Rail Culvert	190 m of 600 mm New Storm Sewer 30 m of 600 mm Culvert	\$871,000
R-5	Willow Park	New Main along 54 Street, from 55 Ave to 57 Ave	305 m of 600 mm New Storm Sewer	\$699,000
R-6	Willow Park	New Main along 52 Street, from 52 Ave to 56 Ave	410 m of 600 mm New Storm Sewer	\$1,069,000
R-7	Willow Park	New Main along 51 Street, from 52 Ave to 54 Ave	235 m of 1050 mm New Storm Sewer	\$881,000
R-8	Lakeside Estates	Lakeside Estates Swale – William Bradbury Place to Black Gold Drive	45 m Swale through PUL	\$118,000
R-9	Caledonia	Caledonia Park Swale - 37 Ave, 41 Street to 42 Street Swale	75 m Swale through PUL	\$87,000
TOTAL (I	Recommended U	ogrades)		\$10,472,000

City of Leduc Stormwater Master Plan Final Report

Number	Neighbourhood	Description Summary	Upgrade	Cost to City (\$)
Future Re	ecommendations	/ Considerations		
C-1	South Park	Twin Main along CP Rail from Rollyview Road to Telford Lake	1500 m of 1350 mm Storm Sewer Twinning	\$10,356,000
C-2	50th Street/ Willow Park	Twin 50 Street Sewer from 54 Avenue to 60 Avenue, and across QEII	1400 m of 1200 mm Storm Sewer Twinning	\$9,191,000
C-3	Leduc Estates	Grant MacEwan Storm Upgrade, Black Gold Drive to Deer Creek & Orifice Upgrade	560 m of 1050 mm Storm Sewer Upsizing	\$4,682,000
TOTAL (Future Recommended Upgrades)				\$24,229,000

10.3 Cost Estimates – Operational Improvements

For the geotechnical assessments of four outfalls (Outfalls 298, 873, 3040 and 3507), it is recommended to carry a \$100,000 budget for assessment.

It is recommended to carry a budget of \$30,000 for the erosion assessment.

The total costs for the proposed Stormceptors are summarized in Table 10.2. Cost estimates include 25% for contingency and 15% for engineering.

Table 10.2: Cost Estimate Summary: Stormceptors

No.	Location	Discharge Body	Estimated Catchment Area (ha)	Cost
1	George Liggins Park	Telford Lake	20	\$375,000
2	South Telford	Telford Lake	30	\$400,000
3	South Park	Telford Lake	120	\$525,000

10.4 Stormwater Flat Rate Assessment

A stormwater rate (also known as a stormwater utility) is a financing system that allocates charges to individual properties and is administered as a user fee, in a similar fashion as a water/wastewater rate. The fee for a stormwater rate is typically applied on a month basis. The City of Leduc currently charges a stormwater rate of \$5.50 per month per user. The basic calculation for a stormwater rate is the municipal stormwater program expense divided by the number of billing units within the municipality.

Based on the proposed storm improvements in each development condition, the required stormwater rate was calculated and is shown in Table 10.1, at various levels of project funding amounts as described in the table.

Notes on the assessment:

- Willow Park improvements were excluded because funding for those improvements is currently included in the capital plan.
- The duration of funding was assumed to be 30 years (360 months)
- The total accounts was assumed to be 13,123, based on an estimated average throughout the 30 years.
- The 'New Amount' presented does not include the currently applied fee (\$5.50).

Table 10.3 Stormwater Flat Rate Assessment

Description	R Improvements Only	R&C Improvements	R Improvements plus Dredging	R&C Improvements plus Dredging
Stormwater Fee	\$9,423,000	\$33,652,000	\$34,423,000	\$58,652,000
Cost per Account	\$718	\$2,564	\$2,623	\$4,469
New Amount	\$1.99	\$7.12	\$7.29	\$12.42

It should be noted that these rates are intended to be order of magnitude only, and do not take into consideration factors such as inflation and costs of borrowing.

