Residential Development in Foothills County
STORMWATER MANAGEMENT PLAN

Prepared for:

2291463 ALBERTA LTD.

Prepared by:

LGN Consulting Engineering Ltd.
stormwater and water resources management

November 2021

Project LGN2116

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1.0 INTRODUCTION

1.1 General

LGN Consulting Engineering Ltd. (LGN) was retained by Township Planning & Design Inc. (TPD) on behalf of 2291463 Alberta Ltd. to prepare a Stormwater Management Plan (SWMP) in support of the proposed Residential Development in Foothills County. The SWMP outlines the drainage concept proposed to accommodate the runoff generated by the sub-catchment area containing the residential development and to provide pre-design information for the associated stormwater management facility (SWMF or Pond).

The Foothills County specified design criteria whereby post development discharge rates should not exceed pre development discharge rates.

The drainage concept for the area and information on the type, size and performance characteristics of the SWMF is presented in this report. This analysis evaluates the control of discharge of stormwater runoff from the development area and stormwater quality enhancement prior to discharge, as required by Foothills County and Alberta Environment and Parks (AEP).

1.2 Study Area

The study area is located in northeast Foothills County. Immediately south of Dunbow Road, approximately 700 m east of Macleod Trail SE and 1.5 kilometers west of Deerfoot Trail. The site is bound by Dunbow Road on the north, country residential development and undeveloped land on the south, a natural drainage course on the east and 2nd Street E on the west. The site is located within the NW ¼ Sec. 32-21-29-W4M and currently comprises the 2 country residential residences and mostly uncultivated land.

The location of the proposed development relative to the City of Calgary is shown in **Figure 1**. The overall Study Area relative to the existing surrounding communities is illustrated in **Figure 2** and the proposed Concept Plan is presented in **Figure 3**.

The Concept Plan application comprises 16.78 ha, from which a 0.97 ha parcel will be subdivided out. The remaining 15.81 ha include 1.35 ha of Environmental Reserve (ER).

1.3 Topography

The site drops from 1061 masl at the southwest corner to 1052.5 masl on the north with an average 2% slope. There a two drainage courses that cross the study area; the major drainage course runs from south to north along the east boundary of the proposed development and a minor course also runs from south to north along the middle of the proposed development; both drainage courses are dedicated as ER. Existing contours and natural drainage channels are illustrated in **Figure 4**.

1.4 Scope of Analysis

Foothills County requires an SWMP in support of a subdivision development. The SWMP involves a detailed hydrologic and hydraulic assessment of the storm drainage of a development area, particularly for the definition of SWMFs in terms of layouts and elevations.

The location, shape and hydraulic characteristics of the SWMFs that will manage the development runoff are defined in this report. The anticipated water quality enhancement for the discharged runoff under ultimate development conditions is also assessed in this report. All these must meet AEP and Foothills County requirements.

Activities performed in preparation of this analysis are as follows:

- Establish drainage boundaries and characteristics of each catchment area, for both, pre-development and post-development.
- Hydrologic modeling to estimate the runoff and water quality from the study area.
- Hydraulic modeling to estimate stormwater storage volume required and anticipated operation of the SWMF and
- Preparation of draft and final reports.

This analysis is an office study based on data and reports by others. No detailed field survey was undertaken by LGN. The pre-development land use distribution was established from aerial photographs. The Concept Plan for the proposed residential development was prepared by Township Planning & Design Inc. (**Figure 3**).

The study addresses overall surface water runoff in the study area to assess pre-development runoff discharge and the operation of the proposed ponds under post-development conditions. No structural, geotechnical or hydrogeological engineering considerations, assessment of subsurface drainage conditions, underground piped drainage system or the drainage of individual development lots was undertaken by this study.

2.0 PROPOSED DRAINAGE STRATEGIES AND DESIGN CRITERIA

2.1 Drainage Catchment

Pre-development drainage catchment boundary is illustrated in **Figure 4,** this is also the Study boundary. The land use composition of the proposed residential development is presented in **Figure 3** and listed below in **Table 1**.

Table 1 – Land Use Breakdown & Imperviousness

Land Use	Area (ha)	Imp. (%)
TO NORTH POND		
Single Family	0.86	67
Multi-family	1.95	67
MR	1.37	0
Roads	0.49	75
Pathways	0.11	100
Pond	0.10	100
Sub-total	**4.88**	**50**
TO SOUTH POND		
Single Family	3.88	67
Multi-family	0.71	67
ER	0.44	0
MR	1.90	0
Roads	1.65	75
Pathways	0.30	100
Pond	0.32	43
Sub-total	**9.20**	**52**
TOTAL	**14.08**	**51**

2.2 Drainage Strategies

The analysis is based on the following assumptions:

- Stormwater runoff from the proposed residential development will drain using the Dual Drainage Concept (minor/major system).
- The drainage system is to convey the entire stormwater runoff to the SWMFS identified in this report.
- The detailed overland drainage design by others must ensure the safe conveyance through the development of the overland flows generated by the 100-year event.
- Any ponding of stormwater runoff on the streets or individual development lots must be acceptable by the approving authorities.
- Back of lots adjacent to any MR or ER lands must drain as sheet flow.
- Because of the topography, the entire development couldn’t drain to a single stormwater facility, reason why the development will be serviced by two (2) SWMFs, the one on the north is to be a Dry Pond and the one in the south is to be a Wet Pond.

2.3 Design characteristics for the Major and Minor Systems

The proposed development will discharge into the proposed ponds, which will discharge via an existing natural drainage channel into Pine Creek and ultimate into the Bow River. The discharge criterion was set by the Foothills County as follows:

- Post-development 1:100 year peak discharge rate from the pond must not exceed the pre-development 1:100 year peak discharge rate.

Major System

The major stormwater drainage system includes all overland drainage routes (roads, lanes, ditches, swales, etc.). This system is the path for the runoff to follow when the capacity of the minor (piped) system has been exceeded; therefore, it must be designed to convey runoff from extreme rainfall events that exceed the capacity of the minor system. Failure to properly plan and design the major system can result in flooding and damage of both private and public property.

The design and analysis of the overland drainage system must conform to the AEP guidelines which have been adopted by Foothills County. Some of the pertinent guidelines are the following:

- The major drainage system must be designed as an overland system and shall be analysed with respect to the 1:100 year return period event, including the SWMFs.
- The grading of the streets and the layout of the major system shall be designed to provide a continuous escape route. Adjacent properties must be protected from possible flooding by these flows.
- The maximum depth of flow at the curbside gutter should be less than 0.30 m.
- Standing water at low points (traplows) should be less than 0.5 m.
- The velocities and depths of flow for the overland drainage system shall not exceed the values outlined in **Table 2**.

Table 2 - Permissible Depths and Velocities for Overland Flows

Water Velocity (m/s)	Permissible Depth (m)
0.5	0.80
1.0	0.32
2.0	0.21
3.0	0.09

- Spillover elevations should be no higher than 0.5 m above the lowest point in the traplow.
- Where the overland escape route for a traplow is via a public road, the minimum building openings must be 0.3 m higher than the 1:100 year water level in adjacent traplows or the spillover elevation, whichever is higher.
- If the overland escape route is via PUL, MR or utility right-of-way, the lowest opening elevation must be set at 0.5 m above the spill elevation or the 1:100 year water level, whichever is higher.
- If the overland escape route is not along a public road or paved public pathway, a concrete swale will be required.

Minor System

The minor system is the underground piping system and must quickly and efficiently remove rainfall runoff below its design capacity. The following are the pertinent design criteria:

- The storm system must be designed as a separate system from the sanitary.
- During detailed design of the surface drainage system by others it must be ascertained that the 100-year maximum hydraulic grade line in the overall system is acceptable. Surcharge to surface is strictly prohibited.
- Inlet Control Devices (ICD) are required to control flows into the pipe system.
- Discharge into the public storm trunks should be based on a minimum Unit Area Release Rate (UARR) of 70 L/s/ha.

2.4 Source Control Best Management Practices

In the interest of an environmentally sensitive development, there are a range of alternative storm servicing concepts that can be considered in new developments. These concepts require additional area for stormwater facilities and/or implementation of some of the concepts outlined in The City of Calgary, Water Resources, Stormwater Source Control Practices Handbook (November 2007).

Is recommended that at detail design and wherever possible the following Best Management Practices (BMP) be implemented:

- All roof drainage to be directed to landscaped areas prior to draining to streets or lanes, this was included in the PCSWMM model;
- Increased topsoil depth - 300 mm of topsoil for all absorbent landscaped areas in the lots, road pervious areas and MR.

2.5 Stormwater Quality Enhancement

AEP and Foothills County have a stormwater quality enhancement requirement for all new developments. This requirement is to remove 85% of the sediment washoff from a development area, of particles greater than 50 µm in size prior to discharge. This stormwater quality requirement will be met using an Oil/Grit separator, more details are provided in **Section 4.0** of this report.

3.0 HYDROLOGIC AND HYDRAULIC ANALYSIS

The City of Calgary Stormwater Management & Design Manual (2011) requires that the major drainage system, including storage facilities be designed to accommodate the runoff resulting from a 1:100 year return period storm event. For this design, there are two approaches to the simulation of runoff characteristics, a single storm event and continuous events model.

Single Storm Event Analysis

The Single Storm Event Analysis is the most common stormwater management analysis method and is based on a single storm event which could be a real historic storm or a theoretical design storm. The precipitation input to the single event simulation model is obtained using the Calgary Intensity Duration Frequency (IDF) curve and the "Chicago Storm" distribution to shape the design hyetograph. For this SWMP study, a storm with 24 hours duration and 5 minute rainfall increments was used.

Continuous Simulation

Continuous simulation modelling for a drainage area allows for a continuous analysis of runoff over an extended period of time, typically several years. The model results include time series of flow or water levels, storage volumes, etc. These results allow a probabilistic analysis to determine frequency of occurrences and capacity requirements for stormwater ponds.

3.1 Computer Model

There are various computer models used and accepted in Calgary, they include SWMHYMO (Single Storm Event), QHM, EPA SWMM, XP-SWMM, PCSWMM and the Water Balance Spreadsheet for the City of Calgary (WBSCC).

The analysis for this study was performed using the PCSWMM 2021 computer model software Version 7.4.3240 Professional. PCSWMM is software developed by Computer Hydraulics International and is a comprehensive, GIS-based, spatial decision support system for urban drainage and watershed modeling. Integrating the full, official US EPA SWMM5 engine Version 5.1.015, it accounts for various hydrologic processes that produce runoff from urban and rural areas. PCSWMM also contains a flexible set of hydraulic modeling capabilities used to route runoff, rainfall-dependent infiltration/inflow, and/or external inflows through the drainage system network of pipes, channels, storage/treatment units and diversion structures.

3.2 Subcatchments

Because of the size of the catchment and to simplify the analysis, the pre-development contributing catchment was lamped into 1 subcatchment, see **Figure 4**. **Table 3** lists the model subcatchments and the parameters used in the pre-development computer model.

Table 3 – Pre-development Catchment Parameters

Catchment *	Description	Area (ha)	Imperviousness (%)	CN	Length (m)	Width (m)	Slope (%)
S1	Undeveloped	14.93	1	72	235	635	2.0

* Name used in the model

The post-development contributing catchment was divided into 2 subcatchments, each one draining to its own pond, see **Figure 5**. **Table 4** lists the model subcatchments and the parameters used in the post-development computer model.

Table 4 – Post-development Catchment Parameters

Catchment *	Discharge Point	Area (ha)	Imperviousness (%)	CN	Length (m)	Width (m)	Slope (%)
S1	South Pond (SU1)	9.20	52	72	30	3067	2.0
S2	North Pond (SU2)	4.88	50	72	30	1627	2.0
Total		**204.00**					

* Name used in the model

The length of each subcatchment was determined by measuring the longest runoff route before runoff is intercepted.

3.3 Infiltration

The SWMM computer model describes rainfall infiltration from the pervious area of a subcatchment into the unsaturated upper soil zone using three different methods:

- Horton Infiltration
- Green-Ampt infiltration
- Curve Number infiltration

The method used in this study is the Curve Number with a CN=72.

The set-up of the computer model was accomplished by the following steps:

- Divide the area into sub-catchments based on existing topography.
- Determine model parameters for each catchment including size and impervious ratio.

The ponds are going to be lined; therefore no infiltration from the ponds was accounted in the analysis.

The version of PCSWMM 2021 used in this runoff analysis contains a Time Pattern Editor that provides the ability to adjust different parameters to reflect seasonal variations. This feature was used to represent frozen ground conditions during the winter months, November to March. A multiplier was applied during these months to all infiltration parameters. The value of the multiplier is 0 for January, 0.10 for February and December, 0.60 for March and November and 0.8 for April; for the other months of the year, the multiplier is 1.0, representing normal conditions.

3.4 Snow Melt

The PCSWMM software simulates snowmelt using the Snow Pack routine along with temperature, evaporation and wind data. Snowmelt was part of the computer runoff analysis presented in this report; the analysis used temperature data provided by the City of Calgary. The other parameters used in the runoff analysis are presented in **Appendix A**.

3.5 Evaporation

Water surface evaporation and pumping for irrigation are part of the SWMF discharges, however, they were not included in the single event model simulation, and it was conservatively assumed that the water level at the start of the simulation was at the Upper Normal Water Level.

The Monthly evaporation provided in the City of Calgary Stormwater Management & Design Manual (2011) was converted to daily evaporation to be used in the PSCWMM mode. The daily evaporation data is presented in **Appendix A**.

3.6 Storage Routing

Storage Routing is a command used to simulate the effects of reservoir (pond, traplow) routing. The routing is conducted with the storage-discharge stage data method where solution is based on the conservation of mass. This command requires that the user provide the outflow-storage relationship of the reservoir. The Stage-Area characteristics of the proposed ponds were obtained from the pond size and shape presented in the Concept Plan provided by TPD and are listed in **Tables 5 and 6.**

Table 5 – Dry Pond Storage Rating Data

Stage	Elevation (m)	Area (m^2)	Total Storage (m^3)
Bottom*	1,053.5	1,032	0
	1,054.0	1,483	629
	1,054.5	1,973	1,493
High Water Level (HWL)	1,055.0	2,503	2,612

Table 6 – Wet Pond Storage Rating Data

Stage	Elevation (m)	Area (m^2)	Total Storage (m^3)
Bottom*	1,049.0	81	0
	1,049.5	227	0
	1,050.0	435	0
	1,050.5	702	0
	1,051.0	1,023	0
Normal Water Level (NWL)	1,051.5	1,387	0
	1,052.0	1,790	794
	1,052.5	2,233	1,800
	1,053.0	2,716	3,037
High Water Level (HWL)	1,053.5	3,237	4,526

3.7 Sediment Removal Analysis

Although PCSWMM is capable of performing a sediment removal analysis, it was not part of the analysis because water quality requirements will be met by an oil/grit separators installed in the last manhole upstream of the pond inlets.

Schematic diagrams and Input and Output report files for the PCSWMM computer model analysis are included in **Appendix A**.

4.0 DESIGN DETAILS

In accordance with the City of Calgary *Stormwater Management & Design Manual* (2011) and Alberta Environment *Stormwater Management Guidelines,* the proposed north pond is classified as a dry pond and the south pond is classified as wet pond. To and ensure that the post-development 1:100 year peak discharge does not exceed the pre-development 1:100 year peak discharge, a control structure will be installed at the outlet pipe of each pond, furnished with an Inlet Control Device (ICD) that will regulate the flows leaving the SWMFs.

4.1 Pre-development Discharge

The pre-development analysis results are presented in Table 7.

Table 7 – Pre-development Analysis

	Unit	Value
Catchment Area	ha	14.93
Discharge	l/s	70
UARR	l/s/ha	4.69

4.2 Pond Layout

In wet ponds, the storage below NWL is not available for discharge rate (quantity) control; it is only significant in terms of water quality with respect to turnover rate and the pond's ability to improve the quality runoff into the receiving stream. The storage above the NWL is referred to as active storage and is the available capacity to allow for the control of discharges from the outlet. **Table 8** summarizes the Wet Pond characteristics.

Table 8 – Wet Pond Characteristics

	Parameter	Value	Unit
General	Contributing Catchment Area	9.20	ha
	Side Slopes below NWL	5.0H:1V	
	Side Slopes between NWL & HWL	5.0H:1V	
	Side Slopes above HWL	4H:1V	
Elevation	Pond Bottom Elevation	1,049.00	m
	NWL Elevation	1,051.50	m
	HWL Elevation	1,053.50	m
	1:100 Year Elevation	1,053.39	m
	Freeboard Elevation	1,053.80	m
Depth	Pond Depth Below NWL	2.50	m
	Storage Fluctuation Depth above NWL	2.00	m
	1:100 year Depth	4.39	m
Area	Area at NWL	1,387	m^2
	Area at HWL	3,237	m^2
Volume	Permanent Pool below NWL	1,561	m^3
	Active Storage Capacity (NWL to HWL)	4,526	m^3
	1:100 Year Active Volume (Single Event)	3,664*	m^3
	1:100 Year Active Volume (Continuous Simulation-FA)	4,190*	m^3
Discharge	Maximum Discharge @HWL	43.2	l/s
	1:100 Discharge	41.9	l/s

* Active Volume above NWL

Table 9 summarizes the proposed dry pond characteristics.

Table 9 – Dry Pond Characteristics

Parameter		Value	Unit
General	Contributing Catchment Area	4.88	ha
	Bottom to HWL Side Slopes	5.0H:1V	
	Side Slopes above HWL	4H:1V	
Elevation	Pond Bottom Elevation	1,053.50	m
	HWL Elevation	1,055.00	m
	1:100 Year Elevation	1,054.83	m
	Freeboard Elevation	1,055.30	m
Depth	Pond Depth	1.50	m
	1:100 year Depth	1.33	m
Area	Area at Bottom	1,032	m^2
	Area at HWL	2,503	m^2
Volume	Active Storage Capacity (Bottom to HWL)	2,612	m^3
	1:100 Year Active Volume (Single Event)	1,929*	m^3
	1:100 Year Active Volume (Continuous Simulation-FA	2,240*	m^3
Discharge	Maximum Discharge @HWL	22.9	l/s
	1:100 Discharge	21.5	l/s

* Active Volume above NWL

4.3 Outlet Control Structure

A control structure will have to be installed at the outlet of each pond to control pond off-site discharge to the allowable rate described in **Section 2.3**. Design of the control structure for each facility will be undertaken by others at the detail design stage of the development.

4.4 Emergency Overflow

The emergency spill from the ponds will be onto the existing natural drainage course which also conveys outflow from the facility.

4.5 Frequency of Ponding

Based on the frequency analysis of the continuous simulation results (PCSWMM), **Figure 7** illustrates the most appropriate frequency distribution of storage volumes for the proposed wet pond. As visually observed and indicated by the results of the regression analysis shown on the figure, the best fit frequency distribution for the wet pond is the GEV distribution. **Tables 10** summarize the modeled frequency of Total Storage volumes. The Frequency Analysis is presented in **Appendix B**.

Table 10 - Ponds Frequency Storage Volumes

	Wet Pond		Dry Pond	
Return Period (Years)	Storage Volume (m^3)	Active Volume (m^3)	Storage Volume (m^3)	Active Volume (m^3)
2	2,660	1,100	588	588
5	3,270	1,710	913	913
10	3,750	2,190	1,170	1,170
20	4,280	2,720	1,450	1,450
50	5,060	3,500	1,870	1,870
100	5,750	4,190	2,240	2,240

The results show that the estimated 1:100 year storage by Frequency Analysis is higher than the maximum annual storage volume over the 55 years of continuous simulation and the single event analysis; therefore, the 1:100 year volume obtained from the Frequency Analysis governs and was used for the pond detail design.

Figure 8 illustrates the maximum and minimum water levels expected for the proposed SWMFs as determined by the continuous simulation (PCSWMM).

4.6 Water Balance

Table 11 presents the PCSWMM model Water Balance as Total Precipitation and losses.

Table 11 – Water Balance

	Depth (mm)
Total Precipitation	22903.400
Evaporation Loss	17170.669
Infiltration Loss	2206.765
Surface Runoff	3508.135
Snow Cover	0.000
Surface Storage	60.511
Continuity Error (%)	-0.063

4.7 Oil/Grit Separator

To meet the water quality requirements, an oil/grit separator is proposed to be installed at the first upstream manhole of each pond inlet into the SWMF. **Appendix C** contains information on the proposed oil/grit separators that unit will meet the water quality requirements imposed by Foothills County and AEP.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This study has concluded that:

- The proposed ponds in combination with the outlet control structures will control the peak discharge from the proposed development to a maximum UARR of 4.69 L/s/ha. This meets the Foothills County requirement that post-development discharge doesn't exceed pre-development discharge.
- Water quality enhancement of stormwater runoff from the proposed development will be achieved via an oil/grit separator type units which will meet the required levels of Total Suspended Solid removal by AEP and Foothills County.

Recommendations

It is recommended that:

- A minimum of 300 mm of topsoil be provided for all landscaped areas.
- Detail design of post-development pond infrastructure be undertaken in conjunction with detail design of the future development
- The analysis presented in this report is accepted by the approving agencies.

Corporate Authorization

This document entitled, “Residential Development in Foothills County, Stormwater Management Plan” was prepared by LGN Consulting Engineering Ltd. It is intended for the use of 2291463 Alberta Ltd., their consultants and contractors responsible for the development of noted property and approval authorities for which it has been prepared. The contents of the report represent LGN Consulting Engineering Ltd.’s best judgement based on available information at the time of preparation. Any use which a third party makes of the report, or reliance on or decisions made based on it, are the responsibilities of such third parties. LGN Consulting Engineering Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on the report.

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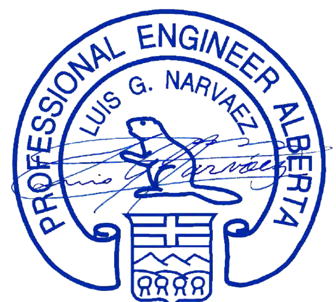

November 26, 2021

RESPONSIBLE ENGINEER

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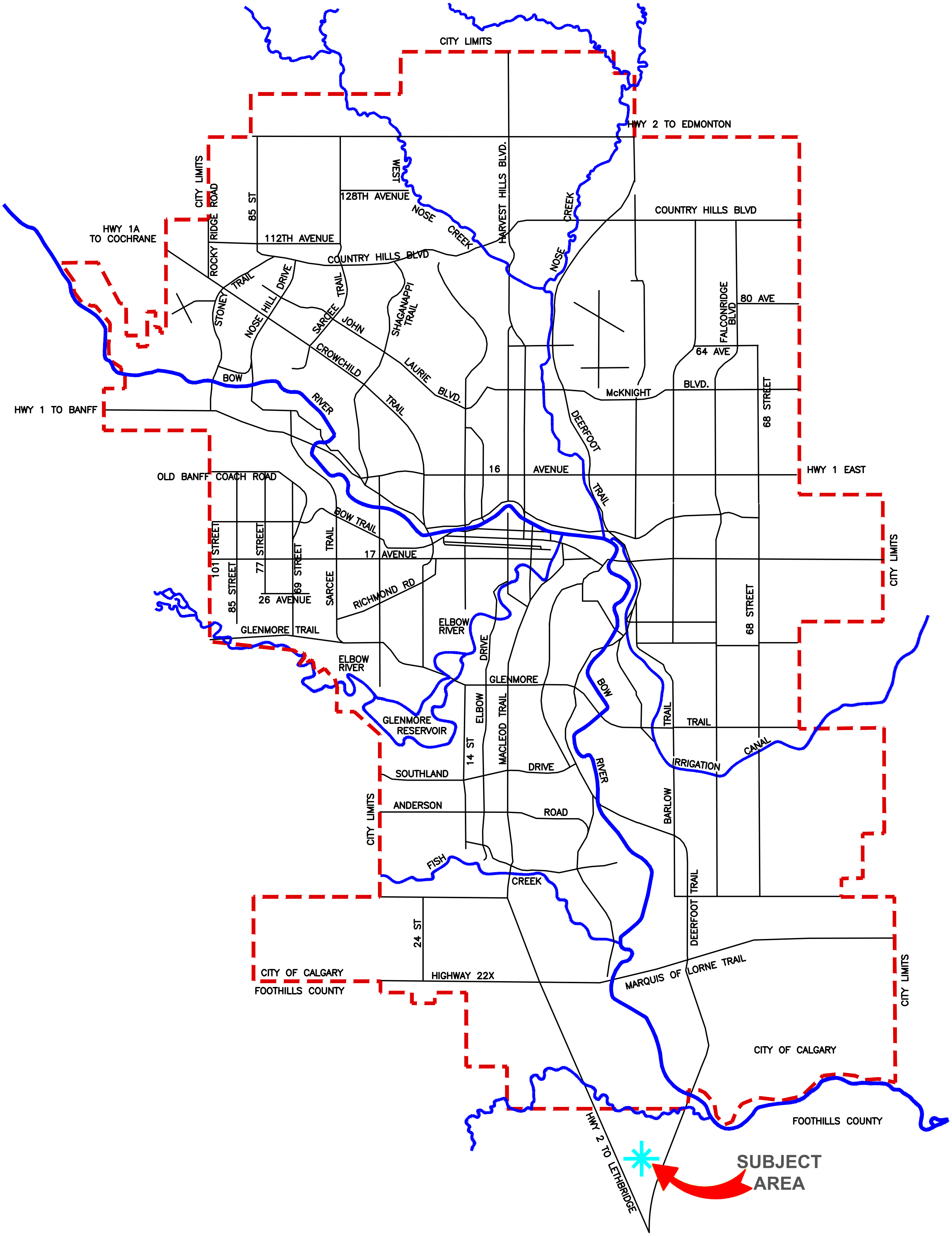
FIGURES



LGN Consulting Engineering Ltd.

Scale: **200,000**

Client/Project

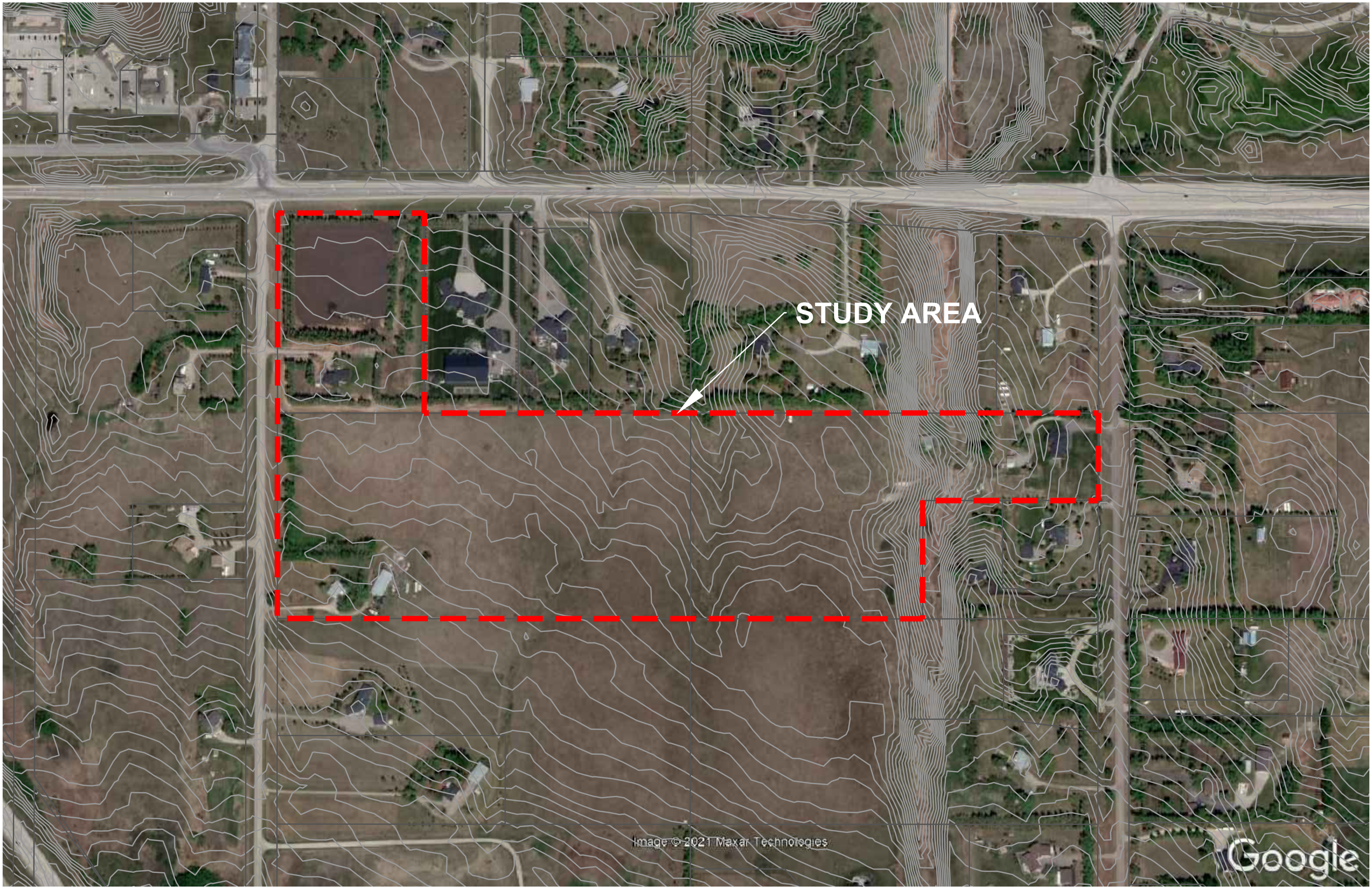
2291463 ALBERTA LTD.

Title

Location Plan

Figure No.

1



Legend

Development Boundary

Scale: **1:5,000**

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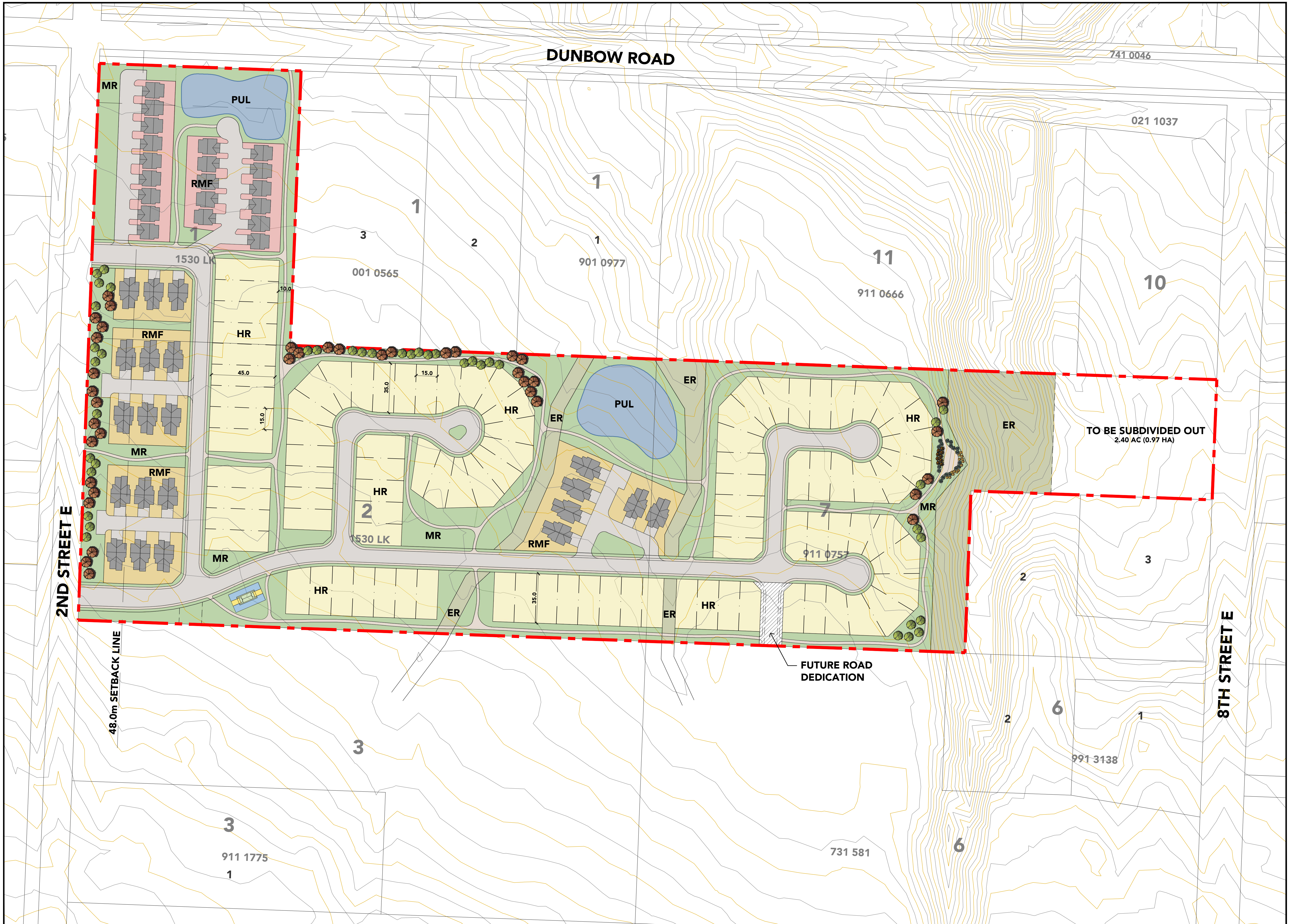
Title

Study Area

Figure No. **2**

LGN Consulting Engineering Ltd.



TOWNSHIP
planning + design inc.

CLIENT
2291463 ALBERTA LTD.

PROJECT NUMBER
21-036

LEGAL ADDRESS
N.W. 1/4 SEC 32-21-29 W4M
FOOTHILLS COUNTY

DATE
November 22, 2021

STATISTICS

	Ac	Ha
Total Site Area	41.46	16.78
Subdivided out Parcel	2.40	0.97
Net Developable	39.06	15.81
Residential Districts		
Single Family (HR)	12.73	5.15
Multi-Family (RMF)	4.25	1.72
Multi-Family (RMF)	2.46	0.99
Environmental Reserve (ER)	3.29	1.35
Municipal Reserve (MR)	9.54	3.84
Public Utility Lot (PUL)	1.42	0.57
Roads	5.29	2.14
Roads Dedication	0.18	0.07

OPTION 2

N SCALE
2500

Figure 3
SITE PLAN

LGN Consulting Engineering Ltd.

Legend

- Outfalls
- Subcatchments

N

50

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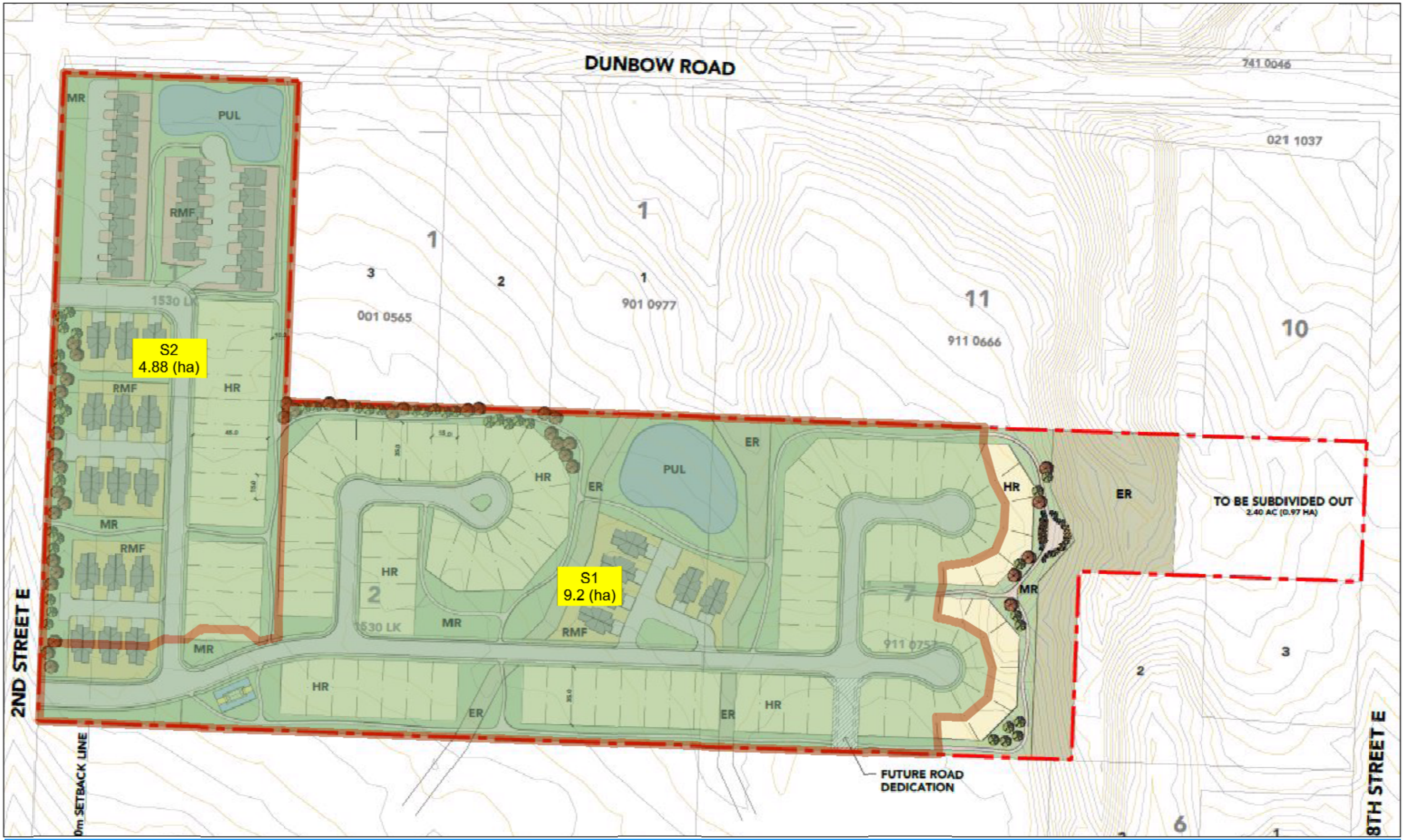
2291463 ALBERTA LTD.

