URBAN SYSTEMS

LOGAN LANDING

Staged Master Drainage Plan

JULY 2020

3038.0027.01

THE CITY OF CALGARY
WATER SERVICES

Development Approvals

Checklist #10: Staged Master Drainage Plan (SMDP)

Project: Logan Landing SMDP **Phase:** _____

Developer: Genesis Land Development Corporation

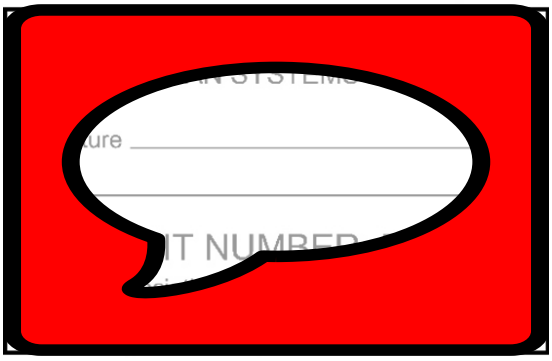
Consultant: Urban Systems Ltd.

Contact Name: Liliana Bozic, P.Eng. **Contact E-mail:** lbozic@urbansystems.ca

Use this checklist to ensure that all Water Resources - Development Approvals requirements for Staged Master Drainage Plans have been met. See the *Guide to Development Approvals Applications* (referred to in this checklist as the "*Guide*") for detailed information about items in this checklist.

Note: This checklist is scheduled to be updated in 2012. Check on the Water Resources - Development Approvals website to ensure that the latest version of this checklist is used. At all times, new Staged Master Drainage Plan submissions must meet the requirements of Section 11.1.4 of the 2011 *Stormwater Management & Design Manual.*

The undersigned agree and certify that all requirements on this checklist have been reviewed and properly identified as part of this submission. The undersigned understand that this checklist will be used as a tool for review of the Staged Master Drainage Plan (SMDP) by Water Services and confirm that a review of the SMDP has been undertaken by a responsible professional member.



Permit to Practice Stamp or Number

Engineer Stamp

YES	NO	N/A	
◉	○		1. All items in the SHADED areas are explained in the comments section of this checklist.
○	◉		2. Submit four (4) copies of report that are signed and include the Professional Engineer's stamp and the company's permit number.
◉	○		3. Cover letter highlights any unresolved issues or areas where guidelines cannot be met.
◉	○	○	4. Include Outline Plan Number (if applicable).
○	◉		5. Include plastic sleeve behind title page for future correspondence.
◉	○		6. State design objectives.
◉	○		7. Identify Watershed, Master/Staged Master Drainage Plans, or any other drainage plans appropriate to submission.
◉	○		8. Identify Biophysical Impact Assessment and Biophysical Inventory reports appropriate to submission and discuss any items that have to be addressed prior to report approval.
◉	○		9. Explicitly state that all details conform to all City of Calgary standard specifications and the *Stormwater Management & Design Manual*, or explicitly state items that have to be addressed prior to report approval.
◉	○		10. Study Area and Location sketches include overall site description and show location, section number and major roadways. It is best to include two figures: one showing the location of the area with respect to the City of Calgary, and the other showing the study area and surrounding Master/ Staged Master plans.
◉	○		11. Include drawing showing catchment and subcatchment area boundaries on preferably 11” x 17” size paper.
◉	○		12. Site description includes legal land location and area in hectares.
○	○	◉	13. Explicitly state all overland flows crossing boundary limits and their locations with references to related reports.
◉	○		14. Boundaries match those of existing reports, or supplemental information is included to rationalize the changes.
◉	○		15. State the permitted release rate (L/s/ha) for minor system and stormwater ponds.
○	◉		16. Identify approximate trunk sizes and alignment, servicing routes and overland drainage routes.
◉	○		17. Identify receiving water body and outfall.
○	○	◉	18. Any increase in flow offsite has been reviewed for the impact on affected downstream works.
◉	○		19. Include brief description of computer model, methodology, design storm parameters, and computer input parameters.
◉	○		20. Include schematic that matches the submitted drawings and computer model.
◉	○		21. Attach computer model input and output files including continuous and single event simulation for stormwater storage requirements.

YES	NO	N/A	
○	○	◉	22. Master or Staged Master Drainage Plan delineates drainage basin beyond plan limit if appropriate.
◉	○		23. Identify and locate stormwater ponds or other Best Management Practices within study area.
◉	○		24. All stormwater management facilities are entirely located within developers property limits or offsite details are provided.
○	○	◉	25. Explicitly state the developer controls the land that offsite facilities occupy or statement of agreement with affected stakeholders is enclosed.
◉	○	○	26. State if pond report will follow.
◉	○		27. Address water quality issues/improvements.
○	○	◉	28. Include completed Alberta Environment `Application Checklist for Storm Drainage Treatment Facilities within the City of Calgary'.
◉	○		29. All plans and engineering drawings submitted include quarter section lines and street names. Pertinent information on the plans uses legible font sizes.
○	○	◉	30. Include a digital copy of the drawing displaying catchment and subcatchment area boundaries in .dxf format with report.

Comments:

2, 5 - Submission is electronic.
13 - No off-site flows enter the study area
18 - No off-site downstream areas are impacted by flows from Logan Landing.
22 - No oversize is provided for off-site areas.
25, 28, 30 - N/A, no additional information is provided.

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FIGURES

TABLES

1.0 INTRODUCTION

1.1 Background

Urban Systems was retained by Genesis Land Development Ltd. (Genesis) to prepare a Staged Master Drainage Plan (SMDP) in support of the Outline Plan application LOC 2020-0100, for the proposed Logan Landing development in the City of Calgary. Logan Landing is located within Ricardo Ranch Area Structure Plan area (RRASP, Bylaw 37P2016). The plan area is identified as a portion of Neighbourhood 1, 2 and 4 on Map 5 of the RRASP, and includes a future Joint Use Site, a Neighbourhood Activity Centre, an Escarpment Green Corridor, a Green Corridor, a regional pathway along with lands identified for future Neighbourhood Area and Environmental Study Area. The Logan Landing development area encompasses 143 hectares of land, fully owned by Genesis Land Development (Southeast) Corporation.

The study area is defined by:

- North Boundary: 212 Avenue and the community of Seton, which is now under development
- East Boundary: lands owned by the Soutzo family, also part of the Ricardo Ranch ASP
- South Boundary: the Bow River
- West Boundary: lands owned by Brookfield Residential, also part of the Ricardo Ranch ASP
- Legal description: NW ¼ Sec 10 Twp22-Rge29-W4M

Figure 1 shows the regional location of the future Logan Landing development.

Figure 2 shows the location of development within the approved Ricardo Ranch ASP.

Figure 1 - Regional Location of Logan Landing

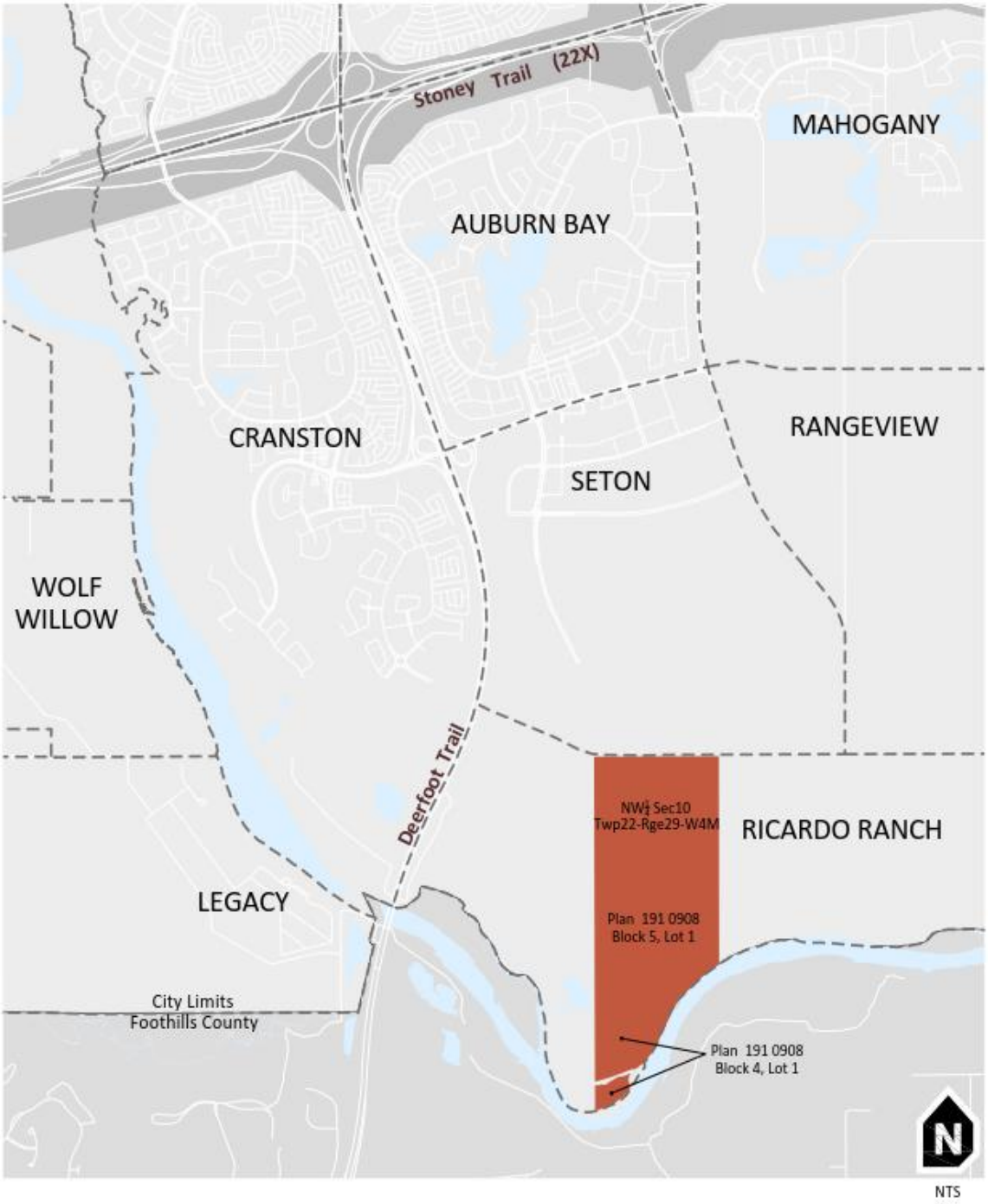
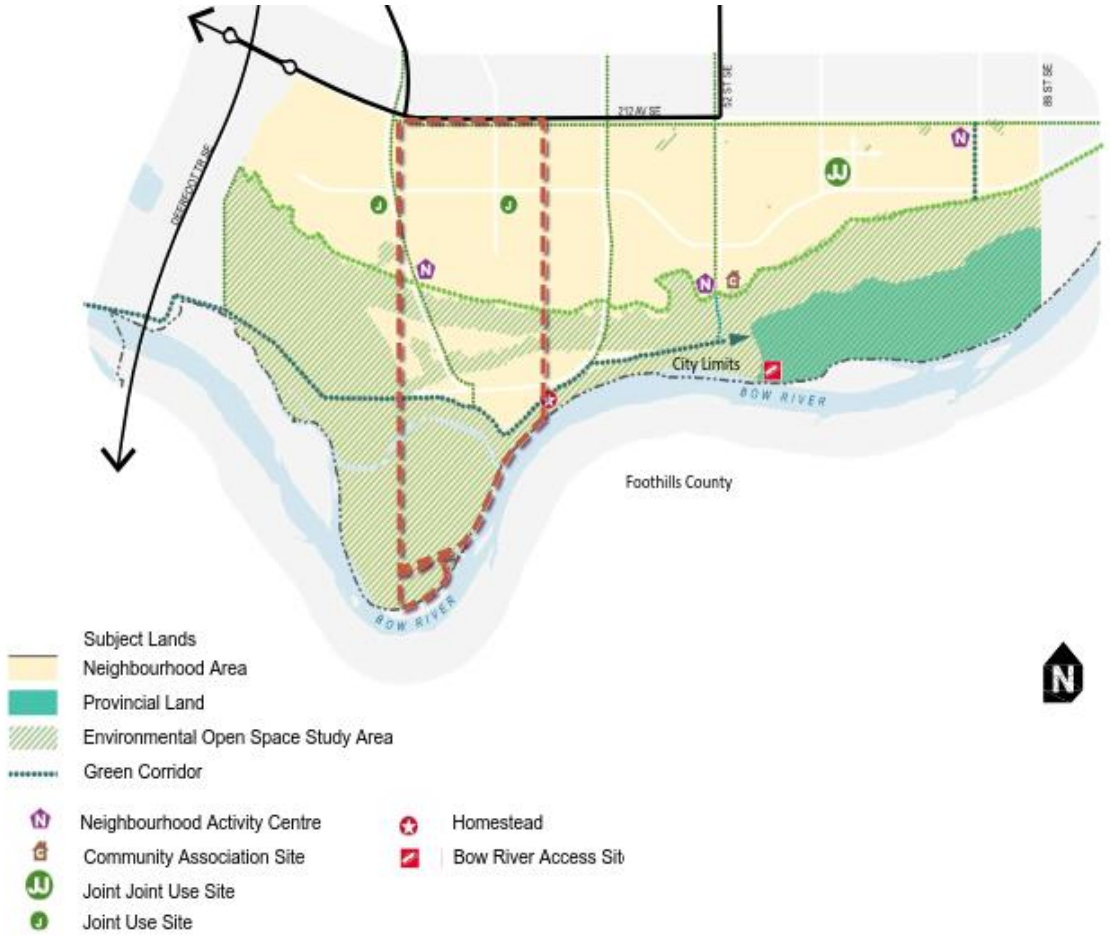


Figure 2 - RRASP Context



Source: LOC 2020-0100

Brown and Associates

1.2 Project Scope

The report outlines the proposed stormwater management concept to accommodate the runoff generated by the development area, and the location, approximate sizing and configuration of the stormwater management facility on the upper bench. The stormwater concept is based on the Ricardo Ranch Master Drainage Plan (RRMDP), submitted to the City of Calgary in August 2019.

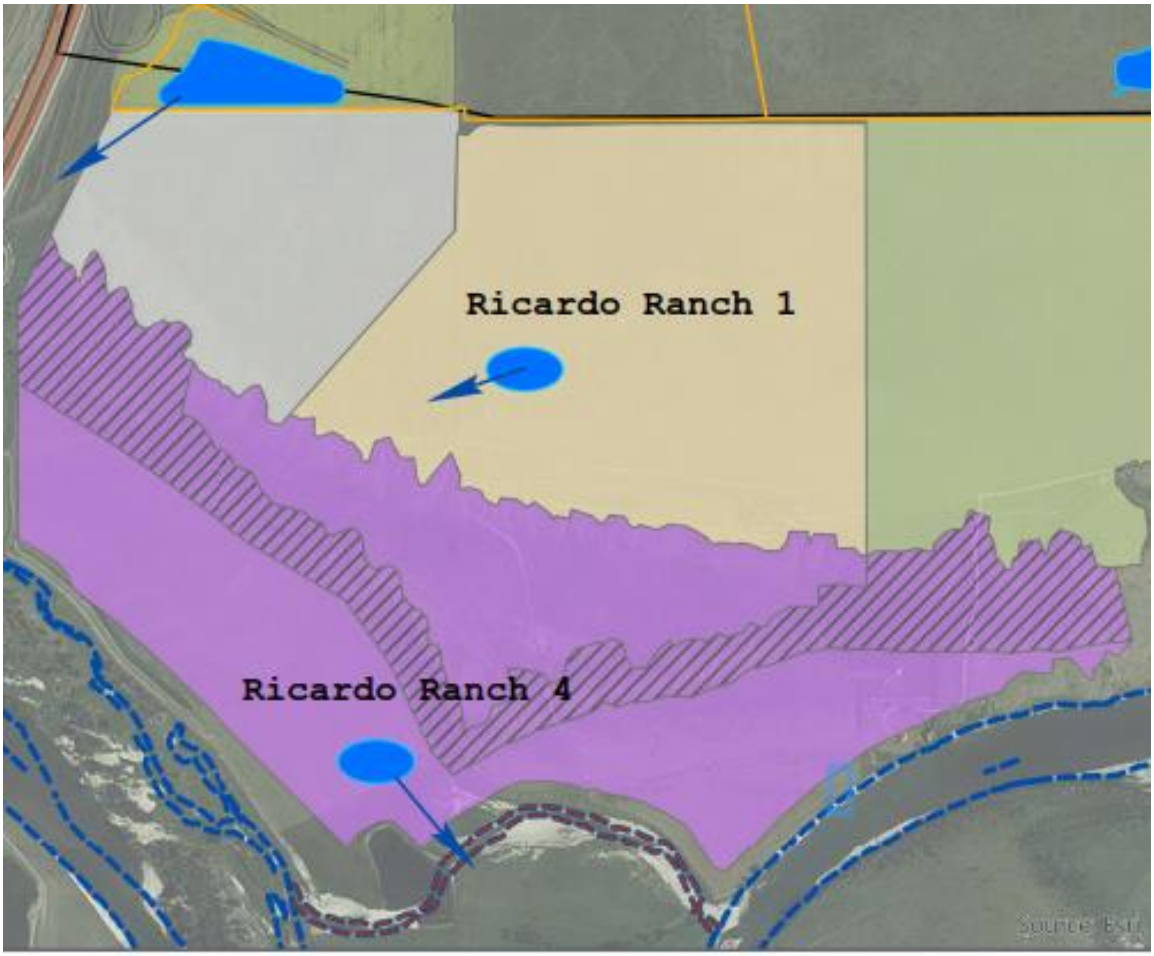
This report includes only the stormwater facility that services the lands on the ridge (upper bench) and portion of mid-bench. The total contributing catchment to the facility is 54 hectares. The remaining development on the mid-bench and lower bench (river valley), totalling 89 hectares, will be serviced by the constructed wetland located within proposed Brookfield development immediately west of Logan Landing. This catchment areas established in RRMDP are shown on **Figure 3** (also referenced as Figure 12 in RRMDP). The facility addressed in this report is referred to as Ricardo Ranch 1 in RRMDP. The land use planning and stormwater management design for Brookfield development is currently in the final stages, with submission to the City of Calgary expected in August 2020.

1.3 Background Documents

The following background reports and information were considered in the development of the SMDP:

- Planning documents:
    - Ricardo Ranch Area Structure Plan (The City of Calgary Bylaw 37P2016)
    - Logan Landing in Broadacres (LOC 2020-0100, July 2020)
- Stormwater Reports:
    - Ricardo Ranch Master Drainage Plan (Urban Systems 2019)
    - Rangeview Master Drainage Plan Update (Urban Systems 2015)
- Hydrogeological studies:
    - Hydrogeological Assessment for Ricardo Ranch (Waterline Resources Inc., 2019)
- Environmental reports:
    - Ricardo Ranch Ecological Inventory (Stantec 2019)
    - Biophysical Impact Assessment (Urban Systems, 2019):
- Geotechnical reports:
    - Ricardo Ranch Geotechnical Assessment (Macintosh Lalani, 2019)

Figure 3 - Stormwater Facilities and Catchments - RRMDP



Source: RRMDP, Figure 12

2.0 SMDP PRINCIPLES

2.1 Site Description & Constraints

The study area is defined by three benches stepping down toward the Bow River (**Figure 4**). These benches are referred to as Ridge, Bench and Valley in the Outline Plan and elsewhere in this report (**Figure 5**). This report addressed stormwater servicing and stormwater facility sizing for the Ridge and an eastern portion of Bench development only.

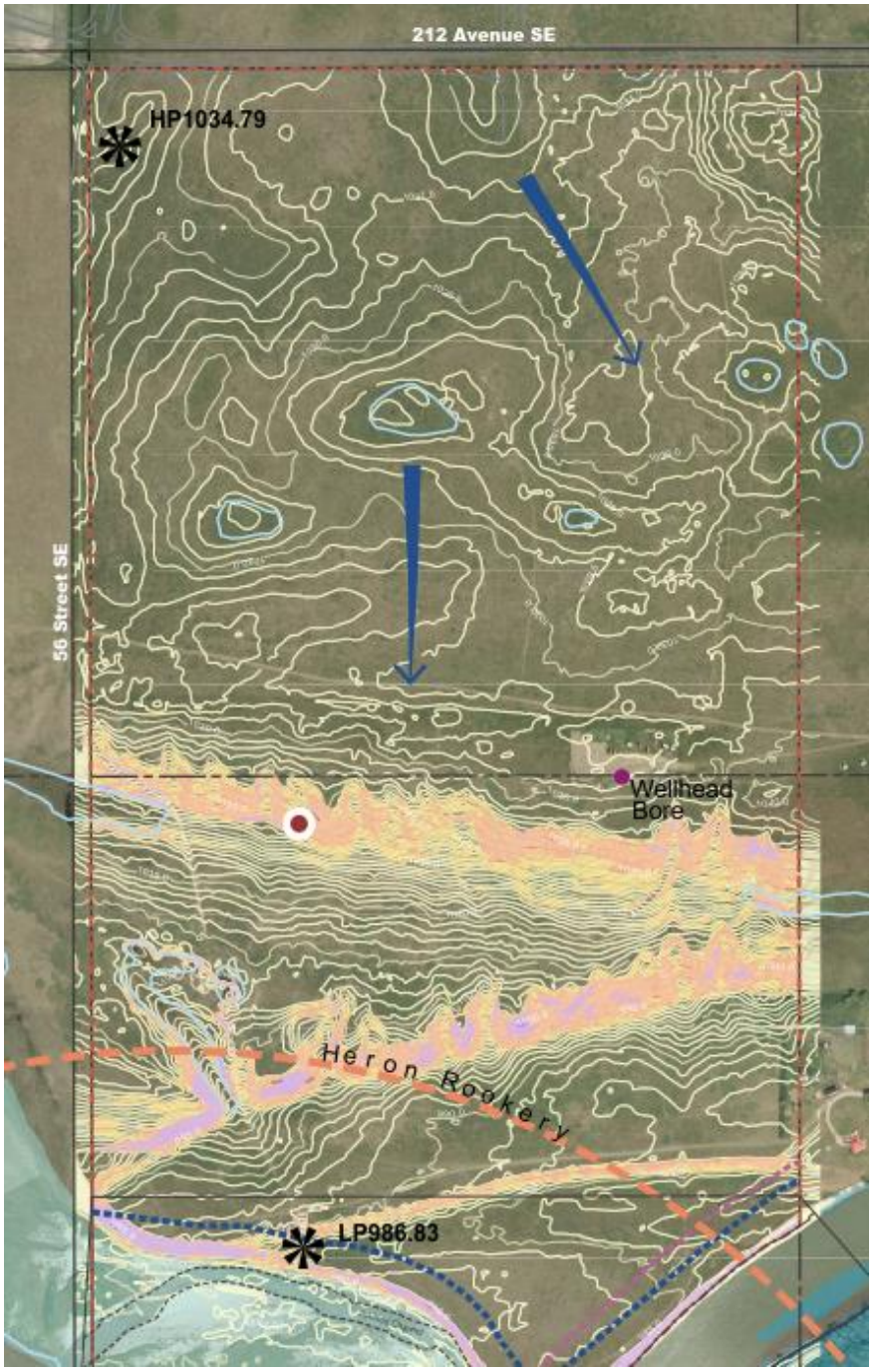
The lands generally slope towards the southeast. Currently, the land is used for cattle grazing and cultivation. The ridge lands north of the escarpment are gently undulating and contain several small prairie pothole wetlands. The escarpment is widely terraced and features several ephemeral drainage courses. The valley bottom has been formed by erosion and deposition caused by flooding of the Bow River, with deposits of gravel and sand present on the surface, or just below shallow layers of undeveloped soils. The study area also contains an abandoned well site, and a heron rookery in the very southwest.

Existing development constraints in the Bow River valley, including the floodway, flood fringe, and the extent of the long-term (200-year) meander belt, are shown on **Figure 6** (also referenced as Figure 4 in RRMDP). A river morphology assessment of the Bow River at Ricardo Ranch area, completed by Golder Associates Ltd. in 2018, determined the extent of changes in the meander width over the short (5-10 years), medium (50-100 years) and long term (up to 200 years). This figure also shows the slope setbacks that are determined as part of a geotechnical investigation conducted by McIntosh Lalani.

The proposed development is outside of flood fringe and the long-term meander belt determined by Golder. The majority of the escarpment, two groundwater (slope) wetlands and associated ephemeral drainages are planned for avoidance and protection as Environmental Reserve (ER). The concept plan has estimated designating 30% of the development area as ER. Combined, the designated ER and MR areas is approximately 40% of the potential developable area. The remaining area is altered by agricultural practices, is highly comprised of non-native species, and will be developed.

The proposed land use concept is shown on **Figure 7**.

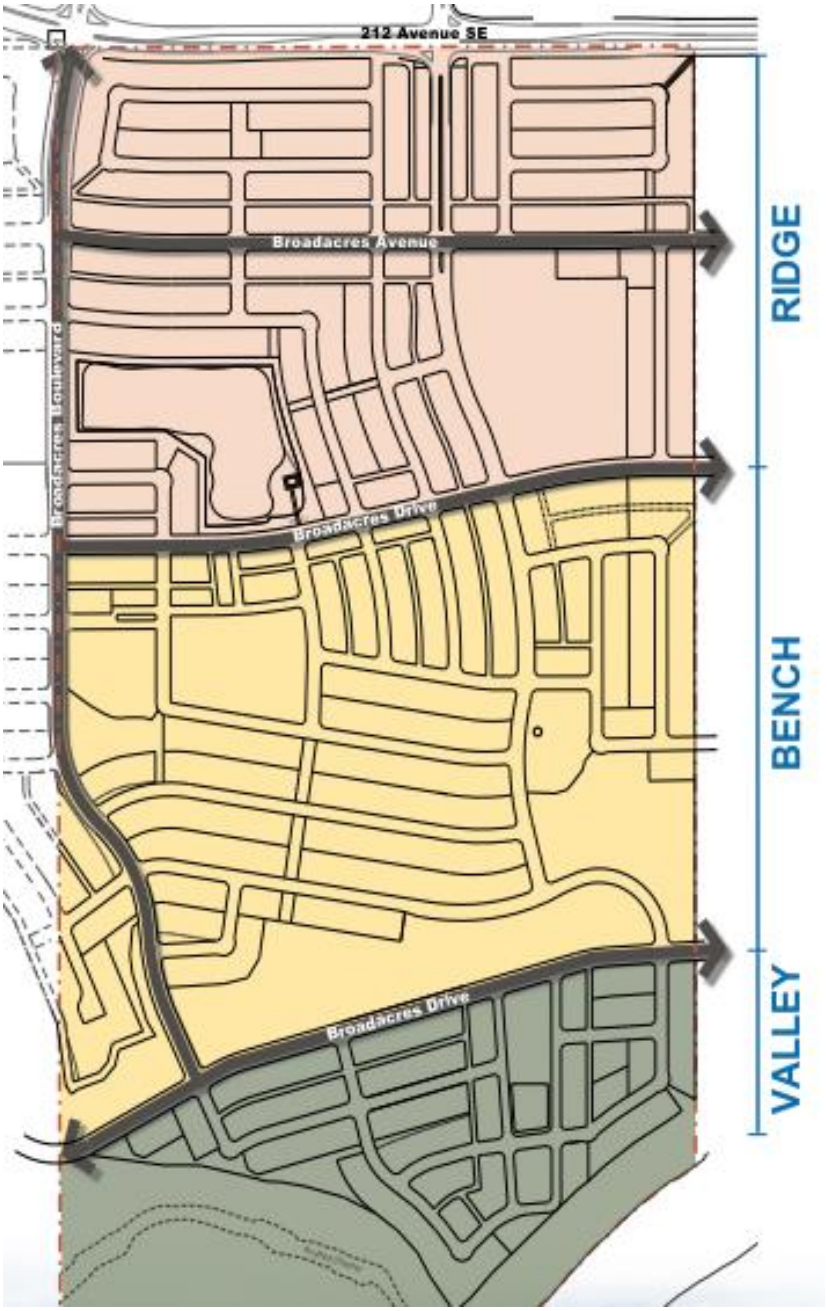
Figure 4 - Existing Topography and Drainage Direction



Source: LOC 2020-0100

Brown and Associates

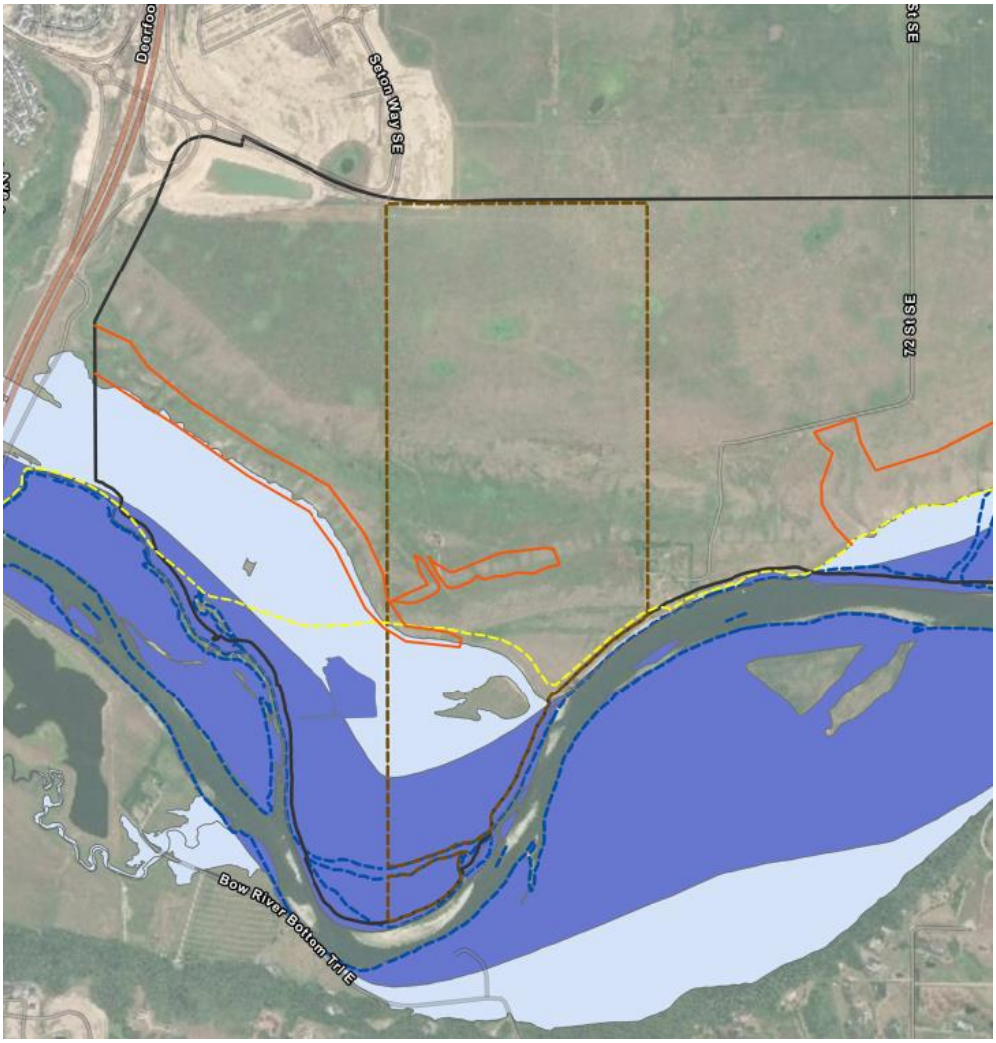
Figure 5 - Topographically Distinct Development Areas



Source: LOC 2020-0100

Brown and Associates

Figure 6 - Development Constraints - RRMDP



Legend

- Slope Stability Setback Line (McIntosh Lalani Engineering Ltd.)
- 200 Year Meander Belt
- Normal River Channel
- Flood Fringe
- Floodway
- Genesis Boundary

Source: RRMDP, Figure 4

Figure 7 - Proposed Land Use Concept

Source: LOC 2020-0100

Brown and Associates

2.2 Design Objectives

The design objectives for Logan Landing stormwater system are summarized as follows:

- The allowable discharge from Logan landing to the Bow River is 2.78 L/s/ha (Rangeview Stormwater Master Drainage Plan, Urban Systems 2015)
- The allowable Unit Area Release Rate (UARR) from the development to the minor storm system is be 115 L/s/ha for all multifamily sites, 70 L/s/ha for all single family residential and low imperviousness sites, and 120 L/s/ha for roadways
- A specific runoff volume target is not established for the study area. Irrigation with stormwater is not proposed
- The performance target for water quality is the removal of a minimum of 85% Total Suspended Solids (TSS) for particle sizes greater than or equal to 50 µm, with a minimum treatment of 90% of the average yearly runoff volume. This target will be achieved through a combination of treatment mechanisms, including oil/grit separators placed upstream of the ponds and constructed wetlands, and further removal of fines in the stormwater facilities
- The stormwater storage and flow attenuation will be provided by one stormwater management facility (constructed wetland)
- The internal stormwater conveyance system will be designed to safely manage peak flows for the 1:100-year precipitation event, as per the current municipal and provincial stormwater guidelines

2.3 Biophysical Impact Assessment (BIA)

The Ecological Inventory report (Stantec, 2019) identified a number of wetlands and environmentally sensitive areas within the Logan Landing project boundary. Onsite investigation confirmed that presence of eight (8) small wetland areas and one (1) manmade waterbody resulting from gravel extraction operations. Fifteen (15) ephemeral drainages were also assessed along the valley escarpment. As mentioned in the Section 2.1, the Ridge wetlands will be removed and compensated. Majority of the escarpment and associated slope wetlands and ephemeral drainages will be avoided and will have an ER designation.

2.4 Hydrogeological Assessment

Waterline Resources Inc. completed a hydrogeological review of the Ricardo Ranch ASP area in July 2018, with final report submitted in January of 2019. Based on Waterline's review there appears to be three groundwater systems present:

- A shallow, localized, small-scale perched groundwater system present on the upper bench (Ridge), which may be infiltrating groundwater vertically, deeper

into the Crossfield Drift. The water source in this system is from snowmelt and precipitation. It does not appear that there are subsurface drainage connections in this region. The subsoil is glacial till with a low hydraulic conductivity and the wetlands appear to be perched with little likelihood of groundwater interaction

- A deeper, intermediate-scale groundwater system present within the Crossfield Drift; the groundwater in this system is sourced from a combination of existing groundwater present upgradient in the Crossfield Drift and snowmelt and precipitation infiltrating from low lying surface depressions such as ephemeral wetlands present on the plateau
- A regional-scale groundwater system is present in the bedrock aquifers; groundwater in this system is sourced from recharge occurring over a large region north of the study area

The conceptual model of groundwater flow along the escarpment demonstrated that an intermediate to regional flow system controls the discharge of groundwater from inter-till aquifers which occur as springs and seeps along the escarpment, and a regional flow system controls the discharge of groundwater from the bedrock at the base of the escarpment.

Waterline concluded that land development could potentially reduce the infiltration on the plateau, which may somewhat reduce the discharge from the associated springs and seeps along the escarpment. However, it should be noted that most of the impacts have already occurred through the development of Rangeview and Seton District areas, as well as earlier developments north of Seton district. The impacts on the intermediate or regional scale groundwater regimes from the development of Logan landing (and the rest of Ricardo Ranch ASP area) are not anticipated.

2.5 Geotechnical Study

McIntosh Lalani undertook a Geotechnical Evaluation of the subject site summarized in their report dated June 24, 2020. Their evaluation consisted of advancing 50 boreholes throughout the development area with select boreholes drilled deep enough to obtain soils information relevant to undertake slope analysis.

The findings of the borehole analysis established that the native inorganic soils were suitable for use in grading operations, and will provide suitable support for residential foundations, utilities, and roadways. The report provides numerous geotechnical considerations for design and construction which should be followed at the next stage.

3.0 POST-DEVELOPMENT ASSESSMENT

3.1 Stormwater Servicing Concept

3.1.1 Servicing Overview

The post-development stormwater servicing concept is presented on **Figure 8**. One stormwater management facility, a constructed wetland, is proposed to provide servicing for Logan Landing Ridge and portion of Bench development. The Brookfield development on the upper bench (above the escarpment), as well as the western portion of Logan Landing Bench and Logan Landing Valley development, will be serviced by the future constructed wetland in the river valley west of Logan Landing, on the land owned by Brookfield Residential.

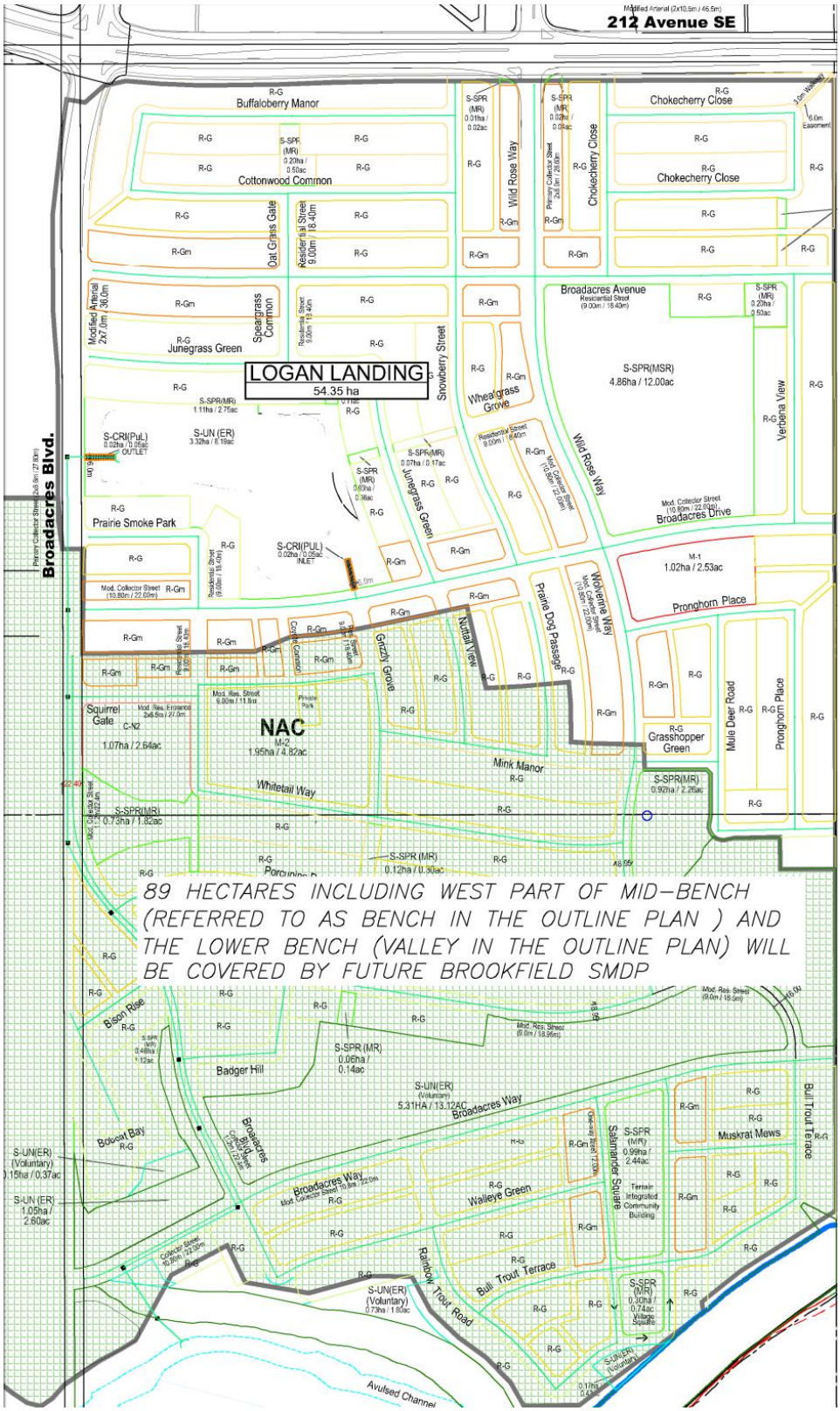
It should be noted that total catchment area of the Ridge stormwater facility is 54 hectares, which is less than 73 hectares specified for Ricardo Ranch 1 pond in the RRMDP. The catchment areas in the RRMDP were approximate since grading and development layout was not available at the time of report preparation. The catchment areas presented in this SMDP are based on detailed civil engineering design and are considered accurate.

The facility will discharge to the developer-funded storm trunk in the 56th Street SE ROW. The discharge will be based on the unit rate of 2.78 L/s/ha, established in the Rangeview MDP (Urban Systems, 2015) and confirmed in the RRMDP. The 56th Street SE storm trunk will be a "clean water trunk" that will also accept discharges form the future Brookfield facility and outlet to the Bow River. The conceptual trunk alignment was presented in the RRMDP. Preliminary trunk design typically required at the SMDP level will be included in the Brookfield SMDP, currently under preparation by Urban Systems.

Irrigation with stormwater is not considered for Logan Landing development. To reduce stormwater volumes discharged to the Bow River, the following LID strategies will be implemented throughout the development area:

- Use of absorbent landscaping for all pervious areas, with a minimum depth of 300 mm
- Routing of impervious areas over pervious areas (hard surface disconnection)

Figure 8 - Post-development Stormwater Servicing Concept



3.1.2 Stormwater Facility

The conceptual layout of the constructed wetland is shown on **Figure 9.**

To ensure that the facility will meet the requirements for ER designation, the proposed design is in accordance with the requirements set out in the 'Alberta Guide to Wetland Construction in Stormwater Management Facilities' (AEP, December 2018). The design includes the following considerations:

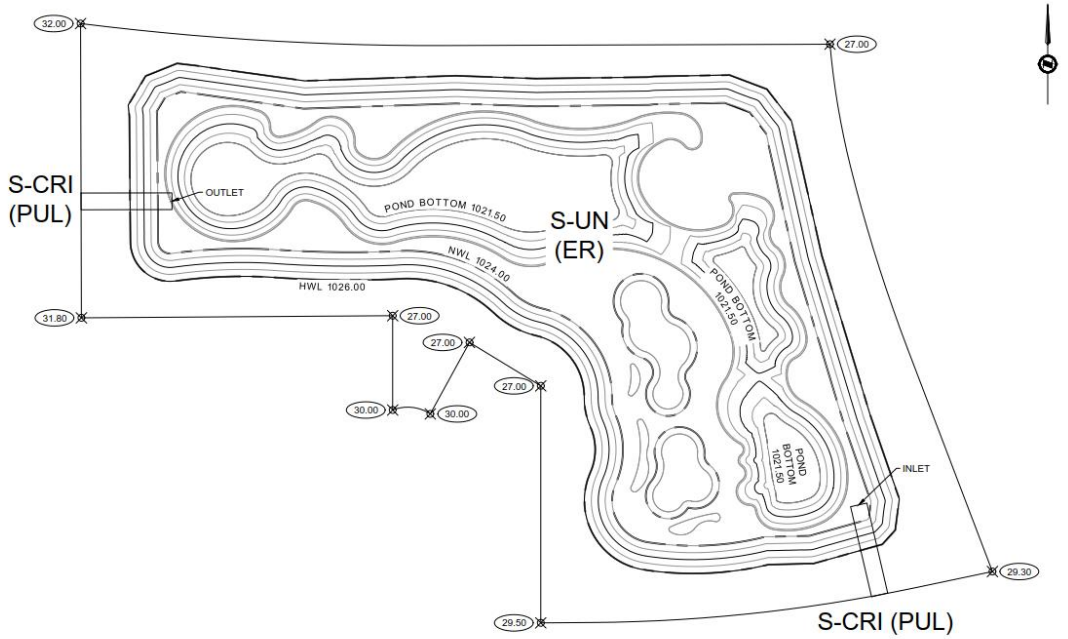
- Prior to discharge to the wetland, stormwater runoff will be pretreated to high standards in an upstream OGS unit. The unit will be designed to remove sediment particles of 50 microns and larger
- The facility incorporates vegetation and design features similar to typical prairie wetlands. Native planting will be chosen to provide diversity and create desirable habitat for fauna and birds
- The permanent pool depth and the frequency of inundation in the active storage zone mimic the hydroperiod of naturally occurring prairie wetlands
- Slopes in the wetland zones between NWL and HWL range from 5:1 to 10:1
- A 6 m environmental setback will be maintained to further protect wetland health

In addition, the wetland operation conforms to the AEP guidelines that specify the duration and frequency of inundation in various wetland zones, as follows:

- Water in the wetland can be up to 0.6 m above the NWL for 20 consecutive days or less, during any one growing season
- The wetland can be in the drawdown state for one consecutive growing season
- The wetland can experience natural drawdown below NWL in late summer due to evaporative losses

An overland escape route for the wetland is not possible due to grade challenges around the facility. The facility has been oversized to provide storage for the 1:500-year event, and a 0.5 m freeboard above the 1:500 level. The 1:500-year elevation is at 1025.62 m. The freeboard is at 1026.50 m.

Figure 9 - Constructed Wetland Concept



Key design characteristics of the wetland are presented in **Tables 1 and 2** below.

Table 1 - Constructed Wetland Characteristics

Parameter	Value
Normal Water Level (NWL)	1024.00 m
High Water Level (HWL)	1026.00 m
Freeboard Elevation	1026.50 m
Active Depth (NWL to HWL)	2.00 m
Area at NWL	1.95 ha
Area at HWL	2.89 ha
Total Available Storage Volume at HWL	71,180 m^3

Table 2 - Constructed Wetland Stage-Storage- Discharge Curve

Elevation (m)	Depth (m)	Area (m^2)	Total volume (m^3)	Discharge (L/s)	Zone
1021.5	0	3,535	0	-	Deep Pool Bottom
1023.4	1.9	10,792	12,970	-	Channel Bottom
1024.0	2.5	19,547	21,962	0	NWL
1024.5	3.0	22,957	32,346	68	
1025.0	3.5	24,892	44,306	103	
1025.5	4.0	26,867	57,245	129	
1026.0	4.5	28,882	71,180	151	HWL
1026.5	5.0	30,897	86,156	-	Freeboard

3.1.3 Storm Sewers

A stormwater sewer system (minor system) will service the development and will drain to the constructed wetland facility. The final minor system layout and sizing will be determined at the detailed design stage and will be included in subsequent Stormwater Management Reports for each of the development phases. The Unit Area Release Rate is set at 70L/s/ha for residential and MR sites, 115 L/s/ha for multifamily and commercial sites, and 120 L/s/ha for roadways.

Preliminary trunk sizing within 56th Street SE ROW is not provided in this report as design has not yet progressed to detailed stage.

3.1.4 Off-site Flows

No off-site flows have been accounted for in stormwater design for Logan Landing.

The drainage from the entire 212th Avenue ROW (north project boundary) has been accounted for in the design of Seton Ponds E and D, as specified in the approved Seton SMDP (Urban Systems, 2018).

Brookfield development west of Logan Landing, as well as future Soutzo development east of study area will manage their stormwater runoff within their development boundaries. No overland or pipe flows will cross the 56th Street SE or 52nd (72nd) Street SE to enter Logan Landing development area.

3.1.5 Water Quality

An oil/grit separator unit will be placed within the stormwater pipe upstream of stormwater facility inlet to achieve the required performance target for sediment removal. OGS units for wet ponds are required to remove 85% of particles below 150 microns, and the OGS units for the constructed wetlands are required to remove 85% of particles below 75 microns, as per City of Calgary standards. For Logan Landing, the OGS unit will be sized to remove 85% of particles below 50 microns, which far exceeds the standard requirements and ensures that wetland will maintain good water quality status.

The sizing of the OGS unit will be provided at the Pond report stage.

3.2 Post-Development Analysis Framework

3.2.1 Methodology

The objective of the post-development analysis was to confirm the sizing and footprint of stormwater facility and the level of service provided by the stormwater management system.

Analysis of storage volumes for the storage facilities was carried out using the latest version of PCSWMM software:

- PCSWMM Professional 2D, version 7.2.2785
- Graphical Interface for EPASWWM version 5.1.013

Both the 24-hour 1:100-year single event and continuous simulation were performed. The single extreme event analysis uses the 1:100-year Chicago design storm event. The design event is based on the criteria established in the 2011 City of Calgary Stormwater Management and Design Manual. The results of the simulation provide the user with a single storage volume required to contain runoff (i.e. below pond HWL) from a 1:100-year theoretical rainfall event.

The City of Calgary precipitation and temperature dataset for the 55-year period (1960 through 2014) were used for modelling. In the simulations, the model continuously updates results for the overall water balance and its constituent processes such as precipitation, infiltration, and evapotranspiration. The simulation provides the user with maximum pond volumes in each of the years of record, 1960 through 2014. The results from the continuous simulation were further analyzed using the City of Calgary's Data and Frequency Analysis Spreadsheet (DFASCC) to determine the statistical 1:100-year storage volume.

Results from the single event simulation, continuous event simulation, and statistical 1:100-year event are then compared to determine the highest value that governs the storage volume requirements for the proposed storage facilities. Results are presented in the following section.

3.2.2 PCSWMM Model Parameters

Stormwater runoff calculation parameters used for this study are based on known conditions at the site and are consistent with City of Calgary guidelines.

A summary of the common input parameters used in each model are:

- Green-Ampt Infiltration parameters for 'Loam' based on the geotechnical study completed for the development area. Parameters are summarized in **Table 3.**
- Abstraction Loss Parameters:
  - Pervious Surfaces = 3.2 mm
  - Impervious Surfaces = 1.6 mm
- Manning 'n' Values:
  - Pervious Areas = 0.25
  - Impervious Areas = 0.015

Table 3 - Green-Ampt Infiltration Parameters

Parameter	Value
Suction Head (mm)	170
Conductivity (mm/hr)	3.302
Initial Deficit	0.347

The post-development layout plan shown on **Figure 7** was used as the basis for model development. Only areas that contribute drainage to the Logan Landing stormwater system were modeled. **Tables 4 and 5** present the post-development land uses and estimated imperviousness percentages.

Table 4 - Post-Development Catchment Parameters

Catchment	Total Area (ha)	Imperviousness (%)	Percent Routed to Pervious (%)
Logan Landing Development Area	51.03	67	25
Wetland NWL	2.11	100	0
Wetland Fringe	1.21	10	100
TOTAL	**54.35**	**70**	**-**

Table 5 -Impervious Area Assumptions

Land Use	Imperviousness (%)
Single Family (R-G)	60
Multi-Family (R-Gm, M-1, M-2)	85
Commercial (C-N2)	90
School Site (S-SPR-MSR)	40
Municipal Reserve (S-SPR-MR)	15
Roadways and Lanes	85

3.2.3 Model Results

The storage volume results are summarized in **Table 6** below.

Table 6 - Wetland Storage Volumes

	Storage Volume (m^3)
Available Active Storage	49,218
100-year Single Event	27,286
500-year Single Event	38,492
Continuous Event Max	32,173
Statistical 100-year	31,338

The allowable release rate for the development area, based on the predevelopment target of 2.78 L/s/ha, is 151 L/s.

Based on post-development condition modeling, and assuming full development of the project area and the release rate of 2.78 L/s/ha, the constructed wetland will maintain a healthy permanent hydroperiod that mimics the typical hydroperiod of the prairie wetlands. Over a 55-year continuous simulation period, the following was observed:

- There were 42 occurrences of the wetland water levels 0.5 m above its NWL, for a total of 965 hours. On average, the wetland was above the NWL for approximately 1 day in a year, or less than 1% of the simulation time
- The wetland levels were 1.0 m above its NWL only 2 times for the entire simulation period, for a total of 68 hours
- The wetland was below NWL for approximately 26% of the time, mostly during late summer and fall. This is typical of prairie wetland hydroperiods, which experience seasonal drawdown in the late summer and early fall due to evaporative losses

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

The stormwater servicing concept presented for Logan Landing provides a 100-year level of service for the development, which is in accordance with the Provincial and City of Calgary requirements. All pertinent Provincial and City of Calgary design guidelines and standards were followed in the stormwater design and analytical approach.

This SMDP addresses only 54 hectares of Logan Landing Outline Plan area. The remainder of the development area (89 hectares) will be included in the SMDP for Brookfield development area just west of Logan Landing. This is in accordance with servicing concepts presented in the RRMDP.

There are no off-site areas that contribute drainage to the study area in the post-development conditions. No oversize was provided in the Logan landing stormwater system design or stormwater facility.

Drainage from the development lands will be directed to a stormwater facility by a combination of piped and overland drainage system. The facility is envisioned as a constructed wetland with primary wetland and secondary stormwater function. All pertinent wetland design considerations, including the frequency and duration of inundation at various wetland zones, are strictly followed to ensure that the facility qualifies for ER designation. The areas with PUL designation will be limited to the inlet and outlet control structure. The facility layout and characteristics are described in Section 3 of the report.

The facility is sized based on the release rate of 2.78 L/s/ha, which is stipulated in the Rangeview Master Drainage Plan (Urban Systems, 2015) and confirmed in the RRMDP (Urban Systems, 2019). The maximum discharge from the facility is 151 L/s/ha.

The facility is significantly oversized from a storm pond perspective, but the active storage oversize helps achieve the natural wetland hydroperiod characteristics. Total available active storage volume is 49,218 m^3. The maximum modelled 100-year volume is 32,173 m^3. Over the 55-year simulation period, the wetland reaches the depth of 1.0 m above NWL only twice.

Stormwater reuse for irrigation is not planned for the development. volume reduction practices such as absorbent landscaping and hard surface disconnection will be utilized throughout the development and is accounted for in the model.

Water quality will be provided by an OGS unit sized to remove 85% of particles smaller than 50 microns. The unit will be placed upstream of the wetland inlet, following all City of Calgary guidelines. The final sizing of the OGS unit will be provided at Pond Report stage.

4.2 Recommendations

The following is a summary of recommended action items that should be addressed during future reporting stages:

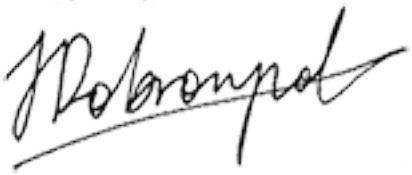
- The analysis and results presented in this report are preliminary and will need to be refined once more detailed development information is available, at Pond Report stage
- Detailed design of the development within the study area should remain consistent with the concepts presented in this report. Specifically, the surface area and active storage volume of stormwater management facilities should be maintained
- Major system design should follow should meet Alberta Environment and Parks guidelines for velocities and depths on the roadways
- Detailed design of the reconstructed wetland should be consistent with the AEP guidelines. The wetland hydroperiod should be refined and further analysed at Pond Report stage. In addition to hydroperiod, other elements of design that mimic natural prairie wetlands should be considered, including vegetation types, wetland zones, etc
- All applicable City of Calgary and provincial guidelines should be followed in the design of stormwater infrastructure within study area, to ensure proper operation of the system post construction
- Operation and maintenance manuals should be provided for the reconstructed wetland

CORPORATE AUTHORIZATION

This report, titled Logan Landing Staged Master Drainage Plan, is prepared for Genesis Land Development Corp. The material in this report reflects the best judgement of Urban Systems Ltd. based on the information available at the time of preparation. Any use that the third party makes of this report, or reliance on or decisions made based on it, is the responsibility of the third party. Urban Systems Ltd. accepts no responsibility for damages, if any, suffered by a third party as a result of decisions made or actions taken based on this report.

URBAN SYSTEMS LTD.

Analysis by:



Yury Dobronravov, E.I.T.

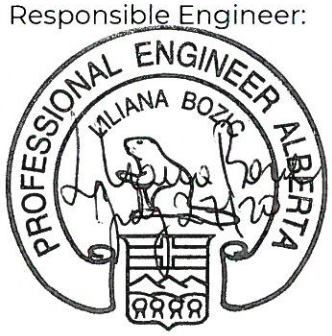
PERMIT TO PRACTICE
URBAN SYSTEMS LTD.

Signature _____

Date _____

PERMIT NUMBER: P 3836
The Association of Professional Engineers and Geoscientists of Alberta

Responsible Engineer:



Liliana Bozic, M.Sc. P.Eng.
Senior Engineer

APPENDIX A

PCSWMM CONTINUOUS SIMULATION MODEL FILES

```
[TITLE]
Hydrologic model of Genesis tributiary area - continuous event (Calgary, Alberta)


[OPTIONS]
;;Options             Value
;;------------------- ------------
FLOW_UNITS            CMS
INFILTRATION          GREEN_AMPT
FLOW_ROUTING          DYNWAVE
LINK_OFFSETS          ELEVATION
MIN_SLOPE             0
ALLOW_PONDING         YES
SKIP_STEADY_STATE     NO
START_DATE            01/01/1960
START_TIME            00:00:00
REPORT_START_DATE     01/01/1960
REPORT_START_TIME     00:00:00
END_DATE              12/31/2014
END_TIME              23:00:00
SWEEP_START           01/01
SWEEP_END             12/31
DRY_DAYS              0
REPORT_STEP           00:15:00
WET_STEP              00:05:00
DRY_STEP              00:05:00
ROUTING_STEP          60
RULE_STEP             00:00:00
INERTIAL_DAMPING      PARTIAL
NORMAL_FLOW_LIMITED   BOTH
FORCE_MAIN_EQUATION   H-W
SURCHARGE_METHOD      Slot
VARIABLE_STEP         0.75
LENGTHENING_STEP      0
MIN_SURFAREA          1.167
MAX_TRIALS            8
HEAD_TOLERANCE        0.0015
SYS_FLOW_TOL          5
LAT_FLOW_TOL          5
MINIMUM_STEP          0.5
THREADS               8

[EVAPORATION]
;;Type           Parameters
;;-------------- ----------
MONTHLY       0.10   0.39   1.12   2.40   3.61   4.57   4.99   4      2.24   0.99   0.27   0.07
DRY_ONLY      NO
[TEMPERATURE]
TIMESERIES    Temp1960-2014
WINDSPEED     MONTHLY    14.8 14.6 15 16.5 16.6 15.6 14.0 13.2 14.1 14.6 13.7 14.9
SNOWMELT               0 0.5 0.6 1100 50.0 0.0
ADC           IMPERVIOUS 0.10 0.35 0.53 0.66 0.75 0.82 0.87 0.92 0.95 0.98
ADC           PERVIOUS   0.10 0.35 0.53 0.66 0.75 0.82 0.87 0.92 0.95 0.98

[RAINGAGES]
;;               Rain      Time   Snow   Data
;;Name           Type      Intrvl Catch  Source
;;-------------- --------- ------ ------ ----------
Calgary_24h-100y INTENSITY 0:05   1.0    TIMESERIES Calgary_24h-100y
Precip1960-2014  INTENSITY 1:00   1.0    TIMESERIES Precip1960-2014

[SUBCATCHMENTS]
;;                                                 Total    Pcnt.             Pcnt.    Curb
Snow
;;Name           Raingage         Outlet           Area     Imperv   Width    Slope    Length
Pack
;;-------------- ---------------- ---------------- -------- -------- -------- -------- --------
--------
LOGAN-LANDING    Precip1960-2014  LOGAN-LANDING-WETLAND 51.03 70     4082.4   2        0
Snowpack
```

```
WETLAND-FRINGE   Precip1960-2014  LOGAN-LANDING-WETLAND 1.21 10      605      20       0
Snowpack
WETLAND-NWL      Precip1960-2014  LOGAN-LANDING-WETLAND 2.11 100     2110     0.5      0
Snowpack

[SUBAREAS]
;;Subcatchment   N-Imperv   N-Perv     S-Imperv   S-Perv     PctZero    RouteTo    PctRouted
;;-------------- ---------- ---------- ---------- ---------- ---------- ---------- ----------
LOGAN-LANDING    0.015      0.25       1.6        3.2        0          PERVIOUS   25
WETLAND-FRINGE   0.015      0.25       1.6        3.2        0          OUTLET
WETLAND-NWL      0          0.25       1.6        3.2        100        OUTLET

[INFILTRATION]
;;Subcatchment   Suction    HydCon     IMDmax
;;-------------- ---------- ---------- ----------
LOGAN-LANDING    88.9       3.302      0.347
WETLAND-FRINGE   88.9       3.302      0.347
WETLAND-NWL      88.9       3.302      0.347

[SNOWPACKS]
Snowpack         PLOWABLE   0.025      0.2        0.0        0.10       0.00       0.00       0
Snowpack         IMPERVIOUS 0.05       0.2        0.0        0.10       0.00       0.00       25
Snowpack         PERVIOUS   0.05       0.2        0.0        0.10       0.00       0.00
100
Snowpack         REMOVAL    25         0.0        0.0        0.5        0.0        0.0

[OUTFALLS]
;;               Invert     Outfall      Stage/Table      Tide
;;Name           Elev.      Type         Time Series      Gate Route To
;;-------------- ---------- ------------ ---------------- ---- ----------------
2                1021.5     FREE                          NO

[STORAGE]
;;               Invert   Max.     Init.    Storage    Curve                              Evap.
;;Name           Elev.    Depth    Depth    Curve      Params                             Frac.
Infiltration parameters
;;-------------- -------- -------- -------- ---------- -------- -------- -------- -------- -----
--- ------------------------
LOGAN-LANDING-WETLAND 1021.5 4.5   2.5      TABULAR    WETLAND                    0        1

[ORIFICES]
;;               Inlet            Outlet           Orifice      Crest      Disch.     Flap
Open/Close
;;Name           Node             Node             Type         Height     Coeff.     Gate Time
;;-------------- ---------------- ---------------- ------------ ---------- ---------- ---- -----
-----
1                LOGAN-LANDING-WETLAND 2           SIDE         1024       0.61       NO   0

[XSECTIONS]
;;Link           Shape        Geom1            Geom2      Geom3      Geom4      Barrels
;;-------------- ------------ ---------------- ---------- ---------- ---------- ----------
1                CIRCULAR     0.227            0          0          0

[CURVES]
;;Name           Type       X-Value    Y-Value
;;-------------- ---------- ---------- ----------
WETLAND          Storage    0          3535
WETLAND                     0.1        3818
WETLAND                     0.2        4113
WETLAND                     0.3        4419
WETLAND                     0.4        4736
WETLAND                     0.5        5065
WETLAND                     0.6        5404
WETLAND                     0.7        5754
WETLAND                     0.8        6116
WETLAND                     0.9        6489
WETLAND                     1          6872
WETLAND                     1.1        7267
WETLAND                     1.2        7673
WETLAND                     1.3        8084
WETLAND                     1.4        8502
```

```
WETLAND                    1.5        8925
WETLAND                    1.6        9354
WETLAND                    1.7        9789
WETLAND                    1.8        10229
WETLAND                    1.9        10792
WETLAND                    2          11379
WETLAND                    2.1        13569
WETLAND                    2.2        15036
WETLAND                    2.3        16514
WETLAND                    2.4        18002
WETLAND                    2.5        19547
WETLAND                    2.6        20037
WETLAND                    2.7        20525
WETLAND                    2.8        21011
WETLAND                    2.9        21497
WETLAND                    3          22957
WETLAND                    3.1        23341
WETLAND                    3.2        23726
WETLAND                    3.3        24113
WETLAND                    3.4        24502
WETLAND                    3.5        24892
WETLAND                    3.6        25284
WETLAND                    3.7        25677
WETLAND                    3.8        26072
WETLAND                    3.9        26469
WETLAND                    4          26867
WETLAND                    4.1        27267
WETLAND                    4.2        27668
WETLAND                    4.3        28071
WETLAND                    4.4        28476
WETLAND                    4.5        28882

[TIMESERIES]
;;Name           Date       Time       Value
;;-------------- ---------- ---------- ----------
;Calgary_24h-100y design storm, rain interval = 5 minutes, rain units = mm/hr.
Calgary_24h-100y            0:00       0
Calgary_24h-100y            0:05       1.094
Calgary_24h-100y            0:10       1.103
Calgary_24h-100y            0:15       1.113
Calgary_24h-100y            24:00      1.077
Rest of Data Removed

;Rainfall (mm/hr)
Precip1960-2014  01/01/1960 00:00:00   0
Precip1960-2014  01/01/1960 01:00:00   0
Precip1960-2014  01/01/1960 02:00:00   0
Precip1960-2014  01/01/1960 03:00:00   0
Precip1960-2014  01/01/1960 04:00:00   0
Precip1960-2014  01/01/1960 05:00:00   0
Precip1960-2014  01/01/1960 06:00:00   0
Precip1960-2014  01/01/1960 07:00:00   0
Precip1960-2014  01/01/1960 08:00:00   0
Precip1960-2014  01/01/1960 09:00:00   0
Precip1960-2014  01/01/1960 10:00:00   0
......
Too many data points (482136 in total).

;Enter function... (degC)
Temp1960-2014    01/01/1960 00:00:00   -13.3
Temp1960-2014    01/01/1960 01:00:00   -12.8
Temp1960-2014    01/01/1960 02:00:00   -12.2
Temp1960-2014    01/01/1960 03:00:00   -12.2
Temp1960-2014    01/01/1960 04:00:00   -13.3
Temp1960-2014    01/01/1960 05:00:00   -13.3
Temp1960-2014    01/01/1960 06:00:00   -13.3
Temp1960-2014    01/01/1960 07:00:00   -13.9
Temp1960-2014    01/01/1960 08:00:00   -13.9
Temp1960-2014    01/01/1960 09:00:00   -15.6
Temp1960-2014    01/01/1960 10:00:00   -14.4
......
```

```
Too many data points (482136 in total).

[PATTERNS]
;;Name           Type       Multipliers
;;-------------- ---------- -----------
Winter           MONTHLY    0.05  0.05  0.05  0.05  1.0   1.0
Winter                       1.0   1.0   1.0   1.0   0.05  0.05


[REPORT]
INPUT      YES
CONTROLS   NO
SUBCATCHMENTS ALL
NODES ALL
LINKS ALL

[ADJUSTMENTS]
;;Parameter    Subcatchment     Monthly Adjustments
;;------------ ---------------- --------------------------------
N-PERV         LOGAN-LANDING    Winter
DSTORE         LOGAN-LANDING    Winter
INFIL          LOGAN-LANDING    Winter
N-PERV         WETLAND-FRINGE   Winter
DSTORE         WETLAND-FRINGE   Winter
INFIL          WETLAND-FRINGE   Winter
N-PERV         WETLAND-NWL      Winter
DSTORE         WETLAND-NWL      Winter
INFIL          WETLAND-NWL      Winter

[TAGS]

[MAP]
DIMENSIONS       3302.09923055715 5635385.2432826  4220.82651543416 5636312.63808069
UNITS            Meters

[COORDINATES]
;;Node           X-Coord          Y-Coord
;;-------------- ---------------- ----------------
2                3363.891         5635759.735
LOGAN-LANDING-WETLAND 3556.166         5635858.545

[VERTICES]
;;Link           X-Coord          Y-Coord
;;-------------- ---------------- ----------------

[POLYGONS]
;;Subcatchment   X-Coord          Y-Coord
;;-------------- ---------------- ----------------
LOGAN-LANDING    3376.748         5635715.754
LOGAN-LANDING    3377.418         5635770.547
LOGAN-LANDING    3354.503         5635770.572
LOGAN-LANDING    3349.97          5635800.271
LOGAN-LANDING    3349.858         5635844.663
LOGAN-LANDING    3349.623         5635930.803
Rest of Data Removed

[SYMBOLS]
;;Gage           X-Coord          Y-Coord
;;-------------- ---------------- ----------------
```

```
  EPA STORM WATER MANAGEMENT MODEL - VERSION 5.1 (Build 5.1.013)
  --------------------------------------------------------------

  Hydrologic model of Genesis tributiary area - continuous event (Calgary, Alberta)


  *************
  Element Count
  *************
  Number of rain gages ...... 2
  Number of subcatchments ... 3
  Number of nodes ........... 2
  Number of links ........... 1
  Number of pollutants ...... 0
  Number of land uses ....... 0


  ****************
  Raingage Summary
  ****************
                                                      Data       Recording
  Name                 Data Source                    Type       Interval
  ----------------------------------------------------------------------
  Calgary_24h-100y     Calgary_24h-100y               INTENSITY    5 min.
  Precip1960-2014      Precip1960-2014                INTENSITY   60 min.


  ********************
  Subcatchment Summary
  ********************
  Name                        Area     Width   %Imperv    %Slope Rain Gage            Outlet
  ------------------------------------------------------------------------------------------
------------
  LOGAN-LANDING             51.03   4082.40     70.00    2.0000 Precip1960-2014      LOGAN-
LANDING-WETLAND
  WETLAND-FRINGE             1.21    605.00     10.00   20.0000 Precip1960-2014      LOGAN-
LANDING-WETLAND
  WETLAND-NWL                2.11   2110.00    100.00    0.5000 Precip1960-2014      LOGAN-
LANDING-WETLAND


  ************
  Node Summary
  ************
                                         Invert      Max.    Ponded    External
  Name                 Type                Elev.     Depth      Area    Inflow
  ----------------------------------------------------------------------------
  2                    OUTFALL           1021.50      0.00       0.0
  LOGAN-LANDING-WETLAND STORAGE           1021.50      4.50       0.0


  ************
  Link Summary
  ************
  Name             From Node        To Node          Type            Length    %Slope Roughness
  ---------------------------------------------------------------------------------------------
  1                LOGAN-LANDING-WETLAND 2               ORIFICE


  *********************
  Cross Section Summary
  *********************
                                      Full     Full     Hyd.     Max.   No. of     Full
  Conduit          Shape             Depth     Area     Rad.    Width  Barrels     Flow
  ---------------------------------------------------------------------------------------
```

```
***********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
***********************************************************

***************
Analysis Options
***************
Flow Units ..............  CMS
Process Models:
  Rainfall/Runoff ........  YES
  RDII ...................  NO
  Snowmelt ...............  YES
  Groundwater ............  NO
  Flow Routing ...........  YES
  Ponding Allowed ........  YES
  Water Quality ..........  NO
Infiltration Method ......  GREEN_AMPT
Flow Routing Method ......  DYNWAVE
Surcharge Method .........  SLOT
Starting Date ............  01/01/1960 00:00:00
Ending Date ..............  12/31/2014 23:00:00
Antecedent Dry Days ......  0.0
Report Time Step .........  00:15:00
Wet Time Step ............  00:05:00
Dry Time Step ............  00:05:00
Routing Time Step ........  60.00 sec
Variable Time Step .......  YES
Maximum Trials ...........  8
Number of Threads ........  1
Head Tolerance ...........  0.001500 m

**************************        Volume         Depth
Runoff Quantity Continuity     hectare-m            mm
**************************     ---------       -------
Initial Snow Cover .......         0.000         0.000
Total Precipitation ......      1244.800     22903.400
Evaporation Loss .........       276.089      5079.826
Infiltration Loss ........       453.297      8340.332
Surface Runoff ...........       516.488      9503.001
Snow Removed .............         0.000         0.000
Final Snow Cover .........         0.000         0.000
Final Storage ............         0.000         0.000
Continuity Error (%) .....        -0.086

**************************        Volume        Volume
Flow Routing Continuity        hectare-m      10^6 ltr
**************************     ---------      ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......       516.488      5164.935
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........       434.998      4350.028
Flooding Loss ............         0.000         0.000
Evaporation Loss .........        81.455       814.560
Exfiltration Loss ........         0.000         0.000
Initial Stored Volume ....         2.194        21.942
Final Stored Volume ......         2.229        22.288
Continuity Error (%) .....         0.000

***************************
Time-Step Critical Elements
***************************
None
```

```
  ********************************
  Highest Flow Instability Indexes
  ********************************
  All links are stable.


  ************************
  Routing Time Step Summary
  ************************
  Minimum Time Step           :    59.50 sec
  Average Time Step           :    60.00 sec
  Maximum Time Step           :    60.00 sec
  Percent in Steady State     :     0.00
  Average Iterations per Step :     2.00
  Percent Not Converging      :     0.00


  ***************************
  Subcatchment Runoff Summary
  ***************************

  ---------------------------------------------------------------------------------------------------
--------------------------------
                             Total      Total      Total      Total     Imperv       Perv
Total       Total     Peak  Runoff
                           Precip      Runon       Evap      Infil     Runoff     Runoff
Runoff      Runoff    Runoff   Coeff
  Subcatchment                mm         mm         mm         mm         mm         mm
mm    10^6 ltr      CMS
  ---------------------------------------------------------------------------------------------------
--------------------------------
  LOGAN-LANDING          22903.40       0.00    5387.16    8423.25   10822.52     996.46
9113.34     4650.57     7.07   0.398
  WETLAND-FRINGE         22903.40       0.00     976.84   19387.48    1592.03     976.56
2568.60       31.08     0.15   0.112
  WETLAND-NWL            22903.40       0.00       0.00       0.00   22903.40       0.00
22903.40      483.26     0.31   1.000


  ******************
  Node Depth Summary
  ******************

  ------------------------------------------------------------------------------
                                Average  Maximum  Maximum  Time of Max    Reported
                                  Depth    Depth      HGL   Occurrence   Max Depth
  Node                 Type       Meters   Meters   Meters  days hr:min      Meters
  ------------------------------------------------------------------------------
  2                    OUTFALL      0.00     0.00  1021.50     0  00:00        0.00
  LOGAN-LANDING-WETLAND STORAGE     2.52     3.89  1025.39  17323  12:02        3.89


  ******************
  Node Inflow Summary
  ******************

  ---------------------------------------------------------------------------------------------------
--
                                Maximum  Maximum                  Lateral       Total
Flow
                                Lateral    Total  Time of Max      Inflow      Inflow
Balance
                                 Inflow   Inflow   Occurrence      Volume      Volume
Error
  Node                 Type         CMS      CMS  days hr:min    10^6 ltr    10^6 ltr
Percent
  ---------------------------------------------------------------------------------------------------
--
  2                    OUTFALL    0.000    0.124  17323  12:02           0    4.35e+03
0.000
```

```
  LOGAN-LANDING-WETLAND STORAGE      7.534    7.534  17322  20:00    5.16e+03    5.19e+03
0.000


  **********************
  Node Surcharge Summary
  **********************

  No nodes were surcharged.


  **********************
  Node Flooding Summary
  **********************

  No nodes were flooded.


  **********************
  Storage Volume Summary
  **********************

  ------------------------------------------------------------------------------------------------
---
                          Average     Avg  Evap Exfil       Maximum     Max    Time of Max
Maximum
                           Volume    Pcnt  Pcnt  Pcnt        Volume    Pcnt     Occurrence
Outflow
  Storage Unit           1000 m3    Full  Loss  Loss       1000 m3    Full    days hr:min
CMS
  ------------------------------------------------------------------------------------------------
---
  LOGAN-LANDING-WETLAND    22.346      31    16     0        54.415      76    17323  12:02
0.125


  ************************
  Outfall Loading Summary
  ************************

  ---------------------------------------------------------
                          Flow       Avg       Max       Total
                          Freq      Flow      Flow      Volume
  Outfall Node            Pcnt       CMS       CMS    10^6 ltr
  ---------------------------------------------------------
  2                      69.48     0.004     0.124    4350.008
  ---------------------------------------------------------
  System                 69.48     0.004     0.124    4350.008


  ********************
  Link Flow Summary
  ********************

  ---------------------------------------------------------------------------
                                 Maximum  Time of Max   Maximum    Max/    Max/
                                  |Flow|   Occurrence   |Veloc|    Full    Full
  Link                  Type         CMS  days hr:min     m/sec    Flow   Depth
  ---------------------------------------------------------------------------
  1                     ORIFICE    0.124  17323  12:02                    1.00


  ***************************
  Flow Classification Summary
  ***************************

  -------------------------------------------------------------------------------------
                     Adjusted    ---------- Fraction of Time in Flow Class ----------
                      /Actual         Up    Down  Sub   Sup   Up    Down  Norm  Inlet
  Conduit               Length    Dry  Dry   Dry   Crit  Crit  Crit  Crit  Ltd   Ctrl
  -------------------------------------------------------------------------------------
```

```
************************
Conduit Surcharge Summary
************************

No conduits were surcharged.


Analysis begun on:  Mon Jul 27 14:33:15 2020
Analysis ended on:  Mon Jul 27 14:34:01 2020
Total elapsed time: 00:00:46
```

APPENDIX B

PCSWMM SINGLE EVENT MODEL FILES

```
[TITLE]
Hydrologic model of Genesis tributiary area - 500year event (Calgary, Alberta)


[OPTIONS]
;;Options             Value
;;------------------- ------------
FLOW_UNITS            CMS
INFILTRATION          GREEN_AMPT
FLOW_ROUTING          DYNWAVE
LINK_OFFSETS          ELEVATION
MIN_SLOPE             0
ALLOW_PONDING         YES
SKIP_STEADY_STATE     NO
START_DATE            07/27/2020
START_TIME            00:00:00
REPORT_START_DATE     07/27/2020
REPORT_START_TIME     00:00:00
END_DATE              07/28/2020
END_TIME              12:00:00
SWEEP_START           01/01
SWEEP_END             12/31
DRY_DAYS              0
REPORT_STEP           00:15:00
WET_STEP              00:05:00
DRY_STEP              00:05:00
ROUTING_STEP          60
RULE_STEP             00:00:00
INERTIAL_DAMPING      PARTIAL
NORMAL_FLOW_LIMITED   BOTH
FORCE_MAIN_EQUATION   H-W
SURCHARGE_METHOD      Slot
VARIABLE_STEP         0.75
LENGTHENING_STEP      0
MIN_SURFAREA          1.167
MAX_TRIALS            8
HEAD_TOLERANCE        0.0015
SYS_FLOW_TOL          5
LAT_FLOW_TOL          5
MINIMUM_STEP          0.5
THREADS               8

[EVAPORATION]
;;Type           Parameters
;;-------------- ----------
MONTHLY       0.10   0.39   1.12   2.40   3.61   4.57   4.99   4      2.24   0.99   0.27   0.07
DRY_ONLY      NO

[RAINGAGES]
;;                Rain      Time   Snow   Data
;;Name            Type      Intrvl Catch  Source
;;--------------- --------- ------ ------ ----------
Calgary_24h_500y  INTENSITY 0:05   1.0    TIMESERIES Calgary_24h_500y
Calgary_24h-100y  INTENSITY 0:05   1.0    TIMESERIES Calgary_24h-100y
Precip1960-2014   INTENSITY 1:00   1.0    TIMESERIES Precip1960-2014

[SUBCATCHMENTS]
;;                                                    Total    Pcnt.             Pcnt.    Curb
Snow
;;Name            Raingage         Outlet            Area     Imperv   Width    Slope    Length
Pack
;;--------------- ---------------- ----------------- -------- -------- -------- -------- --------
--------
LOGAN-LANDING     Calgary_24h_500y LOGAN-LANDING-WETLAND 51.03 70     4082.4   2        0
WETLAND-FRINGE    Calgary_24h_500y LOGAN-LANDING-WETLAND 1.21 10      605      20       0
WETLAND-NWL       Calgary_24h_500y LOGAN-LANDING-WETLAND 2.11 100     2110     0.5      0

[SUBAREAS]
;;Subcatchment    N-Imperv   N-Perv     S-Imperv   S-Perv     PctZero    RouteTo    PctRouted
;;--------------- ---------- ---------- ---------- ---------- ---------- ---------- ----------
LOGAN-LANDING     0.015      0.25       1.6        3.2        0          PERVIOUS   25
```

```
WETLAND-FRINGE   0.015      0.25       1.6        3.2        0          OUTLET
WETLAND-NWL      0          0.25       1.6        3.2        100        OUTLET

[INFILTRATION]
;;Subcatchment   Suction    HydCon     IMDmax
;;-------------- ---------- ---------- ----------
LOGAN-LANDING    88.9       3.302      0.347
WETLAND-FRINGE   88.9       3.302      0.347
WETLAND-NWL      88.9       3.302      0.347

[OUTFALLS]
;;               Invert     Outfall      Stage/Table      Tide
;;Name           Elev.      Type         Time Series      Gate Route To
;;-------------- ---------- ------------ ---------------- ---- ----------------
2                1021.5     FREE                          NO

[STORAGE]
;;               Invert   Max.     Init.    Storage    Curve                              Evap.
;;Name           Elev.    Depth    Depth    Curve      Params                             Frac.
Infiltration parameters
;;-------------- -------- -------- -------- ---------- -------- -------- -------- -------- -----
--- ----------------------
LOGAN-LANDING-WETLAND 1021.5 5     2.5      TABULAR    WETLAND                    0        1

[ORIFICES]
;;               Inlet            Outlet           Orifice      Crest      Disch.     Flap
Open/Close
;;Name           Node             Node             Type         Height     Coeff.     Gate Time
;;-------------- ---------------- ---------------- ------------ ---------- ---------- ---- -----
-----
1                LOGAN-LANDING-WETLAND 2           SIDE         1024       0.61       NO   0

[XSECTIONS]
;;Link           Shape        Geom1            Geom2      Geom3      Geom4      Barrels
;;-------------- ------------ ---------------- ---------- ---------- ---------- ----------
1                CIRCULAR     0.227            0          0          0

[CURVES]
;;Name           Type       X-Value    Y-Value
;;-------------- ---------- ---------- ----------
WETLAND          Storage    0          3535
WETLAND                     0.1        3818
WETLAND                     0.2        4113
WETLAND                     0.3        4419
WETLAND                     0.4        4736
WETLAND                     0.5        5065
WETLAND                     0.6        5404
WETLAND                     0.7        5754
WETLAND                     0.8        6116
WETLAND                     0.9        6489
WETLAND                     1          6872
WETLAND                     1.1        7267
WETLAND                     1.2        7673
WETLAND                     1.3        8084
WETLAND                     1.4        8502
WETLAND                     1.5        8925
WETLAND                     1.6        9354
WETLAND                     1.7        9789
WETLAND                     1.8        10229
WETLAND                     1.9        10792
WETLAND                     2          11379
WETLAND                     2.1        13569
WETLAND                     2.2        15036
WETLAND                     2.3        16514
WETLAND                     2.4        18002
WETLAND                     2.5        19547
WETLAND                     2.6        20037
WETLAND                     2.7        20525
WETLAND                     2.8        21011
WETLAND                     2.9        21497
WETLAND                     3          22957
```

```
WETLAND                      3.1         23341
WETLAND                      3.2         23726
WETLAND                      3.3         24113
WETLAND                      3.4         24502
WETLAND                      3.5         24892
WETLAND                      3.6         25284
WETLAND                      3.7         25677
WETLAND                      3.8         26072
WETLAND                      3.9         26469
WETLAND                      4           26867
WETLAND                      4.1         27267
WETLAND                      4.2         27668
WETLAND                      4.3         28071
WETLAND                      4.4         28476
WETLAND                      4.5         28882
WETLAND                      5           30897

[TIMESERIES]
;;Name           Date       Time       Value
;;-------------- ---------- ---------- ----------
;Calgary_24h_500y design storm, rain interval = 5 minutes, rain units = mm/hr.
Calgary_24h_500y             0:00       0
Calgary_24h_500y             0:05       1.025
Calgary_24h_500y             0:10       1.035
Calgary_24h_500y             0:15       1.045
Calgary_24h_500y             0:20       1.055
Rest of Data Removed

;Rainfall (mm/hr)
Precip1960-2014  01/01/1960 00:00:00   0
Precip1960-2014  01/01/1960 01:00:00   0
Precip1960-2014  01/01/1960 02:00:00   0
Precip1960-2014  01/01/1960 03:00:00   0
Precip1960-2014  01/01/1960 04:00:00   0
Precip1960-2014  01/01/1960 05:00:00   0
Precip1960-2014  01/01/1960 06:00:00   0
Precip1960-2014  01/01/1960 07:00:00   0
Precip1960-2014  01/01/1960 08:00:00   0
Precip1960-2014  01/01/1960 09:00:00   0
Precip1960-2014  01/01/1960 10:00:00   0
......
Too many data points (482136 in total).

;Enter function... (degC)
Temp1960-2014    01/01/1960 00:00:00   -13.3
Temp1960-2014    01/01/1960 01:00:00   -12.8
Temp1960-2014    01/01/1960 02:00:00   -12.2
Temp1960-2014    01/01/1960 03:00:00   -12.2
Temp1960-2014    01/01/1960 04:00:00   -13.3
Temp1960-2014    01/01/1960 05:00:00   -13.3
Temp1960-2014    01/01/1960 06:00:00   -13.3
Temp1960-2014    01/01/1960 07:00:00   -13.9
Temp1960-2014    01/01/1960 08:00:00   -13.9
Temp1960-2014    01/01/1960 09:00:00   -15.6
Temp1960-2014    01/01/1960 10:00:00   -14.4
......
Too many data points (482136 in total).

[REPORT]
INPUT      YES
CONTROLS   NO
SUBCATCHMENTS ALL
NODES ALL
LINKS ALL

[TAGS]

[MAP]
DIMENSIONS       3302.09923055715 5635385.2432826  4220.82651543416 5636312.63808069
UNITS            Meters
```

```
[COORDINATES]
;;Node           X-Coord          Y-Coord
;;-------------- ---------------- ----------------
2                3363.891         5635759.735
LOGAN-LANDING-WETLAND 3556.166         5635858.545

[VERTICES]
;;Link           X-Coord          Y-Coord
;;-------------- ---------------- ----------------

[POLYGONS]
;;Subcatchment   X-Coord          Y-Coord
;;-------------- ---------------- ----------------
LOGAN-LANDING    3376.748         5635715.754
LOGAN-LANDING    3377.418         5635770.547
LOGAN-LANDING    3354.503         5635770.572
LOGAN-LANDING    3349.97          5635800.271
LOGAN-LANDING    3349.858         5635844.663
LOGAN-LANDING    3349.623         5635930.803
Rest of Data Removed

[SYMBOLS]
;;Gage           X-Coord          Y-Coord
;;-------------- ---------------- ----------------
```

```
  EPA STORM WATER MANAGEMENT MODEL - VERSION 5.1 (Build 5.1.013)
  --------------------------------------------------------------

  Hydrologic model of Genesis tributiary area - continuous event (Calgary, Alberta)


  *************
  Element Count
  *************
  Number of rain gages ...... 3
  Number of subcatchments ... 3
  Number of nodes ........... 2
  Number of links ........... 1
  Number of pollutants ...... 0
  Number of land uses ....... 0


  ****************
  Raingage Summary
  ****************
                                                      Data       Recording
  Name                 Data Source                    Type       Interval
  ----------------------------------------------------------------------
  Calgary_24h_500y     Calgary_24h_500y               INTENSITY    5 min.
  Calgary_24h-100y     Calgary_24h-100y               INTENSITY    5 min.
  Precip1960-2014      Precip1960-2014                INTENSITY   60 min.


  ********************
  Subcatchment Summary
  ********************
  Name                         Area     Width   %Imperv    %Slope Rain Gage            Outlet
  ------------------------------------------------------------------------------------------------
------------
  LOGAN-LANDING              51.03   4082.40     70.00    2.0000 Calgary_24h_500y     LOGAN-
LANDING-WETLAND
  WETLAND-FRINGE              1.21    605.00     10.00   20.0000 Calgary_24h_500y     LOGAN-
LANDING-WETLAND
  WETLAND-NWL                 2.11   2110.00    100.00    0.5000 Calgary_24h_500y     LOGAN-
LANDING-WETLAND


  ************
  Node Summary
  ************
                                          Invert      Max.    Ponded    External
  Name                 Type                Elev.     Depth      Area    Inflow
  ----------------------------------------------------------------------------
  2                    OUTFALL           1021.50      0.00       0.0
  LOGAN-LANDING-WETLAND STORAGE           1021.50      5.00       0.0


  ************
  Link Summary
  ************
  Name             From Node        To Node          Type            Length    %Slope Roughness
  ---------------------------------------------------------------------------------------------
  1                LOGAN-LANDING-WETLAND 2               ORIFICE


  *********************
  Cross Section Summary
  *********************
                                     Full     Full     Hyd.     Max.   No. of     Full
  Conduit          Shape            Depth     Area     Rad.    Width  Barrels     Flow
  ---------------------------------------------------------------------------------------
```

```
***********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
***********************************************************

****************
Analysis Options
****************
Flow Units ............... CMS
Process Models:
  Rainfall/Runoff ........ YES
  RDII ................... NO
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ YES
  Water Quality .......... NO
Infiltration Method ...... GREEN_AMPT
Flow Routing Method ...... DYNWAVE
Surcharge Method ......... SLOT
Starting Date ............ 07/27/2020 00:00:00
Ending Date .............. 07/28/2020 12:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:15:00
Wet Time Step ............ 00:05:00
Dry Time Step ............ 00:05:00
Routing Time Step ........ 60.00 sec
Variable Time Step ....... YES
Maximum Trials ........... 8
Number of Threads ........ 1
Head Tolerance ........... 0.001500 m

*************************        Volume         Depth
Runoff Quantity Continuity     hectare-m            mm
*************************     ---------       -------
Total Precipitation ......         6.061       111.515
Evaporation Loss .........         0.275         5.059
Infiltration Loss ........         1.270        23.362
Surface Runoff ...........         4.546        83.640
Final Storage ............         0.000         0.000
Continuity Error (%) .....        -0.489

*************************        Volume        Volume
Flow Routing Continuity        hectare-m      10^6 ltr
*************************     ---------      ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         4.546        45.459
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         1.356        13.557
Flooding Loss ............         0.000         0.000
Evaporation Loss .........         0.019         0.191
Exfiltration Loss ........         0.000         0.000
Initial Stored Volume ....         2.194        21.942
Final Stored Volume ......         5.365        53.649
Continuity Error (%) .....         0.005

***************************
Time-Step Critical Elements
***************************
None
```

```
  ********************************
  Highest Flow Instability Indexes
  ********************************
  All links are stable.


  ************************
  Routing Time Step Summary
  ************************
  Minimum Time Step           :    59.50 sec
  Average Time Step           :    59.97 sec
  Maximum Time Step           :    60.00 sec
  Percent in Steady State     :     0.00
  Average Iterations per Step :     2.00
  Percent Not Converging      :     0.00


  ***************************
  Subcatchment Runoff Summary
  ***************************

  ---------------------------------------------------------------------------------------------------
--------------------------------
                             Total      Total      Total      Total     Imperv       Perv
Total       Total     Peak  Runoff
                           Precip      Runon       Evap      Infil     Runoff     Runoff
Runoff      Runoff   Runoff   Coeff
  Subcatchment                mm         mm         mm         mm         mm         mm
mm    10^6 ltr      CMS
  ---------------------------------------------------------------------------------------------------
--------------------------------
  LOGAN-LANDING            111.51       0.00       5.35      23.56      73.70      27.89
83.17       42.44    19.55   0.746
  WETLAND-FRINGE           111.52       0.00       1.77      55.76      10.50      44.34
54.85        0.66     0.64   0.492
  WETLAND-NWL              111.52       0.00       0.00       0.00     111.52       0.00
111.52        2.35     1.26   1.000


  ******************
  Node Depth Summary
  ******************

  ------------------------------------------------------------------------------
                                Average  Maximum  Maximum  Time of Max    Reported
                                  Depth    Depth      HGL   Occurrence   Max Depth
  Node                 Type       Meters   Meters   Meters  days hr:min      Meters
  ------------------------------------------------------------------------------
  2                    OUTFALL      0.00     0.00  1021.50     0  00:00        0.00
  LOGAN-LANDING-WETLAND STORAGE     3.72     4.12  1025.62     0  15:11        4.12


  *******************
  Node Inflow Summary
  *******************

  ---------------------------------------------------------------------------------------------------
--
                                Maximum  Maximum                  Lateral       Total
Flow
                                Lateral    Total  Time of Max      Inflow      Inflow
Balance
                                 Inflow   Inflow   Occurrence      Volume      Volume
Error
  Node                 Type         CMS      CMS  days hr:min    10^6 ltr    10^6 ltr
Percent
  ---------------------------------------------------------------------------------------------------
--
  2                    OUTFALL    0.000    0.134     0  15:12           0        13.6
0.000
```

```
  LOGAN-LANDING-WETLAND STORAGE     21.437   21.437     0  07:15        45.5        67.4
0.005


  **********************
  Node Surcharge Summary
  **********************

  No nodes were surcharged.


  **********************
  Node Flooding Summary
  **********************

  No nodes were flooded.


  **********************
  Storage Volume Summary
  **********************

  ------------------------------------------------------------------------------------------------
---
                          Average     Avg  Evap Exfil       Maximum     Max    Time of Max
Maximum
                           Volume    Pcnt  Pcnt  Pcnt        Volume    Pcnt     Occurrence
Outflow
  Storage Unit           1000 m3    Full  Loss  Loss       1000 m3    Full    days hr:min
CMS
  ------------------------------------------------------------------------------------------------
---
  LOGAN-LANDING-WETLAND    50.801      59     0     0        60.454      70       0  15:11
0.136


  **********************
  Outfall Loading Summary
  **********************

  ---------------------------------------------------------
                          Flow       Avg       Max       Total
                          Freq      Flow      Flow      Volume
  Outfall Node            Pcnt       CMS       CMS    10^6 ltr
  ---------------------------------------------------------
  2                      94.59     0.111     0.134      13.557
  ---------------------------------------------------------
  System                 94.59     0.111     0.134      13.557


  ********************
  Link Flow Summary
  ********************

  ---------------------------------------------------------------------------
                                 Maximum  Time of Max   Maximum    Max/    Max/
                                  |Flow|   Occurrence   |Veloc|    Full    Full
  Link                  Type         CMS  days hr:min     m/sec    Flow   Depth
  ---------------------------------------------------------------------------
  1                     ORIFICE    0.134     0  15:12                    1.00


  ***************************
  Flow Classification Summary
  ***************************

  -------------------------------------------------------------------------------------
                     Adjusted    ---------- Fraction of Time in Flow Class ----------
                      /Actual         Up    Down  Sub   Sup   Up    Down  Norm  Inlet
  Conduit               Length    Dry  Dry   Dry   Crit  Crit  Crit  Crit  Ltd   Ctrl
  -------------------------------------------------------------------------------------
```

```
************************
Conduit Surcharge Summary
************************

No conduits were surcharged.


Analysis begun on:  Mon Jul 27 16:20:11 2020
Analysis ended on:  Mon Jul 27 16:20:13 2020
Total elapsed time: 00:00:02
```

```
[TITLE]
Hydrologic model of Genesis tributiary area - 100year event (Calgary, Alberta)


[OPTIONS]
;;Options             Value
;;------------------- ------------
FLOW_UNITS           CMS
INFILTRATION         GREEN_AMPT
FLOW_ROUTING         DYNWAVE
LINK_OFFSETS         ELEVATION
MIN_SLOPE            0
ALLOW_PONDING        YES
SKIP_STEADY_STATE    NO
START_DATE           07/27/2020
START_TIME           00:00:00
REPORT_START_DATE    07/27/2020
REPORT_START_TIME    00:00:00
END_DATE             07/28/2020
END_TIME             12:00:00
SWEEP_START          01/01
SWEEP_END            12/31
DRY_DAYS             0
REPORT_STEP          00:15:00
WET_STEP             00:05:00
DRY_STEP             00:05:00
ROUTING_STEP         60
RULE_STEP            00:00:00
INERTIAL_DAMPING     PARTIAL
NORMAL_FLOW_LIMITED  BOTH
FORCE_MAIN_EQUATION  H-W
SURCHARGE_METHOD     Slot
VARIABLE_STEP        0.75
LENGTHENING_STEP     0
MIN_SURFAREA         1.167
MAX_TRIALS           8
HEAD_TOLERANCE       0.0015
SYS_FLOW_TOL         5
LAT_FLOW_TOL         5
MINIMUM_STEP         0.5
THREADS              8

[EVAPORATION]
;;Type          Parameters
;;------------- ----------
MONTHLY      0.10   0.39   1.12   2.40   3.61   4.57   4.99   4      2.24   0.99   0.27   0.07
DRY_ONLY     NO

[RAINGAGES]
;;               Rain      Time   Snow   Data
;;Name           Type      Intrvl Catch  Source
;;-------------- --------- ------ ------ ----------
Calgary_24h_500y INTENSITY 0:05   1.0    TIMESERIES Calgary_24h_500y
Calgary_24h-100y INTENSITY 0:05   1.0    TIMESERIES Calgary_24h-100y
Precip1960-2014  INTENSITY 1:00   1.0    TIMESERIES Precip1960-2014

[SUBCATCHMENTS]
;;                                                 Total    Pcnt.             Pcnt.    Curb
Snow
;;Name           Raingage         Outlet           Area     Imperv   Width    Slope    Length
Pack
;;-------------- ---------------- ---------------- -------- -------- -------- -------- --------
--------
LOGAN-LANDING    Calgary_24h-100y LOGAN-LANDING-WETLAND 51.03 70     4082.4   2        0
WETLAND-FRINGE   Calgary_24h-100y LOGAN-LANDING-WETLAND 1.21 10      605      20       0
WETLAND-NWL      Calgary_24h-100y LOGAN-LANDING-WETLAND 2.11 100     2110     0.5      0

[SUBAREAS]
;;Subcatchment   N-Imperv   N-Perv     S-Imperv   S-Perv     PctZero    RouteTo    PctRouted
;;-------------- ---------- ---------- ---------- ---------- ---------- ---------- ----------
LOGAN-LANDING    0.015      0.25       1.6        3.2        0          PERVIOUS   25
```

```
WETLAND-FRINGE   0.015      0.25       1.6        3.2        0          OUTLET
WETLAND-NWL      0          0.25       1.6        3.2        100        OUTLET

[INFILTRATION]
;;Subcatchment   Suction    HydCon     IMDmax
;;-------------- ---------- ---------- ----------
LOGAN-LANDING    88.9       3.302      0.347
WETLAND-FRINGE   88.9       3.302      0.347
WETLAND-NWL      88.9       3.302      0.347

[OUTFALLS]
;;               Invert     Outfall      Stage/Table      Tide
;;Name           Elev.      Type         Time Series      Gate Route To
;;-------------- ---------- ------------ ---------------- ---- ----------------
2                1021.5     FREE                          NO

[STORAGE]
;;               Invert   Max.     Init.    Storage    Curve                              Evap.
;;Name           Elev.    Depth    Depth    Curve      Params                             Frac.
Infiltration parameters
;;-------------- -------- -------- -------- ---------- -------- -------- -------- -------- -----
--- ----------------------
LOGAN-LANDING-WETLAND 1021.5 4.5   2.5      TABULAR    WETLAND                    0        1

[ORIFICES]
;;               Inlet            Outlet           Orifice      Crest      Disch.     Flap
Open/Close
;;Name           Node             Node             Type         Height     Coeff.     Gate Time
;;-------------- ---------------- ---------------- ------------ ---------- ---------- ---- -----
-----
1                LOGAN-LANDING-WETLAND 2           SIDE         1024       0.61       NO   0

[XSECTIONS]
;;Link           Shape        Geom1            Geom2      Geom3      Geom4      Barrels
;;-------------- ------------ ---------------- ---------- ---------- ---------- ----------
1                CIRCULAR     0.227            0          0          0

[CURVES]
;;Name           Type       X-Value    Y-Value
;;-------------- ---------- ---------- ----------
WETLAND          Storage    0          3535
WETLAND                     0.1        3818
WETLAND                     0.2        4113
WETLAND                     0.3        4419
WETLAND                     0.4        4736
WETLAND                     0.5        5065
WETLAND                     0.6        5404
WETLAND                     0.7        5754
WETLAND                     0.8        6116
WETLAND                     0.9        6489
WETLAND                     1          6872
WETLAND                     1.1        7267
WETLAND                     1.2        7673
WETLAND                     1.3        8084
WETLAND                     1.4        8502
WETLAND                     1.5        8925
WETLAND                     1.6        9354
WETLAND                     1.7        9789
WETLAND                     1.8        10229
WETLAND                     1.9        10792
WETLAND                     2          11379
WETLAND                     2.1        13569
WETLAND                     2.2        15036
WETLAND                     2.3        16514
WETLAND                     2.4        18002
WETLAND                     2.5        19547
WETLAND                     2.6        20037
WETLAND                     2.7        20525
WETLAND                     2.8        21011
WETLAND                     2.9        21497
WETLAND                     3          22957
```

```
WETLAND                      3.1        23341
WETLAND                      3.2        23726
WETLAND                      3.3        24113
WETLAND                      3.4        24502
WETLAND                      3.5        24892
WETLAND                      3.6        25284
WETLAND                      3.7        25677
WETLAND                      3.8        26072
WETLAND                      3.9        26469
WETLAND                      4          26867
WETLAND                      4.1        27267
WETLAND                      4.2        27668
WETLAND                      4.3        28071
WETLAND                      4.4        28476
WETLAND                      4.5        28882

[TIMESERIES]
;;Name           Date       Time       Value
;;-------------- ---------- ---------- ----------
;Calgary_24h_500y design storm, rain interval = 5 minutes, rain units = mm/hr.
Calgary_24h_500y             0:00       0
Calgary_24h_500y             0:05       1.025
Calgary_24h_500y             0:10       1.035
Calgary_24h_500y             0:15       1.045
Calgary_24h_500y             0:20       1.055
Calgary_24h_500y             0:25       1.065
Rest of Data Removed

;Rainfall (mm/hr)
Precip1960-2014  01/01/1960 00:00:00   0
Precip1960-2014  01/01/1960 01:00:00   0
Precip1960-2014  01/01/1960 02:00:00   0
Precip1960-2014  01/01/1960 03:00:00   0
Precip1960-2014  01/01/1960 04:00:00   0
Precip1960-2014  01/01/1960 05:00:00   0
Precip1960-2014  01/01/1960 06:00:00   0
Precip1960-2014  01/01/1960 07:00:00   0
Precip1960-2014  01/01/1960 08:00:00   0
Precip1960-2014  01/01/1960 09:00:00   0
Precip1960-2014  01/01/1960 10:00:00   0
......
Too many data points (482136 in total).

;Enter function... (degC)
Temp1960-2014    01/01/1960 00:00:00   -13.3
Temp1960-2014    01/01/1960 01:00:00   -12.8
Temp1960-2014    01/01/1960 02:00:00   -12.2
Temp1960-2014    01/01/1960 03:00:00   -12.2
Temp1960-2014    01/01/1960 04:00:00   -13.3
Temp1960-2014    01/01/1960 05:00:00   -13.3
Temp1960-2014    01/01/1960 06:00:00   -13.3
Temp1960-2014    01/01/1960 07:00:00   -13.9
Temp1960-2014    01/01/1960 08:00:00   -13.9
Temp1960-2014    01/01/1960 09:00:00   -15.6
Temp1960-2014    01/01/1960 10:00:00   -14.4
......
Too many data points (482136 in total).

[REPORT]
INPUT      YES
CONTROLS   NO
SUBCATCHMENTS ALL
NODES ALL
LINKS ALL

[TAGS]

[MAP]
DIMENSIONS       3302.09923055715 5635385.2432826  4220.82651543416 5636312.63808069
UNITS            Meters
```

```
[COORDINATES]
;;Node           X-Coord          Y-Coord
;;-------------- ---------------- ----------------
2                3363.891         5635759.735
LOGAN-LANDING-WETLAND 3556.166         5635858.545

[VERTICES]
;;Link           X-Coord          Y-Coord
;;-------------- ---------------- ----------------

[POLYGONS]
;;Subcatchment   X-Coord          Y-Coord
;;-------------- ---------------- ----------------
LOGAN-LANDING    3376.748         5635715.754
LOGAN-LANDING    3377.418         5635770.547
LOGAN-LANDING    3354.503         5635770.572
LOGAN-LANDING    3349.97          5635800.271
LOGAN-LANDING    3349.858         5635844.663
LOGAN-LANDING    3349.623         5635930.803
Rest of Data Removed
[SYMBOLS]
;;Gage           X-Coord          Y-Coord
;;-------------- ---------------- ----------------
```

```
  EPA STORM WATER MANAGEMENT MODEL - VERSION 5.1 (Build 5.1.013)
  --------------------------------------------------------------

  Hydrologic model of Genesis tributiary area - continuous event (Calgary, Alberta)


  *************
  Element Count
  *************
  Number of rain gages ...... 3
  Number of subcatchments ... 3
  Number of nodes ........... 2
  Number of links ........... 1
  Number of pollutants ...... 0
  Number of land uses ....... 0


  ****************
  Raingage Summary
  ****************
                                                      Data       Recording
  Name                 Data Source                    Type       Interval
  ----------------------------------------------------------------------
  Calgary_24h_500y     Calgary_24h_500y               INTENSITY    5 min.
  Calgary_24h-100y     Calgary_24h-100y               INTENSITY    5 min.
  Precip1960-2014      Precip1960-2014                INTENSITY   60 min.


  ********************
  Subcatchment Summary
  ********************
  Name                        Area     Width   %Imperv    %Slope Rain Gage            Outlet
  ------------------------------------------------------------------------------------------
------------
  LOGAN-LANDING             51.03   4082.40     70.00    2.0000 Calgary_24h-100y     LOGAN-
LANDING-WETLAND
  WETLAND-FRINGE             1.21    605.00     10.00   20.0000 Calgary_24h-100y     LOGAN-
LANDING-WETLAND
  WETLAND-NWL                2.11   2110.00    100.00    0.5000 Calgary_24h-100y     LOGAN-
LANDING-WETLAND


  ************
  Node Summary
  ************
                                          Invert      Max.    Ponded    External
  Name                 Type                Elev.     Depth      Area    Inflow
  ----------------------------------------------------------------------------
  2                    OUTFALL           1021.50      0.00       0.0
  LOGAN-LANDING-WETLAND STORAGE           1021.50      4.50       0.0


  ************
  Link Summary
  ************
  Name              From Node        To Node          Type            Length    %Slope Roughness
  ---------------------------------------------------------------------------------------------
  1                 LOGAN-LANDING-WETLAND 2               ORIFICE


  *********************
  Cross Section Summary
  *********************
                                     Full     Full     Hyd.     Max.   No. of     Full
  Conduit          Shape            Depth     Area     Rad.    Width  Barrels     Flow
  ---------------------------------------------------------------------------------
```

```
***********************************************************
NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.
***********************************************************

****************
Analysis Options
****************
Flow Units ............... CMS
Process Models:
  Rainfall/Runoff ........ YES
  RDII ................... NO
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ YES
  Water Quality .......... NO
Infiltration Method ...... GREEN_AMPT
Flow Routing Method ...... DYNWAVE
Surcharge Method ......... SLOT
Starting Date ............ 07/27/2020 00:00:00
Ending Date .............. 07/28/2020 12:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:15:00
Wet Time Step ............ 00:05:00
Dry Time Step ............ 00:05:00
Routing Time Step ........ 60.00 sec
Variable Time Step ....... YES
Maximum Trials ........... 8
Number of Threads ........ 1
Head Tolerance ........... 0.001500 m

**************************        Volume         Depth
Runoff Quantity Continuity     hectare-m            mm
**************************     ---------       -------
Total Precipitation ......         4.873        89.667
Evaporation Loss .........         0.274         5.049
Infiltration Loss ........         1.256        23.107
Surface Runoff ...........         3.371        62.021
Final Storage ............         0.000         0.000
Continuity Error (%) .....        -0.568

**************************        Volume         Volume
Flow Routing Continuity        hectare-m       10^6 ltr
**************************     ---------      ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         3.371        33.709
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         1.146        11.462
Flooding Loss ............         0.000         0.000
Evaporation Loss .........         0.018         0.181
Exfiltration Loss ........         0.000         0.000
Initial Stored Volume ....         2.194        21.942
Final Stored Volume ......         4.400        44.005
Continuity Error (%) .....         0.004

***************************
Time-Step Critical Elements
***************************
None

*******************************
```

Highest Flow Instability Indexes
****
All links are stable.

****
Routing Time Step Summary
****
Minimum Time Step : 59.50 sec
Average Time Step : 59.97 sec
Maximum Time Step : 60.00 sec
Percent in Steady State : 0.00
Average Iterations per Step : 2.00
Percent Not Converging : 0.00

****
Subcatchment Runoff Summary
****

Subcatchment	Total Precip mm	Total Runon mm	Total Evap mm	Total Infil mm	Imperv Runoff mm	Perv Runoff mm	Total Runoff mm	Total Runoff 10^6 ltr	Peak Runoff CMS	Runoff Coeff
LOGAN-LANDING	89.67	0.00	5.34	23.32	58.41	17.72	61.53	31.40	13.77	0.686
WETLAND-FRINGE	89.67	0.00	1.69	54.37	8.32	26.29	34.60	0.42	0.45	0.386
WETLAND-NWL	89.67	0.00	0.00	0.00	89.67	0.00	89.67	1.89	0.99	1.000

****
Node Depth Summary
****

Node	Type	Average Depth Meters	Maximum Depth Meters	Maximum HGL Meters	Time of Max Occurrence days hr:min	Reported Max Depth Meters
2	OUTFALL	0.00	0.00	1021.50	0 00:00	0.00
LOGAN-LANDING-WETLAND	STORAGE	3.40	3.69	1025.19	0 16:56	3.69

****
Node Inflow Summary
****

Node	Type	Maximum Lateral Inflow CMS	Maximum Total Inflow CMS	Time of Max Occurrence days hr:min	Lateral Inflow Volume 10^6 ltr	Total Inflow Volume 10^6 ltr	Flow Balance Error Percent
2	OUTFALL	0.000	0.114	0 16:57	0	11.5	0.000
LOGAN-LANDING-WETLAND	STORAGE	15.205	15.205	0 07:15	33.7	55.7	0.004

****
Node Surcharge Summary
****

No nodes were surcharged.

****
Node Flooding Summary
****

No nodes were flooded.

****
Storage Volume Summary
****

Storage Unit	Average Volume 1000 m3	Avg Pcnt Full	Evap Pcnt Loss	Exfil Pcnt Loss	Maximum Volume 1000 m3	Max Pcnt Full	Time of Max Occurrence days hr:min	Maximum Outflow CMS
LOGAN-LANDING-WETLAND	42.375	60	0	0	49.248	69	0 16:56	0.115

****
Outfall Loading Summary
****

Outfall Node	Flow Freq Pcnt	Avg Flow CMS	Max Flow CMS	Total Volume 10^6 ltr
2	94.86	0.093	0.114	11.462
System	94.86	0.093	0.114	11.462

****
Link Flow Summary
****

Link	Type	Maximum |Flow| CMS	Time of Max Occurrence days hr:min	Maximum |Veloc| m/sec	Max/ Full Flow	Max/ Full Depth
1	ORIFICE	0.114	0 16:57			1.00

****
Flow Classification Summary
****

Conduit	Adjusted /Actual Length	Fraction of Time in Flow Class: Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Norm Ltd	Inlet Ctrl

```
************************
Conduit Surcharge Summary
************************

No conduits were surcharged.


Analysis begun on:  Mon Jul 27 15:05:51 2020
Analysis ended on:  Mon Jul 27 15:05:53 2020
Total elapsed time: 00:00:02
```

APPENDIX C

DATA AND FREQUENCY ANALYSIS SPREADSHEET FILES

DFASCC

Data and Frequency Analysis Spreadsheet for the City of Calgary
Version 1.2

PROJECT INFORMATION SHEET

Project Name:	Logan Landing Wetland
Project Description:	
Location:	Calgary, AB
Date:	27/07/2020
Designed by:	Yury Dobronravov
Company Name:	Urban Systems
Reviewed by:	

Clear Project Information Sheet

Hydrologic Data Series Input

NOTES

- This Spreadsheet is designed for a maximum of 1,000 entries (if more are required then formulas need to be adjusted)
- Input dataset must be based on uniform time distribution (i.e.: daily, weekly, monthly, yearly) and must not include multiple values for any of the time steps (duplicates highlighted in red)
- Input dataset must not have any missing cells of data (cells with "0" will be treated as having a value of 0)
- Only positive values should be used
- Please refer to **Section 2.2 of the Frequency Analysis Procedure for Stormwater Design Manual** for Data Series Characteristics detailed descriptions.

Index	Date	Value	Empirical Probability of Non-Exceedance
1	1960	29910	0.228
2	1961	35470	0.681
3	1962	27310	0.065
4	1963	34820	0.609
5	1964	37340	0.808
6	1965	37050	0.790
7	1966	38190	0.862
8	1967	26470	0.047
9	1968	31230	0.409
10	1969	35800	0.699
11	1970	42640	0.935
12	1971	29200	0.192
13	1972	38860	0.880
14	1973	28250	0.101
15	1974	37440	0.826
16	1975	27380	0.083
17	1976	32540	0.536
18	1977	30050	0.301
19	1978	36400	0.754
20	1979	29080	0.174
21	1980	32210	0.500
22	1981	32400	0.518
23	1982	28790	0.156
24	1983	34350	0.591
25	1984	30020	0.283
26	1985	52230	0.971
27	1986	36040	0.717
28	1987	29520	0.210
29	1988	36370	0.736
30	1989	26270	0.011
31	1990	30360	0.355
32	1991	30900	0.373
33	1992	37710	0.844
34	1993	32200	0.482
35	1994	30190	0.319
36	1995	30200	0.337
37	1996	28390	0.120
38	1997	42790	0.953
39	1998	41330	0.917
40	1999	34950	0.627
41	2000	29960	0.246
42	2001	35220	0.663
43	2002	26310	0.029
44	2003	32160	0.464
45	2004	31500	0.428
46	2005	39500	0.899
47	2006	31200	0.391
48	2007	54410	0.989
49	2008	29980	0.264
50	2009	28740	0.138
51	2010	34070	0.572
52	2011	32900	0.554
53	2012	35100	0.645
54	2013	36940	0.772
55	2014	31510	0.446

Clear All Input Data

Basic Characteristics	
Number of Data Entries	55
Maximum Value	54400
Minimum Value	26300
Average (Mean) Value	33700
Median Value	32200
Standard Deviation	5660
Variance	32000000
Variation coefficient (Cv)	0.168
Skewness coefficient (Cs)	1.6
Kurtosis	6.06

*Values assumed to be sample not full population

Empirical Probability of Non-Exceedance (Plotting Position) based on:

F(x(k)) = (k-a)/ (n-2a+1), 0 <=a<=0.5

a = 0.4 Cunnane (1978)

k= rank of the even in question (in ascending order)

n= 55

Summary Sheet

Initial Statistical Tests:

Tests for Stationarity

Test	Result
Spearman Rank Order Correlation Coefficient	No Significant Trend at 0.05 Significance Level
Mann-Whitney Test for jump (a.k.a. Mann-Whitney U test)	No Jump at 0.05 Significance Level
Wald-Wolfowitz Test (The runs test)	No Jump at 0.05 Significance Level

Tests for Homogeneity

Test	Result
Mann-Whitney Test for jump (a.k.a. Mann-Whitney U test)	Sample is Homogeneous at 0.05 Significance Level
Terry Test	Sample is Homogeneous at 0.05 Significance Level

Tests for Independence

Test	Result
Spearman Rank Order Correlation Coefficient	Data is independent at 0.05 Significance Level
Wald-Wolfowitz Test for Independence	Data is independent at 0.05 Significance Level
Anderson Test	Data is independent at 0.05 Significance Level

Test for Outliers

Test	Result
Grubbs and Beck Test for Outliers	
Are any high outliers present?	High Outlier May Be Present
Are and low outliers present?	No Low Outliers Present

Project Information

Project Name:	Logan Landing Wetland
Project Description:	
Location:	Calgary, AB
Date:	27/07/2020
Designed by:	Yury Dobronravov
Company Name:	Urban Systems
Reviewed by:	

Numerical Goodness-of-fit Tests Results

Distribution Type	Numerical Goodness-of-fit Tests from Spreadsheet			Average of Ranks	Ranking from Numerical Tests	Numerical Goodness-of-fit Tests from Hyfran (Input by user)		Notes from Visual Goodness-of-fit Test
	A-D Test	K-S Test	Least Squares Ranking			BIC	AIC	
Normal	8	8	9	8.33	8	1113.541	1109.527	
Lognormal	6	6	6	6.00	6	1102.995	1098.98	
Lognormal III	2	3	2	2.33	1	1097.916	1091.894	
Exponential	9	10	8	9.00	9	1100.13	1096.115	
Pearson III	5	2	4	3.67	5	1097.434	1091.412	
Log Pearson III	1	4	3	2.67	2	1097.776	1091.754	
Gumbel	4	1	5	3.33	4	1095.758	1091.743	
GEV	3	5	1	3.00	3	1098.335	1092.313	
Weibull	10	9	10	9.67	10	1127.564	1123.549	
Gamma	7	7	7	7.00	7	1106.001	1101.986	

Selected Distribution and Results

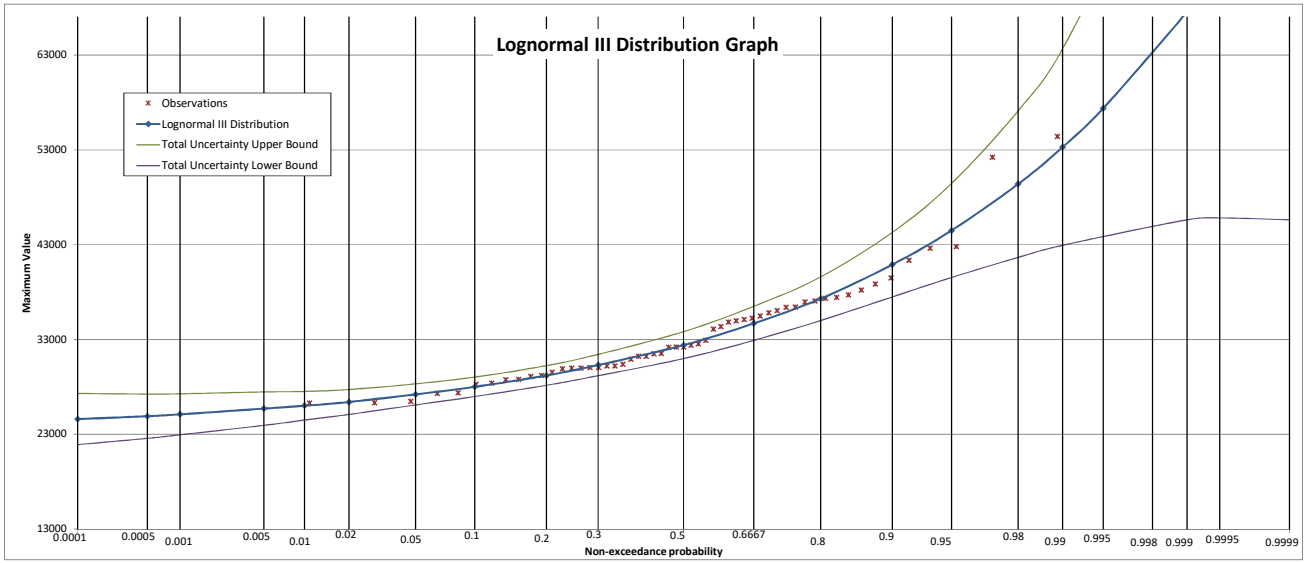
Instructions:

- Based on the results of the numerical and visual goodness-of-fit tests presented above, choose the preferred distribution in the cell on the left

Distribution type chosen based on visual and numerical goodness-of-fit tests:	**Lognormal III**

Return Period	Probability	Magnitude	Total Uncertainty (Upper Bound)	Total Uncertainty (Lower Bound)
10000	0.9999	84200	123000	45600
2000	0.9995	72300	98800	45800
1000	0.9990	67600	89600	45600
500	0.9980	63000	81800	44900
200	0.9950	57400	70800	44000
100	0.9900	53300	63700	42900
50	0.9800	49400	57100	41700
20	0.9500	44500	49500	39500
10	0.9000	40900	44300	37500
5	0.8000	37300	39600	35000
3	0.6667	34700	36500	32900
2	0.5000	32400	33800	31000
1.4286	0.3000	30300	31400	29200
1.25	0.2000	29200	30200	28200
1.1111	0.1000	28000	29000	27000
1.0526	0.0500	27200	28300	26100
1.0204	0.0200	26400	27700	25100
1.0101	0.0100	26000	27500	24500
1.005	0.0050	25700	27500	23900
1.001	0.0010	25100	27300	22900
1.0005	0.0005	24900	27200	22600
1.0001	0.0001	24600	27300	21900

*Total uncertainty is based on sampling uncertainty at ((95%) Confidence Interval) plus distribution uncertainty of Top 4 distributions (based on numerical goodness of fit tests)



Errors and Warnings

Cumulative distribution function warning
No warning
No warning
No warning
No warning
No warning
No warning
No warning
No warning
No warning
No warning

If a warning is present, please check if hyfran output results were pasted correctly. If hyfran results were pasted correctly the warning signifies that the Continuous Distribution Function (CDF) used in this workbook does not produce same output values as the input frequency analysis results, which in turn indicates that the numerical goodness-of-fit tests calculated by this spreadsheet for this distribution may be based on inaccurate numbers. Another possible solution would be to use a different method of estimating the CDF parameters for example: method of weighted moments.