11. Recommended Staging and Implementation Plan

The City's stormwater management system is an integrated network that collects and conveys stormwater that falls throughout the City and upstream areas that drain to Deer Creek, Telford Lake, or Saunders Lake, and eventually to Whitemud or Blackmud Creek. The system utilizes a minor collection, major overland system, 32 stormwater management facilities, ditch and culvert systems, two creeks, the reservoir, and Telford Lake to manage the drainage. The above sections provide a detailed description of the overall system assessment and results of the stormwater management plan and assessment. The following sections provide a summary of the improvements and recommendations discussed thought this report, with the goal of integrating the overall recommendations for the system, including recommendations for:

- Hydraulic Improvements
- Deer Creek Improvements
- Telford Lake Improvements
- Stormwater Quality Improvements
- Condition Assessment Improvements

11.1 Hydraulic Improvements

Normally, staging and implementation plans assess future development and the impact it has on the existing system and provides a timeline for system improvements as development proceeds. The City of Leduc's future development areas are situated such that stormwater can be discharged without a significant impact to existing development areas.

The City does not have a history of significant flooding, and during the recent 2021 event, flooding was contained to streets. Therefore, the proposed stormwater improvements (R-1 through R-9) discussed in Section4.3 can be completed in tandem with roadway improvements to save on improvements costs and disruption to the general public. It should be noted that while flooding has not been an issue in the past, a 100 year event has not occurred recently, in which the assessment has shown that a flood risk exists in some areas.

The proposed Future Upgrades (C-1 through C-3) are larger upgrades and require more significant investment that the more localized upgrades. However, as discussed in Section 8, the future upgrades were identified as having the highest likelihood and consequence of failure within the minor drainage system. It is therefore recommended to begin budgeting for upgrade projects in these locations.

While hydraulic improvements were not recommended for the ponding in front of the Fire Hall, it is recommended to identify the risk of ponding near the Fire Hall in the City's Emergency Response Plan. This should include identification of alternate emergency access routes from the rear doors of the Fire Hall should ponding depths on 50 Street restrict access to and from the front doors.

11.2 Deer Creek Improvements

Deer Creek was assessed hydraulically and from a geomorphological perspective as discussed in Section 5. Hydraulically, it is not anticipated that the creek will spill to adjacent communities during the 100 year event (4 or 24 hour), however, development has occurred within meters of the creek within Deer Valley and Bridgeport, and it is recommended to monitor erosion in these areas, and construct with a larger setback in the future.

To determine an appropriate setback from the creek, the creek was assessed for areas of current erosion. The likelihood of potential movement of the creek was assessed, which was used to develop a meander belt for the Creek.

City of Leduc

City of Leduc Stormwater Master Plan Final Report

The surficial geology has a moderate to high erodibility and is dominated by fines (clay, silt, and sand). The riparian zone is largely limited to tall grasses. Finally, many debris jams are present along the entire water course especially in areas with forest cover. This has led to bank slumping and bank undercutting widespread throughout the study area, with particular areas of concern the Creekside Ravines subdivision and the residential properties on Ameena Drive, where significant bank undercutting and slumping close to the residential properties was observed.

All reaches within the assessment were classified with a 'Transitional' RGA rating, indicating that instability is frequent and downstream reaches (LD-04 through LD-07) are widening. There is evidence from historical air photos that meander belts are being formed and abandoned.

A preliminary meander belt was developed for the reaches which range from 26.4 m to 46.9 m utilizing the empirical meander belt approach. The wider 46.9 m calculated for LD-4 applies to all downstream reaches within the study area.

Implementation for improvements to Deer Creek are as follows:

- Implement a development setback from Deer Creek (as well as other named and unnamed creeks within the boundary of the City of Leduc) based on a minimum distance for the property line from top of bank or 15 m. If a more accurate setback is desired, the developer can utilize a qualified fluvial morphologist to complete a meander belt assessment utilizing the mapping approach.
- Multiway setbacks are recommended to be determined by a geotechnical assessment to determine the minimum setback from the top of bank.
- Implement an erosion protection and rehabilitation plan for Deer Creek within existing development areas. Areas with undercutting and slumping should be identified, and the areas should be repaired and/or armoured as soon as possible to protect from further creek migration towards residential areas.
- Conduct an erosion threshold assessment to determine the critical hydraulic conditions at which erosion will theoretically entrain bed or bank material.

