Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

REVISED

GREATER EAST HILL AREA MASTER DRAINAGE PLAN
RED DEER, ALBERTA

Report Prepared for:
THE CITY OF RED DEER

Prepared by:
MATRIX SOLUTIONS INC.

September 2017
Edmonton, Alberta

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REVISED

EAST HILL MASTER DRAINAGE PLAN

RED DEER, ALBERTA

Report prepared for the City of Red Deer, September 2017

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APEGA Permit to Practice
Permit No. P5540

DISCLAIMER

ABBREVIATIONS

AEP	Alberta Environment and Park
AT	Alberta Transportation
BMP	Best Management Practices
CN	Curve Number
DEM	Digital Elevation Model
ER	Environmental Reserve
FSS	Functional Sanitary and Storm Servicing study
IDF	Intensity-Duration-Frequency
LID	Low Impact Development
MASP	Major Area Structure Plan
MDP	Master Drainage Plan
RFP	Request for Proposal
SWM	Stormwater Management
WAIR	Wetland Assessment and Impact Report

EXECUTIVE SUMMARY

The City of Red Deer (the City) retained Matrix Solutions Inc. to develop this Master Drainage Plan (MDP) for the Greater East Hill area of the City of Red Deer. The study area is located within the Red Deer River basin. Part of the study area is located in the Piper Creek watershed and the rest of the study area drains directly into the Red Deer River. In addition to the 1,670 hectares (ha) study area, surface water runoff from an additional offsite area of 2,610 ha flows through the study area, resulting in a storm drainage area of 4,280 ha. Figure ES-1 shows the study area and the storm drainage boundary for this study. The guiding principles used in the development of this MDP align with Alberta Environment and Parks (AEP)'s objectives.

In general, the MDP considers that each quarter section will have its own stormwater management (SWM) facility. This MDP addresses the drainage design criteria and SWM requirements for the study area. This includes determining the allowable release rates from future development areas draining to Red Deer River, Piper Creek, and various ravines, as well as providing adequate storage and treatment for stormwater flows before being discharged and planning for trunk storm sewer systems to convey stormwater to respective outfalls.

Stormwater flows from the future developed areas will be routed through SWM ponds before being discharged. As the study area is located on multiple watersheds, different release rates are proposed based on outlet locations. The recommended allowable release rates are as follows:

Land Area	1:100-year Release Rate (L/s/ha)	1:5-year Release Rate (L/s/ha)
Draining directly through outfalls into Piper Creek	3.6 L/s/ha	1.8 L/s/ha
Draining directly through outfalls into Ravines/Wetlands	3.6 L/s/ha	1.8 L/s/ha
Draining directly through outfalls into the Red Deer River	9.0 L/s/ha	3.5 L/s/ha

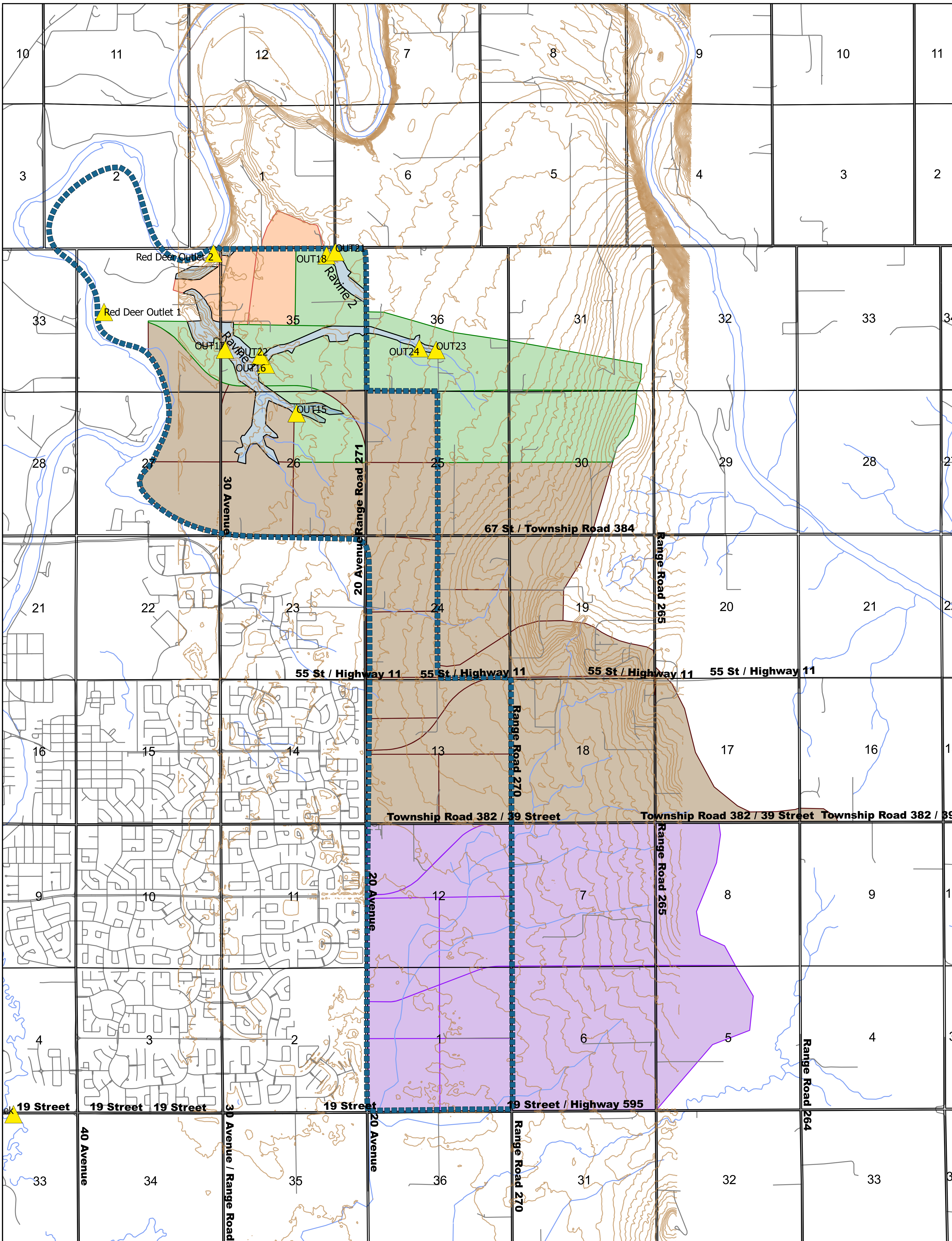
These release rates are recommended based on the findings of the pre-development flow analysis and desktop review of the hydraulic and morphologic characteristics of the Red Deer River, Piper Creek, and any of the tributary ravines that receive runoff from the study area. In order to achieve the allowable release rates, all stormwater flows from the future developed areas will be routed through SWM ponds before being discharged into Red Deer River, Piper Creek, or any of the tributary ravines. Appropriate mitigation measures at each outfall location will be incorporated to minimize any adverse effect to receiving water bodies.