Title

Pre-development Analysis

Figure No. **4**



Legend

Subcatchments

N

100

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Title

Post-development Sub-catchments

Figure No. **5**

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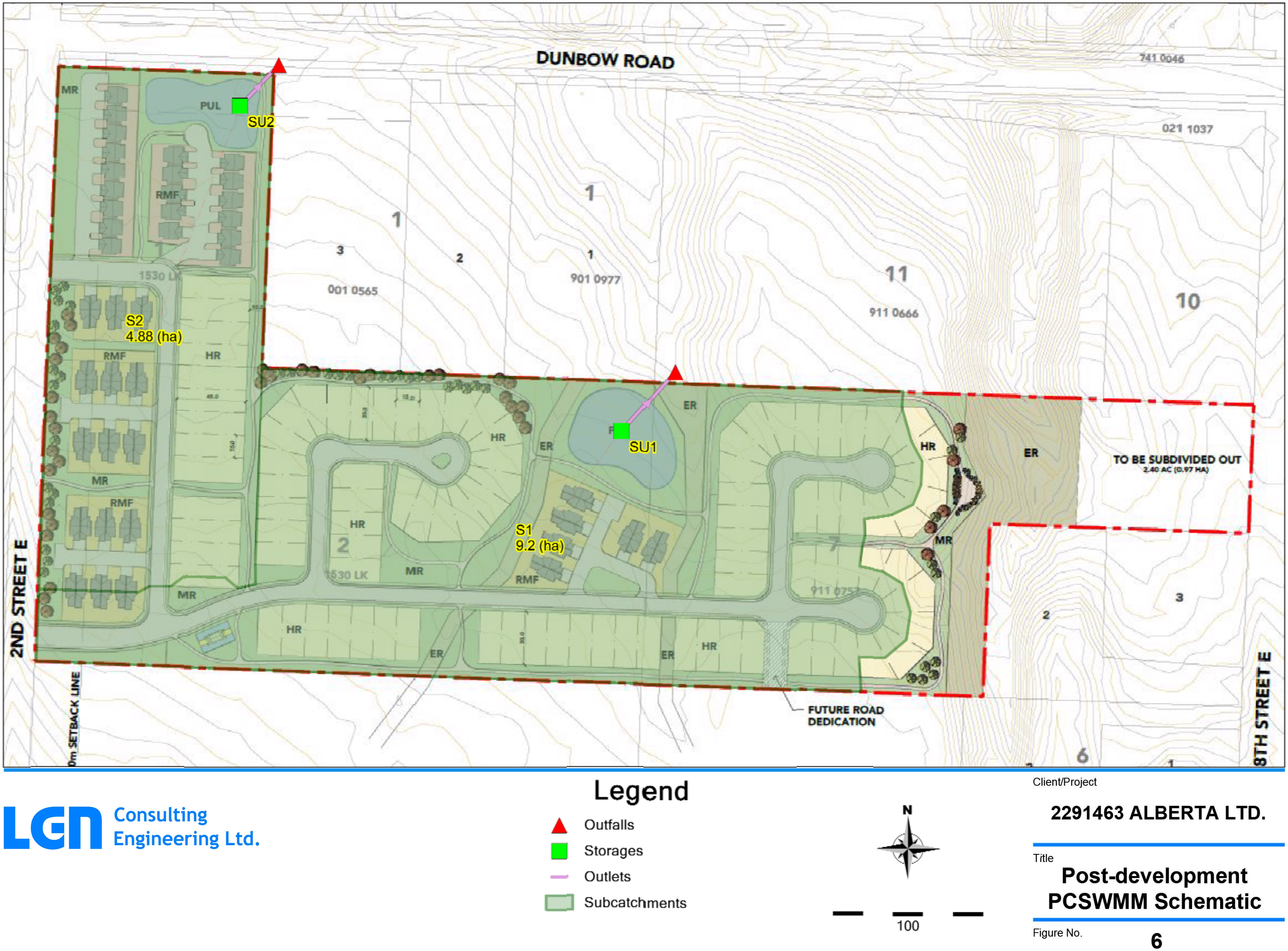

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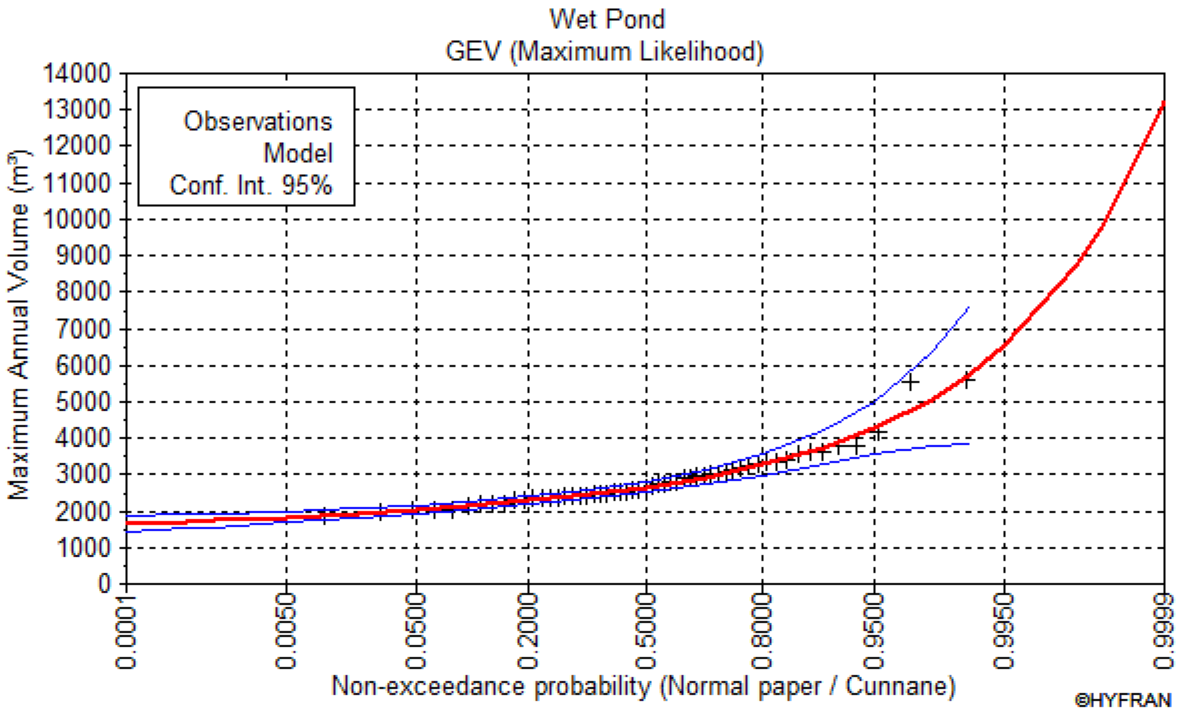
Title

Post-development PCSWMM Schematic

Figure No. **6**



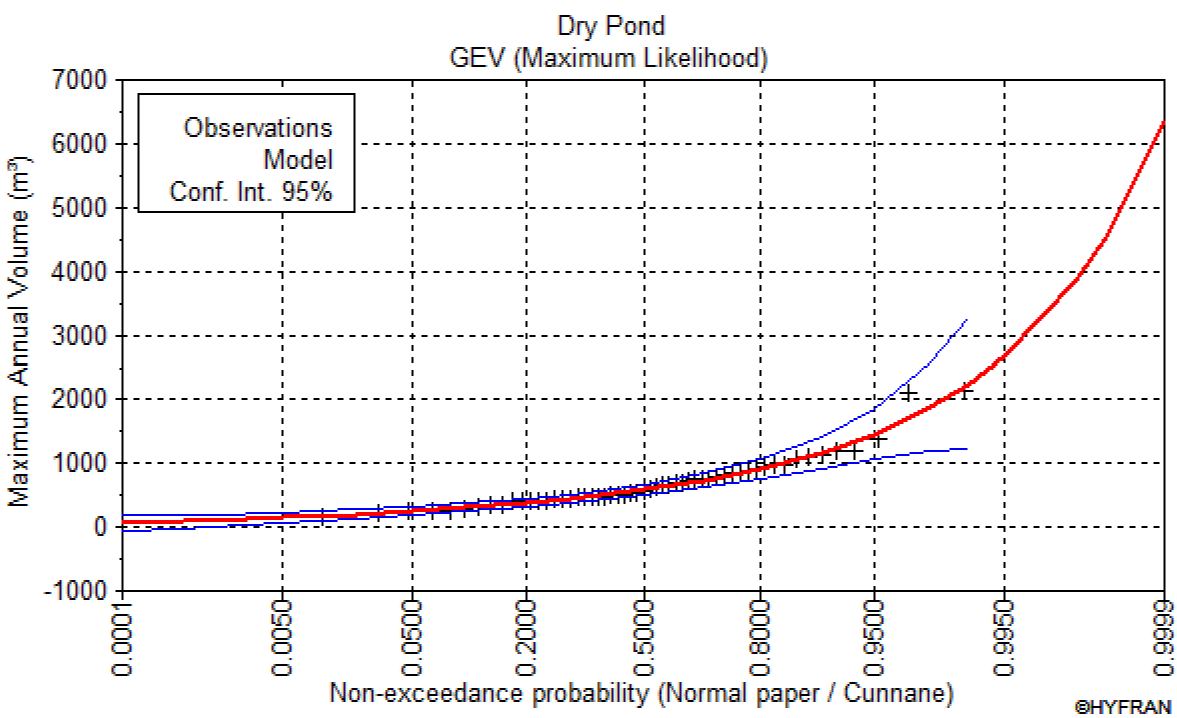
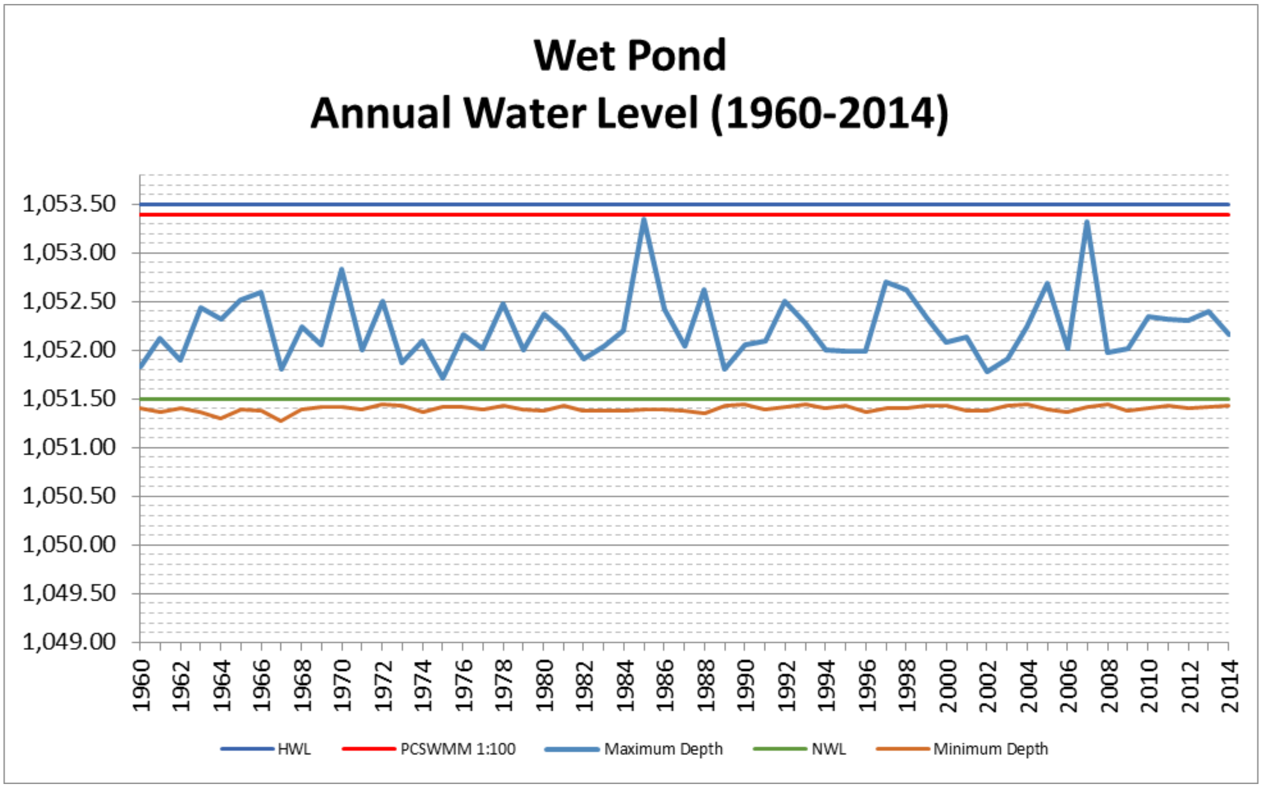


Figure 7 – Wet Pond Frequency Distribution



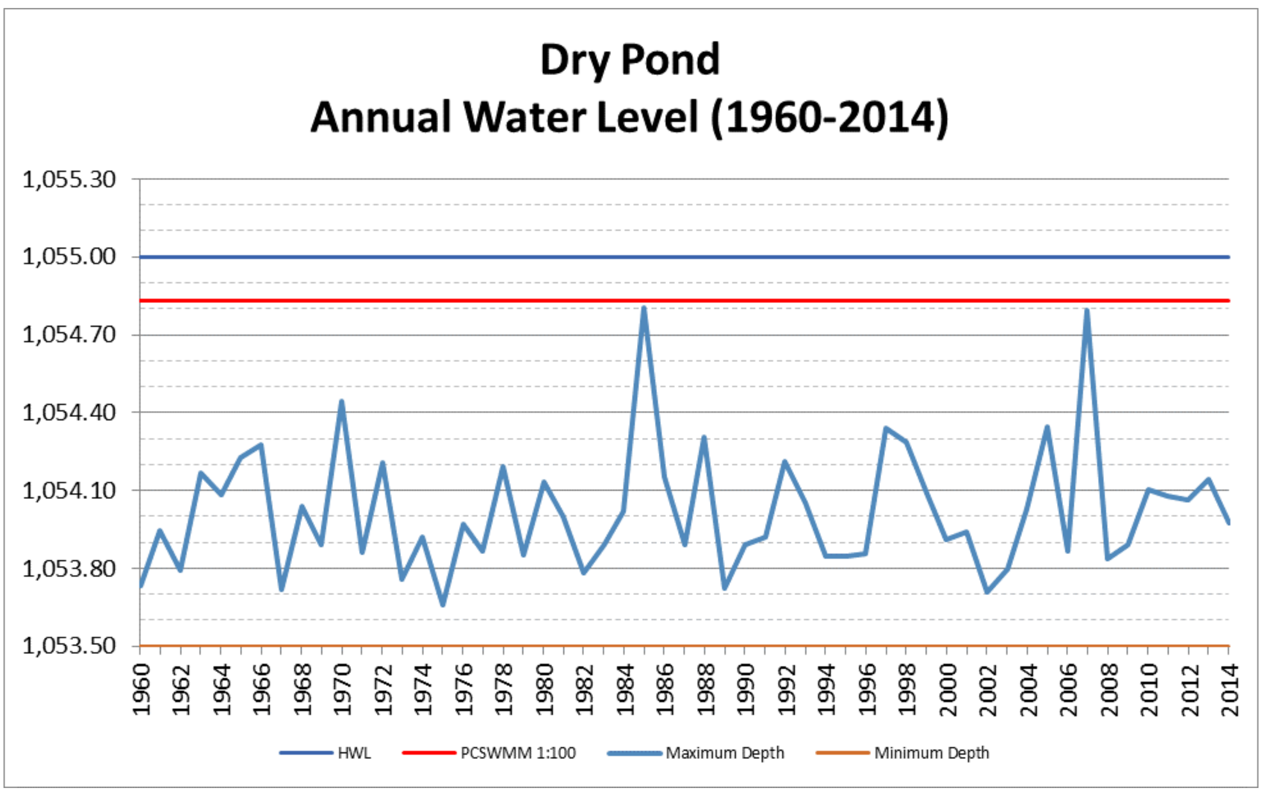


Figure 8 - Annual Water Level

APPENDIX A

PCSWMM Model

Single Storm Event
Pre-development Model
1 hour – 100 year

- **Input File**
- **Report File**

To reduce the amount of data in the input file, the following sections have been excluded in this Appendix:

- Coordinates
- Vertices
- Polygons

```
[TITLE]
;;Project Title/Notes
Residential Development
2291463 Alberta Ltd.
Pre-development Analysis
Calgary 1h-100y Storm Event

[OPTIONS]
;;Option             Value
FLOW_UNITS           CMS
INFILTRATION         CURVE_NUMBER
FLOW_ROUTING         DYNWAVE
LINK_OFFSETS         DEPTH
MIN_SLOPE            0
ALLOW_PONDING        NO
SKIP_STEADY_STATE    NO

START_DATE           09/22/2021
START_TIME           00:00:00
REPORT_START_DATE    09/22/2021
REPORT_START_TIME    00:00:00
END_DATE             09/22/2021
END_TIME             01:00:00
SWEEP_START          01/01
SWEEP_END            12/31
DRY_DAYS             0
REPORT_STEP          00:01:00
WET_STEP             00:05:00
DRY_STEP             00:05:00
ROUTING_STEP         5
RULE_STEP            00:00:00

INERTIAL_DAMPING     PARTIAL
NORMAL_FLOW_LIMITED  BOTH
FORCE_MAIN_EQUATION  H-W
VARIABLE_STEP        0.75
LENGTHENING_STEP     0
MIN_SURFAREA         0
MAX_TRIALS           8
HEAD_TOLERANCE       0.0015
SYS_FLOW_TOL         5
LAT_FLOW_TOL         5
MINIMUM_STEP         0.5
THREADS              6

[EVAPORATION]
;;Data Source    Parameters
;;-------------- ----------------
CONSTANT         0.0
DRY_ONLY         NO

[RAINGAGES]
;;Name           Format    Interval SCF      Source
;;-------------- --------- -------- -------- ----------
Calgary_1h_100y  INTENSITY 0:05     1.0      TIMESERIES Calgary_1h_100y

[SUBCATCHMENTS]
;;Name           Rain Gage        Outlet           Area     %Imperv  Width    %Slope   CurbLen  SnowPack
;;-------------- ---------------- ---------------- -------- -------- -------- -------- -------- ----------------
S1               Calgary_1h_100y  OF1              14.9283  1        635.247  2        0

[SUBAREAS]
;;Subcatchment   N-Imperv   N-Perv     S-Imperv   S-Perv     PctZero    RouteTo    PctRouted
;;-------------- ---------- ---------- ---------- ---------- ---------- ---------- ----------
S1               0.015      0.25       1.6        3.2        0          OUTLET

[INFILTRATION]
;;Subcatchment   Param1     Param2     Param3     Param4     Param5
;;-------------- ---------- ---------- ---------- ---------- ----------
S1               72         3.302      7          0          0

[OUTFALLS]
;;Name           Elevation  Type       Stage Data       Gated    Route To
;;-------------- ---------- ---------- ---------------- -------- ----------------
OF1              1050.5     FREE                        NO

[TIMESERIES]
;;Name           Date       Time       Value
;;-------------- ---------- ---------- ----------
;Calgary_1h_100y design storm, rain interval = 5 minutes, rain units = mm/hr.
Calgary_1h_100y             0:00       0
Calgary_1h_100y             0:05       13.283
Calgary_1h_100y             0:10       18.961
Calgary_1h_100y             0:15       40.516
Calgary_1h_100y             0:20       168.138
Calgary_1h_100y             0:25       54.372
```

```
Calgary_1h_100y             0:30       31.748
Calgary_1h_100y             0:35       23.236
Calgary_1h_100y             0:40       18.66
Calgary_1h_100y             0:45       15.763
Calgary_1h_100y             0:50       13.746
Calgary_1h_100y             0:55       12.251
Calgary_1h_100y             1:00       11.093

[REPORT]
;;Reporting Options
INPUT      YES
CONTROLS   NO
SUBCATCHMENTS ALL
NODES ALL
LINKS ALL

[TAGS]

[MAP]
DIMENSIONS       288840.185       5635187.64575    289532.327       5635645.69125
UNITS            Meters

[COORDINATES]
;;Node           X-Coord            Y-Coord
;;-------------- ------------------ ------------------

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

[POLYGONS]
;;Subcatchment   X-Coord            Y-Coord
;;-------------- ------------------ ------------------

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

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.1 (Build 5.1.015)
--------------------------------------------------------------

Residential Development
2291463 Alberta Ltd.
Pre-development Analysis


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


****************
Raingage Summary
****************
                                                      Data       Recording
Name                 Data Source                      Type       Interval
------------------------------------------------------------------------
Calgary_1h_100y      Calgary_1h_100y                  INTENSITY    5 min.


********************
Subcatchment Summary
********************
Name                       Area     Width   %Imperv    %Slope Rain Gage            Outlet
-----------------------------------------------------------------------------------------------------------
S1                        14.93    635.25      1.00    2.0000 Calgary_1h_100y      OF1


************
Node Summary
************
                                             Invert      Max.    Ponded    External
Name                 Type                     Elev.     Depth      Area    Inflow
-------------------------------------------------------------------------------
OF1                  OUTFALL                1050.50      0.00       0.0


*********************************************************
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 ........... NO
  Water Quality .......... NO
Infiltration Method ...... CURVE_NUMBER
Surcharge Method ......... EXTRAN
Starting Date ............ 09/22/2021 00:00:00
Ending Date .............. 09/22/2021 01:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:01:00
Wet Time Step ............ 00:05:00
Dry Time Step ............ 00:05:00


**************************        Volume         Depth
Runoff Quantity Continuity     hectare-m            mm
**************************     ---------       -------
Total Precipitation ......         0.511        34.219
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         0.376        25.161
Surface Runoff ...........         0.012         0.811
Final Storage ............         0.124         8.313
Continuity Error (%) .....        -0.192


**************************        Volume        Volume
Flow Routing Continuity        hectare-m      10^6 ltr
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         0.011         0.112
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
```

```
External Inflow ..........        0.000        0.000
External Outflow .........        0.011        0.112
Flooding Loss ............        0.000        0.000
Evaporation Loss .........        0.000        0.000
Exfiltration Loss ........        0.000        0.000
Initial Stored Volume ....        0.000        0.000
Final Stored Volume ......        0.000        0.000
Continuity Error (%) .....        0.000


***************************
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
S1	34.22	0.00	0.00	25.16	0.33	0.48	0.81	0.12	0.07	0.024

```
Analysis begun on:  Wed Sep 22 11:44:19 2021
Analysis ended on:  Wed Sep 22 11:44:19 2021
Total elapsed time: < 1 sec
```

Single Storm Event
Post-development Model
24 hour – 100 year

- **Input File**
- **Report File**

To reduce the amount of data in the input file, the following sections have been excluded in this Appendix:

- Coordinates
- Vertices
- Polygons

```
[TITLE]
;;Project Title/Notes
Residential Development
2291463 Alberta Ltd.
Single Storm Event
Calgary 24h-100y

[OPTIONS]
;;Option             Value
FLOW_UNITS           CMS
INFILTRATION         CURVE_NUMBER
FLOW_ROUTING         DYNWAVE
LINK_OFFSETS         DEPTH
MIN_SLOPE            0
ALLOW_PONDING        NO
SKIP_STEADY_STATE    NO

START_DATE           11/18/2021
START_TIME           00:00:00
REPORT_START_DATE    11/18/2021
REPORT_START_TIME    00:00:00
END_DATE             11/19/2021
END_TIME             00:00:00
SWEEP_START          01/01
SWEEP_END            12/31
DRY_DAYS             0
REPORT_STEP          00:01:00
WET_STEP             00:05:00
DRY_STEP             00:05:00
ROUTING_STEP         5
RULE_STEP            00:00:00

INERTIAL_DAMPING     PARTIAL
NORMAL_FLOW_LIMITED  BOTH
FORCE_MAIN_EQUATION  H-W
VARIABLE_STEP        0.75
LENGTHENING_STEP     0
MIN_SURFAREA         0
MAX_TRIALS           8
HEAD_TOLERANCE       0.0015
SYS_FLOW_TOL         5
LAT_FLOW_TOL         5
MINIMUM_STEP         0.5
THREADS              6

[EVAPORATION]
;;Data Source    Parameters
;;-------------- ----------------
CONSTANT         0.10
DRY_ONLY         NO

[RAINGAGES]
;;Name           Format    Interval SCF      Source
;;-------------- --------- -------- -------- ----------
Calgary_24h_100y INTENSITY 0:05     1.0      TIMESERIES Calgary_24h_100y

[SUBCATCHMENTS]
;;Name           Rain Gage        Outlet           Area     %Imperv  Width    %Slope   CurbLen  SnowPack
;;-------------- ---------------- ---------------- -------- -------- -------- -------- -------- ----------------
S1               Calgary_24h_100y SU1              9.2      52       3066.667 2        0
S2               Calgary_24h_100y SU2              4.88     50       1626.667 2        0

[SUBAREAS]
;;Subcatchment   N-Imperv   N-Perv     S-Imperv   S-Perv     PctZero    RouteTo    PctRouted
;;-------------- ---------- ---------- ---------- ---------- ---------- ---------- ----------
S1               0.015      0.25       1.6        3.2        0          PERVIOUS   30
S2               0.015      0.25       1.6        3.2        0          PERVIOUS   30

[INFILTRATION]
;;Subcatchment   Param1     Param2     Param3     Param4     Param5
;;-------------- ---------- ---------- ---------- ---------- ----------
S1               72         0.5        7          0          0
S2               72         0.5        7          0          0

[OUTFALLS]
;;Name           Elevation  Type       Stage Data       Gated    Route To
;;-------------- ---------- ---------- ---------------- -------- ----------------
OF1              1050.5     FREE                        NO
OF2              1053       FREE                        NO

[STORAGE]
;;Name           Elev.    MaxDepth   InitDepth  Shape      Curve Name/Params            N/A      Fevap    Psi      Ksat     IMD
;;-------------- -------- ---------- ----------- ---------- ---------------------------- -------- --------          -------- --------
SU1              1049     5          2.5        TABULAR    Pond                         0        1
SU2              1053.5   1.5        0          TABULAR    Dry_Pond                     0        0
```

```
[OUTLETS]
;;Name           From Node        To Node          Offset     Type            QTable/Qcoeff    Qexpon     Gated
;;-------------- ---------------- ---------------- ---------- --------------- ---------------- ---------- --------
R47              SU2              OF2              0          TABULAR/HEAD    ICD-R48                     NO
R64              SU1              OF1              2.5        TABULAR/HEAD    ICD-R61                     NO

[CURVES]
;;Name           Type       X-Value    Y-Value
;;-------------- ---------- ---------- ----------
ICD-R48          Rating     0          0
ICD-R48                     0.152      0.0074
ICD-R48                     0.352      0.0113
ICD-R48                     0.552      0.0141
ICD-R48                     0.752      0.0165
ICD-R48                     0.952      0.0185
ICD-R48                     1.152      0.0204
ICD-R48                     1.352      0.0221
ICD-R48                     1.452      0.0229

ICD-R61          Rating     0          0
ICD-R61                     0.139      0.0116
ICD-R61                     0.339      0.018
ICD-R61                     0.539      0.0228
ICD-R61                     0.739      0.0266
ICD-R61                     0.939      0.03
ICD-R61                     1.139      0.0331
ICD-R61                     1.339      0.0359
ICD-R61                     1.939      0.0432

Dry_Pond         Storage    0          1032
Dry_Pond                    0.5        1483
Dry_Pond                    1          1973
Dry_Pond                    1.5        2503

Pond             Storage    0          81
Pond                        0.5        227
Pond                        1          435
Pond                        1.5        702
Pond                        2          1023
Pond                        2.5        1387
Pond                        3          1790
Pond                        3.5        2233
Pond                        4          2716
Pond                        4.5        3237

[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            23:50      1.085
Calgary_24h_100y            23:55      1.081
Calgary_24h_100y            24:00      1.077

[REPORT]
;;Reporting Options
INPUT      YES
CONTROLS   NO
SUBCATCHMENTS ALL
NODES ALL
LINKS ALL

[TAGS]

[MAP]
DIMENSIONS       288842.28305     5635189.7353     289488.26795     5635646.6907
UNITS            Meters

[COORDINATES]
;;Node           X-Coord          Y-Coord
;;-------------- ---------------- ----------------

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

[POLYGONS]
;;Subcatchment   X-Coord          Y-Coord
;;-------------- ---------------- ----------------

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

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.1 (Build 5.1.015)
--------------------------------------------------------------

Residential Development
2291463 Alberta Ltd.
Single Storm Event


*************
Element Count
*************
Number of rain gages ...... 1
Number of subcatchments ... 2
Number of nodes ........... 4
Number of links ........... 2
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.


********************
Subcatchment Summary
********************
Name                       Area     Width   %Imperv    %Slope Rain Gage            Outlet
-----------------------------------------------------------------------------------------------------------
S1                         9.20   3066.67     52.00    2.0000 Calgary_24h_100y     SU1
S2                         4.88   1626.67     50.00    2.0000 Calgary_24h_100y     SU2


************
Node Summary
************
                                         Invert      Max.    Ponded    External
Name                 Type                 Elev.     Depth      Area    Inflow
-------------------------------------------------------------------------------
OF1                  OUTFALL            1050.50      0.00       0.0
OF2                  OUTFALL            1053.00      0.00       0.0
SU1                  STORAGE            1049.00      5.00       0.0
SU2                  STORAGE            1053.50      1.50       0.0


************
Link Summary
************
Name             From Node        To Node          Type            Length    %Slope Roughness
---------------------------------------------------------------------------------------------
R47              SU2              OF2              OUTLET
R64              SU1              OF1              OUTLET


*********************
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 ........ NO
  Water Quality .......... NO
Infiltration Method ...... CURVE_NUMBER
Flow Routing Method ...... DYNWAVE
Surcharge Method ......... EXTRAN
Starting Date ............ 11/18/2021 00:00:00
Ending Date .............. 11/19/2021 00:00:00
Antecedent Dry Days ...... 0.0
```

```
  Report Time Step ......... 00:01:00
  Wet Time Step ............ 00:05:00
  Dry Time Step ............ 00:05:00
  Routing Time Step ........ 5.00 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 ......         1.261        89.577
  Evaporation Loss .........         0.001         0.099
  Infiltration Loss ........         0.322        22.874
  Surface Runoff ...........         0.900        63.892
  Final Storage ............         0.041         2.894
  Continuity Error (%) .....        -0.204


  **************************        Volume        Volume
  Flow Routing Continuity        hectare-m      10^6 ltr
  **************************     ---------     ---------
  Dry Weather Inflow .......         0.000         0.000
  Wet Weather Inflow .......         0.899         8.990
  Groundwater Inflow .......         0.000         0.000
  RDII Inflow ..............         0.000         0.000
  External Inflow ..........         0.000         0.000
  External Outflow .........         0.384         3.838
  Flooding Loss ............         0.000         0.000
  Evaporation Loss .........         0.000         0.000
  Exfiltration Loss ........         0.000         0.000
  Initial Stored Volume ....         0.156         1.560
  Final Stored Volume ......         0.671         6.712
  Continuity Error (%) .....         0.005


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


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


  *************************
  Routing Time Step Summary
  *************************
  Minimum Time Step           :      4.50 sec
  Average Time Step           :      5.00 sec
  Maximum Time Step           :      5.00 sec
  Percent in Steady State     :      0.00
  Average Iterations per Step :      2.00
  Percent Not Converging      :      0.00
  Time Step Frequencies       :
      5.000 -   3.155 sec     :    100.00 %
      3.155 -   1.991 sec     :      0.00 %
      1.991 -   1.256 sec     :      0.00 %
      1.256 -   0.792 sec     :      0.00 %
      0.792 -   0.500 sec     :      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
  ------------------------------------------------------------------------------------------------------------------------------
  S1                             89.58       0.00       0.10      22.55      45.69      32.25      64.24        5.91     2.10   0.717
  S2                             89.58       0.00       0.10      23.49      43.93      32.49      63.24        3.09     1.08   0.706


  ******************
  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
  ---------------------------------------------------------------------------------
  OF1                  OUTFALL      0.00     0.00  1050.50     0  00:00        0.00
  OF2                  OUTFALL      0.00     0.00  1053.00     0  00:00        0.00
  SU1                  STORAGE      3.67     4.22  1053.22     0  15:14        4.22
```

SU2	STORAGE	0.82	1.21	1054.71	0	15:30	1.21

****
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
OF1	OUTFALL	0.000	0.041	0 15:14	0	2.54	0.000
OF2	OUTFALL	0.000	0.021	0 15:30	0	1.3	0.000
SU1	STORAGE	2.096	2.096	0 07:15	5.91	7.47	0.005
SU2	STORAGE	1.079	1.079	0 07:15	3.08	3.08	0.006

****
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
SU1	3.999	51	0	0	5.224	67	0 15:14	0.041
SU2	1.284	49	0	0	1.929	74	0 15:30	0.021

****
Outfall Loading Summary
****

Outfall Node	Flow Freq Pcnt	Avg Flow CMS	Max Flow CMS	Total Volume 10^6 ltr
OF1	93.64	0.031	0.041	2.540
OF2	93.46	0.016	0.021	1.299
System	93.55	0.047	0.061	3.838

****
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
R47	DUMMY	0.021	0 15:30			
R64	DUMMY	0.041	0 15:14			

****
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:  Thu Nov 18 08:40:01 2021
Analysis ended on:  Thu Nov 18 08:40:02 2021
Total elapsed time: 00:00:01
```

Continuous Simulation
Post-development Model
1960-2014 Precipitation

- **Input File**
- **Report File**

To reduce the amount of data in the input file, the following sections have been excluded in this Appendix:

- Coordinates
- Vertices
- Polygons

```
[TITLE]
;;Project Title/Notes
Residential Development
2291463 Alberta Ltd.
Comtinuous Simulation Analysis
Calgary 1960-2014

[OPTIONS]
;;Option             Value
FLOW_UNITS           CMS
INFILTRATION         CURVE_NUMBER
FLOW_ROUTING         DYNWAVE
LINK_OFFSETS         DEPTH
MIN_SLOPE            0
ALLOW_PONDING        NO
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          01:00:00
WET_STEP             00:05:00
DRY_STEP             01:00:00
ROUTING_STEP         5
RULE_STEP            00:00:00

INERTIAL_DAMPING     PARTIAL
NORMAL_FLOW_LIMITED  BOTH
FORCE_MAIN_EQUATION  H-W
VARIABLE_STEP        0.75
LENGTHENING_STEP     0
MIN_SURFAREA         0
MAX_TRIALS           8
HEAD_TOLERANCE       0.0015
SYS_FLOW_TOL         5
LAT_FLOW_TOL         5
MINIMUM_STEP         0.5
THREADS              6

[EVAPORATION]
;;Data Source    Parameters
;;-------------- ----------------
MONTHLY          0.10   0.39   1.12   2.40   3.61   4.57   4.99   4.00   2.24   0.99   0.27   0.07
DRY_ONLY         NO

[TEMPERATURE]
TIMESERIES    YYC-Temp60-14
WINDSPEED     MONTHLY    14.8 14.6 15.0 16.5 16.6 15.6 14.0 13.2 14.1 14.6 13.7 14.9
SNOWMELT                0 0.5 0.6 1054 50.0 0.0
ADC           IMPERVIOUS 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0
ADC           PERVIOUS   0.10 0.35 0.53 0.66 0.75 0.82 0.87 0.92 0.95 0.98

[RAINGAGES]
;;Name           Format    Interval SCF      Source
;;-------------- --------- -------- -------- ----------
YYC-Pre60-14     INTENSITY 1:00     1.0      FILE       "D:\__LGN\PCSWMM\STA.3031093 2014.dat" STA.3031093 MM

[SUBCATCHMENTS]
;;Name           Rain Gage        Outlet           Area     %Imperv  Width    %Slope   CurbLen  SnowPack
;;-------------- ---------------- ---------------- -------- -------- -------- -------- -------- ----------------
S1               YYC-Pre60-14     SU1              9.2      52       3066.667 2        0        Snowpack
S2               YYC-Pre60-14     SU2              4.88     50       1626.667 2        0        Snowpack

[SUBAREAS]
;;Subcatchment   N-Imperv   N-Perv     S-Imperv   S-Perv     PctZero    RouteTo    PctRouted
;;-------------- ---------- ---------- ---------- ---------- ---------- ---------- ----------
S1               0.015      0.25       1.6        3.2        0          PERVIOUS   30
S2               0.015      0.25       1.6        3.2        0          PERVIOUS   30

[INFILTRATION]
;;Subcatchment   Param1     Param2     Param3     Param4     Param5
;;-------------- ---------- ---------- ---------- ---------- ----------
S1               72         0.5        7          0          0
S2               72         0.5        7          0          0

[SNOWPACKS]
;;Name           Surface    Parameters
;;-------------- ---------- ----------
Snowpack         PLOWABLE   0.05       0.2        0.0        0.10       0.00       0.00       0.0
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    25.4       0.0        0.0        0.5        0.0        0.0

[OUTFALLS]
;;Name           Elevation  Type       Stage Data       Gated    Route To
;;-------------- ---------- ---------- ---------------- -------- ----------------
OF1              1050.5     FREE                        NO
OF2              1053       FREE                        NO

[STORAGE]
;;Name           Elev.    MaxDepth   InitDepth  Shape      Curve Name/Params            N/A      Fevap    Psi      Ksat     IMD
;;-------------- -------- ---------- ----------- ---------- ---------------------------- -------- --------          -------- --------
SU1              1049     5          2.5        TABULAR    Pond                         0        1
SU2              1053.5   1.5        0          TABULAR    Dry_Pond                     0        0

[OUTLETS]
;;Name           From Node        To Node          Offset     Type            QTable/Qcoeff    Qexpon     Gated
;;-------------- ---------------- ---------------- ---------- --------------- ---------------- ---------- --------
R47              SU2              OF2              0          TABULAR/HEAD    ICD-R48                     NO
R64              SU1              OF1              2.5        TABULAR/HEAD    ICD-R61                     NO

[CURVES]
;;Name           Type       X-Value    Y-Value
;;-------------- ---------- ---------- ----------
ICD-R48          Rating     0          0
ICD-R48                     0.152      0.0074
ICD-R48                     0.352      0.0113
ICD-R48                     0.552      0.0141
ICD-R48                     0.752      0.0165
ICD-R48                     0.952      0.0185
ICD-R48                     1.152      0.0204
ICD-R48                     1.352      0.0221
ICD-R48                     1.452      0.0229

ICD-R61          Rating     0          0
ICD-R61                     0.139      0.0116
ICD-R61                     0.339      0.018
ICD-R61                     0.539      0.0228
ICD-R61                     0.739      0.0266
ICD-R61                     0.939      0.03
ICD-R61                     1.139      0.0331
ICD-R61                     1.339      0.0359
ICD-R61                     1.939      0.0432

Dry_Pond         Storage    0          1032
Dry_Pond                    0.5        1483
Dry_Pond                    1          1973
Dry_Pond                    1.5        2503

Pond             Storage    0          81
Pond                        0.5        227
Pond                        1          435
Pond                        1.5        702
Pond                        2          1023
Pond                        2.5        1387
Pond                        3          1790
Pond                        3.5        2233
Pond                        4          2716
Pond                        4.5        3237

[TIMESERIES]
;;Name           Date       Time       Value
;;-------------- ---------- ---------- ----------
YYC-Temp60-14    FILE "D:\__LGN\PCSWMM\Temp 1960-2014.dat"

[REPORT]
;;Reporting Options
INPUT      YES
CONTROLS   NO
SUBCATCHMENTS ALL
NODES ALL
LINKS ALL

[ADJUSTMENTS]
;;Parameter    Subcatchment     Monthly Adjustments
CONDUCTIVITY                    0      0.33   0.66   1.0    1.0    1.0    1.0    1.0    1.0    1.0    0.66   0.33

[TAGS]

[MAP]
DIMENSIONS       288842.28305     5635189.7353     289488.26795     5635646.6907
UNITS            Meters

[COORDINATES]
;;Node           X-Coord          Y-Coord
;;-------------- ---------------- ----------------

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

[POLYGONS]
```

```
;;Subcatchment   X-Coord          Y-Coord
;;-------------- ---------------- ----------------

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

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.1 (Build 5.1.015)
--------------------------------------------------------------

Residential Development
2291463 Alberta Ltd.
Comtinuous Simulation Analysis


*************
Element Count
*************
Number of rain gages ...... 1
Number of subcatchments ... 2
Number of nodes ........... 4
Number of links ........... 2
Number of pollutants ...... 0
Number of land uses ....... 0


****************
Raingage Summary
****************
                                                 Data      Recording
Name                Data Source                  Type      Interval
------------------------------------------------------------------------
YYC-Pre60-14        D:\__LGN\PCSWMM\STA.3031093 2014.dat


********************
Subcatchment Summary
********************
Name                       Area     Width   %Imperv    %Slope Rain Gage            Outlet
------------------------------------------------------------------------------------------------------------
S1                         9.20   3066.67     52.00    2.0000 YYC-Pre60-14         SU1
S2                         4.88   1626.67     50.00    2.0000 YYC-Pre60-14         SU2


************
Node Summary
************
                                         Invert      Max.    Ponded    External
Name                Type                  Elev.     Depth      Area    Inflow
-------------------------------------------------------------------------------
OF1                 OUTFALL             1050.50      0.00       0.0
OF2                 OUTFALL             1053.00      0.00       0.0
SU1                 STORAGE             1049.00      5.00       0.0
SU2                 STORAGE             1053.50      1.50       0.0


************
Link Summary
************
Name             From Node        To Node          Type            Length    %Slope Roughness
---------------------------------------------------------------------------------------------
R47              SU2              OF2              OUTLET
R64              SU1              OF1              OUTLET


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



*********************
Rainfall File Summary
*********************
Station    First        Last         Recording   Periods    Periods    Periods
ID         Date         Date         Frequency  w/Precip    Missing    Malfunc.
-------------------------------------------------------------------------------
STA.3031093 01/01/1960   12/31/2014      60 min    482136          0          0


*********************************************************
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 ........ NO
  Water Quality .......... NO
Infiltration Method ...... CURVE_NUMBER
Flow Routing Method ...... DYNWAVE
Surcharge Method ......... EXTRAN
Starting Date ............ 01/01/1960 00:00:00
Ending Date .............. 12/31/2014 23:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 01:00:00
Wet Time Step ............ 00:05:00
Dry Time Step ............ 01:00:00
Routing Time Step ........ 5.00 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 ......       322.480     22903.400
Evaporation Loss .........        88.389      6277.632
Infiltration Loss ........       138.573      9841.804
Surface Runoff ...........        96.022      6819.725
Snow Removed .............         0.000         0.000
Final Snow Cover .........         0.000         0.000
Final Storage ............         0.013         0.906
Continuity Error (%) .....        -0.160


**************************        Volume        Volume
Flow Routing Continuity        hectare-m      10^6 ltr
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......        96.022       960.227
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........        90.288       902.893
Flooding Loss ............         0.000         0.000
Evaporation Loss .........         5.733        57.334
Exfiltration Loss ........         0.000         0.000
Initial Stored Volume ....         0.156         1.560
Final Stored Volume ......         0.156         1.560
Continuity Error (%) .....         0.000


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


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


*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     4.50 sec
Average Time Step           :     5.00 sec
Maximum Time Step           :     5.00 sec
Percent in Steady State     :     0.00
Average Iterations per Step :     2.00
Percent Not Converging      :     0.00
Time Step Frequencies       :
    5.000 -  3.155 sec      :   100.00 %
    3.155 -  1.991 sec      :     0.00 %
    1.991 -  1.256 sec      :     0.00 %
    1.256 -  0.792 sec      :     0.00 %
    0.792 -  0.500 sec      :     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
S1	22903.40	0.00	6320.74	9710.36	7619.78	1574.48	6908.32	635.57	1.07	0.302
S2	22903.40	0.00	6196.36	10089.60	7328.35	1522.85	6652.70	324.65	0.56	0.290

****
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
OF1	OUTFALL	0.00	0.00	1050.50	0 00:00	0.00
OF2	OUTFALL	0.00	0.00	1053.00	0 00:00	0.00
SU1	STORAGE	2.49	4.35	1053.35	9386 20:04	4.35
SU2	STORAGE	0.00	1.31	1054.81	9386 20:04	1.31

****
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
OF1	OUTFALL	0.000	0.042	9386 20:04	0	578	0.000
OF2	OUTFALL	0.000	0.022	9386 20:04	0	325	0.000
SU1	STORAGE	1.065	1.065	17322 20:00	636	637	-0.000
SU2	STORAGE	0.557	0.557	17322 20:00	325	325	-0.000

****
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
SU1	1.547	20	9	0	5.618	72	9386 20:04	0.042
SU2	0.005	0	0	0	2.145	82	9386 20:04	0.022

****
Outfall Loading Summary
****

Outfall Node	Flow Freq Pcnt	Avg Flow CMS	Max Flow CMS	Total Volume 10^6 ltr
OF1	12.33	0.003	0.042	578.236
OF2	15.68	0.001	0.022	324.653
System	14.00	0.004	0.064	902.889

****
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
R47	DUMMY	0.022	9386 20:04			
R64	DUMMY	0.042	9386 20:04			

****
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:  Thu Nov 18 08:43:02 2021
Analysis ended on:  Thu Nov 18 08:48:58 2021
Total elapsed time: 00:05:56
```

APPENDIX B

- **Frequency Analysis**

DFASCC

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

PROJECT INFORMATION SHEET

Project Name:	2291463 Alberta Ltd.
Project Description:	Residential Development in Foothills County - WET POND
Location:	Heritage Point
Date:	2021-11-18
Designed by:	Luis G Narvaez
Company Name:	LGN Consulting Engineering Ltd.
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	2058	0.083
2	1961	2571	0.464
3	1962	2183	0.120
4	1963	3236	0.772
5	1964	2984	0.663
6	1965	3412	0.844
7	1966	3583	0.862
8	1967	2023	0.065
9	1968	2802	0.572
10	1969	2449	0.373
11	1970	4163	0.953
12	1971	2355	0.228
13	1972	3365	0.826
14	1973	2126	0.101
15	1974	2539	0.446
16	1975	1873	0.011
17	1976	2655	0.500
18	1977	2392	0.301
19	1978	3305	0.790
20	1979	2361	0.264
21	1980	3092	0.717
22	1981	2731	0.536
23	1982	2191	0.138
24	1983	2425	0.337
25	1984	2744	0.554
26	1985	5617	0.989
27	1986	3186	0.754
28	1987	2444	0.355
29	1988	3636	0.880
30	1989	2020	0.047
31	1990	2451	0.391
32	1991	2533	0.428
33	1992	3361	0.808
34	1993	2892	0.609
35	1994	2357	0.246
36	1995	2336	0.210
37	1996	2329	0.192
38	1997	3815	0.935
39	1998	3640	0.899
40	1999	3011	0.681
41	2000	2516	0.409
42	2001	2604	0.482
43	2002	1989	0.029
44	2003	2210	0.156
45	2004	2820	0.591
46	2005	3802	0.917
47	2006	2389	0.283
48	2007	5530	0.971
49	2008	2312	0.174
50	2009	2396	0.319
51	2010	3035	0.699
52	2011	2973	0.645
53	2012	2933	0.627
54	2013	3143	0.736
55	2014	2666	0.518

Clear All Input Data

Basic Characteristics	
Number of Data Entries	55
Maximum Value	5620
Minimum Value	1870
Average (Mean) Value	2850
Median Value	2660
Standard Deviation	753
Variance	567000
Variation coefficient (Cv)	0.265
Skewness coefficient (Cs)	1.84
Kurtosis	6.84

*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

Stationarity

Test for Trend:

Choose Significance Level (alpha):	5%

1) Spearman Rank Order Correlation Coefficient

$$\rho = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})^2 \sum_i (y_i - \bar{y})^2}}.$$

H_0= Data has no trend

Spearman Correlation Coefficient:	0.091

based on z: **No Significant Trend at 0.05 Significance Level**
based on t: **No Significant Trend at 0.05 Significance Level**

When there are no ties in rankings:

$$\rho = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)}.$$

Spearman Correlation Coefficient:	0.091
t-distribution value	0.664
Degrees of freedom	53

T (Adjustment for ties) =	0
Standard Normal (z)=	0.657

Tests for Jump:

2) Mann-Whitney Test for jump (a.k.a. Mann-Whitney U test)

Index number of subsample divide	22

H_0= Independent samples drawn from the same population (No Jump)

$$U_1 = R_1 - \frac{n_1(n_1+1)}{2}$$

No Jump at 0.05 Significance Level

Number of values in sample 1 n_1=	22
Number of values in sample 2 n_2=	33
Total of Ranking in sample 1 R_1=	588
Total of Ranking in sample 2 R_2=	
U_1=	335

$$U_1 + U_2 = n_1 n_2.$$

U_2=	391
U (Minimum of U_1 and U_2)=	335
Standard Normal (z)=	-0.481

3) Wald-Wolfowitz Test (The runs test)

$$\mu = \frac{2\,N_+\,N_-}{N} + 1, \qquad \sigma^2 = \frac{2\,N_+\,N_-\,(2\,N_+\,N_- - N)}{N^2\,(N-1)} = \frac{(\mu-1)(\mu-2)}{N-1}.$$

Number of data greater than median N_+ =	27
Number of data less than median N_- =	27
Total number of runs =	27

H_0= Data represent sample of single independently distributed random variable (No Jump)

Mean =	28.0
Variance =	13.2
Standard Normal (z)=	-0.4

No Jump at 0.05 Significance Level

NOTES
- For a detailed description of the Stationarity Tests please refer to **Section 2.2.2.1 of the Frequency Analysis Procedure for Stormwater Design Manual**
- For guidance on choosing the significance level value please refer to **Section 2.2.2.6 of the Frequency Analysis Procedure for Stormwater Design Manual**
- The Wald-Wolfowits and the Mann-Whitney tests are valid only if the size of each sample meets or exceeds 20 values (cells will be highlighted in pink)

Homogeneity

Choose Significance Level (alpha):	5%

Mann-Whitney Test for homogeneity (a.k.a. Mann-Whitney U test)

Index number of subsample divide	28

$$U_1 = R_1 - \frac{n_1(n_1+1)}{2}$$

H_0= There is homogeneity between samples with respect to probability of random drawing of a larger observation

Sample is Homogeneous at 0.05 Significance Level

Number of values in sample 1 n_1=	28
Number of values in sample 2 n_2=	27
Total of Ranking in sample 1 R_1=	763
Total of Ranking in sample 1 R_2=	
U_1=	357

$$U_1 + U_2 = n_1 n_2.$$

U_2=	399
U (Minimum of U_1 and U_2)=	357
Standard Normal (z)=	-0.354

Terry Test

Index number of subsample divide	28

H_0= There is homogeneity between samples with respect to probability of random drawing of a larger observation

Total sample size	55
Subsample 1 (m)	28
Subsample 2 (n)	27

Sample is Homogeneous at 0.05 Significance Level

Standard Deviation =	3.654
Sum of ranks in first subsample c =	1.319
z =	0.361

NOTES

Independence

Choose Significance Level (alpha): 5%

1) Spearman Rank Order Correlation Coefficient

$$\rho = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})^2 \sum_i (y_i - \bar{y})^2}}.$$

H_0= Data is independent

Spearman Correlation Coefficient:	-0.09

Data is independent at 0.05 Significance Level

When there are no ties in rankings:

$$\rho = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)}.$$

Spearman Correlation Coefficient:	-0.09
t-distribution value	-0.66
Degrees of freedom	53

2) Wald-Wolfowitz Test

$$R = \sum_{i=1}^{N-1} x_i x_{i+1} + x_1 x_N$$

Statistic R	443000000
Mean	445000000
Variance	1.51E+13

H_0= Data is independent

Data is independent at 0.05 Significance Level

Standard Normal (z)=	-0.5

2) Anderson Test

$$r_1 = \left[\sum_{i=1}^{N-1} x_i x_{i+1} + x_1 x_N - \left(\sum_{i=1}^{N} x_i \right)^2 \Big/ N \right] \Big/ \left[\sum_{i=1}^{N} x_i^2 - \left(\sum_{i=1}^{N} x_i \right)^2 \Big/ N \right]$$

Statistic r	-0.076
Mean	-0.019
Variance	0.018

H_0= Data is independent

Data is independent at 0.05 Significance Level

Standard Normal (z)=	-0.4

Outliers

Significance Level (alpha): 10%

Grubbs and Beck test for Outliers

1) High Outliers

Assumption: logarithms of sample are normally distributed

X_h = exp (xmean+K_nS)

K(n) =-3.62201+6.2844N^1/4-2.49835N^1/2+0.491436N^3/4-0.037911N

K(n) = -0.9043+3.345*SQRT(log(n))-0.4046log(n) for 5<n<150

Sample Size (n) =	55	
K(n) =	2.80	
K(n) for 5<n<150 =	2.80	
X_h=	5320	< Any value higher than X_h is considered a high outlier
Maximum Value	5620	
High Outliers	High Outlier May Be Present	

2) Low Outliers

X_h = exp (xmean-K_nS)

K(n) =-3.62201+6.2844N^1/4-2.49835N^1/2+0.491436N^3/4-0.037911N

K(n) = -0.9043+3.345*SQRT(log(n))-0.4046log(n) for 5<n<150

Sample Size (n) =	55	
K(n) =	2.80	
K(n) for 5<n<150 =	2.80	
X_h=	1440	< Any value lower than X_h is considered a low outlier
Minimum Value	1870	
Low Outliers	No Low Outliers Present	

Dependent Dataset

Choose Significance Level (alpha):	5%

Autocorrelation coefficient

$$R_c(\tau) = \frac{\sum_{i=1}^{N-|\tau|} X_i Y_{i+\tau} - \frac{1}{N-|\tau|}\left(\sum_{i=1}^{N-|\tau|} X_i\right)\left(\sum_{i=\tau+1}^{N} Y_i\right)}{\left[\sum_{i=1}^{N-|\tau|} X_i^2 - \frac{1}{N-|\tau|}\left(\sum_{i=1}^{N-|\tau|} X_i\right)^2\right]^{0.5}\left[\sum_{i=1+|\tau|}^{N} Y_i^2 - \frac{1}{N-|\tau|}\left(\sum_{i-1+|\tau|}^{N} Y_i\right)^2\right]^{0.5}}$$

H_0 - The data is not serially correlated

One Time Period Offset		
Autocorrelation coefficient offset by one time period	r(1) =	-0.081
t-distribution values for one time period offset	t =	-0.594

No Serial Correlation at 0.05 Significance Level

Two Time Periods Offset		
Autocorrelation coefficient offset by two time periods	r(2) =	0.041
t-distribution values for two time periods offset	t =	0.298

No Serial Correlation at 0.05 Significance Level

Instructions:
Compare the results of the autocorrelation tests for one time period offset and for the two time period offset. One of the following 2 scenarios will result:
1. The finding for the one period time step is serially correlated, and the finding for the two time step is also serially correlated. In this case, transposing the data series is unlikely to produce an independent data set suitable for frequency analysis. In this case, other methods, such as the Monte Carlo simulation are necessary.
2. The finding for the one period time step is serially correlated, and the finding for the two time step is NOT serially correlated. In this case, the data series should be transposed to produce an independent data set suitable for frequency analysis.

Frequency Analysis Results Input

Clear All Input Data

NOTES

- This spreadsheet designed to accept the results of 10 specific Frequency Analysis outputs
- The input data must be in the same format as the output table from Hyfran (either copied and pasted special as text in the top left cell of each yellow input box, or manually input as distribution results and hyfran calculated parameters in specified areas.
- Input dataset must be complete (only one method of estimation per distribution type)
- Refer to **Section 3.3.1 and 3.3.2 of the Frequency Analysis Procedures for Stormwater Design Manual** for guidance when choosing methods of estimation
- Refer to **Section 3.3.2 Table 3.1 of the Frequency Analysis Procedures for Stormwater Design Manual** for a description of each distribution type and its limitations
- An additional 11th Frequency Analysis output can be copied into the last input box. This output will be displayed in the visual goodness of fit tab, however no numerical goodness of fit tests will be performed on it.

Normal (Gaussian) type of distributions:

Normal Distribution:

Paste Normal Distribution Hyfran Output in Cell Below (A15)

Wet Pond

Results of the fitting

Normal (Maximum Likelihood)

Number of observations 55

Parameters

mu	2846.61818
sigma	753.249516

Quantiles
q = F(X) : non-exceedance probability
T = 1/(1-q)

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	5.65E+03	2.88E+02	5.08E+03	6.21E+03	
2000	0.9995	5.33E+03	2.59E+02	4.82E+03	5.83E+03	
1000	0.999	5.17E+03	2.46E+02	4.69E+03	5.66E+03	
200	0.995	4.79E+03	2.13E+02	4.37E+03	5.20E+03	
100	0.99	4.60E+03	1.97E+02	4.21E+03	4.99E+03	
50	0.98	4.39E+03	1.80E+02	4.04E+03	4.75E+03	
20	0.95	4.09E+03	157	3.78E+03	4.39E+03	
10	0.9	3.81E+03	138	3.54E+03	4.08E+03	
5	0.8	3.48E+03	118	3.25E+03	3.71E+03	
3	0.6667	3.17E+03	106	2.96E+03	3.38E+03	
2	0.5	2.85E+03	102	2.65E+03	3.05E+03	
1.4286	0.3	2.45E+03	108	2.24E+03	2.66E+03	
1.25	0.2	2.21E+03	118	1.98E+03	2.45E+03	
1.1111	0.1	1.88E+03	138	1.61E+03	2.15E+03	
1.0526	0.05	1.61E+03	157	1.30E+03	1.91E+03	
1.0204	0.02	1.30E+03	1.80E+02	9.46E+02	1.65E+03	
1.0101	0.01	1.09E+03	1.97E+02	7.08E+02	1.48E+03	
1.005	0.005	9.06E+02	2.13E+02	4.89E+02	1.32E+03	
1.001	0.001	5.19E+02	2.46E+02	3.65E+01	1.00E+03	
1.0005	0.0005	3.68E+02	2.59E+02	-1.40E+02	8.76E+02	
1.0001	0.0001	4.52E+01	2.88E+02	-5.20E+02	6.10E+02	

Lognormal Distribution:

Paste Lognormal Distribution Output from Hyfran in Cell Below (A57)

Wet Pond

Results of the fitting

Lognormal (Maximum Likelihood)

Number of observations 55

Parameters

mu	7.925178
sigma	0.233017

Quantiles
q = F(X) : non-exceedance probability

T = 1/(1-q)

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	6.58E+03	5.86E+02	5.43E+03	7.73E+03	
2000	0.9995	5.95E+03	4.78E+02	5.02E+03	6.89E+03	
1000	0.999	5.68E+03	4.32E+02	4.84E+03	6.53E+03	
200	0.995	5.04E+03	3.32E+02	4.39E+03	5.69E+03	
100	0.99	4.76E+03	2.90E+02	4.19E+03	5.32E+03	
50	0.98	4.46E+03	2.49E+02	3.98E+03	4.95E+03	
20	0.95	4.06E+03	1.97E+02	3.67E+03	4.44E+03	
10	0.9	3.73E+03	1.59E+02	3.42E+03	4.04E+03	
5	0.8	3.37E+03	1.23E+02	3.12E+03	3.61E+03	
3	0.6667	3.06E+03	101	2.86E+03	3.25E+03	
2	0.5	2.77E+03	86.9	2.60E+03	2.94E+03	
1.4286	0.3	2.45E+03	82.1	2.29E+03	2.61E+03	
1.25	0.2	2.27E+03	83.3	2.11E+03	2.44E+03	
1.1111	0.1	2.05E+03	87.4	1.88E+03	2.22E+03	
1.0526	0.05	1.89E+03	91.4	1.71E+03	2.06E+03	
1.0204	0.02	1.71E+03	95.6	1.53E+03	1.90E+03	
1.0101	0.01	1.61E+03	98	1.42E+03	1.80E+03	
1.005	0.005	1.52E+03	99.8	1.32E+03	1.71E+03	
1.001	0.001	1.35E+03	102	1.15E+03	1.55E+03	
1.0005	0.0005	1.28E+03	103	1.08E+03	1.49E+03	
1.0001	0.0001	1.16E+03	104	9.60E+02	1.37E+03	

Lognormal III Distribution

Paste Lognormal III Distribution Output from Hyfran in Cell Below (A99)

Wet Pond

Results of the fitting

3-parameter lognormal (Maximum Likelihood)

Number of observations 55

Parameters

m	1621.53477
mu	6.951471
sigma	0.564636

Quantiles
q = F(X) : non-exceedance probability
T = 1/(1-q)

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	1.02E+04	2.61E+03	5.04E+03	1.53E+04	
2000	0.9995	8.32E+03	1.77E+03	4.86E+03	1.18E+04	
1000	0.999	7.60E+03	1.46E+03	4.74E+03	1.05E+04	
200	0.995	6.10E+03	8.84E+02	4.36E+03	7.83E+03	
100	0.99	5.51E+03	6.86E+02	4.16E+03	6.85E+03	
50	0.98	4.95E+03	5.16E+02	3.94E+03	5.97E+03	
20	0.95	4.27E+03	3.34E+02	3.61E+03	4.92E+03	
10	0.9	3.78E+03	2.28E+02	3.33E+03	4.22E+03	
5	0.8	3.30E+03	149	3.01E+03	3.59E+03	
3	0.6667	2.95E+03	108	2.74E+03	3.17E+03	
2	0.5	2.67E+03	84.3	2.50E+03	2.83E+03	
1.4286	0.3	2.40E+03	66.5	2.27E+03	2.53E+03	
1.25	0.2	2.27E+03	58.8	2.16E+03	2.39E+03	
1.1111	0.1	2.13E+03	52.2	2.03E+03	2.23E+03	
1.0526	0.05	2.03E+03	51.2	1.93E+03	2.13E+03	
1.0204	0.02	1.95E+03	5.51E+01	1.84E+03	2.06E+03	
1.0101	0.01	1.90E+03	6.00E+01	1.78E+03	2.02E+03	
1.005	0.005	1.87E+03	6.55E+01	1.74E+03	1.99E+03	
1.001	0.001	1.80E+03	7.82E+01	1.65E+03	1.96E+03	
1.0005	0.0005	1.78E+03	8.32E+01	1.62E+03	1.95E+03	
1.0001	0.0001	1.75E+03	9.37E+01	1.57E+03	1.93E+03	

Exponential and Pearson type of distributions:

Exponential Distribution

Paste Exponential Distribution Output from Hyfran in Cell Below (A142)

Wet Pond

Results of the fitting

Exponential (Maximum Likelihood)

Number of observations 55

Parameters

alpha	991.648148
m	1854.97003

Quantiles
q = F(X) : non-exceedance probability
T = 1/(1-q)

T	q	XT	Standard deviation	Confidence interval (95%)	
10000	0.9999	1.10E+04	1.24E+03	8.56E+03	1.34E+04
2000	0.9995	9.39E+03	1.02E+03	7.39E+03	1.14E+04
1000	0.999	8.71E+03	9.30E+02	6.88E+03	1.05E+04
200	0.995	7.11E+03	7.13E+02	5.71E+03	8.51E+03
100	0.99	6.42E+03	6.19E+02	5.21E+03	7.64E+03
50	0.98	5.73E+03	5.26E+02	4.70E+03	6.77E+03
20	0.95	4.83E+03	4.02E+02	4.04E+03	5.61E+03
10	0.9	4.14E+03	3.09E+02	3.53E+03	4.74E+03
5	0.8	3.45E+03	2.15E+02	3.03E+03	3.87E+03
3	0.6667	2.94E+03	1.47E+02	2.66E+03	3.23E+03
2	0.5	2.54E+03	92.9	2.36E+03	2.72E+03
1.4286	0.3	2.21E+03	49.1	2.11E+03	2.30E+03
1.25	0.2	2.08E+03	33	2.01E+03	2.14E+03
1.1111	0.1	1.96E+03	21.5	1.92E+03	2.00E+03
1.0526	0.05	1.91E+03	18.6	1.87E+03	1.94E+03
1.0204	0.02	1.88E+03	18	1.84E+03	1.91E+03
1.0101	0.01	1.86E+03	18.1	1.83E+03	1.90E+03
1.005	0.005	1.86E+03	18.1	1.82E+03	1.90E+03
1.001	0.001	1.86E+03	18.2	1.82E+03	1.89E+03
1.0005	0.0005	1.86E+03	18.2	1.82E+03	1.89E+03
1.0001	0.0001	1.86E+03	18.2	1.82E+03	1.89E+03

Pearson Type III Distribution

Paste Pearson III Distribution Output from Hyfran in Cell Below (A184)

Wet Pond

Results of the fitting

Pearson type III (Maximum Likelihood)

Number of observations 55

Parameters

alpha	0.002017
lambda	2.059429
m	1825.77866

Quantiles
q = F(X) : non-exceedance probability
T = 1/(1-q)

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	7.72E+03	8.49E+02	6.06E+03	9.38E+03	
2000	0.9995	6.85E+03	6.93E+02	5.49E+03	8.20E+03	
1000	0.999	6.46E+03	6.27E+02	5.24E+03	7.69E+03	
200	0.995	5.57E+03	4.74E+02	4.64E+03	6.50E+03	
100	0.99	5.17E+03	4.09E+02	4.37E+03	5.97E+03	
50	0.98	4.77E+03	3.45E+02	4.09E+03	5.45E+03	
20	0.95	4.22E+03	2.63E+02	3.71E+03	4.74E+03	
10	0.9	3.80E+03	2.03E+02	3.40E+03	4.20E+03	
5	0.8	3.35E+03	147	3.06E+03	3.64E+03	
3	0.6667	3.01E+03	111	2.79E+03	3.22E+03	
2	0.5	2.69E+03	85.6	2.52E+03	2.85E+03	
1.4286	0.3	2.39E+03	68.9	2.26E+03	2.53E+03	
1.25	0.2	2.25E+03	61.8	2.13E+03	2.38E+03	
1.1111	0.1	2.11E+03	52.5	2.00E+03	2.21E+03	
1.0526	0.05	2.02E+03	44.5	1.93E+03	2.10E+03	
1.0204	0.02	1.94E+03	3.57E+01	1.87E+03	2.01E+03	
1.0101	0.01	1.91E+03	3.03E+01	1.85E+03	1.96E+03	
1.005	0.005	1.88E+03	2.59E+01	1.83E+03	1.93E+03	
1.001	0.001	1.84E+03	1.93E+01	1.80E+03	1.88E+03	
1.0005	0.0005	1.83E+03	1.78E+01	1.80E+03	1.87E+03	
1.0001	0.0001	1.82E+03	1.67E+01	1.79E+03	1.85E+03	

Log-Pearson Type III Distribution

Paste Log Pearson III Distribution Output from Hyfran in Cell Below (A226)

Wet Pond

Results of the fitting

Log-Pearson type III (Méthode SAM)

Number of observations 55

Parameters

alpha	21.337469
lambda	4.572497
m	3.227567

Quantiles
q = F(X) : non-exceedance probability
T = 1/(1-q)

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	1.06E+04	4.23E+03	N/D	N/D	
2000	0.9995	8.49E+03	2.64E+03	N/D	N/D	
1000	0.999	7.70E+03	2.11E+03	N/D	N/D	
200	0.995	6.11E+03	1.16E+03	3.83E+03	8.38E+03	
100	0.99	5.50E+03	8.58E+02	3.82E+03	7.18E+03	
50	0.98	4.94E+03	6.10E+02	3.74E+03	6.14E+03	
20	0.95	4.25E+03	3.61E+02	3.55E+03	4.96E+03	
10	0.9	3.77E+03	2.30E+02	3.32E+03	4.22E+03	
5	0.8	3.30E+03	1.49E+02	3.01E+03	3.59E+03	
3	0.6667	2.96E+03	117	2.74E+03	3.19E+03	
2	0.5	2.67E+03	97.7	2.48E+03	2.86E+03	
1.4286	0.3	2.40E+03	73.6	2.26E+03	2.54E+03	
1.25	0.2	2.27E+03	60.8	2.15E+03	2.39E+03	
1.1111	0.1	2.13E+03	60.7	2.01E+03	2.25E+03	
1.0526	0.05	2.03E+03	81.5	1.87E+03	2.19E+03	
1.0204	0.02	1.94E+03	116	1.72E+03	2.17E+03	
1.0101	0.01	1.90E+03	141	N/D	N/D	
1.005	0.005	1.86E+03	165	N/D	N/D	
1.001	0.001	1.80E+03	211	N/D	N/D	
1.0005	0.0005	1.78E+03	229	N/D	N/D	
1.0001	0.0001	1.75E+03	264	N/D	N/D	

Extreme Value type of distributions:

EVI (Gumbel) Distribution

Paste EV Distribution Output from Hyfran in Cell Below (A269)

Wet Pond

Results of the fitting

Gumbel (Maximum Likelihood)

Number of observations 55

Parameters

u	2533.37243
alpha	503.294156

Quantiles
q = F(X) : non-exceedance probability
T = 1/(1-q)

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	7.17E+03	5.21E+02	6.15E+03	8.19E+03	
2000	0.9995	6.36E+03	4.35E+02	5.51E+03	7.21E+03	
1000	0.999	6.01E+03	3.98E+02	5.23E+03	6.79E+03	
200	0.995	5.20E+03	3.14E+02	4.58E+03	5.81E+03	
100	0.99	4.85E+03	2.77E+02	4.31E+03	5.39E+03	
50	0.98	4.50E+03	2.41E+02	4.02E+03	4.97E+03	
20	0.95	4.03E+03	1.93E+02	3.65E+03	4.41E+03	
10	0.9	3.67E+03	1.58E+02	3.36E+03	3.98E+03	
5	0.8	3.29E+03	123	3.05E+03	3.53E+03	
3	0.6667	2.99E+03	97.6	2.80E+03	3.18E+03	
2	0.5	2.72E+03	79.5	2.56E+03	2.87E+03	
1.4286	0.3	2.44E+03	68.9	2.30E+03	2.57E+03	
1.25	0.2	2.29E+03	68	2.16E+03	2.43E+03	
1.1111	0.1	2.11E+03	71.7	1.97E+03	2.25E+03	
1.0526	0.05	1.98E+03	77.4	1.83E+03	2.13E+03	
1.0204	0.02	1.85E+03	85.2	1.68E+03	2.01E+03	
1.0101	0.01	1.76E+03	90.8	1.59E+03	1.94E+03	
1.005	0.005	1.69E+03	96	1.51E+03	1.88E+03	
1.001	0.001	1.56E+03	107	1.35E+03	1.77E+03	
1.0005	0.0005	1.51E+03	111	1.30E+03	1.73E+03	
1.0001	0.0001	1.42E+03	119	1.18E+03	1.65E+03	

GEV (General Extreme Value) Distribution

Paste GEV Distribution Output from Hyfran in Cell Below (A311)

Wet Pond

Results of the fitting

GEV (Maximum Likelihood)

Number of observations 55

Parameters

alpha	454.673459
k	-0.180213
u	2490.0953

Quantiles
q = F(X) : non-exceedance probability
T = 1/(1-q)

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	1.32E+04	6.69E+03	N/D	N/D	
2000	0.9995	9.89E+03	3.69E+03	N/D	N/D	
1000	0.999	8.73E+03	2.80E+03	N/D	N/D	
200	0.995	6.52E+03	1.36E+03	N/D	N/D	
100	0.99	5.75E+03	9.58E+02	3.87E+03	7.62E+03	
50	0.98	5.06E+03	6.53E+02	3.78E+03	6.34E+03	
20	0.95	4.28E+03	3.72E+02	3.55E+03	5.00E+03	
10	0.9	3.75E+03	233	3.29E+03	4.21E+03	
5	0.8	3.27E+03	146	2.99E+03	3.56E+03	
3	0.6667	2.94E+03	105	2.73E+03	3.14E+03	
2	0.5	2.66E+03	81.5	2.50E+03	2.82E+03	
1.4286	0.3	2.41E+03	64.1	2.28E+03	2.53E+03	
1.25	0.2	2.28E+03	58	2.17E+03	2.40E+03	
1.1111	0.1	2.14E+03	55.4	2.03E+03	2.25E+03	
1.0526	0.05	2.04E+03	58.5	1.92E+03	2.15E+03	
1.0204	0.02	1.94E+03	66.3	1.81E+03	2.07E+03	
1.0101	0.01	1.88E+03	73.2	1.74E+03	2.03E+03	
1.005	0.005	1.84E+03	8.01E+01	1.68E+03	1.99E+03	
1.001	0.001	1.75E+03	9.56E+01	1.56E+03	1.94E+03	
1.0005	0.0005	1.72E+03	1.02E+02	1.52E+03	1.92E+03	
1.0001	0.0001	1.66E+03	1.15E+02	1.43E+03	1.88E+03	

EVIII (Weibull) Distribution

Paste Weibull Distribution Output from Hyfran in Cell Below (A353)

Wet Pond

Results of the fitting

Weibull (Maximum Likelihood)

Number of observations 55

Parameters

alpha	3133.52899
c	3.595201

Quantiles
q = F(X) : non-exceedance probability
T = 1/(1-q)

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	5.81E+03	3.75E+02	5.08E+03	6.55E+03	
2000	0.9995	5.51E+03	3.31E+02	4.86E+03	6.16E+03	
1000	0.999	5.36E+03	3.11E+02	4.75E+03	5.97E+03	
200	0.995	4.98E+03	2.60E+02	4.47E+03	5.49E+03	
100	0.99	4.79E+03	2.37E+02	4.33E+03	5.26E+03	
50	0.98	4.58E+03	2.13E+02	4.16E+03	5.00E+03	
20	0.95	4.25E+03	1.80E+02	3.90E+03	4.60E+03	
10	0.9	3.95E+03	1.56E+02	3.65E+03	4.26E+03	
5	0.8	3.58E+03	134	3.31E+03	3.84E+03	
3	0.6667	3.22E+03	125	2.97E+03	3.46E+03	
2	0.5	2.83E+03	125	2.59E+03	3.07E+03	
1.4286	0.3	2.35E+03	133	2.09E+03	2.61E+03	
1.25	0.2	2.06E+03	140	1.79E+03	2.34E+03	
1.1111	0.1	1.68E+03	145	1.39E+03	1.96E+03	
1.0526	0.05	1.37E+03	145	1.09E+03	1.66E+03	
1.0204	0.02	1.06E+03	140	7.85E+02	1.33E+03	
1.0101	0.01	8.72E+02	132	6.13E+02	1.13E+03	
1.005	0.005	7.18E+02	123	4.77E+02	9.60E+02	
1.001	0.001	4.59E+02	99.8	2.63E+02	6.55E+02	
1.0005	0.0005	3.78E+02	89.9	2.02E+02	5.55E+02	
1.0001	0.0001	2.42E+02	68.7	1.07E+02	3.77E+02	

Gamma type of distributions:

Gamma Distribution

Paste Gamma Distribution Output from Hyfran in Cell Below (A396)

Wet Pond

Results of the fitting

Gamma (Maximum Likelihood)