11.3 Telford Lake

Telford Lake was assessed to determine the concentration of chlorides within the lake, the condition of the outfalls within the lake, sedimentation that has occurred in Telford Lake via bathymetric survey, and the discharge from the existing snow storage site located directly north of Telford Lake.

11.3.1 Chloride Concentrations

The long-term chloride exposure guideline from the *Canadian Water Quality Guidelines for the Protection of Aquatic Life: Chloride* fact sheet is 120 mg/L (CCME, 2011). However, this guideline is based on two species of freshwater mussel indigenous to Ontario freshwater systems and whose range does not extend to Alberta. A search of the Fisheries and Wildlife Management Information System (FWMIS) database was conducted on June 6, 2023 to identify what aquatic species are present in Telford Lake as well as downstream (Saunders Lake and Blackmud Creek). Fathead minnow (*Pimephales promelas*) is shown to be present in Telford Lake and downstream locations, and has a long-term chloride exposure 33 day lethal concentration with 10% mortality (LC₁₀) of 598 mg/L. All chloride concentrations were below this value. The highest concentration was recorded at the weir outlet from the lake on the west end at 180 mg/L, and the lowest concentration recorded was recorded at outfall C at 110 mg/L.

It is recommended that Alberta Environment and Protected Areas be consulted about raising the chloride guideline for Telford Lake to the flat head minnow 33 day LC₁₀ concentration of 598 mg/L.

11.3.2 Outfall Assessment

Based on the outfall condition assessment, AECOM recommends the following specific actions for the City's consideration:

- Take immediate action to perform a geotechnical assessment of Outfalls 298, 873, 3040 and 3507 to determine the extent of voiding and risk of instability to the respective systems.
- Locate Outfall 4347; if covered with debris or sediment deposition, it will not function as intended.
- Confirm if the sandbags at Outfalls 285 and 1593 are intended to function as a weir. If not, then add these
 outfalls to a cleaning program.
- Review the need for hydraulic channel improvements at Outfall 4324. If current vegetation conditions are determined to impact hydraulic function, add the outfall to a cleaning program.
- Perform CCTV on Outfall 1593 to determine the extent of corrosion, and consider relining the asset.
- Perform water quality sampling to identify the need for oil-grit separators.
- Add 9 assets to a cleaning program (assuming Outfalls 285, 1593 and 4324 require cleaning).
- Add 6 assets to a rehabilitation work program (assuming Outfall 1593 requires relining).

11.3.3 Sedimentation Assessment

A bathymetric survey of Telford Lake was conducted in October 2023 by Challenger Geomatics to determine areas where significant sedimentation is occurring in Telford Lake. It was determined that sediment levels in the lake may be as much as 1.6 million m³, with an average of 0.4 m of vegetation above it. This is causing shallow water depths, with some areas having less than 1 m.

It is recommended that dredging of the lake be undertaken as a targeted effort to support the proposed paddling race course. There is an estimated 500,000 m³ of sediment that would need to be removed to support the course, with an estimated cost of \$25 million. Preliminary engineering and environmental studies would need to be completed, with an estimated cost of \$300,000. The dredging program could be implemented over a 10 year period, and the City-owned land at the Telford Lake outlet could be considered as an area for sediment management.

11.3.4 Snow Storage Discharge to Telford Lake

The previous studies conducted by ISL Engineering were reviewed. Based on the studies, in the spring chloride concentrations discharged from the existing snow storage facility exceed chloride concentrations, but as dilution occurs through rainwater, the chloride concentrations drop to acceptable limits. The existing snow storage facility discharges by gravity through a Stormceptor to Telford Lake. It is recommended to construct a pond within the existing snow storage facility that can hold the meltwater and rainwater until sufficient dilution of chlorides occurs.