A desktop wetland assessment was conducted to identify and classify wetlands within the study area that may be affected by future developments. Where disturbance of semi-permanent and permanent wetlands is unavoidable, proposed SWM facilities have been aligned adjacent to their locations to reduce future wetland replacement obligations. A sufficient buffer is to be maintained between the SWM facilities and adjacent wetlands and only treated stormwater with acceptable stormwater quality will be discharged to the wetlands to ensure their continued functionality. Forebays will also be used upstream of wetlands to further mitigate potential water quality impacts. Any additional mitigation or compensation for affected or lost wetlands or use of wetlands as SWM facilities should be incorporated during the planning phase of the future developments in accordance with regulatory requirements. Environmental Reserve (ER) should be placed on all wetlands that are not affected by the developments. Wetland impact assessments and a plan for the protection of wetlands should be included as part of the SWM plan as development progresses.

A PCSWMM model developed for post-development conditions includes sizing for SWM facilities, orifices sized to control peak outflows to the allowable release rates, and design details for a trunk sewer system to convey outflows to designated outlet locations. A comparison of the allowable release rates with the modelled outflows from the SWM facilities indicates that modelled outflows are very similar to pre-development release rates.

Figure ES-2 presents the overall SWM plan schematically for the study area. The developed storm drainage plan is briefly described based on the receiving water bodies.

It is recommended that this MDP be adopted as a framework for developments within the basin and be submitted to AEP for approval under the *Water Act*.



StudyArea-Matrix

Contours-5m

Roads

Ravines

Watercourse

Proposed Future Catchments

Piper

Ravine

RedDeer1

RedDeer2

Proposed Outlets

N

0 500 1000 1500 m

1:40,000

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Greater East Hill
Master Drainage Plan
City of Red Deer, Alberta

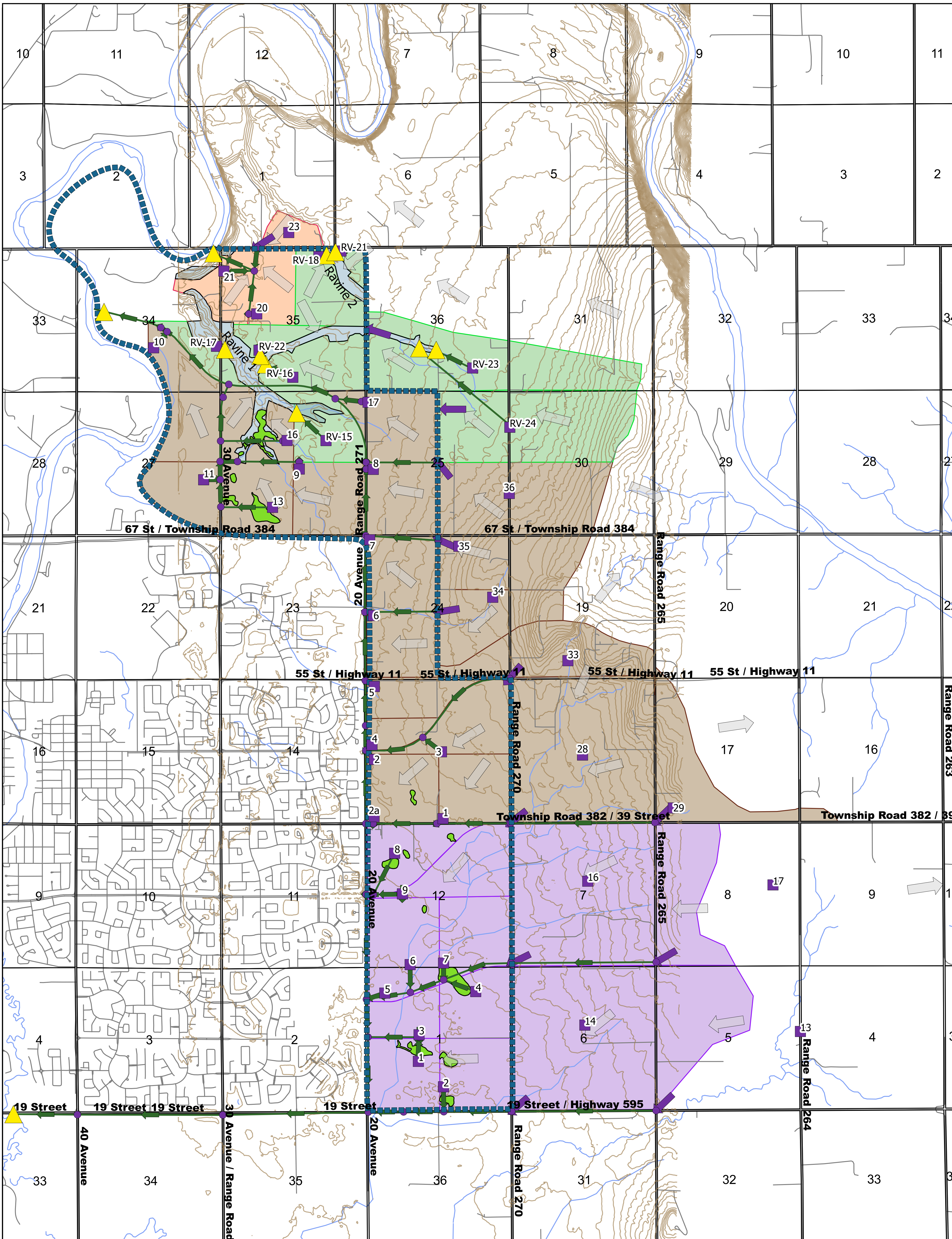
Matrix Project #23973

Study Area

Disclaimer: The information contained herein may be compiled from numerous third party materials that are subject to periodic change without prior notification. While every effort has been made by Matrix Solutions Inc. to ensure the accuracy of the information presented at the time of publication, Matrix Solutions Inc. assumes no liability for any errors, omissions, or inaccuracies in the third party material.

K. Hofbauer
M. Shome

ES-1



StudyArea-Matrix
Proposed Manholes
Proposed Pipes
Proposed Ponds
Proposed Outlets
External Inlets
Contours-5m
Flow Directions
Roads
Ravines
Watercourse
Semi- and Permanent Wetlands

Proposed Future Catchments
Piper
Ravine
RedDeer1
RedDeer2

0 500 1000 1500 m

1:40,000

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Greater East Hill
Master Drainage Plan
City of Red Deer, Alberta

Matrix Project #23973

Stormwater Management Plan

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1 INTRODUCTION

Matrix Solutions Inc. is pleased to provide a Master Drainage Plan (MDP) for the Greater East Hill area for the City of Red Deer (the City). This report has been prepared in accordance with the Request for Proposal (RFP) Number 1090-ENG-T16-236, issued on August 3, 2016, by the City.