Number of observations 55

Parameters

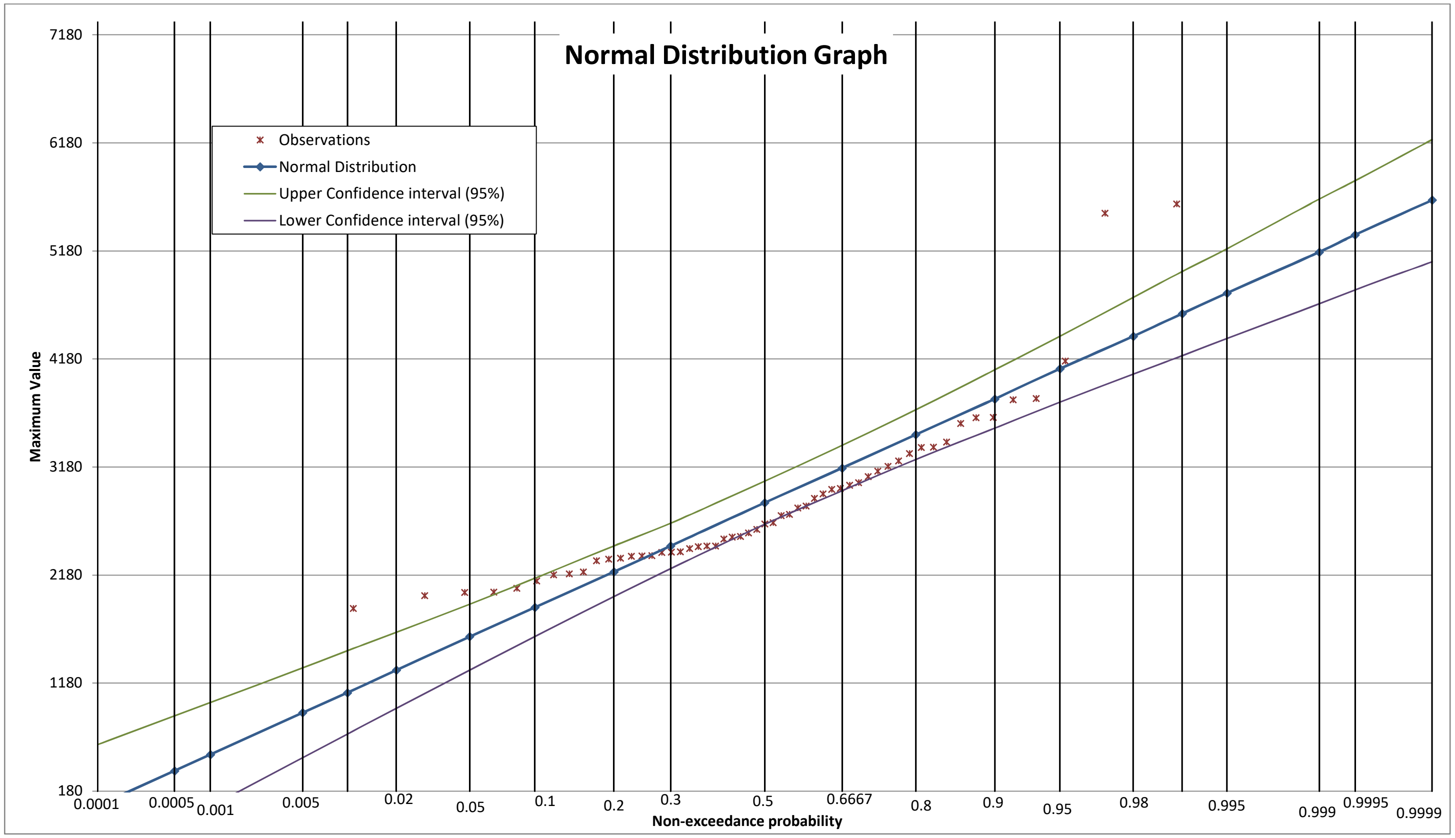
alpha	0.006176
lambda	17.581348

Quantiles
q = F(X) : non-exceedance probability
T = 1/(1-q)

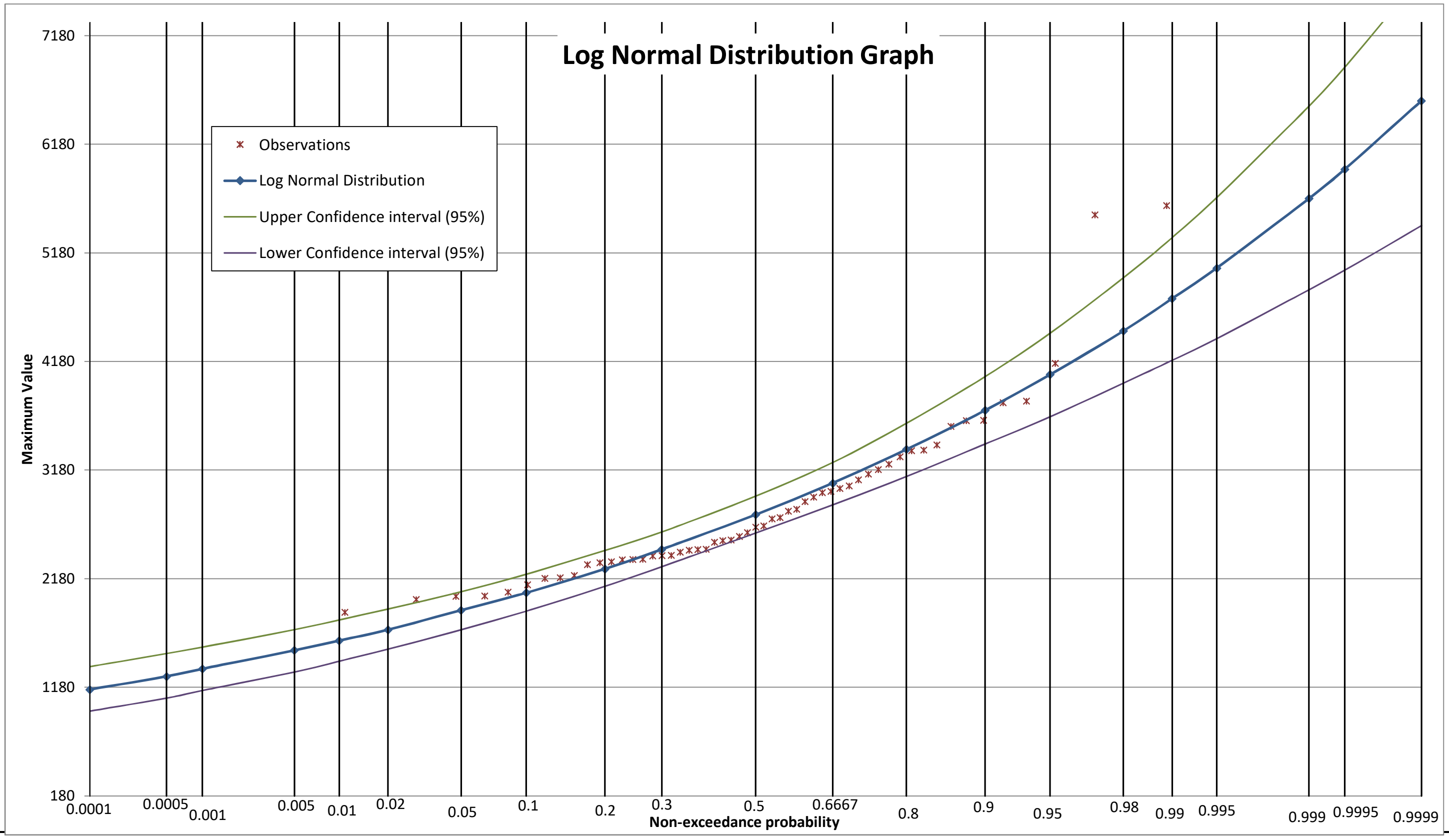
T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	6.09E+03	4.23E+02	5.26E+03	6.91E+03	
2000	0.9995	5.62E+03	3.62E+02	4.91E+03	6.33E+03	
1000	0.999	5.41E+03	3.35E+02	4.75E+03	6.07E+03	
200	0.995	4.90E+03	2.72E+02	4.36E+03	5.43E+03	
100	0.99	4.66E+03	2.44E+02	4.18E+03	5.14E+03	
50	0.98	4.41E+03	2.16E+02	3.99E+03	4.83E+03	
20	0.95	4.05E+03	1.77E+02	3.70E+03	4.40E+03	
10	0.9	3.74E+03	1.48E+02	3.45E+03	4.03E+03	
5	0.8	3.40E+03	120	3.16E+03	3.63E+03	
3	0.6667	3.10E+03	102	2.90E+03	3.30E+03	
2	0.5	2.79E+03	90.4	2.62E+03	2.97E+03	
1.4286	0.3	2.46E+03	88.5	2.28E+03	2.63E+03	
1.25	0.2	2.27E+03	91.5	2.09E+03	2.44E+03	
1.1111	0.1	2.02E+03	98.2	1.82E+03	2.21E+03	
1.0526	0.05	1.83E+03	104	1.62E+03	2.03E+03	
1.0204	0.02	1.63E+03	111	1.41E+03	1.85E+03	
1.0101	0.01	1.51E+03	114	1.28E+03	1.73E+03	
1.005	0.005	1.40E+03	117	1.17E+03	1.63E+03	
1.001	0.001	1.21E+03	120	9.70E+02	1.44E+03	
1.0005	0.0005	1.14E+03	121	8.98E+02	1.37E+03	
1.0001	0.0001	9.95E+02	122	7.57E+02	1.23E+03	

Visual Goodness of Fit

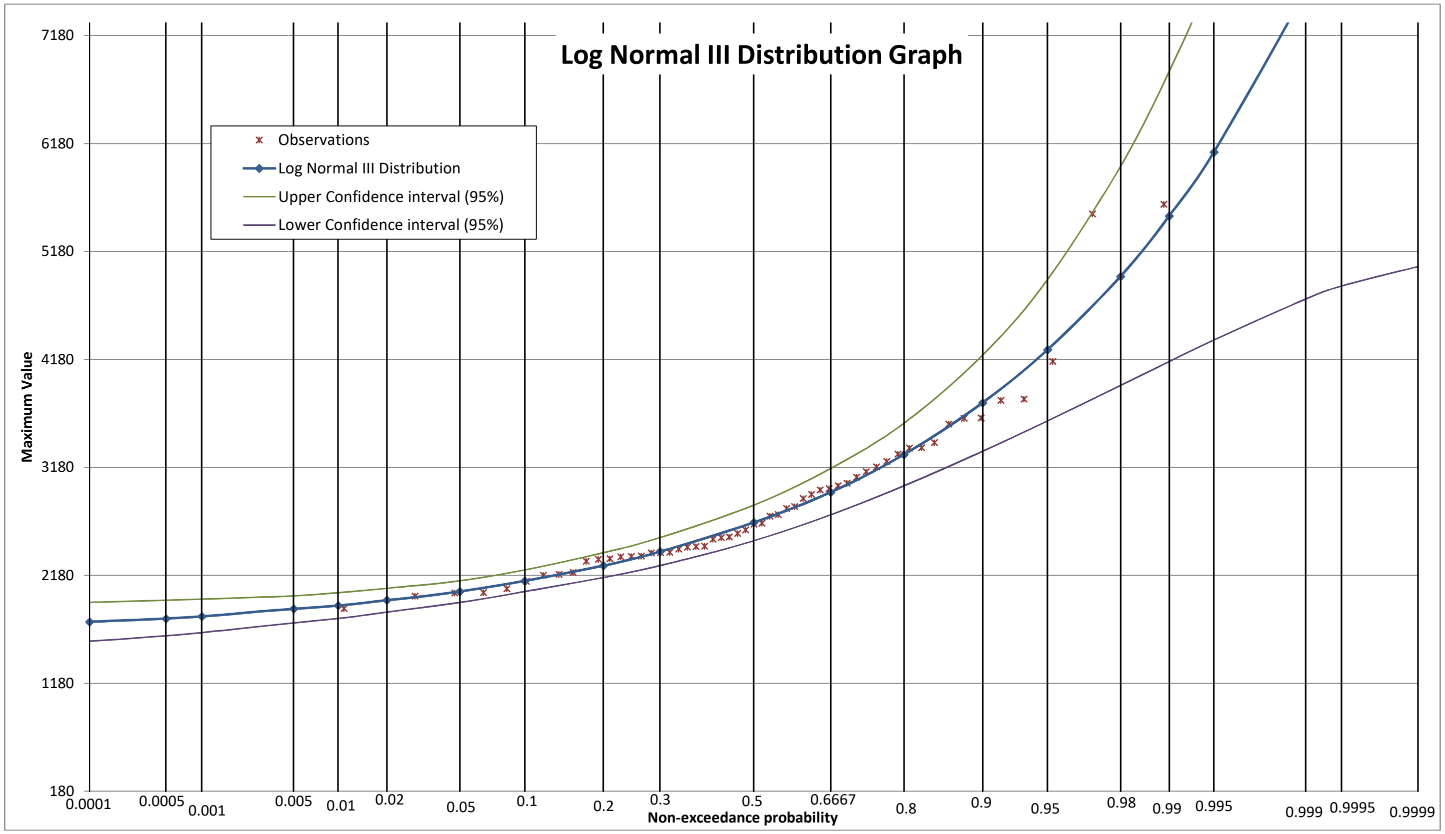
Clear All Note Data



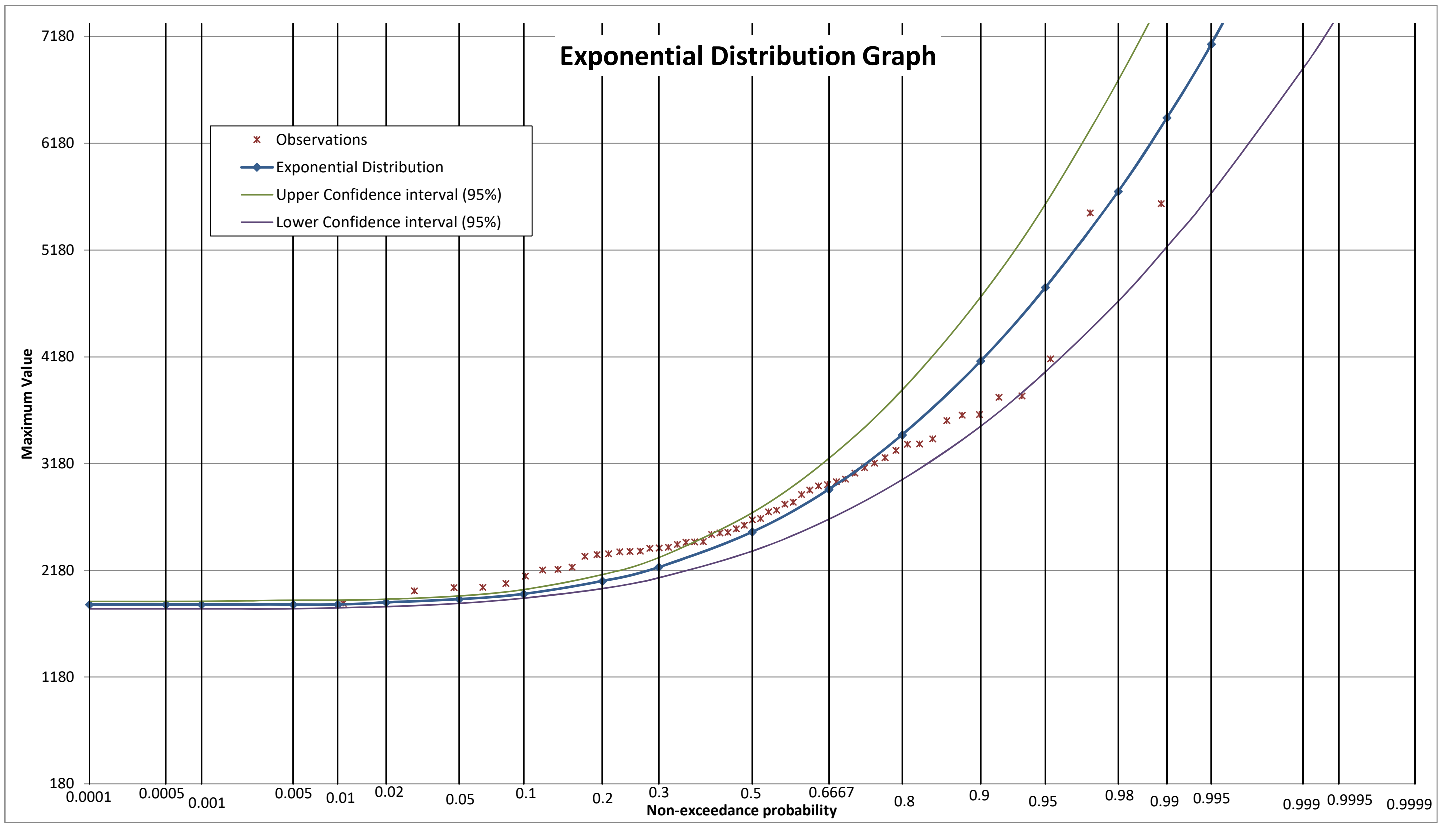
Normal Distribution
Visual Goodness-of-Fit Test Notes:



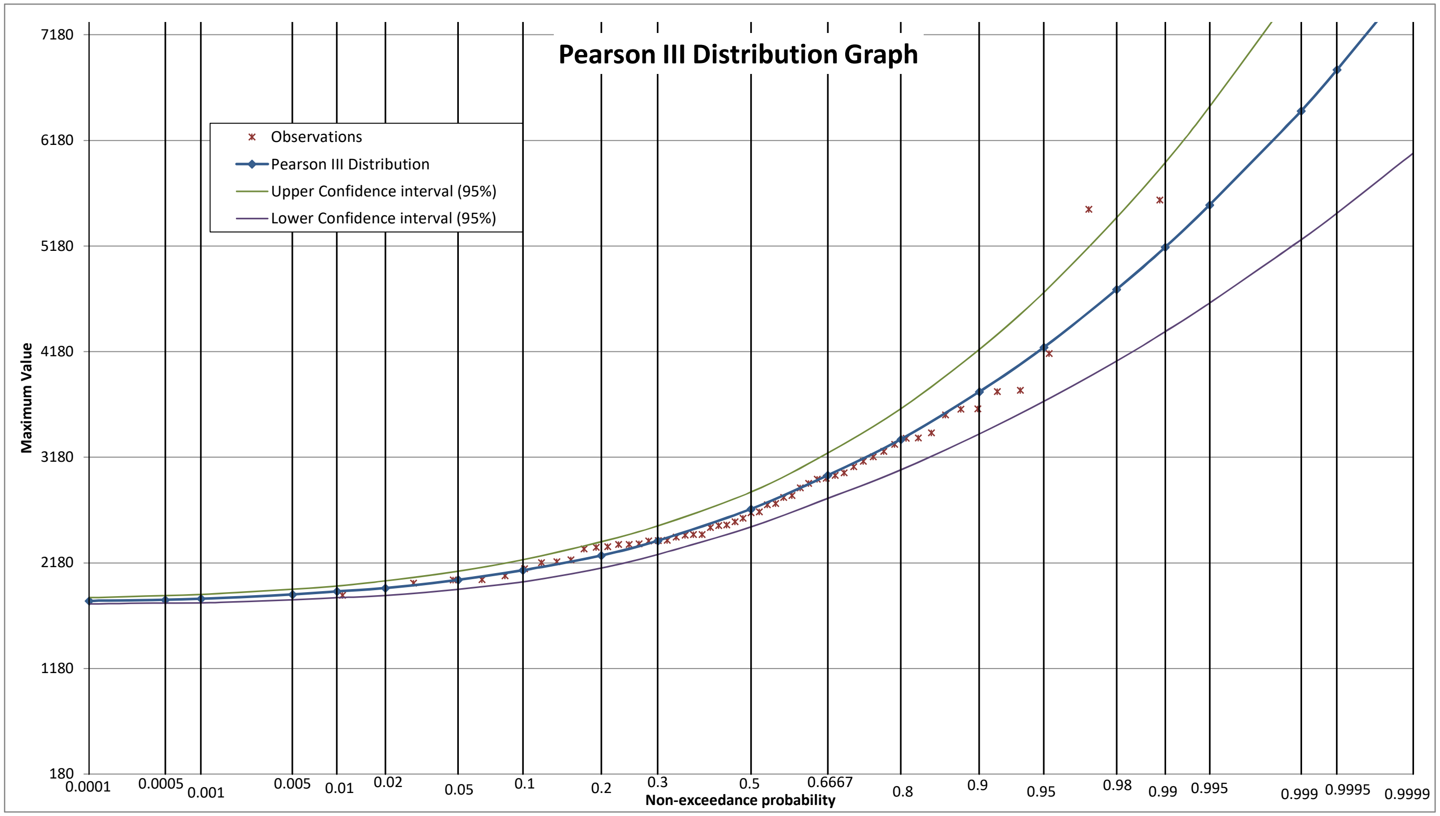
Log Normal Distribution
Visual Goodness-of-Fit Test Notes:



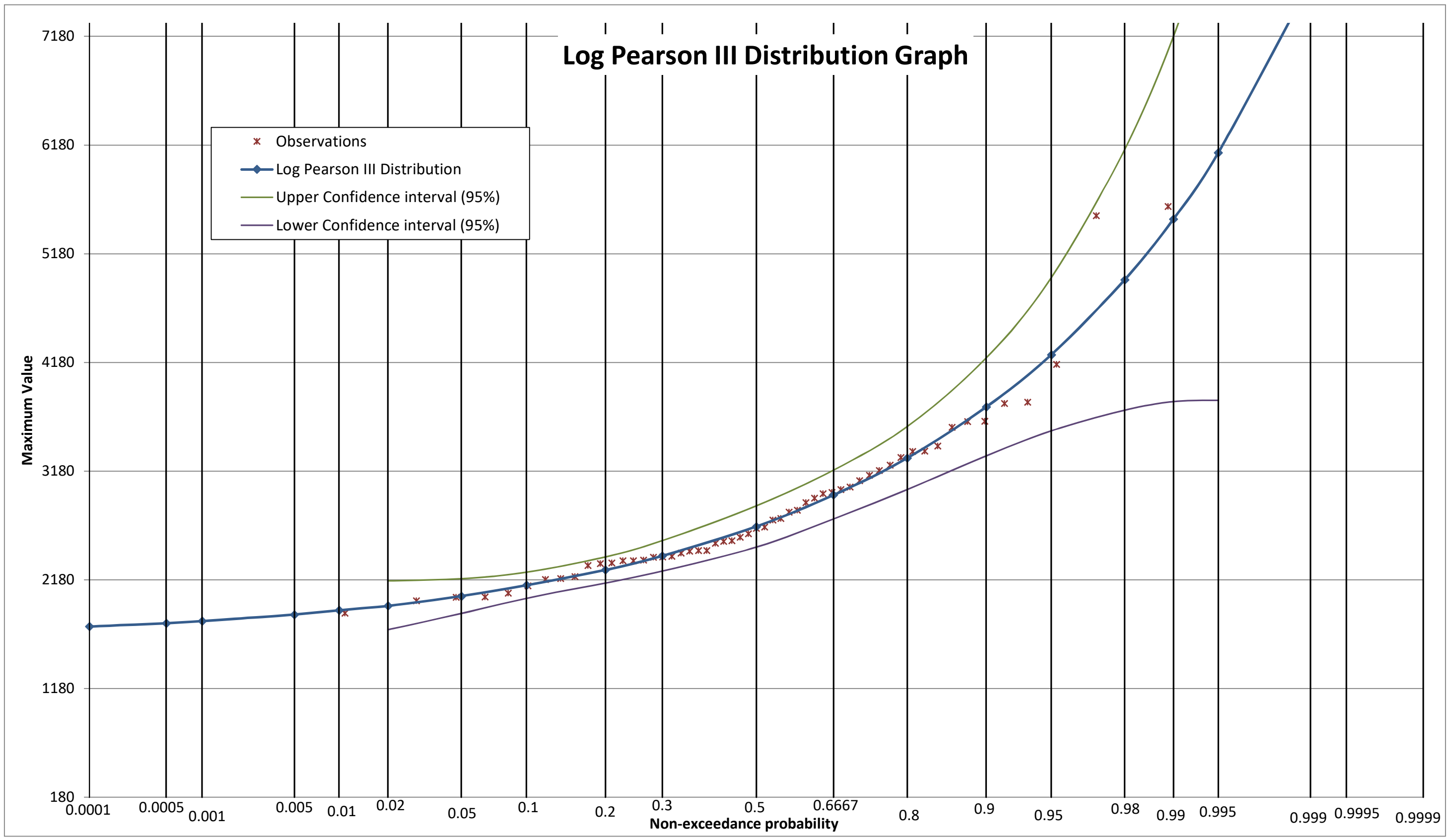
Log Normal III Distribution
Visual Goodness-of-Fit Test Notes:



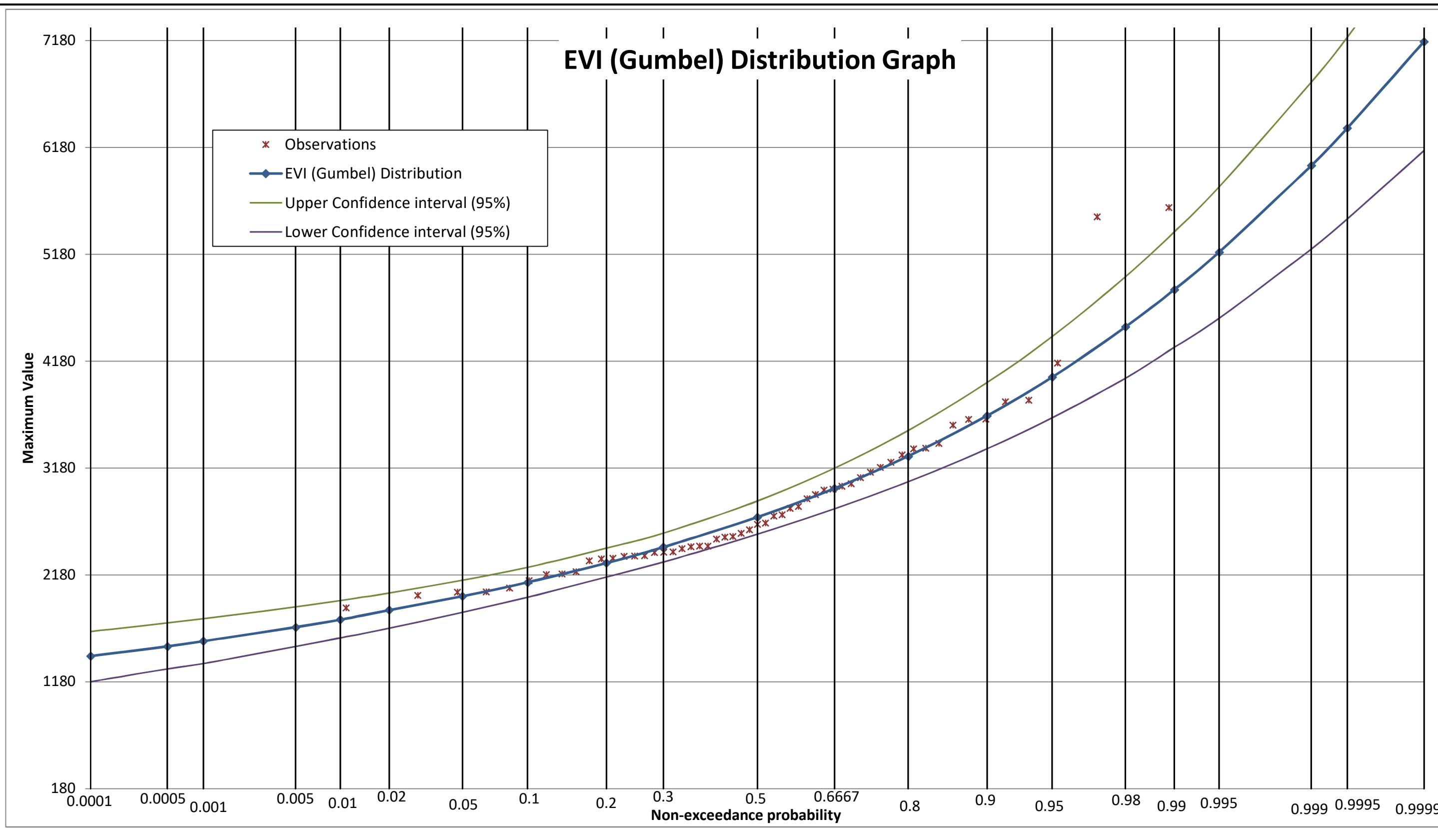
Exponential Distribution Visual Goodness-of-Fit Test Notes:



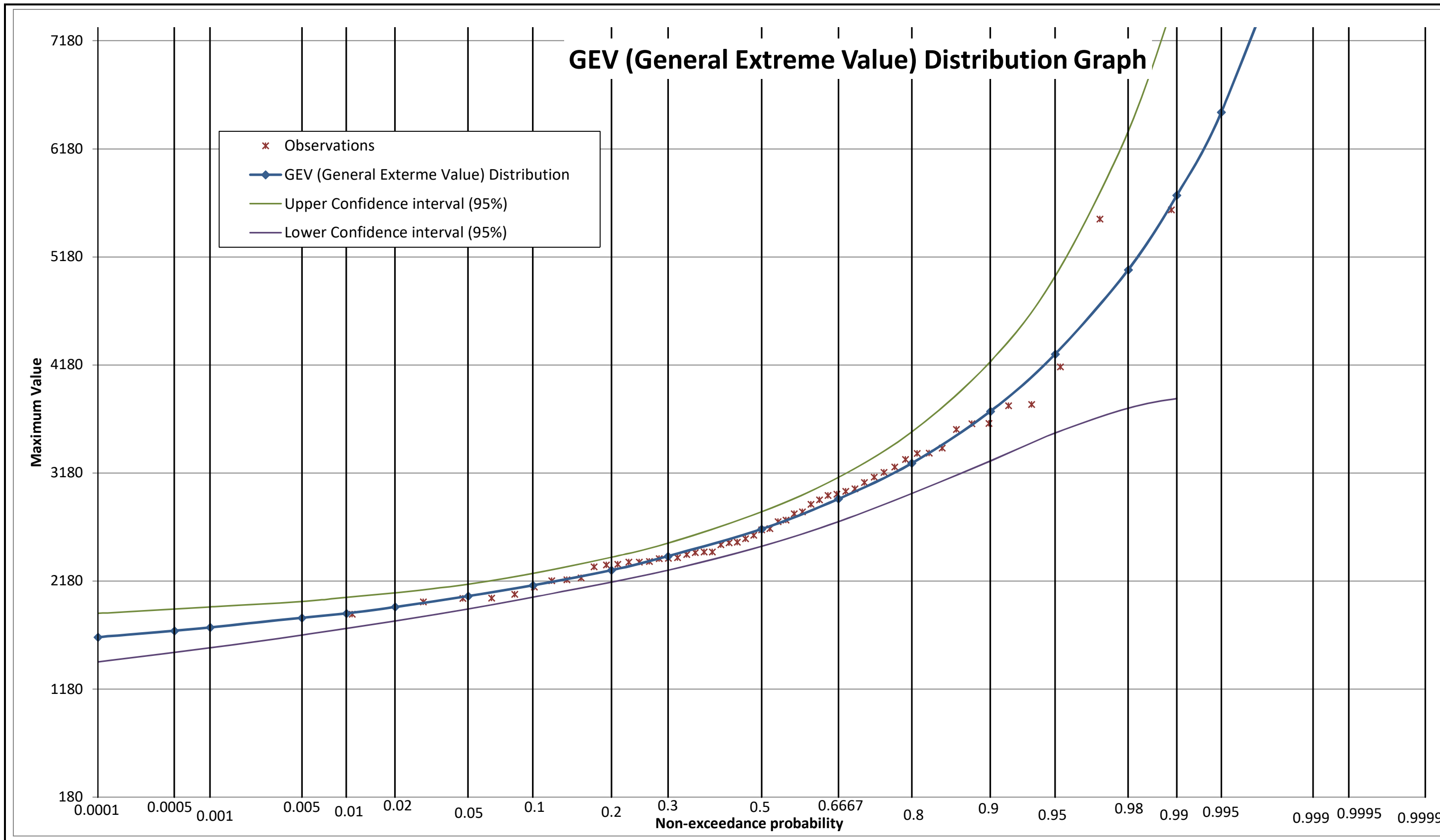
Pearson III Distribution
Visual Goodness-of-Fit Test Notes:



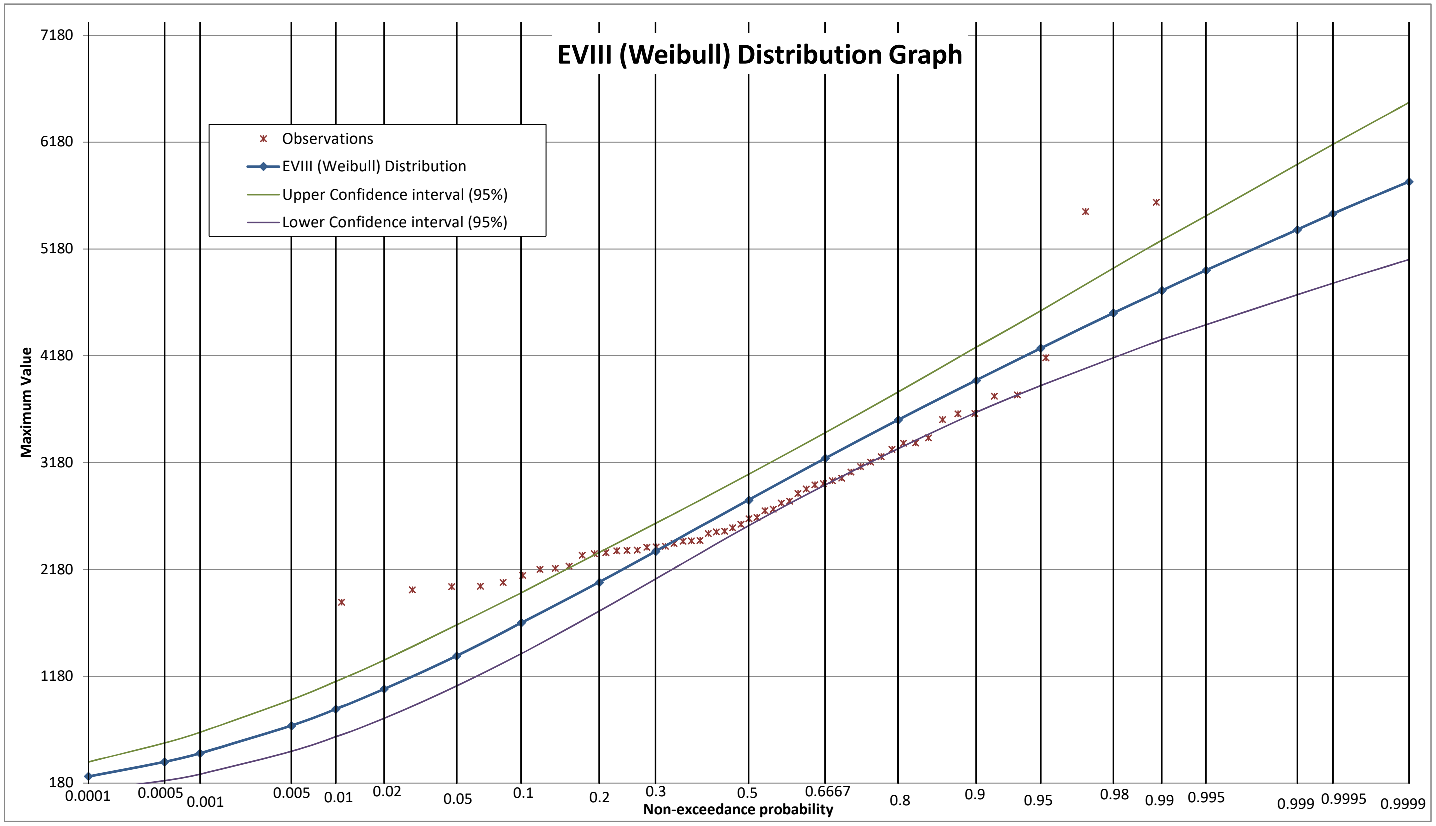
Log Pearson III Distribution Visual Goodness-of-Fit Test Notes:
The log-Pearson III applies to hydrologic frequency analysis only when the following shape tests pass
Lambda shape test
Pass
Alpha shape test
Pass



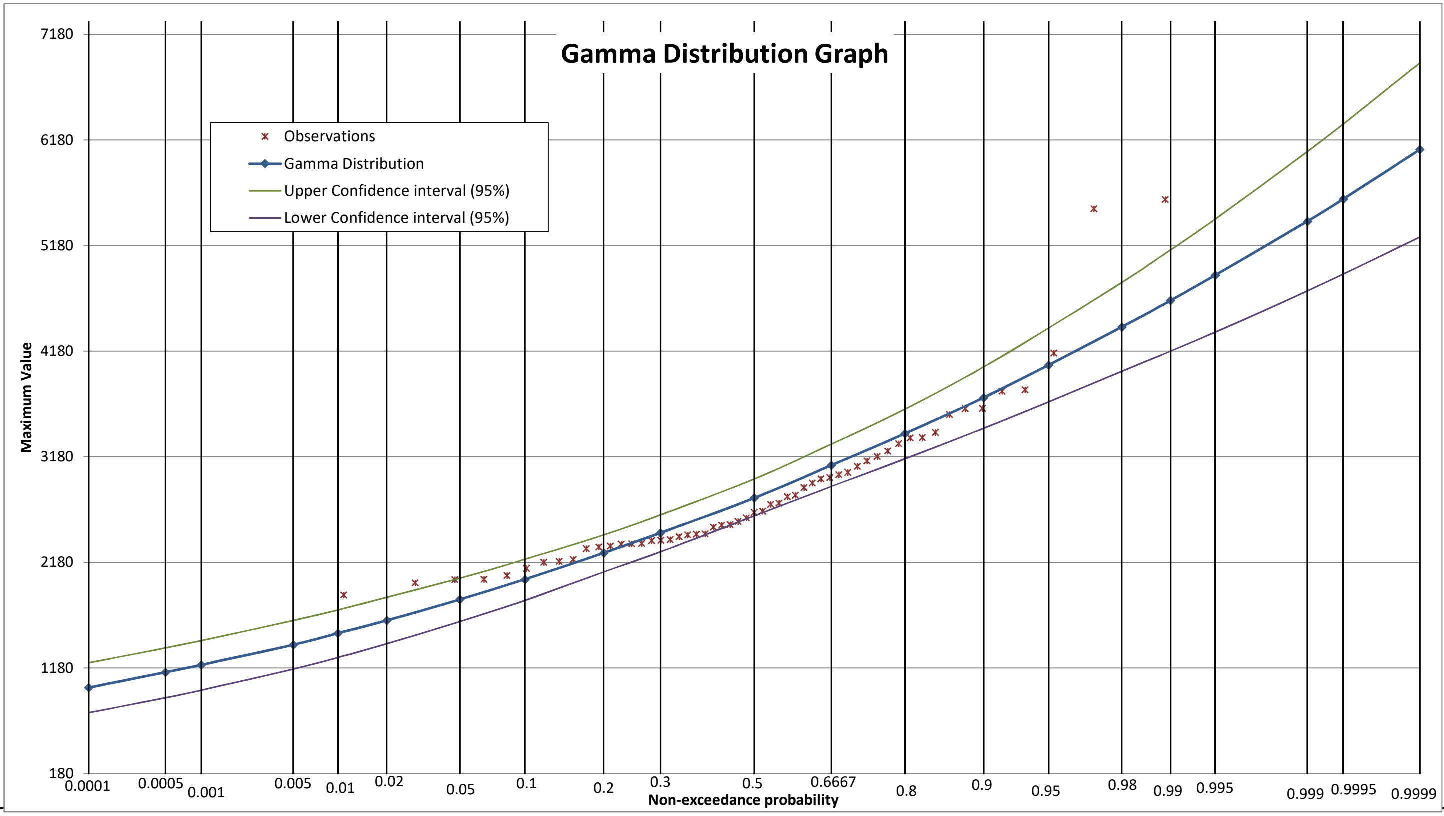
EVI (Gumbel) Distribution
Visual Goodness-of-Fit Test Notes:



GEV (General Extreme Value) Distribution Visual Goodness-of-Fit Test Notes:



EVIII (Weibull) Distribution Visual Goodness-of-Fit Test Notes:



Gamma Distribution
Visual Goodness-of-Fit Test Notes:

Numerical Tests

Choose Significance Level (alpha) : 5%

1) Anderson-Darling Test (1952)

$$A^2 = -n - \frac{1}{n}\sum_{i=1}^{n}(2i-1)\cdot[\ln F(X_i) + \ln(1 - F(X_{n-i+1}))]$$

H0= Data follows specified distribution
HA= Data does not follow the specified distribution

Distribution Type:	Critical Value at 10%	Critical Value at 5%	Critical Value at 1%	A2	Hypothesis	Rank (1 = best fit)
Normal	1.929	2.502	3.907	1.975	Accept H0	8
Lognormal	1.929	2.502	3.907	0.756	Accept H0	6
Lognormal III	1.929	2.502	3.907	0.197	Accept H0	1
Exponential	1.929	2.502	3.907	2.455	Accept H0	9
Pearson III	1.929	2.502	3.907	0.270	Accept H0	4
Log Pearson III	1.929	2.502	3.907	0.197	Accept H0	3
Gumbel	1.929	2.502	3.907	0.392	Accept H0	5
GEV	1.929	2.502	3.907	0.197	Accept H0	2
Weibull	1.929	2.502	3.907	2.720	Reject H0	10
Gamma	1.929	2.502	3.907	1.074	Accept H0	7

*Critical values based on values calculated by EasyFit Software

2) Kolmogorov-Smirnov Test (1933)

$$F_n(x) = \frac{1}{n}\cdot\left[\text{Number of observations} \le x\right] \qquad D_n = \sup_x |F_n(x) - F(x)|$$

H0= Data follows specified distribution
HA= Data does not follow the specified distribution

Distribution Type:	Critical Value at 10%	Critical Value at 5%	Critical Value at 1%	Dn	Hypothesis	Rank (1 = best fit)
Normal	0.165	0.183	0.220	0.109	Accept H0	8
Lognormal	0.165	0.183	0.220	0.080	Accept H0	6
Lognormal III	0.165	0.183	0.220	0.068	Accept H0	2
Exponential	0.165	0.183	0.220	0.206	Reject H0	10
Pearson III	0.165	0.183	0.220	0.078	Accept H0	5
Log Pearson III	0.165	0.183	0.220	0.072	Accept H0	3
Gumbel	0.165	0.183	0.220	0.074	Accept H0	4
GEV	0.165	0.183	0.220	0.059	Accept H0	1
Weibull	0.165	0.183	0.220	0.159	Accept H0	9
Gamma	0.165	0.183	0.220	0.088	Accept H0	7

Least Squares Ranking

Distribution Type:	Standard Error	Rank
Normal	312	9
Lognormal	229	6
Lognormal III	135	3
Exponential	251	7
Pearson III	139	4
Log Pearson III	132	2
Gumbel	209	5
GEV	126	1
Weibull	363	10
Gamma	251	8

$$SE_j = \sqrt{\frac{1}{n-m_j}\sum_{i=1}^{n}(x_i - y_i)^2}$$

NOTES

- For a detailed description of the Numerical Goodness of Fit Tests please refer to **Section 4.3 of the Frequency Analysis Procedure for Stromwater Design Manual**
- For guidance on choosing the significance level value please refer to **Section 2.2.2.6 of the Frequency Analysis Procedure for Stromwater Design Manual**

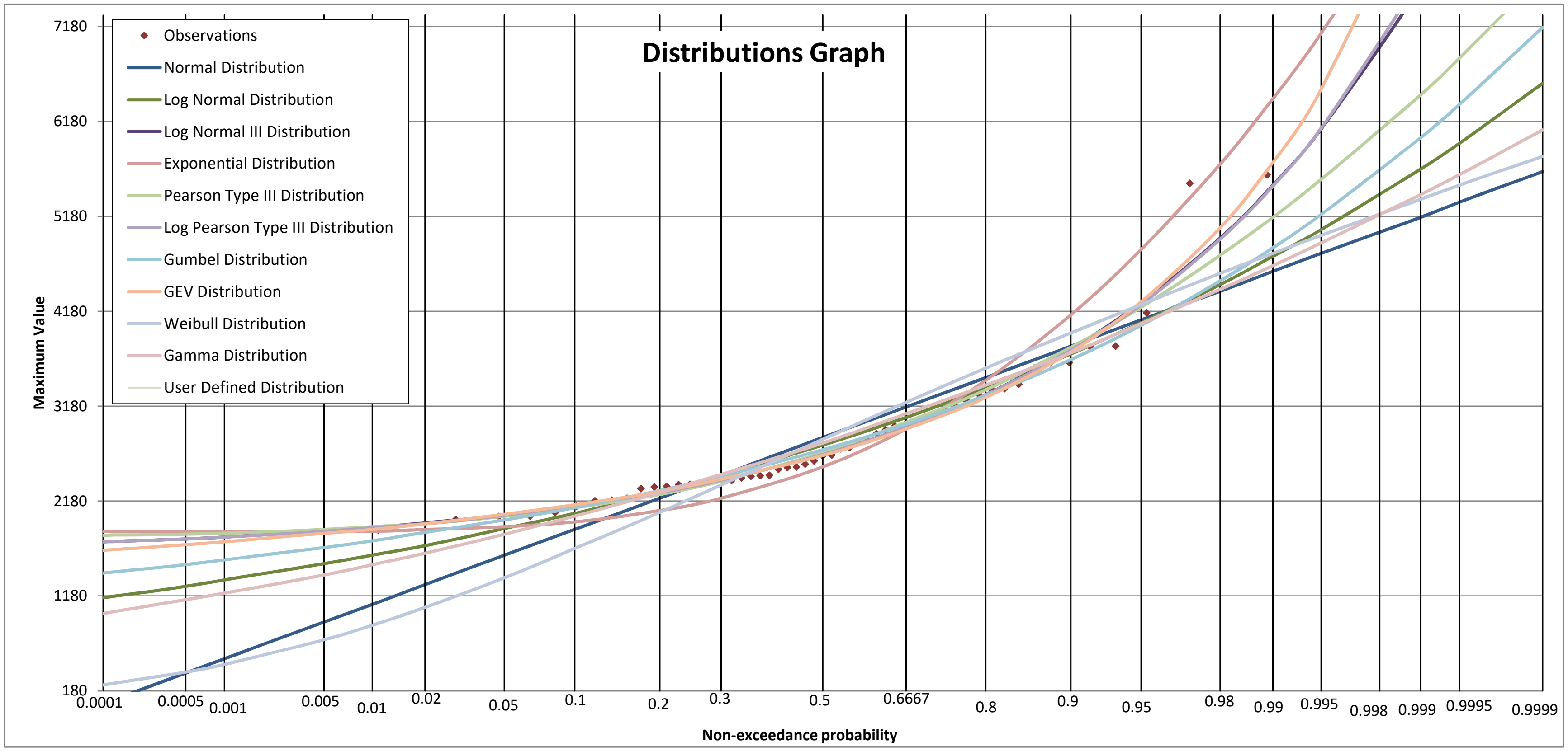
Sampling and Distribution Uncertainty

NOTES

- Select the distribution type and a return period based on the preferred curve from the Summary Sheet.
- The sample uncertainty, distribution uncertainty and total uncertainty for the value will be displayed on the right.
- For more information regarding uncertainty please refer to **Section 4.4 of the Frequency Analysis Procedure for Stormwater Design Manual**
- The plot below displays all the distributions input in the Frequency Analysis Input Tab

Return Period of Interest (Years)	5
Distribution Type	Normal
Corresponding Value	3480

Sampling Uncertainty at (95%) Confidence Interval ±	230
Distribution Uncertainty ±	16.3
Total Uncertainty ±	246



Company Name: LGN Consulting Engineering Ltd.

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:	2291463 Alberta Ltd.
Project Description:	Residential Development in Foothills County - WET POND
Location:	Heritage Point
Date:	2021-11-18
Designed by:	Luis G Narvaez
Company Name:	LGN Consulting Engineering Ltd.
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			
Lognormal	6	6	6	6.00	6			
Lognormal III	1	2	3	2.00	2			
Exponential	9	10	7	8.67	9			
Pearson III	4	5	4	4.33	4			
Log Pearson III	3	3	2	2.67	3			
Gumbel	5	4	5	4.67	5			
GEV	2	1	1	1.33	1			
Weibull	10	9	10	9.67	10			
Gamma	7	7	8	7.33	7			

Selected Distribution and Results

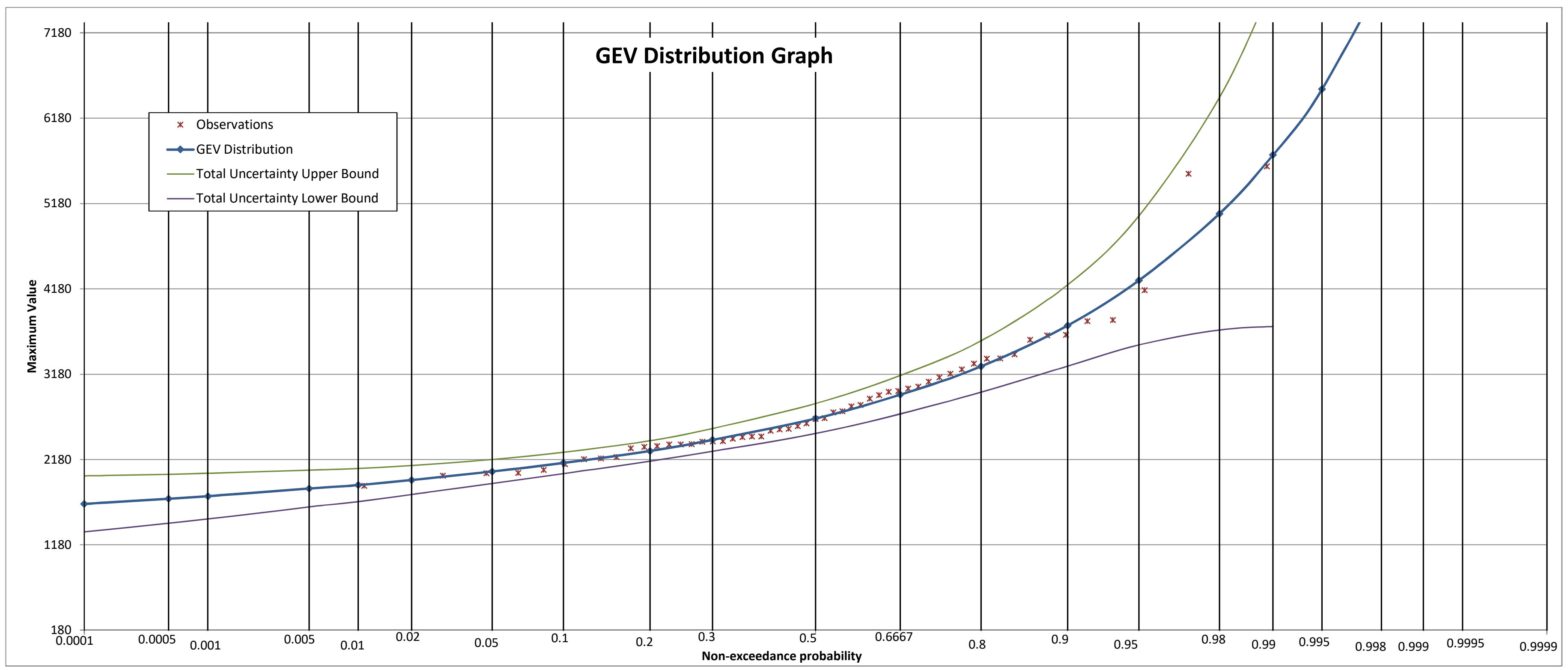
Instructions:

- 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: GEV

Return Period	Probability	Magnitude	Total Uncertainty (Upper Bound)	Total Uncertainty (Lower Bound)
10000	0.9999	13200	#N/A	#N/A
2000	0.9995	9890	#N/A	#N/A
1000	0.9990	8730	#N/A	#N/A
500	0.9980	7700	#N/A	#N/A
200	0.9950	6520	#N/A	#N/A
100	0.9900	5750	7760	3740
50	0.9800	5060	6420	3700
20	0.9500	4280	5040	3520
10	0.9000	3750	4230	3270
5	0.8000	3270	3570	2970
3	0.6667	2940	3170	2720
2	0.5000	2660	2840	2480
1.4286	0.3000	2410	2540	2280
1.25	0.2000	2280	2400	2160
1.1111	0.1000	2140	2270	2020
1.0526	0.0500	2040	2180	1900
1.0204	0.0200	1940	2110	1770
1.0101	0.0100	1880	2080	1690
1.005	0.0050	1840	2060	1630
1.001	0.0010	1750	2020	1480
1.0005	0.0005	1720	2010	1430
1.0001	0.0001	1660	1990	1330

*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.

DFASCC

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

PROJECT INFORMATION SHEET

Project Name:	2291463 Alberta Ltd.
Project Description:	Residential Development in Foothills County - DRY POND
Location:	Heritage Point
Date:	2021-11-18
Designed by:	Luis G Narvaez
Company Name:	LGN Consulting Engineering Ltd.
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	267.1	0.083
2	1961	548.4	0.482
3	1962	338.7	0.138
4	1963	891.1	0.772
5	1964	758.1	0.663
6	1965	986.1	0.844
7	1966	1075	0.862
8	1967	247	0.047
9	1968	685.9	0.591
10	1969	471.9	0.355
11	1970	1383	0.953
12	1971	430.2	0.264
13	1972	954.9	0.808
14	1973	295	0.101
15	1974	512.9	0.428
16	1975	174.5	0.011
17	1976	581.9	0.500
18	1977	441.3	0.301
19	1978	929	0.790
20	1979	421.3	0.228
21	1980	834.2	0.717
22	1981	628.9	0.536
23	1982	327.2	0.120
24	1983	475.7	0.391
25	1984	660.8	0.554
26	1985	2144	0.989
27	1986	865.6	0.754
28	1987	472.5	0.373
29	1988	1124	0.899
30	1989	255.9	0.065
31	1990	469.5	0.319
32	1991	516.1	0.446
33	1992	968.3	0.826
34	1993	708.8	0.609
35	1994	412.8	0.210
36	1995	410.6	0.192
37	1996	424.8	0.246
38	1997	1192	0.917
39	1998	1094	0.880
40	1999	767.5	0.681
41	2000	499.4	0.409
42	2001	538.7	0.464
43	2002	232.3	0.029
44	2003	346.1	0.156
45	2004	673.4	0.572
46	2005	1196	0.935
47	2006	436.9	0.283
48	2007	2116	0.971
49	2008	398.1	0.174
50	2009	471.1	0.337
51	2010	783.8	0.699
52	2011	745.5	0.645
53	2012	729	0.627
54	2013	851.3	0.736
55	2014	592.8	0.518

Clear All Input Data

Basic Characteristics	
Number of Data Entries	55
Maximum Value	2140
Minimum Value	175
Average (Mean) Value	686
Median Value	582
Standard Deviation	399
Variance	160000
Variation coefficient (Cv)	0.582
Skewness coefficient (Cs)	1.83
Kurtosis	6.79

*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

Stationarity

Test for Trend:

Choose Significance Level (alpha): 5%

1) Spearman Rank Order Correlation Coefficient

$$\rho = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})^2 \sum_i (y_i - \bar{y})^2}}.$$

H_0= Data has no trend

Spearman Correlation Coefficient:	0.088

based on z: **No Significant Trend at 0.05 Significance Level**
based on t: **No Significant Trend at 0.05 Significance Level**

When there are no ties in rankings:

$$\rho = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)}.$$

Spearman Correlation Coefficient:	0.088
t-distribution value	0.645
Degrees of freedom	53

T (Adjustment for ties) =	0
Standard Normal (z)=	0.640

Tests for Jump:

2) Mann-Whitney Test for jump (a.k.a. Mann-Whitney U test)

Index number of subsample divide	22

H_0= Independent samples drawn from the same population (No Jump)

$$U_1 = R_1 - \frac{n_1(n_1+1)}{2}$$

No Jump at 0.05 Significance Level

Number of values in sample 1 n_1=	22
Number of values in sample 2 n_2=	33
Total of Ranking in sample 1 R_1=	587
Total of Ranking in sample 2 R_2=	
U_1=	334

$$U_1 + U_2 = n_1 n_2.$$

U_2=	392
U (Minimum of U_1 and U_2)=	334
Standard Normal (z)=	-0.498

3) Wald-Wolfowitz Test (The runs test)

$$\mu = \frac{2\,N_+\,N_-}{N} + 1, \qquad \sigma^2 = \frac{2\,N_+\,N_-\,(2\,N_+\,N_- - N)}{N^2\,(N-1)} = \frac{(\mu-1)(\mu-2)}{N-1}.$$

Number of data greater than median N_+ =	27
Number of data less than median N_- =	27
Total number of runs =	27

H_0= Data represent sample of single independently distributed random variable (No Jump)

Mean =	28.0
Variance =	13.2
Standard Normal (z)=	-0.4

No Jump at 0.05 Significance Level

NOTES

- For a detailed description of the Stationarity Tests please refer to **Section 2.2.2.1 of the Frequency Analysis Procedure for Stormwater Design Manual**
- For guidance on choosing the significance level value please refer to **Section 2.2.2.6 of the Frequency Analysis Procedure for Stormwater Design Manual**
- The Wald-Wolfowits and the Mann-Whitney tests are valid only if the size of each sample meets or exceeds 20 values (cells will be highlighted in pink)

Homogeneity

Choose Significance Level (alpha): 5%

Mann-Whitney Test for homogeneity (a.k.a. Mann-Whitney U test)

Index number of subsample divide	28

$$U_1 = R_1 - \frac{n_1(n_1+1)}{2}$$

H_0= There is homogeneity between samples with respect to probability of random drawing of a larger observation

Sample is Homogeneous at 0.05 Significance Level

Number of values in sample 1 n_1=	28
Number of values in sample 2 n_2=	27
Total of Ranking in sample 1 R_1=	765
Total of Ranking in sample 1 R_2=	
U_1=	359

$$U_1 + U_2 = n_1 n_2.$$

U_2=	397
U (Minimum of U_1 and U_2)=	359
Standard Normal (z)=	-0.320

Terry Test

Index number of subsample divide	28

H_0= There is homogeneity between samples with respect to probability of random drawing of a larger observation

Total sample size	55
Subsample 1 (m)	28
Subsample 2 (n)	27

Sample is Homogeneous at 0.05 Significance Level

Standard Deviation =	3.654
Sum of ranks in first subsample c =	1.358
z =	0.372

NOTES

Independence

Choose Significance Level (alpha):	5%

1) Spearman Rank Order Correlation Coefficient

$$\rho = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})^2 \sum_i (y_i - \bar{y})^2}}.$$

H_0= Data is independent

Spearman Correlation Coefficient:	-0.08

Data is independent at 0.05 Significance Level

When there are no ties in rankings:

$$\rho = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)}.$$

Spearman Correlation Coefficient:	-0.08
t-distribution value	-0.58
Degrees of freedom	53

2) Wald-Wolfowitz Test

$$R = \sum_{i=1}^{N-1} x_i x_{i+1} + x_1 x_N$$

Statistic R	25300000
Mean	25800000
Variance	1.19E+12

H_0= Data is independent

Data is independent at 0.05 Significance Level

Standard Normal (z)=	-0.5

2) Anderson Test

$$r_1 = \left[\sum_{i=1}^{N-1} x_i x_{i+1} + x_1 x_N - \left(\sum_{i=1}^{N} x_i \right)^2 \Big/ N \right] \Big/ \left[\sum_{i=1}^{N} x_i^2 - \left(\sum_{i=1}^{N} x_i \right)^2 \Big/ N \right]$$

Statistic r	-0.077
Mean	-0.019
Variance	0.018

H_0= Data is independent

Data is independent at 0.05 Significance Level

Standard Normal (z)=	-0.4

Outliers

Significance Level (alpha): 10%

Grubbs and Beck test for Outliers

1) High Outliers

Assumption: logarithms of sample are normally distributed

X_h = exp (xmean+K_nS)

K(n) =-3.62201+6.2844N^1/4-2.49835N^1/2+0.491436N^3/4-0.037911N

K(n) = -0.9043+3.345*SQRT(log(n))-0.4046log(n) for 5<n<150

Sample Size (n) =	55	
K(n) =	2.80	
K(n) for 5<n<150 =	2.80	
X_h=	2640	< Any value higher than X_h is considered a high outlier
Maximum Value	2140	
High Outliers	No High Outliers Present	

2) Low Outliers

X_h = exp (xmean-K_nS)

K(n) =-3.62201+6.2844N^1/4-2.49835N^1/2+0.491436N^3/4-0.037911N

K(n) = -0.9043+3.345*SQRT(log(n))-0.4046log(n) for 5<n<150

Sample Size (n) =	55	
K(n) =	2.80	
K(n) for 5<n<150 =	2.80	
X_h=	135	< Any value lower than X_h is considered a low outlier
Minimum Value	175	
Low Outliers	No Low Outliers Present	

Dependent Dataset

Choose Significance Level (alpha): 5%

Autocorrelation coefficient

$$R_c(\tau) = \frac{\sum_{i=1}^{N-|\tau|} X_i Y_{i+\tau} - \frac{1}{N-|\tau|}\left(\sum_{i=1}^{N-|\tau|} X_i\right)\left(\sum_{i=\tau+1}^{N} Y_i\right)}{\left[\sum_{i=1}^{N-|\tau|} X_i^2 - \frac{1}{N-|\tau|}\left(\sum_{i=1}^{N-|\tau|} X_i\right)^2\right]^{0.5}\left[\sum_{i=1+|\tau|}^{N} Y_i^2 - \frac{1}{N-|\tau|}\left(\sum_{i-1+|\tau|}^{N} Y_i\right)^2\right]^{0.5}}$$

H_0 - The data is not serially correlated

One Time Period Offset		
Autocorrelation coefficient offset by one time period	r(1) =	-0.082
t-distribution values for one time period offset	t =	-0.602

No Serial Correlation at 0.05 Significance Level

Two Time Periods Offset		
Autocorrelation coefficient offset by two time periods	r(2) =	0.051
t-distribution values for two time periods offset	t =	0.370

No Serial Correlation at 0.05 Significance Level

Instructions:
Compare the results of the autocorrelation tests for one time period offset and for the two time period offset. One of the following 2 scenarios will result:
1. The finding for the one period time step is serially correlated, and the finding for the two time step is also serially correlated. In this case, transposing the data series is unlikely to produce an independent data set suitable for frequency analysis. In this case, other methods, such as the Monte Carlo simulation are necessary.
2. The finding for the one period time step is serially correlated, and the finding for the two time step is NOT serially correlated. In this case, the data series should be transposed to produce an independent data set suitable for frequency analysis.

Frequency Analysis Results Input

Clear All Input Data

NOTES

- This spreadsheet designed to accept the results of 10 specific Frequency Analysis outputs
- The input data must be in the same format as the output table from Hyfran (either copied and pasted special as text in the top left cell of each yellow input box, or manually input as distribution results and hyfran calculated parameters in specified areas.
- Input dataset must be complete (only one method of estimation per distribution type)
- Refer to **Section 3.3.1 and 3.3.2 of the Frequency Analysis Procedures for Stormwater Design Manual** for guidance when choosing methods of estimation
- Refer to **Section 3.3.2 Table 3.1 of the Frequency Analysis Procedures for Stormwater Design Manual** for a description of each distribution type and its limitations
- An additional 11th Frequency Analysis output can be copied into the last input box. This output will be displayed in the visual goodness of fit tab, however no numerical goodness of fit tests will be performed on it.

Normal (Gaussian) type of distributions:

Normal Distribution:

Paste Normal Distribution Hyfran Output in Cell Below (A15)

Dry Pond

Results of the fitting

Normal (Maximum Likelihood)

Number of observations 55

Parameters

mu	686.489091
sigma	399.496654

Quantiles
q = F(X) : non-exceedance probability
T = 1/(1-q)

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	2.17E+03	1.53E+02	1.87E+03	2.47E+03	
2000	0.9995	2.00E+03	1.37E+02	1.73E+03	2.27E+03	
1000	0.999	1.92E+03	1.30E+02	1.67E+03	2.18E+03	
200	0.995	1.72E+03	1.13E+02	1.49E+03	1.94E+03	
100	0.99	1.62E+03	1.04E+02	1.41E+03	1.82E+03	
50	0.98	1.51E+03	9.56E+01	1.32E+03	1.69E+03	
20	0.95	1.34E+03	83.1	1.18E+03	1.51E+03	
10	0.9	1.20E+03	73	1.06E+03	1.34E+03	
5	0.8	1.02E+03	62.8	8.99E+02	1.15E+03	
3	0.6667	8.58E+02	56.4	7.48E+02	9.69E+02	
2	0.5	6.86E+02	53.9	5.81E+02	7.92E+02	
1.4286	0.3	4.77E+02	57.5	3.64E+02	5.90E+02	
1.25	0.2	3.50E+02	62.8	2.27E+02	4.74E+02	
1.1111	0.1	1.74E+02	73	3.13E+01	3.18E+02	
1.0526	0.05	2.92E+01	83.1	-1.34E+02	1.92E+02	
1.0204	0.02	-1.34E+02	9.56E+01	-3.22E+02	5.32E+01	
1.0101	0.01	-2.43E+02	1.04E+02	-4.48E+02	-3.84E+01	
1.005	0.005	-3.43E+02	1.13E+02	-5.64E+02	-1.22E+02	
1.001	0.001	-5.48E+02	1.30E+02	-8.04E+02	-2.92E+02	
1.0005	0.0005	-6.28E+02	1.37E+02	-8.98E+02	-3.59E+02	
1.0001	0.0001	-7.99E+02	1.53E+02	-1.10E+03	-5.00E+02	

Lognormal Distribution:

Paste Lognormal Distribution Output from Hyfran in Cell Below (A57)

Dry Pond

Results of the fitting

Lognormal (Maximum Likelihood)

Number of observations 55

Parameters

mu	6.390995
sigma	0.530227

Quantiles
q = F(X) : non-exceedance probability

T = 1/(1-q)

T	q	XT	Standard deviation	Confidence interval (95%)	
10000	0.9999	4.29E+03	8.69E+02	2.58E+03	5.99E+03
2000	0.9995	3.41E+03	6.23E+02	2.19E+03	4.64E+03
1000	0.999	3.07E+03	5.32E+02	2.03E+03	4.11E+03
200	0.995	2.34E+03	3.50E+02	1.65E+03	3.02E+03
100	0.99	2.05E+03	2.84E+02	1.49E+03	2.60E+03
50	0.98	1.77E+03	2.25E+02	1.33E+03	2.21E+03
20	0.95	1.43E+03	1.57E+02	1.12E+03	1.74E+03
10	0.9	1.18E+03	1.14E+02	9.53E+02	1.40E+03
5	0.8	9.32E+02	7.77E+01	7.79E+02	1.08E+03
3	0.6667	7.49E+02	56	6.39E+02	8.59E+02
2	0.5	5.96E+02	42.6	5.13E+02	6.80E+02
1.4286	0.3	4.52E+02	34.5	3.84E+02	5.19E+02
1.25	0.2	3.82E+02	31.8	3.19E+02	4.44E+02
1.1111	0.1	3.02E+02	29.3	2.45E+02	3.60E+02
1.0526	0.05	2.49E+02	27.5	1.95E+02	3.03E+02
1.0204	0.02	2.01E+02	25.5	1.51E+02	2.51E+02
1.0101	0.01	1.74E+02	24.1	1.27E+02	2.21E+02
1.005	0.005	1.52E+02	22.8	1.08E+02	1.97E+02
1.001	0.001	1.16E+02	20.1	7.65E+01	1.55E+02
1.0005	0.0005	1.04E+02	19	6.69E+01	1.41E+02
1.0001	0.0001	8.30E+01	16.8	5.00E+01	1.16E+02

Lognormal III Distribution

Paste Lognormal III Distribution Output from Hyfran in Cell Below (A99)

Dry Pond

Results of the fitting

3-parameter lognormal (Maximum Likelihood)

Number of observations 55

Parameters

m	44.644184
mu	6.300109
sigma	0.574381

Quantiles
q = F(X) : non-exceedance probability
T = 1/(1-q)

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	4.66E+03	1.43E+03	1.86E+03	7.45E+03	
2000	0.9995	3.65E+03	9.62E+02	1.76E+03	5.54E+03	
1000	0.999	3.26E+03	7.96E+02	1.70E+03	4.82E+03	
200	0.995	2.44E+03	4.80E+02	1.50E+03	3.38E+03	
100	0.99	2.12E+03	3.71E+02	1.39E+03	2.85E+03	
50	0.98	1.82E+03	2.79E+02	1.27E+03	2.36E+03	
20	0.95	1.45E+03	1.80E+02	1.09E+03	1.80E+03	
10	0.9	1.18E+03	1.22E+02	9.42E+02	1.42E+03	
5	0.8	9.28E+02	79.6	7.72E+02	1.08E+03	
3	0.6667	7.42E+02	57.6	6.29E+02	8.55E+02	
2	0.5	5.89E+02	44.7	5.02E+02	6.77E+02	
1.4286	0.3	4.48E+02	35.1	3.79E+02	5.17E+02	
1.25	0.2	3.81E+02	31	3.20E+02	4.41E+02	
1.1111	0.1	3.05E+02	27.3	2.52E+02	3.59E+02	
1.0526	0.05	2.56E+02	26.7	2.04E+02	3.09E+02	
1.0204	0.02	2.12E+02	2.86E+01	1.56E+02	2.68E+02	
1.0101	0.01	1.88E+02	3.11E+01	1.27E+02	2.49E+02	
1.005	0.005	1.69E+02	3.39E+01	1.02E+02	2.35E+02	
1.001	0.001	1.37E+02	4.04E+01	5.78E+01	2.16E+02	
1.0005	0.0005	1.27E+02	4.30E+01	4.27E+01	2.11E+02	
1.0001	0.0001	1.09E+02	4.83E+01	1.43E+01	2.04E+02	

Exponential and Pearson type of distributions:

Exponential Distribution

Paste Exponential Distribution Output from Hyfran in Cell Below (A142)

Dry Pond

Results of the fitting

Exponential (Maximum Likelihood)

Number of observations 55

Parameters

alpha	521.47037
m	165.018721

Quantiles
q = F(X) : non-exceedance probability
T = 1/(1-q)

T	q	XT	Standard deviation	Confidence interval (95%)	
10000	0.9999	4.97E+03	6.52E+02	3.69E+03	6.25E+03
2000	0.9995	4.13E+03	5.38E+02	3.07E+03	5.18E+03
1000	0.999	3.77E+03	4.89E+02	2.81E+03	4.73E+03
200	0.995	2.93E+03	3.75E+02	2.19E+03	3.66E+03
100	0.99	2.57E+03	3.26E+02	1.93E+03	3.20E+03
50	0.98	2.21E+03	2.76E+02	1.66E+03	2.75E+03
20	0.95	1.73E+03	2.12E+02	1.31E+03	2.14E+03
10	0.9	1.37E+03	1.62E+02	1.05E+03	1.68E+03
5	0.8	1.00E+03	1.13E+02	7.82E+02	1.23E+03
3	0.6667	7.38E+02	7.73E+01	5.86E+02	8.89E+02
2	0.5	5.26E+02	48.8	4.31E+02	6.22E+02
1.4286	0.3	3.51E+02	25.8	3.00E+02	4.02E+02
1.25	0.2	2.81E+02	17.4	2.47E+02	3.15E+02
1.1111	0.1	2.20E+02	11.3	1.98E+02	2.42E+02
1.0526	0.05	1.92E+02	9.77	1.73E+02	2.11E+02
1.0204	0.02	1.76E+02	9.48	1.57E+02	1.94E+02
1.0101	0.01	1.70E+02	9.5	1.52E+02	1.89E+02
1.005	0.005	1.68E+02	9.53	1.49E+02	1.86E+02
1.001	0.001	1.66E+02	9.56	1.47E+02	1.84E+02
1.0005	0.0005	1.65E+02	9.56	1.47E+02	1.84E+02
1.0001	0.0001	1.65E+02	9.57	1.46E+02	1.84E+02

Pearson Type III Distribution

Paste Pearson III Distribution Output from Hyfran in Cell Below (A184)

Dry Pond

Results of the fitting

Pearson type III (Maximum Likelihood)

Number of observations 55

Parameters

alpha	0.003717
lambda	1.988117
m	151.675446

Quantiles
q = F(X) : non-exceedance probability
T = 1/(1-q)

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	3.31E+03	4.53E+02	2.42E+03	4.20E+03	
2000	0.9995	2.83E+03	3.71E+02	2.11E+03	3.56E+03	
1000	0.999	2.63E+03	3.35E+02	1.97E+03	3.29E+03	
200	0.995	2.14E+03	2.54E+02	1.65E+03	2.64E+03	
100	0.99	1.93E+03	2.19E+02	1.50E+03	2.36E+03	
50	0.98	1.72E+03	1.85E+02	1.35E+03	2.08E+03	
20	0.95	1.42E+03	1.41E+02	1.15E+03	1.70E+03	
10	0.9	1.19E+03	1.09E+02	9.80E+02	1.41E+03	
5	0.8	9.53E+02	78.4	7.99E+02	1.11E+03	
3	0.6667	7.70E+02	59.1	6.54E+02	8.86E+02	
2	0.5	6.00E+02	45.3	5.11E+02	6.89E+02	
1.4286	0.3	4.44E+02	36.2	3.73E+02	5.15E+02	
1.25	0.2	3.71E+02	32.3	3.08E+02	4.35E+02	
1.1111	0.1	2.94E+02	27.3	2.40E+02	3.47E+02	
1.0526	0.05	2.47E+02	23	2.02E+02	2.92E+02	
1.0204	0.02	2.09E+02	1.80E+01	1.74E+02	2.44E+02	
1.0101	0.01	1.90E+02	1.48E+01	1.61E+02	2.19E+02	
1.005	0.005	1.77E+02	1.20E+01	1.54E+02	2.01E+02	
1.001	0.001	1.59E+02	6.58E+00	1.46E+02	1.72E+02	
1.0005	0.0005	1.54E+02	4.52E+00	1.45E+02	1.63E+02	
1.0001	0.0001	1.48E+02	N/D	N/D	N/D	

Log-Pearson Type III Distribution

Paste Log Pearson III Distribution Output from Hyfran in Cell Below (A226)

Dry Pond

Results of the fitting

Log-Pearson type III (Méthode SAM)

Number of observations 55

Parameters

alpha	73.82419
lambda	283.020156
m	-1.058131

Quantiles
q = F(X) : non-exceedance probability
T = 1/(1-q)

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	4.80E+03	2.23E+03	N/D	N/D	
2000	0.9995	3.72E+03	1.37E+03	N/D	N/D	
1000	0.999	3.30E+03	1.09E+03	N/D	N/D	
200	0.995	2.44E+03	5.86E+02	1.29E+03	3.59E+03	
100	0.99	2.12E+03	4.31E+02	1.27E+03	2.96E+03	
50	0.98	1.81E+03	3.06E+02	1.21E+03	2.41E+03	
20	0.95	1.44E+03	1.84E+02	1.08E+03	1.80E+03	
10	0.9	1.18E+03	1.21E+02	9.39E+02	1.41E+03	
5	0.8	9.25E+02	7.89E+01	7.70E+02	1.08E+03	
3	0.6667	7.44E+02	58.2	6.30E+02	8.58E+02	
2	0.5	5.90E+02	45	5.02E+02	6.78E+02	
1.4286	0.3	4.50E+02	34.6	3.82E+02	5.17E+02	
1.25	0.2	3.83E+02	30.7	3.22E+02	4.43E+02	
1.1111	0.1	3.07E+02	28.1	2.52E+02	3.62E+02	
1.0526	0.05	2.56E+02	28.1	2.01E+02	3.11E+02	
1.0204	0.02	2.10E+02	29.8	1.51E+02	2.68E+02	
1.0101	0.01	1.84E+02	31.7	1.22E+02	2.46E+02	
1.005	0.005	1.64E+02	33.7	9.74E+01	2.30E+02	
1.001	0.001	1.28E+02	37.6	5.46E+01	2.02E+02	
1.0005	0.0005	1.17E+02	38.9	4.07E+01	1.93E+02	
1.0001	0.0001	9.64E+01	41	1.59E+01	1.77E+02	

Extreme Value type of distributions:

EVI (Gumbel) Distribution

Paste EV Distribution Output from Hyfran in Cell Below (A269)

Dry Pond

Results of the fitting

Gumbel (Maximum Likelihood)

Number of observations 55

Parameters

u	520.082555
alpha	267.352322

Quantiles
q = F(X) : non-exceedance probability
T = 1/(1-q)