Based on the high concentrations tested during spring near the existing snow storage facility, it is recommended to conduct additional Telford Lake sampling. The program should start in Spring 2024, and throughout the season sample at various times near the outlets to determine the chloride concentration when snow melt is at its greatest.

11.4 Stormwater Quality

The City should continue its current practices regarding stormwater management facility construction in new development areas. Stormwater management facilities should be designed to retain stormwater runoff such that it can be discharged to the downstream system at 3 L/s/ha, as per the Blackmud/Whitemud Study. The placement of future stormwater management facilities should consider the restrictions as outlined in the Guidelines for Stormwater Management Facility Design within the Primary Bird Hazard Area in the Vicinity of the Edmonton Internation Airport document.

City of Leduc

City of Leduc Stormwater Master Plan Final Report

Stormceptors should be implemented at areas of existing development that do not have upstream water quality enhancement via stormwater management facilities.

LID in future development areas should be implemented on an opportunistic basis during the design stages of future communities. LID can provide stormwater management for the smaller more frequent rainfall events and reduce sediment deposition to the downstream system. The placement of LID features should also consider the Primary Bird Hazard Area, as some LID features can attract nesting birds.

During rehabilitation projects in existing development areas, LID should be considered strategically as space limitations and contributing catchment areas generally govern the application of LID. It is recommended to assess potential locations for LID during road rehabilitation and community redevelopment projects, and implement as appropriate.

11.5 Condition Assessment

The areas with the highest risk, as shown on Figure 8.1, are:

- the storm sewer parallel to CP Rail from approximately 43 Avenue to the Telford Lake outfall,
- the storm sewer along Grant MacEwan Boulevard from Black Gold Drive to Deer Creek, and
- The QEII crossing along Black Gold Drive north of Corinthia.

This should increase the priority the future upgrades (C-1 and C-3), as well as flag an additional upgrade for the QEII crossing along Black Gold Drive. It is understood that upgrading the crossing under QEII is not currently feasible. However, is recommended to re-assess whether an upgrade opportunity is available in the future.

11.6 Improvement and Cost Summary

Table 11.1 summarizes the proposed improvements, as well as the implementation priority. Suggested timings for implementation are indicated below; however, as indicated in the previous sections, the hydraulic improvements are recommended to be coordinated with road restoration projects where possible.

The Willow Park upgrades are identified for immediate implementation to coordinate with the current neighbourhood renewal.

For the C-1 and C-3 projects, they have been identified as having both risks to flooding and condition risks. Due to the high costs of these projects, it has been recommended that they are included in the long term capital plan. However, the condition of these assets should be re-reviewed on an ongoing basis. If condition is found to be deteriorating, the timing of implementation may need to be accelerated.

Table 11.1: Implementation Plan Summary

No.	Neighbourhood	Description Summary	Upgrade	Cost to City (\$)
		Immediate*		•
-	Telford Lake	Geotechnical Assessment of Outfalls	Outfalls 298, 873, 3040 and 3507	\$100,000
R-5	Willow Park	New Main along 54 Street, from 55 Ave to 57 Ave	305 m of 600 mm New Storm Sewer	\$699,000
R-6	Willow Park	New Main along 52 Street, from 52 Ave to 56 Ave	410 m of 600 mm New Storm Sewer	\$1,069,000
R-7	Willow Park	New Main along 51 Street, from 52 Ave to 54 Ave	235 m of 1050 mm New Storm Sewer	\$881,000
-	Deer Creek	Erosion Assessment of Deer Creek	Site specific studies for erosion	\$30,000
	Deer Creek	Formalize standards for approvals, including development setbacks	-	n/a
		Short Term (<10 years	s)	
R-8	Lakeside Estates	Lakeside Estates Swale – William Bradbury Place to Black Gold Drive	45 m Swale through PUL	\$118,000
R-9	Caledonia	Caledonia Park Swale - 37 Ave, 41 Street to 42 Street Swale	75 m Swale through PUL	\$87,000
D-1	Telford Lake	Dredging Study	Telford Lake	\$300,000
S-1,2,3	Telford Lake	Stormceptors	George Liggins Park, South Telford, South Park	\$1,300,000
		Medium/Long Term Recommended Impro-	vements (10-25 years)	
R-1	Corinthia Dry Pond	Surge Pond + Inlet/Outlet Structure	1,500 m ³ Dry Pond and Inlets/Outlets	\$316,000
R-2	South Park	Local Improvements (41B Street, from Black Gold Drive to 43b Ave)	50 m of 600 mm Storm Sewer Upsizing	\$376,000
R-3	Linsford	Proposed Dry Pond in Linsford Park School	13,000 m³ Dual-use Dry Pond and Inlet/Outlets	\$4,665,000
R-3	Linsford	Storm Sewer Upgrade downstream of Dry Pond (46 Ave, from 51 Street to 50 Street)	100 m of 1050 mm Storm Sewer Upsizing	\$747,000
R-3	Linsford	Back Alley Storm Sewer	270 m of 600 mm New Storm Sewer	\$643,000

City of Leduc Stormwater Master Plan Final Report

No.	Neighbourhood	Description Summary	Upgrade	Cost to City (\$)
R-4	65th Ave	Sparrow Drive and 65 Ave Sewer Upgrade &	190 m of 600 mm New Storm	\$871,000
		New CP Rail Culvert	Sewer, 30 m of 600 mm Culvert	
		Medium/Long Term Considered Improver	ments (10-25+ years)	
C-1	South Park	Twin Main along CP Rail from Rollyview	1500 m of 1350 mm Storm	\$10,356,000
		Road to Telford Lake	Sewer Twinning	
C-2	50th Street/	Twin 50 Street Sewer from 54 Avenue to 60	1400 m of 1200 mm Storm	\$9,191,000
	Willow Park	Avenue, and across QEII	Sewer Twinning	
C-3	Leduc Estates	Grant MacEwan Storm Upgrade, Black Gold	560 m of 1050 mm Storm Sewer	\$4,682,000
		Drive to Deer Creek & Orifice Upgrade	Upsizing	
TOTAL (Hydraulic & Operational Upgrades)				\$36,431,000

^{*} Immediate Upgrades currently funded. Not included in rate calculation in Section 10.4.

As discussed in Section 6.3, dredging options for Telford Lake were considered. Based on the estimated sediment loading, dredging the entire lake would cost an estimated \$80-100 million. It is recommended that targeted dredging efforts be undertaken, to include the west bay of the lake, as well as the area required support for the paddling race course proposed in the Telford Lake Master Plan . This would involve removal of approximately 515,000 m³ of sediment, which is approximately 30% of the total lake sediment levels. The cost for a reduced program would be in the range of \$25 million. If the sediment exceeds contamination guidelines and requires disposal at a landfill, the costs would be expected to double. It is recommended that a sampling program be undertaken in advance to confirm contaminant levels.

Finally, based on the results of the erosion assessment of Deer Creek, funds will likely be required to provide erosion mitigation within the Creek. Prior to the study, it is difficult to quantify the required funds but it is recommended to carry a minimum \$500,000 for erosion mitigation measures.

Appendix A.

Manhole Survey Diagrams

Attached as a separate file

Figure List

Figure A1 – Manhole & Catch Basin Details (Figure 1 of 3)

Figure A2 – Manhole & Catch Basin Details (Figure 2 of 3)

Figure A3 – Manhole & Catch Basin Details (Figure 3 of 3)

City of Leduc Stormwater Master Plan Final Report

Appendix B. Model Setup and Calibration – Supplementary Letter

Attached as a Separate File

Figure List

Figure B1 – Calibration Results May 2021 Event (Figure 1 of 2)

Figure B2 – Calibration Results May 2021 Event (Figure 2 of 2)

Figure B3 – Major System Calibration Results July 4-6, 2022 Event (Figure 1 of 3)

Figure B4 – Major System Calibration Results July 4-6, 2022 Event (Figure 2 of 3)

Figure B5 – Major System Calibration Results July 4-6, 2022 Event (Figure 3 of 3)

Appendix C. Hydraulic Assessment Figures

Attached as a Separate File

Figure List

```
Figure C1 – Existing Minor System Assessment – 5 Year 4 Hour Rainfall Event
Figure C2 – Existing Minor System Assessment – 5 Year 24 Hour Rainfall Event
Figure C3 – Existing Minor System Assessment – 100 Year 4 Hour Rainfall Event
Figure C4 - Existing Minor System Assessment - 100 Year 24 Hour Rainfall Event
Figure C5 – Existing Major System Assessment – 5 Year 4 Hour Rainfall Event (Figure 1 of 3)
Figure C6 - Existing Major System Assessment - 5 Year 4 Hour Rainfall Event (Figure 2 of 3)
Figure C7 – Existing Major System Assessment – 5 Year 4 Hour Rainfall Event (Figure 3 of 3)
Figure C8 – Existing Major System Assessment – 5 Year 24 Hour Rainfall Event (Figure 1 of 3)
Figure C9 - Existing Major System Assessment - 5 Year 24 Hour Rainfall Event (Figure 2 of 3)
Figure C10 - Existing Major System Assessment - 5 Year 24 Hour Rainfall Event (Figure 3 of 3)
Figure C11 – Existing Major System Assessment – 100 Year 4 Hour Rainfall Event (Figure 1 of 3)
Figure C12 - Existing Major System Assessment - 100 Year 4 Hour Rainfall Event (Figure 2 of 3)
Figure C13 - Existing Major System Assessment - 100 Year 4 Hour Rainfall Event (Figure 3 of 3)
Figure C14 - Existing Major System Assessment - 100 Year 24 Hour Rainfall Event (Figure 1 of 3)
Figure C15 - Existing Major System Assessment - 100 Year 24 Hour Rainfall Event (Figure 2 of 3)
Figure C16 - Existing Major System Assessment - 100 Year 24 Hour Rainfall Event (Figure 3 of 3)
Figure C17 – Future Minor System Assessment – 5 Year 4 Hour Rainfall Event
Figure C18 – Future Minor System Assessment – 5 Year 24 Hour Rainfall Event
Figure C19 - Future Minor System Assessment - 100 Year 4 Hour Rainfall Event
Figure C20 - Future Minor System Assessment - 100 Year 24 Hour Rainfall Event
Figure C21 - Future Major System Assessment - 5 Year 4 Hour Rainfall Event (Figure 1 of 3)
Figure C22 - Future Major System Assessment - 5 Year 4 Hour Rainfall Event (Figure 2 of 3)
Figure C23 - Future Major System Assessment - 5 Year 4 Hour Rainfall Event (Figure 3 of 3)
Figure C24 - Future Major System Assessment - 5 Year 24 Hour Rainfall Event (Figure 1 of 3)
Figure C25 - Future Major System Assessment - 5 Year 24 Hour Rainfall Event (Figure 2 of 3)
Figure C26 - Future Major System Assessment - 5 Year 24 Hour Rainfall Event (Figure 3 of 3)
Figure C27 – Future Major System Assessment – 100 Year 4 Hour Rainfall Event (Figure 1 of 3)
Figure C28 - Future Major System Assessment - 100 Year 4 Hour Rainfall Event (Figure 2 of 3)
Figure C29 - Future Major System Assessment - 100 Year 4 Hour Rainfall Event (Figure 3 of 3)
Figure C30 – Future Major System Assessment – 100 Year 24 Hour Rainfall Event (Figure 1 of 3)
Figure C31 - Future Major System Assessment - 100 Year 24 Hour Rainfall Event (Figure 2 of 3)
Figure C32 - Future Major System Assessment - 100 Year 24 Hour Rainfall Event (Figure 3 of 3)
Figure C33 - Recommended Upgrades System Assessment - 5 Year 4 Hour Rainfall Event
Figure C34 - Recommended Upgrades Minor System Assessment - 5 Year 24 Hour Rainfall Event
Figure C35 - Recommended Upgrades Minor System Assessment - 100 Year 4 Hour Rainfall Event
Figure C36 - Recommended Upgrades Minor System Assessment - 100 Year 24 Hour Rainfall Event
Figure C37 - Recommended Upgrades Major System Assessment - 5 Year 4 Hour Rainfall Event (Figure 1 of 3)
Figure C38 - Recommended Upgrades Major System Assessment - 5 Year 4 Hour Rainfall Event (Figure 2 of 3)
Figure C39 – Recommended Upgrades Major System Assessment – 5 Year 4 Hour Rainfall Event (Figure 3 of 3)
Figure C40 - Recommended Upgrades Major System Assessment - 5 Year 24 Hour Rainfall Event (Figure 1 of 3)
Figure C41 - Recommended Upgrades Major System Assessment - 5 Year 24 Hour Rainfall Event (Figure 2 of 3)
```

Figure C42 - Recommended Upgrades Major System Assessment - 5 Year 24 Hour Rainfall Event (Figure 3 of 3)

City of Leduc

City of Leduc Stormwater Master Plan Final Report

```
Figure C43 – Recommended Upgrades Major System Assessment – 100 Year 4 Hour Rainfall Event (Figure 1 of 3)
Figure C44 - Recommended Upgrades Major System Assessment - 100 Year 4 Hour Rainfall Event (Figure 2 of 3)
Figure C45 - Recommended Upgrades Major System Assessment - 100 Year 4 Hour Rainfall Event (Figure 3 of 3)
Figure C46 - Recommended Upgrades Major System Assessment - 100 Year 24 Hour Rainfall Event (Figure 1 of 3)
Figure C47 - Recommended Upgrades Major System Assessment - 100 Year 24 Hour Rainfall Event (Figure 2 of 3)
Figure C48 - Recommended Upgrades Major System Assessment - 100 Year 24 Hour Rainfall Event (Figure 3 of 3)
Figure C49 - Future Upgrades System Assessment - 5 Year 4 Hour Rainfall Event
Figure C50 – Future Upgrades Minor System Assessment – 5 Year 24 Hour Rainfall Event
Figure C51 - Future Upgrades Minor System Assessment - 100 Year 4 Hour Rainfall Event
Figure C52 - Future Upgrades Minor System Assessment - 100 Year 24 Hour Rainfall Event
Figure C53 - Future Upgrades Major System Assessment - 5 Year 4 Hour Rainfall Event (Figure 1 of 3)
Figure C54 - Future Upgrades Major System Assessment - 5 Year 4 Hour Rainfall Event (Figure 2 of 3)
Figure C55 - Future Upgrades Major System Assessment - 5 Year 4 Hour Rainfall Event (Figure 3 of 3)
Figure C56 - Future Upgrades Major System Assessment - 5 Year 24 Hour Rainfall Event (Figure 1 of 3)
Figure C57 - Future Upgrades Major System Assessment - 5 Year 24 Hour Rainfall Event (Figure 2 of 3)
Figure C58 - Future Upgrades Major System Assessment - 5 Year 24 Hour Rainfall Event (Figure 3 of 3)
Figure C59 - Future Upgrades Major System Assessment - 100 Year 4 Hour Rainfall Event (Figure 1 of 3)
```

Figure C60 – Future Upgrades Major System Assessment – 100 Year 4 Hour Rainfall Event (Figure 2 of 3) Figure C61 – Future Upgrades Major System Assessment – 100 Year 4 Hour Rainfall Event (Figure 3 of 3) Figure C62 – Future Upgrades Major System Assessment – 100 Year 24 Hour Rainfall Event (Figure 1 of 3) Figure C63 – Future Upgrades Major System Assessment – 100 Year 24 Hour Rainfall Event (Figure 2 of 3) Figure C64 – Future Upgrades Major System Assessment – 100 Year 24 Hour Rainfall Event (Figure 3 of 3)

Appendix D. IDF Assessment Figures

Attached as a Separate File

Figure List

Figure D1: IDF Analysis – Leduc Current Standards – Existing System 100 Year 4 Hour Figure D2: IDF Analysis – Leduc Current Standards – Existing System 5 Year 4 Hour Figure D3: IDF Analysis – EPCOR 2022 Standards – Existing System 100 Year 4 Hour Figure D4: IDF Analysis – EPCOR 2022 Standards – Existing System 5 Year 4 Hour

Appendix E. Climate Change Assessment – Supplementary Letter

Attached as a Separate File

Figure List

```
Figure E1: Climate Analysis – Blatchford Station – 8.5 Projection – 100 Year 4 Hour (1 of 3) Figure E2: Climate Analysis – Blatchford Station – 8.5 Projection – 100 Year 4 Hour (2 of 3) Figure E3: Climate Analysis – Blatchford Station – 8.5 Projection – 100 Year 4 Hour (3 of 3) Figure E4: Climate Analysis – Blatchford Station – 8.5 Projection – 100 Year 24 Hour (1 of 3) Figure E5: Climate Analysis – Blatchford Station – 8.5 Projection – 100 Year 24 Hour (2 of 3) Figure E6: Climate Analysis – Blatchford Station – 8.5 Projection – 100 Year 24 Hour (3 of 3) Figure E7: Climate Analysis – EIA Station – 8.5 Projection – 100 Year 4 Hour (1 of 3) Figure E8: Climate Analysis – EIA Station – 8.5 Projection – 100 Year 4 Hour (3 of 3) Figure E9: Climate Analysis – EIA Station – 8.5 Projection – 100 Year 24 Hour (1 of 3) Figure E10: Climate Analysis – EIA Station – 8.5 Projection – 100 Year 24 Hour (2 of 3) Figure E11: Climate Analysis – EIA Station – 8.5 Projection – 100 Year 24 Hour (2 of 3) Figure E12: Climate Analysis – EIA Station – 8.5 Projection – 100 Year 24 Hour (2 of 3)
```

Appendix F. Deer Creek Cross Sections

Attached as a Separate File

Figure List

Figure F1: Deer Creek North Plan Figure F2: Deer Creek South Plan

Figure F3: Deer Creek North Sections (1 of 3) Figure F4: Deer Creek North Sections (2 of 3) Figure F5: Deer Creek North Sections (3 of 3)

Figure F6: Deer Creek South Sections

Appendix G. Geomorphological Assessment

Attached as a Separate File

Figure List

Figure G1: Fluvial Geomorphology Report - Study Area

Figure G2: Fluvial Geomorphology Report – Identified Reaches (Figure 1 of 2)

Figure G3: Fluvial Geomorphology Report – Identified Reaches (Figure 2 of 2)

Figure G4: Fluvial Geomorphology Report – Cross Sectional Locations (Figure 1 of 2)

Figure G5: Fluvial Geomorphology Report – Cross Sectional Locations (Figure 2 of 2)

Figure G6: Fluvial Geomorphology Report – Meander Belt

Appendix H. Telford Lake Sampling Program

Attached as a Separate File

Figure List

Figure H1: Telford Lake Site Plan
Figure H2: Telford Lake Outfall Area A
Figure H3: Telford Lake Outfall Area B
Figure H4: Telford Lake Outfall Area C
Figure H5: Telford Lake Outfall Area D
Figure H6: Telford Lake Outfall Area E
Figure H7: Telford Lake Outfall Area O

Analytic Tables & Laboratory Results

FWMIS Search

City of Leduc Stormwater Master Plan Final Report

Attached as a Separate File

Figure List

Figure I1: Telford Lake Outfall Conditional Assessment

Appendix I. Outfall Condition Assessment

Appendix J. Minor System Condition Assessment

Attached as a Separate File

Figure List

Figure J1: Storm Sewer Likelihood of Failure Map Figure J2: Storm Sewer Consequence of Failure Map Figure J3: Storm Sewer Critical Infrastructure Map

Appendix K. Communications Documentation

Attached as a Separate File

Appendix L. Cost Estimates

Attached as a Separate File