The study area is located within the Red Deer River basin. Part of the study area is located in the Piper Creek watershed, which is a subwatershed of Waskasoo Creek (a tributary of the Red Deer River). The rest of the study area drains into the Red Deer River via overland flow or via several ravines. Map 1 depicts the study area with a general overview of the proposed drainage areas and outlet locations.

As the development within the City generally proceeds on a quarter section basis, the MDP considers that, in general, each quarter section that will be developed will have its own stormwater management (SWM) facility.

1.1 Objective and Scope of Work

The purpose of the project was to provide the City of Red Deer (the City) with a MDP for the Greater East Hill area that will work as an overall drainage and SWM framework for future developments within the Greater East Hill study area and satisfy the requirements of Alberta Environment and Parks (AEP). The MDP will also serve as a guiding document for capital budget expenditure planning. The MDP outlines SWM and regulatory requirements, and may be submitted to support regulatory applications.

Matrix's scope of work was guided by requirements set out in the RFP and included the following tasks:

- reviewing existing conditions
- identifying potential wetland areas
- land surveying
- delineating drainage basins for the study area
- computing pre-development runoff rates
- determining post-development release rates
- identifying SWM facility release rates
- identifying outfall locations
- delineating total contributing catchment area to each outfall
- determining the total catchment area for each SWM facility
- charting 1:100-year, 24-hour post-development hydrographs at each SWM facility and outfall
- identifying potential impacts on existing infrastructure or stakeholders and providing remediation options, if necessary
- determining pond sizes and trunk main sizes
- documenting proposed modelled stormwater pond size and simulated design flood levels, design peak inflows, and simulated discharges

- providing a list of all pond characteristics
- preparing a summary report

1.2 Report Outline

To complete the identified tasks and satisfy the MDP objective, Matrix completed the following stages, which are summarized accordingly within this report.

- Section 2: Background Review
  - A review of existing documents and data was completed. This included criteria and guidelines applicable to the project, and relevant previously completed studies.
- Section 3: Existing Conditions
  - A comprehensive gathering of information about the study area's current conditions, including topography, land use, and drainage features.
- Section 4: Wetland Assessment
  - Completion of a desktop wetland assessment, including classification, and regulatory context.
- Section 5: Pre-development and Allowable Release Rates
  - Analysis of a number of different methods for calculating pre-development flow rates, and presentation of recommended allowable release rates.
- Section 6: Proposed Master Drainage Plan
  - A presentation of the proposed drainage plan concept including catchment delineation, hydraulic modelling processes, proposed SWM ponds, and required trunk sewer conceptual design.
- Section 7: Implementation Plan
- Section 8: Regulatory Applications
  - Discussion of regulatory applications that will be required for completion of the recommended works.
- Section 9: Conclusions and Recommendations

2 BACKGROUND REVIEW

2.1 Overview of Stormwater Management Development

Several key factors need to be considered in developing an environmentally friendly and cost-effective SWM plan for an area. These factors include an understanding of the effect of urbanization, SWM philosophy stipulated by the regulatory requirements, stormwater quality requirements, and enhancement and consideration of best management practices (BMPs) such as low impact developments. These factors are briefly described below.

2.1.1 Effect of Urbanization

Urbanized areas present more complex challenges for managing stormwater than those for natural or rural areas, and the complexity increases with size. Urban areas have increased imperviousness, varying land uses, buildings, topography, underground and aboveground surface drainage routes, and surface water management facilities that affects drainage patterns and water quality. Peak flows in developed areas will typically increase compared to pre-development conditions, which could cause increased flooding frequency and severity and erosion. Thus, SWM facilities are designed to store water and release it at the pre-development flow rate so that natural flow conditions can be maintained downstream of the development and mitigate potential effects.

2.1.2 Stormwater Management Philosophy

The development will require SWM BMPs to mitigate potential water quantity and quality effects on the watershed and satisfy regulatory requirements. Stormwater BMPs that may be considered for stormwater quantity and quality controls include the following:

- low-impact development (e.g., bioretention use, green roofs, and stormwater reuse)
- source control (e.g., pollution prevention strategies)
- lot level (e.g., buffer strips or oil/grit separators)
- conveyance system (e.g., grass swales)
- end-of-pipe (e.g., dry ponds, wet ponds, or constructed wetlands)

2.1.3 Stormwater Quality Requirements and Enhancement

The SWM system for the Greater East Hill development area will consist of a minor system, including drainage pipes, catch basins, road gutters and swales, to carry 1:5-year event and a major system to capture runoff generated in excess of the minor system capacity. The major system will consist of SWM facilities as well as the components in the minor system.

The SWM facilities will be designed and configured to improve water quality of the released water. The *Stormwater Management Guidelines for the Province of Alberta* (Alberta Environmental Protection

1999) state that SWM facilities must be designed to remove a minimum of 85% of particles 75 µm in diameter and larger.

2.2 Criteria and Guidelines

This MDP is guided by criteria set out by AEP, the City of Red Deer and also Red Deer County. The following sub-sections summarize the applicable guidelines that have directed this study. The regulatory requirements and design basis for the MDP were confirmed through a meeting (October 4, 2016) and ongoing communication with AEP and the City. Based on this correspondence, the MDP must meet the following criteria (the source of each criteria is provided in brackets).

- provide a minimum of one SWM facility for each quarter section with a maximum catchment area of one quarter section per SWM facility (City request)
- design to the 1:100-year, 24-hour rainfall event using the City's intensity-duration-frequency (IDF) curves (City of Red Deer Engineering Design Guidelines, 2016)
- allowable release rate for each SWM facility will be limited to the approved maximum release rate based on the estimated pre-development flows rates in the study area (Alberta Environmental Protection 1999)
- consider the City of Red Deer engineering design guidelines (2016) and the *Stormwater Management Guidelines for the Province of Alberta* (Alberta Environmental Protection 1999), including, but not limited to:
    - minor system (pipe network) should convey runoff from up to the 1:5-year return period (if applicable)
    - major system should convey runoff in excess of the minor system, up to the 1:100-year return period
    - modelling design parameters
    - SWM facility design parameters
- maintain emergency spillway provisions (City of Red Deer Engineering Design Guidelines 2016, 2010)
- protect wetland areas from development if possible by being dedicated as an Environmental Reserve (ER) status by the City; otherwise minimize effect on wetlands and mitigate as required, satisfying all applicable regulatory requirements, including the AEP (2016) *Alberta Wetland Restoration Directive*.

Other guiding principles of this study include the following:

- operate SWM systems efficiently and effectively by controlling water quantity and improving water quality
- prevent erosion, flooding and decreased water quality of receiving water bodies

- protect the natural environment by controlling erosion and sedimentation during construction, operation, and maintenance of the stormwater drainage system
- protect water quality in the receiving water bodies including wetlands
- use of BMPs
- protect riparian and natural environments

2.3 Relevant Previous Studies

Matrix reviewed the relevant background reports for the project including the following information from the relevant studies was used to inform parts of the MDP and each study is referenced within this MDP report where appropriate.

2.3.1 2009 Functional Servicing Study (Stantec 2011)

Stantec (2011) carried out a functional sanitary and storm servicing study (FSS) for the Greater East Hill area. While the study areas of the FSS study area overlapped with the study area for the current study, the study area for the current project is significantly smaller than that of the FSS. As in the current study, the FSS assumed that each quarter section would be serviced by a neighbourhood SWM facility. Key points of the drainage scheme provided in the Functional Servicing Study include:

- The FSS proposed the following trunk sewer outlets:
  - Along 20th Avenue and Northland Drive outletting to Red Deer River; this sewer outlets to a constructed wetland before discharging into the river.
  - Parallel to the Riverbend Golf Course access road outletting to Red Deer River.
  - To Piper Creek at 19th Street. Due to concerns about sewer depths, the FSS recommended this sewer be routed southerly around the Solid Waste Disposal Facility.
  - Three additional trunk sewers and outlets (two to Red Deer River and one to Piper Creek) were proposed for catchment areas that are largely outside of the current MDP study area.
- The FSS catchment areas indicated that areas south of 39th Street (west of 10th Avenue) and 50th Street (east of 10th Avenue) were intended to discharge to Piper Creek under post-development conditions and remaining areas drain into the Red Deer River.

2.3.2 East Hill Major Area Structure Plan (City of Red Deer 2016a)

The 2013 update to the existing East Hill Major Area Structure Plan (MASP) had three objectives: incorporate 2009 annexation area to the east, complete a full review of the East Hill MASP, and to include direction provided by council on several other planning studies. The City requires neighbourhood area structure plans for each quarter section, which must comply with the East Hill MASP.

2.3.3 City of Red Deer Engineering Services Design Guidelines - 2016 Edition (City of Red Deer 2016b)

The City of Red Deer provides design guidelines on SWM design including: stormwater design, service connections, length of run, lot grading, storm sewer mains (minor system), catch basin and catch basin manholes, culverts major drainage system, dry and wet detention ponds, constructed wetland, natural overland drainage, stormwater treatment units, and miscellaneous design concerns.

2.3.4 City of Red Deer Contract Specifications - 2015 Edition (City of Red Deer 2015)

This document outlines the contract specifications for the following divisions: general requirements, existing conditions, concrete, specialties earthwork, exterior improvements, utilities, transportation, and specification drawings.

2.3.5 Master Drainage Plan for the Wolf Creek and Whelp Brook Watersheds (MPE 2014)

This MDP outlines the criteria for future SWM systems and facilities required for future development. The plan outlines the conveyance of the major and minor system, release rates for SWM facilities based on pre-development discharge rates, sediment removal targets, among other things. The plan also set out best practices which will result in negligible impacts of proposed development within the watershed on Battle River and avoid wetland disturbance.

2.3.6 North Highway Connector Preliminary Design Report (Stantec 2010)

The North Highway connector is the first phase in a project to complete a ring road connecting Highway 2 north and south of the City. Stantec was retained to complete the preliminary design, detailed design and construction management of the North Highway connector in the area of Northland Drive, Gaetz Avenue, 30th Avenue and 67th Street. This report details the preliminary design for the Northland Highway Connector.

2.3.7 Northland Drive/20th Avenue Functional Planning Study (Stantec 2008)

The Northland Drive/20th Avenue Functional Planning Study is the foundation for the preliminary and detailed design for these roadway segments. Some of the objectives relating to drainage include: conduct an assessment of the river crossing, coordinate with the City Engineering’s Utility Section regarding sanitary and storm sewer trunk studies, evaluate stormwater drainage requirements, and review existing and proposed SWM infrastructure.

2.3.8 Red Deer County: Design Guidelines (Tagish Engineering 2010)

This document outlines the design guidelines for the following divisions: general information, constructed and as-constructed drawing standards, engineering services guidelines, area structure plan, servicing study and associated reports, erosion and sediment control measures, site clearing and grading guidelines, water design standards, sanitary design standards, SWM drainage systems, service connections standards, gas, power, telephone, and cable television standards, roadway design standards and landscaping standards.

The design guidelines include a section on SWM drainage systems, providing design guidelines on stormwater design standards, minor and major systems, SWM facilities, miscellaneous design concerns and Wasakoo creek basin SWM pre-development runoff rate.

The *Red Deer County: Design Guidelines* provided information on the AEP approved pre-development flow rate for the Waskasoo watershed (which includes Piper Creek).

2.3.9 Waskasoo Creek and Red Deer Flood Risk Mapping Study (Yaremko 1992)

Yaremko (1992) updated the previously completed flood risk mapping study for Waskasoo Creek according to the specifications of the Canada-Alberta Flood Damage Reduction program and produced flood risk maps for the study area. This report provides a valuable historical perspective of floods in the Waskasoo Creek and its main tributary: Piper Creek.

3 EXISTING CONDITIONS

3.1 Existing Drainage and Water Bodies

Flow within the study area is generally conveyed from east to west via various tributaries of the Red Deer River. Under existing conditions, runoff from the study area is ultimately conveyed to Red Deer River. Catchments within the study area have been delineated based on the initial receiving watercourse, namely Piper Creek, a ravine, or directly to Red Deer River. Lands south of approximately 55th Street (Highway 11) drain southerly to Piper Creek, which is a tributary of Waskasoo Creek, which drains into the Red Deer River. Lands north of this location drain northwesterly to Red Deer River via a number of ravines within the study area. A review of available published documents on topographic data (AAFC 2014) and various reports of the Waskasoo subwatersheds including the *Waskasoo Subwatershed: Red Deer River State of the Watershed Report* prepared by the Red Deer River Watershed Alliance (2009) indicates that 38% of the total land area consists of low relief and relatively flat topography. As such these areas do not contribute a significant volume of water to the river on an annual basis (Red Deer River Watershed Alliance 2009).

The study area encompasses 1,944 hectares (ha) of the Red Deer River watershed. Surface water runoff from an additional offsite area of 2,411 ha flows through the study area before draining into Piper Creek and the Red Deer River. As a result, the storm drainage boundary considered in the current study includes a total land area of 4,355 ha.

The considered land area draining to Piper Creek is 1,970 ha, of which 521 ha is located within the study area. The considered land area draining directly to the Red Deer River via overland flow and ravines is 2,310 ha, of which 1,149 ha is located within the study area. Table 1 summarizes the drainage areas internal and external to the study area.

TABLE 1 Breakdown of Watersheds within the Study Area

Receiving Water Body*	Portion of Total Considered Area	Within Study Area		Offsite Area		Total Area (ha) Considered
		Area (ha)	% of Total	Area (ha)	% of Total	
Red Deer River	18%	642	83%	132	17%	774
Red Deer River via Ravines	43%	726	39%	1,136	61%	1,862
Piper Creek	39%	576	34%	1,143	66%	1,719
Total	**100%**	**1,944**	**45%**	**2,411**	**55%**	**4,355**

*The areas considered to Piper Creek and Red Deer River include only the portion of the storm drainage basins that flow through the study area

Numerous wetlands have been identified within the study area as part of this project (refer to Map 2). Based on the completed desktop assessment, the majority of these wetlands have been tentatively classified as non-permanent (i.e., ephemeral, temporary, or seasonal) wetlands. To properly classify these non-permanent wetlands, historical aerial imagery analysis and field assessments are required, which was outside of the scope of this project. Wetlands that are thought to be permanent or semi-permanent have been considered in the drainage scheme and are discussed below. Discussion of the completed desktop wetland assessment is provided in Section 4.

3.2 Site Reconnaissance and Survey

A site reconnaissance trip was conducted by Matrix personnel on December 2, 2016. The site reconnaissance work included field surveying of area features (e.g., culverts on Range Road 265) and confirming digital elevation model (DEM) data provided by the City. Existing conduits, potential outfall locations, and an existing wildlife crossing were also inspected. The results of the site reconnaissance and surveying were used to identify potential constraints or other factors that may need to be accounted for in the MDP development or future designs. Development progress east of 30th Avenue and north of 67th Street was also documented.

Based on our site reconnaissance, the outfall locations recommended in this MDP were deemed reasonable for preliminary design purposes. Some outfall locations may need to be adjusted slightly during detailed design due to proximity to nearby landowners.

3.3 Land Use

Current land uses within the study area include agricultural, residential, and some oil and gas exploration and production activity. Some sections of land adjacent to Highway 11, between 10th Avenue and Range Road 265, have already been developed into residential areas.

3.4 Climate

Climatic data were used to characterize the historical precipitation and temperature for the study area. Total annual precipitation and minimum and maximum annual temperature data in the region from Alberta Agriculture and Forestry, Alberta Climate Information Service for the period of 1955 to 2016 were compiled and examined.

Based on the climatic data analyses, the historical mean annual maximum and the historical mean annual minimum temperatures in the project area are 9.2 and 3.2°C, respectively from 1955 to 2016. Over the same period, the highest and lowest mean annual temperatures were 12.0°C (1987) and 5.5°C. The maximum daily temperature was 35°C in 1998.

The mean total annual precipitation for the project area from 1955 to 2016 was 464 mm, with the highest and lowest total annual precipitation being 607 mm (1991) and 252 mm (1967), respectively. On average approximately 79% of annual precipitation falls as rain, with the balance falling as snow. The majority of the rainfall occurs in the month of May through October. Climate normal data from 1981 to 2010 obtained from Environment Canada (2017) Station No. 3025441 for Red Deer shows a mean annual temperature of 3.7°C and a mean annual precipitation of 486.3 mm. Annual precipitation consists of 105.9 cm of snowfall and 380.4 mm of rainfall.

Information provided in the AEP (2013) *Evaporation and Evapotranspiration in Alberta* report indicated a mean annual evaporation of 658 mm and a mean annual evapotranspiration of 418 mm for Lacombe. The next closest station to the study area, after Lacombe, is Calgary. As such, the Lacombe data can be used to approximate evaporation and evapotranspiration for this project based on its proximity to Red Deer.

Table 2 below provides details of the various design storms specified by the City and used for the hydrologic and hydraulic modelling of the storm drainage systems in this study.

TABLE 2 Design Storms

Storm	Total Precipitation (mm)	Peak Intensity (mm/hour)
2-year, 4-hour	24.2	76.4
5-year, 4-hour	33.2	114.0
10-year, 4-hour	38.8	138.4
25-year, 4-hour	46.2	170.2
50-year, 4-hour	51.8	193.5
100-year, 24-hour	93.0	225.1

4 WETLANDS ASSESSMENT

Similar to other aspects of this study, correspondence with AEP established the methodology for the wetland desktop assessment. A detailed description of the methodology and the results of this assessment are presented in this section.

4.1 Methodology

Wetlands in the project area were identified and tentatively delineated and classified according to the *Alberta Wetland Identification and Delineation Directive* (AEP 2015a) and the *Alberta Wetland Classification System* (ESRD 2015) using available aerial imagery from Google Earth™. The Google Earth™ imagery spanned the period from May 23, 2002, to August 22, 2015, and included spring, summer, and fall imagery of the project area. The wetlands were delineated in Google Earth™, and individual wetland polygons were saved as a Keyhole Markup language Zipped (.KMZ) file for future access.

The following hydrologic features were not delineated as part of this assessment:

- dugouts, as they are not natural features and, as such, are not afforded any protection under the *Alberta Wetland Policy* and *Water Act*, even though they may have hydrologic and vegetation community characteristics common to wetlands
- drainage pathways, e.g., ditches, swales, or ephemeral drainages, as they are not classified as wetlands, even though they may contain some vegetation community characteristics common to wetlands
- watercourses or water bodies, as they are not classified as wetlands; however, riverine and lacustrine wetlands, including marshes and swamps, were identified and tentatively delineated and classified, when present or apparent

4.2 Regulatory Context

The Province of Alberta released the *Alberta Wetland Policy* in September 2013 (Alberta Environment and Sustainable Resource Development [ESRD] 2013) to protect all (1) natural wetlands, including bogs, fens, swamps, marshes, and shallow open water, and (2) restored natural wetlands as well as wetlands constructed for the purposes of wetland replacement. Wetlands are considered to be any land:

- saturated with water long enough to promote formation of water altered soils
- growth of water-tolerant vegetation species
- various kinds of biological activities that are adapted to the wet environment (ESRD 2013)

In Alberta, wetlands are primarily administered by AEP under the *Water Act* (Province of Alberta 2014a) and the *Public Lands Act* (Province of Alberta 2014b).

4.2.1 Water Act

Any activities or water diversions that may impact wetlands require a *Water Act* approval. If any wetlands classified as temporary, seasonal, semi-permanent, or permanent (i.e., Class II or higher [as previously classified using the Stewart and Kantrud [1971] wetland classifications system]) as well as peat-accumulating wetlands (peatlands), i.e., fens and bogs, are expected to be directly or indirectly impacted by a development, preparation of a Wetland Assessment and Impact Report (WAIR; AEP 2015b), according to the *Alberta Wetland Policy* for the White (Settled) Area, is required as part of the *Water Act* application (Province of Alberta 2014a). If the impact to a wetland is permanent, i.e., a loss of wetland area, the development proponent must meet specific replacement obligations, which entail one of the following:

- purchasing available credits form a third-party wetland bank (currently under development by AEP)
- payment to an in-lieu fee program
- undertake a permittee-responsible replacement program

Any proposed impacts to wetlands classified as ephemeral (i.e., Class I [as previously classified using the Stewart and Kantrud [1971] wetland classifications system]) also require an approval under the *Water Act* (Province of Alberta 2014); however, there is no requirement to complete a WAIR (AEP 2015b) as part of the *Water Act* (Province of Alberta 2013a) application, and there are no replacement obligations.

4.2.2 Public Lands Act

Under the *Public Lands Act* (Province of Alberta 2014b), the Crown has ownership of the bed and shores of semi-permanent and permanent naturally occurring wetlands, which includes peatlands. An assessment of water body permanence, using historical climate data and analyses of historical aerial imagery, must be completed and submitted to the Water Boundaries Unit, Government of Alberta, before initiation of any project in order to determine public land ownership. Modifications to the bed and/or shoreline of a wetland, including drainage, infilling, water control structures, and wetland management structures, require a *Public Lands Act* (Province of Alberta 2014b) approval and are subject to replacement obligations in addition to replacement obligations under the *Water Act* (Province of Alberta 2014a).

4.2.3 Other Acts

In addition to the *Water Act* and *Public Lands Act* (Province of Alberta 2014a, 2014b), wetland vegetation and wildlife species and habitat are protected under several federal, provincial, and municipal acts and policies. These acts and policies include the following:

- Federal
  - *Migratory Birds Convention Act* (Government of Canada 2010)
  - *Species at Risk Act* (Government of Canada 2015)
  - *Fisheries Act* (Government of Canada 2016)

- Federal Policy on Wetland Conservation (Government of Canada 1991)
  - Provincial
  - *Environmental Protection and Enhancement Act* (Province of Alberta 2014c)
  - *Wildlife Act* (Province of Alberta 2014d)

- Municipal
  - *Municipal Government Act* (Province of Alberta 2000b)

4.2.4 Wetland Classification

There are numerous wetlands of various types throughout the study area. Map 2 shows all wetlands within the study area and highlights the semi-permanent and permanent features. Table 3 summarizes the wetland classes, forms, and types in the project area. The wetland classifications follow the *Alberta Wetland Classification System* (ESRD 2015).

TABLE 3 Wetland Classes in the Project Area

Wetlands in the Project Area	Alberta Wetland Classification System
Shrubby Swamps	Swamp (S), shrubby (S), freshwater (f) to slightly brackish (sb) or moderately brackish (mb) to sub-saline (ss), temporary (II) or seasonal (III)
Permanent Wetlands (Class V)	Shallow open water (W), graminoid (G), slightly brackish (sb) or sub-saline (ss), permanent (V)
Semi-permanent Wetlands (Class IV)	Marsh (M), graminoid (G), freshwater (f) to brackish (b), semi-permanent (IV)
-	Shallow open water (W), submersed and/or floating aquatic vegetation (A) or bare (B), freshwater (f) to sub-saline (ss), semi-permanent (IV)
Seasonal Wetlands (Class III)	Marsh (M), graminoid (G), freshwater (f) or moderately brackish (mb), seasonal (III)

Wetlands in the Project Area	Alberta Wetland Classification System
-	Shallow open water (W), submersed and/or floating aquatic vegetation (A) or bare (B), freshwater (f) or moderately brackish (mb), seasonal (III)
Temporary Wetlands (Class II)	Marsh (M), graminoid (G), freshwater (f) to slightly brackish (sb), temporary (II)
Ephemeral Wetlands (Class I)	Not classified

4.3 Results

Using the available Google Earth™ imagery, 419 wetlands were identified and tentatively delineated and classified in the project area. Of these wetlands, 16 wetlands were tentatively classified as either semi-permanent or permanent wetlands (Class IV or V wetlands; Table 4; Map 2). The remaining 403 wetlands in the project area were tentatively classified as either ephemeral, temporary, or seasonal wetlands (Class I, II, or III, respectively) or as shrubby swamps (ESRD 2015). Table 5 provides the list of tentatively classified shrubby swamps in the project area.

TABLE 4 Tentatively Classified Semi-permanent and Permanent Wetlands in the Project Area

Tentative Wetland Classes	Wetland Polygons
Class IV or V	19
Class IV or V	28
Class IV or V	35
Class IV or V	55
Class IV or V	83
Class IV or V	95
Class IV or V	96
Class IV or V	107
Class IV or V	117
Class IV or V	203
Class IV or V	206
Class IV or V	214
Class IV or V	218
Class IV or V	219
Class IV or V	220
Class IV or V	221

TABLE 5 Tentatively Classified Shrubby Swamps in the Project Area

Tentative Wetland Class	Wetland Polygons
Shrubby Swamp	35
Shrubby Swamp	40
Shrubby Swamp	43
Shrubby Swamp	52
Shrubby Swamp	55
Shrubby Swamp	66
Shrubby Swamp	71
Shrubby Swamp	73
Shrubby Swamp	74
Shrubby Swamp	76
Shrubby Swamp	77
Shrubby Swamp	78
Shrubby Swamp	83
Shrubby Swamp	100
Shrubby Swamp	141
Shrubby Swamp	152
Shrubby Swamp	165
Shrubby Swamp	196
Shrubby Swamp	203
Shrubby Swamp	228
Shrubby Swamp	239
Shrubby Swamp	252
Shrubby Swamp	257
Shrubby Swamp	266
Shrubby Swamp	382

4.4 Discussion

Impacts to all 419 wetlands in the project area require approval under the *Water Act*, and 16 of the 419 wetlands may also require approval under the *Public Lands Act* before any developments can commence, as wetlands are protected under the *Alberta Wetland Policy*.

The exact number of semi-permanent and permanent (Class IV and V) wetlands in the project area needs to be verified using a combination of older aerial imagery, i.e., aerial imagery that dates back to 1949/50, in combination with detailed field assessments during the growing season. Similarly, some of the tentatively identified Class I, II, and/or III wetlands may not be wetlands and could be removed from the wetland pool following detailed field and aerial imagery assessments. Ultimately, the existence, delineation, and classification of all wetlands must be determined during field assessments, following the *Alberta Wetland Identification and Delineation Directive* (AEP 2015a) and the *Alberta Wetland Classification System* (ESRD 2015). Data collected during the field assessments also support the development of the WAIR, which is required as supporting documentation for the *Water Act* application.

Some of the semi-permanent and permanent (Class IV and V) wetlands may be used toward SWM, if they meet specific design specifications. As such, they may be used toward wetland replacement obligations as part of the permittee-responsible replacement program. In order to facilitate this use of wetlands, where feasible SWM facilities have been identified to correspond with the locations of semi-permanent and permanent wetlands. This includes wetland polygons 218, 203, 96, 55, 35, and 28 (refer to Map 4). As part of the proposed MDP (refer to Section 6), it has been assumed that the temporary wetlands will be removed during future development.

Shrubby swamps, albeit relatively common in the White Zone of Alberta, provide greater habitat heterogeneity than Class I, II, and III wetlands, as swamps contain herbaceous, graminoid, and woody vegetation strata. In addition, some shrubby swamps also contain shallow open water components, which provide habitat for floating and submersed aquatic vegetation communities. In contrast, Class I, II, and III wetlands consist primarily of herbaceous and/or graminoid vegetation communities, and, as such, are less vegetation species rich and provide less habitat for wildlife communities, particularly if they have already been impacted by agricultural activities in the past, e.g., many of the wetlands in the project area have either been entirely or partially cultivated by agricultural operations.

5 PRE-DEVELOPMENT FLOW ASSESSMENT AND ALLOWABLE RELEASE RATES

Information on allowable release rates from each SWM facility is required to determine storage requirements and to size conveyance infrastructure. This section provides information on methods, assumptions, and analysis tools used to determine the maximum allowable release rates.

Since the study area is located on multiple watersheds, different release rates are proposed depending on the proposed discharge locations. These proposed rates are based on establishing pre-development flow rates and a concept-level assessment of the interaction of outfall discharges with the flows in the receiving watercourses such as the Red Deer River.

The pre-development flow rates may be used to:

- determine allowable release rates from the SWM facilities
    - Maximum discharges from the SWM facilities will be limited to the approved allowable release rates established based on the findings of the pre-development flow rate assessment in the watershed located within the study area.
    - The allowable release rates will be used to size the stormwater infrastructure.
- set SWM targets that minimize adverse effects on the ecology, morphology, and hydraulic characteristics of the receiving water bodies
- define release rates that ensure downstream flooding is not increased

5.1 Review of Established Release Rates

Flows recorded from a watershed during rainfall events, in combination with corresponding records of the watershed's condition at the time of a given event, typically represent the best dataset to be used for estimating pre-development flow rates. In the absence of such data, regional hydrologic analysis of recorded streamflow data and stormwater modelling software is often used to determine pre-development flow rates. Due to a lack of measured flows during rainfall events available for the study area, the following methods were used in this assessment to generate a range of pre-development peak flows for comparison and evaluation:

- reviewing literature to gather information on allowable release rates adopted by other municipalities located in the general vicinity of the study area
- evaluating the Alberta Transportation (AT 2006) runoff depth method
- evaluating previous study findings
- computer-modelling of land areas with various sizes and topographies under the pre-development scenario using single and multiple non-linear regression analysis under a 1:100-year, 24-hour design rainfall event
  - The modelling results were used to develop relationships between peak flows, drainage areas, and ground slopes.
- assessing hydraulic and morphologic characteristics of receiving watercourses

A discussion of each of these methods and their results are provided in the following sections.

5.1.1 Nearby Approved Release Rates

Allowable release rates for 100-year storm control, adopted by nearby municipalities and approved by AEP reported by MPE (2014) are as follows:

- Red Deer County: 5.0 L/s/ha
- Town of Blackfalds: 6.0 L/s/ha
- Sylvan Lake: 2.6 L/s/ha
- Wolf Creek watershed: 2.0 L/s/ha
- Town of Ponoka: 2.5 L/s/ha

5.1.2 Alberta Transportation Runoff Depth

In this method, runoff depth for the area of interest is obtained from the runoff depth map published by AT (2006) for the Province of Alberta. By selecting an appropriate value for time to peak, a peak flow independent of any return period is computed to determine unit flow rates per hectare.

Through this method it has been determined that a runoff depth of 40 mm is applicable for the study area. AT recommends using a 20-hour period for time to peak when estimating rainfall generated peak runoff for the study area. Using the formula provided in the AT (2006) document, the estimated pre-development flow rate is 5.5 L/s/ha for the study area.

5.1.3 Previous Studies

Based on a review of available documents listed in Section 2, the relevant findings of the following studies are summarized in the subsections below:

- *Waskasoo Creek and Red Deer Flood Risk Mapping Study* (Yaremko 1992)
- *Red Deer County: Design Guidelines* (Tagish Engineering 2010)
- *Master Drainage Plan for the Wolf Creek and Whelp Brook Watersheds* (MPE 2014)
- *City of Red Deer, 2009 Greater East Hill Functional Servicing Study* (Stantec 2011)

5.1.3.1 Waskasoo Creek and Red Deer Flood Risk Mapping Study

Yaremko (1992) updated the previously completed flood risk mapping study for Waskasoo Creek according to the specifications of the Canada-Alberta Flood Damage Reduction program and produced flood risk maps for the study area. This report provides a valuable historical perspective of floods in the Waskasoo Creek and its main tributary: Piper Creek. Yaremko (1992) documented gross-drainage areas of 174 km^2 and 313 km^2 for Piper Creek and Waskasoo Creek, respectively, above the confluence of the two creeks. Yaremko (1992) provided a 1:100-year flood flow estimate of 44 m^3/s in Piper Creek above its confluence with Waskasoo Creek.

5.1.3.2 Red Deer County Design Guidelines

The *Red Deer County: Design Guidelines* provided information on the pre-development flow rate for the Waskasoo watershed. Based on the established pre-development flow rate, the 100-year allowable release rate from the SWM facilities is 5.0 L/s/ha. Therefore, the allowable release rate for developments within the Piper Creek watershed, which is a tributary of Waskasoo Creek, could be up to 5.0 L/s/ha (Tagish Engineering 2010).

5.1.3.3 2009 Greater East Hill Functional Servicing Study

Stantec Consulting Ltd. (2011) carried out a functional sanitary and storm servicing study for the Greater East Hill area. Referring to an earlier study conducted in 2004, this report stated that the 1:100-year pre-development flow rate in the Piper Creek watershed is 3.6 L/s/ha and for the Red Deer River watershed is 4.5 L/s/ha.

In the Stantec (2011) study, the release rates for the Piper Creek and the Red Deer River were re-evaluated. Based on this assessment, a 1:100-year pre-development rate of 1.25 L/s/ha for the Piper

Creek watershed was recommended using recorded streamflow data of the gauging station on Waskasoo Creek at Red Deer (05CC011).

Based on hydrologic modelling using SWMHYMO software, pre-development flow rates ranging from 6.9 to 9 L/s/ha were computed by Stantec for the Red Deer River watershed. The land areas considered in the modelling varied from 492 to 764 ha and the assumed Curve Number (CN) for the modelling was 57.

A second approach was utilized in the 2009 Functional Servicing Study to determine the release rates for the land area that drains into the Red Deer River by optimizing land requirements for SWM facilities and conveyance infrastructure requirements. Based on an optimization analysis of land requirements for SWM facilities, sizing of conveyance pipes, and cost for these infrastructure, a cost-effective release rate of 9 L/s/ha from the SWM facilities was recommended by Stantec (2011) for the areas draining into the Red Deer River through constructed outfalls. The City has requested that the current study review the recommended release rates and the calculation methods.

5.1.3.4 Master Drainage Plan for the Wolf Creek and Whelp Brook Watersheds

A review of the Wolf Creek and Whelp Brook Watersheds MDP was completed as it also included a detailed regional analysis of pre-development flow rates using local recorded hydrometric data. In that study MPE (2014) established a 100-year pre-development flow rate of 2.0 L/s/ha for the Wolf Creek watershed just north of Red Deer based on a regional flow analysis of recorded streamflow data. The following hydrometric gauging stations were considered in the study:

- Waskasoo Creek at Red Deer (05CC011)
- Haynes Creek near Haynes (05CD006)
- Parlby Creek at Alix (05CD007)
- Pipestone Creek near Wetaskiwin (05FA102)
- Maskwa Creek No. 1 above Beaverhills Lake (05FA014)
- Weiller Creek near Wetaskiwin (05FA024)

MPE (2014) developed relationships between peak flows corresponding to various return periods and drainage areas using the recorded flow data at these stations. The developed relationship between 1:100-year pre-development peak flow and drainage area is presented in the equation below.

$$Q = 0.9869 \times A^{0.6315} \qquad \textbf{Equation [1]}$$

where *A* is the drainage area in kilometre squared (km^2)

5.1.4 Stormwater Management Modelling

As a part of the current MDP study for the Greater East Hill development area, Matrix completed hydrologic modelling using EPA SWMM software to establish pre-development flow rates that can be expected in the study area during a 100-year, 24-hour design rainfall event. The findings were compared to the findings of the previous studies summarized above. Particularly the results are compared to the MPE (2014) results as it contained a more thorough analysis than the Stantec (2011) study. The current land use characteristics and topography have been used in completing the hydrologic modelling exercise.

It has been well-established that peak flows from a watershed during rainfall events primarily depend on land use, ground topography (slope), and soil characteristics. It is also well understood that flow rates per unit area decrease as the drainage areas increase.

A combination of various drainage areas and ground slopes was used in computing peak flows through the developed hydrologic model. Representative ground slopes within the study area ranging from 0.5% to 1.8% and drainage areas ranging from 0.2 to 20 km^2 were assessed with the model.

The estimated peak flows for various ground slopes and drainage areas were used to develop a relationship between peak flows and these two variables. Using a non-linear multiple regression analysis, the following relationship was obtained:

$$\text{1:100-year peak flow} = 0.83 \times A^{0.604} \times S^{0.48} \qquad \textbf{Equation [2]}$$

where *A* is the drainage area in km^2 and S is the slope in percent (%)

Since it is normal practice to express peak flows as a function of drainage areas only, the modelling results were used to establish the following relationship between peak flows and drainage areas for comparison with Equation [1]:

$$\text{1:100-year peak flow} = 0.82 \times A^{0.608} \qquad \textbf{Equation [3]}$$

where *A* is the drainage area in km^2

A comparison of Equation [1] based on regional analysis of stream flows and Equation [3] based on hydrologic modelling of 100-year, 24-hour design storm event indicates that these two relationships are very similar. Figure 1 shows the variation of peak flows with drainage areas using Equation [1] derived by MPE (2014) and Equations [2] and [3] derived in this study. An additional curve showing peak flow versus drainage area for a particular slope of 1.8% using Equation [2] is also shown on Figure 1, which is in excellent agreement with MPE (2014). The relationship provided in Equation [3] between peak flows and drainage areas (for all slopes considered) derived in this study provides relatively lower peak flow for a given drainage area in comparison to the MPE (2014) report. A comparison of these curves demonstrates that the hydrologic modelling results from the current study are in agreement with the regional analysis results as provided in the MPE (2014) report.

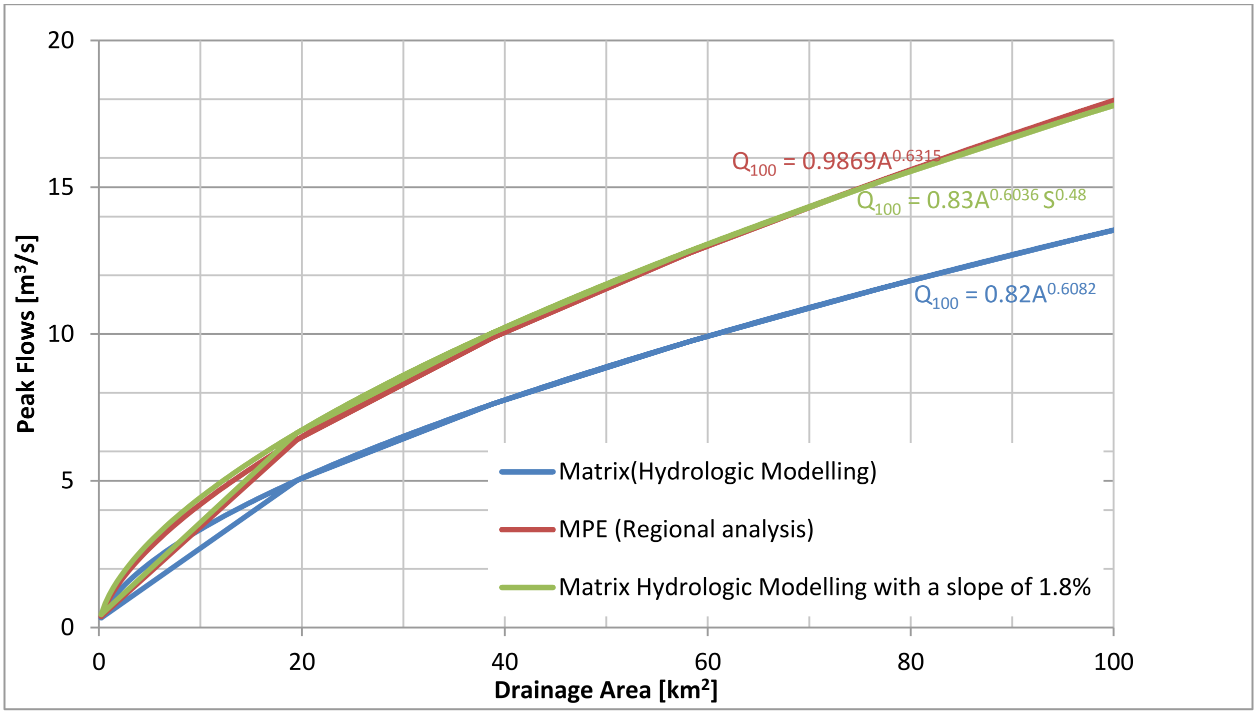

FIGURE 1 Peak Flow Variation with Drainage Area

Figure 2 shows the relationship between peak flows per unit area and drainage areas based on Equation [1] as derived in the MPE (2014) report and Equation [3] derived in this study. It is evident that peak flows per unit area decrease as drainage areas increase. This reduction in flow rate per unit area is due to routing and storage effects as water flows through the natural watercourses and water bodies. Peak flow per unit area varies between 3.0 L/s/ha to 5.0 L/s/ha for drainage areas ranging from 5 to 10 km^2 for both relationships. Peak flows per unit area could exceed 10 L/s/ha for small drainage areas, although the magnitude of peak flows would be relatively small due to the small total area. For reference, for a quarter section (e.g., the scale at which development is to occur), a peak flow per unit area of 9.8 L/s/ha can be expected. Using this flow rate per unit area, the expected peak flow from a given quarter section of land is 0.64 m^3/s. Peak flows from a series of SWM facilities constructed on a