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	2.98E+03	2.77E+02	2.44E+03	3.52E+03	
2000	0.9995	2.55E+03	2.31E+02	2.10E+03	3.01E+03	
1000	0.999	2.37E+03	2.12E+02	1.95E+03	2.78E+03	
200	0.995	1.94E+03	1.67E+02	1.61E+03	2.26E+03	
100	0.99	1.75E+03	1.47E+02	1.46E+03	2.04E+03	
50	0.98	1.56E+03	1.28E+02	1.31E+03	1.81E+03	
20	0.95	1.31E+03	1.03E+02	1.11E+03	1.52E+03	
10	0.9	1.12E+03	8.39E+01	9.57E+02	1.29E+03	
5	0.8	9.21E+02	65.2	7.93E+02	1.05E+03	
3	0.6667	7.61E+02	51.9	6.60E+02	8.63E+02	
2	0.5	6.18E+02	42.2	5.35E+02	7.01E+02	
1.4286	0.3	4.70E+02	36.6	3.99E+02	5.42E+02	
1.25	0.2	3.93E+02	36.1	3.22E+02	4.64E+02	
1.1111	0.1	2.97E+02	38.1	2.22E+02	3.72E+02	
1.0526	0.05	2.27E+02	41.1	1.46E+02	3.07E+02	
1.0204	0.02	1.55E+02	45.3	6.66E+01	2.44E+02	
1.0101	0.01	1.12E+02	48.2	1.72E+01	2.06E+02	
1.005	0.005	7.43E+01	51	-2.56E+01	1.74E+02	
1.001	0.001	3.39E+00	56.6	-1.08E+02	1.14E+02	
1.0005	0.0005	-2.22E+01	58.7	-1.37E+02	9.29E+01	
1.0001	0.0001	-7.35E+01	63.1	-1.97E+02	5.02E+01	

GEV (General Extreme Value) Distribution

Paste GEV Distribution Output from Hyfran in Cell Below (A311)

Dry Pond

Results of the fitting

GEV (Maximum Likelihood)

Number of observations 55

Parameters

alpha	240.759667
k	-0.18503
u	496.462539

Quantiles
q = F(X) : non-exceedance probability
T = 1/(1-q)

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	6.35E+03	3.68E+03	N/D	N/D	
2000	0.9995	4.51E+03	2.02E+03	N/D	N/D	
1000	0.999	3.87E+03	1.52E+03	N/D	N/D	
200	0.995	2.66E+03	7.37E+02	N/D	N/D	
100	0.99	2.24E+03	5.18E+02	1.23E+03	3.26E+03	
50	0.98	1.87E+03	3.52E+02	1.18E+03	2.56E+03	
20	0.95	1.45E+03	2.00E+02	1.06E+03	1.84E+03	
10	0.9	1.17E+03	125	9.24E+02	1.41E+03	
5	0.8	9.13E+02	77.7	7.60E+02	1.06E+03	
3	0.6667	7.33E+02	55.9	6.23E+02	8.43E+02	
2	0.5	5.88E+02	43.2	5.03E+02	6.72E+02	
1.4286	0.3	4.53E+02	33.9	3.86E+02	5.19E+02	
1.25	0.2	3.87E+02	30.6	3.27E+02	4.47E+02	
1.1111	0.1	3.10E+02	29.2	2.53E+02	3.68E+02	
1.0526	0.05	2.57E+02	30.8	1.97E+02	3.18E+02	
1.0204	0.02	2.06E+02	34.9	1.38E+02	2.75E+02	
1.0101	0.01	1.76E+02	38.5	1.01E+02	2.52E+02	
1.005	0.005	1.51E+02	4.21E+01	6.84E+01	2.34E+02	
1.001	0.001	1.05E+02	5.02E+01	6.79E+00	2.04E+02	
1.0005	0.0005	8.93E+01	5.35E+01	-1.55E+01	1.94E+02	
1.0001	0.0001	5.81E+01	6.04E+01	-6.03E+01	1.77E+02	

EVIII (Weibull) Distribution

Paste Weibull Distribution Output from Hyfran in Cell Below (A353)

Dry Pond

Results of the fitting

Weibull (Maximum Likelihood)

Number of observations 55

Parameters

alpha	777.997854
c	1.871642

Quantiles
q = F(X) : non-exceedance probability
T = 1/(1-q)

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	2.55E+03	3.16E+02	1.93E+03	3.17E+03	
2000	0.9995	2.30E+03	2.65E+02	1.78E+03	2.82E+03	
1000	0.999	2.18E+03	2.43E+02	1.71E+03	2.66E+03	
200	0.995	1.90E+03	1.90E+02	1.52E+03	2.27E+03	
100	0.99	1.76E+03	1.67E+02	1.43E+03	2.09E+03	
50	0.98	1.61E+03	1.44E+02	1.33E+03	1.89E+03	
20	0.95	1.40E+03	1.14E+02	1.18E+03	1.62E+03	
10	0.9	1.21E+03	9.19E+01	1.03E+03	1.39E+03	
5	0.8	1.00E+03	72.3	8.61E+02	1.15E+03	
3	0.6667	8.18E+02	60.8	6.99E+02	9.37E+02	
2	0.5	6.40E+02	54.1	5.34E+02	7.46E+02	
1.4286	0.3	4.48E+02	48.8	3.53E+02	5.44E+02	
1.25	0.2	3.49E+02	45.3	2.60E+02	4.38E+02	
1.1111	0.1	2.34E+02	38.9	1.57E+02	3.10E+02	
1.0526	0.05	1.59E+02	32.4	9.56E+01	2.23E+02	
1.0204	0.02	9.67E+01	24.5	4.87E+01	1.45E+02	
1.0101	0.01	6.66E+01	19.4	2.86E+01	1.05E+02	
1.005	0.005	4.59E+01	15.1	1.63E+01	7.56E+01	
1.001	0.001	1.94E+01	8.12	3.51E+00	3.53E+01	
1.0005	0.0005	1.34E+01	6.12	1.41E+00	2.54E+01	
1.0001	0.0001	5.67E+00	3.1	-3.98E-01	1.17E+01	

Gamma type of distributions:

Gamma Distribution

Paste Gamma Distribution Output from Hyfran in Cell Below (A396)

Dry Pond

Results of the fitting

Gamma (Maximum Likelihood)

Number of observations 55

Parameters

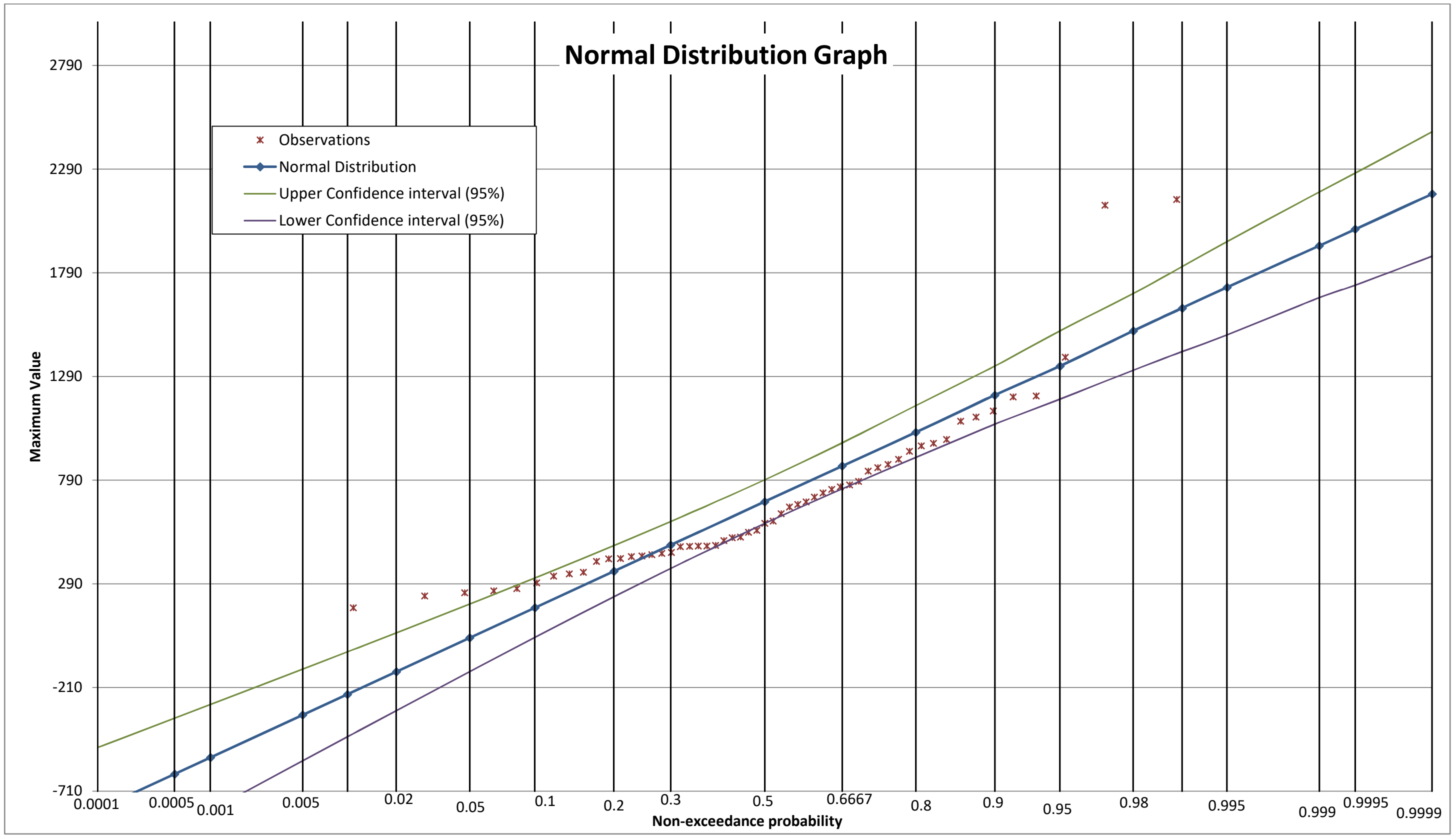
alpha	0.005412
lambda	3.715514

Quantiles
q = F(X) : non-exceedance probability
T = 1/(1-q)

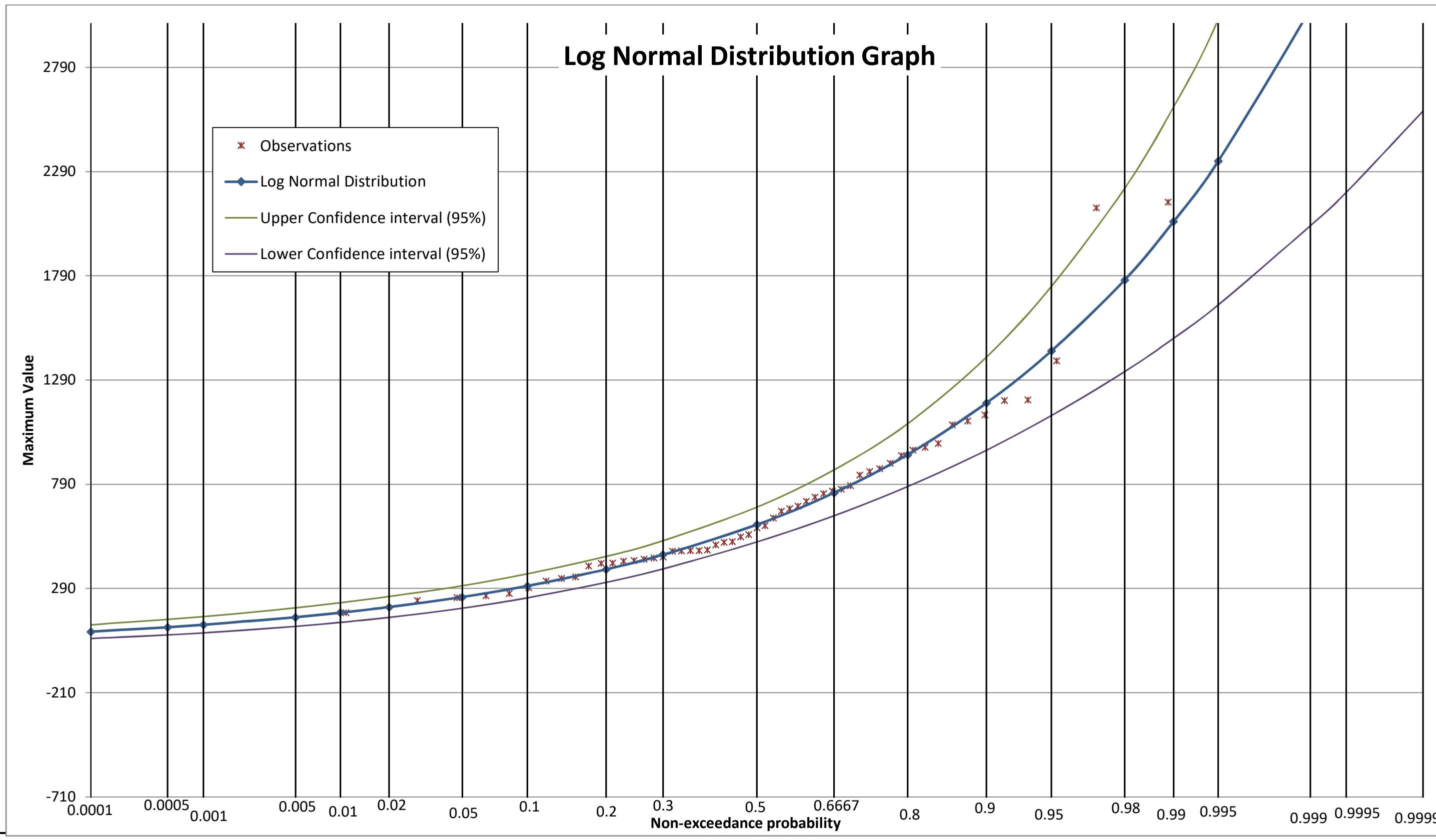
T	q	XT	Standard deviation	Confidence interval (95%)	
10000	0.9999	2.84E+03	3.38E+02	2.18E+03	3.50E+03
2000	0.9995	2.48E+03	2.80E+02	1.93E+03	3.03E+03
1000	0.999	2.32E+03	2.55E+02	1.82E+03	2.82E+03
200	0.995	1.94E+03	1.98E+02	1.55E+03	2.33E+03
100	0.99	1.77E+03	1.73E+02	1.43E+03	2.11E+03
50	0.98	1.60E+03	1.48E+02	1.31E+03	1.89E+03
20	0.95	1.36E+03	1.16E+02	1.13E+03	1.59E+03
10	0.9	1.16E+03	9.25E+01	9.83E+02	1.35E+03
5	0.8	9.55E+02	69.8	8.18E+02	1.09E+03
3	0.6667	7.88E+02	55.2	6.79E+02	8.96E+02
2	0.5	6.26E+02	45.1	5.37E+02	7.14E+02
1.4286	0.3	4.65E+02	39.5	3.88E+02	5.43E+02
1.25	0.2	3.84E+02	37.7	3.10E+02	4.57E+02
1.1111	0.1	2.88E+02	35.6	2.18E+02	3.58E+02
1.0526	0.05	2.23E+02	33.6	1.57E+02	2.89E+02
1.0204	0.02	1.64E+02	30.8	1.03E+02	2.24E+02
1.0101	0.01	1.31E+02	28.7	7.48E+01	1.87E+02
1.005	0.005	1.05E+02	26.6	5.33E+01	1.58E+02
1.001	0.001	6.39E+01	22.2	2.04E+01	1.07E+02
1.0005	0.0005	5.12E+01	20.4	1.11E+01	9.12E+01
1.0001	0.0001	2.93E+01	16.7	-3.43E+00	6.21E+01

Visual Goodness of Fit

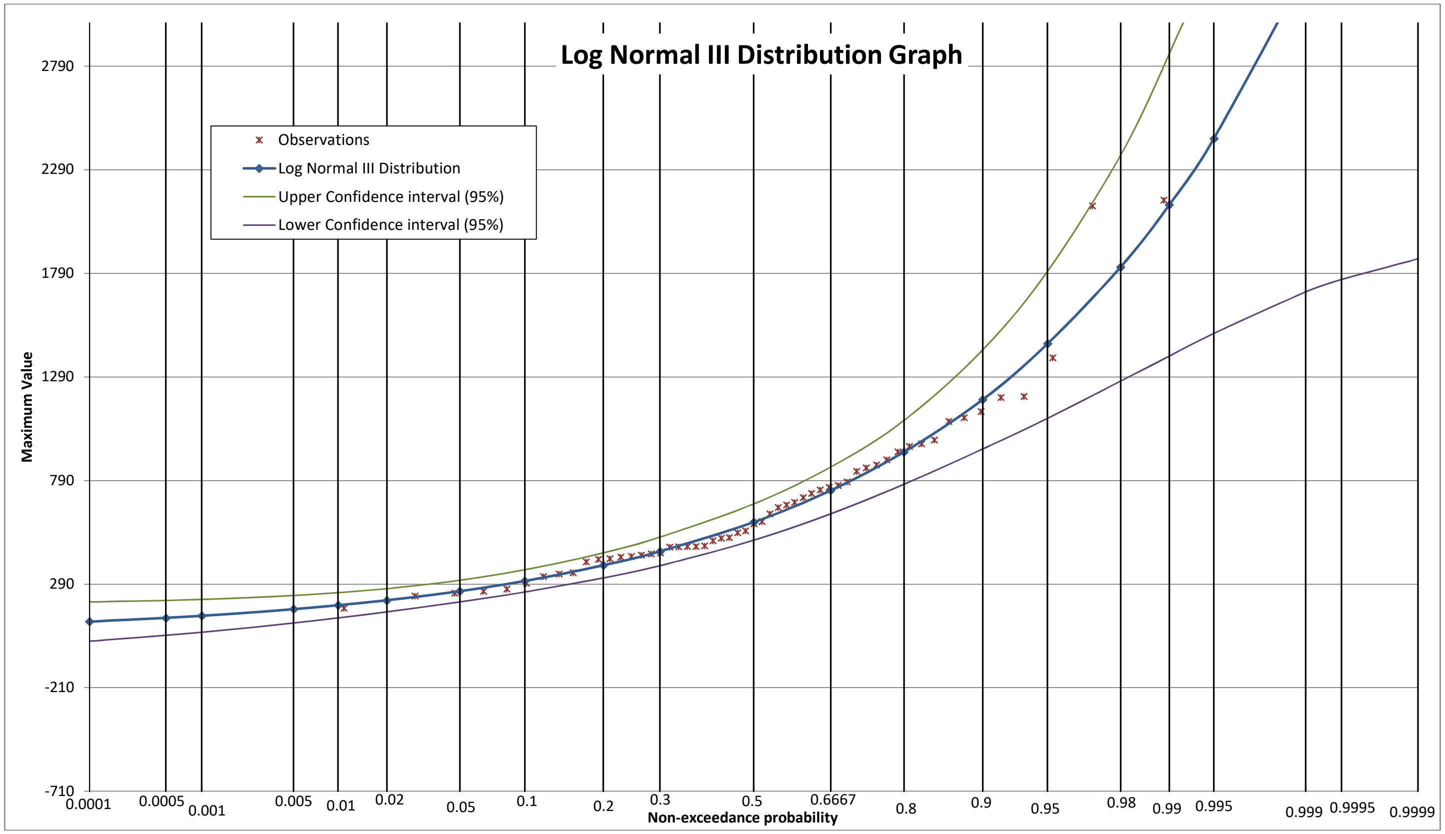
Clear All Note Data



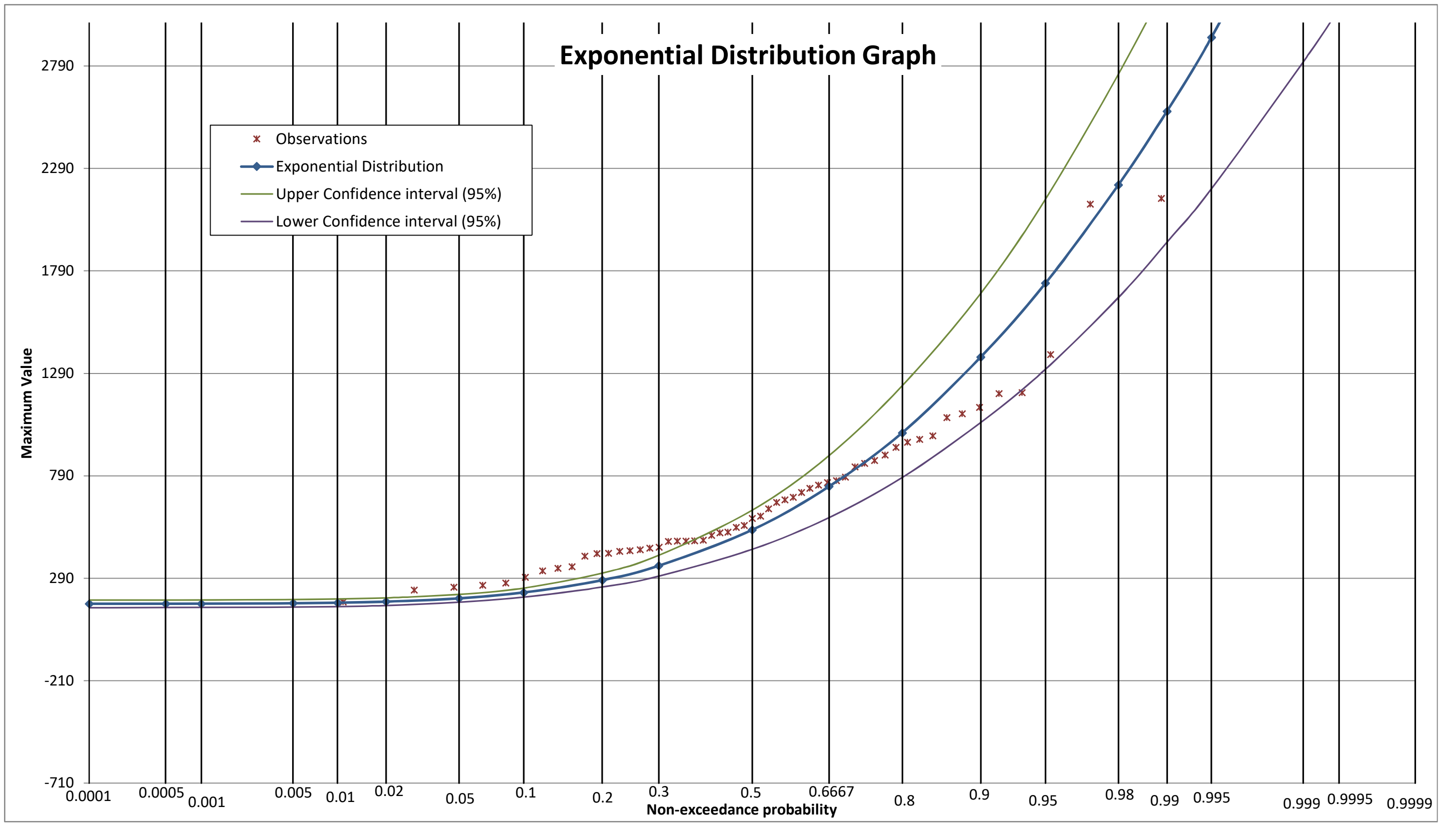
Normal Distribution
Visual Goodness-of-Fit Test Notes:



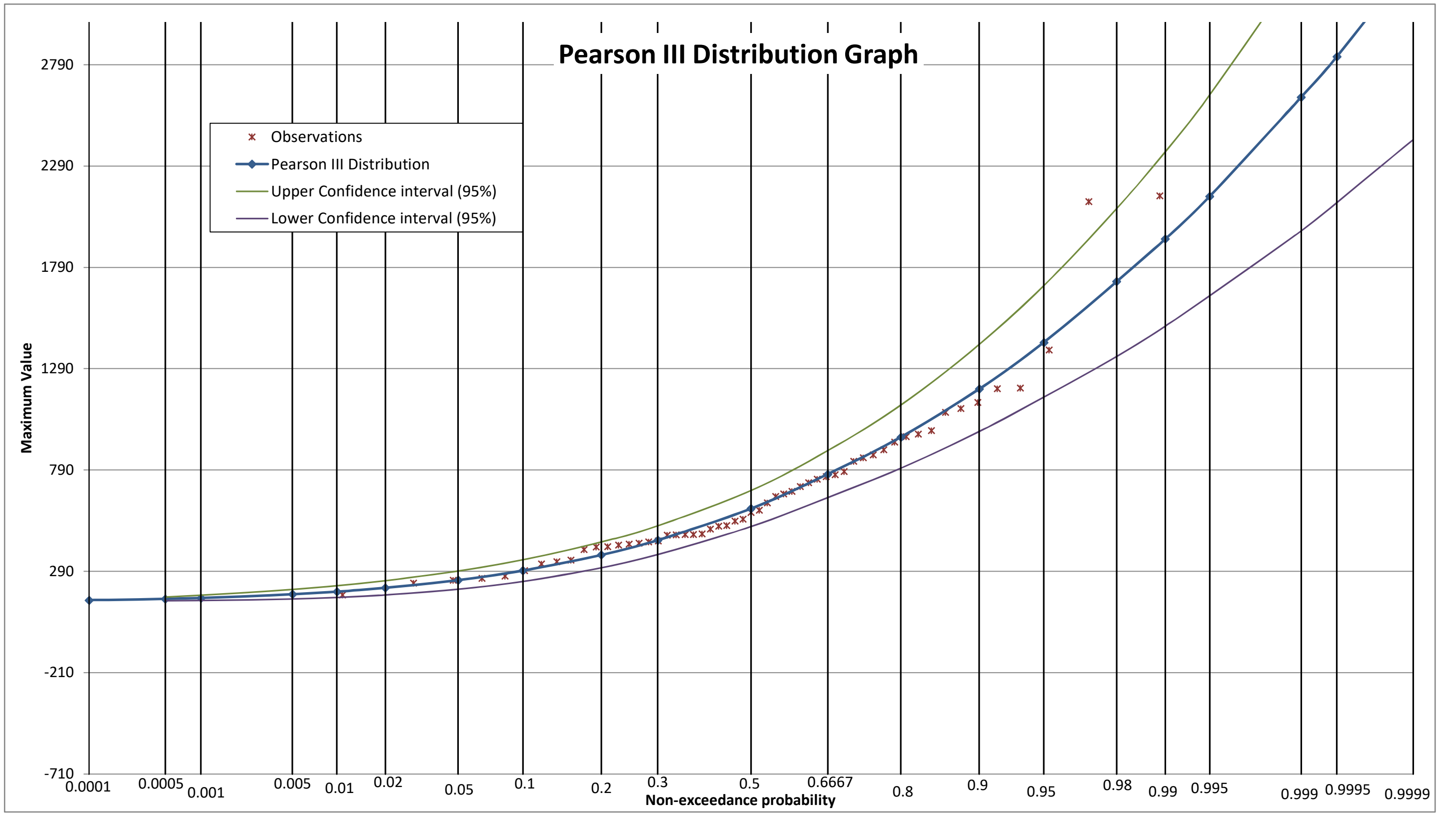
Log Normal Distribution
Visual Goodness-of-Fit Test Notes:



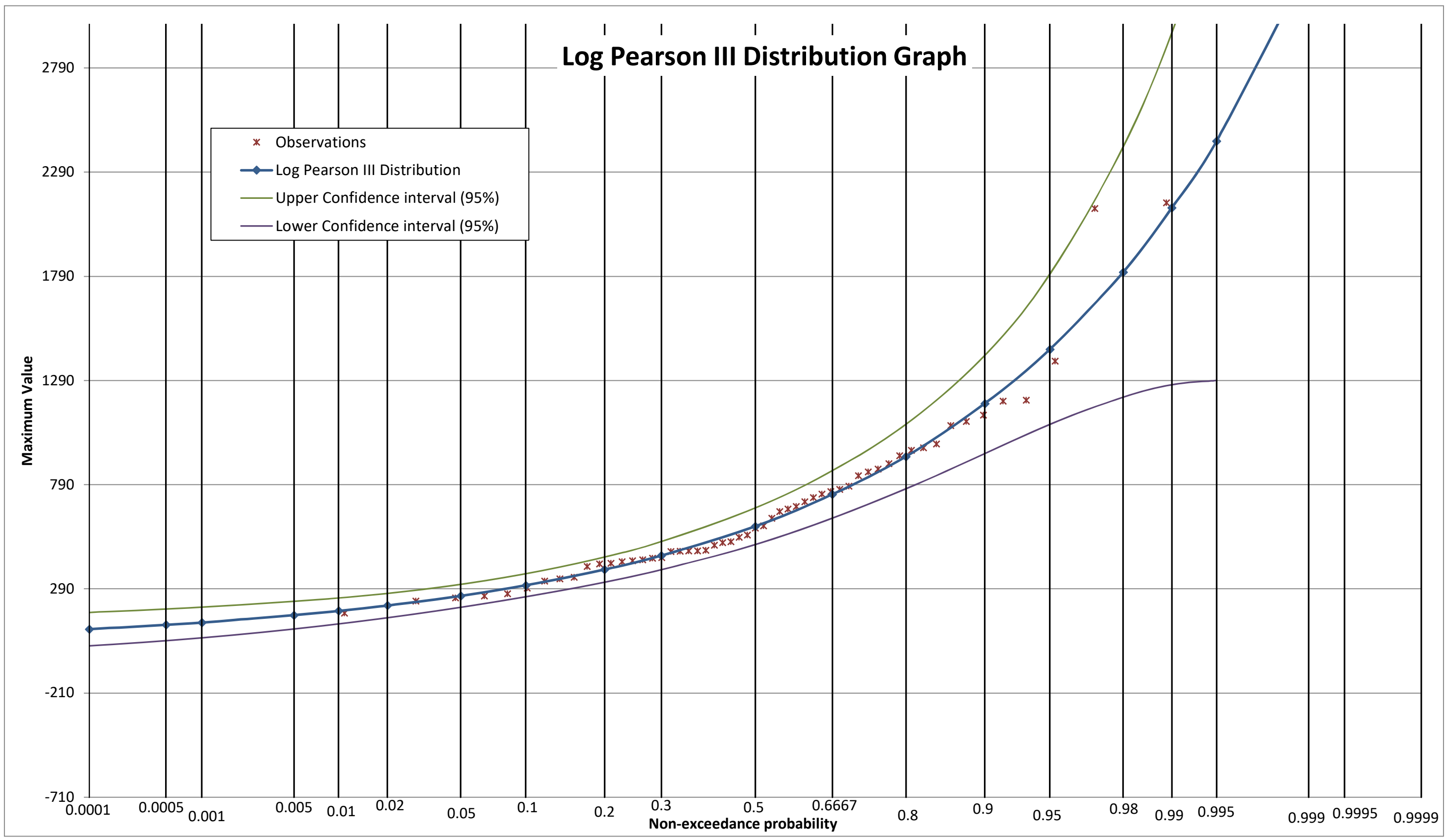
Log Normal III Distribution
Visual Goodness-of-Fit Test Notes:



Exponential Distribution
Visual Goodness-of-Fit Test Notes:



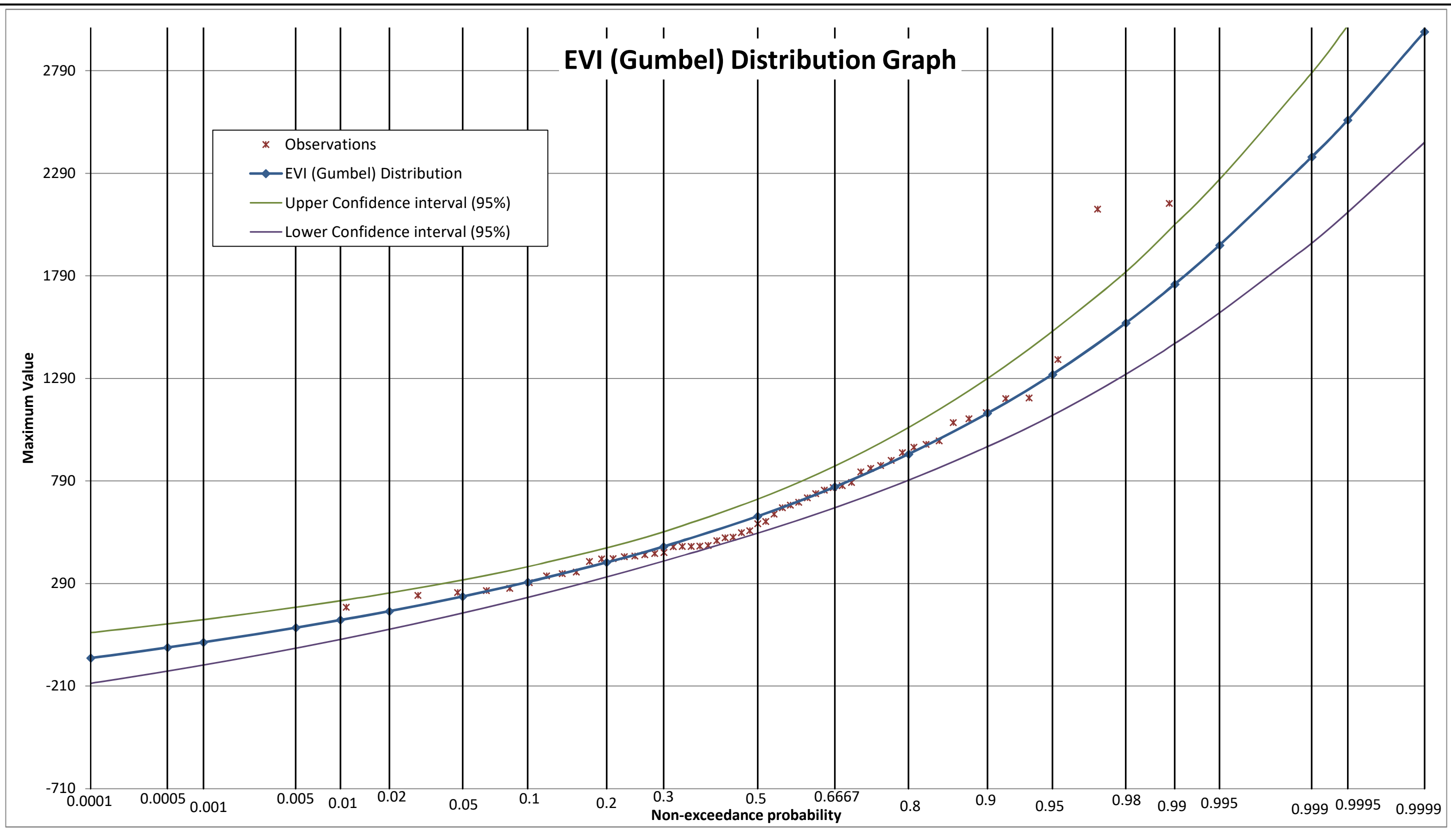
Pearson III Distribution
Visual Goodness-of-Fit Test Notes:



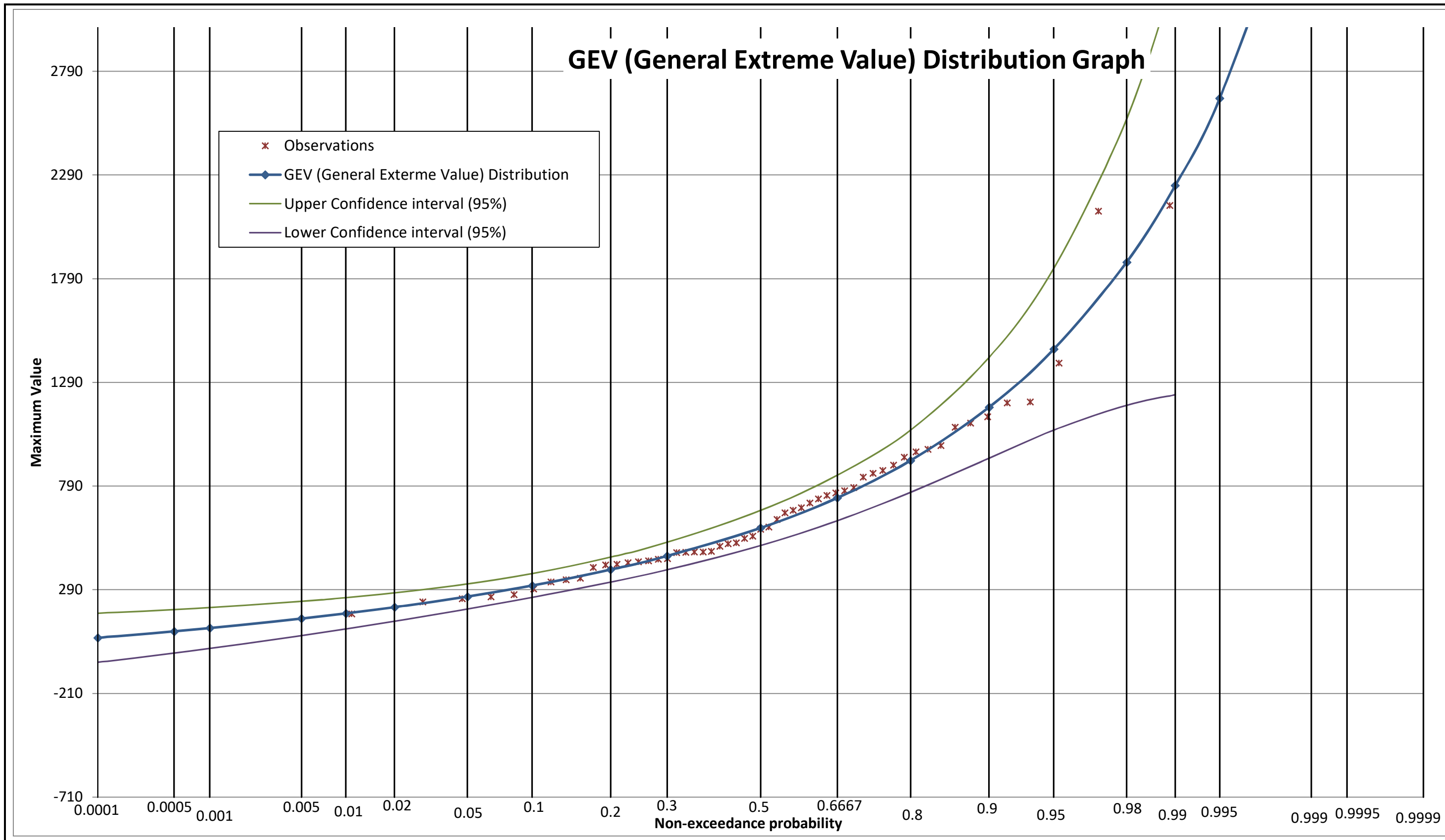
Log Pearson III Distribution
Visual Goodness-of-Fit Test Notes:

The log-Pearson III applies to hydrologic frequency analysis only when the following shape tests pass

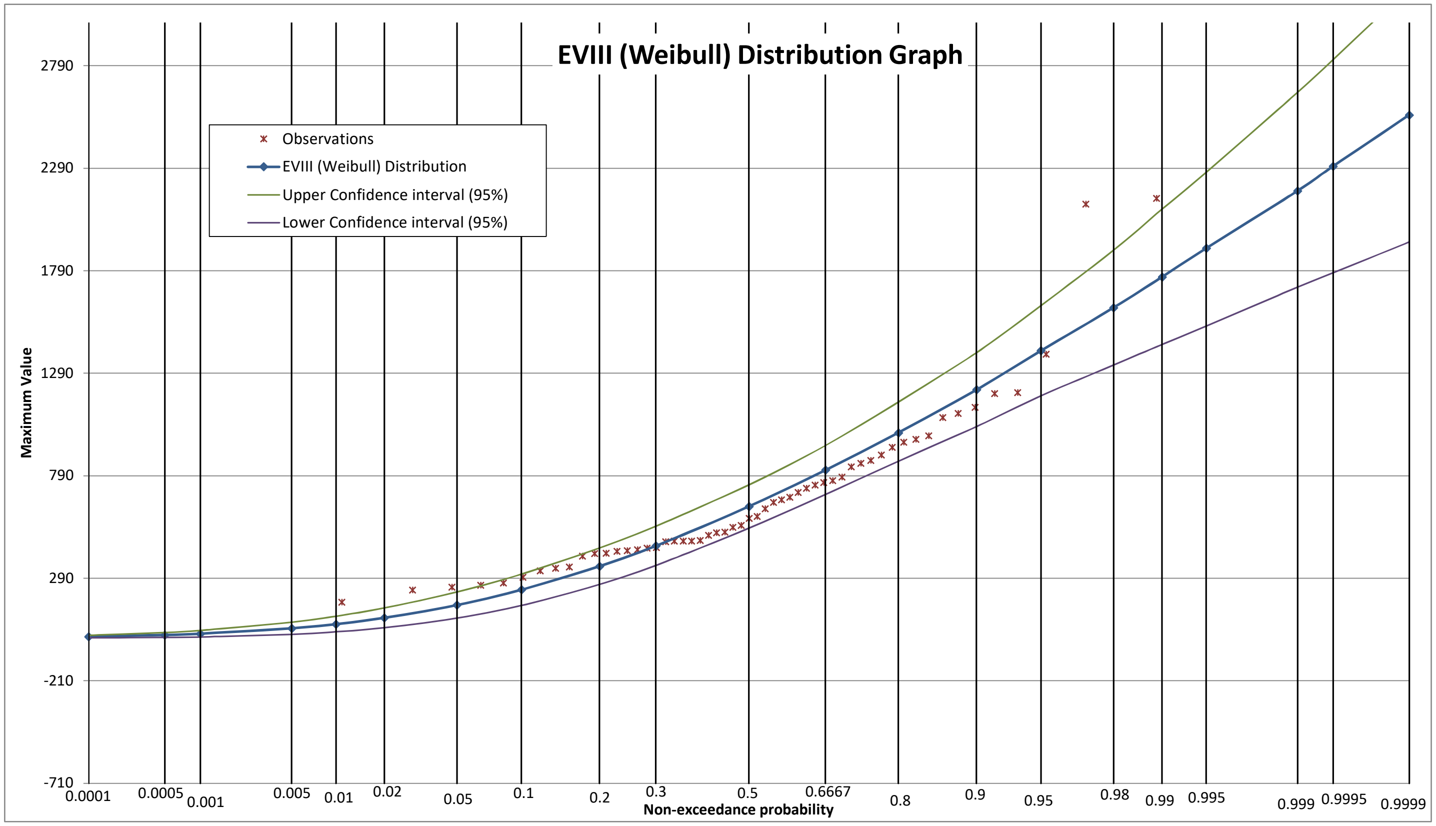
Lambda shape test
Pass
Alpha shape test
Pass



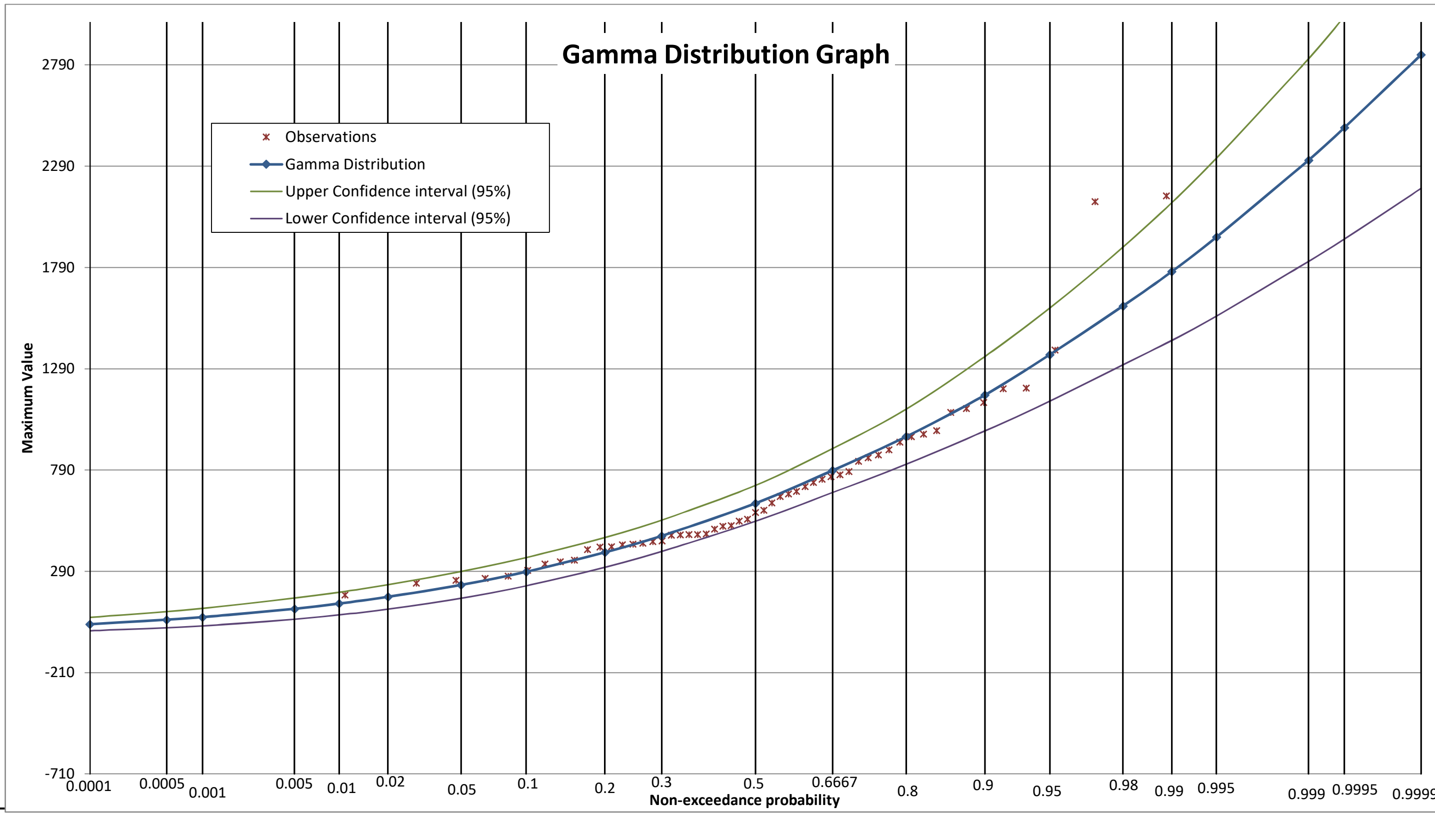
EVI (Gumbel) Distribution
Visual Goodness-of-Fit Test Notes:



GEV (General Extreme Value) Distribution Visual Goodness-of-Fit Test Notes:



EVIII (Weibull) Distribution
Visual Goodness-of-Fit Test Notes:



Gamma Distribution
Visual Goodness-of-Fit Test Notes:

Numerical Tests

Choose Significance Level (alpha) : 5%

1) Anderson-Darling Test (1952)

$$A^2 = -n - \frac{1}{n}\sum_{i=1}^{n}(2i-1)\cdot[\ln F(X_i) + \ln(1 - F(X_{n-i+1}))]$$

H0= Data follows specified distribution
HA= Data does not follow the specified distribution

Distribution Type:	Critical Value at 10%	Critical Value at 5%	Critical Value at 1%	A2	Hypothesis	Rank (1 = best fit)
Normal	1.929	2.502	3.907	1.949	Accept H0	9
Lognormal	1.929	2.502	3.907	0.204	Accept H0	3
Lognormal III	1.929	2.502	3.907	0.203	Accept H0	2
Exponential	1.929	2.502	3.907	2.299	Accept H0	10
Pearson III	1.929	2.502	3.907	0.261	Accept H0	5
Log Pearson III	1.929	2.502	3.907	0.199	Accept H0	1
Gumbel	1.929	2.502	3.907	0.401	Accept H0	6
GEV	1.929	2.502	3.907	0.211	Accept H0	4
Weibull	1.929	2.502	3.907	0.977	Accept H0	8
Gamma	1.929	2.502	3.907	0.440	Accept H0	7

*Critical values based on values calculated by EasyFit Software

2) Kolmogorov-Smirnov Test (1933)

$$F_n(x) = \frac{1}{n}\cdot\left[\text{Number of observations} \le x\right] \qquad D_n = \sup_x |F_n(x) - F(x)|$$

H0= Data follows specified distribution
HA= Data does not follow the specified distribution

Distribution Type:	Critical Value at 10%	Critical Value at 5%	Critical Value at 1%	Dn	Hypothesis	Rank (1 = best fit)
Normal	0.165	0.183	0.220	0.110	Accept H0	9
Lognormal	0.165	0.183	0.220	0.059	Accept H0	2
Lognormal III	0.165	0.183	0.220	0.063	Accept H0	4
Exponential	0.165	0.183	0.220	0.197	Reject H0	10
Pearson III	0.165	0.183	0.220	0.073	Accept H0	6
Log Pearson III	0.165	0.183	0.220	0.062	Accept H0	3
Gumbel	0.165	0.183	0.220	0.075	Accept H0	7
GEV	0.165	0.183	0.220	0.054	Accept H0	1
Weibull	0.165	0.183	0.220	0.085	Accept H0	8
Gamma	0.165	0.183	0.220	0.072	Accept H0	5

Least Squares Ranking

Distribution Type:	Standard Error	Rank
Normal	165	10
Lognormal	75	5
Lognormal III	71	3
Exponential	130	9
Pearson III	74	4
Log Pearson III	70	2
Gumbel	110	7
GEV	68	1
Weibull	116	8
Gamma	106	6

$$SE_j = \sqrt{\frac{1}{n-m_j}\sum_{i=1}^{n}(x_i - y_i)^2}$$

NOTES

- For a detailed description of the Numerical Goodness of Fit Tests please refer to **Section 4.3 of the Frequency Analysis Procedure for Stromwater Design Manual**
- For guidance on choosing the significance level value please refer to **Section 2.2.2.6 of the Frequency Analysis Procedure for Stromwater Design Manual**

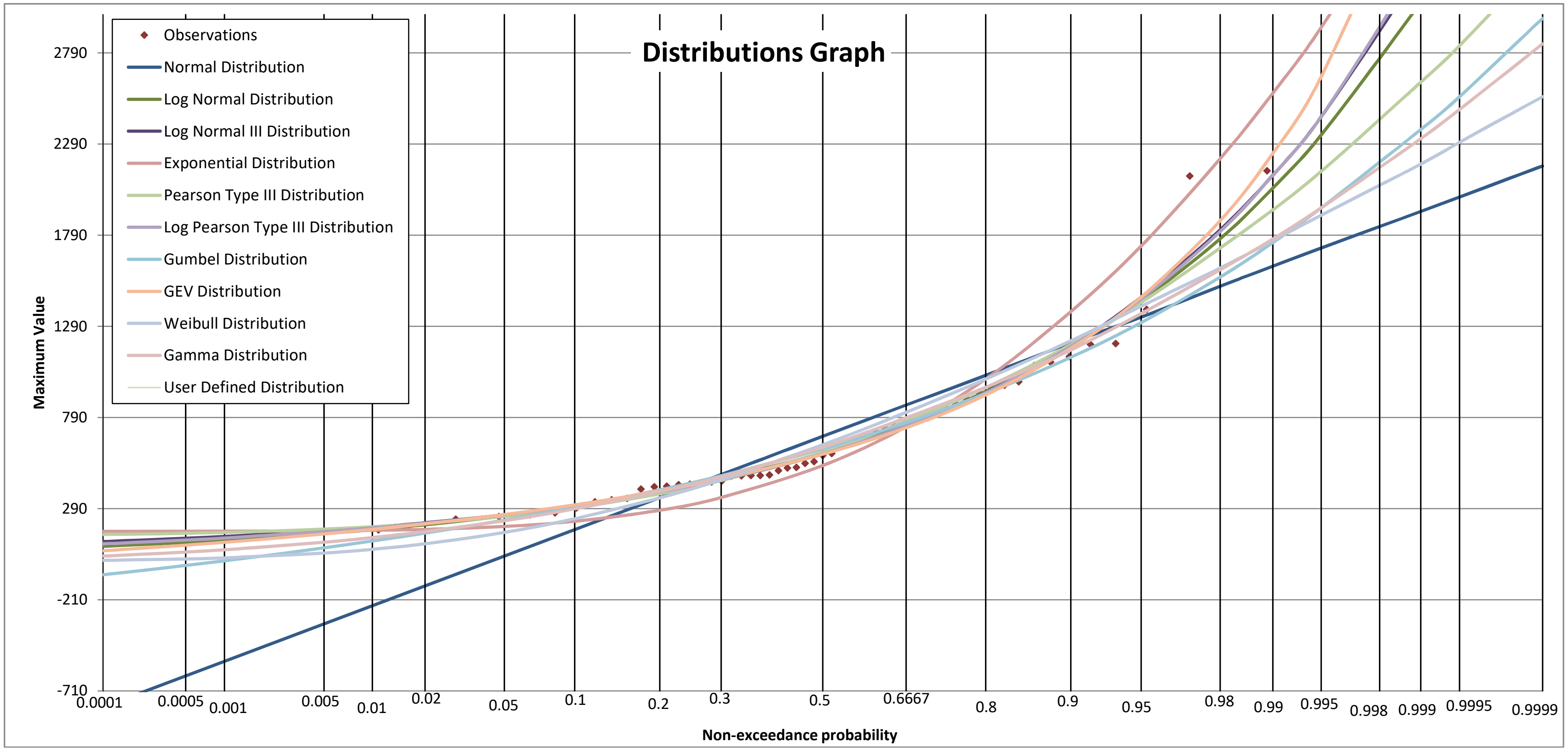
Sampling and Distribution Uncertainty

NOTES

- Select the distribution type and a return period based on the preferred curve from the Summary Sheet.
- The sample uncertainty, distribution uncertainty and total uncertainty for the value will be displayed on the right.
- For more information regarding uncertainty please refer to **Section 4.4 of the Frequency Analysis Procedure for Stormwater Design Manual**
- The plot below displays all the distributions input in the Frequency Analysis Input Tab

Return Period of Interest (Years)	5
Distribution Type	Normal
Corresponding Value	1020

Sampling Uncertainty at (95%) Confidence Interval ±	126
Distribution Uncertainty ±	5.25
Total Uncertainty ±	131



Company Name: LGN Consulting Engineering Ltd.

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?	No High Outliers Present
Are and low outliers present?	No Low Outliers Present

Project Information

Project Name:	2291463 Alberta Ltd.
Project Description:	Residential Development in Foothills County - DRY POND
Location:	Heritage Point
Date:	2021-11-18
Designed by:	Luis G Narvaez
Company Name:	LGN Consulting Engineering Ltd.
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	9	9	10	9.33	9			
Lognormal	3	2	5	3.33	4			
Lognormal III	2	4	3	3.00	3			
Exponential	10	10	9	9.67	10			
Pearson III	5	6	4	5.00	5			
Log Pearson III	1	3	2	2.00	1			
Gumbel	6	7	7	6.67	7			
GEV	4	1	1	2.00	1			
Weibull	8	8	8	8.00	8			
Gamma	7	5	6	6.00	6			

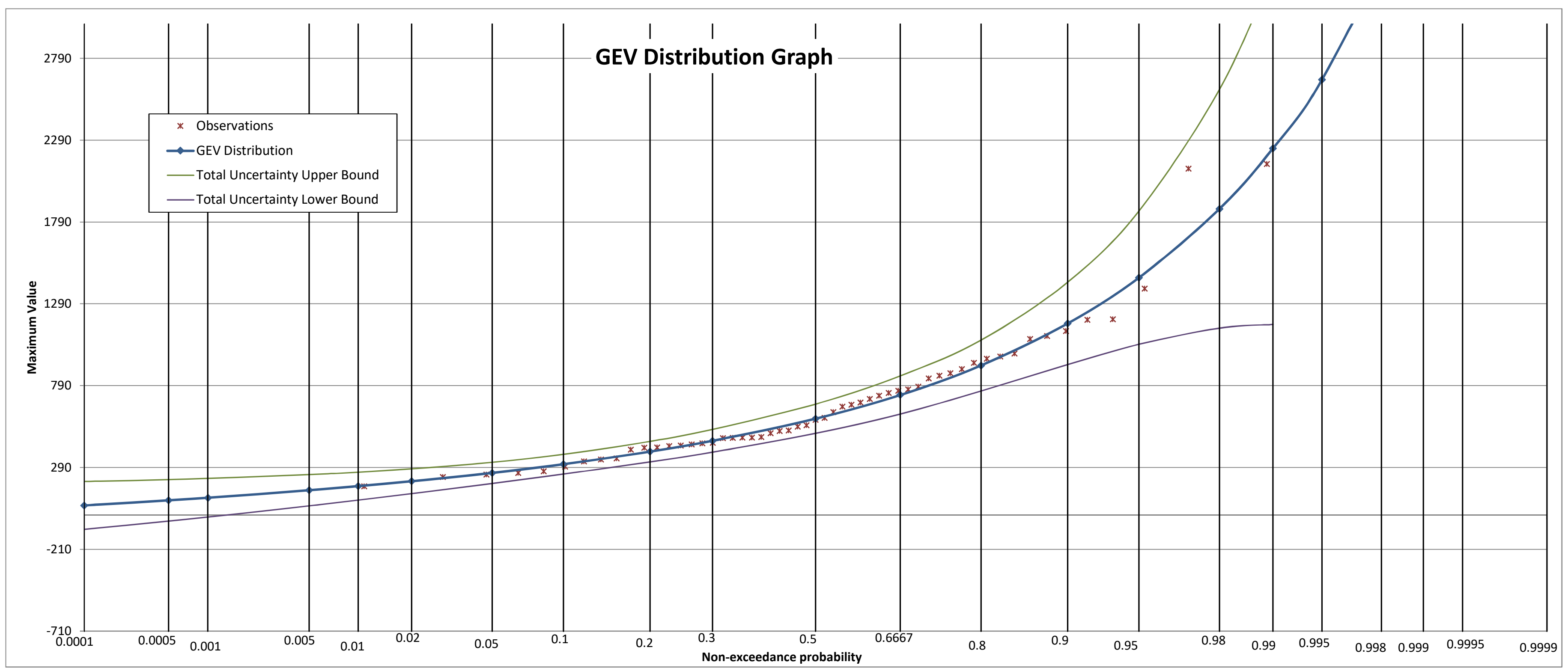
Selected Distribution and Results

Instructions:

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

Return Period	Probability	Magnitude	Total Uncertainty (Upper Bound)	Total Uncertainty (Lower Bound)
10000	0.9999	6350	#N/A	#N/A
2000	0.9995	4510	#N/A	#N/A
1000	0.9990	3870	#N/A	#N/A
500	0.9980	3300	#N/A	#N/A
200	0.9950	2660	#N/A	#N/A
100	0.9900	2240	3320	1160
50	0.9800	1870	2600	1140
20	0.9500	1450	1860	1040
10	0.9000	1170	1420	918
5	0.8000	913	1070	758
3	0.6667	733	850	616
2	0.5000	588	677	499
1.4286	0.3000	453	523	383
1.25	0.2000	387	450	324
1.1111	0.1000	310	370	250
1.0526	0.0500	257	322	192
1.0204	0.0200	206	282	130
1.0101	0.0100	176	261	90.8
1.005	0.0050	151	247	55.4
1.001	0.0010	105	223	-13.1
1.0005	0.0005	89.3	216	-37.5
1.0001	0.0001	58.1	204	-88.2

*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.

APPENDIX C

Oil/Grit Separators Documentation

To: LGN Consulting Engineering
From: Rainwater Management
Date: 26-Nov-21

Project City: Calgary
Designation: North OGS
Revision: 0

Re: Foothills County Residential

Sizing Estimate Package

Engineering Information:

1) Particle Size Distribution: 85% removal of the ETV particle size distribution *

2) Site Criteria and Results:

Drainage Area (ha)	Total Imperviousness (%)	RWM Model	Avg. Net Annual TSS % Removal Estimate	Avg. % Rainfall Volume Treated
4.88	50%	3025-6	95%	92%

3) EPA SWWM Design Criteria:

Flow (l/s)	Slope (%)	Imperv./Perv. Depression Storage (mm)	Imperv./Perv. Manning's n	Min/Max Infiltration Rate (mm/hr)	Decay Rate	Daily Evaporation Rate (mm)
342	2%	1.6/3.2	0.015/0.25	75/7.5	0.00115	2.54

Design Parameters:

1) The unit for this project has been designed to remove a minimum 85% TSS annually for every year on record from a minimum 90 % of the total runoff volume over the period of record. This is based on the requirements defined in the City of Calgary.

2) This unit provides removal for small, frequent storm events that represent the majority of annual rainfall volume and pollutant load. Treatment continues for large, infrequent events; however, such events have little impact on the average annual TSS removal as they represent a small percentage of the total runoff volume and pollutant load.

3) The peak flows will be conveyed through the unit without re-suspending the previously trapped pollutants. The sediment storage sump is separate from the high flow area.

4) Max. nominal pipe sizes reflect, or in part, City of Calgary Max. Pipe Sizes In Round Manholes (Rev 2) Max. inlet and outlet pipe diameter for 180 Deg. pipe configuration is 1050mm/1050mm (Conctete/PVC) and for 90 Deg. pipe configuration is 750mm/750mm.

* ETV particle size distribution utilized, or in part, shown on Page 9.

City of Calgary Checklist:

7) The unit is designed to operate in free flow conditions but can also handle submerged or backwater conditions without resuspending previously captured material. This condition is met.

8) The unit will treat a minimum 90 % of the total runoff volume over the period of record. This condition is met.

9) The unit has a minimum annual TSS removal rate of 85 % for each and every year. This condition is met.

10) Average volume treated = Area x Conversion Factor x Avg. Annual Precipitation x Total Imperviousness x Avg. Volume Treated from Page 8.

Drainage Area (ha)	Conversion Factor	Agv. Annual Precipitation (mm)	Total Imperviousness (%)	Avg. % Volume Treated as per p.8	Avg. Volume Treated (m3)
4.88	10	400	50%	92%	8,943

Average annual sediment removed = Avg. Volume Treated x Avg. Removal Efficiency from Page 8 x Sediment Concentration.

Avg. Volume Treated (m3)	Avg. Removal Efficiency as per p.8	Sediment Concentration (kg/m3)	Avg. Annual Sediment Removed (kg)	RWM Model Sump Capacity (kg)	Sump Capacity Condition
8,943	95%	0.444	3,781	6,367	Condition Met

11) The allowable treatment flow:

RWM Model	Manhole Diameter (mm)	Max Hydraulic Loading Rate (l/s/m2)	Allowable Treatable Flow (l/s)	Allowable Treatment Flow Condition
3025-6	1,830	27	71.0	Condition Met

12) Items a and b are covered in the attached tables. Item c is covered in requirement 10 above. These conditions are met.

13) A product guide is enclosed. This condition is met.

rainwater
MANAGEMENT

Sizing Summary:

The unit is a hydrodynamic separator that combines screening and enhanced gravity settling to remove floating, neutrally buoyant and non-buoyant solids from stormwater runoff. The non-blocking screen captures 100% of the pollutants equal to the screen aperture size (2400 microns) and larger. All non-buoyant solids are directed to a sump that separates the captured pollutants from the treatment flow path to prevent the larger storm events from re-suspending previously trapped material. The floatable debris and oil/grease are trapped upstream of the baffle for easy removal.

The unit can be installed as a bend structure and can accommodate multiple inlets.

The unit can operate with no drop between the inlet and outlet; however, can accommodate a drop without issue. The typical 0.03m drop through City of Calgary manholes can easily be accommodated and any drop (if any) will be reflected in the approval drawing.

Maintenance is a key to any systems proper long-term effectiveness. The unit allows for easy access without confined space requirements. Rainwater Management is available to train a maintenance crew or to provide regular inspection/maintenance services.

Rainwater Management is happy to provide further information if required.

Kind Regards,

Peter Law P.Eng.

2021-11-26

Permit to Practice Rainwater Management Ltd. Permit Number P11426

This report confirms that the above stormwater unit is designed to the manufacturer's specifications to meet the design criteria.

502-1952 Kingsway Ave, Port Coquitlam, BC V3C 6C2 p: 778-846-7246 f: 604-676-2601
e: pete@rainwatermanagement.ca

Annual Runoff/Year in Cubic Meters

Flow l/s	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	Flow l/s
1	131	104	94	97	147	193	132	98	127	181	130	149	1
2	343	195	157	245	296	465	270	187	256	312	276	322	2
3	117	150	174	173	369	573	252	164	216	402	228	212	3
4	378	135	113	243	425	623	300	114	268	373	247	348	4
5	255	175	135	320	280	483	340	112	242	352	247	344	5
6	143	95	116	379	217	352	336	137	118	380	315	123	6
7	45	120	114	212	159	337	341	137	113	211	161	349	7
8	161	107	162	218	353	190	302	79	159	220	162	134	8
9	91	61	60	184	92	184	243	94	185	278	64	61	9
10	170	169	35	138	104	275	371	71	172	345	70	134	10
11	38	153	114	189	153	149	39	75	228	338	76	153	11
12	122	123	86	42	165	121	165	247	290	327	41	168	12
13	92	46	0	138	134	489	137	136	353	225	132	91	13
14	194	98	291	49	192	97	50	49	0	99	197	195	14
15	416	54	158	158	0	260	51	214	106	210	53	51	15
16	113	223	54	170	112	0	54	56	0	113	54	168	16
17	294	59	177	119	177	118	181	0	59	119	0	119	17
18	187	62	65	63	126	129	187	63	125	61	0	188	18
20	743	67	66	204	269	344	273	0	201	70	0	414	20
25	698	721	75	628	166	1286	169	248	239	532	244	628	25
30	106	810	302	786	475	287	812	303	384	395	299	106	30
35	110	345	121	705	113	225	1007	0	585	742	362	0	35
40	129	274	259	391	273	0	142	0	138	253	0	130	40
45	0	159	162	0	0	300	0	144	152	0	0	0	45
50	0	494	164	0	505	0	332	0	0	0	173	166	50
55	187	0	0	185	0	758	0	0	0	0	194	376	55
60	0	399	0	202	0	212	0	0	0	0	211	214	60
65	220	219	448	0	0	0	0	0	0	0	226	0	65
122	0	673	0	0	0	637	0	245	349	264	266	264	122
179	0	0	0	1027	0	0	0	0	0	0	603	0	179
236	0	677	0	0	684	815	0	0	0	0	1473	0	236
293	0	0	0	0	0	0	0	0	0	0	0	0	293
350	0	0	0	0	0	0	0	0	0	0	0	0	350
350 +	0	0	0	0	0	0	0	0	0	0	0	0	350 +
Total Runoff	**5487**	**6967**	**3703**	**7263**	**5986**	**9903**	**6487**	**2972**	**5067**	**6800**	**6504**	**5611**	**Total Runoff**

Annual Runoff/Year in Cubic Meters

1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	Flow l/s
184	159	127	188	168	174	254	103	158	202	179	118	161	1
311	320	201	296	316	245	268	181	263	275	295	111	228	2
276	246	197	305	312	335	464	172	213	330	238	249	336	3
192	309	277	216	359	299	245	105	261	363	216	86	274	4
400	274	242	353	318	290	530	161	182	389	291	140	403	5
219	242	344	222	220	196	335	143	198	237	399	100	217	6
232	145	90	229	231	328	235	92	285	180	186	142	67	7
300	105	107	267	241	319	430	109	317	295	214	188	164	8
122	125	95	156	152	125	272	0	303	431	183	152	30	9
103	103	173	232	338	138	580	103	69	405	168	140	206	10
451	300	0	113	186	189	414	36	112	266	116	342	298	11
126	169	121	84	124	330	658	41	126	209	122	40	206	12
130	136	46	92	134	90	227	0	90	90	181	44	226	13
0	340	47	97	144	149	290	49	50	49	98	96	95	14
161	316	0	103	52	105	52	105	205	210	103	103	205	15
0	111	0	111	226	56	223	56	282	114	167	57	110	16
294	178	117	0	0	119	238	120	58	418	60	60	181	17
378	248	62	64	124	124	127	62	125	187	124	0	249	18
198	137	270	136	70	203	65	273	203	208	200	0	206	20
736	482	617	167	239	571	1014	312	626	326	973	324	568	25
188	208	107	378	567	105	99	196	689	486	200	493	197	30
467	123	118	0	827	241	361	239	363	1224	233	123	231	35
0	0	273	0	546	134	0	274	534	404	0	126	271	40
0	294	298	0	0	0	0	0	450	455	0	0	0	45
163	0	332	163	0	169	0	171	350	166	0	0	0	50
0	0	0	182	0	563	0	0	0	0	0	0	0	55
417	0	0	0	0	202	0	206	407	211	209	205	0	60
0	0	0	0	0	0	0	218	0	0	0	0	0	65
1310	0	362	533	0	249	252	0	0	302	790	0	0	122
0	0	459	0	0	0	0	0	0	0	0	0	0	179
0	0	0	0	0	0	0	0	0	0	0	0	0	236
0	0	0	0	0	0	0	0	0	0	0	0	0	293
0	0	0	0	0	0	0	0	0	0	0	0	0	350
0	0	0	0	0	0	0	0	0	0	0	0	0	350 +
7358	**5072**	**5082**	**4688**	**5896**	**6045**	**7634**	**3526**	**6918**	**8433**	**5943**	**3438**	**5132**	**Total Runoff**

Annual Runoff/Year in Cubic Meters

1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	Flow l/s
183	142	177	168	233	165	119	222	194	202	190	194	153	1
302	244	202	337	437	319	289	387	272	248	302	570	202	2
243	171	223	153	261	167	173	506	316	362	508	440	281	3
164	367	153	289	224	251	166	227	247	319	308	223	298	4
316	557	115	150	244	239	176	247	722	441	264	467	243	5
278	435	217	136	241	176	220	195	343	324	277	220	140	6
162	161	204	96	142	90	254	161	212	184	501	233	627	7
110	162	249	267	161	266	133	214	246	269	225	219	187	8
94	92	181	212	182	150	243	151	154	93	276	272	182	9
107	272	242	276	102	101	69	478	204	168	268	69	100	10
149	75	229	111	39	148	111	304	38	0	192	37	303	11
165	121	167	207	40	166	42	206	205	41	370	43	331	12
44	137	135	310	271	225	224	454	135	44	137	44	538	13
246	145	146	146	97	248	95	98	47	94	142	0	0	14
53	211	0	0	104	157	261	154	158	214	0	156	157	15
54	55	112	167	165	55	55	110	56	166	0	54	54	16
119	118	177	176	237	235	176	238	536	59	0	60	119	17
0	127	248	314	0	63	125	61	189	127	0	62	0	18
0	349	69	275	68	142	71	135	201	70	138	270	198	20
651	564	384	839	258	395	424	614	489	234	0	166	802	25
298	718	579	596	290	91	499	792	197	302	0	301	485	30
342	455	236	120	0	467	587	240	116	113	0	117	234	35
411	1180	129	538	142	142	140	135	284	143	0	137	0	40
313	464	0	762	300	0	299	149	151	0	457	148	144	45
173	0	177	0	163	0	343	176	503	0	0	0	0	50
187	184	0	0	0	182	196	0	193	0	0	0	0	55
0	0	0	0	0	427	0	213	0	0	0	0	0	60
0	228	0	0	0	223	0	0	0	0	0	0	227	65
938	0	658	0	238	0	573	773	0	538	1036	0	262	122
0	0	0	0	0	0	0	0	528	0	0	0	0	179
0	0	0	0	0	0	0	0	0	0	0	0	694	236
0	0	0	0	0	0	0	0	0	0	0	0	0	293
0	0	0	0	0	0	0	0	0	0	0	0	0	350
0	0	0	0	0	0	0	0	0	0	0	0	0	350 +
6102	**7731**	**5410**	**6646**	**4639**	**5292**	**6062**	**7639**	**6937**	**4755**	**5594**	**4501**	**6961**	**Total Runoff**

Annual Runoff/Year in Cubic Meters

1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
181	201	163	115	175	160	156	158	147	181	208	100
312	395	245	272	339	297	245	244	276	286	330	310
419	430	304	355	211	299	238	264	181	287	578	184
255	571	213	102	275	321	241	162	316	361	428	261
284	753	277	180	163	298	96	211	210	268	467	328
304	190	257	276	179	497	134	172	156	241	471	38
253	231	139	213	238	291	307	284	72	298	329	114
297	303	163	266	136	325	213	298	214	159	163	110
151	61	184	122	243	307	214	215	155	247	305	153
274	205	473	174	33	136	308	336	0	305	346	35
225	73	191	0	192	229	114	382	193	149	114	116
126	0	249	163	245	82	84	205	41	40	125	164
225	46	134	175	0	89	226	275	135	227	89	45
194	50	96	147	146	98	49	96	391	150	194	0
53	53	365	0	52	104	104	204	156	105	51	0
167	170	0	57	57	225	57	55	225	170	115	0
351	410	59	119	59	59	0	61	120	239	59	0
311	0	0	126	62	0	126	189	127	126	61	64
345	140	270	264	209	137	135	337	134	208	137	0
1519	690	455	244	315	464	151	707	490	708	774	78
299	274	493	98	100	302	206	374	588	290	754	0
109	0	236	110	0	0	0	120	338	343	221	0
542	1057	130	260	267	275	142	143	286	419	388	133
606	161	0	0	147	303	318	608	144	307	0	158
521	0	348	0	0	505	0	523	166	696	0	347
195	0	183	180	0	181	744	575	187	0	0	182
206	0	0	214	0	206	412	613	0	0	201	206
222	0	0	230	0	0	0	219	0	0	0	0
533	520	290	0	578	238	323	0	1374	628	603	0
0	0	442	571	0	0	0	1054	0	0	0	471
0	0	0	0	0	0	0	650	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
9481	**6982**	**6360**	**5034**	**4420**	**6428**	**5347**	**9732**	**6820**	**7439**	**7510**	**3598**

TSS Removal

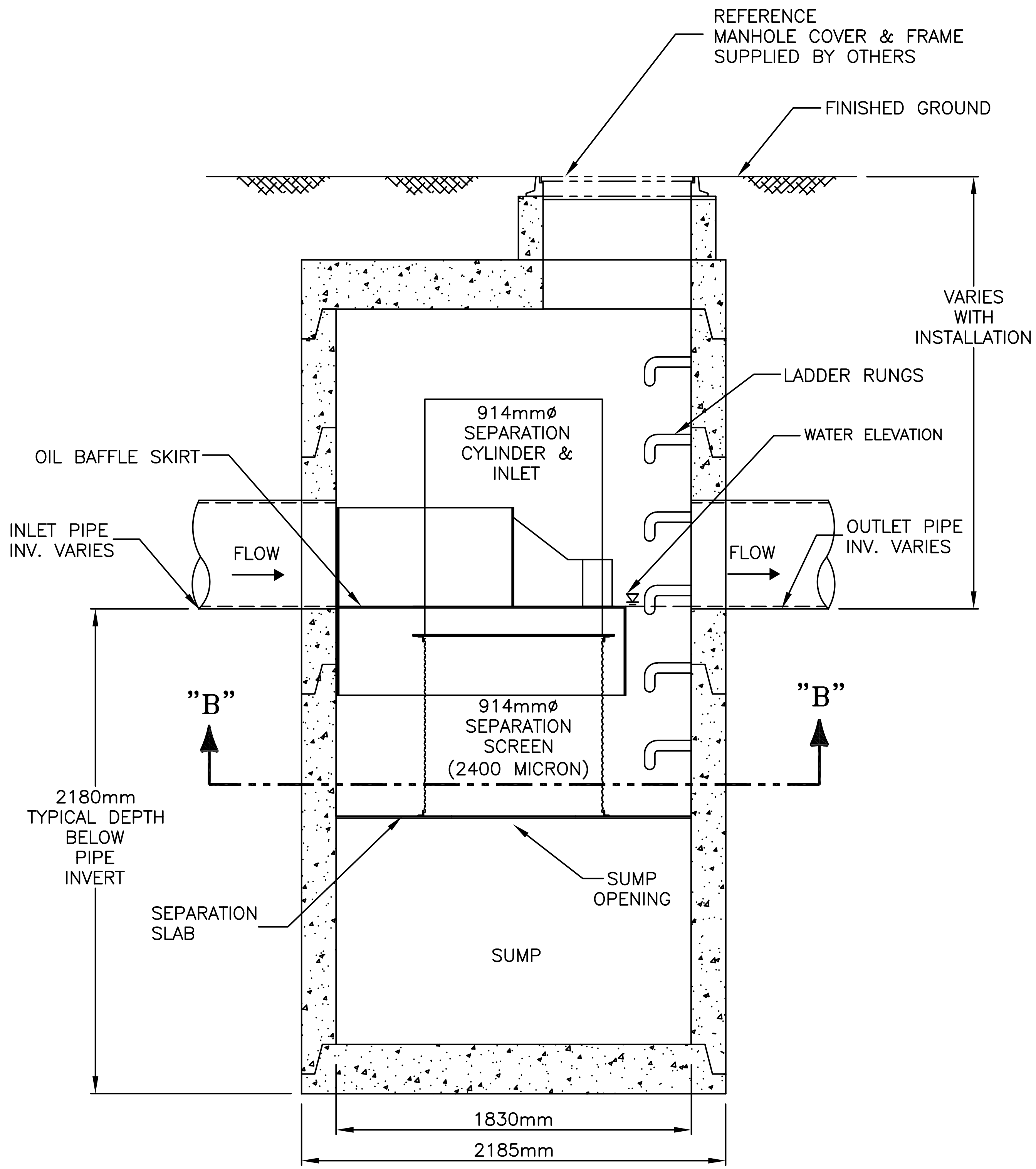
Year	Removal
1960	95%
1961	92%
1962	93%
1963	95%
1964	96%
1965	95%
1966	95%
1967	97%
1968	96%
1969	96%
1970	94%
1971	95%
1972	95%
1973	97%
1974	95%
1975	97%
1976	96%
1977	95%
1978	97%
1979	93%
1980	94%
1981	95%
1982	96%
1983	95%
1984	97%
1985	95%
1986	94%
1987	96%
1988	95%
1989	96%
1990	94%
1991	94%
1992	96%
1993	95%
1994	97%
1995	98%
1996	97%
1997	96%
1998	94%
1999	96%
2000	96%
2001	95%
2002	97%
2003	95%
2004	93%
2005	93%
2006	95%
2007	95%
2008	96%
2009	94%
Average	**95%**

Runoff Treated

Year	Treated
1960	100%
1961	81%
1962	100%
1963	86%
1964	89%
1965	85%
1966	100%
1967	92%
1968	93%
1969	96%
1970	64%
1971	95%
1972	82%
1973	100%
1974	84%
1975	89%
1976	100%
1977	96%
1978	97%
1979	100%
1980	100%
1981	96%
1982	87%
1983	100%
1984	100%
1985	85%
1986	100%
1987	88%
1988	100%
1989	95%
1990	100%
1991	91%
1992	90%
1993	92%
1994	89%
1995	81%
1996	100%
1997	86%
1998	94%
1999	93%
2000	89%
2001	89%
2002	87%
2003	96%
2004	94%
2005	82%
2006	80%
2007	92%
2008	92%
2009	87%
Average	**92%**

ETV Particle Size Distribution:

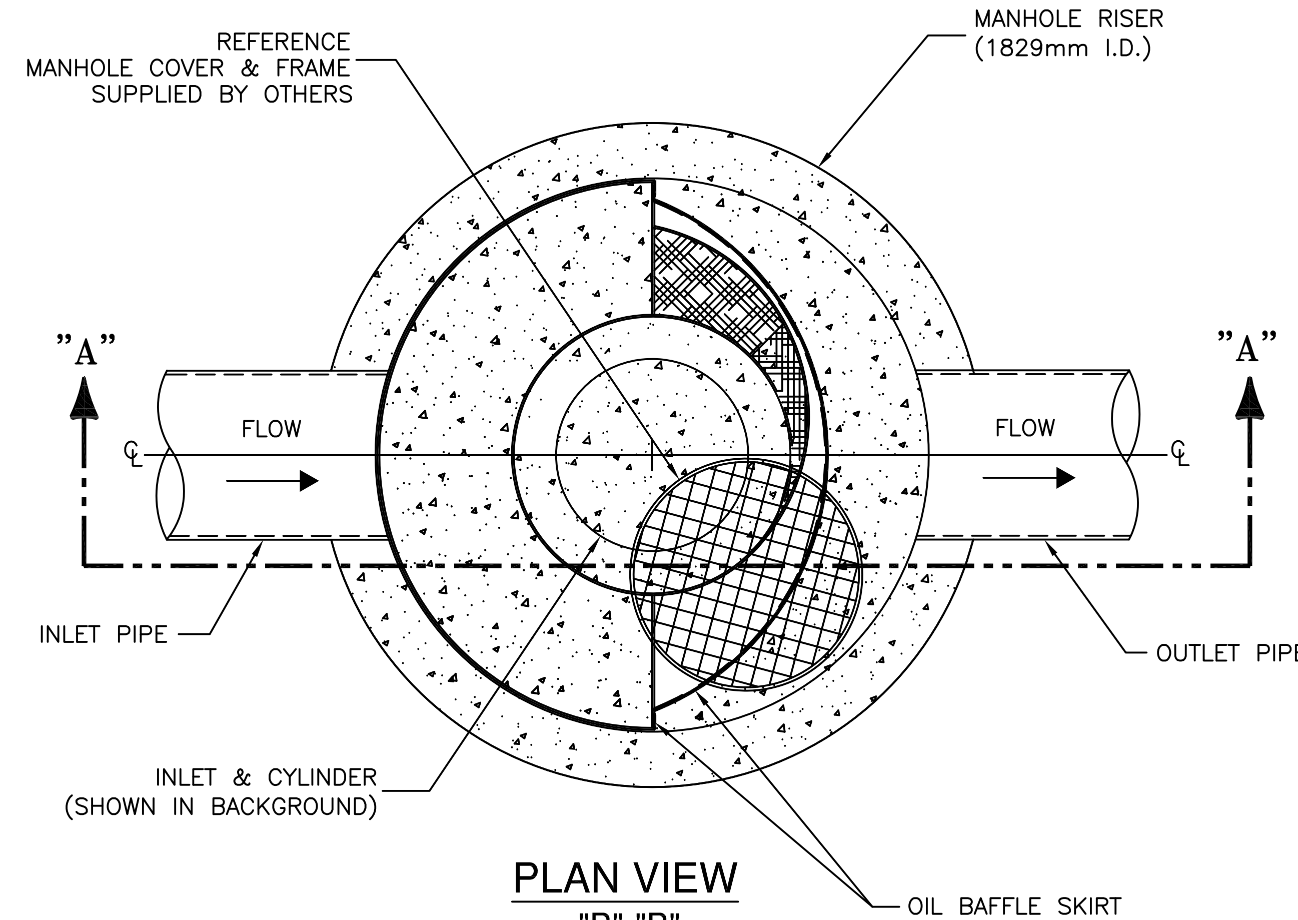
Particle Size Fraction (um)	Percent
500-1000	5
250-500	5
150-250	15
100-150	15
75-100	10
50-75	5
20-50	10
8-20	15
5-8	10
2-5	5
<2	5



ELEVATION VIEW

"A"-"A"

NOT TO SCALE



PLAN VIEW

"B"-"B"

NOT TO SCALE

DESIGN NOTES

1. THE STANDARD RWM3025 CONFIGURATION IS SHOWN. ALTERNATE CONFIGURATIONS ARE AVAILABLE, PLEASE CONTACT RAINWATER MANAGEMENT. SOME CONFIGURATIONS MAY BE COMBINED TO SUIT SITE REQUIREMENTS.
2. THE UNIT CAN HANDLE A TOP INLET, MULTIPLE INLET PIPES AND CAN ACCOMODATE INLET PIPES AT AN ANGLE TO THE OUTLET.

GENERAL NOTES

1. RAINWATER MANAGEMENT TO PROVIDE ALL MATERIALS UNLESS NOTED OTHERWISE.
2. ALL DIMENSIONS ARE SHOWN IN MILLIMETERS.
3. FOR FABRICATION DRAWINGS WITH DETAILED STRUCTURE DIMENSIONS AND WEIGHTS, PLEASE CONTACT RAINWATER MANAGEMENT REPRESENTATIVE. www.rainwatermanagement.ca
4. WATER QUALITY STRUCTURE SHALL BE IN ACCORDANCE WITH ALL DESIGN DATA AND INFORMATION CONTAINED IN THIS DRAWING.
5. STRUCTURE AND CASTINGS SHALL MEET LOAD RATINGS AS REQUIRED, ASSUMING GROUNDWATER ELEVATION AT, OR BELOW THE OUTLET PIPE INVERT ELEVATION. ENGINEER OF RECORD TO CONFIRM ACTUAL GROUNDWATER ELEVATION.
6. MANHOLE MANUFACTURED TO ASTM C478 SPECIFICATIONS.

INSTALLATION NOTES

1. ANY SUB–BASE, BACKFILL DEPTH, AND/OR ANTI–FLOTATION PROVISIONS ARE SITE–SPECIFIC DESIGN CONSIDERATIONS AND SHALL BE SPECIFIED BY THE ENGINEER OF RECORD.
2. CONTRACTOR TO PROVIDE EQUIPMENT WITH SUFFICIENT LIFTING AND REACH CAPACITY TO LIFT AND SET THE MANHOLE STRUCTURE (LIFTING CLUTCHES PROVIDED). HEAVIEST LIFT TO PLAN FOR IS 7500kg.
3. CONTRACTOR TO ADD GASKETS OR JOINT SEALANT BETWEEN ALL STRUCTURE SECTIONS, AND ASSEMBLE STRUCTURE.
4. CONTRACTOR TO PROVIDE, INSTALL, AND GROUT PIPES, MATCH PIPE INVERTS WITH ELEVATIONS SHOWN.
5. CONTRACTOR TO TAKE APPROPRIATE MEASURES TO ASSURE UNIT IS WATER TIGHT, HOLDING WATER TO FLOWLINE INVERT MINIMUM. IT IS SUGGESTED THAT ALL JOINTS BELOW PIPE INVERTS ARE GROUTED.

SITE SPECIFIC DATA REQUIREMENTS FOR RWM3025-6

STRUCTURE ID		PIPE DATA:	I.E.	MATERIAL	DIAMETER
WATER QUALITY FLOW RATE (L/S)	*	INLET PIPE 1	*	*	*
PEAK FLOW RATE (L/S)	*	INLET PIPE 2	*	*	*
RETURN PERIOD OF PEAK FLOW (YRS)	*	OUTLET PIPE	*	*	*
SCREEN APERTURE (2400)	*	RIM ELEVATION			*

ANIT-FLOTATION BALLAST	WIDTH	HEIGHT
	*	*

NOTES / SPECIAL REQUIREMENTS

* PER ENGINEER OF RECORD

rainwater MANAGEMENT

www.rainwatermanagement.ca

TEL : 604–944–9265

RWM3025-6 INLINE UNIT STANDARD DETAIL

Plotted:

rainwater MANAGEMENT

To: LGN Consulting Engineering
From: Rainwater Management
Date: 26-Nov-21

Project City: Calgary
Designation: South OGS
Revision: **0**

Re: Foothills County Residential

Sizing Estimate Package

Engineering Information:

1) Particle Size Distribution: 85% removal of the ETV particle size distribution *

2) Site Criteria and Results:

Drainage Area (ha)	Total Imperviousness (%)	RWM Model	Avg. Net Annual TSS % Removal Estimate	Avg. % Rainfall Volume Treated
9.20	52%	4030-8	95%	92%

3) EPA SWWM Design Criteria:

Flow (l/s)	Slope (%)	Imperv./Perv. Depression Storage (mm)	Imperv./Perv. Manning's n	Min/Max Infiltration Rate (mm/hr)	Decay Rate	Daily Evaporation Rate (mm)
644	2%	1.6/3.2	0.015/0.25	75/7.5	0.00115	2.54

Design Parameters:

1) The unit for this project has been designed to remove a minimum 85% TSS annually for every year on record from a minimum 90 % of the total runoff volume over the period of record. This is based on the requirements defined in the City of Calgary.

2) This unit provides removal for small, frequent storm events that represent the majority of annual rainfall volume and pollutant load. Treatment continues for large, infrequent events; however, such events have little impact on the average annual TSS removal as they represent a small percentage of the total runoff volume and pollutant load.

3) The peak flows will be conveyed through the unit without re-suspending the previously trapped pollutants. The sediment storage sump is separate from the high flow area.

4) Max. nominal pipe sizes reflect, or in part, City of Calgary Max. Pipe Sizes In Round Manholes (Rev 2) Max. inlet and outlet pipe diameter for 180 Deg. pipe configuration is 1650mm/1500mm (Conctete/PVC) and for 90 Deg. pipe configuration is 1050mm/1050mm.

* ETV particle size distribution utilized, or in part, shown on Page 9.

City of Calgary Checklist:

7) The unit is designed to operate in free flow conditions but can also handle submerged or backwater conditions without resuspending previously captured material. This condition is met.

8) The unit will treat a minimum 90 % of the total runoff volume over the period of record. This condition is met.

9) The unit has a minimum annual TSS removal rate of 85 % for each and every year. This condition is met.

10) Average volume treated = Area x Conversion Factor x Avg. Annual Precipitation x Total Imperviousness x Avg. Volume Treated from Page 8.

Drainage Area (ha)	Conversion Factor	Agv. Annual Precipitation (mm)	Total Imperviousness (%)	Avg. % Volume Treated as per p.8	Avg. Volume Treated (m3)
9.20	10	400	52%	92%	17,517

Average annual sediment removed = Avg. Volume Treated x Avg. Removal Efficiency from Page 8 x Sediment Concentration.

Avg. Volume Treated (m3)	Avg. Removal Efficiency as per p.8	Sediment Concentration (kg/m3)	Avg. Annual Sediment Removed (kg)	RWM Model Sump Capacity (kg)	Sump Capacity Condition
17,517	95%	0.444	7,379	11,301	Condition Met

11) The allowable treatment flow:

RWM Model	Manhole Diameter (mm)	Max Hydraulic Loading Rate (l/s/m2)	Allowable Treatable Flow (l/s)	Allowable Treatment Flow Condition
4030-8	2,440	27	126.3	Condition Met

12) Items a and b are covered in the attached tables. Item c is covered in requirement 10 above. These conditions are met.

13) A product guide is enclosed. This condition is met.

Sizing Summary:

The unit is a hydrodynamic separator that combines screening and enhanced gravity settling to remove floating, neutrally buoyant and non-buoyant solids from stormwater runoff. The non-blocking screen captures 100% of the pollutants equal to the screen aperture size (2400 microns) and larger. All non-buoyant solids are directed to a sump that separates the captured pollutants from the treatment flow path to prevent the larger storm events from re-suspending previously trapped material. The floatable debris and oil/grease are trapped upstream of the baffle for easy removal.

The unit can be installed as a bend structure and can accommodate multiple inlets.

The unit can operate with no drop between the inlet and outlet; however, can accommodate a drop without issue. The typical 0.03m drop through City of Calgary manholes can easily be accommodated and any drop (if any) will be reflected in the approval drawing.

Maintenance is a key to any systems proper long-term effectiveness. The unit allows for easy access without confined space requirements. Rainwater Management is available to train a maintenance crew or to provide regular inspection/maintenance services.

Rainwater Management is happy to provide further information if required.

Kind Regards,

Peter Law P.Eng.

2021-11-26

Permit to Practice Rainwater Management Ltd. Permit Number P11426

This report confirms that the above stormwater unit is designed to the manufacturer’s specifications to meet the design criteria.

Annual Runoff/Year in Cubic Meters

Flow l/s	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	Flow l/s
1	100	63	29	74	82	139	86	42	57	55	45	102	1
2	174	153	167	130	218	256	171	169	219	302	227	210	2
3	484	237	106	264	270	562	259	170	233	279	164	377	3
4	190	141	214	198	352	443	295	182	262	337	382	257	4
5	140	126	159	218	254	497	207	149	270	424	209	175	5
6	105	174	155	164	520	576	301	171	138	410	231	235	6
7	428	164	165	352	414	623	412	116	255	375	326	283	7
8	351	135	84	165	342	618	162	108	355	378	220	516	8
9	210	215	0	336	214	456	338	153	122	302	92	334	9
10	204	138	236	276	345	442	407	66	266	340	342	236	10
11	75	73	228	340	227	370	267	187	151	379	415	39	11
12	250	41	43	373	250	542	544	212	166	329	168	339	12
13	0	43	135	134	133	359	270	44	138	224	222	228	13
14	147	291	148	290	144	47	142	96	50	192	144	336	14
15	106	0	105	211	366	156	315	155	209	155	155	102	15
18	357	295	229	592	525	708	883	185	419	827	239	233	18
20	272	269	70	347	139	553	600	137	411	819	208	337	20
25	318	540	394	402	885	1258	490	718	1547	1608	418	648	25
30	1386	498	996	590	378	791	491	700	301	609	602	578	30
35	1171	572	350	690	816	358	724	232	362	576	0	936	35
40	1744	132	256	402	529	1514	537	0	395	567	0	959	40
45	759	762	146	1062	158	625	159	152	298	442	305	752	45
50	334	837	0	353	524	1548	175	335	175	174	353	342	50
75	681	2352	1344	3250	1054	652	3569	597	1902	2732	1113	465	75
80	0	282	0	271	280	0	281	284	271	0	0	0	80
90	0	952	639	0	0	593	323	0	299	0	0	0	90
100	0	329	0	0	993	0	331	0	0	0	340	686	100
125	802	1215	882	761	0	1905	0	0	0	0	1238	804	125
230	0	1323	0	0	0	1253	0	481	687	519	523	519	230
335	0	0	0	2017	0	0	0	0	0	0	1185	0	335
440	0	1329	0	0	1343	0	0	0	0	0	1296	0	440
545	0	0	0	0	0	1600	0	0	0	0	1590	0	545
650	0	0	0	0	0	0	0	0	0	0	0	0	650
650 +	0	0	0	0	0	0	0	0	0	0	0	0	650 +
Total Runoff	**10787**	**13680**	**7278**	**14263**	**11751**	**19445**	**12738**	**5844**	**9956**	**13355**	**12749**	**11027**	**Total Runoff**

Annual Runoff/Year in Cubic Meters

1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	Flow l/s
100	88	54	80	71	98	111	57	66	76	111	55	63	1
261	259	214	298	297	264	401	149	236	333	264	181	268	2
322	303	176	274	304	260	276	184	236	305	313	162	311	3
319	287	221	304	300	244	297	189	332	224	263	106	120	4
302	195	215	271	330	401	532	211	224	379	255	295	276	5
193	331	185	354	338	234	384	98	156	296	215	134	425	6
165	299	260	139	353	326	233	73	304	378	326	141	168	7
240	319	325	271	295	268	241	163	185	348	78	56	467	8
585	275	152	433	394	303	546	152	154	369	363	214	275	9
238	205	272	232	204	308	473	169	203	370	276	68	443	10
111	188	187	230	224	153	336	0	185	265	340	0	230	11
250	287	539	294	250	162	286	287	245	293	414	161	167	12
362	45	44	268	270	498	269	90	226	178	179	134	89	13
96	290	97	147	293	194	293	98	437	96	194	196	0	14
313	157	105	418	104	524	469	51	364	310	260	209	155	15
512	246	304	490	712	363	874	110	706	1198	598	410	291	18
345	346	275	328	684	206	1218	276	208	813	201	419	627	20
1247	1048	329	478	571	1195	2233	80	482	970	642	696	969	25
318	1400	92	592	582	498	854	303	594	510	682	393	773	30
1196	951	352	112	582	589	1030	469	913	1413	583	229	1061	35
518	270	675	395	280	684	396	538	542	408	395	0	405	40
616	451	1070	155	160	0	1340	615	924	307	1073	469	611	45
836	497	0	175	524	837	509	0	165	334	843	167	507	50
1289	651	702	745	2898	947	906	1115	2852	3881	852	1457	1104	75
0	0	281	0	563	0	0	281	842	557	0	0	271	80
323	580	906	323	0	0	0	0	312	608	0	0	0	90
0	0	332	359	0	690	0	338	689	326	0	0	0	100
820	0	0	0	0	1148	0	834	802	416	412	403	0	125
2577	0	712	1049	0	489	496	0	0	594	1554	0	0	230
0	0	903	0	0	0	0	0	0	0	0	0	0	335
0	0	0	0	0	0	0	0	0	0	0	0	0	440
0	0	0	0	0	0	0	0	0	0	0	0	0	545
0	0	0	0	0	0	0	0	0	0	0	0	0	650
0	0	0	0	0	0	0	0	0	0	0	0	0	650 +
14452	**9966**	**9978**	**9212**	**11582**	**11881**	**15003**	**6929**	**13585**	**16555**	**11686**	**6755**	**10076**	**Total Runoff**

Annual Runoff/Year in Cubic Meters

1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	Flow l/s
54	56	53	64	108	80	88	87	73	72	60	83	87	1
321	233	291	301	361	281	153	350	328	342	325	296	234	2
332	267	162	378	259	346	281	413	255	261	355	454	238	3
258	236	232	260	625	297	303	344	269	259	223	719	204	4
210	194	162	145	213	112	195	312	286	280	399	334	239	5
252	203	295	226	276	158	159	676	403	394	595	495	281	6
161	370	119	189	283	411	96	257	186	445	339	230	332	7
191	271	189	291	136	166	272	359	357	246	295	244	237	8
458	431	92	92	211	178	122	181	764	304	359	491	244	9
171	668	139	273	303	275	171	167	582	547	203	368	238	10
304	612	187	112	149	111	150	265	603	522	225	229	74	11
293	247	376	83	288	206	331	81	0	42	293	246	978	12
136	225	179	45	135	135	270	270	271	221	226	224	224	13
96	98	100	293	195	49	194	147	195	193	715	192	193	14
52	155	159	207	156	360	156	209	156	313	106	264	259	15
348	421	699	650	471	475	596	536	709	412	1134	700	596	18
351	407	482	620	202	205	142	808	272	267	269	208	141	20
561	563	883	1002	415	984	575	1347	652	165	1192	169	1781	25
693	897	378	485	886	799	793	1150	494	606	461	416	868	30
233	353	1056	1059	580	696	697	700	1406	568	0	238	235	35
0	953	423	666	134	278	141	407	523	264	272	530	388	40
771	305	305	465	0	611	160	892	617	463	0	160	1085	45
509	665	519	1182	507	347	850	349	344	0	0	167	495	50
1782	4625	1500	2182	568	920	1961	2117	615	815	0	1092	1415	75
281	0	0	563	281	280	564	0	559	280	0	0	281	80
613	914	0	1214	911	0	300	293	297	0	902	291	0	90
340	0	349	0	0	358	675	345	988	0	0	0	0	100
368	808	0	0	0	1280	386	418	380	0	0	0	447	125
1842	0	1294	0	468	0	1126	1520	0	1058	2038	0	515	230
0	0	0	0	0	0	0	0	1037	0	0	0	0	335
0	0	0	0	0	0	0	0	0	0	0	0	1363	440
0	0	0	0	0	0	0	0	0	0	0	0	0	545
0	0	0	0	0	0	0	0	0	0	0	0	0	650
0	0	0	0	0	0	0	0	0	0	0	0	0	650 +
11982	**15176**	**10622**	**13047**	**9121**	**10399**	**11908**	**15000**	**13620**	**9337**	**10985**	**8841**	**13670**	**Total Runoff**

Annual Runoff/Year in Cubic Meters

1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
91	88	84	38	78	76	51	62	94	96	98	60
271	321	245	191	269	240	263	248	206	268	320	146
303	475	214	177	290	254	195	242	311	327	307	385
346	339	257	375	402	372	303	260	254	259	350	231
389	530	406	246	155	268	183	310	176	301	507	109
417	257	212	422	272	260	297	177	135	239	618	236
189	547	259	92	259	204	161	237	347	475	442	327
322	884	193	108	241	456	298	79	328	295	690	187
301	553	215	182	184	152	59	246	188	271	431	180
236	611	271	207	172	476	173	170	239	169	312	465
191	373	342	338	192	454	152	298	112	268	453	76
455	43	204	252	168	707	40	40	124	420	460	43
360	316	136	45	133	266	360	316	46	223	229	134
99	95	195	386	290	147	290	287	196	245	287	47
367	262	0	367	105	155	261	256	209	158	157	52
462	582	774	295	640	994	597	765	415	608	827	465
681	417	735	343	66	339	614	738	0	680	689	68
899	0	1038	664	858	714	673	1274	725	492	572	638
684	295	998	288	390	395	393	971	1181	684	481	0
1523	1139	116	594	350	560	235	614	691	930	465	125
819	561	820	519	411	414	537	676	535	535	555	0
2009	895	606	306	456	770	154	905	300	1050	907	152
829	531	0	175	164	0	0	519	522	701	691	0
1322	2254	1693	922	444	855	407	791	1822	879	2321	262
551	0	0	0	277	281	281	282	845	826	0	0
1195	317	0	0	290	594	626	1194	0	606	0	311
1024	0	684	355	0	1350	715	1026	325	1367	0	1042
1228	0	361	421	0	406	1558	2767	366	0	396	406
1049	1023	569	452	1137	468	636	0	2700	1207	1186	0
0	0	867	1121	0	0	0	2071	0	0	0	924
0	0	0	0	0	0	0	1273	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
18614	**13709**	**12495**	**9884**	**8692**	**12625**	**10513**	**19094**	**13392**	**14578**	**14751**	**7069**

TSS Removal	
Year	Removal
1960	95%
1961	92%
1962	93%
1963	94%
1964	95%
1965	95%
1966	95%
1967	96%
1968	96%
1969	96%
1970	94%
1971	95%
1972	95%
1973	96%
1974	95%
1975	96%
1976	95%
1977	94%
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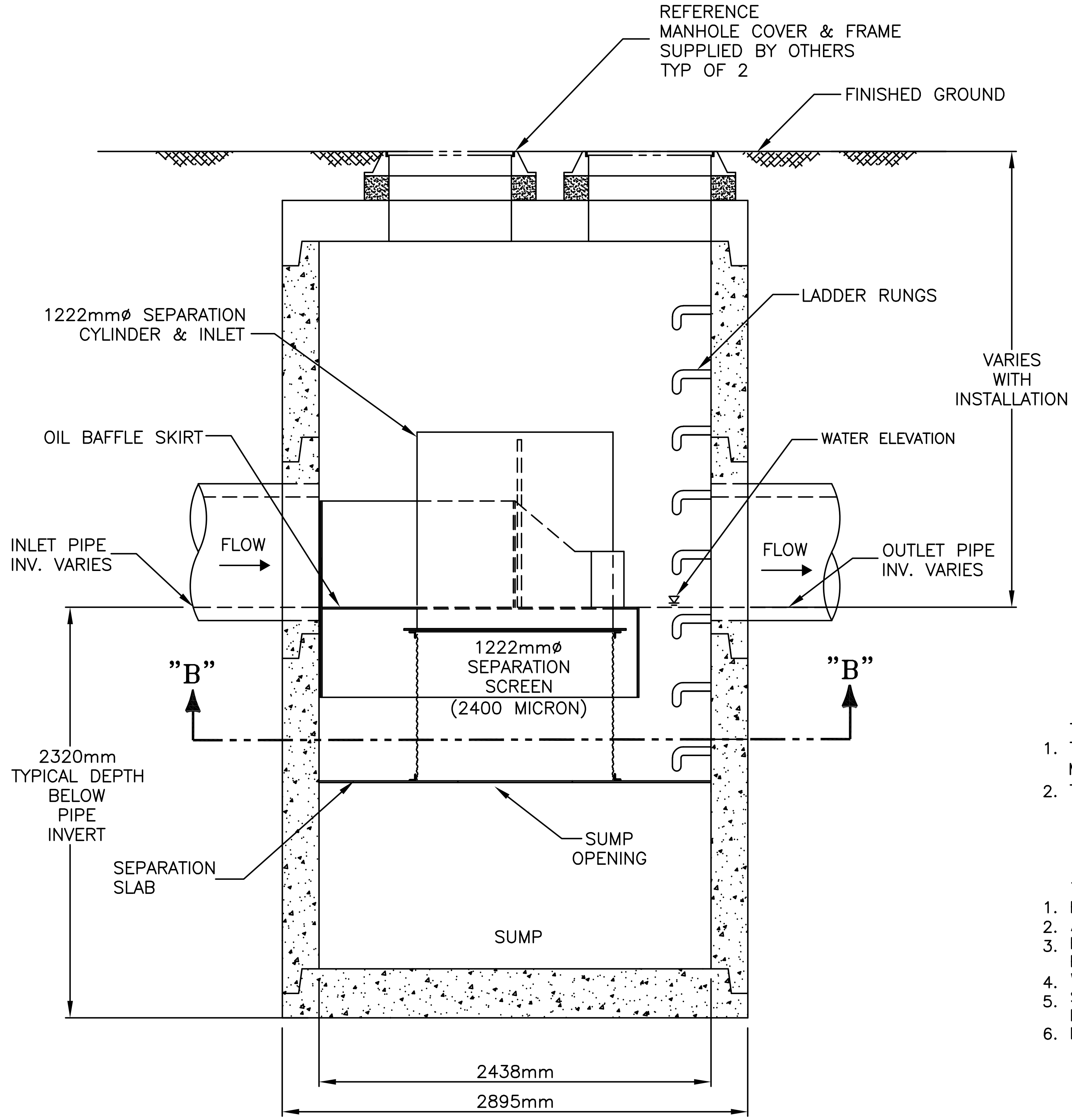
1994	97%
1995	97%
1996	97%
1997	96%
1998	93%
1999	96%
2000	95%
2001	95%
2002	97%
2003	94%
2004	93%
2005	92%
2006	94%
2007	94%
2008	96%
2009	94%
Average	**95%**

Runoff Treated	
Year	Treated
1960	100%
1961	81%
1962	100%
1963	86%
1964	89%
1965	85%
1966	100%
1967	92%
1968	93%
1969	96%
1970	64%
1971	95%
1972	82%
1973	100%
1974	84%
1975	89%
1976	100%
1977	96%
1978	97%
1979	100%
1980	100%
1981	96%
1982	87%
1983	100%
1984	100%
1985	85%
1986	100%
1987	88%
1988	100%
1989	95%
1990	100%
1991	91%
1992	90%
1993	92%
1994	89%
1995	81%
1996	100%
1997	86%
1998	94%
1999	93%
2000	89%
2001	84%
2002	87%
2003	96%
2004	94%
2005	82%
2006	80%
2007	92%
2008	92%
2009	87%
Average	**92%**

ETV Particle Size Distribution:

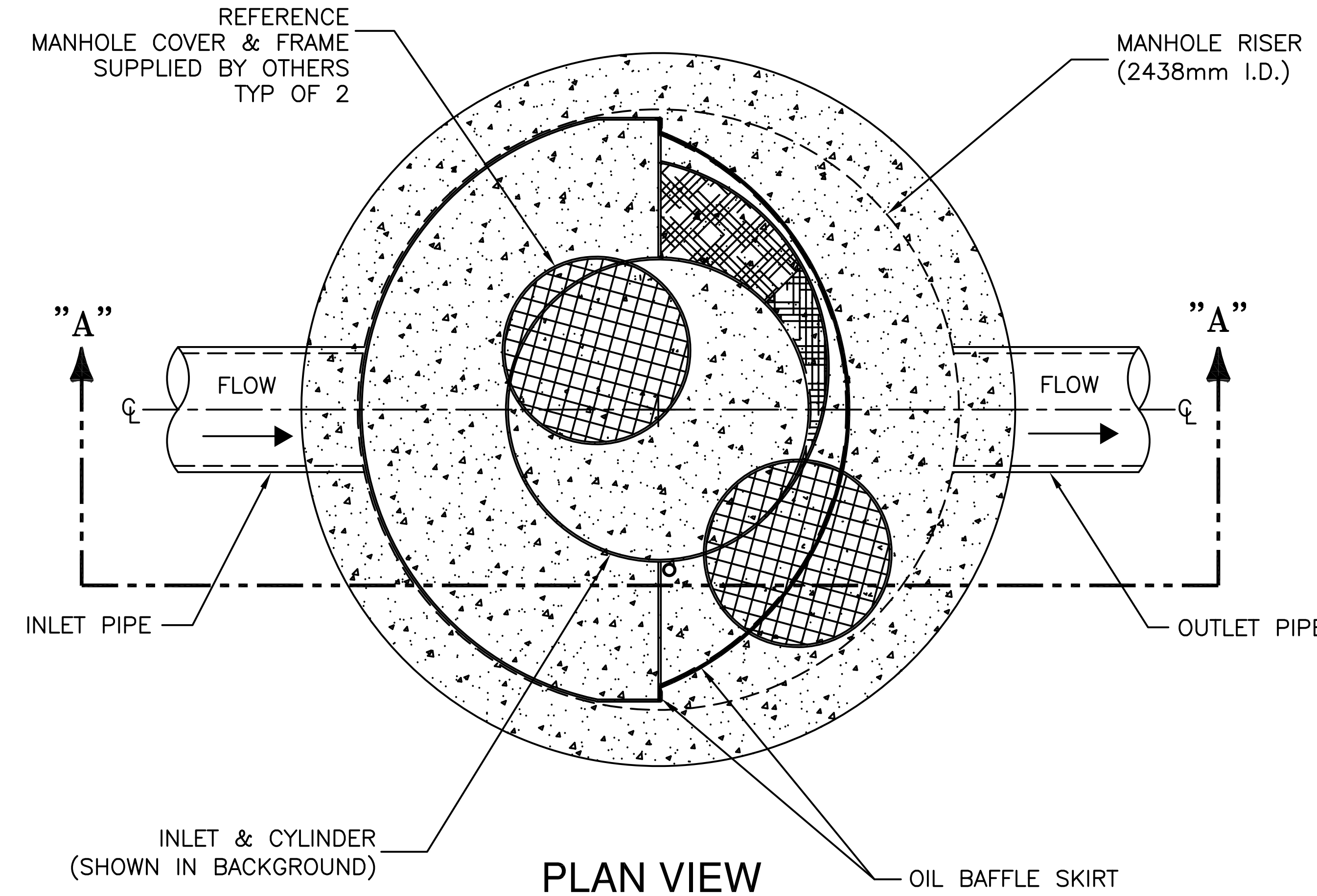
Particle Size Fraction (um)	Percent
500-1000	5
250-500	5
150-250	15
100-150	15
75-100	10
50-75	5
20-50	10
8-20	15
5-8	10
2-5	5
<2	5



ELEVATION VIEW

"A"-"A"

NOT TO SCALE



PLAN VIEW

"B"-"B"

NOT TO SCALE

DESIGN NOTES

1. THE STANDARD RWM4030 CONFIGURATION IS SHOWN. ALTERNATE CONFIGURATIONS ARE AVAILABLE, PLEASE CONTACT RAINWATER MANAGEMENT. SOME CONFIGURATIONS MAY BE COMBINED TO SUIT SITE REQUIREMENTS.
2. THE TREATMENT UNIT CAN HANDLE MULTIPLE INLET PIPES AND CAN ACCOMODATE INLET PIPES AT AN ANGLE TO THE OUTLET.

GENERAL NOTES

1. RAINWATER MANAGEMENT TO PROVIDE ALL MATERIALS UNLESS NOTED OTHERWISE.
2. ALL DIMENSIONS ARE SHOWN IN MILLIMETERS.
3. FOR FABRICATION DRAWINGS WITH DETAILED STRUCTURE DIMENSIONS AND WEIGHTS, PLEASE CONTACT YOUR RAINWATER MANAGEMENT PRODUCTS REPRESENTATIVE. www.rainwatermanagement.ca
4. WATER QUALITY STRUCTURE SHALL BE IN ACCORDANCE WITH ALL DESIGN DATA AND INFORMATION CONTAINED IN THIS DRAWING.
5. STRUCTURE AND CASTINGS SHALL MEET HS20 LOAD RATINGS, ASSUMING GROUNDWATER ELEVATION AT, OR BELOW THE OUTLET PIPE INVERT ELEVATION. ENGINEER OF RECORD TO CONFIRM ACTUAL GROUNDWATER ELEVATION.
6. MANHOLE MANUFACTURED TO ASTM 478 SPECIFICATIONS.

INSTALLATION NOTES

1. ANY SUB-BASE, BACKFILL DEPTH, AND/OR ANTI-FLOTATION PROVISIONS ARE SITE-SPECIFIC DESIGN CONSIDERATIONS AND SHALL BE SPECIFIED BY THE ENGINEER OF RECORD.
2. CONTRACTOR TO PROVIDE EQUIPMENT WITH SUFFICIENT LIFTING AND REACH CAPACITY TO LIFT AND SET THE MANHOLE STRUCTURE (LIFTING CLUTCHES PROVIDED). HEAVIEST LIFT TO PLAN FOR IS 12,540kg.
3. CONTRACTOR TO ADD GASKETS OR JOINT SEALANT BETWEEN ALL STRUCTURE SECTIONS, AND ASSEMBLE STRUCTURE.
4. CONTRACTOR TO PROVIDE, INSTALL, AND GROUT PIPES, MATCH PIPE INVERTS WITH ELEVATIONS SHOWN.
5. CONTRACTOR TO TAKE APPROPRIATE MEASURES TO ASSURE UNIT IS WATER TIGHT, HOLDING WATER TO FLOWLINE INVERT MINIMUM. IT IS SUGGESTED THAT ALL JOINTS BELOW PIPE INVERTS ARE GROUTED.

SITE SPECIFIC DATA REQUIREMENTS FOR RWM4030-8

STRUCTURE ID		PIPE DATA:	I.E.	MATERIAL	DIAMETER
WATER QUALITY FLOW RATE (L/S)	*	INLET PIPE 1	*	*	*
PEAK FLOW RATE (L/S)	*	INLET PIPE 2	*	*	*
RETURN PERIOD OF PEAK FLOW (YRS)	*	OUTLET PIPE	*	*	*
SCREEN APERTURE (2400)	*	RIM ELEVATION			*

ANIT-FLOTATION BALLAST	WIDTH	HEIGHT
	*	*

NOTES / SPECIAL REQUIREMENTS

* PER ENGINEER OF RECORD

rainwater MANAGEMENT

www.rainwatermanagement.ca

TEL : 604-944-9265

INLINE RWM 4030-8 STANDARD DETAIL

Plotted: