ASCENSION
STAGED MASTER DRAINAGE PLAN

Prepared for:

HIGHFIELD LAND MANAGEMENT

Prepared by:

LGN Consulting Engineering Ltd.
stormwater and water resources management

August 2020

Project LGN2009

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1.0 INTRODUCTION

1.1 General

Highfield Land Management Inc. is currently in the process of developing Ascension, a mixed use residential development within Rocky View County. LGN Consulting Engineering Ltd. (LGN) was retained to prepare a Staged Master Drainage Plan report (SMDP) for the above noted development. The SMDP outlines the drainage concept to accommodate the runoff generated by the sub-catchments within the Ascension development and offsite lands flowing through the proposed development. It also provides design information for the associated stormwater management facility (SWMF or Pond).

The following reports have set the guidelines for stormwater management for land development in the Bearspaw area:

- Worley Parsons; Bearspaw – Glenbow Master Drainage Plan; June 2010.
- ISL Engineering and Land Services, Rocky View County; Glenbow Ranch ASP Master Drainage Plan; January 2017.
- Kerr Wood Leidal Associates Ltd; Haskayne Master Drainage Plan; November 2017.

This SMDP complies with all the criteria's set by the above noted reports. Information on the type, size and performance characteristics of the SWMF is also presented and, in combination with the drainage concept for the area, forms the basis for future development within the study area. As required by Rocky View County and Alberta Environment and Sustainable Resource Development (Alberta ESRD), this analysis evaluates the control of discharge of stormwater runoff and stormwater quality enhancement prior to discharge to the receiving water body.

1.2 Study Area

The study area is located in Rocky View County, immediately west of the City of Calgary, south of Highway 1A. Is bound by Highway 1A on the north, 12 Mile Coulee Road and the Community of Tuscany on the east, Blueridge country residential development on the south and undeveloped lands on the west. The site is located within the E ½ Sec. 19-25-2-W5M and currently is being cultivated.

Figure 1 shows the location of the proposed development relative to Rocky View County and the City of Calgary, **Figure 2** shows the Study Area relative to the existing surrounding communities, **Figure 3** shows the proposed Land Use Concept Plan provided by b&a Planning Group (**b&a**).

1.3 Topography

The site naturally drains from north to south and towards the natural drainage course at the centre of the site. Elevations range from 1245 m (±) at the north to 1182 (±) at the south. The natural drainage course enters the site on the north as a low grass swale and exists the site as a steep narrow ravine with slopes ranging from 15 – 25 %; **Figure 4** shows the existing contours and drainage pattern.

1.4 Scope of Analysis

Rocky View County requires an SMDP in support of a land development Concept Plan. The SMDP addresses a component of the area included in a major storm catchment. The SMDP involves a more 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. This information is addressed in concept in the overall Master Drainage Plan for a larger area, and in detail for the smaller component area of the SMDP.

The location, shape and hydraulic characteristics of the SWMF for the Ascension development are defined in this report. The anticipated volume control and water quality enhancement for the SWMF under ultimate development conditions is also assessed. All these must meet Alberta ESRD and Rocky View County requirements.

Activities performed in preparation of this analysis:

- Outline pre-development subcatchment boundaries.
- Hydrologic model to establish pre-development flows and wetland hydroperiods.
- Establish post-development drainage boundaries and catchment areas draining to each SWMF.
- Hydrologic modeling to estimate the runoff and water quality from the study catchment area utilizing both single and continuous computer simulation modeling.
- Hydraulic modeling to estimate stormwater storage volume required and anticipated operation of the SWMF.
- Estimate anticipated annual average volume discharge 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 land use distribution and location of the SWMFs has been defined by the Concept Plan provided by b&a (**Figure 3**)

The study addresses overall surface water runoff in the study area to assess the operation of the SWMF presented in this report. No structural or hydrogeological engineering considerations, assessment of subsurface drainage conditions, the underground piped drainage system or the drainage of individual development lots was undertaken by this study.

2.0 Pre-development Hydrologic Assessment

2.1 Methodology

A pre-development analysis of the study area was conducted to establish key stormwater management conditions and targets in support of the proposed development, and will provide the basis for evaluating the impacts of post-development discharges to potential natural drainage connections and pre-development drainage courses in the study area. The key stormwater conditions to be established are the maximum unit release rate for the development area in terms of L/s/ha and the volumetric release rate in terms of average mm/year.

The following basic steps were taken in the analysis:

* Gather and review relevant background data.
* Review City Guidelines and Province Guidelines for appropriate modeling parameters.
* Establish potential overland flow paths.
* Compile results for appropriate reporting tables and graphs.

2.2 Data Sources

The following key sources of information were used:

* Topographical data prepared using 2015 LiDAR was utilized to determine sub-catchment boundaries for significant pre-development drainage courses and their surface drainage connections, as well as to estimate sub-catchment slopes, flow lengths, and widths; this information was necessary for hydrologic modeling.
* Land cover data was determine from site visits.
* The Green amp infiltration parameters used in the pre-development PCSWMM model were obtained from the Haskayne Master Drainage Plan.

2.3 Pre-development Study Area

The pre-development catchment area is 154.20 ha of land that is mainly being used as agricultural land. Based on contours generated from a topographical data, the pre-development study area was divided into 4 subcatchments; three discharging into the natural drainage course and the fourth one into the existing wetland. The land cover imperviousness values utilized are in the Table below:

Table 1 - Land Cover Imperviousness Values

Land Cover Type	Percent Imperviousness (%)
Vegetated and/or Cultivated	0
Buildings	100
Gravel Roads	50
Wetlands at HWL	100

Figure 5 illustrates the pre-development subcatchments and **Table 2** lists the model subcatchments and parameters used in the model.

Table 2 – Pre-development Sub-Catchment Parameters

Model ID - Land Use	Area (ha)	Imperviousness (%)	Length (m)	Width (m)	Slope (%)
A1 - Agricultural	67.83	2	412	1646	5
A2 - Agricultural	35.07	0	311	1128	9
A3 - Agricultural	23.46	0	500	469	10
B – Agricultural*	27.84	4	430	647	9
Total	154.20				

* Catchment to Existing Wetland

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

2.4 Drainage Patterns

The Biophysical Impact Assessment (Westhoff, 2017) identified a watercourse within the Project Site. Following is **Section 3.8, Watercourse** out of this report:

> *"We identify a watercourse within the Project Site (Figure 5). The watercourse bisects the Site flowing from the north and exiting along the southwest boundary. The watercourse is classified as "Transitional" based on field observations of a well-defined, non-vegetated channel and flowing water observed on October 12 and November 1, 2016. In a typical transitional watercourse, the banks and non-vegetated channel are well defined, with channel width greater than 0.4 m to 0.7 m; the channel carries flow year round but may freeze in winter or dry up during a drought year (Alberta Environment and Sustainable Resource Development 2012).*
>
> *There are two smaller ravines that meet the central watercourse on its northern boundary. No surface water was observed in the ravines during field surveys; however, there are small isolated patches of wetland vegetation in each ravine. No hydric soils were observed associated with these areas. The ravines are classified as ephemeral watercourses based on field observations and review of historical photographs (Alberta Environment and Sustainable Resource Development 2012).*
>
> *The watercourse and both small ravines have been left mostly undisturbed in all the photographs reviewed. There was historical disturbance of the watercourse between approximately 1977 and 1981. Two dugouts were created along with berms transecting the watercourse and a small culvert was installed in the berm located between the dugouts. Bearspaw Village Road crosses the central watercourse, southwest of the Site; a culvert is present at this crossing."*

2.5 Climate Data and Design Storm

Hourly precipitation and temperature data for the period 1960 to 2014 (55 years) for the City of Calgary were utilized for modeling. The data was provided by the City of Calgary, Development Approvals. Continuous simulation over the 55 years of historic climate data for the City of Calgary was utilized in the stormwater models to estimate runoff volume and peak flow targets from pre-development conditions. PC-SWMM utilizes the hourly time step of the existing data; reporting was provided using an hourly time step.

The City of Calgary 1:100yr 24hr synthetic design storm with a Chicago distribution was used for the single event model analysis. The distribution parameters a, b, & c in the City of Calgary Stormwater Management and Design Manual (2011) are 663.1, 1.87, 0.712 respectively. The time to peak, r, is set to 0.3.

2.6 Model Development

The PCSWMM model was utilized to assess the hydrological importance of pre-development potential surface drainage connections, determine pre-development flow-duration relationships, and to determine the 1:100yr pre-development peak flow rate.

Stormwater runoff calculation parameters used for this study area are based on known site conditions and are consistent with City of Calgary guidelines. A summary of the common input parameters used in each model are:

- Land cover GIS layer for area weighted imperviousness values for sub-catchment boundaries.
- Green-Ampt Infiltration Parameters used in the pre-development analysis were obtained from the approved Haskayne Master Drainage Plan, November 2017 and listed in **Table 3**.

Table 3 – Sandy Loam Infiltration Parameters

	Value				Units
Parameter Subcatchment ID	**A1**	**A2**	**A3**	**B**	
Suction Head (Ψ)	126	270.53	270.69	213.88	mm
Hydraulic Conductivity (K)	0.99	1	0.99	1.68	mm/hr.
Initial Moisture Deficit (IMD)	21	21	0.25	0.29	%

- Depression Storage Parameters: Pervious Surfaces 7.5 mm, Impervious Surfaces 2 mm.
- Manning 'n' Values: Pervious Areas 0.3, Impervious Areas 0.014.

2.7 PCSWMM Peak Runoff Rate

The pre-development peak runoff rate was determined running a single event analysis with the City of Calgary Chicago Design Storm for the 1:100 year 24 hour storm event.

The natural drainage course was modelled as an irregular channel with two (2) representative cross-section extracted from cross-sections and profile generated by a field survey. The runoff from sub-catchments A1 to A3 was routed through the natural channel. Runoff from sub-catchment B was routed through the existing wetland. See **Appendix B** for the PCSWMM model schematic and output files.

2.8 Model Results

This section describes key results of the hydrological analysis. The sub-sections below discuss two primary aspects of the results, namely, drainage courses and overland flow paths.

The results are reflective of the most accurate modeling capabilities readily available from the PC-SWMM modeling software using currently available topography, soil texture, geotechnical, and land cover data for the study area.

Pre-development Peak Runoff Rate

The PC-SWMM model was utilized to obtain the peak runoff rate during a 1:100 year 24 hour single event utilizing a Calgary Chicago Design Storm. The results are tabulated below:

Table 4 - Peak Flow Results

Natural Channel ID	Single Event 24h-100y (m^3/s)
OF-3	2.295
OF-W	0.253
TOTAL	**2.548**

Pre-development Runoff Volume

The average annual runoff volume was calculated as shown in **Table 5**. The total site produced a total of 1,668,911 m^3 over the 55 years of analysis.

Table 5 - PCSWMM Runoff Volume Results

Sub-catchment ID	Area (ha)	Total Volume (m3)	Average Annual Runoff Volume (m3)	Average Annual Runoff Volume (mm)
A1 to A3	126.36	1,535,975	27,927	22
B	27.84	132,936	2,417	9
TOTAL	154.20	1,668,911	30,344	20

2.9 Potential Surface Drainage Connections

The identified drainage course was modeled to determine the hydrologic significance. The continuous simulation analysis results indicate that the flow generated by rainfall is discharged overland to the natural conveyance channel, this is observed during the entire simulation period.

2.10 Summary of Findings for the Existing Conditions

The major findings of the pre-development hydrological analysis are:

- The estimated 1:100yr 24hr existing peak runoff release rate from the study area is 2.548 m^3/s; equivalent to an over all 16.52 L/s/ha release rate for the site.
- Based on a 55 year analysis period (1960-2014), the average annual runoff from the study area is found to be 20 mm based on the PCSWMM model results.

3.0 PROPOSED DRAINAGE STRATEGIES AND DESIGN CRITERIA

3.1 Related Reports

The following reports are associated with the area:

- Worley Parsons; Bearspaw – Glenbow Master Drainage Plan; June 2010.
- Exp Services Inc.; Geotechnical Investigation Report; November 2016.
- Westhoff Engineering Resources Inc.; Biophysical Impact Assessment; July 2017.
- Kerr Wood Leidal Associates Ltd; Haskayne Master Drainage Plan; November 2017.
- Stantec Consulting Ltd.; Haskayne Staged Master Drainage Plan; May 2019.
- IBI Group; Morton Development Staged Master Drainage Plan; July 2020.

3.2 Drainage Strategies

The analysis is based on the following assumptions:

- Post-development peak and runoff volume discharge must not exceed pre-development levels.
- The entire development area will be drained using the Dual Drainage Concept (minor/major system).
- The drainage system is to convey the entire stormwater runoff to the regional 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 to prevent erosion.

3.3 Geotechnical Considerations

Exp Engineering Services Inc. completed a Geotechnical Investigation for the Hawkwood Lands (now known as Ascension) and reported that:

"The subsurface soil conditions encountered were generally found to consist of topsoil overlying lacustrine clay and/or clay till atop bedrock."

"Topsoil-like materials were encountered in all the boreholes, with thicknesses between 0.1 m to 0.6 m. The term "topsoil" in this report refers to a surficial soil layer with high organic content, and does not have any implications whatsoever as to the quality or suitability for re-use as a growing medium. The topsoil was generally described as having trace to some silt and sandy. The topsoil thicknesses have been determined at the borehole locations only. These thicknesses may not necessarily be representative across the project site as they may vary significantly between relatively widely spaced borehole locations. Additional shallow test locations would be needed to more accurately assess the topsoil thicknesses." Copy of the geotechnical report is included in **Appendix A**.

A further Grain Size Distribution analysis identified the following topsoil composition:

Table 6 - Topsoil Composition

	BH16-3	BH16-9	BH16-11	BH16-18	BH16-20	MW16-6	Average
Clay	14	11	14	6	6	11	10
Silt	33	29	24	23	17	41	28
Sand	53	60	62	71	77	48	62
Soil Type	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam

The soil infiltration parameters used in the model for the Sandy Loam soil were obtained from the Soil Water Characteristics Chart by the USDA Agricultural Research Service and Table 3-12 of the City of Calgary Stormwater Management and Design Manual (2011). Copy of the USDA chart is attached in **Appendix C**. Infiltration parameters used in the PCSWMM computer model are listed in **Table 7**.

Table 7 – Sandy Loam Infiltration Parameters

Parameter	Value	Units
Hydraulic Conductivity (K)	27.08	mm/hr.
Suction Head (Ψ)	110	mm
Porosity Fraction (Φ)	0.396	
Field Capacity Fraction (FC)	0.175	
Wilting Point Fraction (WP)	0.081	
Initial Moisture Deficit (IMD)	24.6	%

3.4 Design characteristics for the Major and Minor Systems

The discharge criterion for the study area has been established by the Bearspaw - Glenbow Master Drainage Plan report and is as follows:

- Maximum Allowable Release Rate to Weed Lake:
  - 1:100 year 0.99 L/s/ha
- Runoff Volume Control:
  - The majority of rainfall should be retained on site through the use of LID and best management practices (BMP) techniques.
  - The average annual amount of rainfall discharged to the Bow River should not exceed.

    50 mm.

To reduce the runoff volume discharge, the following BMPs are proposed:

- 400 mm of topsoil in all landscaped areas, including public and private sites.
- All roof downspouts to be directed to pervious areas prior to discharging into an impervious area.
- Convey as much is possible runoff from hard surfaces via pervious areas before entering the minor system.

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.
- ICDs are required to control flows into the pipe system.
- It is recommended that the minor system be designed for a unit area release rate of 115 L/s/ha for Multi-family and commercial sites and 70 L/s/ha for the residential.

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 will most likely result in flooding and damage of both private and public property.

The design and analysis of the overland drainage system must conform to the Alberta ESRD guidelines which have been adopted by most municipalities. 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 8**.

Table 8 - 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.

3.5 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).

To reduce the runoff volume discharge from the new development, the following BMPs were included in the PCSWMM model:

- Increased topsoil depth - 400 mm of topsoil for all landscaped areas in the lots, road pervious areas and MR;
- All roof drainage from single family houses and garages to be directed to landscaped areas prior to draining to streets or lanes. Items like wide splash pads should be used to ensure that the roof drainage is properly distributed over the landscaped areas, for a sample see image below.



3.6 Stormwater Quality Enhancement

Alberta ESRD and Rocky View 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 forebays and Oil/Grit separators (OGS), more details are provided in **Section 5.8** of this report.

3.7 Biophysical Impact Assessment

A biophysical impact assessment for the development area was prepared by Westhoff Engineering Resources Inc. Following is Westhoff's report Executive Summary:

"Highfield Land Management is proposing The Ascension Lands development in Rocky View County (SW/SE-19-25-2 W5M). Westhoff Engineering Resources Inc. (Westhoff) was retained to prepare a Biophysical Impact Assessment (BIA) for The Ascension Lands. The BIA describes existing environmental conditions, the potential impacts of the development, and mitigation measures to reduce these impacts. The significance of identified impacts is also evaluated along with the potential for cumulative effects. The information presented in the BIA is directly applicable to required provincial referrals and applications under the *Water Act* and *Public Lands Act*.

Existing Conditions

The Project Site is located within the Parkland Natural Region and Foothills Parkland Natural Subregion. The native grassland associated with the Foothills Parkland Natural Subregion is no longer represented within the Site, although patches of native vegetation remain along a central watercourse.

Terrain conditions within the Project Site are variable with rolling uplands, several wetlands and a natural watercourse running through the centre of the Site. The watercourse enters the Site in the north as a low open swale and then develops into a relatively steep narrow ravine as it drains south and west, where it leaves the Site. Slopes are relatively steep (15- 25% or greater) along the southern portion of the watercourse and in two associated ravines on its north boundary. Dunvargan soils consisting of Orthic Black and Rego Black Chernozems are dominant throughout, with Orthic Humic Gleysols found in low lying areas.

A total of four naturally occurring wetlands are identified within the Project Site: two Temporary, one swamp, and one Permanent Shallow Open Water wetland. The central creek is classified as Transitional watercourse and the two smaller associated ravines are classified as ephemeral watercourses. Road construction has impacted Wetland 1, located along the southern boundary, and Wetland 4, located along the central watercourse. Wetlands 2 and 3 appear to be undisturbed.

A range of wildlife species have the potential to occur within the Project Site. We recorded incidental observations of 22 species during field surveys; two are listed provincially as Sensitive. Wildlife are likely to use the central watercourse valley as a natural route for travelling from the Site to areas west, including the Bow River Valley. However, there are considerable barriers to wildlife movement on the north and east boundaries due to Bow Valley Trail and 12 Mile Coulee Road.

We applied provincial Environmentally Significant Areas (ESA) criteria to evaluate natural features on the landscape. The central watercourse and associated wetland and riparian zone is considered an ESA because it is a natural watercourse and because it provides natural habitat conditions for wildlife. None of the remaining wetlands meet the provincial criteria for Aquatic ESAs.

Potential Impacts and Mitigations

The potential impacts of the proposed development were assessed with reference to a concept for development provided to Westhoff by Brown & Associates Planning Group on June 21, 2017.

Potential Impacts include:

- loss of soil from compaction, removal, erosion and/or admixing;
- sediment runoff to adjacent wetlands, watercourses and surrounding areas;
- accidental spills of fuels, chemicals, and other potentially hazardous materials;

- loss or alteration of vegetation, including native plant communities;
- loss of 2 out of 4 naturally occurring wetlands;
- local loss of portions of Wetland 4 at road crossings;
- potential changes in the hydrology of Wetland 1 and Wetland 4;
- potential impacts to the central watercourse due to the introduction of stormwater, including bank erosion and possible reduction in water quality;
- damage, disturbance, and/or loss of individual wildlife species and their residence; and
- changes in local wildlife diversity.

The following mitigation measures will be implemented to reduce, eliminate, or control the potential negative impacts of the proposed development.

- Erosion and Sediment Control (ESC) Plan to limit or control deleterious substances leaving the Site or entering area water bodies;
- Environmental Protection Plan (EPP) to manage potential environmental impacts resulting from construction;
- Landscape and Weed Management Program to reduce post-development impacts to native plant communities and wildlife habitat;
- Setbacks applied to both the central watercourse and Wetland 1 for the purposes of pollution prevention and slope stability;
- Stormwater management strategies to mitigate for potential impacts to the central watercourse and Wetland 1;
- A Wetland Management Plan to document the detailed approach to mitigating potential impacts to Wetlands 1 and 4;
- In-lieu payment to the Province (wetland replacement), as per the Alberta Wetland Mitigation Directive, for Wetlands 2 and 3;
- Land Owner's Manual to educate area residents on what they can do to maintain the health of natural open spaces over the long-term and how to avoid conflicts with wildlife; and
- A monitoring program to document the implementation and success of the ESC Plan and EPP.

Ideally, stripping and grading will be completed outside the critical time period for many wildlife species: approximately April 1 to August 31. If stripping and grading within the critical time period cannot be avoided, on-site monitoring will be conducted to avoid impacting wildlife and wildlife residences, in particular active breeding sites.

Residual Impacts and Significance

We predicted that the proposed development will have residual impacts after mitigation measures are implemented. These residual impacts are the loss of upland plant communities, wetlands and associated wildlife habitat, and the loss of individual wildlife species.

At the time this BIA was prepared, there was no formal process, or available provincial or municipal criteria, for determining what qualifies as a significant residual loss of native plant communities. As per the Bearspaw Area Structure Plan, (adopted June 1994), native plant communities are not automatically acquired and/or protected from development. The current concept plan retains and integrates a considerable portion of the natural plant communities and associated topography within the area.

The proposed development will result in the permanent loss of 2 of the 4 wetlands. Wetland replacement is one of multiple accepted approaches to managing loss of wetlands on both provincial and municipal scales. We conclude this residual impact is not significant provided wetland loss is off-set through wetland replacement applying accepted provincial standards.

Wildlife fatalities are a residual impact of the development, particularly as a result of stripping and grading. In general, we would consider a significant residual impact on wildlife to be the damage or loss of a listed species. Stripping and grading is expected to occur outside of the breeding season when less mobile juveniles are present: April 1 to August 31. We anticipate the fatality risk of listed species outside the breeding season to be low. Therefore, no significant residual impacts to wildlife are expected.

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Cumulative Effects

We considered the potential for cumulative effects on wetlands and water resources resulting from the proposed development. To date, the cumulative effects of development on wetlands have been mitigated primarily through the Province's replacement program, as will be the case for this Project. Overall, we anticipate that the cumulative effects of past, current and future land use and activity in this region will be managed through the retention of wetlands within the Project Site coupled with the application of provincially approved wetland replacement measures.

We identify water resources when describing potential cumulative effects even though project-related impacts on water were not assessed in the BIA. The Bow River Basin Council identifies most significant challenges in this sub-basin are the effective flow management of the Bow River downstream of the Bearspaw Dam and management of stormwater runoff. We anticipate the potential local impacts on water will be addressed through other studies pertaining to stormwater management. Provided best management practices are implemented that meet available municipal and provincial standards, the proposed development is not expected to contribute to cumulative adverse effects on water resources in the sub-basin as a whole."

4.0 POST-DEVELOPMENT 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 SMDP 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 the stormwater ponds.

The continuous simulation was performed using precipitation data recorded at the Calgary International Airport for the period of 1960 – 2014 (inclusive). The output of the continuous simulation modelling is peak storage volumes for each year analysed in the model. Following, a frequency analysis of these annuals maximum storage series is carried out to estimate the volume required for a 1:100 year return frequency. Other parameters also used in the model are presented in **Appendix C**.

4.1 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 of both events for this study was performed using the PCSWMM 2019 computer model software Version 7.2.2785 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 US EPA SWMM5 engine Version 5.1.013, 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.

Figure 6 shows the Regional Storm Plan and **Figure 7** shows the preliminary internal storm minor system.

4.2 Post-development Subcatchments

The land use composition of the study area is listed in **Table 9** and the proposed development land use composition is presented in **Figure 3**.

Table 9 – Land Use Breakdown & Imperviousness

Land Use	Area (ha)	Imperviousness (%)
To Dry Pond		
Single Family lots	3.27	47
Front of Lots	0.66	76
Back of Lots	0.58	25
Roads	1.49	79
Municipal Reserve (MR)	1.19	5
Environmental Reserve (ER)	1.12	0
Dry Pond at HWL	0.19	100
Sub-Total	**8.50**	**43**
To Existing Wetland		
MR	0.32	5
ER	0.69	0
Country Residential Road	0.33	25
Wetland @ HWL	1.13	100
Sub-Total	**2.47**	**50**
To East Pond		
Country Residential (OS-1)*	3.78	6
Country Residential (OS-2)*	1.74	9
Single Family lots	34.02	51
Front of Lots	4.88	76
Back of Lots	0.89	25
Multi-family	1.14	65
Commercial	19.37	85
Roads	18.50	79
MR	6.73	5
ER	1.07	0
Pond at HWL	2.44	42
Sub-Total	**94.56**	**59**
Existing Areas		
North (Ex-1	37.79	4
Middle (Ex-2)	5.79	8
South (Ex-3)	13.52	2
Sub-Total	**57.10**	**4**
Study Area Total	**162.63**	**38**

* Flow Through Areas

The above noted imperviousness is based on the City of Calgary Stormwater Management and Design Manual (2011).

Because of the size of the catchment and to simplify the analysis, the contributing catchment was divided into 13 subcatchments. **Table 10** lists the model subcatchments and the parameters used in the computer model.

Table 10 – Post-development Sub-Catchment Shape Parameters

Sub-Catchment Model ID	Area (ha)	Length (m)	Width (m)	Slope (%)
To Dry Pond				
SF-1	8.50	125	680	3.0
To Wet Pond				
SF-2	13.35	125	1068	3.0
OS-1*	3.78	100	378	5.0
OS-2*	1.74	50	347	5.0
SF-3	45.78	125	3662	5.0
Comm-MF	26.03	125	2082	2.0
Pond-ER	3.89	40	973	2.0
Sub-Total	94.57			
To Existing Wetland				
Wetland-ER	2.47	120	206	2.0
Directly to Natural Drainage Course				
Ex-1	37.79	412	917	5.0
Ex-2	5.79	100	579	3.0
Ex-3	13.52	100	1352	8.0
Sub-Total	57.10			
Total Study Area	162.64			

* Areas that Flow Through the SWMF

The length of each subcatchment was determined by measuring the longest runoff route before runoff is intercepted; for example, the drainage length of 125 m was established by adding the average depth of a lot (35 m) and the distance along the road between catchbasin (90 m).

4.3 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 Green-Ampt Infiltration. Infiltration in the lots and roads pervious surface was estimated based on the proposed BMP (400 mm of absorbent landscape). The infiltration parameters for the BMP are listed in **Table 7**.

The pond was assumed to be lined; therefore no infiltration was accounted for in the analysis. Infiltration in the lots and roads is estimated based on the BMP used in the site. BMP infiltration parameters are presented in **Appendix C**.

The latest version of PCSWMM 2019 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 April. During these months a multiplier of 0.05 was applied to the soil conductivity; for the other months of the year, the multiplier is 1.0, representing normal conditions.

4.4 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 C**.

4.5 Evaporation

Water surface evaporation is part of the SWMF discharges, however, was 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 Normal Water Level (NWL).

Evaporation

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

4.6 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. **Tables 11 and 12** summarizes the storage-discharge rating for the proposed SWMFs and **Table 13** summarizes the storage rating for the existing wetland.

Table 11 – Proposed Dry Pond - Storage Rating Data

Stage	Elevation* (m)	Area (m^2)	Total Storage (m^3)	ICD Discharge Rate (L/s)
Bottom	1,170.00	1,053	0	0
	1,170.25	1,175	278	3.26
	1,170.50	1,301	588	4.76
	1,170.75	1,432	930	5.89
	1,171.00	1,568	1,305	6.83
	1,171.25	1,707	1,714	7.66
HWL	1,171.50	1,868	2,161	8.41

* Elevations to be confirmed during detail design

Table 12 – Proposed Constructed Wetland - Storage Rating Data

Stage	Elevation* (m)	Area (m^2)	Total Storage (m^3)	Active Storage (m^3)	ICD Discharge Rate (m^3/s)
Bottom	1,192.50	1,265	0	0	0
	1,193.00	1,897	790	0	0
	1,193.50	3,556	2,028	0	0
	1,194.00	5,728	4,440	0	0
	1,194.50	7,250	7,681	0	0
	1,195.00	8,882	11,711	0	0
	1,195.50	11,112	16,645	0	0
NWL	1,196.00	15,788	23,352	0	0
	1,196.50	18,721	32,081	8,729	0.120
	1,197.00	20,588	41,907	18,555	0.188
	1,197.50	22,493	52,676	29,325	0.237
HWL	1,198.00	24,432	64,407	41,055	0.278

* Elevations to be confirmed during detail design

Table 13 – Existing Wetland Storage Rating Data

Stage	Elevation (m)	Area (m^2)	Total Storage (m^3)
Bottom	1,197.50	1,018	0
	1,197.75	7,072	1,011
	1,198.00	8,482	2,956
	1,198.25	9,674	5,225
Spill Level	1,198.50	11,306	7,848

4.7 Sediment Removal Analysis

Water Quality modeling requires input data for pollutant *built-up*, pollutant *washoff* and pond *settling velocities*. **Tables 14 and 15** summarize the build-up and washoff parameters used in this SMDP; these were taken from the Glenmore Reservoir Stormwater Quality Improvement Study (J N MacKenzie, May 1992). **Table 16** lists the sediment particle size distribution and settling velocities that are contained within the City of Calgary Stormwater Management and Design Manual (September 2011).

Table 14 - Pollutant Build-up Parameters

Parameter	Impervious Areas	Pervious Areas
Build-up Method	Power Linear	Power Linear
Equivalent Initial Accumulation Period	30 Days	30 Days
Maximum Accumulation	0.20 kg/m^2	0.20 kg/m^2
Built-up	0.00055 kg/m^2 per Day	0.00055 kg/m^2 per Day

Table 15 - Pollutant Washoff Parameters

Parameter	Impervious Areas	Pervious Areas
Washoff Method	Build-up/Washoff	Build-up/Washoff
Washoff Coefficient	6000 per m^3	3000 per m^3
Washoff Exponent	1.2	1.2

Table 16 - Settling Velocity Data

Fraction Number	Particle Size (µm)	Size Classification	Size Fraction (%)	Settling Velocity (m/s)
1	≤10	Fine silt	23	0.00000592
2	10-20	Medium silt	9	0.0000473
3	20-50	Medium silt	13	0.000283
4	50-150	Coarse silt	23	0.00195
5	≥150	Fine sand	32	0.0124

Schematic diagram and Input and Output files for the PCSWMM continuous simulation are included in **Appendix C**.

4.8 **Water for** Wetland **to be** retained

To provide water to the wetland to be retained, runoff will be diverted prior to entering the SWMF from the minor system via a flow splitter. During detail design the splitter structure and the appropriate filtration will be designed to ensure the quality of the water entering the existing wetland.

5.0 DESIGN DETAILS

The ponds proposed to control the discharge of run off generated by the proposed development are in accordance with the City of Calgary *Stormwater Management & Design Manual* (2011) and Alberta Environment *Stormwater Management Guidelines.*

The first pond is a Dry Pond, which will service 8.50 ha of land that because of the topography of the site could not be directed by gravity into the main pond.

The main pond is a wet pond, which will provide discharge control for the remaining of the development. This pond will be finished as a constructed wetland, in a way that blends with the existing wetland and th natural drainage course.

In the dry pond the entire storage is active and available for discharge rate (quantity) control. In the constructed wetland, the storage below NWL is not available for discharge rate control; it is only significant in terms of water quality with respect to turnover rate and the pond's ability to improve the quality of the receiving runoff. The storage above the NWL is referred to as active storage and is the available capacity to control of discharges to the receiving outlet.

Water quality control for the discharge from the dry pond will be achieved by an OGS unit installed in the pond outlet pipe. Water quality for the discharge from the constructed wetland will be achieved by the pond itself, in two stages. Primary treatment, sediment removal for particles greater than 50 um within the forebays and secondary treatment in the constructed wetland portion.

5.1 Pond Layout

The proposed Wet Ponds were sized to retain runoff for up to the 1:100 year storm event from the drainage catchment being serviced. The ponds will discharge into the existing natural drainage course at a rate based on the unit discharge rate described in **Section 3.4** of this report. **Tables 17 and 18** summarize the characteristics of the proposed SWMFs.

Table 17 – Dry Pond Characteristics

	Parameter	Value	Unit
General	Contributing Catchment Area	8.50	ha
	Side Slopes below NWL	5H:1V	
	Side Slopes between NWL & HWL	5H:1V	
	Side Slopes above HWL	4H:1V max	
Elevation	Pond Bottom Elevation	1,170.00	m
	HWL Elevation	1,171.50	m
	1:100 Year Elevation	**1,171.36**	**m**
	Freeboard Elevation	1,171.66	m
Depth	Pond Depth Below HWL	1.50	m
Area	Area at Bottom	1,053	m^2
	Area at HWL	1,868	m^2
Volume	Active Storage Capacity (Bottom to HWL)	2,161	m^3
	1:100 Year Active Volume (Single Event)	1,854	m^3
	1:100 Year Active Volume (Continuous simulation)	**1,901**	**m^3**
Discharge	Maximum Discharge @ HWL	8.4	l/s
	Preliminary ICD radius	28.8	mm
	1:100 Year Discharge	**8**	l/s

* Active Volume above NWL

Table 18 – Constructed Wetland Characteristics

Parameter		Value	Unit
General	Contributing Catchment Area	89.04	ha
	Side Slopes below UNWL	Varies	
	Side Slopes between UNWL & HWL	Varies	
	Side Slopes above HWL	4H:1V max	
Elevation	Pond Bottom Elevation	1,192.50	m
	NWL Elevation	1.196.00	m
	HWL Elevation	1,198.00	m
	1:100 Year Elevation	**1,197.40**	**m**
	Freeboard Elevation	1,198.30	m
Depth	Pond Depth Below HWL	3.50	m
	Active Fluctuation Depth above HWL	2.00	m
Area	Area at Bottom	1,265	m^2
	Area at NWL	15,788	m^2
	Area at HWL	24,432	m^2
Volume	Permanent Pool below NWL	23,352	m^3
	Permanent Pool Required for water quality	22,260	m^3
	Active Storage Capacity (NWL to HWL)	41,055	m^3
	1:100 Year Active Volume (Single Event)	25,252*	m^3
	1:100 Year Active Volume (Continuous simulation)	**27,118***	**m^3**
Discharge	Maximum Allowable Discharge from proposed development	88.2	l/s
	Flow through from offsite lands	190	l/s
	Maximum Discharge at HWL	278.2	l/s
	Preliminary ICD radius	156.6	mm
	1:100 Year Discharge	**228**	l/s

* Active Volume above NWL

Figure 15 illustrates the maximum and minimum water levels expected for the proposed SWMFs as determined by the continuous simulation (PCSWMM). **Figure 17** presents a comparison of the maximum and minimum water levels for the existing wetland under pre-development and post-development conditions, it also shows the depth duration exceedance under both pre and post development conditions.

5.2 Outlet Control Structure

The Dry Pond outlet piping is proposed to be located at the south end of the pond. The outlet pipe connects the pond to the outlet control structure which will discharge to the natural watercourse. The Constructed Wetland outlet piping is proposed to be located at the west side of the pond. The outlet pipe connects the pond to the outlet control structure which will also discharge to the natural watercourse.

The outlet control structures are intended to control the pond discharge to the allowable rate described in **Section 3.4**. Preliminary design proposes a two-chamber system, with a weir wall at the HWL and discharge controlled by an orifice plate. The preliminary ICD sizes for ultimate conditions are presented in **Tables 17 and 18**.

5.3 Emergency Overflow

The overland escape route for the Dry Pond is located at the south end of the pond directed to natural drainage course. The overland escape route for the Constructed Wetland is located at the west side of the pond, also directed to natural watercourse.

Final pond details (i.e. shape, escape route, control structure, etc.) will be established during pond detail design. **Figures 9 and 10** show preliminary pond design and cross section for the proposed Dry Pond and Figures 12 and 13 show preliminary pond design and cross section for the proposed Constructed Wetland. **Figures 11 and 14** show preliminary outlet control structure designs for each pond.

5.4 Frequency of Ponding

The frequency distribution analysis was based on the application of the "Frequency Analysis Procedure Manual" and spreadsheet DFASCC_v1.2 provided by Water Resources. **Figure 16** illustrates the most appropriate frequency distribution of storage volumes for the proposed SWMFs based on the frequency analysis of the continuous simulation results (PCSWMM). The Frequency Analysis is included in **Appendix D**. **Table 19** summarize the modeled frequency of Total Storage volumes.

Table 19 – Frequency of Total Storage Volumes

Return Period (Years)	Storage Volume (m^3)	
	Dry Pond	Constructed Wetland
2	577	30,800
5	830	32,300
10	1,010	34,400
20	1,200	37,300
50	1,450	40,700
100	1,650	46,000

The maximum volume calculated by the continuous simulation for the proposed Ponds is higher than the single event and the 1:100 year volume estimated by the Frequency Analysis; therefore, the maximum volume from the PCSWMM model should be used for design purposes.

5.5 Post-development Peak Runoff Rate

The PC-SWMM model was utilized to obtain the peak runoff rate during a 1:100 year 24 hour single event utilizing a Calgary Chicago Design Storm. The results are tabulated below:

Table 20 - Peak Flow Results

Natural Channel ID	Single Event 24h-100y (m^3/s)
OF-3	0.996
OF-W	0.041
TOTAL	**1.037**

A graphical comparison of pre vs post development flows in the natural drainage course is presented in **Figure 18**.

5.6 Runoff Volume Discharges

Table 21 summarizes the target runoff volume discharge and estimated average annual runoff volume resulting from the PCSWMM continuous simulation analysis presented in this report; total discharge volume (55 years) is 746,366 m^3.

Table 21 - Average Annual Runoff Volumes

Catchment	Total Area (ha)	Target Avg. Annual Runoff		Estimated Avg. Annual Runoff	
		Volume (m^3)	Depth (mm)	Volume (m^3)	Depth (mm)
Ascension	162.63	81,314	50	86,367	53

The above Table shows that the volume control target established by the Bearspaw – Glenbow Master Drainage Plan and listed in **Section 3.4** is met.

5.7 Water Balance

Table 22 presents the PCSWMM model Water Balance as Total Precipitation and losses.

Table 22 – Water Balance

	Depth (mm)
Total Precipitation	22903.400
Evaporation Loss	8688.759
Infiltration Loss	10850.831
Surface Runoff	3449.780
Snow Cover	2.600
Surface Storage	15.987
Continuity Error (%)	-0.424

5.8 Oil/Grit Separator

Water quality requirements for subcatchment SF-1 will be achieved by an OGS unit installed in the first manhole upstream of the Dry Pond inlet. **Appendix E** contains information on the proposed OGS unit that will meet the water quality requirements imposed by the City of Calgary and Alberta Environment.

5.9 Storm Pond Sediment Removal

Ascension, will be met by the forebay that will be incorporated in the proposed Constructed Wetland. Water quality improvement by the proposed pond was modelled with the PCSWMM computer software; **Tables 23** summarize the results of the sediment removal simulation for the various size fractions, as determined by the PCSWMM model. The results meet the Alberta Environment and Rocky View County target objective which is 85% removal of particles greater than 50 µm.

Table 23 - Pond Sediment Removal Efficiency

Particle size (µm)	% Removed
< 10	79.4
10 - 20	89.8
20 - 50	97.2
50 - 150	**99.6**
> 150	99.9
Totals	**94.0**

Forebay Sizing

The size of the forebay for the Stormwater Detention Facility is based on the calculations presented in the City of Calgary *Stormwater Management & Design Manual,* for minimum forebay length (based on settling and dispersion) and for minimum bottom width. **Tables 24 and 25** provide the sizing of the sedimentation forebays for the west and east inlet into the Constructed Wetland that meets the City of Calgary criteria.

Table 24 - West Inlet Forebay Sizing

Sedimentation Forebay Characteristics		
Forebay Side Slopes below NWL	5	H to 1V
Forebay Length at NWL	70	
Forebay Width at NWL	55	
Effective Forebay Width at NWL (m)	19	
Forebay Depth @ NWL (m)	3.5	
Maximum flow rate from pond (m^3/s)	0.094	94.56 ha @ 0.99 L/s/ha
Design settling velocity for 50 µm (m/s)	0.00195	
Maximum inlet flow rate (m^3/s)	4.525	64.64 ha @ 70 L/s/ha
Design velocity in forebay (m/s)	0.5	

Hydraulic Design Criteria			
	Calculated		**Required**
Forebay length at NWL (m)	70.0	to be greater than or equal to	68.1
Forebay bottom width (m)	19.0	to be greater than or equal to	8.5
Effective Forebay cross-section area @ NWL (m^2)	66.5		
Forebay cross-section velocity (m/s)	0.001	to be less than or equal to	0.15
Calculated Length/Width Ratio	102.1	to be greater than or equal to	2.0
Calculated Hydraulic Parameters			
Minimum Forebay Settling Length (m)	68		
Minimum Forebay Dispersion Length (m)	21		
Minimum Bottom Width (m)	9		

Table 25 – East inlet Forebay Sizing

Sedimentation Forebay Characteristics		
Forebay Side Slopes below NWL	5	H to 1V
Forebay Length at NWL	75	
Forebay Width at NWL	55	
Effective Forebay Width at NWL (m)	19	
Forebay Depth @ NWL (m)	3.5	
Maximum flow rate from pond (m^3/s)	0.094	94.56 ha @ 0.99 L/s/ha
Design settling velocity for 50 µm (m/s)	0.00195	
Maximum inlet flow rate (m^3/s)	2.993	26.03 ha @ 115 L/s/ha
Design velocity in forebay (m/s)	0.5	

Hydraulic Design Criteria			
	Calculated		**Required**
Forebay length at NWL (m)	75.0	to be greater than or equal to	55.4
Forebay bottom width (m)	19.0	to be greater than or equal to	6.9
Effective Forebay cross-section area @ NWL (m^2)	66.5		
Forebay cross-section velocity (m/s)	0.001	to be less than or equal to	0.15
Calculated Length/Width Ratio	117.2	to be greater than or equal to	2.0

Calculated Hydraulic Parameters	
Minimum Forebay Settling Length (m)	55
Minimum Forebay Dispersion Length (m)	14
Minimum Bottom Width (m)	7

6.0 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This study has concluded that:

- The Sandy Loam topsoil as identified in Geotechnical Investigation for the Hawkwood Lands (now known as Ascension), exp Engineering Services Inc., is well suited for the BMP measures suggested in this report.

- The stormwater management facilities proposed in this report, will control the peak discharge from the Ascension development to 228 L/s, which is well within the allowable 278 L/s as stipulated in the Bearspaw – Glenbow Master Drainage Plan, Worley Parsons; June 2010.

- Because the peak discharge into the Natural Drainage course has been reduced from existing conditions, negative impact in the natural channel is no expected.

- The Best Management Practices suggested in this report will reduce the runoff volume discharge from Ascension to the receiving natural watercourse, to an average annual of 53 mm; therefore meeting the 50 mm average annual volume control discharge stipulated in the Bearspaw – Glenbow Master Drainage Plan, Worley Parsons; June 2010.

- Water quality targets will be achieved by the proposed forebays in the Constructed Wetland and the oil/grit separator to be installed in the first manhole upstream of the Dry Pond inlet. They will meet the required levels of TSS removal by AENV and Rocky View County.

Recommendations

It is recommended that:

- 400 mm of topsoil be placed on all landscaped areas, public and private.

- The BMPs presented in this study be implemented in each stage of development to ensure a runoff volume reduction.

- Since the Staged Master Drainage Plan is based on preliminary information, a pond report be prepared at detailed design and submitted to the approving agencies. The pond report should detail pond design components, including the Inlet Control Device, Outlet Control Structures and computer simulation modeling to verify the performance and operation of the ultimate stormwater management facility.

- The analysis presented in this report is accepted by the approving agencies.

Corporate Authorization

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PROFESSIONAL ENGINEER ALBERTA
LUIS G. NARVAEZ

Aug. 27, 2020
RESPONSIBLE ENGINEER

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FIGURES

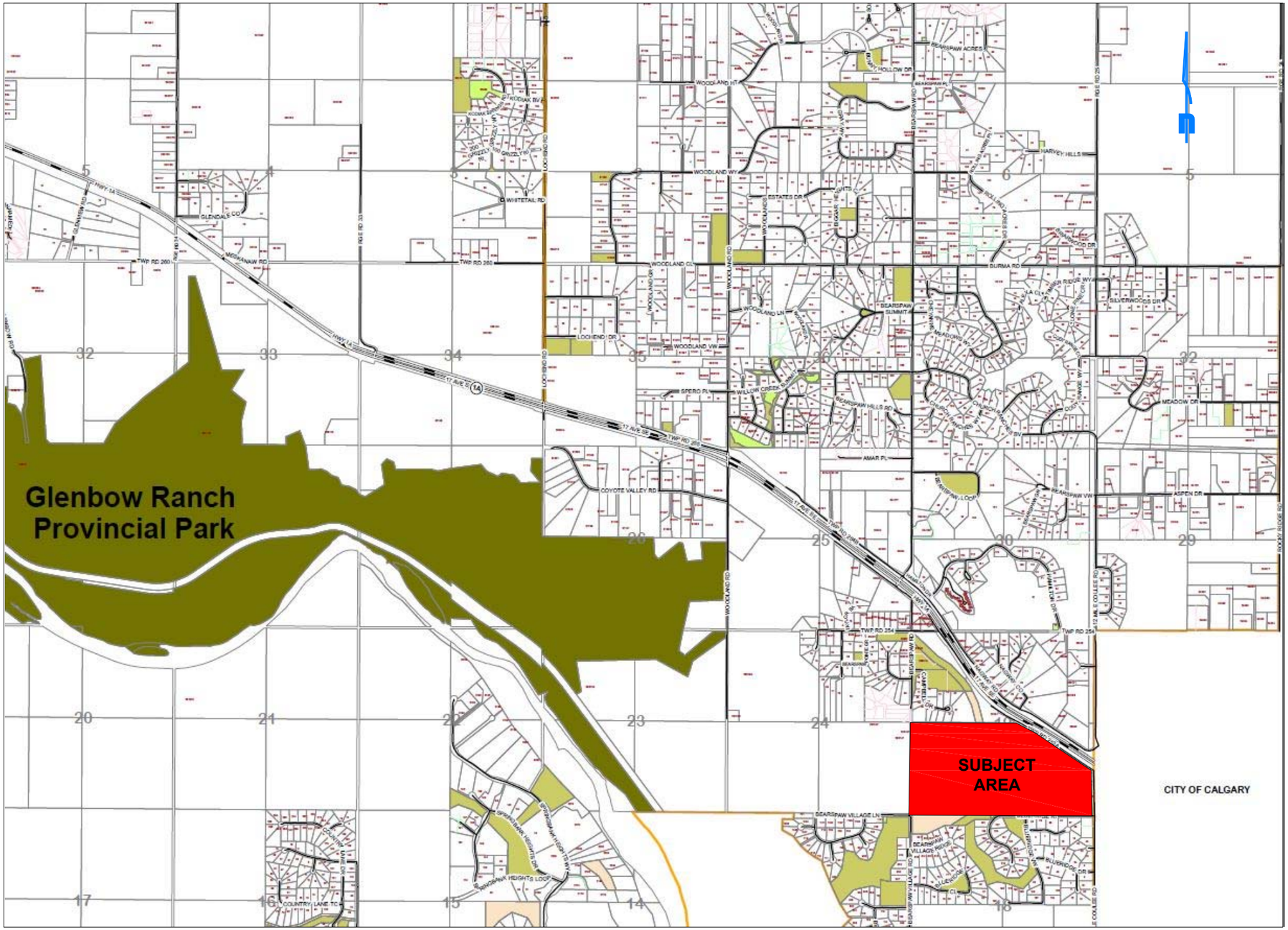

Figure 1 - Location Plan



Figure 2 - Study Area



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b&a

- Subject Land
- Municipal Boundary
- Regional Pathway
- Trail
- Market Place
- Comprehensive Residential Area
- Single Residential
- Municipal Reserve
- Environmental Reserve
- Stormpond
- Stormpond Forebay (PUL)
- Dry Pond (PUL)
- Wetland
- Road Widening

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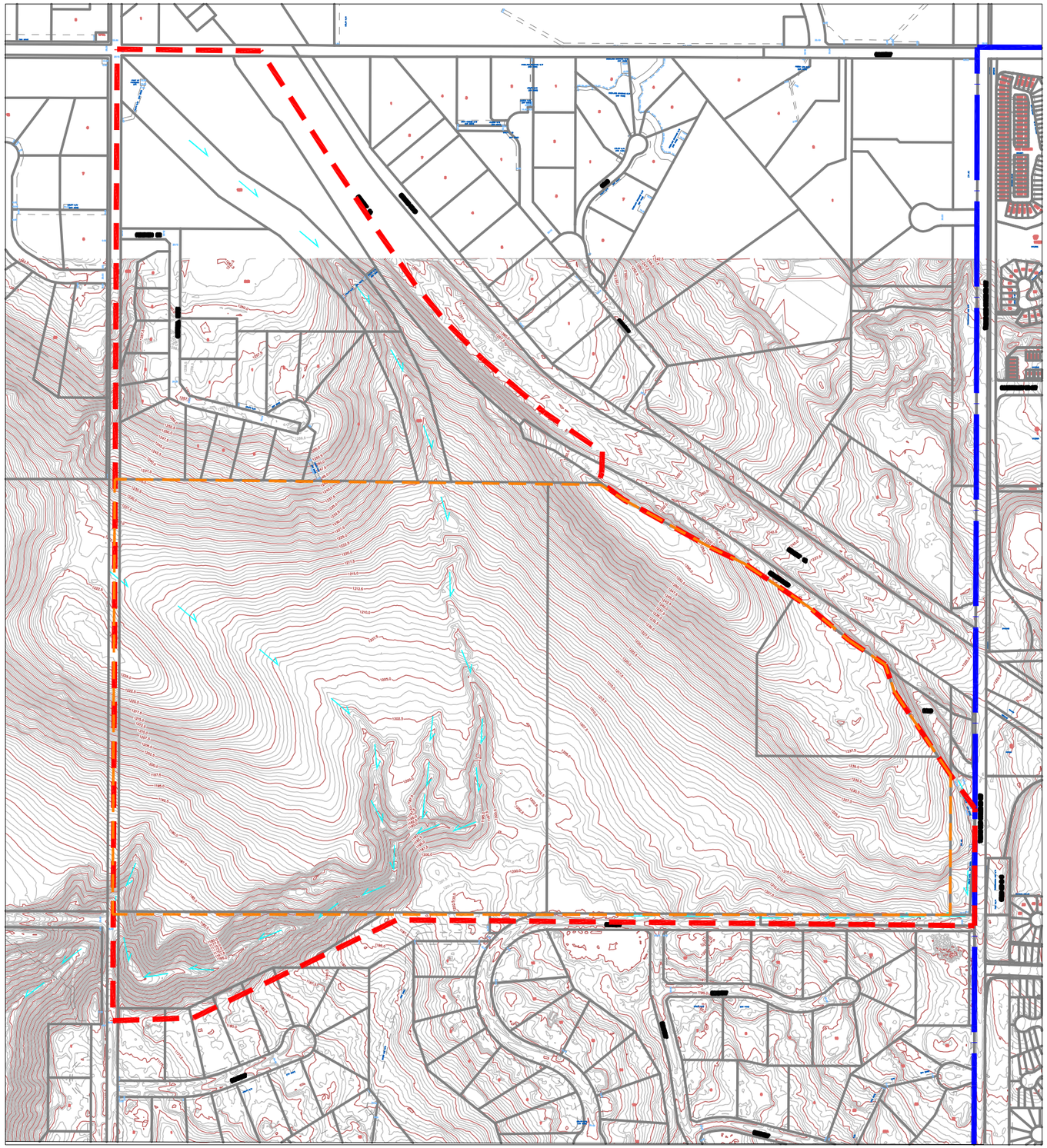
ASCENSION

Concept Plan

Figure 3

August 2020



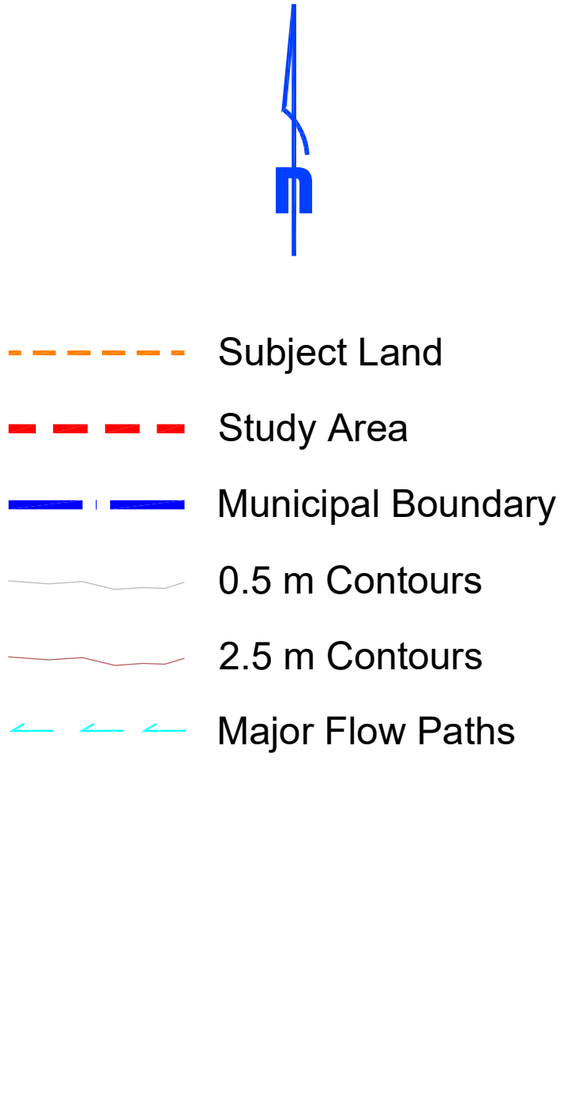


Figure 4 - Existing Topography



Figure 5 – Pre-development Subcatchments

Figure 6 - Regional Stormwater Servicing Plan

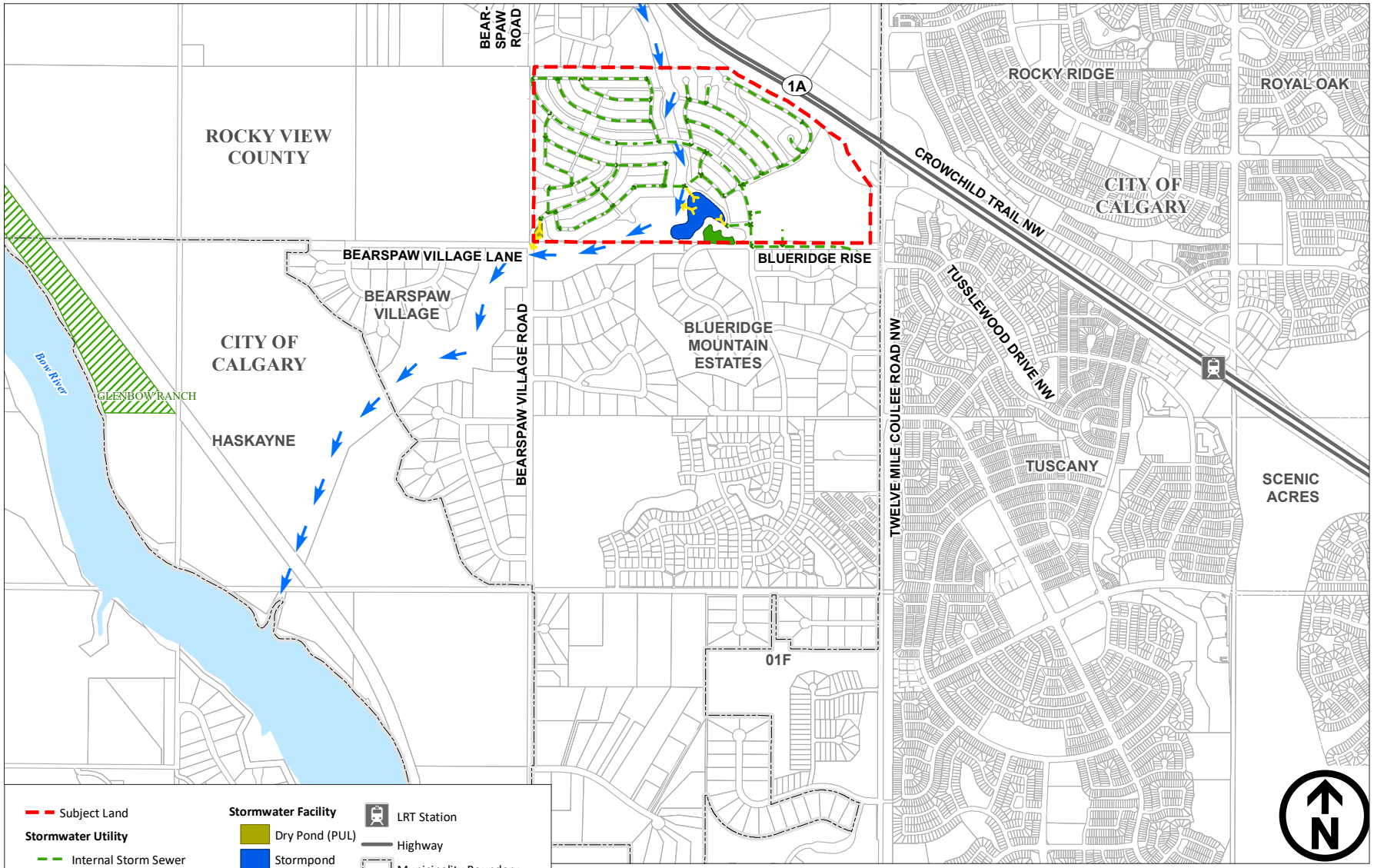
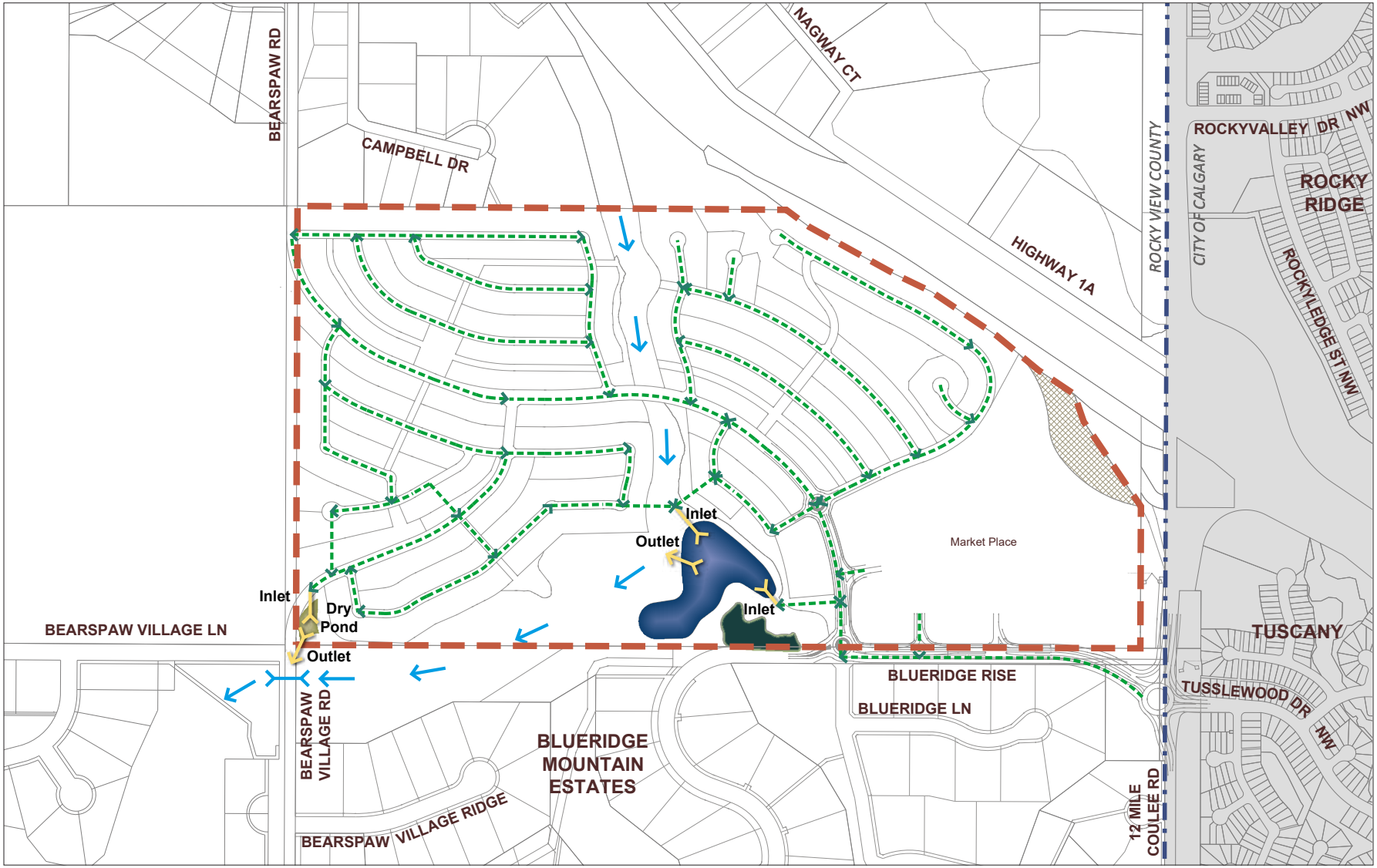


Figure 7 - Internal Stormwater Servicing Plan



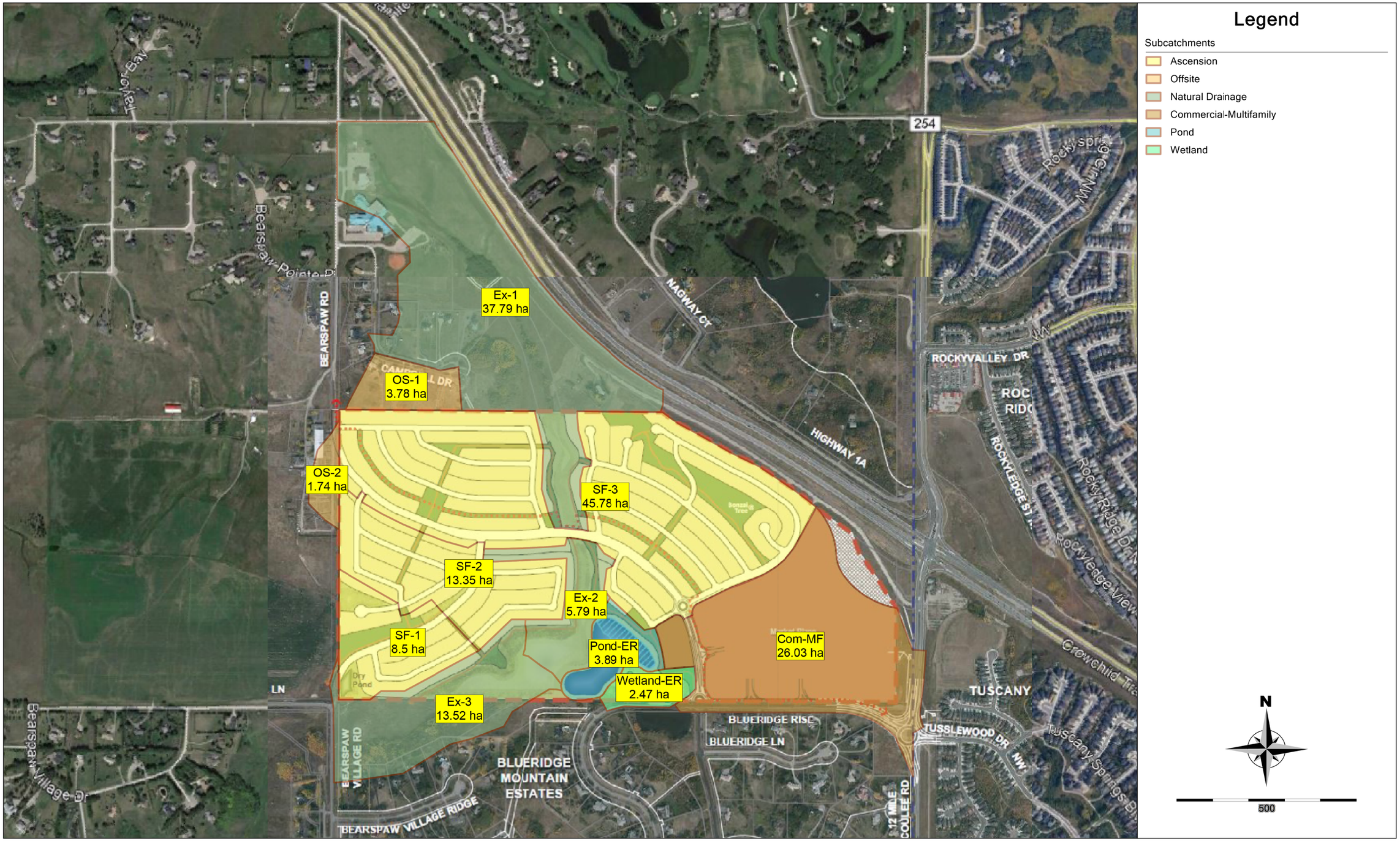


Figure 8 – Post-development Subcatchments

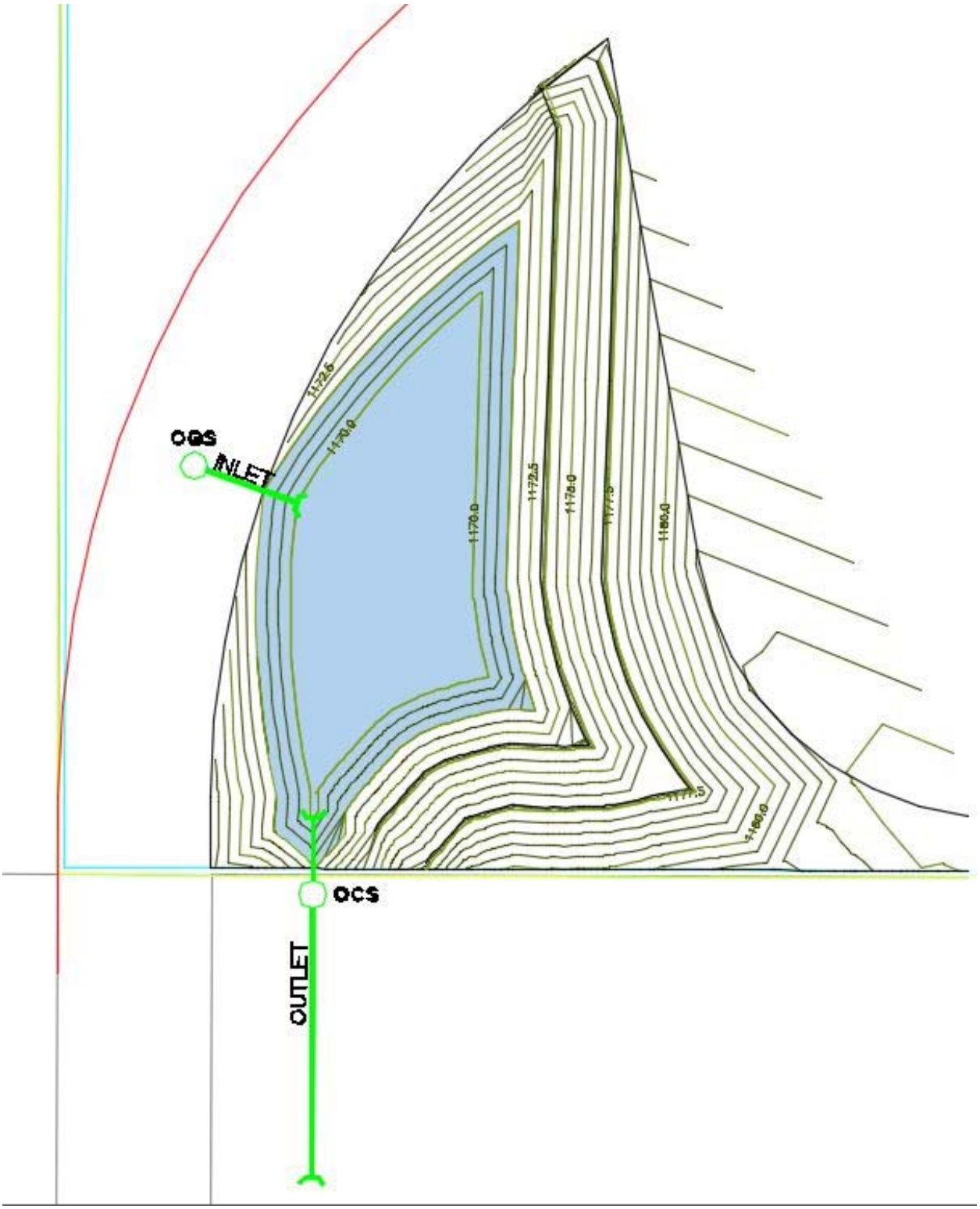


Figure 9 – Dry Pond Design

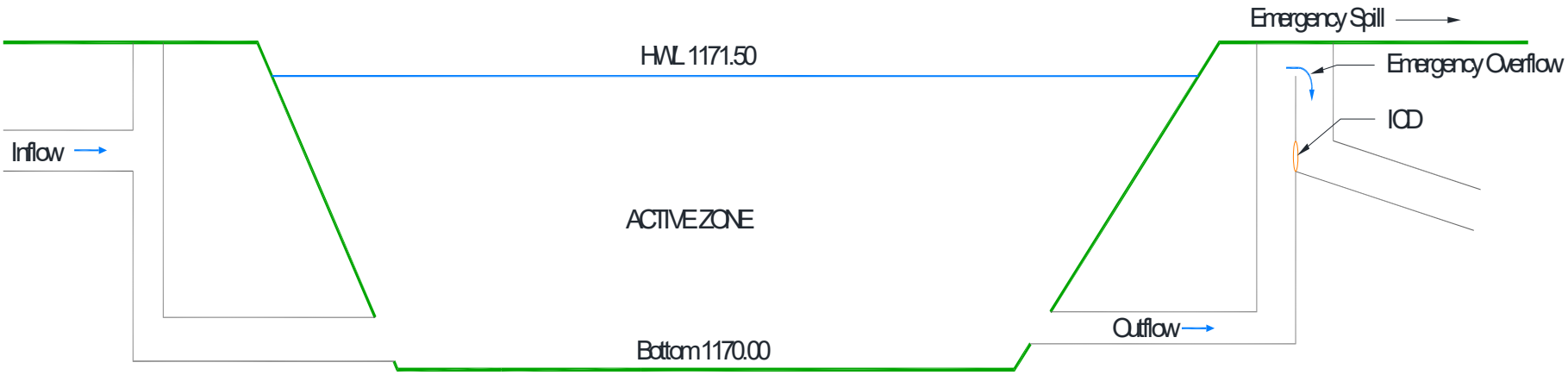
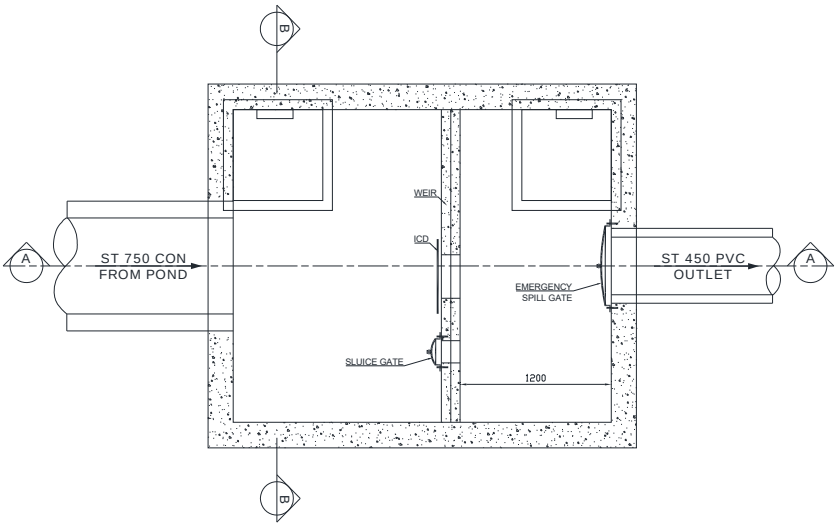
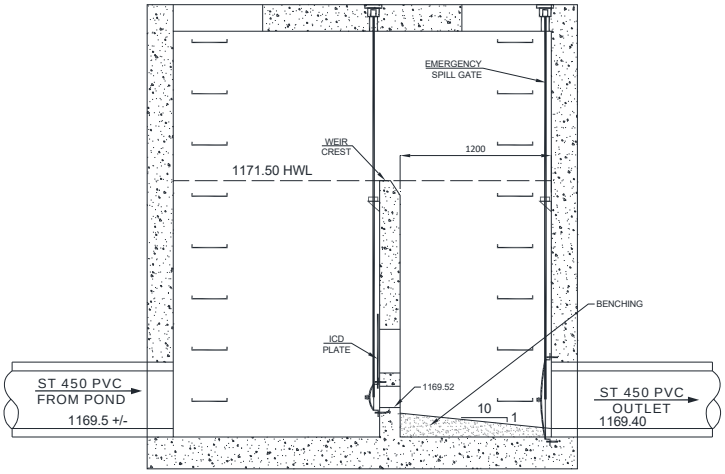


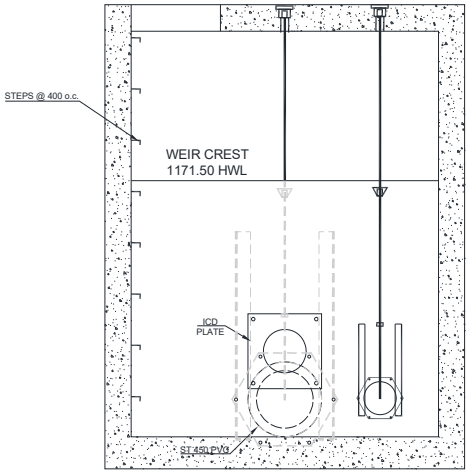
Figure 10 – Dry Pond Preliminary Cross-Section



PLAN VIEW



SECTION A-A



SECTION B-B

NOTE: CONTROL STRUCTURE GEOMETRY, PIPE SIZES,
INVERETS ARE SUBJECT TO CHANGE AT DETAILDESIGN

Figure 11 - West Pond Preliminary Outlet Control Structure

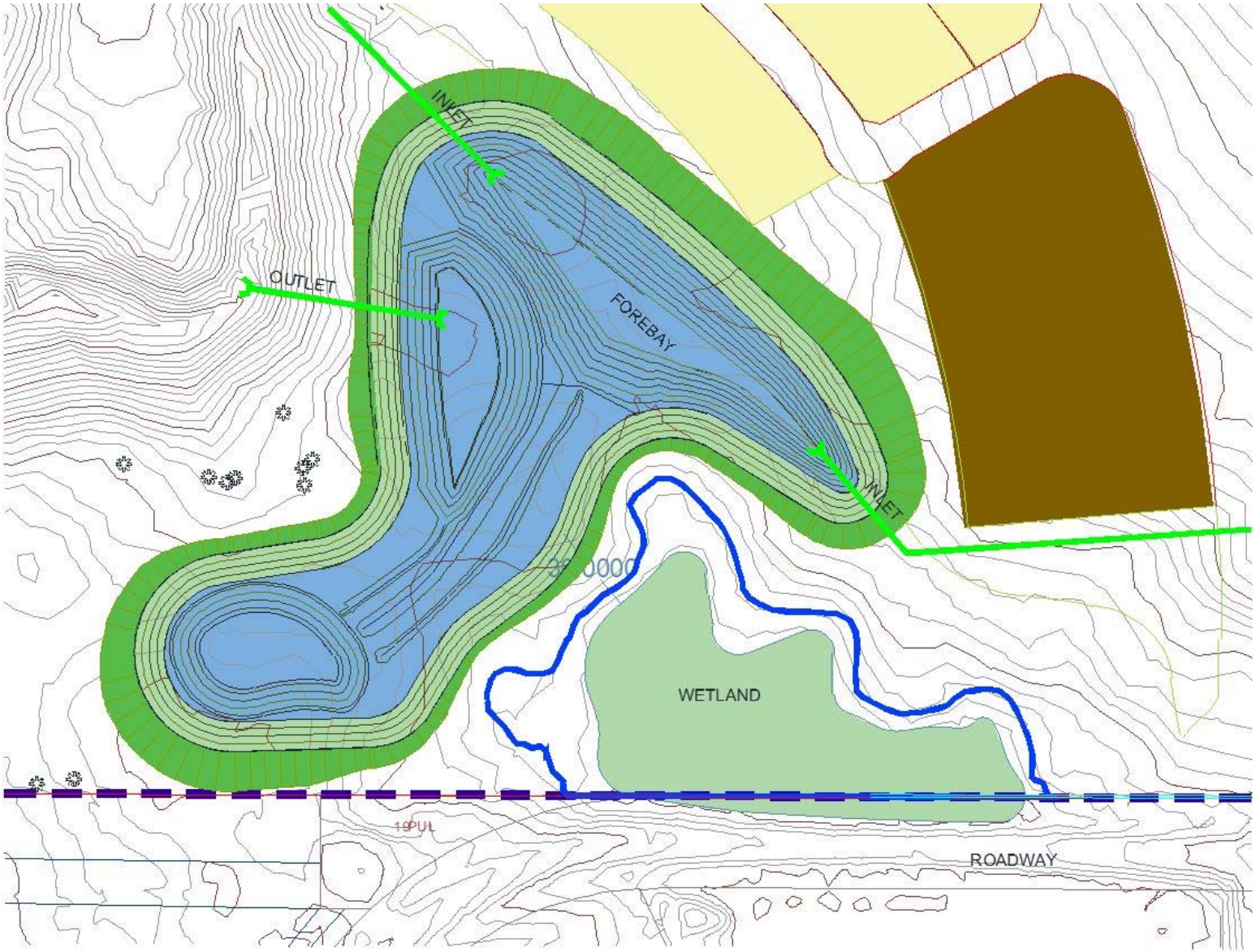


Figure 12 – Constructed Wetland Preliminary Design

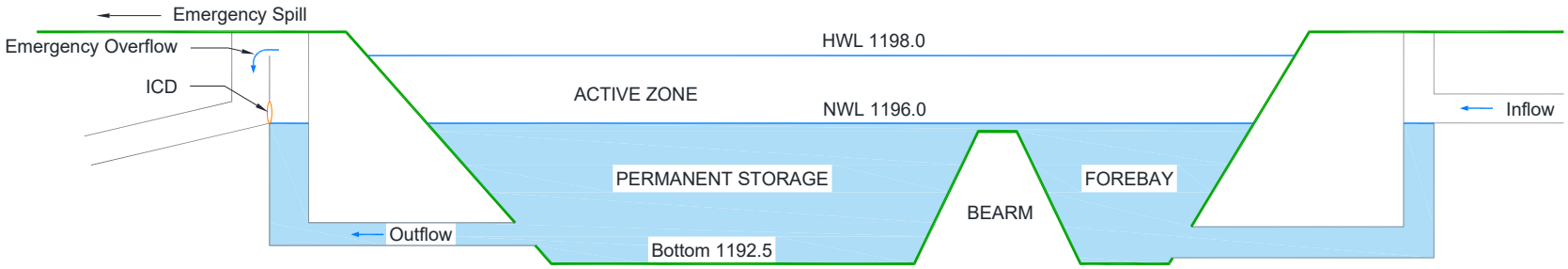
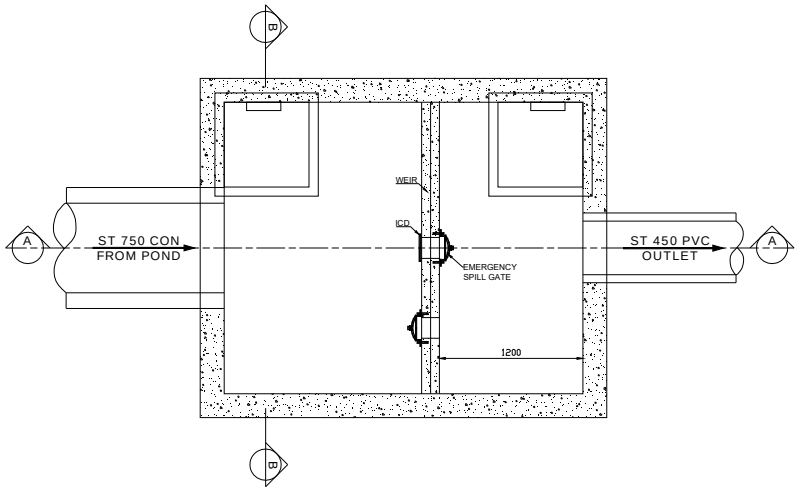
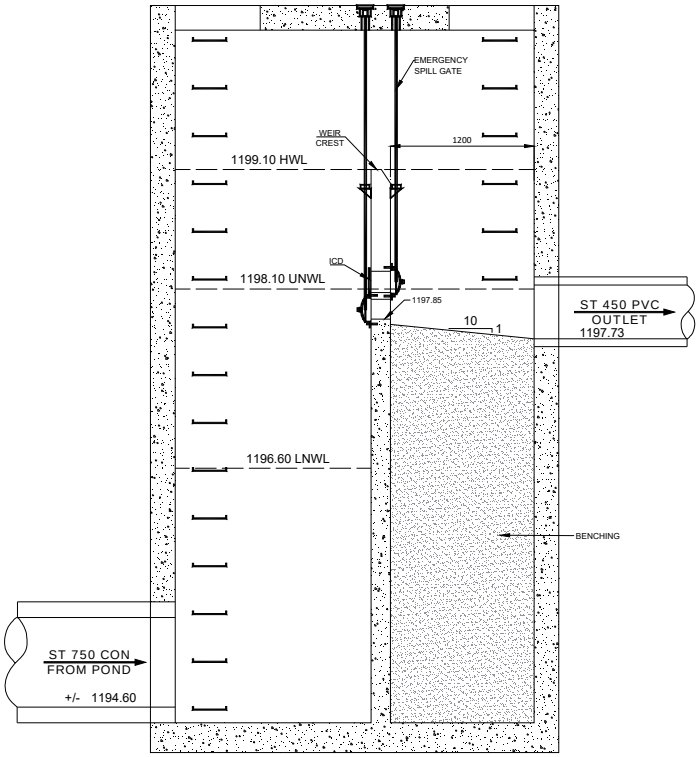


Figure 13 - East Pond Preliminary Plan and Cross-section



PLAN VIEW



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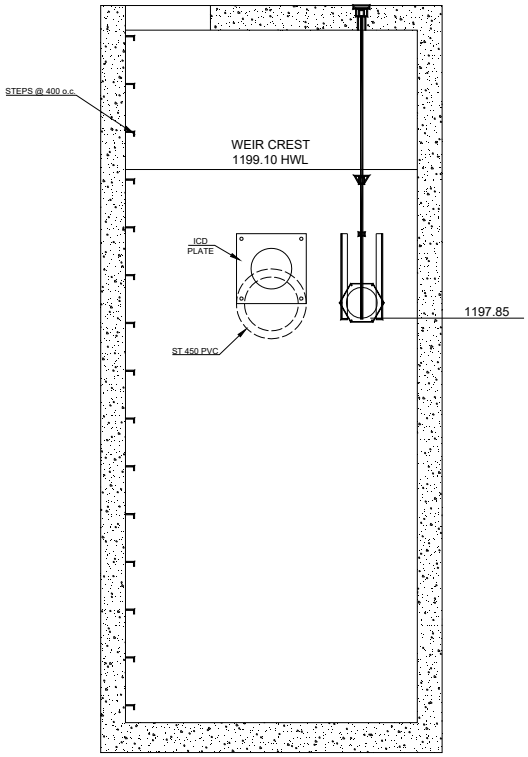
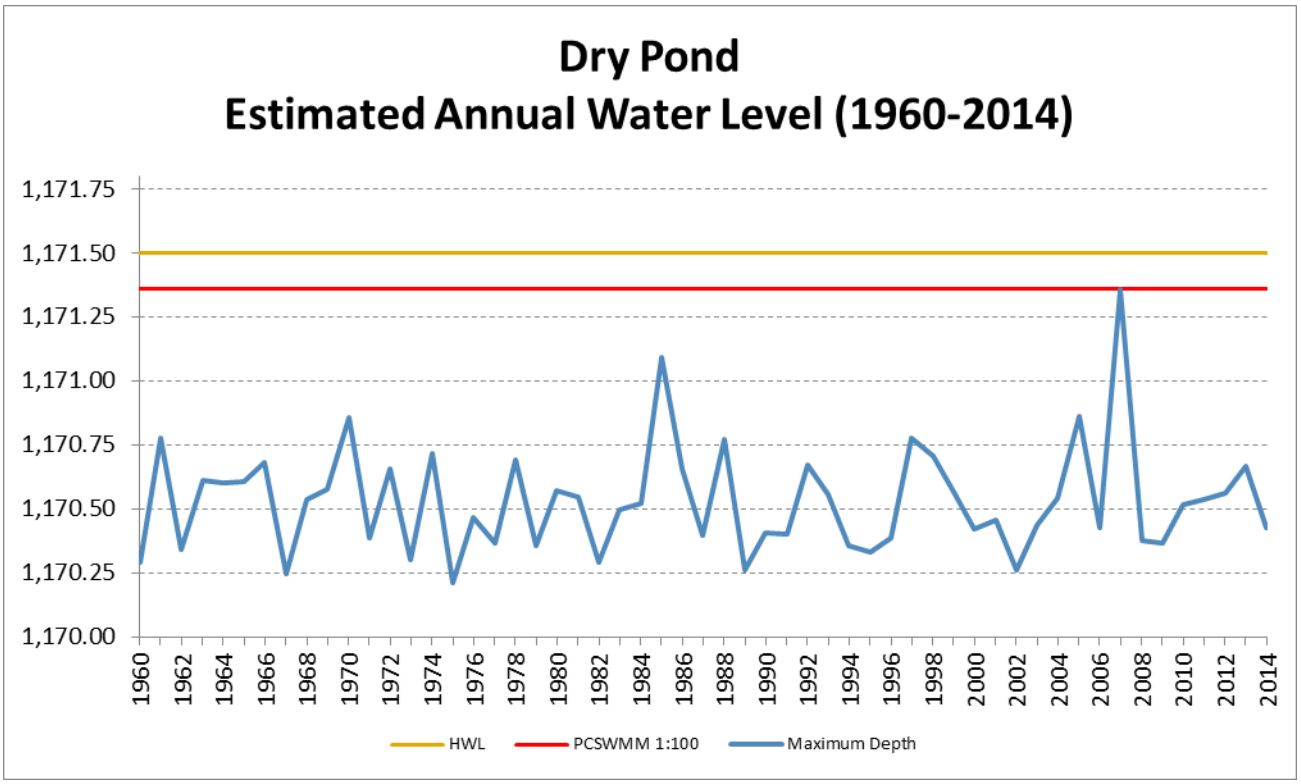


SECTION B-B

NOTE: CONTROL STRUCTURE GEOMETRY, PIPE SIZES,
INVERETS ARE SUBJECT TO CHANGE AT DETAILDESIGN

Figure 14 - East Pond Preliminary Outlet Control Structure



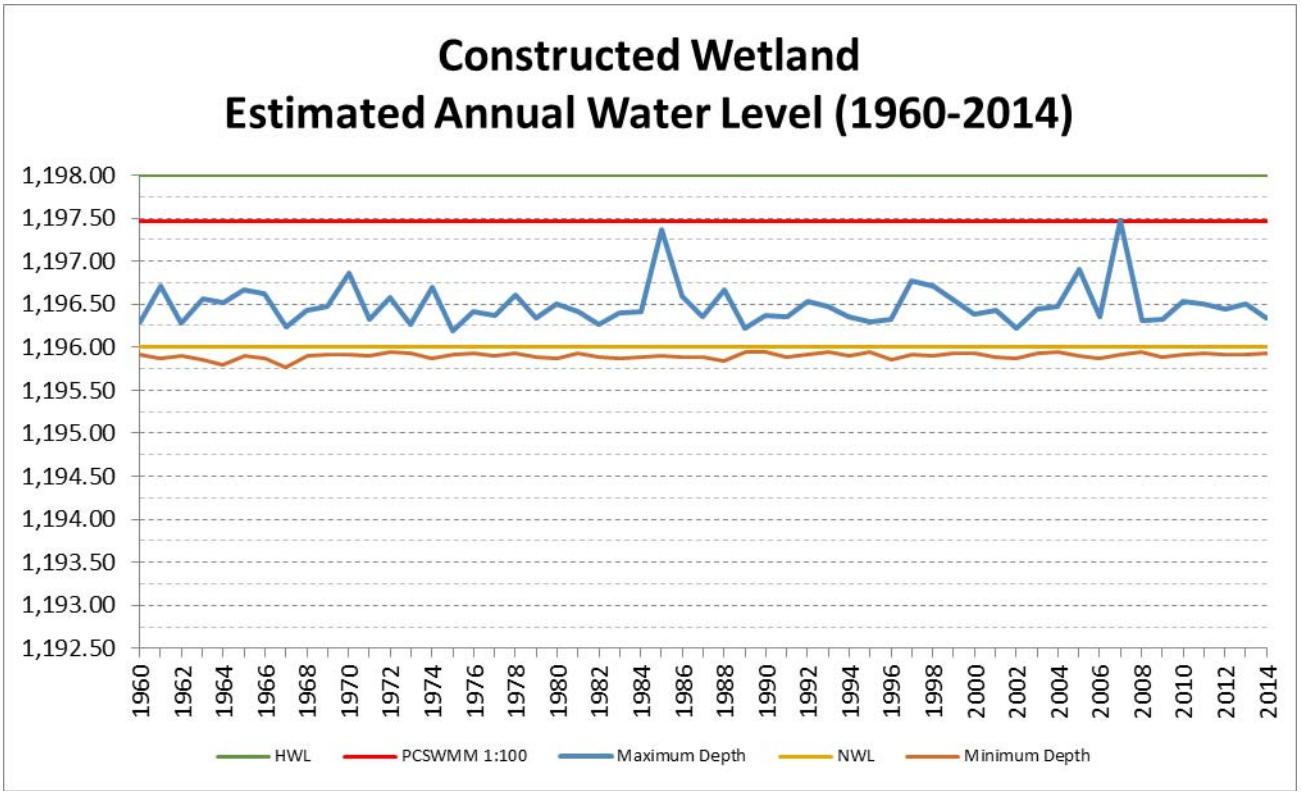
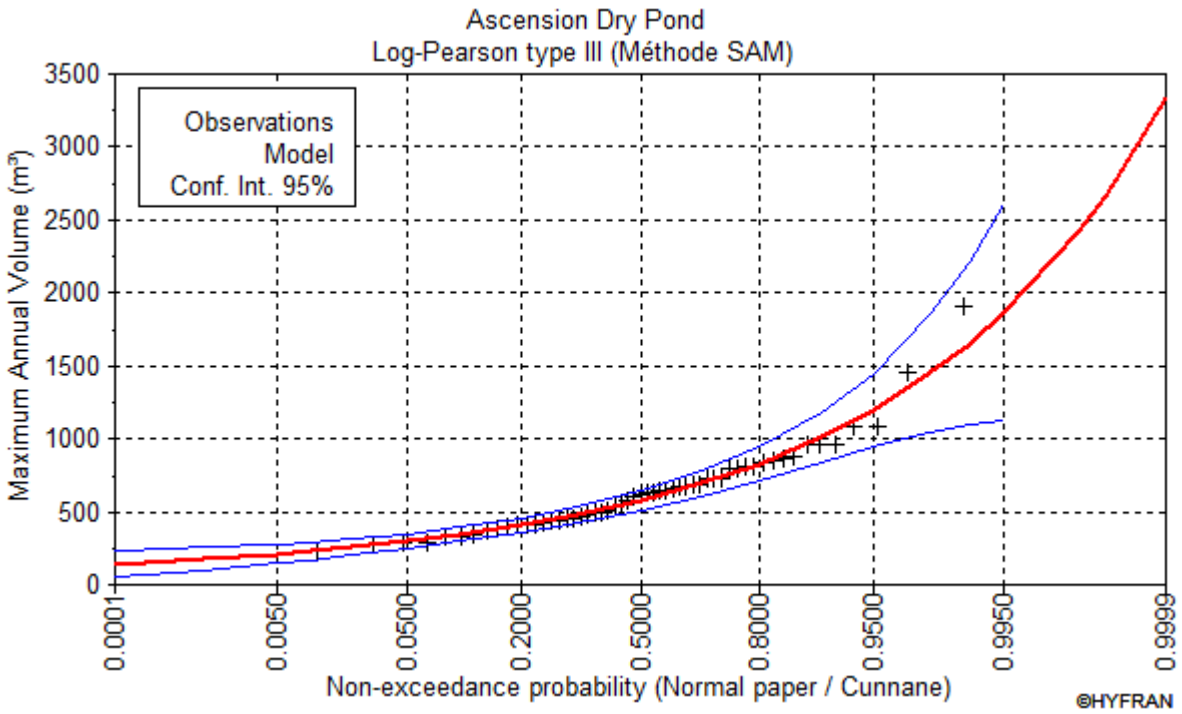


Figure 15 - SWMFs Annual Water Levels



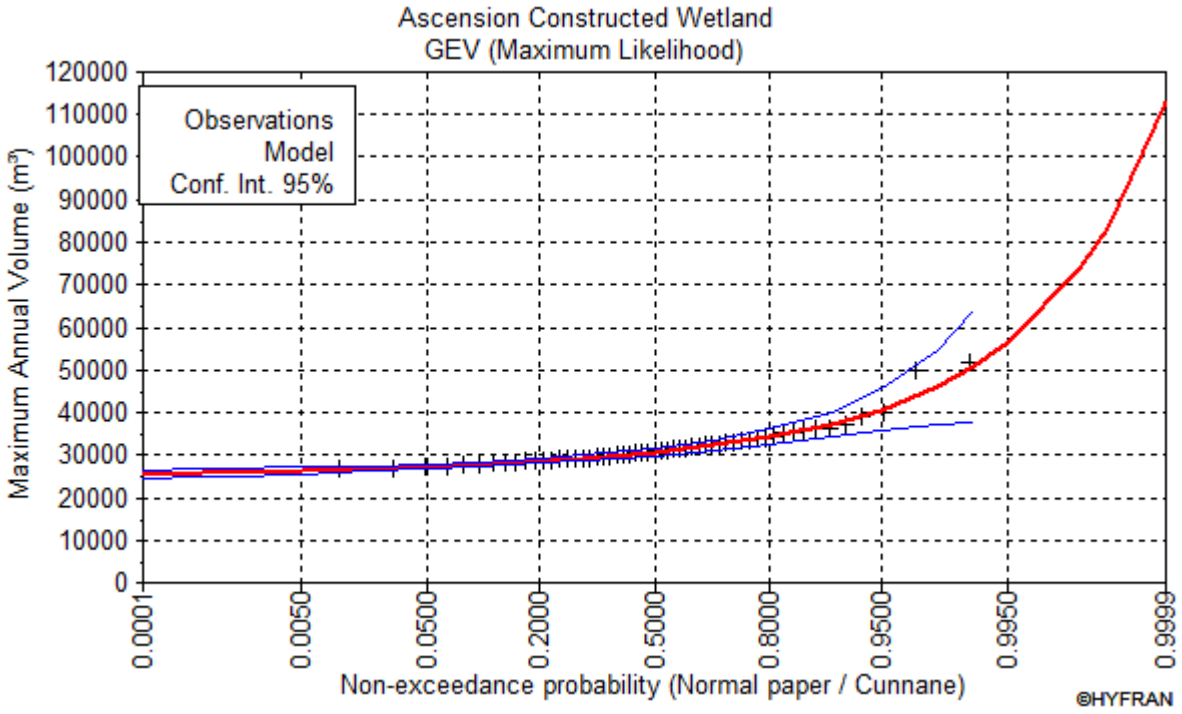
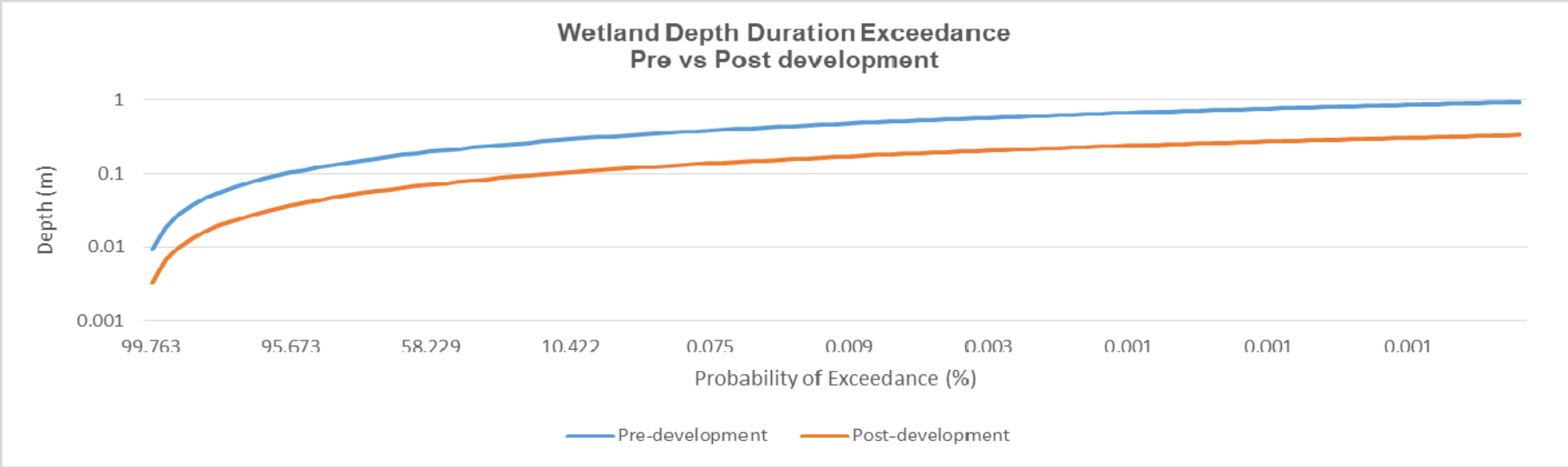


Figure 16 - SWMFs Frequency Distribution



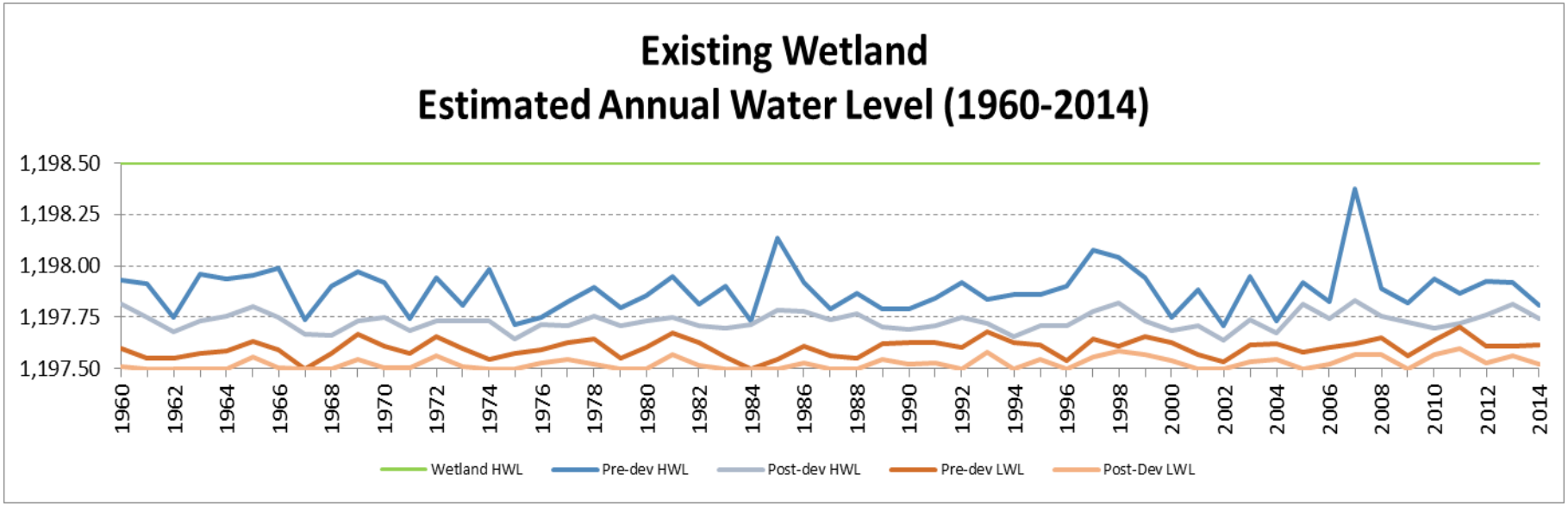


Figure 17 - Pre vs Post-development Wetland hydroperiods

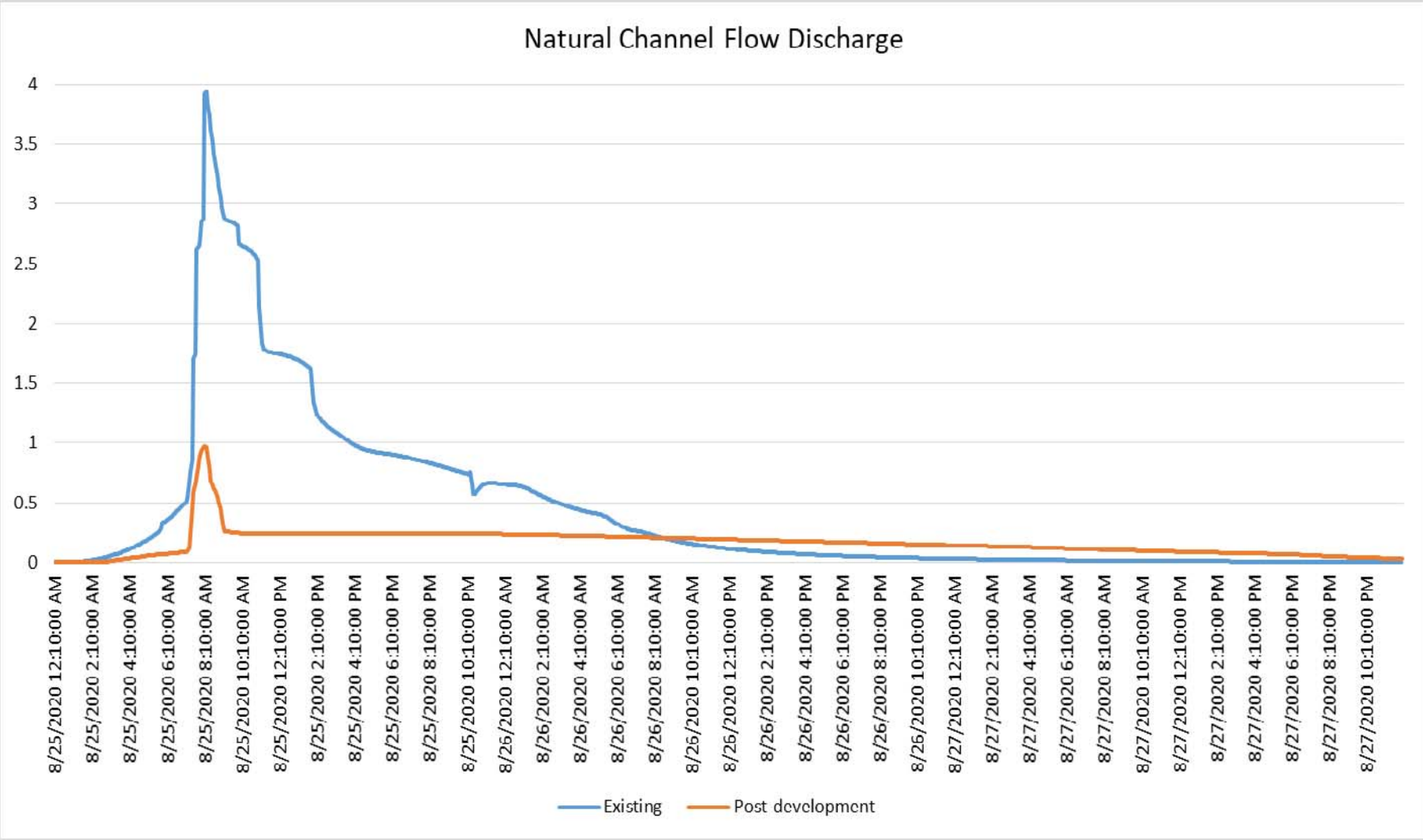


Figure 18 - Pre vs Post-development Flows in Natural Drainage Course

APPENDIX A

- **Geotechnical Report**
- **USDA Agricultural Research Service Chart**

Geotechnical Investigation Report

for

Highfield Land Management Inc.

Type of Document
Final

Project Name
Hawkwood Lands

Project Number
CGY-00092055-00

Prepared By: Melodie Tang, P.Eng.

Reviewed By: Joel Kliner, M.Sc., P.Eng.

exp Services Inc.
375, 7220 Fisher Street SE.
Calgary, AB. T2H 2H8
Canada

Date Submitted
11.18.16

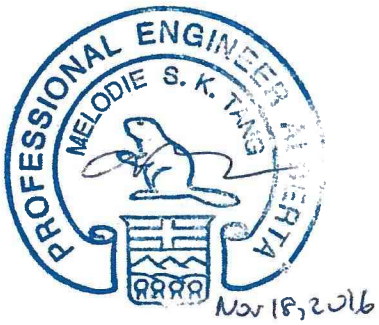
Geotechnical Investigation Report

Highfield Land Management Inc.

Type of Document:
Report

Project Number:
CGY-00092055-00

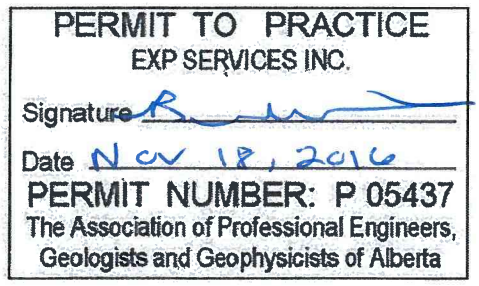
exp Services Inc.
375, 7220 Fisher Street SE.
Calgary, AB. T2H 2H8 Canada
T: +1.403.509.3030 www.exp.com



Prepared by:
Melodie Tang, P.Eng.
Geotechnical Engineer
Ph: 403.509.3030 ext.2288
melodie.tang@exp.com



Reviewed by:
Joel Kliner, M.Sc., P.Eng.
Senior Geotechnical Engineer
Ph. 403.509.3030 ext.2613
joel.kliner@exp.com



Date Submitted:
11.18.16

Legal Notification

This report is intended solely for Highfield Land Management Inc. and only for the issues addressed in the report. The material in this report represents the professional opinion of **exp** Services Inc. and its best judgment under the natural limitations imposed by the Scope of Work, in context of the information available to **exp** Services Inc. at the time of the report was prepared.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. **Exp** Services Inc. accepts no responsibility for damages of any kind, if any, suffered by a third party as a result of decisions made or actions taken on the basis of this report.

This report is limited in scope to only those elements that are specifically referenced in the report. There may be existing deficiencies in the project that were not apparent to us due to the limitations imposed by the scope of work. Therefore, **exp** can accept no liability for any costs or effects incurred by the Client for subsequent discovery, manifestation or rectification of such deficiencies.

Cost estimates, if any, provided in this report are approximations based in 2016 dollars, do not include engineering fees, and are the **exp** Services Inc. opinions of probable construction costs and quantities. These estimates do not reflect any unforeseen conditions that may require adjustments to work plans and scope when the work is done and the conditions are discovered. Any cost estimates provided are subject to confirmation or adjustment at the time competitive bids are obtained from contractors who specialize in the various items of work required. **Exp** Services Inc. makes no representation or warranty, express or implied, as to the accuracy or reliability of these cost estimates.

No part of this report may be extracted and used as a separate reference. The report has been written to be read in its entirety and for the exclusive use of the Client named.

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1.0 Introduction

As requested by Highfield Land Management Inc. (Highfield), **exp** Services Inc. (**exp**) has conducted a geotechnical assessment for the proposed Hawkwood Lands mixed-use development. The scope of work was outlined in the **exp** Proposal Ref. CGY-00092055-00, dated April 28, 2016. The geotechnical study is limited to the evaluation of the geotechnical characteristics of the site and does not include any environmental or chemical assessments of the soil and groundwater.

The following existing geotechnical information, as provided by the client (Highfield), was reviewed by **exp** and utilized as supplementary information for the proposed Hawkwood Lands mixed-use development:

- Report entitled "Geotechnical Evaluation, Hanewood Property Acquisition, M.D. of Rocky View, Alberta" dated August 15, 2007 prepared by McIntosh Lalani Engineering Ltd. (Reference No.: ML 3660).

This report presents the available subsurface exploration data and provides general geotechnical discussions and recommendations pertaining to the design and construction of the proposed development. An Interpretation & Use of Study and Report outlining the intended use and interpretation of this report is attached in ***Appendix A***. The Interpretation & Use of Study and Report forms an integral part of this report and should be included with any copies of the report.

2.0 Proposed Development

It is understood that the project site will be developed into a mixed use residential subdivision development with single and multi-family dwellings, as well as the potential for some small commercial retail structures and associated access roads.

The project will include the stripping and grading of the site, construction of the underground utilities, and construction of supporting roadways. This report serves to present the results of the field drilling program, laboratory soil testing and geotechnical design and construction recommendations for the general subdivision development.

Any commercial structures and some multifamily units (depending on the size) will require site specific geotechnical evaluations, once specific development design/locations are known.

3.0 Site Description

It is understood that the proposed site to be developed currently consists of 270 acres of land located in Rocky View County, AB within quarter sections SW 19-25-2-W5M and SE 19-25-2-W5M. The site is bound by Crowchild Trail and agricultural land to the north, 12 Mile Coulee Road (The City of Calgary boundary limits) and existing residential developments to the east, agricultural land to the west, and Township Road 253 to the south as shown on the Site Plan (***Figure 1*** in ***Appendix B***). The site is currently vacant farmland, with one farmstead located within the northeastern portion of the site. Topography of the site generally sloped from north to south and towards the natural drainage course at the centre of the site.

Based on review of surficial geology maps, the subsoil is expected to consist of Porcupine Hills formation sandstone and mudstone underlying silt and clay deposits, silt, sand and gravel deposits, and Spy Hill drift pebble loam till.

The site is understood to have a natural drainage course/coulee running north/south through the centre of the site, the slopes of which are anticipated to exceed fifteen percent. As per the City of Calgary Design Guidelines for Subdivision Servicing and Rocky View County Servicing Standards, a slope stability assessment for possible impacts on subdivision setbacks has been addressed in ***Section 6.0***.

4.0 Site Exploration Program

4.1 Field Exploration

The borehole drilling was carried out between October 17, 2016 and October 21, 2016. Prior to the fieldwork, the borehole locations were cleared of underground utilities by Alberta One-Call and a private locator. Twenty-nine (29) boreholes, denoted as BH16-01 through BH16-22 and MW16-01 through MW16-07 (completed as monitoring wells) were drilled at the approximate locations shown on the attached Borehole and Cross Section Location Plan (***Figure 2*** in ***Appendix B***). The boreholes were advanced to depths ranging from 4.0 m to 9.9 m below existing grade using a truck mounted drill rig equipped with 150 mm diameter solid stem augers owned and operated by Earth Drilling Co. Ltd. of Calgary, Alberta.

The subsurface soil conditions were continuously logged and visually classified in the field by **exp** personnel using the Modified Unified Soil Classification System. Soil stratigraphy was logged where changes in stratigraphy were noted, groundwater observed/encountered, and any other significant observations during borehole drilling and sample recovery. Representative soil samples were obtained at regular intervals from split spoon sampling and disturbed samples were collected from the auger flights for each soil stratum. Standard Penetration Tests (SPT's) were conducted at regular intervals to the maximum depth in each borehole. Pocket penetrometer tests were also performed at selected intervals on partially disturbed samples retrieved from the auger flights to determine an indication of the undrained shear strength of the cohesive soils.

Standpipe piezometers were installed in all boreholes in order to permit groundwater level monitoring. Seven (7) groundwater monitoring wells with 50 mm diameter standpipe were installed and constructed as per the recommendations of a hydrogeological consultant and as per the City of Calgary's LID Module 1 to assist in future hydrogeological studies.

The boreholes were backfilled to the surface grade elevation with drill cuttings and a bentonite chip seal as shown on the detailed borehole logs presented in ***Appendix C***.

4.2 Laboratory Testing

Laboratory testing was performed on selected samples, including:

- Natural moisture content determinations (158 tests);
- Atterberg Limits tests (12 tests);
- Hydrometer grain size tests on subsoil (12 tests) and hydrometer grain size analyses on topsoil (6 tests); and
- Water soluble sulphate (SO_4) content (8 tests).

The results of the laboratory testing are provided on the borehole logs in ***Appendix C*** and are discussed in the text of this report.

5.0 Subsurface Conditions

5.1 General

The subsurface strata and groundwater conditions encountered at each test location is described in detail on the borehole logs, with a more generalized description provided in this section for discussion purposes. The borehole logs are provided in ***Appendix C*** for reference.

The subsurface soil conditions encountered were generally found to consist of topsoil overlying lacustrine clay and/or clay till atop bedrock. A summary of the subsurface conditions observed at the borehole locations are presented in the following sections.

It should be noted that the soil boundaries indicated on the borehole logs are inferred from select sampling and observations during drilling. These boundaries are intended to reflect approximate transition zones for the purpose of geotechnical design and should not be interpreted as exact planes of geological change. The actual soil and groundwater conditions across the project site may vary between the boreholes.

It should be understood that geological conditions are naturally variable across any project site. Glacial tills are not typically homogenous and uniform across their stratigraphy. The geotechnical information within this report is based on the available subsurface information attained at the twenty-nine (29) discrete borehole and/or monitoring well locations. The precision of the subsurface conditions summarized depends on the methods used, frequency of sampling and the uniformity of the subsurface conditions. The spacing of the boreholes, frequency of soil sampling and the method of exploration have been selected to meet the needs of the project within constraints of the project plans, current exploration budget and schedule for geotechnical purposes. It is necessary to make some assumptions on the anticipated subsurface conditions across the project site between/surrounding the borehole locations to provide geotechnical recommendations for the proposed development. Adequate field reviews during construction should be undertaken to confirm that these assumptions are reasonably applicable for the specific development proposed.

5.2 Topsoil-Like Materials

Topsoil-like materials were encountered in all the boreholes, with thicknesses between 0.1 m to 0.6 m. The term “topsoil” in this report refers to a surficial soil layer with high organic content, and does not have any implications whatsoever as to the quality or suitability for re-use as a growing medium. The topsoil was generally described as having trace to some silt and sandy. The topsoil thicknesses have been determined at the borehole locations only. These thicknesses may not necessarily be representative across the project site as they may vary significantly between relatively widely spaced borehole locations. Additional shallow test locations would be needed to more accurately assess the topsoil thicknesses.

5.3 Clay Fill

Clay fill was encountered beneath the topsoil in BH16-07 with an approximate thickness of 1.6 m. The clay fill was generally described as silty, trace sand, damp to moist, low to medium plastic, and light brown in colour. A layer of buried topsoil was encountered below the clay fill at this borehole location.

5.4 Sand

Sand was encountered in BH16-20 below the topsoil layer to the termination depth of 6.6 m. The sand was described as silty, gravelly, occasional cobbles and boulders, dry to damp, fine grained, compact, and brown in colour.

5.5 Lacustrine Clay

Lacustrine clay was encountered beneath the topsoil in most boreholes with approximate thicknesses between 1.0 m to 7.0 m. The lacustrine clay was generally described as silty, trace sand, damp to moist, medium plastic (with high plastic clay identified in select boreholes), stiff to very stiff, and brown in colour.

5.6 Clay Till

Clay till was encountered beneath the topsoil or lacustrine clay in all boreholes. The clay till extended to depths between 2.7 m to greater than 9.6 m (where borehole termination depth was reached) below existing ground surface. The clay till was generally described as silty, trace sand, trace gravel, moist, low to medium plastic (with high plastic clay identified in select boreholes), stiff to very stiff, brown in colour, and contained traces of oxides and coal.

As per typical local till strata, sporadically distributed sand seams/pockets (potential source of perched/trapped groundwater) as well as cobbles and/or boulders may occur in the till soils; which were noted at specific borehole locations.

5.7 Bedrock

Sandstone or mudstone bedrock was encountered in boreholes BH16-3, BH16-5, BH16-6, BH16-8, BH16-9, BH16-14, BH16-15, BH16-17, BH16-18, and BH16-19. The depth to bedrock from existing ground surface ranged between 2.7 m to 7.9 m. The sandstone or mudstone bedrock encountered was generally described as extremely weak to very weak, highly to moderately weathered, dry, and light brown to grey in colour.

5.8 Groundwater

As discussed under ***Section 4.1*****,** standpipe piezometers were installed in all the boreholes in order to permit groundwater level monitoring. The groundwater level in each borehole was observed and recorded at the completion of drilling. As required for subdivision developments and as stated in the proposal, the groundwater levels will be monitored once a month over a six-month period. The standpipe piezometers were monitored on October 28, 2016.

Table 5-1 below presents a summary of our findings with respect to the groundwater levels encountered. In addition, the groundwater observations are presented on the borehole logs in ***Appendix C.***

TABLE 5-1: GROUNDWATER LEVELS, OCTOBER 28, 2016

Borehole Number	Groundwater Depth (below surface grade), m	
	@ Drilling Completion (October 17-21, 2016)	@ ≈ 1 Week after Drilling Completion (October 28, 2016)
BH16-01	Dry	Dry
BH16-02	Dry	Dry
BH16-03	Dry	Dry
BH16-04	Dry	Dry
BH16-05	Dry	8.95
BH16-06	Dry	Dry
BH16-07	Dry	Dry
BH16-08	Dry	Dry
BH16-09	Dry	7.86
BH16-10	Dry	4.95
BH16-11	9.45	8.64
BH16-12	Dry	6.22
BH16-14	Dry	5.10
BH16-15	Dry	5.32
BH16-16	Dry	Dry
BH16-17	Dry	Dry
BH16-18	Dry	Dry
BH16-19	Dry	5.90
BH16-20	Dry	Dry
BH16-21	Dry	Dry
BH16-22	6.55	6.64
MW16-01	Dry	Dry

Borehole Number	Groundwater Depth (below surface grade), m	
	@ Drilling Completion (October 17-21, 2016)	@ ≈ 1 Week after Drilling Completion (October 28, 2016)
MW16-02	9.45	3.5
MW16-03	1.22	2.20
MW16-04	3.05	1.54
MW16-05	4.88	4.64
MW16-06	Dry	Dry
MW16-07	Dry	4.85

It should be noted that the groundwater elevation varies with seasonal conditions including precipitation, surface drainage, localized hydrogeology and temperature (response to climatic conditions). Typically, groundwater conditions measured in late winter or early spring are often considered seasonal lows until the spring melt begins and localized groundwater response is affected. The long-term static groundwater table can fluctuate as much as 2.0 m over the course of one year in the general geographic area, with the peak groundwater levels generally occurring in June or July. Thus, groundwater levels should be measured periodically until the commencement of construction.

Based on the most recent groundwater depth readings as shallow as approximately 1.5 m across the project site, groundwater is anticipated to be encountered at shallow depths (< ≈ 4.0 m) associated with localized anticipated project site excavations for the proposed development. It is anticipated that a shallow groundwater table may pose some construction challenges during excavation and should be anticipated in localized areas. Permanent groundwater control/drainage should also be reviewed and provided as deemed necessary for the proposed development.

6.0 Slope Stability Analysis

Various global stability analyses for the existing elevation contours across the development site, corresponding to the representative cross-sections (as shown on ***Figure 3***, ***Figure 4*** and ***Figure 5***), were completed by **exp** utilizing the SLOPE/W software program. Six (6) representative cross-sections were created for review based on the geometry taken from the development/contour plans provided by **exp**'s Infrastructure division.

The results of the global stability analyses undertaken for the three most representative cross-sections are presented below and illustrated via the profiles associated with the SLOPE/W outputs as ***Figure 6***, ***Figure 7***, and ***Figure 8***.

Exp has not been provided any historic site-specific stripping and fill placement records across the project site; thus, it is assumed that the overall development site has not undergone any significant grading works over time. Proper site stripping and grading procedures should be undertaken to ensure that unsuitable organic or deleterious soils are not trapped at the base of any fill embankments that may be constructed. All general engineered fill soils for embankment fill should be compacted as per

Section 7.3. Fill placement for embankment fills should not be undertaken in a frozen state, as this could result is horizontal weak layer development within constructed fill embankments. Landscape slopes proposed across the development site should be limited to 5H:1V or flatter with proper drainage controls to prevent surficial erosion.

It is also recommended to consider methods such as notching the sideslopes of any cut slopes required prior to placing fill soils against a development cut slope. The notching with greatly improve bonding between the embankment fill and the underlying soil, reducing the risk of soil failure at the new/existing soil interface.

The global stability results refer to short-term stability during the initial stages of construction, which are generally considered to be the most critical case, due to pore pressure generation within overall development site grading, fill slope construction, and exposure of cut slopes prior to surficial vegetation taking root. The pore pressures will dissipate within the overall development site grading of fill slopes over the long-term and deep rooting of surface vegetation will protect against shallow surficial slumping/erosion, resulting in an improvement for the factor of safety against instability with the passage of time. The existing slopes are covered with mature vegetation; thus, these slopes, unless disturbed during development, have a strong surficial matting already intact for resistance to surficial erosion and sloughing.

The predominant soil strata utilized for SLOPE/W modelling was a silty clay surficial soil above a silty clay till overlying a highly weathered sandstone/mudstone bedrock (where encountered). The following soil parameters and groundwater conditions, which are interpreted to be reasonable and based on the most representative sections and existing slope conditions, have been assumed for the analysis as per ***Table 6-1*** below:

TABLE 6-1: SLOPE STABILITY PARAMETERS

SOIL TYPE	STRATA THICKNESS	UNIT WEIGHT (KN/M^3)	COHESION (KPA)	SOIL FRICTION ANGLE (^{O})
Stiff Silty Clay	≈3 m	18.0	1.0	26
Very Stiff Clay	≈9 m	19.0	2.0	28

Notes: An assumed piezometric line was applied at the bottom of the natural drainage course/coulee within the stiff and very stiff silty clay layers. Groundwater level readings on October 28, 2016 indicated the boreholes in the area were dry.

These analyses assumed that the existing elevation contours in the area of the natural drainage course/coulee site are not to be significantly altered via grading/lot development particulars and all development is carried out in accordance with the geotechnical recommendations contained in this letter report. As per the three specific analyses carried out, the following minimum global stability factors of safety (FoS) as shown in Table 6-2 were obtained for the existing elevation contours across the slopes, as well as for the assumed regulatory setback of 6.0 m:

TABLE 6-2: MINIMUM FACTOR OF SAFETY

SECTION	MINIMUM FOS	MINIMUM FOS (6M SETBACK)
B	1.309	1.517
C	1.857	1.989
D	1.399	1.757

A minimum global stability factor of safety greater than 1.5 for an assumed regulatory setback of 6.0 m was achieved for the most representative existing elevation contours and development configurations/profiles (typical lot development) analyzed, as illustrated in the SLOPE/W outputs as ***Figure 6***, ***Figure 7***, and ***Figure 8***.

As it is not recommended to develop right up to the crest of an existing slope with a gradient greater than 15%, especially those of significant vertical elevation difference, a development setback is recommended. An anticipated regulatory setback of 6.0 m was used in the slope stability analysis and was found to be acceptable with a minimum FOS of 1.5 or greater for all representative cross-sections. The slope crest can generally be defined as the transition of slope gradients from less than to steeper than 15%. The aforementioned minimum factors of safety will increase further upon adherence to the 6.0 m minimum development setback, as shown in ***Table 6-2***.

NOTE: Absolutely no development should be undertaken within the recommended 6.0 m minimum development setback (i.e.: building structures, cut/fill grading changes, retaining walls, etc.).

Exp has no geotechnical concerns with the proposed development of Hawkwood Lands from a slope stability perspective, provided that the recommendations of this report are implemented as development stages progress. Final overall cut/fill development plans should be reviewed by a qualified geotechnical engineer to determine if any additional slope stability concerns have arisen as a result of final development particulars such as proposed site grading (exposed cut slopes or proposed embankment fill slopes), individual lot development, roadway alignments, etc. (as these aspects were unknown at this stage of the development planning).

7.0 Discussions and Recommendations

7.1 Geotechnical Considerations

7.1.1 General

Based on the information obtained during our geotechnical explorations, the site soil and groundwater conditions are considered suitable for support of the proposed development, provided that the recommendations outlined within this report are adhered to. The following presents some geotechnical concerns that are based on the subsurface exploration.

7.1.2 Frost Susceptibility

The existing native lacustrine clay and clay till soils above the bedrock were noted to be silty in composition. Based on the laboratory results and our experience with similar silty clay soils, these soils are considered to be highly frost susceptible. Thus, a high potential for frost heave in the presence of water and freezing temperatures should be anticipated.

The measures provided in **Section 7.7** should be implemented to mitigate frost heave concerns for the proposed building structures. Any pavement designs will be aimed at providing commonly accepted levels of deflection for the design, and not for the purpose of fully mitigating the frost heave potential of the subgrade soils; therefore, there is some risk of heaving within the roadways and routine maintenance works may be required.

7.1.3 High Plastic Clay Soils

As high plastic clay soils were also identified sporadically across the project site from the limited Atterberg limits tests conducted, it is recommended to conduct verification testing of all bearing/subgrade soils at the time of construction to identify if high plastic clay soils have been encountered. Specific geotechnical recommendations may be required if high plastic clay soils are exposed in specific development areas.

7.1.4 Erodible Soils

As discussed under ***Section 7.1.2***, the existing native lacustrine clay and clay till soils above the bedrock were noted to have a high percentage of silt. Based on the laboratory results and our experience with similar silty clay soils, these materials are considered to be highly erodible.

7.1.5 Shallow Bedrock

As discussed under ***Section 5.7***, relatively shallow bedrock was encountered within the proposed development site in localized areas during the subsurface exploration. The depth to bedrock from existing ground surface ranged between 2.7 m (BH16-8 and BH16-19) to 7.9 m (BH16-14), where encountered. The shallow bedrock may be more difficult to excavate and may be encountered during deep utility installation within localized areas. Further discussion on construction issues due to the shallow bedrock is provided in ***Section 7.4*** of this report.

7.2 Site Preparation and Grading

Prior to placing any fill materials, the surface topsoil-like layer and any existing organic-rich soil, uncontrolled fill, soft or water softened soil should be removed from areas to be filled. Qualified geotechnical personnel should then review the subgrade prior to fill placement.

A minimum 50 mm depth of scarification is recommended in areas subject to additional fill placement (prior to fill placement) once initial stripping of deleterious materials has been undertaken. The depth of scarification should be moisture conditioned in the same manner as required for the subsequent fill

All fill soil placement should adhere to the Backfill and Compaction Specification report section. Organic soils should not be buried or mixed with general engineered or structural fill soils within the proposed building footprints, as this may lead to undesirable fill settlements or methane generation. Organic soils could be used for general landscape areas and it is recommended they be compacted with a reasonable amount of effort. Their value as a growing medium would need to be evaluated by others. High plastic clay soils are not recommended to be placed within 2.0 m laterally of any below grade foundation walls. Full-time monitoring and compaction testing during fill placement is recommended for subgrade construction by a qualified geotechnical engineer or technician independent of the contractor.

For areas requiring structural support, the fill materials for the grading works should consist of either structural fill or general engineered fill as defined in ***Section 7.3***. For all areas requiring structural support (building and road areas) in proposed fill areas, it is recommended that the exposed subgrade be graded to a 5H:1V gradient or flatter to mitigate differential settlements that may occur under any

key structures. Fill should not be placed on frozen subgrades and fill subgrade surfaces should not be allowed to freeze prior to placing subsequent lifts of fill. It is recommended that winter grading activities should be avoided.

Care should be taken to moisture condition, compact and document all grading activates. Deep fill assessments are recommended for all areas receiving 2.0m depth or more of fill.

7.3 Backfill Materials and Compaction

It is understood that some site grading may be required for the proposed development. The existing subsurface soils across the project site comprising the surficial silty clay (existing fill and native soils) within the upper approximate 4.0 m are suitable for use as general engineered fill on a limited basis. These soils, specifically the medium to high plastic clay soils, are considered to be highly frost susceptible and should not be used in areas exposed to frost penetration where subsequent frost heave is undesirable from a serviceability perspective. As well, areas prone to performance issues as a result of shrinkage or swelling potential of the medium to high plastic clay soils (e.g.: directly adjacent to below grade foundation walls, etc.) should also be avoided. Further verification testing is recommended during construction to identify if high plastic clay soils have been encountered. The proposed engineered fill soils for each specific construction aspect should be reviewed by the geotechnical engineer of record for the project site.

Moisture conditioning of the proposed backfill soils may be required prior to placement to achieve proper compaction results. The excavated site soils may be too wet or too dry at the time of construction; thus, moisture conditioning should be anticipated and carried out in a uniform manner to achieve a suitable moisture content range for the backfill soils during compaction.

All general engineered fill soils (cohesive or granular soils) are recommended to be compacted at a minimum Standard Proctor Maximum Dry Density (SPMDD) of 98% in maximum compacted lift thicknesses of 200 mm. All structural fill soils (well-graded granular soils with fines content generally less than 10% only) are recommended to be compacted at a minimum Standard Proctor Maximum Dry Density (SPMDD) of 100% in maximum compacted lift thicknesses of 200 mm. The site-specific excavated soils proposed for general engineered fill usage comprise of silty clay cohesive soils. Cohesive soils (silts, clays) should be uniformly moisture conditioned between the optimum moisture content (OMC) and 3% above the OMC prior to or during placement for compaction. Granular soils (sands, gravels) should be uniformly moisture conditioned between 3% below the OMC and 3% above the OMC prior to or during placement for compaction.

Structural fill may be required in special situations and should be used as directed by the geotechnical engineer. Structural fill can generally provide a higher bearing capacity than engineered fill and would be less settlement sensitive, and for example, may be desirable under building areas.

Where washing of fines is possible, fill material placed should be separated from coarser or finer backfill (comprising cohesive soils) material by a suitable geotextile.

Topsoil and soils containing organic manner or contamination should not be buried, mixed into, or used as general engineered fill soils. These soils should only be used as landscape fill soils due to their potential for methane generation and/or post-construction settlement potential. As well, all deleterious materials, contaminated soils (if encountered), and construction debris shall be removed prior to placement as a landscape fill soil.

The use of excavated bedrock soils as engineered fill soils is not recommended as these soils are prone to degradation over time and may exhibit large differential settlements. These soils may be utilized as landscape fill.

It should be recognized that it is difficult to compact soils during the winter unless the fill soils are placed and compacted in an unfrozen condition and the working area is prevented from freezing. Therefore, it should generally be avoided if at all practical. Any frost penetration that may have occurred should be thawed, scarified, and recompacted prior to fill placement. Fill soils should be free of any snow or ice lenses, should not be placed on a frozen or snow covered subgrade, and not be allowed to freeze following placement.

7.4 Construction Excavation and Temporary Dewatering

The composition and consistencies of the surficial soils at the site are such that conventional hydraulic excavators should be able to excavate the surficial soils. Though the bedrock has been classified as "extremely to very weak" from a geotechnical perspective, when excavations encounter bedrock, pneumatic rock breakers or ripper teeth may be required to break the stronger sandstone/ mudstone bedrock layers and possible hard inclusions.

Temporary excavations (durations of less than 2 months) will be required for utility trenches and footing or pile cap preparation. The excavations for this project site are anticipated to be primarily within the existing clay soils in the upper 3.0 m to 5.0 m. Conventional construction equipment (i.e.: hydraulic excavators, hydrovac, etc.) should be able to remove these subsurface soils without difficulty.

For the typical excavations anticipated at the site, short-term trench and excavation sideslopes through the clay soils may be cut back at sideslopes no steeper than 1H (Horizontal):1V (Vertical) to a maximum depth of 5.0 m. Vertical sideslopes must not exceed 1.5 m in height for shallow excavations where sloping of the sideslopes are not feasible due to space restrictions (vertical sideslopes should not be facilitated if groundwater seepage is encountered). Flatter slopes up to 2H:1V or flatter will be required where sand layers, soft and wet/saturated soils, or poor quality fill are encountered (i.e.: groundwater and soil instability are anticipated within a depth of approximately 1.5 m from the existing site grades in localized areas). The stability of excavated trench walls decrease with time; therefore, it is best to minimize the length of time that service trenches are left open. The applicable sections in the Occupational Health and Safety Act must be adhered to.

Deep excavations may encounter groundwater infiltration and require dewatering. Any groundwater seepage or surficial water influx encountered in the temporary excavations should be handled with a conventional sump pump application consisting of a system of ditches or perimeter trenches leading to sump pits (low points) with pumps to dewater the excavations.

Prior to allowing workers to enter the construction excavations, a thorough inspection should be undertaken for evidence of instability (cracks, bulging, sloughing, seepage, etc). Any loose/unstable soils or cobbles/boulders should be scaled from the excavations prior to worker entry. All unsupported excavations should be monitored on a daily basis for slope movements such as slumping, bulging, etc. Any such movements should be reported to **exp** and remedial stability measures undertaken immediately.

Stockpiles of construction materials, excavated soil, construction equipment, or traffic should be kept away from the slope crest/edge by a distance equal to the depth of excavation. The vibration created from heavy machinery operations or compaction processes can destabilize a slope; hence, use of heavy machinery within close proximity to excavated slopes should be minimized.

Temporary shoring design will be required for worker safety if the aforementioned safe excavation geometry cannot be facilitated (i.e.: due to proximity of adjacent property lines) or deeper excavations are required for construction aspects. **Exp** can provide these services as additional scope items, if requested.

7.5 Pipe Support

No difficulties are generally anticipated with regard to the pipe support; however, there could be some localized soft subgrade that may require some improvements for consistent pipe foundation support. Conventional methods for pipe support are considered feasible. Due to the presence of silty clay soils across the project site, **exp** recommends the use of compacted clay plugs at regular intervals. In addition, weep holes to direct groundwater into storm manholes should be used in these silty clay soils as per the City of Calgary detail (Sheet 59, file number 452.1005.006 entitled *Clay Plugs and Weeping Holes at Storm Manholes)*. This is to prevent erosion of the silts/clays and possible future subsidence due to loss of fine grained soils into the 40 mm washed drainage gravel. **Exp** should be notified during construction to provide on-site recommendations for the frequency of the clay plugs in the pipe zone.

7.6 Weeping Tile

Exp recommends subsurface weeping tile be installed for all below grade structures. The subsurface weeping tile should consist of minimum 100 mm diameter perforated PVC pipe and should be embedded in City of Calgary 40 mm diameter washed drainage gravel wrapped with a suitable filter fabric. The weeping tile should drain to a storm sewer or sump pump to overland drainage, subject to the approval of Rocky View County (the County).

7.7 Foundations

Based on the results of the geotechnical exploration, conventional strip and spread footings may be used for residential house structures within this development. It is anticipated that a factored geotechnical bearing resistance of 100 kPa should be attainable across the project site for the proposed residential structures.

Bearing certificates should be prepared by a qualified geotechnical engineer for all footings placed on fill or native soil. The surficial silty clay soils within the proposed development site may require some over-excavation (if soft saturated soils are encountered) and replacement with structural fill or engineered fill soils, to prepare adequate bearings surfaces.

All shallow foundation elements should be constructed on the undisturbed very stiff native clay till soils. Any pockets of existing fill soils, soft/wet/disturbed soils, or otherwise unsuitable bearing soils exposed at the foundation depth shall be subexcavated to acceptable bearing conditions and replaced with compacted structural fill (well-graded granular soils as per the Backfill and Compaction Specifications section of this report). The structural fill should extend laterally beyond the foundation footprint equal to the depth of subexcavation required. Alternately, the footings may be stepped down or the subexcavated depth below the proposed footing elevation may be backfilled with a low strength leancrete concrete.

Open excavations should be protected from any influx of precipitation from harsh weather and/or poor site grading prior to structural fill placement, concrete/leancrete placement, and/or backfill placement adjacent to the footings (i.e.: positive site grading away from open footing excavations and temporary covers are simple methods to consider prior to complete footing construction and backfill placement around the footings up to site grades, localized ditches and sumps to direct water away from footing

layouts, etc.). The exposed footing excavations should not be allowed to dry excessively or freeze prior to footing construction and cover fill placement up to final site grades. As well, it is not recommended to allow influx/accumulation of water adjacent to footings post-structural fill or concrete placement. Any standing water on the exposed bearing surfaces should be removed immediately. Additional bearing observations may be required if footing construction and structural fill and/or post-concrete placement is delayed and inclement weather arises or if the exposed bearing soils are prone to heavy disturbance during footing construction. It is recommended to protect the exposed bearing subgrades with an approximately 50 mm thick mudslab (leancrete concrete) after bearing observations have been conducted, if the foundation elements are not promptly constructed after excavation or unfavorable exposure conditions are anticipated.

Footings within heated structures should be founded at a depth of 1.4 m below grade and for unheated structures at a depth of 2.1 m below grade to protect against the effects of frost heaving. Appropriately designed ridged styrofoam insulation can be considered to reduce footing embedment depth. Exterior foundations such as deck footings and wing walls require 2.1 m of soil cover or equivalent insulation for frost protection.

Final grades around all permanent structures should be graded away from the foundation walls at a minimum 2 percent gradient. Downspout extensions should be used to direct roof water sufficiently away from the foundation walls.

7.8 Seismic Class

The seismic response of the site is classified according to the National Building Code of Canada 2010 (NBCC), which categorizes the soil conditions into six types - Class ‘A’ to ‘F’. This classification is based on the average shear wave velocity, energy-corrected SPT N values, or undrained shear strength over the top 30 m of the soil profile.

The site may be categorized as Class ‘D’ according to the NBCC 2010. Shear wave velocity data was not obtained from this site, and borings were not advanced to 30 m depth. Thus, the seismic classification is based on the SPT ‘N’ values within the depths drilled at the site, as well as on the assumption that the soil strength below the borehole termination depths is at least equivalent or greater.

7.9 Concrete Type

Eight (8) soil samples were selected at various depths for soluble sulphate testing to determine the water-soluble sulphate content of the subsurface soils. These tests yielded negligible to moderate degree of sulphate exposure. Therefore, it is recommended that the Canadian Standards Association (CSA) requirement of A23.1-09, **Table 2**, for Class S-3 exposure is adhered to as a minimum concrete specification. All concrete in contact with soils at this site can be made from CSA Type HS or HSb (Sulphate Resistant) Portland cement possessing a minimum compressive strength of 30 MPa at 56 days, a maximum water/cement ratio of 0.50, and air entrainment of 4-7% for concrete with nominal maximum coarse aggregate sizes of 14-20 mm. The structural engineer should make an independent determination of concrete specification requirements based on specific design function.

Any imported fill to be placed in contact with concrete should also be tested for water-soluble sulphate content and the above recommendations reevaluated.

7.10 Further Work and Geotechnical Review

Design recommendations presented in this report are based on the assumption that an adequate level of field reviews and testing will be provided during construction and that construction will be carried out

by a suitably qualified contractor experienced in underground utility installation and earthworks. An adequate level of field review is considered to be:

- For earthworks related to building pads, roads and paved areas - full time monitoring and compaction testing.
- For underground utility installation and backfilling - full time monitoring and compaction testing.

All geotechnical field reviews and testing should be carried out by a qualified geotechnical engineer or technician independent of the contractor. The purpose of providing an adequate level of field reviews is to check that recommendations, based on the data obtained at discrete borehole locations, are relevant to other areas of the site and confirm that the project requirements are adhered to.

8.0 Closure

Recommendations presented herein are based on a geotechnical evaluation of the findings at the five boreholes advanced at the site. If conditions other than those reported are noted during subsequent phases of the project, **exp** should be notified and given the opportunity to review the current recommendations in light of any new findings.

Soil conditions, by their nature, can be highly variable across a site. Recommendations presented herein may not be valid if an adequate level of field reviews and testing is not provided during construction, or if relevant building code requirements are not met.

A contingency amount should be included in the construction budget to allow for the possibility of variations in soil conditions, which may result in modification of the design, and/or changes in construction procedures. Contractors should make their own assessment of subsurface conditions and select the construction means and methods most appropriate to the site conditions. This geotechnical report should not be included in contract specifications without suitable qualifications and prior review by **exp**. However, the geotechnical report may be used as an attachment to contract specifications, for information purposes only.

This report has been prepared for the exclusive use of Highfield Land Management Inc. and their agents for specified application of this project. It has been prepared in accordance with generally accepted soil and foundation engineering practices. No other warranty, expressed or implied, is made.

Appendix A –
Interpretation and Use of Study & Report

INTERPRETATION & USE OF STUDY AND REPORT

1. STANDARD OF CARE

This study and Report have been prepared in accordance with generally accepted engineering consulting practices in this area. No other warranty, expressed or implied, is made. Engineering studies and reports do not include environmental consulting unless specifically stated in the engineering report.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report which is of a summary nature and is not intended to stand alone without reference to the instructions given to us by the Client, communications between us and the Client, and to any other reports, writings, proposals or documents prepared by us for the Client relative to the specific site described herein, all of which constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. WE CANNOT BE RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF THE REPORT

The Report has been prepared for the specific site, development, building, design or building assessment objectives and purpose that were described to us by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the document are only valid to the extent that there has been no material alteration to or variation from any of the said descriptions provided to us unless we are specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT OUR WRITTEN CONSENT. WE WILL CONSENT TO ANY REASONABLE REQUEST BY THE CLIENT TO APPROVE THE USE OF THIS REPORT BY OTHER PARTIES AS “APPROVED USERS”. The contents of the Report remain our copyright property and we authorise only the Client and Approved Users to make copies of the Report only in such quantities as are reasonably necessary for the use of the Report by those parties. The Client and Approved Users may not give, lend, sell or otherwise make the Report, or any portion thereof, available to any party without our written permission. Any use which a third party makes of the Report, or any portion of the Report, are the sole responsibility of such third parties. We accept no responsibility for damages suffered by any third party resulting from unauthorised use of the Report.

5. INTERPRETATION OF THE REPORT

a. Nature and Exactness of Descriptions: Classification and identification of soils, rocks, geological units, contaminant materials, building envelopment assessments, and engineering estimates have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature and even comprehensive sampling and testing programs, implemented with the appropriate equipment by experienced personnel, may fail to locate some conditions. All investigations, or building envelope descriptions, utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarising such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and all persons making use of such documents or records should be aware of, and accept, this risk. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. Where special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b. Reliance on Provided information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to us. We have relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, we cannot accept responsibility for any deficiency, misstatement or inaccuracy contained in the report as a result of misstatements, omissions, misrepresentations or fraudulent acts of persons providing information.

c. To avoid misunderstandings, **exp** Services Inc. (**exp**) should be retained to work with the other design professionals to explain relevant engineering findings and to review their plans, drawings, and specifications relative to engineering issues pertaining to consulting services provided by **exp**. Further, **exp** should be retained to provide field reviews during the construction, consistent with building codes guidelines and generally accepted practices. Where applicable, the field services recommended for the project are the minimum necessary to ascertain that the Contractor’s work is being carried out in general conformity with **exp**’s recommendations. Any reduction from the level of services normally recommended will result in **exp** providing qualified opinions regarding adequacy of the work.

6.0 ALTERNATE REPORT FORMAT

When **exp** submits both electronic file and hard copies of reports, drawings and other documents and deliverables (**exp**’s instruments of professional service), the Client agrees that only the signed and sealed hard copy versions shall be considered final and legally binding. The hard copy versions submitted by **exp** shall be the original documents for record and working purposes, and, in the event of a dispute or discrepancy, the hard copy versions shall govern over the electronic versions. Furthermore, the Client agrees and waives all future right of dispute that the original hard copy signed version archived by **exp** shall be deemed to be the overall original for the Project.

The Client agrees that both electronic file and hard copy versions of **exp**’s instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except **exp**. The Client warrants that **exp**’s instruments of professional service will be used only and exactly as submitted by **exp**.

The Client recognizes and agrees that electronic files submitted by **exp** have been prepared and submitted using specific software and hardware systems. **Exp** makes no representation about the compatibility of these files with the Client’s current or future software and hardware systems.

Appendix B – Figures



exp.

LEGEND:

CITY LIMITS BOUNDARY LINE

HAWKWOOD LANDS

PROJECT NAME:

HAWKWOOD LANDS

DATE: **2016.08.25** SCALE: **NTS**

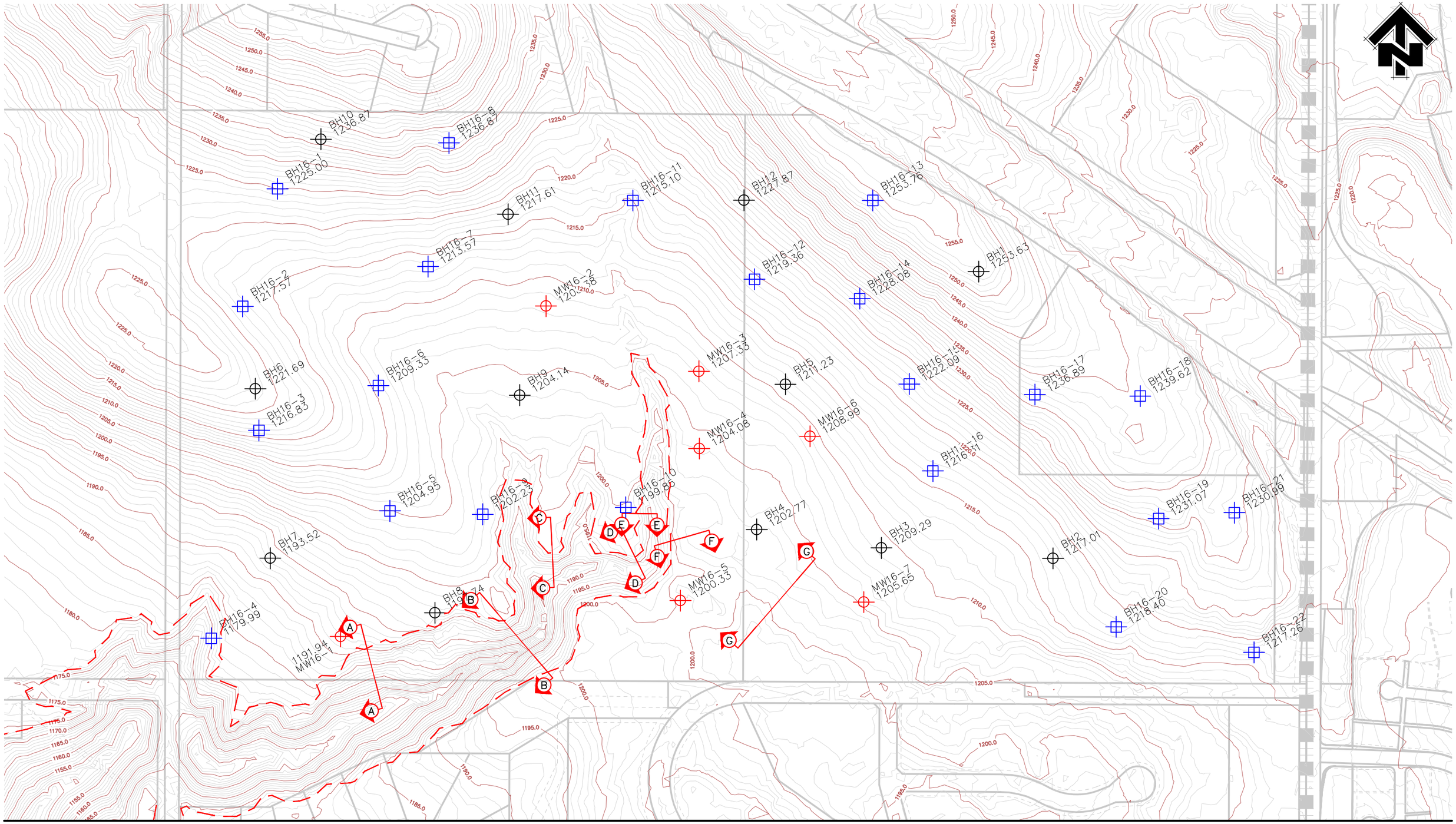
TITLE:

SITE LOCATION PLAN

FIGURE NO.:

01

Plot Date: Nov 17, 2016 - 01:38:13pm Plotted by:MeszarosR
O:\CGY-00092055-00\60 Project Execution\2 Design Data\Concept\2016-08-25-Figure 1-Project Area\CGY-00092055-00-Figure 1-Project Area.dwg XREFS: CGY-00092055-00 - Legal (3TM).dwg



LEGEND:

- BH8 1197.741 — EXISTING MCINTOSH LALANI TEST HOLE (AUGUST 2007)
- EXP GEOTECHNICAL TEST HOLE
- EXP MONITORING WELL
- CREST OF SLOPE (20%)

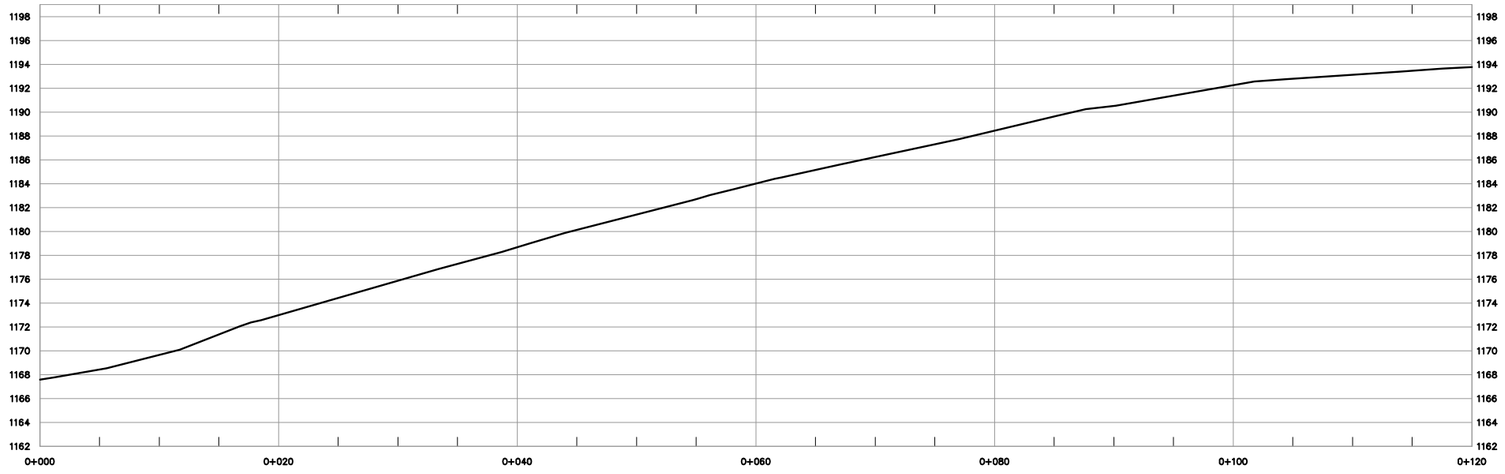
PROJECT NAME:
HAWKWOOD LANDS

PROJECT NO.: **CGY-00092055-00** DATE: **2016.11.15** SCALE: **1:5000**

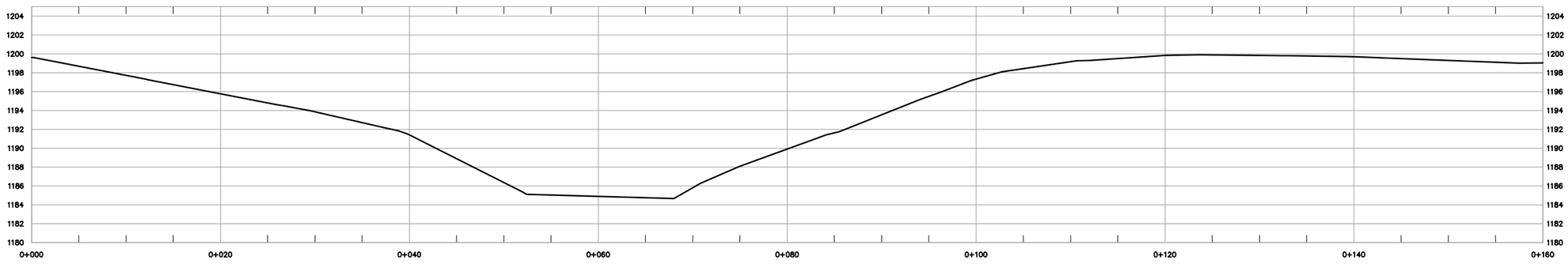
TITLE:
BOREHOLE & CROSS SECTION LOCATION PLAN

FIGURE NO.:
02

Section A



Section B



LEGEND:

ORIGINAL GROUND

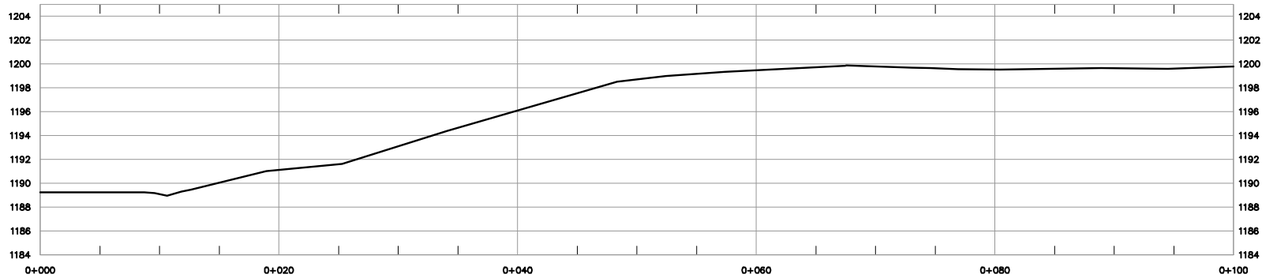
PROJECT NAME:
HAWKWOOD LANDS

PROJECT NO.: **CGY-00092055-00** DATE: **2016.11.15** SCALE: **1:500**

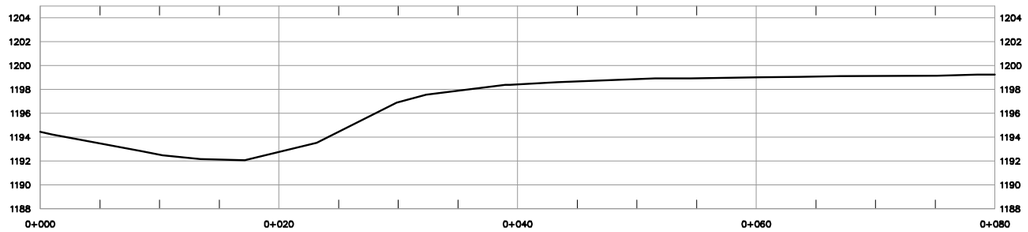
TITLE:
CROSS SECTIONS (A and B)

FIGURE NO.:
03

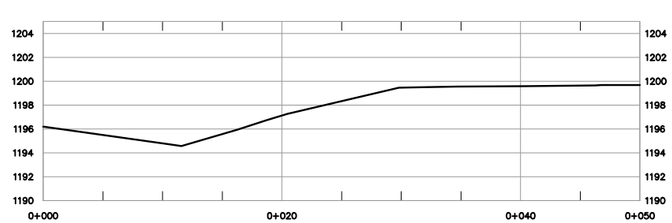
Section C



Section D



Section E



LEGEND:

ORIGINAL GROUND

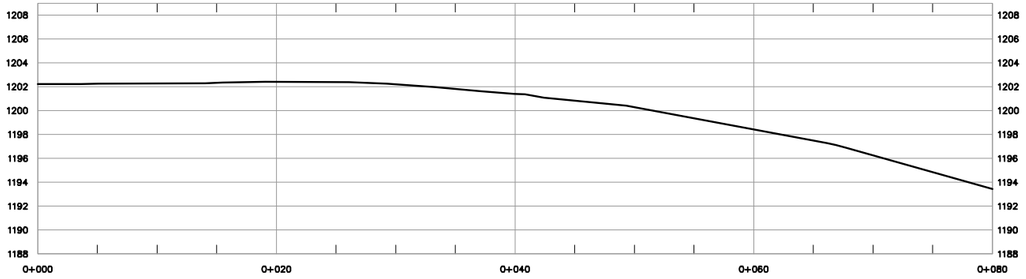
PROJECT NAME:
HAWKWOOD LANDS

PROJECT NO.: **CGY-00092055-00** DATE: **2016.11.15** SCALE: **1:500**

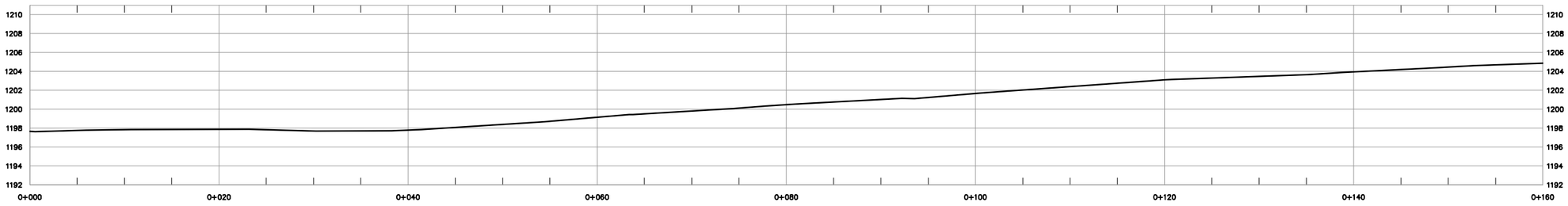
TITLE:
CROSS SECTIONS (C, D, and E)

FIGURE NO.:
04

Section F



Section G



LEGEND:

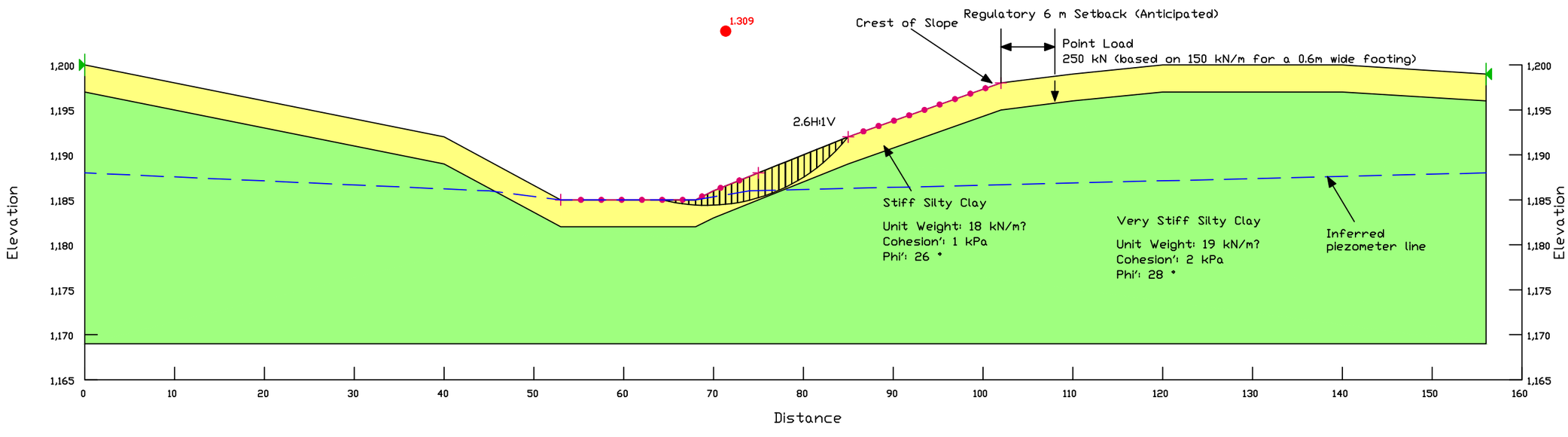
ORIGINAL GROUND

PROJECT NAME:
HAWKWOOD LANDS

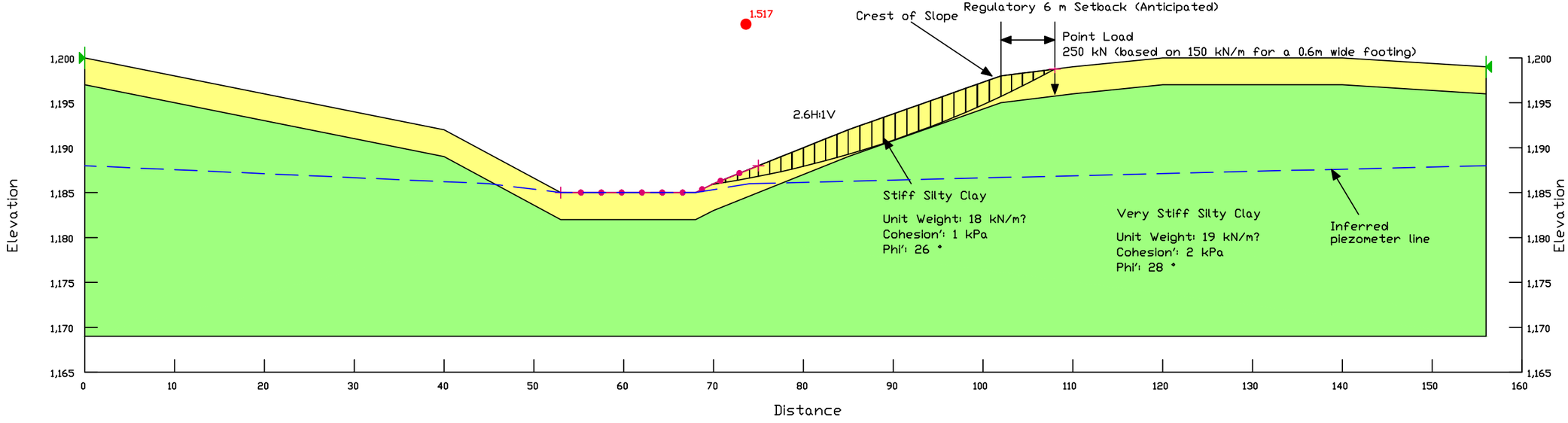
PROJECT NO.: **CGY-00092055-00** DATE: **2016.11.15** SCALE: **1:500**

TITLE:
CROSS SECTIONS (F and G)

FIGURE NO.:
05



SECTION B
SLOPE STABILITY ANALYSIS



SECTION B
(FORCED SLIP SURFACE AT 6m SETBACK)
SLOPE STABILITY ANALYSIS

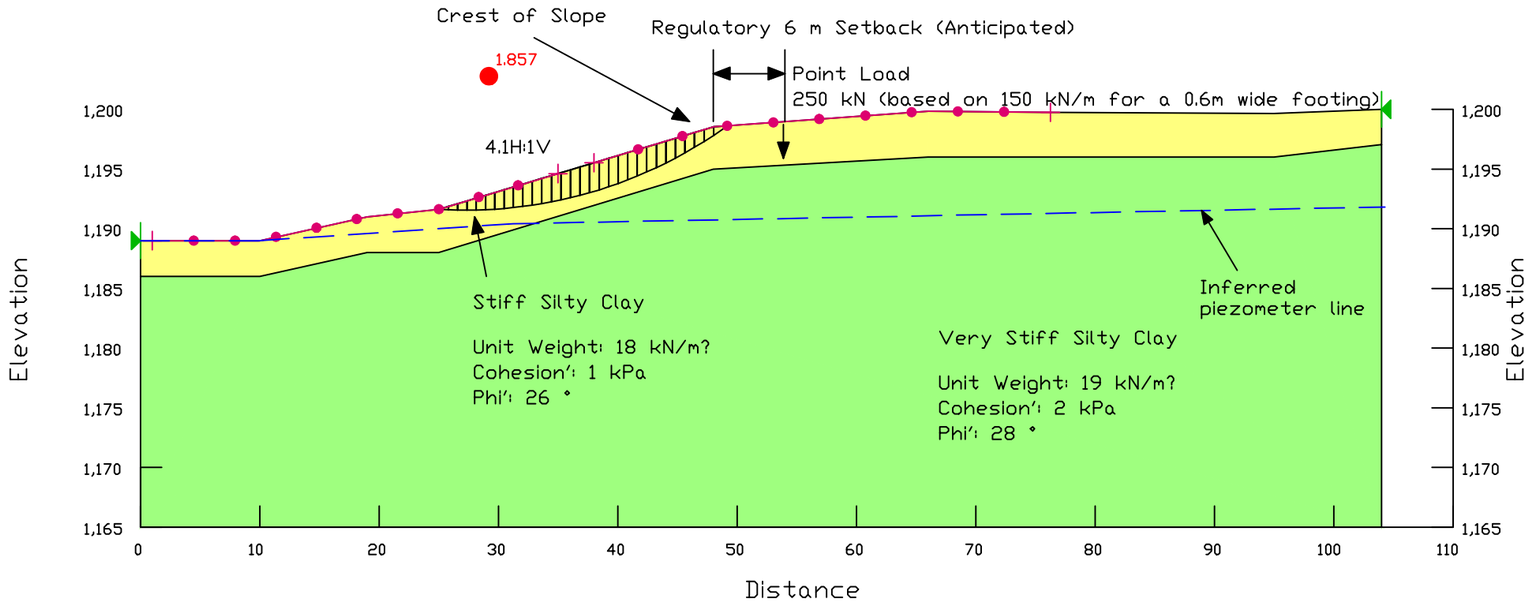
exp.

PROJECT NAME:
HAWKWOOD LANDS

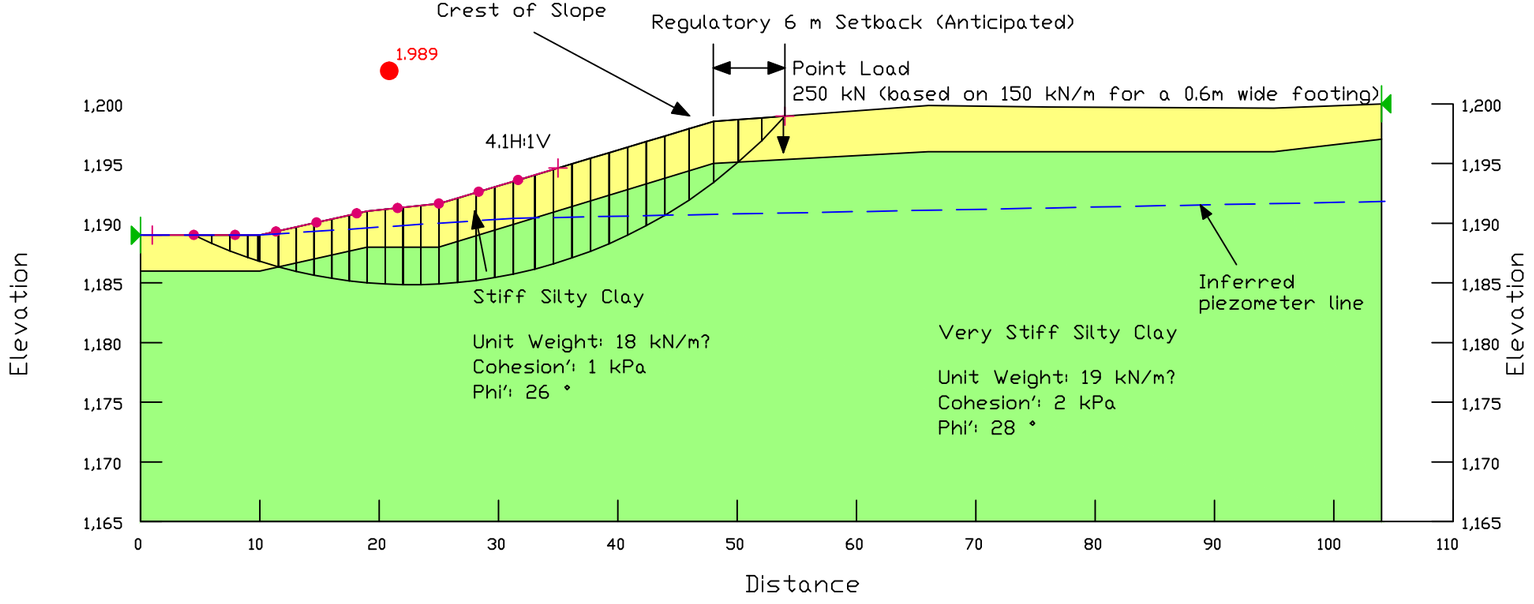
PROJECT NO.: CGY-00092055-00 DATE: 2016.11.15 SCALE: 1:500

TITLE:
EXISTING GROUND SLOPE STABILITY SECTION B

FIGURE NO.:
06



SECTION C
SLOPE STABILITY ANALYSIS



SECTION C
(FORCED SLIP SURFACE AT 6m SETBACK)
SLOPE STABILITY ANALYSIS

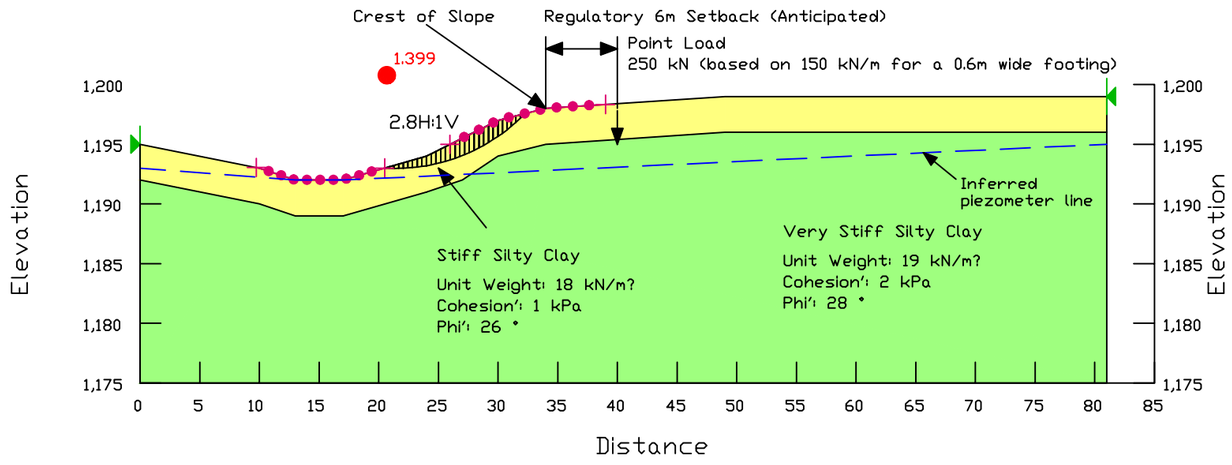
exp.

PROJECT NAME:
HAWKWOOD LANDS

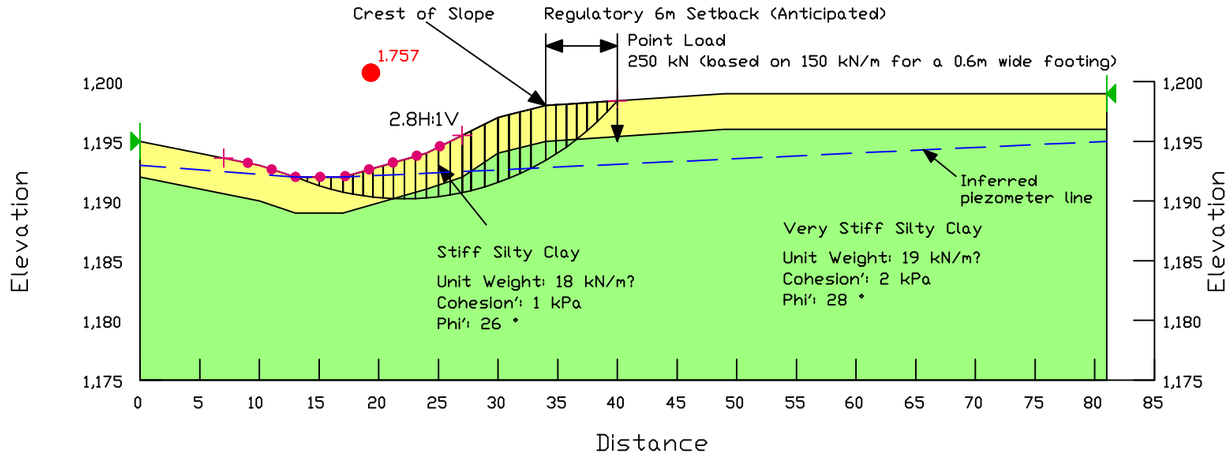
PROJECT NO.: CGY-00092055-00 DATE: 2016.11.15 SCALE: 1:500

TITLE:
EXISTING GROUND SLOPE STABILITY SECTION C

FIGURE NO.:
07



SECTION D
SLOPE STABILITY ANALYSIS



SECTION D
(FORCED SLIP SURFACE AT 6m SETBACK)
SLOPE STABILITY ANALYSIS

exp.

PROJECT NAME:
HAWKWOOD LANDS

PROJECT NO.: CGY-00092055-00 DATE: 2016.11.15 SCALE: 1:500

TITLE:
EXISTING GROUND SLOPE STABILITY SECTION D

FIGURE NO.:
08

Appendix C – Borehole Logs

RECORD OF BOREHOLE : BH16-01

exp Services Inc.

PROJECT NUMBER CGY-00092055-00
CLIENT Highfield Land Management Inc.
PROJECT NAME Hawkwood Lands
PROJECT LOCATION Calgary, Alberta
DRILLING DATE 2016-10-20
BOREHOLE LOCATION
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
ELEVATION 1225.05m
DRILLING METHOD Solid Stem Auger
GROUND WATER LEVELS: ▽ **AT TIME OF DRILLING** ---
EQUIPMENT TYPE Truck Mounted Auger Drill
▼ **AT END OF DRILLING** --- Dry
LOGGED BY CS **CHECKED BY** MT
▼ **AFTER DRILLING** --- 28/10/2016 Dry

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY %	SPT N VALUE BLOWS/0.3m (20 40 60 80) / DYNAMIC CONE BLOWS/0.3m (20 40 60 80)	POCKET PEN. (kPa) (100 200 300 400) / FIELD VANE SHEAR (kPa) Peak Remold (40 80 120 160)	FINES CONTENT (%) (20 40 60 80) / PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL (20 40 60 80)	WELL DIAGRAM Casing Top Elev: m
0		TOPSOIL, some clay, trace silt, sandy, some organics, dark brown, moist	1224.7	1	GB					Bentonite
			0.3							
1		CLAY, silty, trace sand, medium plasticity, stiff, greyish brown, damp to moist		2	GB				18	
			1223.2	3	SS	100	12	335	14	
2		CLAY (TILL), silty, trace to some sand, trace rounded to sub-rounded gravel, medium plasticity, stiff to very stiff, brown, moist -some coarse gravel, occasional coal fragments	1.9	4	GB					Cuttings
3		-some angular gravel fragments, occasional cobbles		5	SS	100	50/140mm		11	
4		-some gravel		6	GB					Sand
		-trace to some gravel, hard		7	SS	100	36	431		
5		-some gravel		8	GB				7	Screen
6				9	SS	30	30	431		
			1218.5							

Bottom of hole at 6.6m.

RECORD OF BOREHOLE : BH16-02

exp Services Inc.

PROJECT NUMBER CGY-00092055-00
CLIENT Highfield Land Management Inc.
PROJECT NAME Hawkwood Lands
PROJECT LOCATION Calgary, Alberta
DRILLING DATE 2016-10-20
BOREHOLE LOCATION
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
ELEVATION 1217.57m
DRILLING METHOD Solid Stem Auger
GROUND WATER LEVELS: ▽ **AT TIME OF DRILLING** ---
EQUIPMENT TYPE Truck Mounted Auger Drill
▼ **AT END OF DRILLING** --- Dry
LOGGED BY CS **CHECKED BY** MT
▼ **AFTER DRILLING** --- 28/10/2016 Dry

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m / DYNAMIC CONE BLOWS/0.3m	POCKET PEN. (kPa) / FIELD VANE SHEAR (kPa) Peak Remold	FINES CONTENT (%) / PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL	WELL DIAGRAM Casing Top Elev: m
		TOPSOIL, some clay, trace silt, sandy, some rootlets/organics, dark brown, moist	1217.1	1	GB					Bentonite
1		CLAY (TILL), silty, trace fine rounded to sub-rounded gravel, trace sand, trace sulphates, medium plasticity, firm, greyish brown, moist	0.5	2	GB				22	
			1216.0							
2		CLAY, silty, trace sand, trace sulphates, medium plasticity, firm to stiff, brown, moist -Sulphate Content <0.1% -soft Grain Size Analysis: Gravel = 0.0% Sand = 2.2% Silt = 84.1% Clay = 13.7% -minor oxidation	1.5	3	SS	100	9	239	23	
				4	GB				29 (22 / 48)	
3				5	SS	100	9	192	32	Cuttings
4				6	GB					
			1213.0							
5		CLAY (TILL), silty, some sand, trace rounded to sub-rounded gravel, medium plasticity, stiff, possible bedrock fragments, minor oxidation -trace to some gravel -boulder/cobble, sandy -bouncing SPT	4.6	7	SS	100	13	335	16	
6				8	GB				14	Sand
				9	SS					
7				10	GB				16	
8		-very stiff		11	SS	50	24	335		Screen
		-occasional cobbles		12	GB				14	
9		-occasional silt layers		13	SS	100	30	431	20	
			1208.0							

Bottom of hole at 9.6m.

EXP GEO CGY-00092055 LOGS.GPJ EXP STD.GDT 21/11/16

RECORD OF BOREHOLE : BH16-03

exp Services Inc.

PROJECT NUMBER CGY-00092055-00
CLIENT Highfield Land Management Inc.
PROJECT NAME Hawkwood Lands
PROJECT LOCATION Calgary, Alberta
DRILLING DATE 2016-10-20
BOREHOLE LOCATION
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
ELEVATION 1216.27m
DRILLING METHOD Solid Stem Auger
GROUND WATER LEVELS: **AT TIME OF DRILLING** ---
EQUIPMENT TYPE Truck Mounted Auger Drill
AT END OF DRILLING --- Dry
LOGGED BY CS **CHECKED BY** MT
AFTER DRILLING --- 28/10/2016 Dry

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m / DYNAMIC CONE BLOWS/0.3m (20 40 60 80)	POCKET PEN. (kPa) / FIELD VANE SHEAR (kPa) Peak Remold (100 200 300 400 / 40 80 120 160)	FINES CONTENT (%) / PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL (20 40 60 80)	WELL DIAGRAM Casing Top Elev: m
		TOPSOIL, some clay, silty, sandy, some organics, dark brown, moist Grain Size Analysis: Gravel = 2.3% Sand = 51.0% Silt = 33.6% Clay = 13.7%	1215.8 0.5	1	GB					Bentonite
1		CLAY, silty, trace to some sand, trace sulfates, medium plasticity, firm, light brown, moist		2	GB				26	
		-stiff, trace fine to coarse sub-rounded gravel		3	SS	100	9	192	27	Cuttings
2				4	GB				24	Sand
3		-greyish brown, occasional coal fragments	1213.1							
		SANDSTONE, extremely weak to very weak, highly to moderately weathered, brown, dry	3.2	5	SS	100	50 50/130mm			Screen
			1212.3	6	GB					

Refusal at 4.0m.

RECORD OF BOREHOLE : BH16-04

exp Services Inc.

PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-20
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1183.78m
GROUND WATER LEVELS: **AT TIME OF DRILLING** ---
AT END OF DRILLING --- Dry
AFTER DRILLING --- 28/10/2016 Dry

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m / DYNAMIC CONE BLOWS/0.3m	POCKET PEN. (kPa) / FIELD VANE SHEAR (kPa) Peak, Remold	FINES CONTENT (%) / PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL	WELL DIAGRAM Casing Top Elev: m
		TOPSOIL, some clay, some silt, sandy, some organics, dark brown, moist	1183.5 / 0.3	1	GB					Bentonite
1		CLAY, silty, trace to some sand, trace sulphates, medium plasticity, stiff, brown, moist		2	GB					
		-occasional grey mottling, occasional quartz crystals from 1.5 to 2.4m		3	SS	100	14	335	23	
2		-sand seams -Sulphate Content = 0.3%		4	GB					
3		-some sand to sandy, minor oxidation, occasional grey mottling		5	SS	100	11	383	30	Cuttings
		-medium to high plasticity, occasional quartz crystals Grain Size Analysis: Gravel = 5.7% Sand = 25.7% Silt = 57.6% Clay = 11.0% -trace fine sand, very stiff		6	GB				26 (20 – 50)	
4				7	SS	100	16	383	21	
		-occasional sandy seams -occasional trace coarse rounded gravel		8	GB					
5		-occasional silt seams and lenses		9	SS		17		16	
		-grey								
6		-occasional coal fragments		10	GB					Sand
			1176.5							
		CLAY (TILL), silty, some sand, trace rounded to sub-rounded gravel, occasional cobbles, medium plastic, very stiff, greyish brown, moist	7.3							
7		-trace bedrock fragments		11	SS	100	25	383	19	Screen
				12	GB					
8										
		-occasional silt and fine sand seams		13	SS	100	24		23	
9			1174.2							

Bottom of hole at 9.6m.

EXP GEO CGY-00092055 LOGS.GPJ EXP STD.GDT 21/11/16

RECORD OF BOREHOLE : BH16-05

exp Services Inc.

PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-20
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1204.99m
GROUND WATER LEVELS: **AT TIME OF DRILLING** ---
AT END OF DRILLING --- Dry
AFTER DRILLING 8.9m 28/10/2016

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m / DYNAMIC CONE BLOWS/0.3m	POCKET PEN. (kPa) / FIELD VANE SHEAR (kPa) Peak Remold	FINES CONTENT (%) / PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL	WELL DIAGRAM Casing Top Elev: m
		TOPSOIL, some clay, trace to some silt, sandy, some organics, dark brown, moist	1204.8 / 0.2	1	GB					Bentonite
1		CLAY, silty, trace sulphates, medium plasticity, firm to stiff, light brown, damp to moist		2	GB				26	
		-stiff, moist		3	SS	100	13	192	29	
2				4	GB				21	
		-trace rounded to sub-rounded gravel and cobbles								
3			1201.8	5	SS	100	13	239		Cuttings
		CLAY (TILL), silty, some sand, trace rounded to sub-rounded gravel, medium plasticity, stiff, light brown, moist	3.2	6	GB				17	
4		-trace to some gravel								
			1200.1	7	SS	100	27	335		
5		MUDSTONE, extremely weak, highly weathered, minor to major oxidation, light brown, some grey mottling, dry to damp	4.9	8	GB				17	
6		-crumbled		9	SS	100	57			Sand
				10	GB				9	
7										
				11	SS	100	66			Screen
8		-very weak, moderately weathered		12	GB				13	
9		-extremely weak, brown		13	SS	100	20			
			1195.2 / 9.8	14	GB					

Refusal at 9.9m.

EXP GEO CGY-00092055 LOGS.GPJ EXP STD.GDT 21/11/16

RECORD OF BOREHOLE : BH16-06

exp Services Inc.

PROJECT NUMBER CGY-00092055-00 **CLIENT** Highfield Land Management Inc.

PROJECT NAME Hawkwood Lands **PROJECT LOCATION** Calgary, Alberta

DRILLING DATE 2016-10-20 **BOREHOLE LOCATION**

DRILLING CONTRACTOR Earth Drilling Co. Ltd. **ELEVATION** 1209.41m

DRILLING METHOD Solid Stem Auger **GROUND WATER LEVELS:** ▽ **AT TIME OF DRILLING** ---

EQUIPMENT TYPE Truck Mounted Auger Drill ▼ **AT END OF DRILLING** --- Dry

LOGGED BY CS **CHECKED BY** MT ▼ **AFTER DRILLING** --- 28/10/2016 Dry

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m (▲) 20 40 60 80 / DYNAMIC CONE BLOWS/0.3m 20 40 60 80	POCKET PEN. (kPa) (⊙) 100 200 300 400 / FIELD VANE SHEAR (kPa) Peak Remold 40 80 120 160	FINES CONTENT (%) (□) 20 40 60 80 / PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL 20 40 60 80	WELL DIAGRAM Casing Top Elev: m
0		TOPSOIL, some clay, sandy, trace silt, some rootlets, dark brown, moist	1209.2	1	GB					Bentonite
			0.2							
		CLAY, silty, trace fine sand, medium plasticity, stiff, light brown, moist		2	GB			192	29	
1										
		-occasional fine to medium sand seams		3	SS	60	11	287	26	
2										
		-trace coarse rounded gravel from 2.7 to 3.3m, medium to high plasticity Grain Size Analysis: Gravel = 0.0% Sand = 4.4% Silt = 84.2% Clay = 11.5% -minor oxidation		4	GB				31 (20 – 51)	Cuttings
3				5	SS	80	9	287	29	
		-occasional sand seams with trace gravel from 3.0 to 4.5m		6	GB					
4			1204.8							Sand
		CLAY (TILL), silty, some sand, trace sub-rounded sub-angular gravel, medium plastic, very stiff, occasional coal fragments, oxidation, brown, dry	4.6 1204.5	7	SS	100	26	335	16	
5			4.9							
		MUDSTONE, extremely weak, highly weathered, light brown, dry		8	GB				17	Screen
6										
			1202.9	9	SS	100	50			

Bottom of hole at 6.6m.

RECORD OF BOREHOLE : BH16-07

exp Services Inc.

PROJECT NUMBER CGY-00092055-00
CLIENT Highfield Land Management Inc.
PROJECT NAME Hawkwood Lands
PROJECT LOCATION Calgary, Alberta
DRILLING DATE 2016-10-19
BOREHOLE LOCATION
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
ELEVATION 1213.57m
DRILLING METHOD Solid Stem Auger
GROUND WATER LEVELS: **AT TIME OF DRILLING** ---
EQUIPMENT TYPE Truck Mounted Auger Drill
AT END OF DRILLING --- Dry
LOGGED BY CS **CHECKED BY** MT
AFTER DRILLING --- 28/10/2016 Dry

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m (▲) 20 40 60 80 / DYNAMIC CONE BLOWS/0.3m 20 40 60 80	POCKET PEN. (kPa) (⊙) 100 200 300 400 / FIELD VANE SHEAR (kPa) Peak Remold 40 80 120 160	FINES CONTENT (%) (□) 20 40 60 80 / PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL 20 40 60 80	WELL DIAGRAM Casing Top Elev: m
0		TOPSOIL, some clay, trace silt, sandy, some rootlets, dark brown, moist	1213.4 / 0.2	1	GB					Bentonite
1		CLAY (FILL), silty, trace sand, medium plasticity, light brown, damp to moist -Sulphate Content <0.1%		2	GB				20	
			1211.7	3	SS	100	5			
2		TOPSOIL, trace organics and rootlets, dark brown, moist	1.8 / 1211.4							
		CLAY, silty, trace sand, medium plasticity, stiff, brown, moist -grey	2.1	4	GB				25	Cuttings
3		-stiff to very stiff, occasional silt seams -minor oxidation, brown		5	SS	100	9	144	26	
4		-trace gravel		6	GB					
				7	SS	100	15	239	22	
5				8	GB					Screen Sand
6			1207.4							
		CLAY (TILL), silty, trace to some sand, trace gravel, medium plasticity, very stiff, brown, moist	6.1 / 1207.0	9	SS	100	16	287	15	

Bottom of hole at 6.6m.

RECORD OF BOREHOLE : BH16-08

exp Services Inc.

PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-20
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1237.11m
GROUND WATER LEVELS: **AT TIME OF DRILLING** ---
AT END OF DRILLING --- Dry
AFTER DRILLING --- 28/10/2016 Dry

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m / DYNAMIC CONE BLOWS/0.3m	POCKET PEN. (kPa) / FIELD VANE SHEAR (kPa)	FINES CONTENT (%) / PLASTIC & LIQUID LIMIT MOISTURE CONTENT	WELL DIAGRAM Casing Top Elev: m
0		TOPSOIL, some clay, trace silt, sandy, trace cobbles, some organics, dark brown, moist	1236.9 / 0.3	1	GB					
1		CLAY, silty, trace sulphates, medium plasticity, stiff, brown with oxidation, moist		2	GB				19	Bentonite
2		-very stiff -Sulphate Content <0.1% -grey, minor oxidation, dry		3	SS	50	29			
		-light brown, dry	1234.4	4	GB				16	
3		MUDSTONE, completely weathered to residual soil, extremely weak, trace to some sand, greyish brown, dry to damp	2.7	5	SS	90	50/150mm		14	Cuttings
4				6	GB					Sand
5		-minor oxidation		7	SS	100	50/75mm		12	
				8	GB					Screen
6			1230.8	9	SS	100	50/50mm			

Bottom of hole at 6.3m.

RECORD OF BOREHOLE : BH16-09

exp Services Inc.

PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-20
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1202.32m
GROUND WATER LEVELS: ▽ **AT TIME OF DRILLING** ---
▼ **AT END OF DRILLING** --- Dry
▼ **AFTER DRILLING** 7.9m 28/10/2016

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m / DYNAMIC CONE BLOWS/0.3m (20 40 60 80)	POCKET PEN. (kPa) / FIELD VANE SHEAR (kPa) Peak Remold (100 200 300 400 / 40 80 120 160)	FINES CONTENT (%) / PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL (20 40 60 80)	WELL DIAGRAM Casing Top Elev: m
0		TOPSOIL, trace clay, silty, sandy, some rootlets, dark brown, moist	1202.0	1	GB					Bentonite
		Grain Size Analysis: Gravel = 0.0% Sand = 60.1% Silt = 28.8% Clay = 11.2%	0.3							
1		CLAY, silty, medium plasticity, soft to firm, trace sulphates, greyish brown, moist		2	GB					
		-stiff, some dark grey mottling		3	SS	100	8	192	25	
2				4	GB					
3		-occasional silt seams, firm, damp		5	SS	100	7	239	36	Cuttings
				6	GB				24	
4		-trace gravel, silt seams								
		-ocasional silt and sand seams, medium to high plasticity, soft to firm		7	SS	100	9	96	25	
5				8	GB				22	
		-occasional cobbles, trace gravel								
6										Sand
			1195.9	9	SS	100	14	192	28	
		CLAY (TILL), silty, some sand, trace rounded to sub-rounded gravel, occasional cobbles, very stiff, medium plastic, minor oxidation, brown, moist	6.4							
7				10	GB				14	Screen
			1194.5	11	SS		32/75mm			
		SANDSTONE/MUDSTONE, extremely weak, highly weathered, grey, dry	7.8 1194.5							
		Refusal at 7.8m.								

RECORD OF BOREHOLE : BH16-10

exp Services Inc.

PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-19
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1199.83m
GROUND WATER LEVELS: ▽ **AT TIME OF DRILLING** ---
▼ **AT END OF DRILLING** --- Dry
▼ **AFTER DRILLING** 4.9m 28/10/2016

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m ▲ 20 40 60 80 / DYNAMIC CONE BLOWS/0.3m 20 40 60 80	POCKET PEN. (kPa) ⊙ 100 200 300 400 / FIELD VANE SHEAR (kPa) Peak ● Remold ○ 40 80 120 160	FINES CONTENT (%) □ 20 40 60 80 / PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL 20 40 60 80	WELL DIAGRAM Casing Top Elev: m
0		TOPSOIL, some clay, sandy, trace silt, dark brown, moist	1199.6	1	GB					Bentonite
		CLAY, silty, trace sand, medium plasticity, trace sand, brown, damp to moist, firm	0.3	2	GB				31	
1										
				3	SS	67	7 ▲	192 ⊙		
2			1197.7							
		CLAY (TILL), silty, trace to some sand, trace rounded to sub-rounded gravel, medium plasticity, stiff, brown, damp to moist	2.1	4	GB				14	
3		Grain Size Analysis: Gravel = 0.9% Sand = 5.5% Silt = 84.2% Clay = 9.4%		5	SS	100	11 ▲	239 ⊙	25 16 38	Cuttings
		-trace grey mottling, moist		6	GB				19	
4										
		-silt seams, damp		7	SS	100	10 ▲	239 ⊙	26	
5				8	GB				24	
6		-very stiff		9	SS	100	18 ▲	192 ⊙		Sand
		-trace fine to coarse rounded gravel		10	GB				23	
7										
		-trace coal fragments		11	SS	100	15 ▲	287 ⊙	21	Screen
8				12	GB					
9										
			1190.2	13	GB	100	21 ▲	287 ⊙	21	

Bottom of hole at 9.6m.

RECORD OF BOREHOLE : BH16-11

exp Services Inc.

PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-19
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1217.42m
GROUND WATER LEVELS: ▽ **AT TIME OF DRILLING** ---
▼ **AT END OF DRILLING** 9.45m
▼ **AFTER DRILLING** 8.6m 28/10/2016

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m (▲) 20 40 60 80	POCKET PEN. (kPa) (⊙) 100 200 300 400	FINES CONTENT (%) (□) 20 40 60 80	WELL DIAGRAM Casing Top Elev: m
							DYNAMIC CONE BLOWS/0.3m 20 40 60 80	FIELD VANE SHEAR (kPa) Peak ● Remold ○ 40 80 120 160	PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL 20 40 60 80	
0		TOPSOIL, some rootlets, trace to some clay, silty, sandy, dark brown, moist	1217.1	1	GB					
		Grain Size Analysis: Gravel = 0.2% Sand = 61.7% Silt = 24.4% Clay = 13.7%	0.3	2	GB				25	
1		CLAY, silty, medium plasticity, trace sand, brown, damp to moist, firm								
		-trace fine rounded gravel, moist	1215.6	3	SS	100	15	287		
2		CLAY (TILL), silty, some sand, trace rounded to sub-rounded gravel, occasional cobbles, medium plasticity, stiff, brown, damp to moist	1.8	4	GB				17	
3		-occasional sand lenses Grain Size Analysis: Gravel = 22.8% Sand = 16.8% Silt = 50.7% Clay = 9.7% -trace to some coarse gravel, silt layers		5	SS	100	36	311	15 16 43	
4				6	GB				15	
		-trace gravel, moist		7	SS	100	15	311		
5				8	GB				14	
6		-occasional coal fragments		9	SS	100	31	359		
7		-some coarse rounded gravel		10	GB				15	
8				11	SS	100	19	335		
9		-trace gravel		12	GB				14	
		-some gravel (rock in SPT), wet	1207.8	13	SS	50	50/150mm			

WELL DIAGRAM: Bentonite; Cuttings; Sand; Screen

Bottom of hole at 9.6m.

RECORD OF BOREHOLE : BH16-12

exp Services Inc.

PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-19
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1219.42m
GROUND WATER LEVELS: ▽ **AT TIME OF DRILLING** ---
▼ **AT END OF DRILLING** --- Dry
▼ **AFTER DRILLING** 6.2m 28/10/2016

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m (▲) 20 40 60 80 / DYNAMIC CONE BLOWS/0.3m 20 40 60 80	POCKET PEN. (kPa) (⊙) 100 200 300 400 / FIELD VANE SHEAR (kPa) Peak ● Remold ○ 40 80 120 160	FINES CONTENT (%) (□) 20 40 60 80 / PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL 20 40 60 80	WELL DIAGRAM Casing Top Elev: m
		TOPSOIL, some rootlets, trace to some clay, trace to some silt, sandy, dark brown, moist	1219.2	1	GB					Bentonite
			0.3							
1		CLAY, silty, trace sand, medium plasticity, stiff, brown, damp to moist		2	GB				26	
			1217.9							
		SAND, silty, trace clay, fine to medium, light brown, dry to damp, compact	1.5	3	SS	90	17	239		
2			1217.7							
		CLAY (TILL), silty, some sand, trace fine to coarse sub-rounded gravel, medium plasticity, stiff to very stiff, light brown, moist	1.7	4	GB				15	Cuttings
		-minor oxidation								
3		-very stiff		5	SS	0	16			
				6	GB				16	
4		-trace to some rounded gravel, occasional cobbles								Sand
		-hard		7	SS	80	33	431		
5				8	GB				15	Screen
6		-very stiff		9	SS	100	26	431	15	
			1212.9							

Bottom of hole at 6.6m.

RECORD OF BOREHOLE : BH16-13

exp Services Inc.

PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-20
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1263.69m
GROUND WATER LEVELS: **AT TIME OF DRILLING** ---
AT END OF DRILLING --- Dry
AFTER DRILLING ---

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m / DYNAMIC CONE BLOWS/0.3m	POCKET PEN. (kPa) / FIELD VANE SHEAR (kPa) Peak Remold	FINES CONTENT (%) / PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL
		TOPSOIL, some clay, trace to some silt, sandy, some organics, dark brown, moist	1263.4	1	GB				
		CLAY (TILL), silty, some sand to sandy, trace to some angular gravel, medium plasticity, stiff, brown, damp to moist	0.3	2	GB				8
1									
2		-layers of well graded sand and gravel, cobbles, some silt, occasional boulders, very stiff		3	SS	100	39		13
				4	GB				
3					SS	0			
4					GB				
		-some cobbles		5	SS	0	23		
5									
6									
				6	SS	2933	0 50/125mm		
			1257.0						

Refusal at 6.7m.

RECORD OF BOREHOLE : BH16-14

exp Services Inc.

PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-19
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1228.18m
GROUND WATER LEVELS: ▽ **AT TIME OF DRILLING** ---
▼ **AT END OF DRILLING** --- Dry
▼ **AFTER DRILLING** 5.1m 28/10/2016

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m / DYNAMIC CONE BLOWS/0.3m	POCKET PEN. (kPa) / FIELD VANE SHEAR (kPa) Peak Remold	FINES CONTENT (%) / PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL	WELL DIAGRAM Casing Top Elev: m
		TOPSOIL, some clay, some silt, sandy, some rootlets and organics, dark brown, moist	1227.7	1	GB					
		CLAY, silty, trace to some sand, medium plasticity, brown, damp to moist, firm	0.5	2	GB				18	
1			1226.7							
		CLAY (TILL), silty, trace to some sand, trace rounded to sub-rounded gravel, some sulphates, medium plasticity, very stiff, brown, moist -Sulphate Content <0.1%	1.5	3	SS	80	16	192		Bentonite
2				4	GB				15 (19 — 41)	
		-occasional cobbles, minor oxidation, trace sulphates Grain Size Analysis: Gravel = 0.0% Sand = 4.6% Silt = 83.9% Clay = 11.4% -trace to some coarse gravel, stiff		5	SS	67	12	383	16	
3				6	GB					
4		-dry								
		-some gravel, major oxidation, very stiff		7	SS	100	17		19	Cuttings
5		▼		8	GB					
		-minor grey mottling, minor oxidation								
6				9	SS	100	24	287	16	Sand
		-trace fine sub-rounded gravel, trace to some sand		10	GB					
7										
			1220.3	11	SS	100	49		17	Screen
8		MUDSTONE, completely weathered to residual soil, extremely weak, light brown to grey, dry	7.9	12	GB					
9										
			1218.6	13	GB		89		14	

Bottom of hole at 9.6m.

RECORD OF BOREHOLE : BH16-15

exp Services Inc.

PROJECT NUMBER CGY-00092055-00 **CLIENT** Highfield Land Management Inc.
PROJECT NAME Hawkwood Lands **PROJECT LOCATION** Calgary, Alberta
DRILLING DATE 2016-10-19 **BOREHOLE LOCATION**
DRILLING CONTRACTOR Earth Drilling Co. Ltd. **ELEVATION** 1222.07m
DRILLING METHOD Solid Stem Auger **GROUND WATER LEVELS:** ▽ **AT TIME OF DRILLING** ---
EQUIPMENT TYPE Truck Mounted Auger Drill ▼ **AT END OF DRILLING** --- Dry
LOGGED BY CS **CHECKED BY** MT ▼ **AFTER DRILLING** 5.3m 28/10/2016

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m (▲) 20 40 60 80 / DYNAMIC CONE BLOWS/0.3m 20 40 60 80	POCKET PEN. (kPa) (⊙) 100 200 300 400 / FIELD VANE SHEAR (kPa) Peak Remold 40 80 120 160	FINES CONTENT (%) (□) 20 40 60 80 / PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL 20 40 60 80	WELL DIAGRAM Casing Top Elev: m
		TOPSOIL, some clay, trace silt, sandy, some organics, dark brown, moist	1221.5	1	GB				21	
1		CLAY, silty, trace sand, medium plasticity, stiff, brown, damp to moist	0.6	2	GB					
2		-occasional silt seams, minor oxidation		3	SS	80	7	192		
		-trace coarse sand, trace cobbles, trace gravel	1219.3	4	GB				23	Bentonite
3		CLAY (TILL), silty, some sand, trace rounded to sub-rounded gravel, minor oxidation, low to medium plasticity, very stiff, brown, damp to moist	2.7	5	SS	100	17			
4		-light brown, dry	1217.3	6	GB				15	
5		MUDSTONE, completely weathered to residual soil, extremely weak, light brown, minor oxidation, dry	4.7	7	SS	100	51			
				8	GB				12	Screen and Sand
6		-extremely weak, highly weathered	1215.5	9	SS		82			

Bottom of hole at 6.6m.

RECORD OF BOREHOLE : BH16-16

exp Services Inc.

PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-19
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1216.30m
GROUND WATER LEVELS: **AT TIME OF DRILLING** ---
AT END OF DRILLING --- Dry
AFTER DRILLING --- 28/10/2016 Dry

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m / DYNAMIC CONE BLOWS/0.3m (20 40 60 80)	POCKET PEN. (kPa) / FIELD VANE SHEAR (kPa) Peak Remold (100 200 300 400 / 40 80 120 160)	FINES CONTENT (%) / PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL (20 40 60 80)	WELL DIAGRAM Casing Top Elev: m
		TOPSOIL, some clay, sandy, trace silt, some organics, dark brown, moist	1216.0	1	GB					Bentonite
		CLAY, silty, trace sand, trace rootlets, medium plasticity, stiff, light brown, damp	0.3	2	GB					
1										
		-trace gravel	1214.6	3	SS	100	8	192	23	
2		CLAY (TILL), silty, trace sand, trace fine to coarse rounded to sub-rounded gravel, medium plasticity, stiff, brown, damp	1.7	4	GB					
		-moist								Cuttings
3				5	SS	90	13	239	18	
				6	GB					
4		-trace rounded gravel								Sand
		-silt seams, trace gravel, damp to moist		7	SS	100	19	287	16	
5				8	GB					Screen
		-trace fine to coarse rounded to sub-rounded gravel, sand seams								
6		-damp to moist		9	SS	100	25	335	16	
			1209.7							

Bottom of hole at 6.6m.

RECORD OF BOREHOLE : BH16-17

exp Services Inc.

PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-17
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1236.97m
GROUND WATER LEVELS: **AT TIME OF DRILLING** ---
AT END OF DRILLING --- Dry
AFTER DRILLING --- 28/10/2016 Dry

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m / DYNAMIC CONE BLOWS/0.3m	POCKET PEN. (kPa) / FIELD VANE SHEAR (kPa) Peak Remold	FINES CONTENT (%) / PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL	WELL DIAGRAM Casing Top Elev: m
		TOPSOIL, some clay, trace silt, sandy, some organics, dark brown, moist	1236.7 / 0.3	1	GB					Bentonite
1		CLAY (TILL), silty, some sand, trace fine sub-rounded to sub-angular gravel, trace sulphates, trace organics, medium plasticity, stiff, light brown, moist		2	GB				29	
2		-some fine to coarse sub-rounded to sub-angular gravel, occasional sulphates, minor oxidation, very stiff -Sulphate Content <0.1%		3	SS	100	22			
		-trace fine gravel, light brown/light grey with major oxidation, damp		4	GB				17	
3		-sulphates, rust stains, hard		5	SS	100	52			Cuttings
4		-some angular gravel, minor oxidation		6	GB				9	
5		-trace to some sand, trace gravel, occasional oxidation seams		7	SS	100	73			
		-some sand, medium to high plastic Grain Size Analysis: Gravel = 0.4% Sand = 18.4% Silt = 61.7% Clay = 19.5%		8	GB				16 20 — 52	
6				9	SS	67	81		14	Sand
7		-some sand to sandy, trace fine angular gravel,	1230.0 / 7.0	10	GB					
		SANDSTONE, extremely weak, highly weathered, brown, dry		11	SS	100	0 50/100mm			Screen
8				12	GB					
9		-very weak, moderately weathered	1227.5	13	SS		50/50mm			
				14	GB					
		Refusal at 9.4m.		15	SS		50/25mm			

RECORD OF BOREHOLE : BH16-18

exp Services Inc.

PROJECT NUMBER CGY-00092055-00
CLIENT Highfield Land Management Inc.
PROJECT NAME Hawkwood Lands
PROJECT LOCATION Calgary, Alberta
DRILLING DATE 2016-10-17
BOREHOLE LOCATION
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
ELEVATION 1239.18m
DRILLING METHOD Solid Stem Auger
GROUND WATER LEVELS: ▽ **AT TIME OF DRILLING** ---
EQUIPMENT TYPE Truck Mounted Auger Drill
▼ **AT END OF DRILLING** --- Dry
LOGGED BY CS **CHECKED BY** MT
▼ **AFTER DRILLING** --- 28/10/2016 Dry

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY %	SPT N VALUE BLOWS/0.3m / DYNAMIC CONE BLOWS/0.3m (20 40 60 80)	POCKET PEN. (kPa) / FIELD VANE SHEAR (kPa) Peak Remold (100 200 300 400 / 40 80 120 160)	FINES CONTENT (%) / PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL (20 40 60 80)	WELL DIAGRAM Casing Top Elev: m
		TOPSOIL, trace clay, some silt, sandy, some organics, dark brown, dry to moist Grain Size Analysis: Gravel = 0.7% Sand = 70.6% Silt = 22.4% Clay = 6.3%	1239.1 0.1	1	GB					Bentonite
1				2	GB				18	
		CLAY, silty, some sulphates, trace sand, low to medium plasticity, stiff, greyish brown, dry	1237.7							
		CLAY (TILL), silty, some sand, trace fine to coarse sub-angular to sub-rounded gravel, some sulphates, medium plasticity, very stiff, brown, damp to moist -some fine to coarse rounded to sub-rounded gravel, occasional coal fragments, greyish brown Grain Size Analysis: Gravel = 10.5% Sand = 17.1% Silt = 60.8% Clay = 11.6%	1.5	3	SS	100	18	431	14	
2				4	GB				14 17 40	Cuttings
3				5	SS	100	50/100mm	431	11	
		SILT, sandy, (fine sand), trace to some clay, non to low plasticity, light brown, minor oxidation, dry	1235.8 3.4 1235.2	6	GB					
4		CLAY, silty, trace sand, low to medium plasticity, light brown with major to minor oxidation, dry, hard, (possible extremely weak and completely weathered MUDSTONE bedrock) -trace to some sand, medium plasticity, minor oxidation	4.0	7	SS	100	50/125mm			Sand
5		-trace sand, occasional mudstone fragments		8	GB				7	Screen
6			1233.0	9	SS	100	50/125mm			

Refusal at 6.2m.

RECORD OF BOREHOLE : BH16-19

exp Services Inc.

PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-17
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1231.14m
GROUND WATER LEVELS: ▽ **AT TIME OF DRILLING** ---
▼ **AT END OF DRILLING** --- Dry
▼ **AFTER DRILLING** 5.9m 28/10/2016

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m / DYNAMIC CONE BLOWS/0.3m	POCKET PEN. (kPa) / FIELD VANE SHEAR (kPa)	FINES CONTENT (%) / PLASTIC & LIQUID LIMIT MOISTURE CONTENT	WELL DIAGRAM Casing Top Elev: m
		TOPSOIL, clayey, silty, some sand, some organics and rootlets, trace gravel, dark brown, dry to moist	1230.9	1	GB					
			0.3							
1		CLAY (TILL), silty, some sand to sandy, trace fine to coarse rounded to sub-rounded gravel, some sulphates, medium plasticity, brown, damp to moist, very stiff		2	GB			383	18	
			1229.6							
		CLAY, silty, low to medium plasticity, hard, light brown to brownish grey, damp	1.5	3	SS	100	42			
2		-major oxidation from 1.8m		4	GB				15	
		-trace mudstone fragments	1228.4							
3		MUDSTONE, extremely weak, highly to completely weathered, occasional black lenses, grey to brownish grey, minor oxidation	2.7	5	SS	100	62			
				6	GB				12	
4										
				7	SS		86			
5				8	GB				14	
6										
		-grey, occasional oxidation seams, extremely to very weak, highly weathered	1224.7	9	SS		50/100mm			
				10	GB					

Refusal at 6.4m.

WELL DIAGRAM: Bentonite; Cuttings; Sand; Screen

RECORD OF BOREHOLE : BH16-20

exp Services Inc.

PROJECT NUMBER CGY-00092055-00 **CLIENT** Highfield Land Management Inc.

PROJECT NAME Hawkwood Lands **PROJECT LOCATION** Calgary, Alberta

DRILLING DATE 2016-10-17 **BOREHOLE LOCATION**

DRILLING CONTRACTOR Earth Drilling Co. Ltd. **ELEVATION** 1218.40m

DRILLING METHOD Solid Stem Auger **GROUND WATER LEVELS:** ▽ **AT TIME OF DRILLING** ---

EQUIPMENT TYPE Truck Mounted Auger Drill ▼ **AT END OF DRILLING** --- Dry

LOGGED BY CS **CHECKED BY** MT ▼ **AFTER DRILLING** --- 28/10/2016 Dry

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m (▲) 20 40 60 80 / DYNAMIC CONE BLOWS/0.3m 20 40 60 80	POCKET PEN. (kPa) (⊙) 100 200 300 400 / FIELD VANE SHEAR (kPa) Peak Remold 40 80 120 160	FINES CONTENT (%) (□) 20 40 60 80 / PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL 20 40 60 80	WELL DIAGRAM Casing Top Elev: m
0		TOPSOIL, trace clay, some silt, sandy, some organics, trace gravel, dark brown, moist Grain Size Analysis: Gravel = 17.5% Sand = 59.5% Silt = 17.0% Clay = 6.0%	1218.2 0.2	1	GB					
1				2	GB				4	
2		SAND, silty, some sand, gravelly, rounded to sub-rounded gravel, occasional cobbles and boulders, brown, dry to damp, compact -cobbles and boulders, some gravel to gravelly		3	GB					Bentonite
3				4	GB				13	
		-coarse sand, trace to some gravel		5	GB					
4		-some gravel		6	GB				7	Cuttings
										Sand
5				7	SS	0	19			
		-well graded sand		8	GB				9	Screen
6										
				9	SS	40	20			
			1211.8							

Bottom of hole at 6.6m.

RECORD OF BOREHOLE : BH16-21

exp Services Inc.

PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-17
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1231.00m
GROUND WATER LEVELS: **AT TIME OF DRILLING** ---
AT END OF DRILLING --- Dry
AFTER DRILLING --- 28/10/2016 Dry

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m / DYNAMIC CONE BLOWS/0.3m	POCKET PEN. (kPa) / FIELD VANE SHEAR (kPa) Peak Remold	FINES CONTENT (%) / PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL	WELL DIAGRAM Casing Top Elev: m
		TOPSOIL, clayey, silty, some sand, some organics, trace gravel, dark brown, moist	1230.8	1	GB					Bentonite
			0.2							
1		CLAY (TILL), silty, some sand, some fine to coarse rounded to sub-rounded gravel, trace sulphates, medium plasticity, brown, damp to moist, stiff -occasional cobbles to 1.5m -Sulphate Content <0.1%		2	GB					
2				3	SS	0	16			
		-trace gravel, occasional sulphates		4	GB				14	
3		-sand layers from 3.0 to 4.6m		5	SS	25	8			Cuttings
4		-some gravel to gravelly, moist		6	GB				9	
		-some sand to sandy, very stiff		7	SS	60	30	335		
5				8	GB				11	
6		-cobbles and boulders		9	SS	32	22			Sand
7		-cobbles		10	GB				9	Screen
8			1222.9	11	SS	25	26			

Bottom of hole at 8.1m.

EXP GEO CGY-00092055 LOGS.GPJ EXP STD.GDT 21/11/16

RECORD OF BOREHOLE : BH16-22

exp Services Inc.

PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-17
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1217.32m
GROUND WATER LEVELS: ▽ **AT TIME OF DRILLING** ---
▼ **AT END OF DRILLING** 6.55m
▼ **AFTER DRILLING** 6.6m 28/10/2016

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	TYPE	RECOVERY %	SPT N VALUE BLOWS/0.3m (20 40 60 80) / DYNAMIC CONE BLOWS/0.3m (20 40 60 80)	POCKET PEN. (kPa) (100 200 300 400) / FIELD VANE SHEAR (kPa) Peak Remold (40 80 120 160)	FINES CONTENT (%) (20 40 60 80) / PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL (20 40 60 80)	WELL DIAGRAM Casing Top Elev: m
		TOPSOIL, trace to some clay, trace to some silt, , some sand to sandy, some organics, dark brown, moist	1216.7	1	GB					Bentonite
1		CLAY (TILL), silty, some sand, trace fine sub-rounded gravel,trace organics, occasional cobbles, medium plasticity, very stiff, brown, damp to moist	0.6	2	GB				12	
		-trace to some gravel		3	SS	20	30			
2		-gravelly, light brown, moist		4	GB				9	
3		-minor oxidation		5	SS	25	20			
				6	GB					Cuttings
4		-some gravel to gravelly, occasional coal fragments								
				7	SS	100	22		15	
5				8	GB				15	
6		-trace to some rounded to sub-rounded gravel								
				9	SS		22			
	▼	-gravelly		10	GB				19	
7		-cobbly, gravelly, grey, wet								
				11	SS	50	47			Sand
8				12	GB					Screen
9		-some gravel	1207.7	13	SS	50	26		17	

Bottom of hole at 9.6m.

RECORD OF TESTHOLE : MW16-01

exp Services Inc.

PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-17
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1192.03m
GROUND WATER LEVELS: **AT TIME OF DRILLING** ---
AT END OF DRILLING --- Dry
AFTER DRILLING --- 28/10/2016 Dry

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m / DYNAMIC CONE BLOWS/0.3m	POCKET PEN. (kPa) / FIELD VANE SHEAR (kPa)	FINES CONTENT (%) / PLASTIC & LIQUID LIMIT MOISTURE CONTENT	WELL DIAGRAM Casing Top Elev: m
		TOPSOIL, some clay, trace to some silt, sandy, trace gravel, some organics, dark brown, moist	1191.8 / 0.2	1	GB					
1		CLAY, silty, trace fine sand, trace sulphates, trace rootlets, medium plasticity, light brown, moist, firm to stiff		2	GB				24	
		-trace rootlets, occasional silt layers		3	SS	100	7	287	19	
2		-some silt		4	GB				16	Cuttings
3		-occasional sand seams and layers	1188.9 / 3.1	5	SS	100	13			
		SAND, some silt to silty, trace clay, fine grained, brown, moist, compact	1188.4	6	GB				18	
4		CLAY, silty, some fine sand, medium plasticity, stiff to very stiff, brown, moist	3.7							
		-trace sand		7	SS	100	17			
5		-sandy								Bentonite
		-trace sand to sandy, stratified	1186.2	8	GB				20	
6		SAND, some silt to silty, trace clay, fine grained, brown, moist, loose to compact	5.8	9	SS	50	14		21	Sand
			1185.2	10	GB			239		
7		CLAY, silty, trace to some sand, low to medium plasticity, stiff, brown, moist	6.9							
		-occasional silt seams and lenses		11	SS	100	12	192	31	Screen
8		-occasional sandy seams and layers		12	GB					
9		-occasional sand lenses	1182.4	13	SS	100	15	168	22	

Bottom of hole at 9.6m.

RECORD OF TESTHOLE : MW16-02

exp Services Inc.

PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-19
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1208.34m
GROUND WATER LEVELS: ▽ **AT TIME OF DRILLING** ---
▼ **AT END OF DRILLING** 9.45m
▼ **AFTER DRILLING** 3.5m 28/10/2016

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m / DYNAMIC CONE BLOWS/0.3m	POCKET PEN. (kPa) / FIELD VANE SHEAR (kPa) Peak Remold	FINES CONTENT (%) / PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL	WELL DIAGRAM Casing Top Elev: m
		TOPSOIL, some rootlets, trace to some clay, trace to some silt, sandy, dark brown, moist	1208.1	1	GB					
			0.3							
1		CLAY, silty, trace sand, trace rootlets, medium plasticity, stiff, brown, moist		2	GB				33 / 26 41	
		Grain Size Analysis: Gravel = 0.0% Sand = 22.1% Silt = 67.0% Clay = 10.9%								
		-trace to some sand, trace sulphates	1206.5	3	SS	100	10	239	23	Cuttings
2		CLAY (TILL), silty, some sand, trace rounded to sub-rounded gravel, medium plastic, stiff, brown, moist	1.8	4	GB					
3			1205.3							
		SILT, trace to some sand, trace clay, non to low plasticity, brown with grey mottling, moist, stiff	3.0	5	SS	67	14	96	23	
4		-some clay, low to medium plasticity		6	GB				26	Bentonite
			1203.8							
		CLAY, silty, trace to some sand, medium plasticity, stiff, light brown, damp to moist	4.6	7	SS	40	12	144	24	
5		-trace fine rounded to sub-rounded gravel		8	GB					
6			1202.2							Sand
		CLAY (TILL), silty, some sand, trace rounded to sub-rounded gravel, medium plastic, stiff to very stiff, brown, moist	6.1	9	SS	100	15	287	18	
7				10	GB					
8				11	SS	33	15	239	19	Screen
		-trace coarse gravel		12	GB					
9		-cobble in SPT		13	SS	100	56	287	19	
			1198.7							

Bottom of hole at 9.6m.

EXP GEO CGY-00092055 LOGS.GPJ EXP STD.GDT 21/11/16

RECORD OF TESTHOLE : MW16-03

exp Services Inc.

PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-18
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1208.90m
GROUND WATER LEVELS: ▽ **AT TIME OF DRILLING** ---
▼ **AT END OF DRILLING** 1.22m
▼ **AFTER DRILLING** 2.2m 28/10/2016

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m ▲ 20 40 60 80 / DYNAMIC CONE BLOWS/0.3m 20 40 60 80	POCKET PEN. (kPa) ⊙ 100 200 300 400 / FIELD VANE SHEAR (kPa) Peak ● Remold ○ 40 80 120 160	FINES CONTENT (%) □ 20 40 60 80 / PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL 20 40 60 80	WELL DIAGRAM Casing Top Elev: m
0		TOPSOIL, clayey, some silt, sandy, some organics and rootlets, low/medium plasticity, dark brown, moist	1208.7 / 0.2	1	GB					
1		CLAY, some silt to silty, trace sand, medium to high plasticity, brown, moist, firm		2	GB				35	Cuttings
		-occasional silt seams, stratified layers of clay		3	SS	100	6	96	35	
2		-Sulphate Content <0.1%		4	GB					
3		-stiff Grain Size Analysis: Gravel = 0.2% Sand = 7.9% Silt = 84.5% Clay = 7.4% -trace to some sand, trace to some sub-rounded gravel		5	SS	100	9	120	17 / 20 32	Bentonite
4			1204.3	6	GB					
		CLAY (TILL), silty, some sand, trace gravel, medium plasticity, very stiff, brown, moist	4.6	7	SS	50	11	239	20	
5		-occasional coal fragments		8	GB					
6				9	SS	67	15	287	18	Sand
7				10	GB					
8		- some sand to sandy		11	SS	33	20	239	16	Screen
				12	GB					
9				13	SS	60	25	287	18	
		- sand seam, dark brown	1199.3							

Bottom of hole at 9.6m.

RECORD OF TESTHOLE : MW16-04

exp Services Inc.

PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-18
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1204.05m
GROUND WATER LEVELS: ▽ **AT TIME OF DRILLING** ---
▼ **AT END OF DRILLING** 3.05m
▼ **AFTER DRILLING** 1.5m 28/10/2016

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m (20 40 60 80) / DYNAMIC CONE BLOWS/0.3m (20 40 60 80)	POCKET PEN. (kPa) (100 200 300 400) / FIELD VANE SHEAR (kPa) Peak Remold (40 80 120 160)	FINES CONTENT (%) (20 40 60 80) / PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL (20 40 60 80)	WELL DIAGRAM Casing Top Elev: m
0		TOPSOIL, some clay, trace silt, sandy, some organics, dark brown, moist	1204.0 / 0.0	1	GB					
1		CLAY, silty, trace fine sand, trace sulphates, medium plasticity, stiff, light brown, moist -occasional grey mottling, trace rootlets to 1.8m		2	GB					
2				3	SS	100	8	287	27	
				4	GB					Cuttings
3		-occasional silt seams, wet		5	SS	100	8	96	32	
4			1199.5	6	GB					
5		CLAY (TILL), silty, some sand, trace fine to coarse sub-angular to sub-rounded gravel, medium plasticity, stiff, brown, moist	4.6	7	SS	100	10	215	25	
		-wet		8	GB					Bentonite
6		-occasional silt seams		9	SS	100	12	239	26	Sand
			1197.2	10	GB					
7		CLAY, some silt to silty, medium plasticity, stiff, brown, moist	6.9							
			1196.3	11	SS	100	11	287	20	Screen
8		CLAY (TILL), silty, some sand, trace fine to coarse rounded to sub-rounded gravel, medium plasticity, stiff, brown, moist	7.8	12	GB					
9		-some gravel		13	SS	100	19	335	19	
			1194.4							

Bottom of hole at 9.6m.

EXP GEO CGY-00092055 LOGS.GPJ EXP STD.GDT 21/11/16

RECORD OF TESTHOLE : MW16-05

exp Services Inc.

PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-18
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1200.60m
GROUND WATER LEVELS: ▽ **AT TIME OF DRILLING** ---
▼ **AT END OF DRILLING** 4.88m
▼ **AFTER DRILLING** 4.6m 28/10/2016

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m / DYNAMIC CONE BLOWS/0.3m (20 40 60 80)	POCKET PEN. (kPa) / FIELD VANE SHEAR (kPa) Peak Remold (100 200 300 400 / 40 80 120 160)	FINES CONTENT (%) / PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL (20 40 60 80)	WELL DIAGRAM Casing Top Elev: m
0		TOPSOIL, some clay, trace silt, sandy, some organics, dark brown, moist	1200.5 / 0.1	1	GB					Cuttings
1		CLAY (TILL), silty, some sand, trace fine to coarse sub-rounded gravel, trace rootlets, trace sulphates, low to medium plasticity, stiff, brown, damp		2	GB					
				3	SS	100	13	311	13	
2				4	GB				15 / PL 16 — 40	
3		Grain Size Analysis: Gravel = 3.7% Sand = 16.4% Silt = 67.1% Clay = 12.8%								
		-trace fine gravel, very stiff		5	SS	100	17	335	14	
4		-light brown		6	GB					Bentonite
5		-grey ▽ ▼		7	SS	100	18	263	14	
				8	GB					
6		-sandy, gravelly, medium plasticity, stiff		9	SS	80	14	192	15	Sand
7		-brown		10	GB				16	
			1192.8	11	SS	100	13	192	25	Screen
8		CLAY, some silt, trace coarse sand, medium plasticity, light brown, moist, stiff	7.8							
		- silty		12	GB				23	
9		- occasional silt seams, grey, occasional oxidation	1191.0	13	SS	90	17		22	

Bottom of hole at 9.6m.

EXP GEO CGY-00092055 LOGS.GPJ EXP STD.GDT 21/11/16

RECORD OF TESTHOLE : MW16-06

exp Services Inc.

PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-18
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1209.00m
GROUND WATER LEVELS: ▽ **AT TIME OF DRILLING** ---
▼ **AT END OF DRILLING** --- Dry
▼ **AFTER DRILLING** --- 28/10/2016 Dry

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m (20 40 60 80) / DYNAMIC CONE BLOWS/0.3m (20 40 60 80)	POCKET PEN. (kPa) (100 200 300 400) / FIELD VANE SHEAR (kPa) Peak Remold (40 80 120 160)	FINES CONTENT (%) (20 40 60 80) / PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL (20 40 60 80)	WELL DIAGRAM Casing Top Elev: m
0		TOPSOIL, trace to some clay, silty, sandy, some organics, dark brown, moist	1208.7	1	GB					
		Grain Size Analysis: Gravel = 0.2% Sand = 47.9% Silt = 40.5% Clay = 11.4%	0.3	2	GB				22	
1		CLAY, silty, trace sand, trace rootlets, medium plasticity, light brown, damp to moist								
		-occasional silt seams and lenses		3	SS	100	9			
2				4	GB				19	Cuttings
		-trace coarse round gravel, damp								
3		-very stiff		5	SS	100	15			
				6	GB				18	
4			1204.7							
		CLAY (TILL), silty, some sand, trace sub-angular to rounded gravel, medium plasticity, brown, damp to moist, stiff	4.3	7	SS	100	14			
5		-occasional grey lenses		8	GB				14	Bentonite
6										Sand
				9	SS	40	22			
				10	GB				15	
7		-occasional coal fragments								
				11	SS	50	19			Screen
8				12	GB				15	
		-occasional cobbles								
9				13	SS	100	24			
			1199.4							

Bottom of hole at 9.6m.

RECORD OF TESTHOLE : MW16-07

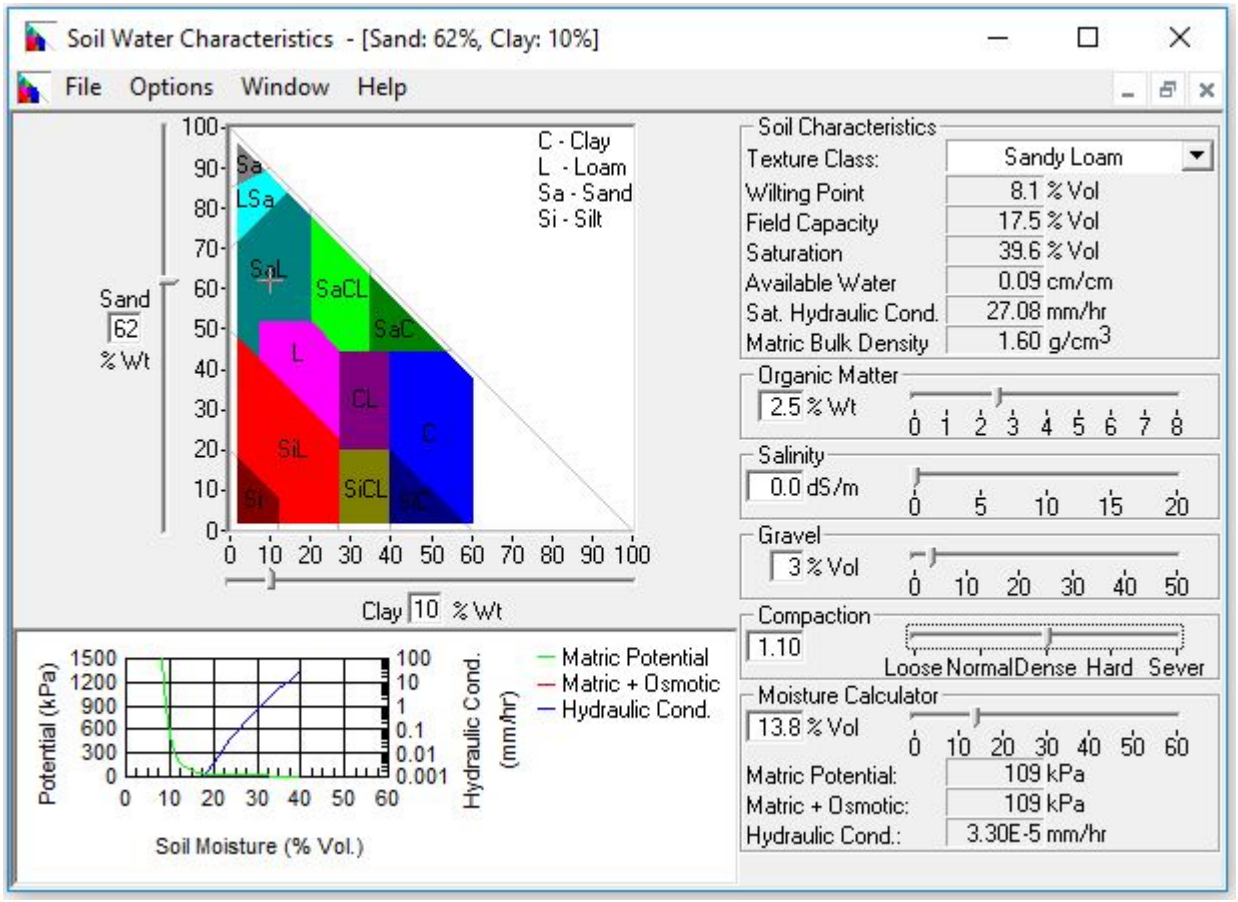
exp Services Inc.

PROJECT NUMBER CGY-00092055-00 **CLIENT** Highfield Land Management Inc.
PROJECT NAME Hawkwood Lands **PROJECT LOCATION** Calgary, Alberta
DRILLING DATE 2016-10-18 **BOREHOLE LOCATION**
DRILLING CONTRACTOR Earth Drilling Co. Ltd. **ELEVATION** 1205.68m
DRILLING METHOD Solid Stem Auger **GROUND WATER LEVELS:** ▽ **AT TIME OF DRILLING** ---
EQUIPMENT TYPE Truck Mounted Auger Drill ▼ **AT END OF DRILLING** --- Dry
LOGGED BY CS **CHECKED BY** MT ▼ **AFTER DRILLING** 4.8m 28/10/2016

DEPTH (m)	STRATA	SOIL DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m (20 40 60 80) / DYNAMIC CONE BLOWS/0.3m (20 40 60 80)	POCKET PEN. (kPa) (100 200 300 400) / FIELD VANE SHEAR (kPa) Peak Remold (40 80 120 160)	FINES CONTENT (%) (20 40 60 80) / PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL (20 40 60 80)	WELL DIAGRAM Casing Top Elev: m
0		TOPSOIL, some clay, trace to some silt, sandy, some organics, dark brown, moist	1205.4 / 0.2	1	GB					
1		CLAY (TILL), silty, some sand to sandy, some rounded to angular gravel, medium plasticity, very stiff, brown, damp to moist		2	GB				11	Cuttings
2		-some rounded gravel, some sand		3	SS	40	23	239		
		-trace sand, trace sulphates Grain Size Analysis: Gravel = 9.1% Sand = 19.2% Silt = 64.5% Clay = 7.2%		4	GB				13 14 36	
3		CLAY, silty, sandy, low to medium plasticity, brown, occasional grey mottling, moist, very stiff	1202.6 / 3.0 / 1202.2	5	SS	50	19		18	
4		SILT, trace to some sand, trace to some clay, non to low plastic, stiff, brown with occasional grey mottling, moist to wet	3.5	6	GB				18	Bentonite
5	▼			7	SS	30	15			
		CLAY (TILL), silty, some sand, trace fine to coarse rounded to sub-rounded gravel, medium plasticity, very stiff, brown, moist	1200.5 / 5.2	8	GB			287	11	
6		-occasional cobbles and boulders		9	SS	0	50			Sand
7		-some gravel		10	GB				12	
8		-occasional coal fragments		11	SS	10	19			Screen
				12	GB					
9		CLAY, silty, trace sand, medium plasticity, light brown, occasional oxidation, moist, stiff -grey	1196.5 / 9.1 / 1196.1	13	SS	90	13		27	

Bottom of hole at 9.6m.

EXP GEO CGY-00092055 LOGS.GPJ EXP STD.GDT 21/11/16


Soil Water Characteristics - [Sand: 62%, Clay: 10%]
File
Options
Window
Help
C - Clay
L - Loam
Sa - Sand
Si - Silt
Sa
LSa
SaL
SaCL
SaC
L
CL
C
SiL
SiCL
SiC
Si
Sand
62
% Wt
Clay 10 % Wt
Soil Characteristics
Texture Class: Sandy Loam
Wilting Point 8.1 % Vol
Field Capacity 17.5 % Vol
Saturation 39.6 % Vol
Available Water 0.09 cm/cm
Sat. Hydraulic Cond. 27.08 mm/hr
Matric Bulk Density 1.60 g/cm3
Organic Matter
2.5 % Wt
Salinity
0.0 dS/m
Gravel
3 % Vol
Compaction
1.10
Loose Normal Dense Hard Sever
Moisture Calculator
13.8 % Vol
Matric Potential: 109 kPa
Matric + Osmotic: 109 kPa
Hydraulic Cond.: 3.30E-5 mm/hr
Potential (kPa)
Hydraulic Cond. (mm/hr)
Matric Potential
Matric + Osmotic
Hydraulic Cond.
Soil Moisture (% Vol.)

APPENDIX B

PCSWMM
Existing Conditions Analysis

- Schematic
- Input and Report Files



Pre-development PCSWMM Schematic

Single Storm Event

- **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]
Ascension Pre-development
Single Event
Calgary 24h-100y


[OPTIONS]
;;Options            Value
;;------------------ ------------
FLOW_UNITS           CMS
INFILTRATION         GREEN_AMPT
FLOW_ROUTING         DYNWAVE
LINK_OFFSETS         DEPTH
MIN_SLOPE            0
ALLOW_PONDING        NO
SKIP_STEADY_STATE    NO
START_DATE           08/25/2020
START_TIME           00:00:00
REPORT_START_DATE    08/25/2020
REPORT_START_TIME    00:00:00
END_DATE             08/28/2020
END_TIME             00:00:00
SWEEP_START          01/01
SWEEP_END            12/31
DRY_DAYS             0
REPORT_STEP          00:05:00
WET_STEP             00:05:00
DRY_STEP             00:30:00
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              4

[EVAPORATION]
;;Type          Parameters
;;------------- ----------
CONSTANT     0
DRY_ONLY     NO

[RAINGAGES]
;;               Rain      Time   Snow   Data
;;Name           Type      Intrvl Catch  Source
;;-------------- --------- ------ ------ ----------
Calgary_24h_100y INTENSITY 0:05   1.0    TIMESERIES Calgary_24h_100y

[SUBCATCHMENTS]
;;                                          Total    Pcnt.            Pcnt.    Curb     Snow
;;Name           Raingage         Outlet     Area     Imperv   Width   Slope    Length   Pack
;;-------------- ---------------- ---------- -------- -------- ------- -------- -------- --------
A1               Calgary_24h_100y J1         67.8322  2        1646.413 4        0
A2               Calgary_24h_100y J2         35.0722  0        1127.723 9        0
A3               Calgary_24h_100y J3         23.4569  0        469.138  10       0
B                Calgary_24h_100y Ex-Wetland 27.8421  4.1      647.491  9        0

[SUBAREAS]
;;Subcatchment   N-Imperv   N-Perv     S-Imperv   S-Perv     PctZero    RouteTo    PctRouted
;;-------------- ---------- ---------- ---------- ---------- ---------- ---------- ----------
A1               0.014      0.3        2          7.5        0          PERVIOUS   100
A2               0.014      0.3        2          7.5        0          OUTLET
A3               0.014      0.3        2          7.5        0          OUTLET
B                0.014      0.3        2          7.5        100        OUTLET

[INFILTRATION]
```

```
;;Subcatchment   Suction    HydCon     IMDmax
;;-------------- ---------- ---------- ----------
A1               126        0.99       0.21
A2               270.53     1          0.21
A3               270.69     0.99       0.25
B                213.88     1.68       0.29

[AQUIFERS]
;;               Por-   Wilt   Field  Hyd    Cond   Tens   Upper  Lower  Lower  Bottom Water  Upper  Upper
;;Name           osity  Point  Capac  Cond   Slope  Slope  Evap   Evap   Loss   Elev   Table  Moist  Evap Pat
;;-------------- ------ ------ ------ ------ ------ ------ ------ ------ ------ ------ ------ ------ ------------
AquiferEast      0.453  0.185  0.307  3.663  0.1    0.1    0.5    0.1    0.15   0.0    2      0.307
AquiferWest      0.453  0.185  0.307  3.663  0.1    0.1    0.5    0.1    0.044  0.0    2      0.307

[GROUNDWATER]
;;Subcatchment   Aquifer          Node             Elev   A1     B1     A2     B2     A3     Depth  Elev   Ebot   Wgr    Umc
;;-------------- ---------------- ---------------- ------ ------ ------ ------ ------ ------ ------ ------ ------ ------ --
----
A1               AquiferWest      J1               3      0.6    1.9    0      0      0      0      2      *      *      *
A2               AquiferWest      J2               3      0.6    1.9    0      0      0      0      2      *      *      *
A3               AquiferWest      J3               3      0.6    1.9    0      0      0      0      2      *      *      *
B                AquiferEast      Ex-Wetland       3      0.35   3.1    0      0      0      0      2      *      *      *

[JUNCTIONS]
;;               Invert     Max.       Init.      Surcharge  Ponded
;;Name           Elev.      Depth      Depth      Depth      Area
;;-------------- ---------- ---------- ---------- ---------- ----------
J1               1192       2          0          100        0
J2               1186       2          0          100        0
J3               1166.5     2          0          100        0
UpCulv           1155.74    2          0          100        0

[OUTFALLS]
;;               Invert     Outfall      Stage/Table      Tide
;;Name           Elev.      Type         Time Series      Gate Route To
;;-------------- ---------- ------------ ---------------- ---- ----------------
OF-3             1153.47    FREE                          NO
OF-W             1197.5     FREE                          NO

[STORAGE]
;;               Invert   Max.     Init.    Storage    Curve                                Evap.
;;Name           Elev.    Depth    Depth    Curve      Params                               Frac.    Infiltration parameters
;;-------------- -------- -------- -------- ---------- -------- -------- -------- -------- -------- ----------------------
Ex-Wetland       1197.5   1        0.3      TABULAR    Wetland                   0        0

[CONDUITS]
;;               Inlet            Outlet                      Manning    Inlet      Outlet     Init.      Max.
;;Name           Node             Node             Length     N          Offset     Offset     Flow       Flow
;;-------------- ---------------- ---------------- ---------- ---------- ---------- ---------- ---------- ----------
1                Ex-Wetland       OF-W             18.6       0.015      0.3        0          0          0
;Natural Channel
C1               J1               J2               146.45     0.01       0          0          0          0
;Natural Channel
C2_1             J2               J3               352.28     0.01       0          0          0          0
;Natural Channel
C2_2             J3               UpCulv           305.17     0.01       0          0          0          0
ExCulvert        UpCulv           OF-3             77.33      0.022      0          0          0          0

[XSECTIONS]
;;Link           Shape        Geom1            Geom2      Geom3      Geom4      Barrels
;;-------------- ------------ ---------------- ---------- ---------- ---------- ----------
1                CIRCULAR     0.45             0          0          0          1
C1               IRREGULAR    Section18        0          0          0          1
C2_1             IRREGULAR    Section6         0          0          0          1
C2_2             IRREGULAR    Section6         0          0          0          1
ExCulvert        CIRCULAR     0.63             0          0          0          1

[TRANSECTS]

NC 0.35     0.35     0.07
X1 Section18        8        72.899   74.312   0.0       0.0       0.0      0.0      0.0
GR 1189.24  65.507   1188.46  69.488   1188.22  72.899   1187.75  73.041   1187.74  73.839
GR 1188.19  74.312   1188.47  75.614   1189.37  79.324

NC 0.35     0.35     0.07
X1 Section6         8        83.111   83.945   0.0       0.0       0.0      0.0      0.0
GR 1177.03  80.013   1176.29  81.881   1176.24  83.111   1175.8   83.269   1175.8   83.745
GR 1176.26  83.945   1176.47  85.422   1177.79  86.958
```

```
[LOSSES]
;;Link           Inlet      Outlet     Average    Flap Gate  SeepageRate
;;-------------- ---------- ---------- ---------- ---------- ----------

[CURVES]
;;Name           Type       X-Value    Y-Value
;;-------------- ---------- ---------- ----------
OGS              Rating     0          0
OGS                         0.25       0.0066
OGS                         0.5        0.0098
OGS                         0.75       0.0122
OGS                         1          0.0142

R33              Rating     0          0
R33                         0.25       0.0043
R33                         0.5        0.0062
R33                         0.75       0.0077
R33                         1          0.009
R33                         1.25       0.0101
R33                         1.5        0.0111

R96              Rating     0          0
R96                         0.25       0.0303
R96                         0.5        0.0492
R96                         0.75       0.0626
R96                         1          0.0736
R96                         1.25       0.0831
R96                         1.5        0.0917

Wetland          Storage    0          1018
Wetland                     0.25       7072
Wetland                     0.5        8482
Wetland                     0.75       9674
Wetland                     1          11306

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

[TAGS]

[MAP]
DIMENSIONS       -19799.6330607589 5666764.72393014 -17942.8048367753 5668793.47605977
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 5.1.013)
--------------------------------------------------------------

Ascension Pre-development
Single Event
Calgary 24h-100y


*************
Element Count
*************
Number of rain gages ...... 1
Number of subcatchments ... 4
Number of nodes ........... 7
Number of links ........... 5
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
-----------------------------------------------------------------------------------------------------
A1                          67.83   1646.41      2.00    4.0000 Calgary_24h_100y     J1
A2                          35.07   1127.72      0.00    9.0000 Calgary_24h_100y     J2
A3                          23.46    469.14      0.00   10.0000 Calgary_24h_100y     J3
B                           27.84    647.49      4.10    9.0000 Calgary_24h_100y     Ex-Wetland


************
Node Summary
************
                                      Invert      Max.    Ponded    External
Name                 Type               Elev.     Depth      Area    Inflow
------------------------------------------------------------------------
J1                   JUNCTION         1192.00      2.00       0.0
J2                   JUNCTION         1186.00      2.00       0.0
J3                   JUNCTION         1166.50      2.00       0.0
UpCulv               JUNCTION         1155.74      2.00       0.0
OF-3                 OUTFALL          1153.47      0.63       0.0
OF-W                 OUTFALL          1197.50      0.45       0.0
Ex-Wetland           STORAGE          1197.50      1.00       0.0


************
Link Summary
************
Name             From Node        To Node          Type            Length    %Slope Roughness
-----------------------------------------------------------------------------------------------
1                Ex-Wetland       OF-W             CONDUIT           18.6    1.6131    0.0150
C1               J1               J2               CONDUIT          146.4    4.1004    0.0700
C2_1             J2               J3               CONDUIT          352.3    5.5439    0.0700
C2_2             J3               UpCulv           CONDUIT          305.2    3.5281    0.0700
ExCulvert        UpCulv           OF-3             CONDUIT           77.3    2.9367    0.0220


********************
Cross Section Summary
********************
                                    Full     Full     Hyd.     Max.   No. of     Full
Conduit          Shape             Depth     Area     Rad.    Width  Barrels     Flow
---------------------------------------------------------------------------------------
1                CIRCULAR           0.45     0.16     0.11     0.45        1     0.31
C1               Section18          1.63    10.77     0.20    13.82        1    10.53
C2_1             Section6           1.99     8.68     0.21     6.94        1    10.22
C2_2             Section6           1.99     8.68     0.21     6.94        1     8.15
ExCulvert        CIRCULAR           0.63     0.31     0.16     0.63        1     0.71
```

```
***************
Transect Summary
***************

Transect Section18
Area:
            0.0021     0.0047     0.0075     0.0103     0.0133
            0.0165     0.0198     0.0232     0.0267     0.0304
            0.0342     0.0381     0.0422     0.0464     0.0511
            0.0572     0.0652     0.0751     0.0868     0.1004
            0.1159     0.1332     0.1520     0.1717     0.1923
            0.2139     0.2363     0.2597     0.2840     0.3091
            0.3352     0.3622     0.3901     0.4190     0.4487
            0.4793     0.5109     0.5434     0.5767     0.6110
            0.6462     0.6823     0.7194     0.7573     0.7961
            0.8359     0.8763     0.9171     0.9584     1.0000
Hrad:
            0.1322     0.2706     0.3943     0.5064     0.6094
            0.7050     0.7944     0.8788     0.9590     1.0356
            1.1091     1.1800     1.2485     1.3210     1.4092
            1.4583     1.4527     1.4120     1.3526     1.2861
            1.2195     1.1566     1.1062     1.0681     1.0387
            1.0157     0.9977     0.9835     0.9724     0.9637
            0.9570     0.9520     0.9483     0.9458     0.9443
            0.9436     0.9437     0.9444     0.9456     0.9473
            0.9495     0.9520     0.9548     0.9580     0.9614
            0.9651     0.9731     0.9817     0.9907     1.0000
Width:
            0.0607     0.0639     0.0671     0.0703     0.0735
            0.0767     0.0799     0.0831     0.0863     0.0895
            0.0927     0.0959     0.0990     0.1039     0.1246
            0.1692     0.2137     0.2582     0.3027     0.3472
            0.3917     0.4362     0.4603     0.4820     0.5038
            0.5256     0.5474     0.5691     0.5909     0.6127
            0.6344     0.6562     0.6780     0.6997     0.7215
            0.7433     0.7650     0.7868     0.8086     0.8303
            0.8521     0.8739     0.8956     0.9174     0.9392
            0.9609     0.9708     0.9805     0.9903     1.0000

Transect Section6
Area:
            0.0023     0.0047     0.0072     0.0099     0.0127
            0.0157     0.0188     0.0221     0.0255     0.0291
            0.0328     0.0387     0.0493     0.0618     0.0760
            0.0920     0.1097     0.1285     0.1479     0.1680
            0.1888     0.2102     0.2323     0.2551     0.2786
            0.3027     0.3276     0.3530     0.3792     0.4060
            0.4335     0.4614     0.4896     0.5179     0.5464
            0.5752     0.6041     0.6333     0.6627     0.6923
            0.7221     0.7522     0.7824     0.8128     0.8435
            0.8744     0.9055     0.9368     0.9683     1.0000
Hrad:
            0.1677     0.3004     0.4104     0.5047     0.5878
            0.6627     0.7312     0.7949     0.8546     0.9113
            0.9653     0.9750     0.8867     0.8151     0.7601
            0.7176     0.6850     0.6662     0.6567     0.6532
            0.6536     0.6568     0.6620     0.6685     0.6760
            0.6843     0.6931     0.7023     0.7118     0.7215
            0.7317     0.7449     0.7585     0.7725     0.7866
            0.8010     0.8154     0.8299     0.8444     0.8588
            0.8733     0.8877     0.9021     0.9163     0.9305
            0.9446     0.9586     0.9725     0.9863     1.0000
Width:
            0.0731     0.0776     0.0822     0.0867     0.0913
            0.0958     0.1004     0.1049     0.1095     0.1140
            0.1186     0.2711     0.3653     0.4201     0.4748
            0.5296     0.5788     0.5999     0.6211     0.6422
            0.6633     0.6845     0.7056     0.7267     0.7479
            0.7690     0.7901     0.8113     0.8324     0.8535
            0.8733     0.8800     0.8866     0.8933     0.9000
            0.9066     0.9133     0.9200     0.9266     0.9333
            0.9400     0.9467     0.9533     0.9600     0.9667
            0.9733     0.9800     0.9867     0.9933     1.0000


*****************************************************
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 ..... YES
  Flow Routing ..... YES
  Ponding Allowed ..... NO
  Water Quality ..... NO
Infiltration Method ..... GREEN_AMPT
Flow Routing Method ..... DYNWAVE
Surcharge Method ..... EXTRAN
Starting Date ..... 08/25/2020 00:00:00
Ending Date ..... 08/28/2020 00:00:00
Antecedent Dry Days ..... 0.0
Report Time Step ..... 00:05:00
Wet Time Step ..... 00:05:00
Dry Time Step ..... 00:30:00
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 ......        13.827        89.667
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         9.160        59.402
Surface Runoff ...........         4.675        30.320
Final Storage ............         0.003         0.018
Continuity Error (%) .....        -0.081

*************************        Volume         Depth
Groundwater Continuity         hectare-m            mm
*************************     ---------       -------
Initial Storage ..........       187.049      1213.000
Infiltration .............         9.160        59.402
Upper Zone ET ............         0.000         0.000
Lower Zone ET ............         0.000         0.000
Deep Percolation .........         0.488         3.164
Groundwater Flow .........         8.201        53.185
Final Storage ............       187.520      1216.054
Continuity Error (%) .....        -0.000

*************************        Volume        Volume
Flow Routing Continuity        hectare-m      10^6 ltr
*************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         4.675        46.748
Groundwater Inflow .......         8.201        82.015
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........        12.866       128.664
Flooding Loss ............         0.000         0.000
Evaporation Loss .........         0.000         0.000
Exfiltration Loss ........         0.000         0.000
Initial Stored Volume ....         0.137         1.372
Final Stored Volume ......         0.175         1.751
Continuity Error (%) .....        -0.216

*************************
Time-Step Critical Elements
*************************
Link 1 (35.55%)
```

```
  ********************************
  Highest Flow Instability Indexes
  ********************************
  Link C2_2 (2)
  Link C2_1 (2)


  *************************
  Routing Time Step Summary
  *************************
  Minimum Time Step           :     3.06 sec
  Average Time Step           :     4.67 sec
  Maximum Time Step           :     5.00 sec
  Percent in Steady State     :     0.00
  Average Iterations per Step :     2.27
  Percent Not Converging      :     3.13


  ***************************
  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
  ---------------------------------------------------------------------------------------------------------------------
-----
  A1                        89.67       0.00       0.00      54.47       1.75      35.21      35.21       23.88     1.92
0.393
  A2                        89.67       0.00       0.00      62.12       0.00      27.66      27.66        9.70     1.31
0.308
  A3                        89.67       0.00       0.00      65.21       0.00      24.53      24.53        5.75     0.62
0.274
  B                         89.67       0.00       0.00      63.11       3.68      22.96      26.64        7.42     0.91
0.297


  *******************
  Groundwater Summary
  *******************

  ---------------------------------------------------------------------------------------------------
                                          Total    Total  Maximum  Average  Average    Final    Final
                         Total    Total    Lower  Lateral  Lateral    Upper    Water    Upper    Water
                         Infil     Evap  Seepage  Outflow  Outflow   Moist.    Table   Moist.    Table
  Subcatchment              mm       mm       mm       mm      CMS                 m                 m
  ---------------------------------------------------------------------------------------------------
  A1                      54.47     0.00     2.15    51.48     0.41     0.31     2.04     0.31     2.01
  A2                      62.12     0.00     2.16    59.25     0.32     0.31     2.04     0.31     2.00
  A3                      65.21     0.00     2.16    62.34     0.23     0.31     2.04     0.31     2.00
  B                       63.11     0.00     7.74    41.99     0.16     0.31     2.15     0.31     2.09


  ******************
  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
  ---------------------------------------------------------------------------------
  J1                   JUNCTION     0.62    37.87  1229.87     0  08:12       36.99
  J2                   JUNCTION     0.98    43.63  1229.63     0  08:12       42.75
  J3                   JUNCTION     2.33    61.12  1227.62     0  08:12       60.26
  UpCulv               JUNCTION     3.57    69.34  1225.08     0  08:12       68.52
  OF-3                 OUTFALL      0.27     0.63  1154.10     0  07:33        0.63
  OF-W                 OUTFALL      0.14     0.40  1197.90     0  09:33        0.40
  Ex-Wetland           STORAGE      0.44     0.71  1198.21     0  09:33        0.71


  *******************
  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
J1	JUNCTION	2.241	2.241	0 07:45	58.8	58.8	-0.157
J2	JUNCTION	1.492	3.690	0 07:40	30.5	89.4	-0.080
J3	JUNCTION	0.750	4.381	0 07:41	20.4	110	-0.141
UpCulv	JUNCTION	0.000	3.960	0 08:12	0	110	0.046
OF-3	OUTFALL	0.000	3.960	0 08:12	0	110	0.000
OF-W	OUTFALL	0.000	0.337	0 09:33	0	18.7	0.000
Ex-Wetland	STORAGE	0.918	0.918	0 07:15	19.1	20.5	0.002

****
Node Surcharge Summary
****

Surcharging occurs when water rises above the top of the highest conduit.

Node	Type	Hours Surcharged	Max. Height Above Crown Meters	Min. Depth Below Rim Meters
J1	JUNCTION	1.34	36.237	0.000
J2	JUNCTION	2.16	41.638	0.000
J3	JUNCTION	4.17	59.126	0.000
UpCulv	JUNCTION	9.89	67.346	0.000

****
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
Ex-Wetland	2.475	32	0	0	4.800	61	0 09:33	0.337

****
Outfall Loading Summary
****

Outfall Node	Flow Freq Pcnt	Avg Flow CMS	Max Flow CMS	Total Volume 10^6 ltr
OF-3	98.48	0.519	3.960	109.923
OF-W	97.30	0.085	0.337	18.740
System	97.89	0.604	0.337	128.664

****
Link Flow Summary
****

Link	Type	Maximum |Flow| CMS	Time of Max Occurrence days hr:min	Maximum |Veloc| m/sec	Max/ Full Flow	Max/ Full Depth
1	CONDUIT	0.337	0 09:33	2.25	1.07	0.89
C1	CHANNEL	2.239	0 07:47	1.05	0.21	1.00
C2_1	CHANNEL	3.631	0 07:41	0.80	0.36	1.00
C2_2	CHANNEL	3.960	0 08:12	1.13	0.49	1.00
ExCulvert	CONDUIT	3.960	0 08:12	12.70	5.59	1.00

****
Flow Classification Summary
****

Conduit	Adjusted /Actual Length	Fraction of Time in Flow Class: Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Norm Ltd	Inlet Ctrl
1	1.00	0.00	0.00	0.00	0.03	0.96	0.00	0.00	0.26	0.00
C1	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.96	0.00
C2_1	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.93	0.00
C2_2	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.17	0.00
ExCulvert	1.00	0.01	0.00	0.00	0.26	0.74	0.00	0.00	0.17	0.00

****
Conduit Surcharge Summary
****

Conduit	Hours Full: Both Ends	Upstream	Dnstream	Hours Above Full Normal Flow	Hours Capacity Limited
1	0.01	0.01	0.01	2.19	0.01
C1	1.34	1.34	2.70	0.01	0.01
C2_1	2.16	2.16	4.17	0.01	0.01
C2_2	4.17	4.17	9.89	0.01	0.01
ExCulvert	0.01	14.88	0.01	15.03	0.01

Analysis begun on: Tue Aug 25 08:44:15 2020
Analysis ended on: Tue Aug 25 08:44:16 2020
Total elapsed time: 00:00:01

Continuous Simulation

- **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]
Ascension Pre-development
Continuous Simulation
Calgary 1960-2014


[OPTIONS]
;;Options            Value
;;------------------ ------------
FLOW_UNITS           CMS
INFILTRATION         GREEN_AMPT
FLOW_ROUTING         DYNWAVE
LINK_OFFSETS         DEPTH
MIN_SLOPE            0
ALLOW_PONDING        NO
SKIP_STEADY_STATE    NO
START_DATE           01/01/1960
START_TIME           01:00:00
REPORT_START_DATE    01/01/1960
REPORT_START_TIME    01:00:00
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             00:15:00
DRY_STEP             01:00:00
ROUTING_STEP         60
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              4

[EVAPORATION]
;;Type          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               2 0.5 0.6 1200 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]
;;               Rain      Time    Snow   Data
;;Name           Type      Intrvl Catch  Source
;;-------------- --------- ------ ------ ----------
YYC-Pre60-14     INTENSITY 1:00   1.0    FILE       "D:\__LGN\PCSWMM\STA.3031093 2014.dat" STA.3031093 MM

[SUBCATCHMENTS]
;;                                                 Total    Pcnt.             Pcnt.    Curb     Snow
;;Name           Raingage         Outlet           Area     Imperv   Width    Slope    Length   Pack
;;-------------- ---------------- ---------------- -------- -------- -------- -------- -------- --------
A1               YYC-Pre60-14     J1               67.8322  2        1646.413 4        0        Snowpack
A2               YYC-Pre60-14     J2               35.0722  0        1127.723 9        0        Snowpack
A3               YYC-Pre60-14     J3               23.4569  0        469.138  10       0        Snowpack
B                YYC-Pre60-14     Ex-Wetland       27.8421  4.1      647.491  9        0        Snowpack

[SUBAREAS]
;;Subcatchment   N-Imperv   N-Perv     S-Imperv   S-Perv     PctZero    RouteTo    PctRouted
;;-------------- ---------- ---------- ---------- ---------- ---------- ---------- ----------
```

```
A1              0.014      0.3        2          7.5        0          PERVIOUS   100
A2              0.014      0.3        2          7.5        0          OUTLET
A3              0.014      0.3        2          7.5        0          OUTLET
B               0.014      0.3        2          7.5        100        OUTLET

[INFILTRATION]
;;Subcatchment   Suction    HydCon     IMDmax
;;-------------- ---------- ---------- ----------
A1              126        0.99       0.21
A2              270.53     1          0.21
A3              270.69     0.99       0.25
B               213.88     1.68       0.29

[AQUIFERS]
;;               Por-   Wilt   Field  Hyd    Cond   Tens   Upper  Lower  Lower  Bottom Water  Upper  Upper
;;Name           osity  Point  Capac  Cond   Slope  Slope  Evap   Evap   Loss   Elev   Table  Moist  Evap Pat
;;-------------- ------ ------ ------ ------ ------ ------ ------ ------ ------ ------ ------ ------ ------------
AquiferEast     0.453  0.185  0.307  3.663  0.1    0.1    0.5    0.1    0.15   0.0    2      0.307
AquiferWest     0.453  0.185  0.307  3.663  0.1    0.1    0.5    0.1    0.044  0.0    2      0.307

[GROUNDWATER]
;;Subcatchment   Aquifer          Node             Elev   A1     B1     A2     B2     A3     Depth  Elev   Ebot   Wgr    Umc
;;-------------- ---------------- ---------------- ------ ------ ------ ------ ------ ------ ------ ------ ------ ------ --
----
A1              AquiferWest      J1               3      0.6    1.9    0      0      0      0      *      *      *      *
A2              AquiferWest      J2               3      0.6    1.9    0      0      0      0      *      *      *      *
A3              AquiferWest      J3               3      0.6    1.9    0      0      0      0      *      *      *      *
B               AquiferEast      Ex-Wetland       3      0.35   3.1    0      0      0      0      *      *      *      *

[SNOWPACKS]
Snowpack        PLOWABLE   0.05       0.2        0.0        0.10       0.00       0.00       0.3
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       25
Snowpack        REMOVAL    25         0.0        0.0        0.5        0.0        0.0

[JUNCTIONS]
;;               Invert     Max.       Init.      Surcharge  Ponded
;;Name           Elev.      Depth      Depth      Depth      Area
;;-------------- ---------- ---------- ---------- ---------- ----------
J1              1192       2          0          100        0
J2              1186       2          0          100        0

[OUTFALLS]
;;               Invert     Outfall      Stage/Table      Tide
;;Name           Elev.      Type         Time Series      Gate Route To
;;-------------- ---------- ------------ ---------------- ---- ----------------
OF-3            1153.47    FREE                          NO
OF-W            1197.5     FREE                          NO

[STORAGE]
;;               Invert   Max.     Init.    Storage    Curve                                Evap.
;;Name           Elev.    Depth    Depth    Curve      Params                               Frac.    Infiltration parameters
;;-------------- -------- -------- -------- ---------- -------- -------- -------- -------- -------- ----------------------
Ex-Wetland      1197.5   1        0.3      TABULAR    Wetland                   0        1
;Junction
J3              1166.5   2        0        FUNCTIONAL 1000     0        0        150      0
;Junction
UpCulv          1155.74  2        0        FUNCTIONAL 1000     0        0        200      0

[CONDUITS]
;;               Inlet            Outlet                      Manning    Inlet      Outlet     Init.      Max.
;;Name           Node             Node             Length     N          Offset     Offset     Flow       Flow
;;-------------- ---------------- ---------------- ---------- ---------- ---------- ---------- ---------- ----------
;Culvert
1               Ex-Wetland       OF-W             18.6       0.015      0.3        0          0          0
;Natural Channel
C1              J1               J2               146.45     0.01       0          0          0          0
;Natural Channel
C2_1            J2               J3               352.28     0.01       0          0          0          0
;Natural Channel
C2_2            J3               UpCulv           305.17     0.01       0          0          0          0
;Culvert
ExCulvert       UpCulv           OF-3             77.33      0.022      0          0          0          0

[XSECTIONS]
;;Link           Shape        Geom1            Geom2      Geom3      Geom4      Barrels
;;-------------- ------------ ---------------- ---------- ---------- ---------- ----------
1               CIRCULAR     0.45             0          0          0          1
C1              IRREGULAR    Section18        0          0          0          1
```

```
C2_1            IRREGULAR    Section6         0          0          0          1
C2_2            IRREGULAR    Section6         0          0          0          1
ExCulvert       CIRCULAR     0.63             0          0          0          1

[TRANSECTS]

NC 0.35     0.35     0.07
X1 Section18        8        72.899   74.312   0.0       0.0       0.0      0.0      0.0
GR 1189.24  65.507   1188.46  69.488   1188.22  72.899   1187.75  73.041   1187.74  73.839
GR 1188.19  74.312   1188.47  75.614   1189.37  79.324

NC 0.35     0.35     0.07
X1 Section6         8        83.111   83.945   0.0       0.0       0.0      0.0      0.0
GR 1177.03  80.013   1176.29  81.881   1176.24  83.111   1175.8   83.269   1175.8   83.745
GR 1176.26  83.945   1176.47  85.422   1177.79  86.958

[LOSSES]
;;Link           Inlet      Outlet     Average    Flap Gate  SeepageRate
;;-------------- ---------- ---------- ---------- ---------- ----------

[CURVES]
;;Name           Type       X-Value    Y-Value
;;-------------- ---------- ---------- ----------
OGS              Rating     0          0
OGS                         0.25       0.0066
OGS                         0.5        0.0098
OGS                         0.75       0.0122
OGS                         1          0.0142

R33              Rating     0          0
R33                         0.25       0.0043
R33                         0.5        0.0062
R33                         0.75       0.0077
R33                         1          0.009
R33                         1.25       0.0101
R33                         1.5        0.0111

R96              Rating     0          0
R96                         0.25       0.0303
R96                         0.5        0.0492
R96                         0.75       0.0626
R96                         1          0.0736
R96                         1.25       0.0831
R96                         1.5        0.0917

Wetland          Storage    0          1018
Wetland                     0.25       7072
Wetland                     0.5        8482
Wetland                     0.75       9674
Wetland                     1          11306

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

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

[ADJUSTMENTS]
;;Parameter    Subcatchment     Monthly Adjustments
;;------------ ---------------- --------------------------------
CONDUCTIVITY                    0.05   0.05   0.05   0.05   1.0    1.0    1.0    1.0    1.0    1.0    0.05   0.05

[TAGS]

[MAP]
DIMENSIONS       -19799.6333      5666764.724      -17942.8047      5668793.476
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 5.1.013)
--------------------------------------------------------------

Ascension Pre-development
Continuous Simulation
Calgary 1960-2014


*************
Element Count
*************
Number of rain gages ...... 1
Number of subcatchments ... 4
Number of nodes ........... 7
Number of links ........... 5
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
-------------------------------------------------------------------------------------------------------
A1                          67.83   1646.41      2.00    4.0000 YYC-Pre60-14         J1
A2                          35.07   1127.72      0.00    9.0000 YYC-Pre60-14         J2
A3                          23.46    469.14      0.00   10.0000 YYC-Pre60-14         J3
B                           27.84    647.49      4.10    9.0000 YYC-Pre60-14         Ex-Wetland


************
Node Summary
************
                                      Invert      Max.    Ponded    External
Name                 Type               Elev.     Depth      Area    Inflow
-----------------------------------------------------------------------------
J1                   JUNCTION         1192.00      2.00       0.0
J2                   JUNCTION         1186.00      2.00       0.0
OF-3                 OUTFALL          1153.47      0.63       0.0
OF-W                 OUTFALL          1197.50      0.45       0.0
Ex-Wetland           STORAGE          1197.50      1.00       0.0
J3                   STORAGE          1166.50      2.00       0.0
UpCulv               STORAGE          1155.74      2.00       0.0


************
Link Summary
************
Name             From Node        To Node          Type            Length    %Slope Roughness
-----------------------------------------------------------------------------------------------
1                Ex-Wetland       OF-W             CONDUIT           18.6    1.6131    0.0150
C1               J1               J2               CONDUIT          146.4    4.1004    0.0700
C2_1             J2               J3               CONDUIT          352.3    5.5439    0.0700
C2_2             J3               UpCulv           CONDUIT          305.2    3.5281    0.0700
ExCulvert        UpCulv           OF-3             CONDUIT           77.3    2.9367    0.0220


********************
Cross Section Summary
********************
                                      Full     Full     Hyd.     Max.   No. of     Full
Conduit          Shape               Depth     Area     Rad.    Width  Barrels     Flow
-----------------------------------------------------------------------------------------
1                CIRCULAR             0.45     0.16     0.11     0.45        1     0.31
C1               Section18            1.63    10.77     0.20    13.82        1    10.53
C2_1             Section6             1.99     8.68     0.21     6.94        1    10.22
C2_2             Section6             1.99     8.68     0.21     6.94        1     8.15
ExCulvert        CIRCULAR             0.63     0.31     0.16     0.63        1     0.71
```

```
***************
Transect Summary
***************

Transect Section18
Area:
            0.0021     0.0047     0.0075     0.0103     0.0133
            0.0165     0.0198     0.0232     0.0267     0.0304
            0.0342     0.0381     0.0422     0.0464     0.0511
            0.0572     0.0652     0.0751     0.0868     0.1004
            0.1159     0.1332     0.1520     0.1717     0.1923
            0.2139     0.2363     0.2597     0.2840     0.3091
            0.3352     0.3622     0.3901     0.4190     0.4487
            0.4793     0.5109     0.5434     0.5767     0.6110
            0.6462     0.6823     0.7194     0.7573     0.7961
            0.8359     0.8763     0.9171     0.9584     1.0000
Hrad:
            0.1322     0.2706     0.3943     0.5064     0.6094
            0.7050     0.7944     0.8788     0.9590     1.0356
            1.1091     1.1800     1.2485     1.3210     1.4092
            1.4583     1.4527     1.4120     1.3526     1.2861
            1.2195     1.1566     1.1062     1.0681     1.0387
            1.0157     0.9977     0.9835     0.9724     0.9637
            0.9570     0.9520     0.9483     0.9458     0.9443
            0.9436     0.9437     0.9444     0.9456     0.9473
            0.9495     0.9520     0.9548     0.9580     0.9614
            0.9651     0.9731     0.9817     0.9907     1.0000
Width:
            0.0607     0.0639     0.0671     0.0703     0.0735
            0.0767     0.0799     0.0831     0.0863     0.0895
            0.0927     0.0959     0.0990     0.1039     0.1246
            0.1692     0.2137     0.2582     0.3027     0.3472
            0.3917     0.4362     0.4603     0.4820     0.5038
            0.5256     0.5474     0.5691     0.5909     0.6127
            0.6344     0.6562     0.6780     0.6997     0.7215
            0.7433     0.7650     0.7868     0.8086     0.8303
            0.8521     0.8739     0.8956     0.9174     0.9392
            0.9609     0.9708     0.9805     0.9903     1.0000

Transect Section6
Area:
            0.0023     0.0047     0.0072     0.0099     0.0127
            0.0157     0.0188     0.0221     0.0255     0.0291
            0.0328     0.0387     0.0493     0.0618     0.0760
            0.0920     0.1097     0.1285     0.1479     0.1680
            0.1888     0.2102     0.2323     0.2551     0.2786
            0.3027     0.3276     0.3530     0.3792     0.4060
            0.4335     0.4614     0.4896     0.5179     0.5464
            0.5752     0.6041     0.6333     0.6627     0.6923
            0.7221     0.7522     0.7824     0.8128     0.8435
            0.8744     0.9055     0.9368     0.9683     1.0000
Hrad:
            0.1677     0.3004     0.4104     0.5047     0.5878
            0.6627     0.7312     0.7949     0.8546     0.9113
            0.9653     0.9750     0.8867     0.8151     0.7601
            0.7176     0.6850     0.6662     0.6567     0.6532
            0.6536     0.6568     0.6620     0.6685     0.6760
            0.6843     0.6931     0.7023     0.7118     0.7215
            0.7317     0.7449     0.7585     0.7725     0.7866
            0.8010     0.8154     0.8299     0.8444     0.8588
            0.8733     0.8877     0.9021     0.9163     0.9305
            0.9446     0.9586     0.9725     0.9863     1.0000
Width:
            0.0731     0.0776     0.0822     0.0867     0.0913
            0.0958     0.1004     0.1049     0.1095     0.1140
            0.1186     0.2711     0.3653     0.4201     0.4748
            0.5296     0.5788     0.5999     0.6211     0.6422
            0.6633     0.6845     0.7056     0.7267     0.7479
            0.7690     0.7901     0.8113     0.8324     0.8535
            0.8733     0.8800     0.8866     0.8933     0.9000
            0.9066     0.9133     0.9200     0.9266     0.9333
            0.9400     0.9467     0.9533     0.9600     0.9667
            0.9733     0.9800     0.9867     0.9933     1.0000


********************
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 ............ YES
  Flow Routing ........... YES
  Ponding Allowed ........ NO
  Water Quality .......... NO
Infiltration Method ...... GREEN_AMPT
Flow Routing Method ...... DYNWAVE
Surcharge Method ......... EXTRAN
Starting Date ............ 01/01/1960 01:00:00
Ending Date .............. 12/31/2014 23:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 01:00:00
Wet Time Step ............ 00:15:00
Dry Time Step ............ 01:00:00
Routing Time Step ........ 60.00 sec
Variable Time Step ....... YES
Maximum Trials ........... 8
Number of Threads ........ 1
Head Tolerance ........... 0.001500 m

*************************        Volume         Depth
Runoff Quantity Continuity     hectare-m            mm
*************************     ---------       -------
Initial Snow Cover .......         0.000         0.000
Total Precipitation ......      3531.782     22903.400
Evaporation Loss .........       301.967      1958.236
Infiltration Loss ........      3056.091     19818.574
Surface Runoff ...........       191.616      1242.618
Snow Removed .............         0.000         0.000
Final Snow Cover .........         0.401         2.600
Final Storage ............         0.001         0.009
Continuity Error (%) .....        -0.518

*************************        Volume         Depth
Groundwater Continuity         hectare-m            mm
*************************     ---------       -------
Initial Storage ..........       187.049      1213.000
Infiltration .............      3056.091     19818.574
Upper Zone ET ............      2847.136     18463.508
Lower Zone ET ............         0.000         0.000
Deep Percolation .........       247.891      1607.556
Groundwater Flow .........         0.000         0.000
Final Storage ............       148.105       960.451
Continuity Error (%) .....         0.000

*************************        Volume        Volume
Flow Routing Continuity        hectare-m      10^6 ltr
*************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......       191.360      1913.621
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........       166.890      1668.919
Flooding Loss ............         0.192         1.916
Evaporation Loss .........        24.427       244.268
```

```
  Exfiltration Loss ........          0.000         0.000
  Initial Stored Volume ....          0.137         1.372
  Final Stored Volume ......          0.087         0.875
  Continuity Error (%) .....         -0.051


  **************************
  Time-Step Critical Elements
  **************************
  Link 1 (11.00%)


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


  ************************
  Routing Time Step Summary
  ************************
  Minimum Time Step           :     1.61 sec
  Average Time Step           :    55.97 sec
  Maximum Time Step           :    60.00 sec
  Percent in Steady State     :     0.00
  Average Iterations per Step :     2.00
  Percent Not Converging      :     0.01


  **************************
  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
  ---------------------------------------------------------------------------------------------------------------
------
  A1                     22903.40       0.00    2446.13   19285.00     292.54    1312.59    1312.59     890.36     4.20
0.057
  A2                     22903.40       0.00    1883.81   19958.99       0.00    1177.49    1177.49     412.97     3.13
0.051
  A3                     22903.40       0.00    1755.90   20244.75       0.00    1008.75    1008.75     236.62     1.62
0.044
  B                      22903.40       0.00    1033.78   20582.59     838.95     512.27    1351.22     376.21     1.88
0.059


  ******************
  Groundwater Summary
  ******************

  ---------------------------------------------------------------------------------------------
                                      Total    Total  Maximum  Average  Average    Final    Final
                        Total     Total Lower Lateral Lateral    Upper    Water    Upper    Water
                        Infil      Evap Seepage Outflow Outflow Moist.    Table Moist.    Table
  Subcatchment             mm        mm      mm      mm     CMS                m                m
  ---------------------------------------------------------------------------------------------
  A1                 19285.00 18251.95 1276.72    0.00    0.00     0.27     0.18     0.30     0.45
  A2                 19958.99 18790.44 1413.78    0.00    0.00     0.27     0.20     0.30     0.45
  A3                 20244.75 18822.86 1658.51    0.00    0.00     0.27     0.23     0.30     0.51
  B                  20582.59 18264.34 2614.73    0.00    0.00     0.29     0.11     0.30     0.08


  ******************
  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
  ------------------------------------------------------------------------------
  J1                   JUNCTION  0.01    97.19  1289.19  17322  19:04       59.26
  J2                   JUNCTION  0.01   102.00  1288.00  17322  19:04       64.93
```

OF-3	OUTFALL	0.01	0.63	1154.10	2028	17:24	0.63
OF-W	OUTFALL	0.00	0.42	1197.92	17322	21:05	0.42
Ex-Wetland	STORAGE	0.22	0.93	1198.43	17322	21:05	0.93
J3	STORAGE	0.02	118.40	1284.90	17322	19:04	81.93
UpCulv	STORAGE	0.02	123.77	1279.51	17322	19:04	89.44

****
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
J1	JUNCTION	4.200	6.037	17322	19:01	889	889	-0.028
J2	JUNCTION	3.130	7.189	17322	19:00	412	1.3e+03	-0.284
OF-3	OUTFALL	0.000	5.812	17322	19:04	0	1.54e+03	0.000
OF-W	OUTFALL	0.000	0.413	17322	21:05	0	133	0.000
Ex-Wetland	STORAGE	1.876	1.876	17322	19:00	376	377	0.001
J3	STORAGE	1.623	7.873	17322	18:58	236	1.54e+03	-0.054
UpCulv	STORAGE	0.000	8.235	17322	18:58	0	1.54e+03	0.248

****
Node Surcharge Summary
****

Surcharging occurs when water rises above the top of the highest conduit.

Node	Type	Hours Surcharged	Max. Height Above Crown Meters	Min. Depth Below Rim Meters
J1	JUNCTION	2.13	95.561	0.000
J2	JUNCTION	2.59	100.010	0.000
J3	STORAGE	8.93	116.408	0.000
UpCulv	STORAGE	25.40	121.776	0.000

****
Node Flooding Summary
****

Flooding refers to all water that overflows a node, whether it ponds or not.

Node	Hours Flooded	Maximum Rate CMS	Time of Max Occurrence days hr:min		Total Flood Volume 10^6 ltr	Maximum Ponded Depth Meters
J2	0.46	2.611	17322	19:04	1.916	100.000

****
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
Ex-Wetland	0.845	11	64	0	7.052	90	17322	21:05	0.414
J3	0.010	1	0	0	2.000	100	9386	10:47	8.235
UpCulv	0.008	0	0	0	2.000	100	1647	19:04	5.812

****
Outfall Loading Summary
****

Outfall Node	Flow Freq Pcnt	Avg Flow CMS	Max Flow CMS	Total Volume 10^6 ltr

```
OF-3                    7.44     0.083     5.812    1535.975
OF-W                    8.59     0.008     0.413     132.936
-----------------------------------------------------------
System                  8.02     0.092     0.413    1668.911


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

-------------------------------------------------------------------------------
                                Maximum  Time of Max   Maximum    Max/    Max/
                                |Flow|   Occurrence   |Veloc|    Full    Full
Link                 Type          CMS  days hr:min     m/sec    Flow   Depth
-------------------------------------------------------------------------------
1                    CONDUIT     0.413  17322  21:05      2.62    1.32    0.97
C1                   CHANNEL     4.120  17322  19:01      0.96    0.39    1.00
C2_1                 CHANNEL     6.297  17322  18:58      1.69    0.62    1.00
C2_2                 CHANNEL     8.235  17322  18:58      1.62    1.01    1.00
ExCulvert            CONDUIT     5.812  17322  19:04     18.64    8.21    1.00


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

-------------------------------------------------------------------------------------------
                   Adjusted    ---------- Fraction of Time in Flow Class ----------
                   /Actual         Up    Down  Sub   Sup   Up    Down  Norm  Inlet
Conduit             Length    Dry  Dry   Dry   Crit  Crit  Crit  Crit  Ltd   Ctrl
-------------------------------------------------------------------------------------------
1                     1.00   0.89  0.00  0.00  0.01  0.11  0.00  0.00  0.00  0.00
C1                    1.00   0.94  0.01  0.00  0.04  0.00  0.00  0.00  1.00  0.00
C2_1                  1.00   0.83  0.12  0.00  0.05  0.00  0.00  0.00  0.99  0.00
C2_2                  1.00   0.01  0.82  0.00  0.17  0.00  0.00  0.00  0.99  0.00
ExCulvert             1.00   0.01  0.00  0.00  0.91  0.08  0.00  0.00  0.00  0.00


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

-------------------------------------------------------------------------------
                                                      Hours        Hours
                    --------- Hours Full --------   Above Full   Capacity
Conduit             Both Ends  Upstream  Dnstream   Normal Flow   Limited
-------------------------------------------------------------------------------
1                        0.01      3.92      0.01      4.76         0.01
C1                       2.13      2.13      3.05      0.01         0.01
C2_1                     2.59      2.59      8.93      0.01         0.01
C2_2                     8.85      8.93     25.40      0.01         0.01
ExCulvert                0.01     99.79      0.01    113.51         0.01


Analysis begun on:  Tue Aug 25 11:18:31 2020
Analysis ended on:  Tue Aug 25 11:20:11 2020
Total elapsed time: 00:01:40
```

APPENDIX C

PCSWMM
Post-development Analysis

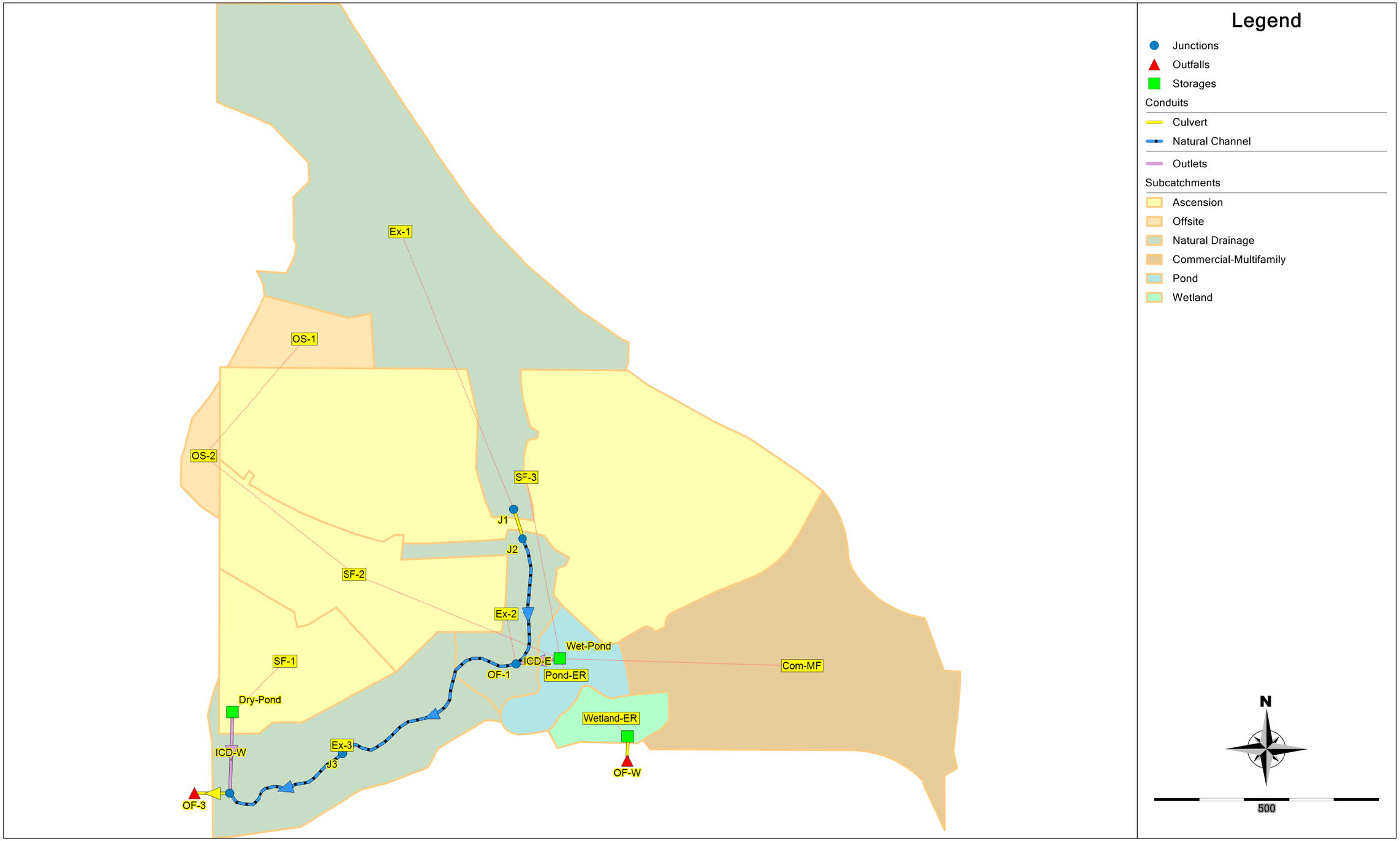
- Input Parameters
- Schematic
- Input and Report Files

Catchment Parameters Used in the PCSWMM Model

Catchment ID	Area (ha)	Imp (%)	Imp. (ha)	Imp. Directly Connected (%)	Imp. Directly Connected (ha)	Imp. Routed to Perv. (%)	Imp. Routed through Perv. (ha)
Com-MF	26.03	82.8	21.56	71.1	15.34	28.9	6.22
Ex-1 *	37.79	3.7	1.41	76.9	1.08	23.1	0.33
Ex-2 *	5.79	8.0	0.47	0.0	0.00	100.0	0.47
Ex-3 *	13.52	2.1	0.28	0.0	0.00	100.0	0.28
OS-1 **	3.78	6.1	0.23	0.0	0.00	100.0	0.23
OS-2 **	1.74	9.2	0.16	0.0	0.00	100.0	0.16
Pond-ER	3.89	41.7	1.62	97.4	1.58	2.6	0.04
SF-1	8.50	42.6	3.62	55.5	2.01	44.5	1.61
SF-2	13.35	55.3	7.38	51.6	3.81	48.4	3.57
SF-3	45.78	53.3	24.39	53.1	12.94	46.9	11.45
Wetland-ER	2.47	49.7	1.23	92.0	1.13	8.0	0.10
Total	162.64	38.3	62.35	60.8	37.89	39.2	24.46

* Exiting Areas (Natural Drainage Course)

** Flow through Areas



Post-development PCSWMM Schematic

Single Storm Event

- 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]
Ascension Post-Development
400 mm Sandy Loam
Single Event
Calgary 24h-100y


[OPTIONS]
;;Options            Value
;;------------------ ------------
FLOW_UNITS           CMS
INFILTRATION         GREEN_AMPT
FLOW_ROUTING         DYNWAVE
LINK_OFFSETS         DEPTH
MIN_SLOPE            0
ALLOW_PONDING        NO
SKIP_STEADY_STATE    NO
START_DATE           08/22/2020
START_TIME           00:00:00
REPORT_START_DATE    08/22/2020
REPORT_START_TIME    00:00:00
END_DATE             08/25/2020
END_TIME             00:00:00
SWEEP_START          01/01
SWEEP_END            12/31
DRY_DAYS             0
REPORT_STEP          00:05:00
WET_STEP             00:05:00
DRY_STEP             00:30:00
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              4

[EVAPORATION]
;;Type          Parameters
;;------------- ----------
CONSTANT     0
DRY_ONLY     NO

[RAINGAGES]
;;               Rain      Time   Snow   Data
;;Name           Type      Intrvl Catch  Source
;;-------------- --------- ------ ------ ----------
Calgary_24h_100y INTENSITY 0:05   1.0    TIMESERIES Calgary_24h_100y

[SUBCATCHMENTS]
;;                                                Total    Pcnt.             Pcnt.    Curb     Snow
;;Name           Raingage         Outlet          Area     Imperv   Width    Slope    Length   Pack
;;-------------- ---------------- --------------- -------- -------- -------- -------- -------- --------
;Commercial-MF
Com-MF           Calgary_24h_100y Wet-Pond        26.0265  100      2082.12  2        0
;Natural Drainage Course
Ex-1             Calgary_24h_100y J1              37.7858  3.7      917.131  5        0
;Natural Drainage Course
Ex-2             Calgary_24h_100y OF-1            5.7895   8        578.95   3        0
;Natural Drainage Course
Ex-3             Calgary_24h_100y J3              13.52    2        1352     8        0
;Offsite Areas
OS-1             Calgary_24h_100y OS-2            3.7839   6        378.39   5        0
;Offsite Areas
OS-2             Calgary_24h_100y SF-2            1.7365   9        347.3    5        0
;Pond Area
```

```
Pond-ER          Calgary_24h_100y Wet-Pond         3.8906   41.7     972.65   2        0
;Residential
SF-1             Calgary_24h_100y Dry-Pond         8.4971   100      679.768  3        0
;Residential
SF-2             Calgary_24h_100y Wet-Pond         13.3461  100      1067.688 3        0
;Residential
SF-3             Calgary_24h_100y Wet-Pond         45.7774  100      3662.192 5        0
;Wetland Area
Wetland-ER       Calgary_24h_100y Ex-Wetland       2.4733   49.7     206.108  2        0

[SUBAREAS]
;;Subcatchment   N-Imperv   N-Perv     S-Imperv   S-Perv     PctZero    RouteTo    PctRouted
;;-------------- ---------- ---------- ---------- ---------- ---------- ---------- ----------
Com-MF           0.015      0.25       1.6        3.2        0          PERVIOUS   29
Ex-1             0.014      0.3        2          7.5        0          PERVIOUS   100
Ex-2             0.014      0.3        2          7.5        0          PERVIOUS   100
Ex-3             0.014      0.3        2          7.5        0          PERVIOUS   100
OS-1             0.014      0.3        2          7.5        0          PERVIOUS   100
OS-2             0.014      0.3        2          7.5        0          PERVIOUS   100
Pond-ER          0.015      0.25       1.6        3.2        0          PERVIOUS   3
SF-1             0.015      0.25       1.6        3.2        0          PERVIOUS   44
SF-2             0.015      0.25       1.6        3.2        0          PERVIOUS   48
SF-3             0.015      0.25       1.6        3.2        0          PERVIOUS   47
Wetland-ER       0.015      0.25       1.6        3.2        0          PERVIOUS   8

[INFILTRATION]
;;Subcatchment   Suction    HydCon     IMDmax
;;-------------- ---------- ---------- ----------
Com-MF           110        14.15      0.246
Ex-1             110        14.15      0.246
Ex-2             110        14.15      0.246
Ex-3             110        14.15      0.246
OS-1             110        14.15      0.246
OS-2             110        14.15      0.246
Pond-ER          110        14.15      0.246
SF-1             110        14.15      0.246
SF-2             110        14.15      0.246
SF-3             110        14.15      0.246
Wetland-ER       110        14.15      0.246

[LID_CONTROLS]
;;               Type/Layer Parameters
;;-------------- ---------- ----------
SandyLoam        BC
SandyLoam        SURFACE    5          0.2        0.41       2          5
SandyLoam        SOIL       400        0.396      0.175      0.081      27.08      7          110
SandyLoam        STORAGE    0.0001     0.75       0.5        0
SandyLoam        DRAIN      0          0.5        6          6          0          0

[LID_USAGE]
;;Subcatchment   LID Process      Number  Area       Width      InitSatur  FromImprv  ToPerv     Report File
Drain to          FromPerv
;;-------------- ---------------- ------- ---------- ---------- ---------- ---------- ---------- --------------------------
- ---------------- ----------------
Com-MF           SandyLoam        1       44639      0          0          29         0          *
*                0
SF-1             SandyLoam        1       48806      0          0          44         0          *
*                0
SF-2             SandyLoam        1       59639      0          0          48         0          *
*                0
SF-3             SandyLoam        1       213860     0          0          47         0          *
*                0

[JUNCTIONS]
;;               Invert     Max.       Init.      Surcharge  Ponded
;;Name           Elev.      Depth      Depth      Depth      Area
;;-------------- ---------- ---------- ---------- ---------- ----------
J1               1205.5     0          0          0          0
J2               1202.5     0          0          0          0
J3               1166.5     5.327      0          0          0
OF-1             1192       1.69       0          0          0
OF-2             1155.74    3          0          0          0

[OUTFALLS]
;;               Invert     Outfall      Stage/Table      Tide
;;Name           Elev.      Type         Time Series      Gate Route To
;;-------------- ---------- ------------ ---------------- ---- ----------------
OF-3             1153.47    FREE                          NO
OF-W             1197       FREE                          NO
```

```
[STORAGE]
;;               Invert   Max.     Init.    Storage    Curve                            Evap.
;;Name          Elev.    Depth    Depth    Curve      Params                           Frac.    Infiltration parameters
;;-------------- -------- -------- -------- ---------- -------- -------- -------- -------- ----------------------
Dry-Pond         1170     1.5      0        TABULAR    Dry-Pond                 0        0
Ex-Wetland       1197.5   1.5      0.3      TABULAR    Wetland                  0        0
Wet-Pond         1192.5   5.5      3.5      TABULAR    Wet-Pond                 0        0

[CONDUITS]
;;               Inlet            Outlet                      Manning    Inlet      Outlet     Init.      Max.
;;Name          Node             Node             Length     N          Offset     Offset     Flow       Flow
;;-------------- ---------------- ---------------- ---------- ---------- ---------- ---------- ---------- ----------
;Culvert
1                Ex-Wetland       OF-W             18.6       0.015      0.3        0          0          0
;Culvert
2                J1               J2               67.687     0.017      0          0          0          0
;Natural Channel
3                J2               OF-1             291.26     0.01       0          0          0          0
;Natural Channel
C2_1             OF-1             J3               498.745    0.01       0          0          0          0
;Natural Channel
C2_2             J3               OF-2             305.17     0.01       0          0          0          0
;Culvert
ExCulvert        OF-2             OF-3             77.33      0.017      0          0          0          0

[OUTLETS]
;;               Inlet            Outlet           Outflow    Outlet           Qcoeff/                    Flap
;;Name          Node             Node             Height     Type             QTable           Qexpon    Gate
;;-------------- ---------------- ---------------- ---------- ---------------- ---------------- ---------- ----
ICD-E            Wet-Pond         OF-1             3.5        TABULAR/HEAD     R156.6                     NO
ICD-W            Dry-Pond         OF-2             0          TABULAR/HEAD     R28.8                      NO

[XSECTIONS]
;;Link           Shape        Geom1            Geom2      Geom3      Geom4      Barrels
;;-------------- ------------ ---------------- ---------- ---------- ---------- ----------
1                CIRCULAR     0.45             0          0          0          1
2                CIRCULAR     0.6              0          0          0          1
3                IRREGULAR    Section18        0          0          0          1
C2_1             IRREGULAR    Section18        0          0          0          1
C2_2             IRREGULAR    Section6         0          0          0          1
ExCulvert        CIRCULAR     0.63             0          0          0          1

[TRANSECTS]

NC 0.35     0.35     0.07
X1 Section18        8        72.899   74.312   0.0       0.0       0.0      0.0      0.0
GR 1189.24  65.507   1188.46  69.488   1188.22  72.899   1187.75  73.041   1187.74  73.839
GR 1188.19  74.312   1188.47  75.614   1189.37  79.324

NC 0.35     0.35     0.07
X1 Section6         8        83.111   83.945   0.0       0.0       0.0      0.0      0.0
GR 1177.03  80.013   1176.29  81.881   1176.24  83.111   1175.8   83.269   1175.8   83.745
GR 1176.26  83.945   1176.47  85.422   1177.79  86.958

[LOSSES]
;;Link           Inlet      Outlet     Average    Flap Gate  SeepageRate
;;-------------- ---------- ---------- ---------- ---------- ----------

[CURVES]
;;Name           Type       X-Value    Y-Value
;;-------------- ---------- ---------- ----------
R156.6           Rating     0          0
R156.6                      0.093      0.0626
R156.6                      0.343      0.12
R156.6                      0.593      0.1578
R156.6                      0.843      0.1881
R156.6                      1.093      0.2142
R156.6                      1.343      0.2374
R156.6                      1.593      0.2586
R156.6                      1.8434     0.2781
R156.6                      2.143      0.2999

R28.8            Rating     0          0
R28.8                       0.221      0.0033
R28.8                       0.471      0.0048
R28.8                       0.721      0.0059
R28.8                       0.971      0.0068
R28.8                       1.221      0.0077
```

```
R28.8                       1.4712      0.0084
R28.8                       1.771       0.0092

Dry-Pond          Storage   0           1052.764
Dry-Pond                    0.25        1174.707
Dry-Pond                    0.5         1301.147
Dry-Pond                    0.75        1432.084
Dry-Pond                    1           1567.517
Dry-Pond                    1.25        1707.447
Dry-Pond                    1.5         1868.381

Wetland           Storage   0           1018
Wetland                     0.25        7072
Wetland                     0.5         8482
Wetland                     0.75        9674
Wetland                     1           11306

Wet-Pond          Storage   0           1265.308
Wet-Pond                    0.25        1576.948
Wet-Pond                    0.5         1897.202
Wet-Pond                    0.75        2226.072
Wet-Pond                    1           3555.796
Wet-Pond                    1.25        5008.793
Wet-Pond                    1.5         5728.093
Wet-Pond                    1.75        6475.087
Wet-Pond                    2           7249.775
Wet-Pond                    2.25        8052.157
Wet-Pond                    2.5         8882.233
Wet-Pond                    2.75        9740.003
Wet-Pond                    3           11112.413
Wet-Pond                    3.25        13375.288
Wet-Pond                    3.5         15788.106
Wet-Pond                    3.75        17662.38
Wet-Pond                    4           18721.113
Wet-Pond                    4.25        19649.843
Wet-Pond                    4.5         20588.121
Wet-Pond                    4.75        21535.948
Wet-Pond                    5           22493.323
Wet-Pond                    5.25        23460.247
Wet-Pond                    5.5         24432.341

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

[TAGS]

[MAP]
DIMENSIONS       -19800.5545345242 5666764.72393014 -17906.5841223704 5668793.47605977
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 5.1.013)
--------------------------------------------------------------

Ascension Post-Development
400 mm Sandy Loam
Single Event


*************
Element Count
*************
Number of rain gages ...... 1
Number of subcatchments ... 11
Number of nodes ........... 10
Number of links ........... 8
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
-------------------------------------------------------------------------------------------------------
Com-MF                      26.03   2082.12    100.00    2.0000 Calgary_24h_100y     Wet-Pond
Ex-1                        37.79    917.13      3.70    5.0000 Calgary_24h_100y     J1
Ex-2                         5.79    578.95      8.00    3.0000 Calgary_24h_100y     OF-1
Ex-3                        13.52   1352.00      2.00    8.0000 Calgary_24h_100y     J3
OS-1                         3.78    378.39      6.00    5.0000 Calgary_24h_100y     OS-2
OS-2                         1.74    347.30      9.00    5.0000 Calgary_24h_100y     SF-2
Pond-ER                      3.89    972.65     41.70    2.0000 Calgary_24h_100y     Wet-Pond
SF-1                         8.50    679.77    100.00    3.0000 Calgary_24h_100y     Dry-Pond
SF-2                        13.35   1067.69    100.00    3.0000 Calgary_24h_100y     Wet-Pond
SF-3                        45.78   3662.19    100.00    5.0000 Calgary_24h_100y     Wet-Pond
Wetland-ER                   2.47    206.11     49.70    2.0000 Calgary_24h_100y     Ex-Wetland


********************
LID Control Summary
********************
                               No. of        Unit        Unit      % Area    % Imperv      % Perv
Subcatchment     LID Control    Units        Area       Width     Covered     Treated     Treated
-------------------------------------------------------------------------------------------------
Com-MF           SandyLoam          1    44639.00        0.00       17.15       29.00        0.00
SF-1             SandyLoam          1    48806.00        0.00       57.44       44.00        0.00
SF-2             SandyLoam          1    59639.00        0.00       44.69       48.00        0.00
SF-3             SandyLoam          1   213860.00        0.00       46.72       47.00        0.00


************
Node Summary
************
                                    Invert      Max.    Ponded    External
Name                 Type            Elev.     Depth      Area    Inflow
-----------------------------------------------------------------------
J1                   JUNCTION      1205.50      0.60       0.0
J2                   JUNCTION      1202.50      1.63       0.0
J3                   JUNCTION      1166.50      5.33       0.0
OF-1                 JUNCTION      1192.00      1.69       0.0
OF-2                 JUNCTION      1155.74      3.00       0.0
OF-3                 OUTFALL       1153.47      0.63       0.0
OF-W                 OUTFALL       1197.00      0.45       0.0
Dry-Pond             STORAGE       1170.00      1.50       0.0
Ex-Wetland           STORAGE       1197.50      1.50       0.0
Wet-Pond             STORAGE       1192.50      5.50       0.0


************
Link Summary
```

```
************
Name             From Node        To Node          Type            Length    %Slope Roughness
-------------------------------------------------------------------------------------------
1                Ex-Wetland       OF-W             CONDUIT           18.6    4.3051    0.0150
2                J1               J2               CONDUIT           67.7    4.4365    0.0170
3                J2               OF-1             CONDUIT          291.3    3.6074    0.0700
C2_1             OF-1             J3               CONDUIT          498.7    5.1195    0.0700
C2_2             J3               OF-2             CONDUIT          305.2    3.5281    0.0700
ExCulvert        OF-2             OF-3             CONDUIT           77.3    2.9367    0.0170
ICD-E            Wet-Pond         OF-1             OUTLET
ICD-W            Dry-Pond         OF-2             OUTLET


********************
Cross Section Summary
********************
                                    Full     Full     Hyd.     Max.   No. of     Full
Conduit          Shape              Depth     Area     Rad.    Width  Barrels     Flow
-------------------------------------------------------------------------------------
1                CIRCULAR            0.45     0.16     0.11     0.45        1     0.51
2                CIRCULAR            0.60     0.28     0.15     0.60        1     0.99
3                Section18           1.63    10.77     0.20    13.82        1     9.87
C2_1             Section18           1.63    10.77     0.20    13.82        1    11.76
C2_2             Section6            1.99     8.68     0.21     6.94        1     8.15
ExCulvert        CIRCULAR            0.63     0.31     0.16     0.63        1     0.92


****************
Transect Summary
****************

Transect Section18
Area:
            0.0021     0.0047     0.0075     0.0103     0.0133
            0.0165     0.0198     0.0232     0.0267     0.0304
            0.0342     0.0381     0.0422     0.0464     0.0511
            0.0572     0.0652     0.0751     0.0868     0.1004
            0.1159     0.1332     0.1520     0.1717     0.1923
            0.2139     0.2363     0.2597     0.2840     0.3091
            0.3352     0.3622     0.3901     0.4190     0.4487
            0.4793     0.5109     0.5434     0.5767     0.6110
            0.6462     0.6823     0.7194     0.7573     0.7961
            0.8359     0.8763     0.9171     0.9584     1.0000
Hrad:
            0.1322     0.2706     0.3943     0.5064     0.6094
            0.7050     0.7944     0.8788     0.9590     1.0356
            1.1091     1.1800     1.2485     1.3210     1.4092
            1.4583     1.4527     1.4120     1.3526     1.2861
            1.2195     1.1566     1.1062     1.0681     1.0387
            1.0157     0.9977     0.9835     0.9724     0.9637
            0.9570     0.9520     0.9483     0.9458     0.9443
            0.9436     0.9437     0.9444     0.9456     0.9473
            0.9495     0.9520     0.9548     0.9580     0.9614
            0.9651     0.9731     0.9817     0.9907     1.0000
Width:
            0.0607     0.0639     0.0671     0.0703     0.0735
            0.0767     0.0799     0.0831     0.0863     0.0895
            0.0927     0.0959     0.0990     0.1039     0.1246
            0.1692     0.2137     0.2582     0.3027     0.3472
            0.3917     0.4362     0.4603     0.4820     0.5038
            0.5256     0.5474     0.5691     0.5909     0.6127
            0.6344     0.6562     0.6780     0.6997     0.7215
            0.7433     0.7650     0.7868     0.8086     0.8303
            0.8521     0.8739     0.8956     0.9174     0.9392
            0.9609     0.9708     0.9805     0.9903     1.0000

Transect Section6
Area:
            0.0023     0.0047     0.0072     0.0099     0.0127
            0.0157     0.0188     0.0221     0.0255     0.0291
            0.0328     0.0387     0.0493     0.0618     0.0760
            0.0920     0.1097     0.1285     0.1479     0.1680
            0.1888     0.2102     0.2323     0.2551     0.2786
            0.3027     0.3276     0.3530     0.3792     0.4060
            0.4335     0.4614     0.4896     0.5179     0.5464
            0.5752     0.6041     0.6333     0.6627     0.6923
            0.7221     0.7522     0.7824     0.8128     0.8435
            0.8744     0.9055     0.9368     0.9683     1.0000
```

```
Hrad:
            0.1677     0.3004     0.4104     0.5047     0.5878
            0.6627     0.7312     0.7949     0.8546     0.9113
            0.9653     0.9750     0.8867     0.8151     0.7601
            0.7176     0.6850     0.6662     0.6567     0.6532
            0.6536     0.6568     0.6620     0.6685     0.6760
            0.6843     0.6931     0.7023     0.7118     0.7215
            0.7317     0.7449     0.7585     0.7725     0.7866
            0.8010     0.8154     0.8299     0.8444     0.8588
            0.8733     0.8877     0.9021     0.9163     0.9305
            0.9446     0.9586     0.9725     0.9863     1.0000
Width:
            0.0731     0.0776     0.0822     0.0867     0.0913
            0.0958     0.1004     0.1049     0.1095     0.1140
            0.1186     0.2711     0.3653     0.4201     0.4748
            0.5296     0.5788     0.5999     0.6211     0.6422
            0.6633     0.6845     0.7056     0.7267     0.7479
            0.7690     0.7901     0.8113     0.8324     0.8535
            0.8733     0.8800     0.8866     0.8933     0.9000
            0.9066     0.9133     0.9200     0.9266     0.9333
            0.9400     0.9467     0.9533     0.9600     0.9667
            0.9733     0.9800     0.9867     0.9933     1.0000


***********************************************************
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 ...... GREEN_AMPT
Flow Routing Method ...... DYNWAVE
Surcharge Method ......... EXTRAN
Starting Date ............ 08/22/2020 00:00:00
Ending Date .............. 08/25/2020 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:05:00
Wet Time Step ............ 00:05:00
Dry Time Step ............ 00:30:00
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 LID Storage ......         1.189         7.311
Total Precipitation ......        14.582        89.667
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         6.719        41.313
Surface Runoff ...........         4.490        27.606
Final Storage ............         4.604        28.309
Continuity Error (%) .....        -0.258


*************************        Volume        Volume
Flow Routing Continuity        hectare-m      10^6 ltr
*************************     ---------      ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         4.490        44.896
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         4.352        43.525
```

```
  Flooding Loss ............         0.000         0.000
  Evaporation Loss .........         0.000         0.000
  Exfiltration Loss ........         0.000         0.000
  Initial Stored Volume ....         2.472        24.721
  Final Stored Volume ......         2.609        26.090
  Continuity Error (%) .....         0.003


  ***************************
  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


  ***************************
  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
  ---------------------------------------------------------------------------------------------------------------------------
-----
  Com-MF                 89.67       0.00       0.00       5.57      73.42       0.00     64.98     16.91      9.99
0.725
  Ex-1                   89.67       0.00       0.00      85.55       3.25       4.10      4.10      1.55      0.44
0.046
  Ex-2                   89.67       0.00       0.00      81.70       7.02       7.96      7.96      0.46      0.19
0.089
  Ex-3                   89.67       0.00       0.00      81.80       1.75       8.06      8.06      1.09      0.53
0.090
  OS-1                   89.67       0.00       0.00      79.78       5.26       9.98      9.98      0.38      0.16
0.111
  OS-2                   89.67      21.75       0.00      81.98       9.85      29.68     29.68      0.52      0.19
0.266
  Pond-ER                89.67       0.00       0.00      45.01      36.78       8.75     44.42      1.73      0.99
0.495
  SF-1                   89.67       0.00       0.00      18.57      37.66       0.00     27.61      2.35      2.49
0.308
  SF-2                   89.67       3.86       0.00      14.47      52.84       0.00     35.52      4.74      4.45
0.380
  SF-3                   89.67       0.00       0.00      15.11      47.15       0.00     32.48     14.87     15.16
0.362
  Wetland-ER             89.67       0.00       0.00      40.60      44.02       8.17     48.67      1.20      0.57
0.543


  ***********************
  LID Performance Summary
  ***********************

  ---------------------------------------------------------------------------------------------------------------------------
                                     Total       Evap      Infil    Surface     Drain    Initial      Final  Continuity
                                    Inflow       Loss       Loss    Outflow   Outflow    Storage    Storage       Error
  Subcatchment      LID Control         mm         mm         mm         mm        mm         mm         mm           %
  ---------------------------------------------------------------------------------------------------------------------------
  Com-MF            SandyLoam       213.82       0.00      32.50      74.89      0.00      32.40     139.04       -0.09
  SF-1              SandyLoam       118.52       0.00      32.33      11.35      0.00      32.40     107.30       -0.04
```

SF-2	SandyLoam	146.42	0.00	32.37	18.01	0.00	32.40	128.58	-0.08
SF-3	SandyLoam	137.10	0.00	32.33	16.03	0.00	32.40	121.19	-0.04

****
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
J1	JUNCTION	0.00	0.28	1205.78	0 07:30	0.28
J2	JUNCTION	0.01	0.40	1202.90	0 07:35	0.40
J3	JUNCTION	0.42	1.02	1167.52	0 07:51	1.02
OF-1	JUNCTION	0.18	0.50	1192.50	0 07:39	0.50
OF-2	JUNCTION	0.17	0.56	1156.30	0 08:04	0.56
OF-3	OUTFALL	0.17	0.59	1154.06	0 08:05	0.59
OF-W	OUTFALL	0.02	0.09	1197.09	0 08:11	0.09
Dry-Pond	STORAGE	0.94	1.33	1171.33	0 18:45	1.33
Ex-Wetland	STORAGE	0.32	0.39	1197.89	0 08:11	0.39
Wet-Pond	STORAGE	4.14	4.82	1197.32	0 14:41	4.82

****
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
J1	JUNCTION	0.443	0.443	0 07:30	1.55	1.55	-0.023
J2	JUNCTION	0.000	0.443	0 07:30	0	1.55	-0.099
J3	JUNCTION	0.527	1.206	0 07:31	1.09	40.8	0.175
OF-1	JUNCTION	0.190	0.826	0 07:31	0.461	39.7	-0.046
OF-2	JUNCTION	0.000	0.996	0 07:59	0	42.4	0.038
OF-3	OUTFALL	0.000	0.971	0 08:05	0	42.4	0.000
OF-W	OUTFALL	0.000	0.041	0 08:11	0	1.15	0.000
Dry-Pond	STORAGE	2.494	2.494	0 07:15	2.35	2.35	0.003
Ex-Wetland	STORAGE	0.571	0.571	0 07:15	1.2	2.58	0.000
Wet-Pond	STORAGE	30.586	30.586	0 07:15	38.2	61.6	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
Dry-Pond	1.241	57	0	0	1.854	86	0 18:45	0.008
Ex-Wetland	1.536	11	0	0	2.029	14	0 08:11	0.041
Wet-Pond	35.161	55	0	0	48.604	75	0 14:41	0.235

****
Outfall Loading Summary
****

Outfall Node	Flow Freq Pcnt	Avg Flow CMS	Max Flow CMS	Total Volume 10^6 ltr
OF-3	96.91	0.169	0.971	42.377
OF-W	95.90	0.005	0.041	1.148
System	96.40	0.173	0.041	43.525

****
Link Flow Summary
****

Link	Type	Maximum |Flow| CMS	Time of Max Occurrence days hr:min	Maximum |Veloc| m/sec	Max/ Full Flow	Max/ Full Depth
1	CONDUIT	0.041	0 08:11	1.94	0.08	0.19
2	CONDUIT	0.443	0 07:30	3.26	0.45	0.57
3	CHANNEL	0.442	0 07:35	0.91	0.04	0.28
C2_1	CHANNEL	0.796	0 07:39	0.74	0.07	0.46
C2_2	CHANNEL	0.989	0 07:59	1.27	0.12	0.39
ExCulvert	CONDUIT	0.971	0 08:05	3.35	1.06	0.91
ICD-E	DUMMY	0.235	0 14:41			
ICD-W	DUMMY	0.008	0 18:45			

****
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
1	1.00	0.02	0.00	0.00	0.00	0.97	0.00	0.00	0.17	0.00
2	1.00	0.43	0.54	0.00	0.01	0.03	0.00	0.00	0.90	0.00
3	1.00	0.02	0.41	0.00	0.57	0.00	0.00	0.00	0.90	0.00
C2_1	1.00	0.02	0.00	0.00	0.98	0.00	0.00	0.00	0.96	0.00
C2_2	1.00	0.02	0.00	0.00	0.97	0.00	0.00	0.00	0.01	0.00
ExCulvert	1.00	0.02	0.00	0.00	0.00	0.98	0.00	0.00	0.02	0.00

****
Conduit Surcharge Summary
****

Conduit	Hours Full: Both Ends	Upstream	Dnstream	Hours Above Full Normal Flow	Hours Capacity Limited
ExCulvert	0.01	0.01	0.01	0.35	0.01

Analysis begun on: Tue Aug 25 10:57:20 2020
Analysis ended on: Tue Aug 25 10:57:20 2020
Total elapsed time: < 1 sec

Continuous Simulation

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

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

- Coordinates
- Vertices
- Polygons

```
[TITLE]
Ascension Post-Development
400 mm Sandy Loam
Continuous Simulation
Calgary 1960-2014


[OPTIONS]
;;Options            Value
;;------------------ ------------
FLOW_UNITS           CMS
INFILTRATION         GREEN_AMPT
FLOW_ROUTING         DYNWAVE
LINK_OFFSETS         DEPTH
MIN_SLOPE            0
ALLOW_PONDING        NO
SKIP_STEADY_STATE    NO
START_DATE           01/01/1960
START_TIME           01:00:00
REPORT_START_DATE    01/01/1960
REPORT_START_TIME    01:00:00
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             00:15:00
DRY_STEP             01:00:00
ROUTING_STEP         60
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              4

[EVAPORATION]
;;Type          Parameters
;;------------- ----------
MONTHLY      0.10   0.39   1.12   2.40   3.61   4.57   4.99   4.00   2.24   0.99   0.57   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 1200 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]
;;               Rain      Time   Snow   Data
;;Name           Type      Intrvl Catch  Source
;;-------------- --------- ------ ------ ----------
YYC-Pre60-14     INTENSITY 1:00   1.0    FILE       "D:\__LGN\PCSWMM\STA.3031093 2014.dat" STA.3031093 MM

[SUBCATCHMENTS]
;;                                                 Total    Pcnt.             Pcnt.    Curb     Snow
;;Name           Raingage         Outlet           Area     Imperv   Width    Slope    Length   Pack
;;-------------- ---------------- ---------------- -------- -------- -------- -------- -------- --------
;Commercial-MF
Com-MF           YYC-Pre60-14     Wet-Pond         26.0265  100      2082.12  2        0        Snowpack1
;Natural Drainage Course
Ex-1             YYC-Pre60-14     J1               37.7858  3.7      917.131  5        0        Snowpack1
;Natural Drainage Course
Ex-2             YYC-Pre60-14     OF-1             5.7895   8        578.95   3        0        Snowpack
;Natural Drainage Course
```

```
Ex-3             YYC-Pre60-14     J3               13.52    2        1352     8        0        Snowpack
;Offsite Areas
OS-1             YYC-Pre60-14     OS-2             3.7839   6        378.39   5        0        Snowpack1
;Offsite Areas
OS-2             YYC-Pre60-14     SF-2             1.7365   9        347.3    5        0        Snowpack1
;Pond Area
Pond-ER          YYC-Pre60-14     Wet-Pond         3.8906   41.7     972.65   2        0        Snowpack1
;Residential
SF-1             YYC-Pre60-14     Dry-Pond         8.4971   100      679.768  3        0        Snowpack1
;Residential
SF-2             YYC-Pre60-14     Wet-Pond         13.3461  100      1067.688 3        0        Snowpack1
;Residential
SF-3             YYC-Pre60-14     Wet-Pond         45.7774  100      3662.192 5        0        Snowpack1
;Wetland Area
Wetland-ER       YYC-Pre60-14     Ex-Wetland       2.4733   49.7     206.108  2        0        Snowpack1

[SUBAREAS]
;;Subcatchment   N-Imperv   N-Perv     S-Imperv   S-Perv     PctZero    RouteTo    PctRouted
;;-------------- ---------- ---------- ---------- ---------- ---------- ---------- ----------
Com-MF           0.015      0.25       1.6        3.2        0          PERVIOUS   29
Ex-1             0.014      0.3        2          7.5        0          PERVIOUS   100
Ex-2             0.014      0.3        2          7.5        0          PERVIOUS   100
Ex-3             0.014      0.3        2          7.5        0          PERVIOUS   100
OS-1             0.014      0.3        2          7.5        0          PERVIOUS   100
OS-2             0.014      0.3        2          7.5        0          PERVIOUS   100
Pond-ER          0.015      0.25       1.6        3.2        0          PERVIOUS   3
SF-1             0.015      0.25       1.6        3.2        0          PERVIOUS   44
SF-2             0.015      0.25       1.6        3.2        0          PERVIOUS   48
SF-3             0.015      0.25       1.6        3.2        0          PERVIOUS   47
Wetland-ER       0.015      0.25       1.6        3.2        0          PERVIOUS   8

[INFILTRATION]
;;Subcatchment   Suction    HydCon     IMDmax
;;-------------- ---------- ---------- ----------
Com-MF           110        14.15      0.246
Ex-1             110        14.15      0.246
Ex-2             110        14.15      0.246
Ex-3             110        14.15      0.246
OS-1             110        14.15      0.246
OS-2             110        14.15      0.246
Pond-ER          110        14.15      0.246
SF-1             110        14.15      0.246
SF-2             110        14.15      0.246
SF-3             110        14.15      0.246
Wetland-ER       110        14.15      0.246

[LID_CONTROLS]
;;               Type/Layer Parameters
;;-------------- ---------- ----------
SandyLoam        BC
SandyLoam        SURFACE    5          0.2        0.41       2          5
SandyLoam        SOIL       400        0.396      0.175      0.081      27.08      7          110
SandyLoam        STORAGE    0.0001     0.75       0.5        0
SandyLoam        DRAIN      0          0.5        6          6          0          0

[LID_USAGE]
;;Subcatchment   LID Process      Number  Area       Width      InitSatur  FromImprv  ToPerv     Report File
Drain to          FromPerv
;;-------------- ---------------- ------- ---------- ---------- ---------- ---------- ---------- --------------------------
- ---------------- ----------------
Com-MF           SandyLoam        1       44639      0          0          29         0          *
*                0
SF-1             SandyLoam        1       48806      0          0          44         0          *
*                0
SF-2             SandyLoam        1       59639      0          0          48         0          *
*                0
SF-3             SandyLoam        1       213860     0          0          47         0          *
*                0

[SNOWPACKS]
Snowpack         PLOWABLE   0.05       0.2        0.0        0.10       0.00       0.00       0.3
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       25
Snowpack         REMOVAL    25         0.0        0.0        0.5        0.0        0.0
Snowpack1        PLOWABLE   0.05       0.2        0.0        0.10       0.00       0.00       0.3
Snowpack1        IMPERVIOUS 0.05       0.2        0.0        0.10       0.00       0.00       25
Snowpack1        PERVIOUS   0.05       0.2        0.0        0.10       0.00       0.00       100
Snowpack1        REMOVAL    25         0.0        0.0        0.5        0.0        0.0
```

```
[JUNCTIONS]
;;               Invert     Max.       Init.      Surcharge  Ponded
;;Name           Elev.      Depth      Depth      Depth      Area
;;-------------- ---------- ---------- ---------- ---------- ----------
J1               1205.5     0          0          0          0
J2               1202.5     0          0          0          0
J3               1166.5     5.327      0          0          0
OF-1             1192       1.69       0          0          0
OF-2             1155.74    3          0          0          0

[OUTFALLS]
;;               Invert     Outfall      Stage/Table      Tide
;;Name           Elev.      Type         Time Series      Gate Route To
;;-------------- ---------- ------------ ---------------- ---- ----------------
OF-3             1153.47    FREE                          NO
OF-W             1197       FREE                          NO

[STORAGE]
;;               Invert   Max.     Init.    Storage    Curve                              Evap.
;;Name           Elev.    Depth    Depth    Curve      Params                             Frac.    Infiltration parameters
;;-------------- -------- -------- -------- ---------- -------- -------- -------- -------- -------- ------------------------
Dry-Pond         1170     1.5      0        TABULAR    Dry-Pond                  0        1
Ex-Wetland       1197.5   1.5      0.3      TABULAR    Wetland                   0        1
Wet-Pond         1192.5   5.5      3.5      TABULAR    Wet-Pond                  0        1

[CONDUITS]
;;               Inlet            Outlet                      Manning    Inlet      Outlet     Init.      Max.
;;Name           Node             Node             Length     N          Offset     Offset     Flow       Flow
;;-------------- ---------------- ---------------- ---------- ---------- ---------- ---------- ---------- ----------
;Culvert
1                Ex-Wetland       OF-W             18.6       0.015      0.3        0          0          0
;Culvert
2                J1               J2               67.687     0.017      0          0          0          0
;Natural Channel
3                J2               OF-1             291.26     0.01       0          0          0          0
;Natural Channel
C2_1             OF-1             J3               498.745    0.01       0          0          0          0
;Natural Channel
C2_2             J3               OF-2             305.17     0.01       0          0          0          0
;Culvert
ExCulvert        OF-2             OF-3             77.33      0.017      0          0          0          0

[OUTLETS]
;;               Inlet            Outlet           Outflow    Outlet           Qcoeff/                    Flap
;;Name           Node             Node             Height     Type             QTable           Qexpon    Gate
;;-------------- ---------------- ---------------- ---------- ---------------- ---------------- ---------- ----
ICD-E            Wet-Pond         OF-1             3.5        TABULAR/HEAD     R156.6                     NO
ICD-W            Dry-Pond         OF-2             0          TABULAR/HEAD     R28.8                      NO

[XSECTIONS]
;;Link           Shape        Geom1            Geom2      Geom3      Geom4      Barrels
;;-------------- ------------ ---------------- ---------- ---------- ---------- ----------
1                CIRCULAR     0.45             0          0          0          1
2                CIRCULAR     0.6              0          0          0          1
3                IRREGULAR    Section18        0          0          0          1
C2_1             IRREGULAR    Section18        0          0          0          1
C2_2             IRREGULAR    Section6         0          0          0          1
ExCulvert        CIRCULAR     0.63             0          0          0          1

[TRANSECTS]

NC 0.35     0.35     0.07
X1 Section18        8        72.899   74.312   0.0       0.0       0.0      0.0      0.0
GR 1189.24  65.507   1188.46  69.488   1188.22  72.899   1187.75  73.041   1187.74  73.839
GR 1188.19  74.312   1188.47  75.614   1189.37  79.324

NC 0.35     0.35     0.07
X1 Section6         8        83.111   83.945   0.0       0.0       0.0      0.0      0.0
GR 1177.03  80.013   1176.29  81.881   1176.24  83.111   1175.8   83.269   1175.8   83.745
GR 1176.26  83.945   1176.47  85.422   1177.79  86.958

[LOSSES]
;;Link           Inlet      Outlet     Average    Flap Gate  SeepageRate
;;-------------- ---------- ---------- ---------- ---------- ----------

[POLLUTANTS]
;;               Mass   Rain       GW         I&I        Decay      Snow  Co-Pollut.       Co-Pollut. DWF        Init.
;;Name           Units  Concen.    Concen.    Concen.    Coeff.     Only  Name             Fraction   Concen.    Concen.
;;-------------- ------ ---------- ---------- ---------- ---------- ----- ---------------- ---------- ---------- ----------
```

```
TSS010          MG/L   0          0          0          0          NO    *               0.0        0          0
TSS020          MG/L   0          0          0          0          NO    *               0.0        0          0
TSS050          MG/L   0          0          0          0          NO    *               0.0        0          0
TSS150          MG/L   0          0          0          0          NO    *               0.0        0          0
TSS500          MG/L   0          0          0          0          NO    *               0.0        0          0

[LANDUSES]
;;               Cleaning   Fraction   Last
;;Name           Interval   Available  Cleaned
;;-------------- ---------- ---------- ----------
Commercial       0          0          0
Park             0          0          0
Residential      0          0          0

[COVERAGES]
;;Subcatchment   Land Use         Percent
;;-------------- ---------------- ----------
Com-MF           Commercial       74
Com-MF           Residential      26
OS-1             Park             94
OS-1             Residential      6
OS-2             Park             91
OS-2             Residential      9
Pond-ER          Park             100
SF-2             Park             3.5
SF-2             Residential      96.5
SF-3             Park             13
SF-3             Residential      87

[LOADINGS]
;;Subcatchment   Pollutant        Loading
;;-------------- ---------------- ----------

[BUILDUP]
;;LandUse        Pollutant        Function   Coeff1     Coeff2     Coeff3     Normalizer
;;-------------- ---------------- ---------- ---------- ---------- ---------- ----------
Commercial       TSS010           POW        460        1.26       0.95       AREA
Commercial       TSS020           POW        180        0.493      0.95       AREA
Commercial       TSS050           POW        260        0.712      0.95       AREA
Commercial       TSS150           POW        460        1.26       0.95       AREA
Commercial       TSS500           POW        640        1.753      0.95       AREA
Park             TSS010           POW        4.8        0.0132     0.95       AREA
Park             TSS020           POW        2.4        0.00658    0.95       AREA
Park             TSS050           POW        39.6       0.1085     0.95       AREA
Park             TSS150           POW        60         0.1644     0.95       AREA
Park             TSS500           POW        13.2       0.0362     0.95       AREA
Residential      TSS010           POW        460        1.26       0.95       AREA
Residential      TSS020           POW        180        0.493      0.95       AREA
Residential      TSS050           POW        260        0.712      0.95       AREA
Residential      TSS150           POW        460        1.26       0.95       AREA
Residential      TSS500           POW        460        1.753      0.95       AREA

[WASHOFF]
;;                                                                 Cleaning   BMP
;;Land Use       Pollutant        Function   Coeff1     Coeff2     Effic.     Effic.
;;-------------- ---------------- ---------- ---------- ---------- ---------- ----------
Commercial       TSS010           EMC        41.4       1          0.0        0.0
Commercial       TSS020           EMC        16.2       1          0.0        0.0
Commercial       TSS050           EMC        23.4       1          0.0        0.0
Commercial       TSS150           EMC        41.4       1          0.0        0.0
Commercial       TSS500           EMC        57.6       1          0.0        0.0
Park             TSS010           EMC        8          1          0.0        0.0
Park             TSS020           EMC        4          1          0.0        0.0
Park             TSS050           EMC        66         1          0.0        0.0
Park             TSS150           EMC        100        1          0.0        0.0
Park             TSS500           EMC        22         1          0.0        0.0
Residential      TSS010           EMC        102        1          0.0        0.0
Residential      TSS020           EMC        40         1          0.0        0.0
Residential      TSS050           EMC        58         1          0.0        0.0
Residential      TSS150           EMC        102        1          0.0        0.0
Residential      TSS500           EMC        142        1          0.0        0.0

[TREATMENT]
;;Node           Pollutant        Function
;;-------------- ---------------- ----------
Wet-Pond         TSS010           C=TSS010*exp(-0.00000592*DT/DEPTH)
Wet-Pond         TSS020           C=TSS020*exp(-0.0000473*DT/DEPTH)
Wet-Pond         TSS050           C=TSS050*exp(-0.000283*DT/DEPTH)
Wet-Pond         TSS150           C=TSS150*exp(-0.00195*DT/DEPTH)
```

```
Wet-Pond         TSS500           C=TSS500*exp(-0.0124*DT/DEPTH)

[CURVES]
;;Name           Type       X-Value    Y-Value
;;-------------- ---------- ---------- ----------
R156.6           Rating     0          0
R156.6                      0.093      0.0626
R156.6                      0.343      0.12
R156.6                      0.593      0.1578
R156.6                      0.843      0.1881
R156.6                      1.093      0.2142
R156.6                      1.343      0.2374
R156.6                      1.593      0.2586
R156.6                      1.8434     0.2781
R156.6                      2.143      0.2999

R28.8            Rating     0          0
R28.8                       0.221      0.0033
R28.8                       0.471      0.0048
R28.8                       0.721      0.0059
R28.8                       0.971      0.0068
R28.8                       1.221      0.0077
R28.8                       1.4712     0.0084
R28.8                       1.771      0.0092

Dry-Pond         Storage    0          1052.764
Dry-Pond                    0.25       1174.707
Dry-Pond                    0.5        1301.147
Dry-Pond                    0.75       1432.084
Dry-Pond                    1          1567.517
Dry-Pond                    1.25       1707.447
Dry-Pond                    1.5        1868.381

Wetland          Storage    0          1018
Wetland                     0.25       7072
Wetland                     0.5        8482
Wetland                     0.75       9674
Wetland                     1          11306

Wet-Pond         Storage    0          1265.308
Wet-Pond                    0.25       1576.948
Wet-Pond                    0.5        1897.202
Wet-Pond                    0.75       2226.072
Wet-Pond                    1          3555.796
Wet-Pond                    1.25       5008.793
Wet-Pond                    1.5        5728.093
Wet-Pond                    1.75       6475.087
Wet-Pond                    2          7249.775
Wet-Pond                    2.25       8052.157
Wet-Pond                    2.5        8882.233
Wet-Pond                    2.75       9740.003
Wet-Pond                    3          11112.413
Wet-Pond                    3.25       13375.288
Wet-Pond                    3.5        15788.106
Wet-Pond                    3.75       17662.38
Wet-Pond                    4          18721.113
Wet-Pond                    4.25       19649.843
Wet-Pond                    4.5        20588.121
Wet-Pond                    4.75       21535.948
Wet-Pond                    5          22493.323
Wet-Pond                    5.25       23460.247
Wet-Pond                    5.5        24432.341

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

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

[ADJUSTMENTS]
;;Parameter    Subcatchment     Monthly Adjustments
;;------------ ---------------- ------------------------------
CONDUCTIVITY                  0.05   0.05   0.05   0.05   1.0    1.0    1.0    1.0    1.0    1.0    0.05   0.05
```

```
[TAGS]

[MAP]
DIMENSIONS       -19800.5545345242 5666764.72393014 -17906.5841223704 5668793.47605977
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 5.1.013)
--------------------------------------------------------------

Ascension Post-Development
400 mm Sandy Loam
Continuous Simulation


*************
Element Count
*************
Number of rain gages ...... 1
Number of subcatchments ... 11
Number of nodes ........... 10
Number of links ........... 8
Number of pollutants ...... 5
Number of land uses ....... 3


*****************
Pollutant Summary
*****************
                            Ppt.      GW         Kdecay
Name                 Units  Concen.   Concen.    1/days    CoPollutant
------------------------------------------------------------------------
TSS010                MG/L      0.00      0.00      0.00
TSS020                MG/L      0.00      0.00      0.00
TSS050                MG/L      0.00      0.00      0.00
TSS150                MG/L      0.00      0.00      0.00
TSS500                MG/L      0.00      0.00      0.00


***************
Landuse Summary
***************
                      Sweeping   Maximum      Last
Name                  Interval   Removal     Swept
-----------------------------------------------------
Commercial                0.00      0.00      0.00
Park                      0.00      0.00      0.00
Residential               0.00      0.00      0.00


****************
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
-----------------------------------------------------------------------------------------------
Com-MF                      26.03   2082.12    100.00    2.0000 YYC-Pre60-14         Wet-Pond
Ex-1                        37.79    917.13      3.70    5.0000 YYC-Pre60-14         J1
Ex-2                         5.79    578.95      8.00    3.0000 YYC-Pre60-14         OF-1
Ex-3                        13.52   1352.00      2.00    8.0000 YYC-Pre60-14         J3
OS-1                         3.78    378.39      6.00    5.0000 YYC-Pre60-14         OS-2
OS-2                         1.74    347.30      9.00    5.0000 YYC-Pre60-14         SF-2
Pond-ER                      3.89    972.65     41.70    2.0000 YYC-Pre60-14         Wet-Pond
SF-1                         8.50    679.77    100.00    3.0000 YYC-Pre60-14         Dry-Pond
SF-2                        13.35   1067.69    100.00    3.0000 YYC-Pre60-14         Wet-Pond
SF-3                        45.78   3662.19    100.00    5.0000 YYC-Pre60-14         Wet-Pond
Wetland-ER                   2.47    206.11     49.70    2.0000 YYC-Pre60-14         Ex-Wetland


********************
LID Control Summary
********************
                                 No. of        Unit        Unit      % Area    % Imperv      % Perv
Subcatchment     LID Control      Units        Area       Width     Covered     Treated     Treated
-----------------------------------------------------------------------------------------------------
Com-MF           SandyLoam            1    44639.00        0.00       17.15       29.00        0.00
SF-1             SandyLoam            1    48806.00        0.00       57.44       44.00        0.00
```

SF-2	SandyLoam	1	59639.00	0.00	44.69	48.00	0.00
SF-3	SandyLoam	1	213860.00	0.00	46.72	47.00	0.00

****
Node Summary
****

Name	Type	Invert Elev.	Max. Depth	Ponded Area	External Inflow
J1	JUNCTION	1205.50	0.60	0.0	
J2	JUNCTION	1202.50	1.63	0.0	
J3	JUNCTION	1166.50	5.33	0.0	
OF-1	JUNCTION	1192.00	1.69	0.0	
OF-2	JUNCTION	1155.74	3.00	0.0	
OF-3	OUTFALL	1153.47	0.63	0.0	
OF-W	OUTFALL	1197.00	0.45	0.0	
Dry-Pond	STORAGE	1170.00	1.50	0.0	
Ex-Wetland	STORAGE	1197.50	1.50	0.0	
Wet-Pond	STORAGE	1192.50	5.50	0.0	

****
Link Summary
****

Name	From Node	To Node	Type	Length	%Slope	Roughness
1	Ex-Wetland	OF-W	CONDUIT	18.6	4.3051	0.0150
2	J1	J2	CONDUIT	67.7	4.4365	0.0170
3	J2	OF-1	CONDUIT	291.3	3.6074	0.0700
C2_1	OF-1	J3	CONDUIT	498.7	5.1195	0.0700
C2_2	J3	OF-2	CONDUIT	305.2	3.5281	0.0700
ExCulvert	OF-2	OF-3	CONDUIT	77.3	2.9367	0.0170
ICD-E	Wet-Pond	OF-1	OUTLET			
ICD-W	Dry-Pond	OF-2	OUTLET			

****
Cross Section Summary
****

Conduit	Shape	Full Depth	Full Area	Hyd. Rad.	Max. Width	No. of Barrels	Full Flow
1	CIRCULAR	0.45	0.16	0.11	0.45	1	0.51
2	CIRCULAR	0.60	0.28	0.15	0.60	1	0.99
3	Section18	1.63	10.77	0.20	13.82	1	9.87
C2_1	Section18	1.63	10.77	0.20	13.82	1	11.76
C2_2	Section6	1.99	8.68	0.21	6.94	1	8.15
ExCulvert	CIRCULAR	0.63	0.31	0.16	0.63	1	0.92

****
Transect Summary
****

Transect Section18
Area:

0.0021	0.0047	0.0075	0.0103	0.0133
0.0165	0.0198	0.0232	0.0267	0.0304
0.0342	0.0381	0.0422	0.0464	0.0511
0.0572	0.0652	0.0751	0.0868	0.1004
0.1159	0.1332	0.1520	0.1717	0.1923
0.2139	0.2363	0.2597	0.2840	0.3091
0.3352	0.3622	0.3901	0.4190	0.4487
0.4793	0.5109	0.5434	0.5767	0.6110
0.6462	0.6823	0.7194	0.7573	0.7961
0.8359	0.8763	0.9171	0.9584	1.0000

Hrad:

0.1322	0.2706	0.3943	0.5064	0.6094
0.7050	0.7944	0.8788	0.9590	1.0356
1.1091	1.1800	1.2485	1.3210	1.4092
1.4583	1.4527	1.4120	1.3526	1.2861
1.2195	1.1566	1.1062	1.0681	1.0387
1.0157	0.9977	0.9835	0.9724	0.9637
0.9570	0.9520	0.9483	0.9458	0.9443
0.9436	0.9437	0.9444	0.9456	0.9473
0.9495	0.9520	0.9548	0.9580	0.9614
0.9651	0.9731	0.9817	0.9907	1.0000

```
Width:
            0.0607     0.0639     0.0671     0.0703     0.0735
            0.0767     0.0799     0.0831     0.0863     0.0895
            0.0927     0.0959     0.0990     0.1039     0.1246
            0.1692     0.2137     0.2582     0.3027     0.3472
            0.3917     0.4362     0.4603     0.4820     0.5038
            0.5256     0.5474     0.5691     0.5909     0.6127
            0.6344     0.6562     0.6780     0.6997     0.7215
            0.7433     0.7650     0.7868     0.8086     0.8303
            0.8521     0.8739     0.8956     0.9174     0.9392
            0.9609     0.9708     0.9805     0.9903     1.0000

Transect Section6
Area:
            0.0023     0.0047     0.0072     0.0099     0.0127
            0.0157     0.0188     0.0221     0.0255     0.0291
            0.0328     0.0387     0.0493     0.0618     0.0760
            0.0920     0.1097     0.1285     0.1479     0.1680
            0.1888     0.2102     0.2323     0.2551     0.2786
            0.3027     0.3276     0.3530     0.3792     0.4060
            0.4335     0.4614     0.4896     0.5179     0.5464
            0.5752     0.6041     0.6333     0.6627     0.6923
            0.7221     0.7522     0.7824     0.8128     0.8435
            0.8744     0.9055     0.9368     0.9683     1.0000
Hrad:
            0.1677     0.3004     0.4104     0.5047     0.5878
            0.6627     0.7312     0.7949     0.8546     0.9113
            0.9653     0.9750     0.8867     0.8151     0.7601
            0.7176     0.6850     0.6662     0.6567     0.6532
            0.6536     0.6568     0.6620     0.6685     0.6760
            0.6843     0.6931     0.7023     0.7118     0.7215
            0.7317     0.7449     0.7585     0.7725     0.7866
            0.8010     0.8154     0.8299     0.8444     0.8588
            0.8733     0.8877     0.9021     0.9163     0.9305
            0.9446     0.9586     0.9725     0.9863     1.0000
Width:
            0.0731     0.0776     0.0822     0.0867     0.0913
            0.0958     0.1004     0.1049     0.1095     0.1140
            0.1186     0.2711     0.3653     0.4201     0.4748
            0.5296     0.5788     0.5999     0.6211     0.6422
            0.6633     0.6845     0.7056     0.7267     0.7479
            0.7690     0.7901     0.8113     0.8324     0.8535
            0.8733     0.8800     0.8866     0.8933     0.9000
            0.9066     0.9133     0.9200     0.9266     0.9333
            0.9400     0.9467     0.9533     0.9600     0.9667
            0.9733     0.9800     0.9867     0.9933     1.0000


**********
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 .......... YES
Infiltration Method ...... GREEN_AMPT
Flow Routing Method ...... DYNWAVE
Surcharge Method ......... EXTRAN
Starting Date ............ 01/01/1960 01:00:00
```

```
Ending Date ..... 12/31/2014 23:00:00
Antecedent Dry Days ..... 0.0
Report Time Step ..... 01:00:00
Wet Time Step ..... 00:15:00
Dry Time Step ..... 01:00:00
Routing Time Step ..... 60.00 sec
Variable Time Step ..... YES
Maximum Trials ..... 8
Number of Threads ..... 1
Head Tolerance ..... 0.001500 m
```

Runoff Quantity Continuity	Volume hectare-m	Depth mm
Initial LID Storage	1.189	7.311
Initial Snow Cover	0.000	0.000
Total Precipitation	3724.704	22903.400
Evaporation Loss	1413.024	8688.759
Infiltration Loss	1764.635	10850.831
Surface Runoff	561.026	3449.780
Snow Removed	0.000	0.000
Final Snow Cover	0.423	2.600
Final Storage	2.600	15.987
Continuity Error (%)	-0.424	

Runoff Quality Continuity	TSS010 kg	TSS020 kg	TSS050 kg	TSS150 kg	TSS500 kg
Initial Buildup	0.000	0.000	0.000	0.000	0.000
Surface Buildup	652371.539	255960.271	387941.702	678489.383	900394.339
Wet Deposition	0.000	0.000	0.000	0.000	0.000
Sweeping Removal	0.000	0.000	0.000	0.000	0.000
Infiltration Loss	10.873	4.910	52.230	79.812	23.277
BMP Removal	362479.244	142211.097	212773.889	372638.929	505793.711
Surface Runoff	253448.921	99484.485	154272.963	268959.397	354617.903
Remaining Buildup	36419.900	14254.188	20789.277	36729.509	39933.742
Continuity Error (%)	0.002	0.002	0.014	0.012	0.003

Flow Routing Continuity	Volume hectare-m	Volume 10^6 ltr
Dry Weather Inflow	0.000	0.000
Wet Weather Inflow	559.857	5598.632
Groundwater Inflow	0.000	0.000
RDII Inflow	0.000	0.000
External Inflow	0.000	0.000
External Outflow	475.017	4750.218
Flooding Loss	0.000	0.000
Evaporation Loss	84.976	849.770
Exfiltration Loss	0.000	0.000
Initial Stored Volume	2.472	24.721
Final Stored Volume	2.385	23.852
Continuity Error (%)	-0.009	

Quality Routing Continuity	TSS010 kg	TSS020 kg	TSS050 kg	TSS150 kg	TSS500 kg
Dry Weather Inflow	0.000	0.000	0.000	0.000	0.000
Wet Weather Inflow	251859.549	98860.600	153311.981	267283.113	352395.202
Groundwater Inflow	0.000	0.000	0.000	0.000	0.000
RDII Inflow	0.000	0.000	0.000	0.000	0.000
External Inflow	0.000	0.000	0.000	0.000	0.000
External Outflow	52146.427	10190.968	4402.045	1068.372	200.458
Flooding Loss	0.000	0.000	0.000	0.000	0.000
Exfiltration Loss	0.000	0.000	0.000	0.000	0.000
Mass Reacted	197297.530	88643.681	149000.164	266231.935	352158.170
Initial Stored Mass	0.000	0.000	0.000	0.000	0.000
Final Stored Mass	7.528	0.011	0.000	0.000	0.000
Continuity Error (%)	0.956	0.026	-0.059	-0.006	0.010

```
**************************
Time-Step Critical Elements
**************************
Link ExCulvert (16.81%)
```

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


  ************************
  Routing Time Step Summary
  ************************
  Minimum Time Step           :     5.00 sec
  Average Time Step           :    55.27 sec
  Maximum Time Step           :    60.00 sec
  Percent in Steady State     :     0.00
  Average Iterations per Step :     2.00
  Percent Not Converging      :     0.00


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

  ---------------------------------------------------------------------------------------------------------------
                          Total      Total      Total      Total     Imperv      Perv     Total      Total     Peak    Runoff
                         Precip      Runon       Evap      Infil     Runoff     Runoff    Runoff     Runoff   Runoff     Coeff
  Subcatchment             mm         mm         mm         mm         mm         mm        mm  10^6 ltr      CMS
  ---------------------------------------------------------------------------------------------------------------
  Com-MF              22903.40       0.00   11531.38    2599.95   12252.46       0.00   8913.02    2319.76     3.32      0.389
  Ex-1                22903.40       0.00     377.89   22517.03     537.12      24.06     24.06       9.09     0.36      0.001
  Ex-2                22903.40       0.00     761.37   22126.07    1165.78      54.59     54.59       3.16     0.18      0.002
  Ex-3                22903.40       0.00     230.62   22645.10     295.41      41.18     41.18       5.57     0.46      0.002
  OS-1                22903.40       0.00     578.15   22314.38     878.54      43.00     43.00       1.63     0.13      0.002
  OS-2                22903.40      93.70     841.61   22068.06    1329.40     139.09    139.09       2.42     0.12      0.006
  Pond-ER             22903.40       0.00    3401.46   13462.39    6322.50      66.07   6198.89     241.18     0.39      0.271
  SF-1                22903.40       0.00   16688.61    2700.40    6385.10       0.00   3607.98     306.58     0.64      0.158
  SF-2                22903.40      18.10   15447.04    3205.48    8283.15       0.00   4385.35     585.28     1.27      0.191
  SF-3                22903.40       0.00   15643.12    3085.38    7996.98       0.00   4302.80    1969.72     4.11      0.188
  Wetland-ER          22903.40       0.00    4104.44   12041.58    7403.97      60.41   6872.06     169.97     0.24      0.300


  ***********************
  LID Performance Summary
  ***********************

  ---------------------------------------------------------------------------------------------------------------
                                      Total       Evap       Infil    Surface     Drain    Initial      Final  Continuity
                                     Inflow       Loss       Loss    Outflow   Outflow    Storage    Storage       Error
  Subcatchment      LID Control          mm         mm         mm         mm        mm         mm         mm           %
  ---------------------------------------------------------------------------------------------------------------
  Com-MF            SandyLoam      43620.21   27195.88   15158.83    1246.36      0.00      32.40      69.83       -0.04
  SF-1              SandyLoam      27794.63   23003.15    4701.39      56.27      0.00      32.40      69.83       -0.01
  SF-2              SandyLoam      31800.76   24420.64    7173.27     174.81      0.00      32.40      69.83       -0.02
  SF-3              SandyLoam      30948.76   24173.65    6604.36     137.87      0.00      32.40      69.83       -0.01

  ****************************
  Subcatchment Washoff Summary
  ****************************

  ---------------------------------------------------------------------------------------
                            TSS010        TSS020        TSS050        TSS150        TSS500
  Subcatchment                kg            kg            kg            kg            kg
  ---------------------------------------------------------------------------------------
  Com-MF                111959.511     43854.501     63458.492    111959.511    155814.012
```

Ex-1	0.000	0.000	0.000	0.000	0.000
Ex-2	0.000	0.000	0.000	0.000	0.000
Ex-3	0.000	0.000	0.000	0.000	0.000
OS-1	22.181	10.017	106.546	162.811	47.484
OS-2	49.666	21.963	205.284	314.721	100.439
Pond-ER	832.763	415.187	6846.401	10373.697	2284.124
SF-1	0.000	0.000	0.000	0.000	0.000
SF-2	35570.784	13954.260	20582.679	36104.177	49582.982
SF-3	105085.863	41260.538	63385.391	110522.013	146936.786
Wetland-ER	0.000	0.000	0.000	0.000	0.000
System	253520.768	99516.465	154584.793	269436.929	354765.827

****
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
J1	JUNCTION	0.00	0.25	1205.75	17322 19:00	0.25
J2	JUNCTION	0.00	0.34	1202.84	17322 19:02	0.33
J3	JUNCTION	0.03	0.88	1167.38	473 23:15	0.85
OF-1	JUNCTION	0.01	0.45	1192.45	17322 19:06	0.42
OF-2	JUNCTION	0.01	0.40	1156.14	473 23:18	0.39
OF-3	OUTFALL	0.01	0.39	1153.86	473 23:18	0.39
OF-W	OUTFALL	0.00	0.03	1197.03	17323 10:14	0.03
Dry-Pond	STORAGE	0.02	1.36	1171.36	17323 11:02	1.36
Ex-Wetland	STORAGE	0.13	0.33	1197.83	17323 10:14	0.33
Wet-Pond	STORAGE	3.50	4.97	1197.47	17322 21:24	4.96

****
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
J1	JUNCTION	0.360	0.360	17322 19:00	9.09	9.09	-0.021
J2	JUNCTION	0.000	0.360	17322 19:00	0	9.09	-0.737
J3	JUNCTION	0.457	1.018	17322 19:01	5.56	4.46e+03	0.011
OF-1	JUNCTION	0.182	0.725	17322 19:01	3.16	4.46e+03	-0.019
OF-2	JUNCTION	0.000	0.659	17322 19:15	0	4.75e+03	0.002
OF-3	OUTFALL	0.000	0.658	473 23:18	0	4.75e+03	0.000
OF-W	OUTFALL	0.000	0.005	17323 10:14	0	0.712	0.000
Dry-Pond	STORAGE	0.640	0.640	17322 19:00	306	306	-0.000
Ex-Wetland	STORAGE	0.239	0.239	17322 19:00	170	171	0.000
Wet-Pond	STORAGE	9.093	9.093	17322 19:00	5.11e+03	5.13e+03	-0.002

****
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

Dry-Pond	0.026	1	5	0	1.902	88	17323	11:02	0.008
Ex-Wetland	0.393	3	98	0	1.611	11	17323	10:14	0.006
Wet-Pond	23.328	36	13	0	51.933	81	17322	21:24	0.249

****
Outfall Loading Summary
****

Outfall Node	Flow Freq Pcnt	Avg Flow CMS	Max Flow CMS	Total Volume 10^6 ltr	Total TSS010 kg	Total TSS020 kg	Total TSS050 kg	Total TSS150 kg	Total TSS500 kg
OF-3	31.13	0.020	0.658	4749.483	52145.442	10190.861	4402.307	1068.628	200.524
OF-W	0.41	0.000	0.005	0.712	0.000	0.000	0.000	0.000	0.000
System	15.77	0.021	0.005	4750.196	52145.442	10190.861	4402.307	1068.628	200.524

****
Link Flow Summary
****

Link	Type	Maximum |Flow| CMS	Time of Max Occurrence days hr:min	Maximum |Veloc| m/sec	Max/ Full Flow	Max/ Full Depth
1	CONDUIT	0.005	17323 10:14	1.04	0.01	0.07
2	CONDUIT	0.360	17322 19:00	2.92	0.36	0.49
3	CHANNEL	0.336	17322 19:02	0.82	0.03	0.24
C2_1	CHANNEL	0.653	17322 19:06	0.84	0.06	0.40
C2_2	CHANNEL	0.652	473 23:15	1.25	0.08	0.32
ExCulvert	CONDUIT	0.658	473 23:18	3.20	0.72	0.63
ICD-E	DUMMY	0.248	17322 21:24			
ICD-W	DUMMY	0.008	17323 11:02			

****
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
1	1.00	0.99	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
2	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98	0.00
3	1.00	0.67	0.32	0.00	0.00	0.00	0.00	0.00	0.98	0.00
C2_1	1.00	0.63	0.04	0.00	0.33	0.00	0.00	0.00	0.99	0.00
C2_2	1.00	0.00	0.63	0.00	0.37	0.00	0.00	0.00	0.92	0.00
ExCulvert	1.00	0.00	0.00	0.00	0.63	0.37	0.00	0.00	0.02	0.00

****
Conduit Surcharge Summary
****

No conduits were surcharged.

****
Link Pollutant Load Summary
****

	TSS010	TSS020	TSS050	TSS150	TSS500

Link	kg	kg	kg	kg	kg
1	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000
C2_1	5.195e+04	1.017e+04	4466.554	1128.813	215.682
C2_2	5.213e+04	1.019e+04	4407.620	1073.751	201.845
ExCulvert	5.215e+04	1.019e+04	4402.307	1068.628	200.524
ICD-E	5.209e+04	1.018e+04	4395.770	1072.038	202.855
ICD-W	0.000	0.000	0.000	0.000	0.000

Analysis begun on: Wed Aug 26 09:39:40 2020
Analysis ended on: Wed Aug 26 09:42:37 2020
Total elapsed time: 00:02:57

APPENDIX D

Data and Frequency Analysis Spreadsheet

DFASCC

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

PROJECT INFORMATION SHEET

Project Name:	Ascension Development
Project Description:	Residential Development - Dry Pond
Location:	Rocky View County
Date:	2020-08-22
Designed by:	Luis Gerardo 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	327.1	0.101
2	1961	965.3	0.917
3	1962	387.6	0.156
4	1963	733.8	0.717
5	1964	722.4	0.681
6	1965	728	0.699
7	1966	831.8	0.808
8	1967	275.3	0.029
9	1968	635.5	0.536
10	1969	689.6	0.663
11	1970	1086	0.935
12	1971	445.1	0.283
13	1972	794.3	0.736
14	1973	338.5	0.120
15	1974	878	0.862
16	1975	232.5	0.011
17	1976	544	0.446
18	1977	418.1	0.228
19	1978	844.7	0.826
20	1979	407.6	0.192
21	1980	683.3	0.645
22	1981	650	0.572
23	1982	325.8	0.083
24	1983	583.1	0.464
25	1984	617.6	0.500
26	1985	1453	0.971
27	1986	799.9	0.754
28	1987	456.4	0.301
29	1988	959	0.880
30	1989	291.9	0.047
31	1990	465.5	0.337
32	1991	458	0.319
33	1992	814.7	0.790
34	1993	663.1	0.591
35	1994	402.6	0.174
36	1995	375.1	0.138
37	1996	443	0.264
38	1997	964.9	0.899
39	1998	869.5	0.844
40	1999	676.2	0.627
41	2000	484.9	0.355
42	2001	530.8	0.428
43	2002	292.9	0.065
44	2003	504.4	0.409
45	2004	642.5	0.554
46	2005	1089	0.953
47	2006	489.9	0.373
48	2007	1901	0.989
49	2008	426.9	0.246
50	2009	414.8	0.210
51	2010	608	0.482
52	2011	632.2	0.518
53	2012	669.4	0.609
54	2013	813.9	0.772
55	2014	490.7	0.391

Clear All Input Data

Basic Characteristics	
Number of Data Entries	55
Maximum Value	1900
Minimum Value	233
Average (Mean) Value	641
Median Value	618
Standard Deviation	298
Variance	88900
Variation coefficient (Cv)	0.465
Skewness coefficient (Cs)	1.78
Kurtosis	7.41

*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:	-0.006

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

When there are no ties in rankings:

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

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

Spearman Correlation Coefficient:	-0.006
t-distribution value	-0.042
Degrees of freedom	53

T (Adjustment for ties) =	0
Standard Normal (z)=	-0.042

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)

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

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=	625
Total of Ranking in sample 2 R_2=	
U_1=	372

No Jump at 0.05 Significance Level

$$U_1 + U_2 = n_1 n_2.$$

U_2=	354
U (Minimum of U_1 and U_2)=	354
Standard Normal (z)=	-0.155

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 =	29

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

Mean =	28.0
Variance =	13.2

No Jump at 0.05 Significance Level

Standard Normal (z)=	0.1

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=	797
Total of Ranking in sample 1 R_2=	
U_1=	391

$$U_1 + U_2 = n_1 n_2.$$

U_2=	365
U (Minimum of U_1 and U_2)=	365
Standard Normal (z)=	-0.219

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 =	0.335
z =	0.092

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:	-0.22

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:	-0.22
t-distribution value	-1.68
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	21700000
Mean	22500000
Variance	3.65E+11

H_0= Data is independent

Data is independent at 0.05 Significance Level

Standard Normal (z)=	-1.2

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	-0.171
Mean	-0.019
Variance	0.018

H_0= Data is independent

Data is independent at 0.05 Significance Level

Standard Normal (z)=	-1.1

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=	1930	< Any value higher than X_h is considered a high outlier
Maximum Value	1900	
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=	177	< Any value lower than X_h is considered a low outlier
Minimum Value	233	
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) =	-0.184
t-distribution values for one time period offset	t =	-1.360

No Serial Correlation at 0.05 Significance Level

Two Time Periods Offset		
Autocorrelation coefficient offset by two time periods	r(2) =	0.104
t-distribution values for two time periods offset	t =	0.764

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)

Ascension Dry Pond

Results of the fitting

Normal (Maximum Likelihood)

Number of observations 55

Parameters

mu	640.529091
sigma	298.097063

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

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	1.75E+03	1.14E+02	1.53E+03	1.97E+03	
2000	0.9995	1.62E+03	1.03E+02	1.42E+03	1.82E+03	
1000	0.999	1.56E+03	9.73E+01	1.37E+03	1.75E+03	
200	0.995	1.41E+03	8.41E+01	1.24E+03	1.57E+03	
100	0.99	1.33E+03	7.79E+01	1.18E+03	1.49E+03	
50	0.98	1.25E+03	7.13E+01	1.11E+03	1.39E+03	
20	0.95	1.13E+03	62	1.01E+03	1.25E+03	
10	0.9	1.02E+03	54.5	9.16E+02	1.13E+03	
5	0.8	8.91E+02	46.9	7.99E+02	9.83E+02	
3	0.6667	7.69E+02	42	6.86E+02	8.51E+02	
2	0.5	6.41E+02	40.2	5.62E+02	7.19E+02	
1.4286	0.3	4.84E+02	42.9	4.00E+02	5.68E+02	
1.25	0.2	3.90E+02	46.9	2.98E+02	4.82E+02	
1.1111	0.1	2.58E+02	54.5	1.52E+02	3.65E+02	
1.0526	0.05	1.50E+02	62	2.86E+01	2.72E+02	
1.0204	0.02	2.82E+01	7.13E+01	-1.12E+02	1.68E+02	
1.0101	0.01	-5.31E+01	7.79E+01	-2.06E+02	9.97E+01	
1.005	0.005	-1.27E+02	8.41E+01	-2.92E+02	3.75E+01	
1.001	0.001	-2.81E+02	9.73E+01	-4.72E+02	-8.99E+01	
1.0005	0.0005	-3.40E+02	1.03E+02	-5.42E+02	-1.39E+02	
1.0001	0.0001	-4.68E+02	1.14E+02	-6.92E+02	-2.45E+02	

Lognormal Distribution:

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

Ascension Dry Pond

Results of the fitting

Lognormal (Maximum Likelihood)

Number of observations 55

Parameters

mu	6.370902
sigma	0.425956

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

T = 1/(1-q)

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	2.85E+03	4.64E+02	1.94E+03	3.76E+03	
2000	0.9995	2.37E+03	3.48E+02	1.69E+03	3.06E+03	
1000	0.999	2.18E+03	3.03E+02	1.59E+03	2.78E+03	
200	0.995	1.75E+03	2.11E+02	1.34E+03	2.16E+03	
100	0.99	1.57E+03	1.75E+02	1.23E+03	1.92E+03	
50	0.98	1.40E+03	1.43E+02	1.12E+03	1.68E+03	
20	0.95	1.18E+03	1.04E+02	9.74E+02	1.38E+03	
10	0.9	1.01E+03	7.86E+01	8.55E+02	1.16E+03	
5	0.8	8.37E+02	5.60E+01	7.27E+02	9.46E+02	
3	0.6667	7.02E+02	42.2	6.19E+02	7.85E+02	
2	0.5	5.85E+02	33.6	5.19E+02	6.50E+02	
1.4286	0.3	4.68E+02	28.7	4.11E+02	5.24E+02	
1.25	0.2	4.08E+02	27.4	3.55E+02	4.62E+02	
1.1111	0.1	3.39E+02	26.4	2.87E+02	3.90E+02	
1.0526	0.05	2.90E+02	25.7	2.40E+02	3.40E+02	
1.0204	0.02	2.44E+02	24.8	1.95E+02	2.92E+02	
1.0101	0.01	2.17E+02	24.2	1.70E+02	2.64E+02	
1.005	0.005	1.95E+02	23.5	1.49E+02	2.41E+02	
1.001	0.001	1.57E+02	21.8	1.14E+02	1.99E+02	
1.0005	0.0005	1.44E+02	21.1	1.03E+02	1.85E+02	
1.0001	0.0001	1.20E+02	19.5	8.16E+01	1.58E+02	

Lognormal III Distribution

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

Ascension Dry Pond

Results of the fitting

3-parameter lognormal (Maximum Likelihood)

Number of observations 55

Parameters

m	84.246179
mu	6.196658
sigma	0.500457

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

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	3.24E+03	8.88E+02	1.50E+03	4.98E+03	
2000	0.9995	2.63E+03	6.14E+02	1.43E+03	3.84E+03	
1000	0.999	2.39E+03	5.14E+02	1.38E+03	3.40E+03	
200	0.995	1.87E+03	3.18E+02	1.24E+03	2.49E+03	
100	0.99	1.66E+03	2.50E+02	1.17E+03	2.15E+03	
50	0.98	1.46E+03	1.91E+02	1.08E+03	1.83E+03	
20	0.95	1.20E+03	1.26E+02	9.57E+02	1.45E+03	
10	0.9	1.02E+03	8.74E+01	8.46E+02	1.19E+03	
5	0.8	8.33E+02	58.8	7.17E+02	9.48E+02	
3	0.6667	6.93E+02	44	6.07E+02	7.80E+02	
2	0.5	5.75E+02	35.3	5.06E+02	6.44E+02	
1.4286	0.3	4.62E+02	28.7	4.06E+02	5.18E+02	
1.25	0.2	4.07E+02	25.8	3.56E+02	4.57E+02	
1.1111	0.1	3.43E+02	23.6	2.97E+02	3.89E+02	
1.0526	0.05	3.00E+02	23.8	2.53E+02	3.47E+02	
1.0204	0.02	2.60E+02	26.3	2.08E+02	3.12E+02	
1.0101	0.01	2.38E+02	29	1.81E+02	2.94E+02	
1.005	0.005	2.20E+02	31.9	1.57E+02	2.82E+02	
1.001	0.001	1.89E+02	3.86E+01	1.13E+02	2.65E+02	
1.0005	0.0005	1.79E+02	4.13E+01	9.79E+01	2.60E+02	
1.0001	0.0001	1.61E+02	4.69E+01	6.86E+01	2.53E+02	

Exponential and Pearson type of distributions:

Exponential Distribution

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

Ascension Dry Pond

Results of the fitting

Exponential (Maximum Likelihood)

Number of observations 55

Parameters

alpha	415.585185
m	224.943906

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

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	4.05E+03	5.20E+02	3.03E+03	5.07E+03	
2000	0.9995	3.38E+03	4.29E+02	2.54E+03	4.22E+03	
1000	0.999	3.10E+03	3.90E+02	2.33E+03	3.86E+03	
200	0.995	2.43E+03	2.99E+02	1.84E+03	3.01E+03	
100	0.99	2.14E+03	2.60E+02	1.63E+03	2.65E+03	
50	0.98	1.85E+03	2.20E+02	1.42E+03	2.28E+03	
20	0.95	1.47E+03	1.69E+02	1.14E+03	1.80E+03	
10	0.9	1.18E+03	1.29E+02	9.28E+02	1.44E+03	
5	0.8	8.94E+02	9.03E+01	7.17E+02	1.07E+03	
3	0.6667	6.82E+02	6.16E+01	5.61E+02	8.02E+02	
2	0.5	5.13E+02	38.9	4.37E+02	5.89E+02	
1.4286	0.3	3.73E+02	20.6	3.33E+02	4.14E+02	
1.25	0.2	3.18E+02	13.8	2.91E+02	3.45E+02	
1.1111	0.1	2.69E+02	9.02	2.51E+02	2.86E+02	
1.0526	0.05	2.46E+02	7.78	2.31E+02	2.62E+02	
1.0204	0.02	2.33E+02	7.56	2.19E+02	2.48E+02	
1.0101	0.01	2.29E+02	7.57	2.14E+02	2.44E+02	
1.005	0.005	2.27E+02	7.59	2.12E+02	2.42E+02	
1.001	0.001	2.25E+02	7.62	2.10E+02	2.40E+02	
1.0005	0.0005	2.25E+02	7.62	2.10E+02	2.40E+02	
1.0001	0.0001	2.25E+02	7.62	2.10E+02	2.40E+02	

Pearson Type III Distribution

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

Ascension Dry Pond

Results of the fitting

Pearson type III (Maximum Likelihood)

Number of observations 55

Parameters

alpha	0.005243
lambda	2.289413
m	203.839899

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

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	2.57E+03	3.42E+02	1.90E+03	3.24E+03	
2000	0.9995	2.23E+03	2.79E+02	1.68E+03	2.78E+03	
1000	0.999	2.08E+03	2.52E+02	1.58E+03	2.57E+03	
200	0.995	1.73E+03	1.90E+02	1.35E+03	2.10E+03	
100	0.99	1.57E+03	1.64E+02	1.25E+03	1.89E+03	
50	0.98	1.41E+03	1.38E+02	1.14E+03	1.68E+03	
20	0.95	1.20E+03	1.05E+02	9.91E+02	1.40E+03	
10	0.9	1.03E+03	8.12E+01	8.68E+02	1.19E+03	
5	0.8	8.47E+02	59	7.32E+02	9.63E+02	
3	0.6667	7.09E+02	45.1	6.20E+02	7.97E+02	
2	0.5	5.79E+02	35.4	5.09E+02	6.48E+02	
1.4286	0.3	4.57E+02	29.2	4.00E+02	5.14E+02	
1.25	0.2	3.99E+02	26.4	3.47E+02	4.51E+02	
1.1111	0.1	3.35E+02	22.8	2.91E+02	3.80E+02	
1.0526	0.05	2.96E+02	19.8	2.57E+02	3.35E+02	
1.0204	0.02	2.62E+02	1.69E+01	2.29E+02	2.95E+02	
1.0101	0.01	2.45E+02	1.55E+01	2.15E+02	2.76E+02	
1.005	0.005	2.33E+02	1.47E+01	2.04E+02	2.62E+02	
1.001	0.001	2.15E+02	1.45E+01	1.87E+02	2.43E+02	
1.0005	0.0005	2.10E+02	1.48E+01	1.81E+02	2.39E+02	
1.0001	0.0001	2.03E+02	1.60E+01	1.72E+02	2.34E+02	

Log-Pearson Type III Distribution

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

Ascension Dry Pond

Results of the fitting

Log-Pearson type III (Méthode SAM)

Number of observations 55

Parameters

alpha	58.673097
lambda	115.567164
m	0.797169

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

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	3.33E+03	1.30E+03	N/D	N/D	
2000	0.9995	2.67E+03	8.30E+02	N/D	N/D	
1000	0.999	2.41E+03	6.68E+02	N/D	N/D	
200	0.995	1.87E+03	3.77E+02	1.13E+03	2.60E+03	
100	0.99	1.65E+03	2.83E+02	1.10E+03	2.21E+03	
50	0.98	1.45E+03	2.06E+02	1.05E+03	1.85E+03	
20	0.95	1.20E+03	1.28E+02	9.45E+02	1.45E+03	
10	0.9	1.01E+03	8.61E+01	8.43E+02	1.18E+03	
5	0.8	8.30E+02	5.79E+01	7.17E+02	9.44E+02	
3	0.6667	6.96E+02	44.1	6.09E+02	7.82E+02	
2	0.5	5.77E+02	35.4	5.08E+02	6.47E+02	
1.4286	0.3	4.64E+02	28.5	4.09E+02	5.20E+02	
1.25	0.2	4.09E+02	25.9	3.58E+02	4.59E+02	
1.1111	0.1	3.44E+02	24.5	2.95E+02	3.92E+02	
1.0526	0.05	2.99E+02	25.4	2.49E+02	3.49E+02	
1.0204	0.02	2.56E+02	28.4	2.01E+02	3.12E+02	
1.0101	0.01	2.32E+02	31.1	1.71E+02	2.93E+02	
1.005	0.005	2.12E+02	34	1.45E+02	2.79E+02	
1.001	0.001	1.77E+02	40.2	9.86E+01	2.56E+02	
1.0005	0.0005	1.66E+02	42.5	8.24E+01	2.49E+02	
1.0001	0.0001	1.44E+02	47	5.18E+01	2.36E+02	

Extreme Value type of distributions:

EVI (Gumbel) Distribution

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

Ascension Dry Pond

Results of the fitting

Gumbel (Maximum Likelihood)

Number of observations 55

Parameters

u	513.67314
alpha	210.430426

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

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	2.45E+03	2.18E+02	2.02E+03	2.88E+03	
2000	0.9995	2.11E+03	1.82E+02	1.76E+03	2.47E+03	
1000	0.999	1.97E+03	1.67E+02	1.64E+03	2.29E+03	
200	0.995	1.63E+03	1.31E+02	1.37E+03	1.89E+03	
100	0.99	1.48E+03	1.16E+02	1.25E+03	1.71E+03	
50	0.98	1.33E+03	1.01E+02	1.14E+03	1.53E+03	
20	0.95	1.14E+03	8.09E+01	9.80E+02	1.30E+03	
10	0.9	9.87E+02	6.60E+01	8.58E+02	1.12E+03	
5	0.8	8.29E+02	51.3	7.29E+02	9.30E+02	
3	0.6667	7.04E+02	40.8	6.24E+02	7.84E+02	
2	0.5	5.91E+02	33.2	5.26E+02	6.56E+02	
1.4286	0.3	4.75E+02	28.8	4.18E+02	5.31E+02	
1.25	0.2	4.14E+02	28.4	3.58E+02	4.69E+02	
1.1111	0.1	3.38E+02	30	2.79E+02	3.97E+02	
1.0526	0.05	2.83E+02	32.4	2.19E+02	3.46E+02	
1.0204	0.02	2.27E+02	35.6	1.57E+02	2.96E+02	
1.0101	0.01	1.92E+02	38	1.18E+02	2.67E+02	
1.005	0.005	1.63E+02	40.1	8.42E+01	2.41E+02	
1.001	0.001	1.07E+02	44.5	1.97E+01	1.94E+02	
1.0005	0.0005	8.69E+01	46.2	-3.71E+00	1.77E+02	
1.0001	0.0001	4.64E+01	49.7	-5.09E+01	1.44E+02	

GEV (General Extreme Value) Distribution

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

Ascension Dry Pond

Results of the fitting

GEV (Maximum Likelihood)

Number of observations 55

Parameters

alpha	197.319684
k	-0.113518
u	502.419714

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

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	3.71E+03	1.74E+03	N/D	N/D	
2000	0.9995	2.88E+03	1.04E+03	N/D	N/D	
1000	0.999	2.57E+03	8.16E+02	N/D	N/D	
200	0.995	1.94E+03	4.30E+02	1.09E+03	2.78E+03	
100	0.99	1.69E+03	3.13E+02	1.08E+03	2.31E+03	
50	0.98	1.47E+03	2.21E+02	1.04E+03	1.90E+03	
20	0.95	1.20E+03	1.32E+02	9.41E+02	1.46E+03	
10	0.9	1.01E+03	86.5	8.39E+02	1.18E+03	
5	0.8	8.25E+02	57.1	7.13E+02	9.37E+02	
3	0.6667	6.90E+02	43	6.06E+02	7.74E+02	
2	0.5	5.76E+02	34.5	5.09E+02	6.44E+02	
1.4286	0.3	4.66E+02	28	4.11E+02	5.21E+02	
1.25	0.2	4.11E+02	25.9	3.60E+02	4.62E+02	
1.1111	0.1	3.45E+02	25.4	2.96E+02	3.95E+02	
1.0526	0.05	2.99E+02	27.3	2.45E+02	3.52E+02	
1.0204	0.02	2.53E+02	31.3	1.92E+02	3.15E+02	
1.0101	0.01	2.26E+02	34.8	1.58E+02	2.94E+02	
1.005	0.005	2.03E+02	3.82E+01	1.28E+02	2.78E+02	
1.001	0.001	1.60E+02	4.58E+01	7.02E+01	2.50E+02	
1.0005	0.0005	1.45E+02	4.89E+01	4.91E+01	2.41E+02	
1.0001	0.0001	1.15E+02	5.55E+01	6.43E+00	2.24E+02	

EVIII (Weibull) Distribution

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

Ascension Dry Pond

Results of the fitting

Weibull (Maximum Likelihood)

Number of observations 55

Parameters

alpha	724.294844
c	2.266107

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

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	1.93E+03	1.98E+02	1.54E+03	2.32E+03	
2000	0.9995	1.77E+03	1.69E+02	1.44E+03	2.10E+03	
1000	0.999	1.70E+03	1.56E+02	1.39E+03	2.01E+03	
200	0.995	1.51E+03	1.25E+02	1.27E+03	1.76E+03	
100	0.99	1.42E+03	1.12E+02	1.20E+03	1.64E+03	
50	0.98	1.32E+03	9.76E+01	1.13E+03	1.51E+03	
20	0.95	1.18E+03	7.90E+01	1.02E+03	1.33E+03	
10	0.9	1.05E+03	6.54E+01	9.18E+02	1.17E+03	
5	0.8	8.94E+02	53.2	7.89E+02	9.98E+02	
3	0.6667	7.55E+02	46.4	6.64E+02	8.46E+02	
2	0.5	6.16E+02	43	5.32E+02	7.01E+02	
1.4286	0.3	4.60E+02	41.3	3.79E+02	5.41E+02	
1.25	0.2	3.74E+02	40.1	2.95E+02	4.52E+02	
1.1111	0.1	2.68E+02	36.9	1.96E+02	3.41E+02	
1.0526	0.05	1.95E+02	32.9	1.31E+02	2.60E+02	
1.0204	0.02	1.29E+02	27.1	7.63E+01	1.83E+02	
1.0101	0.01	9.51E+01	22.9	5.03E+01	1.40E+02	
1.005	0.005	7.00E+01	19	3.27E+01	1.07E+02	
1.001	0.001	3.44E+01	11.9	1.11E+01	5.76E+01	
1.0005	0.0005	2.53E+01	9.54	6.61E+00	4.40E+01	
1.0001	0.0001	1.24E+01	5.61	1.44E+00	2.34E+01	

Gamma type of distributions:

Gamma Distribution

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

Ascension Dry Pond

Results of the fitting

Gamma (Maximum Likelihood)

Number of observations 55

Parameters

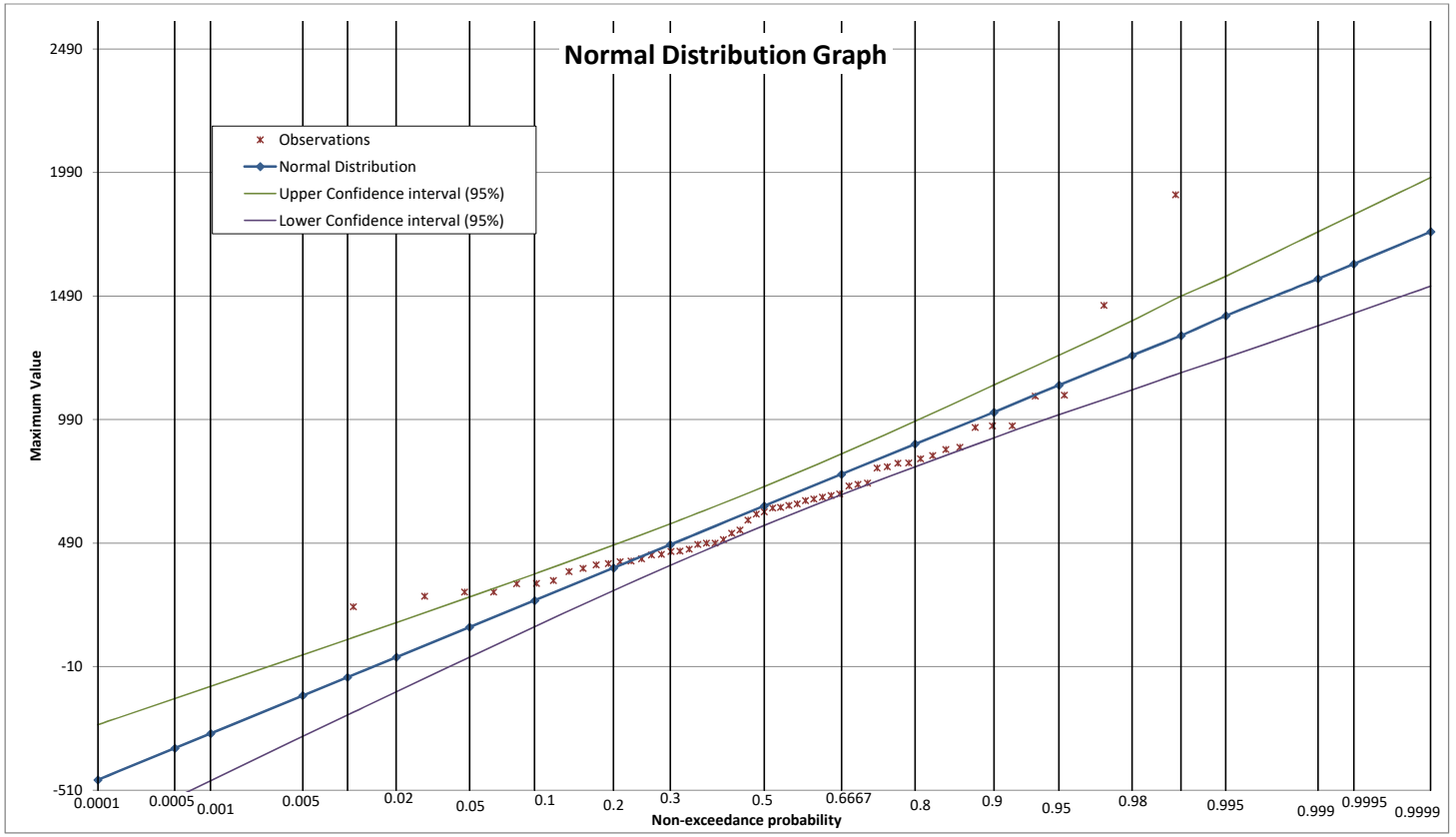
alpha	0.008794
lambda	5.632764

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

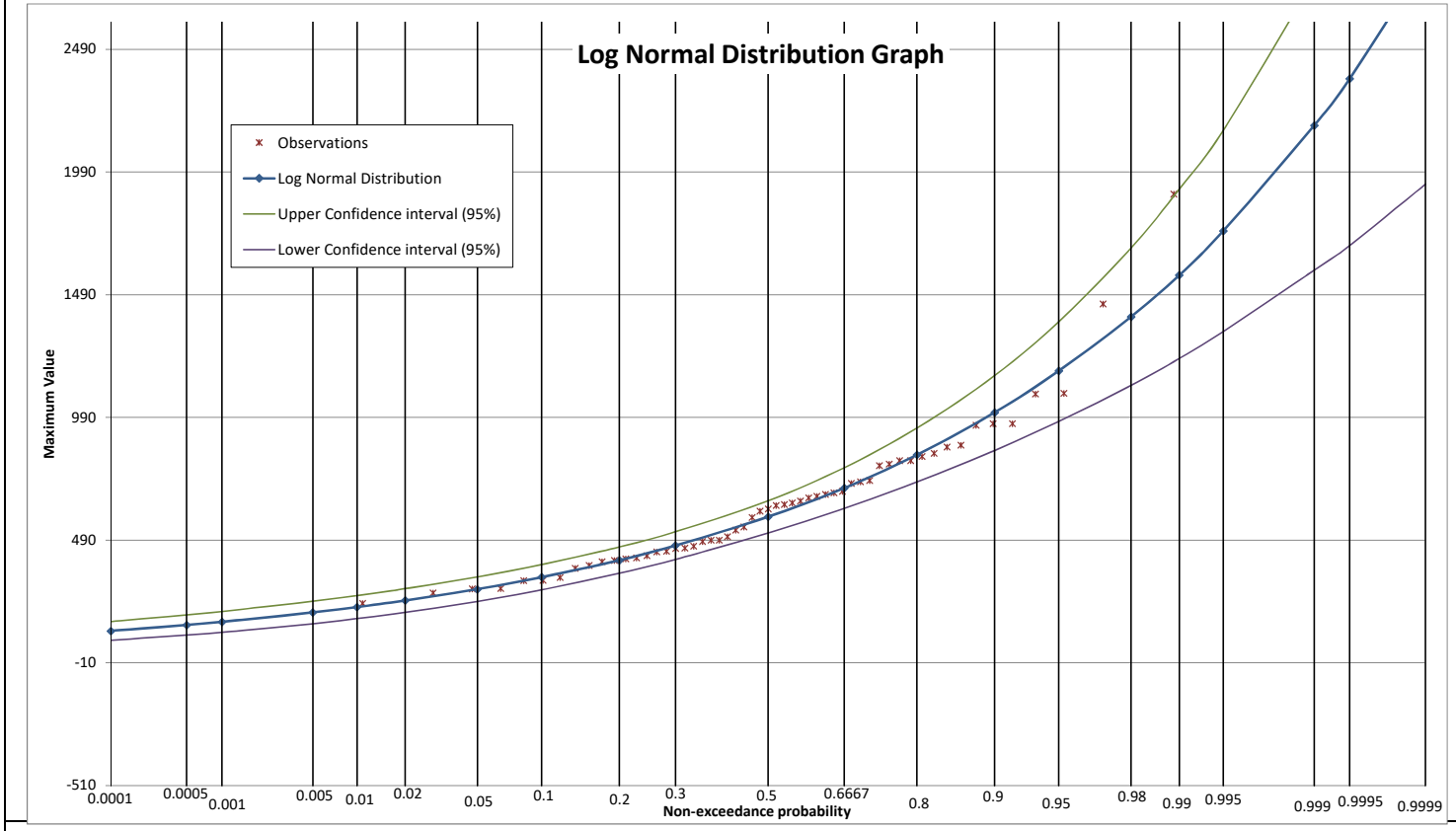
T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	2.15E+03	2.24E+02	1.71E+03	2.59E+03	
2000	0.9995	1.91E+03	1.88E+02	1.54E+03	2.28E+03	
1000	0.999	1.80E+03	1.72E+02	1.47E+03	2.14E+03	
200	0.995	1.54E+03	1.35E+02	1.28E+03	1.81E+03	
100	0.99	1.43E+03	1.19E+02	1.20E+03	1.66E+03	
50	0.98	1.31E+03	1.03E+02	1.11E+03	1.51E+03	
20	0.95	1.14E+03	8.20E+01	9.78E+02	1.30E+03	
10	0.9	1.00E+03	6.63E+01	8.72E+02	1.13E+03	
5	0.8	8.50E+02	51.2	7.49E+02	9.50E+02	
3	0.6667	7.26E+02	41.5	6.44E+02	8.07E+02	
2	0.5	6.03E+02	35	5.35E+02	6.72E+02	
1.4286	0.3	4.77E+02	31.9	4.14E+02	5.39E+02	
1.25	0.2	4.10E+02	31.4	3.48E+02	4.71E+02	
1.1111	0.1	3.28E+02	31.1	2.67E+02	3.89E+02	
1.0526	0.05	2.70E+02	30.8	2.09E+02	3.30E+02	
1.0204	0.02	2.14E+02	29.9	1.55E+02	2.73E+02	
1.0101	0.01	1.82E+02	29	1.25E+02	2.39E+02	
1.005	0.005	1.56E+02	28.1	1.01E+02	2.11E+02	
1.001	0.001	1.11E+02	25.6	6.09E+01	1.61E+02	
1.0005	0.0005	9.65E+01	24.6	4.84E+01	1.45E+02	
1.0001	0.0001	6.98E+01	22.1	2.66E+01	1.13E+02	

Visual Goodness of Fit

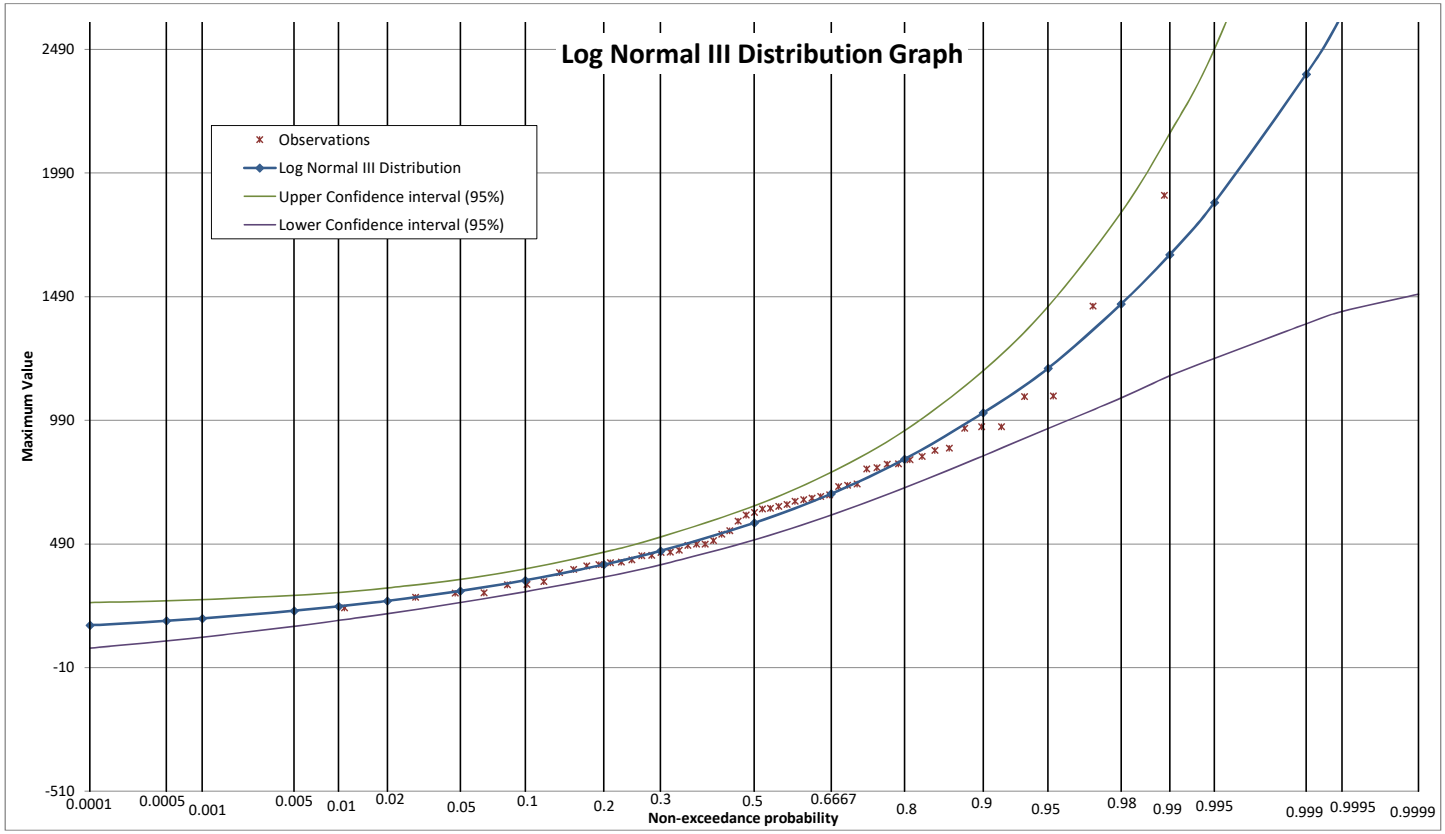
Clear All Note Data



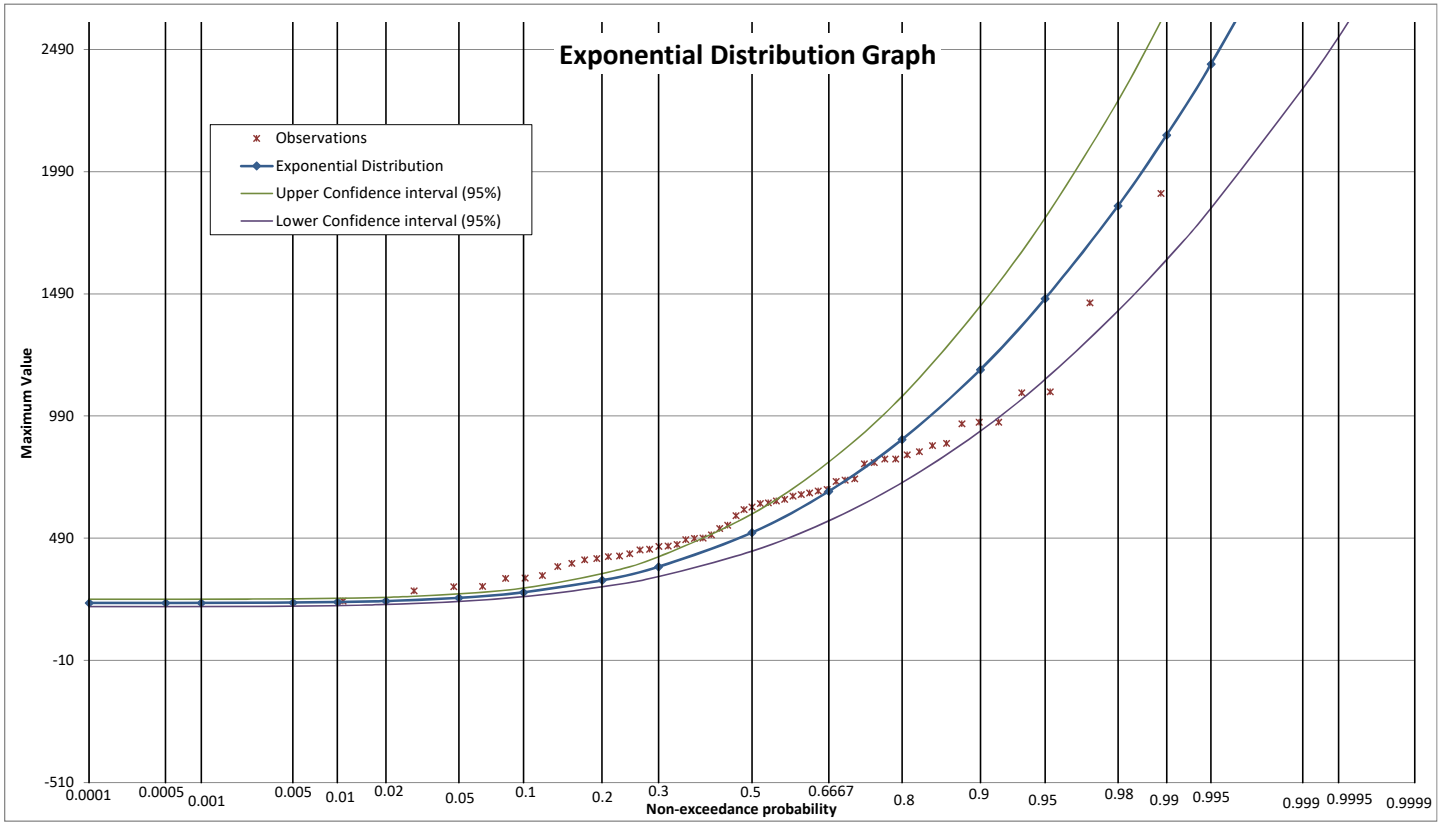
Normal Distribution
Visual Goodness-of-Fit Test Notes:



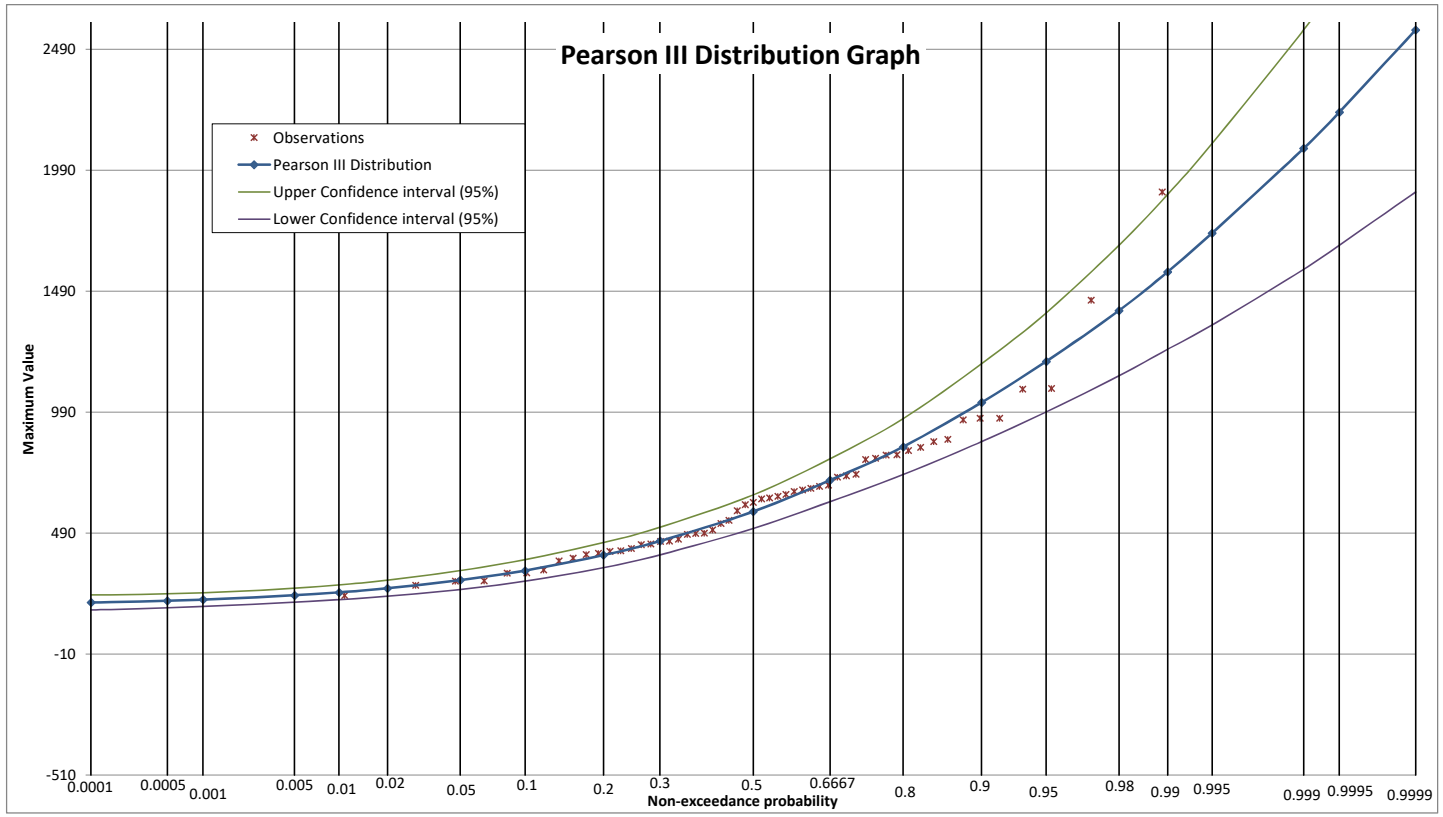
Log Normal Distribution
Visual Goodness-of-Fit Test Notes:



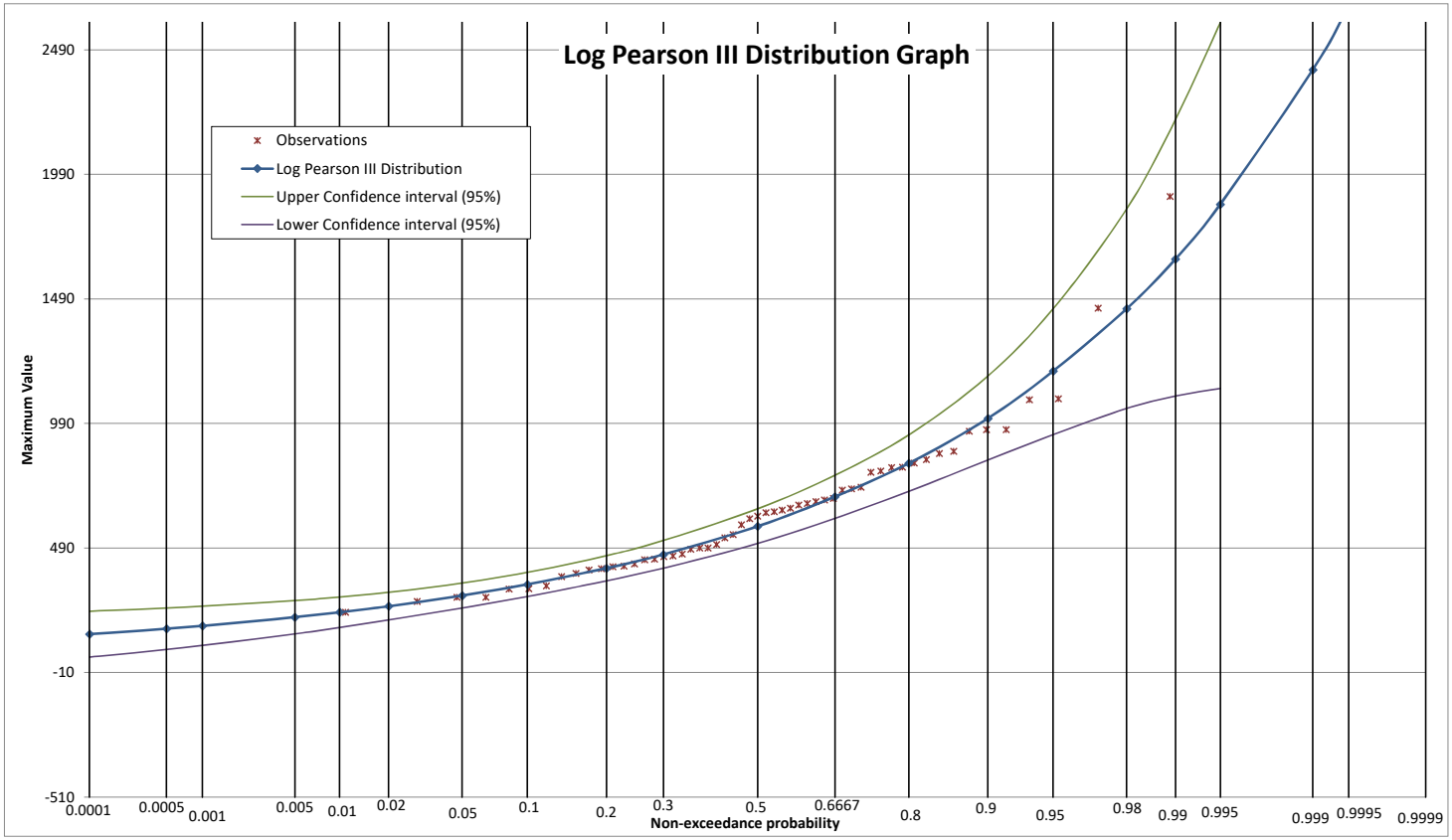
Log Normal III Distribution
Visual Goodness-of-Fit Test Notes:



Exponential Distribution
Visual Goodness-of-Fit Test Notes:



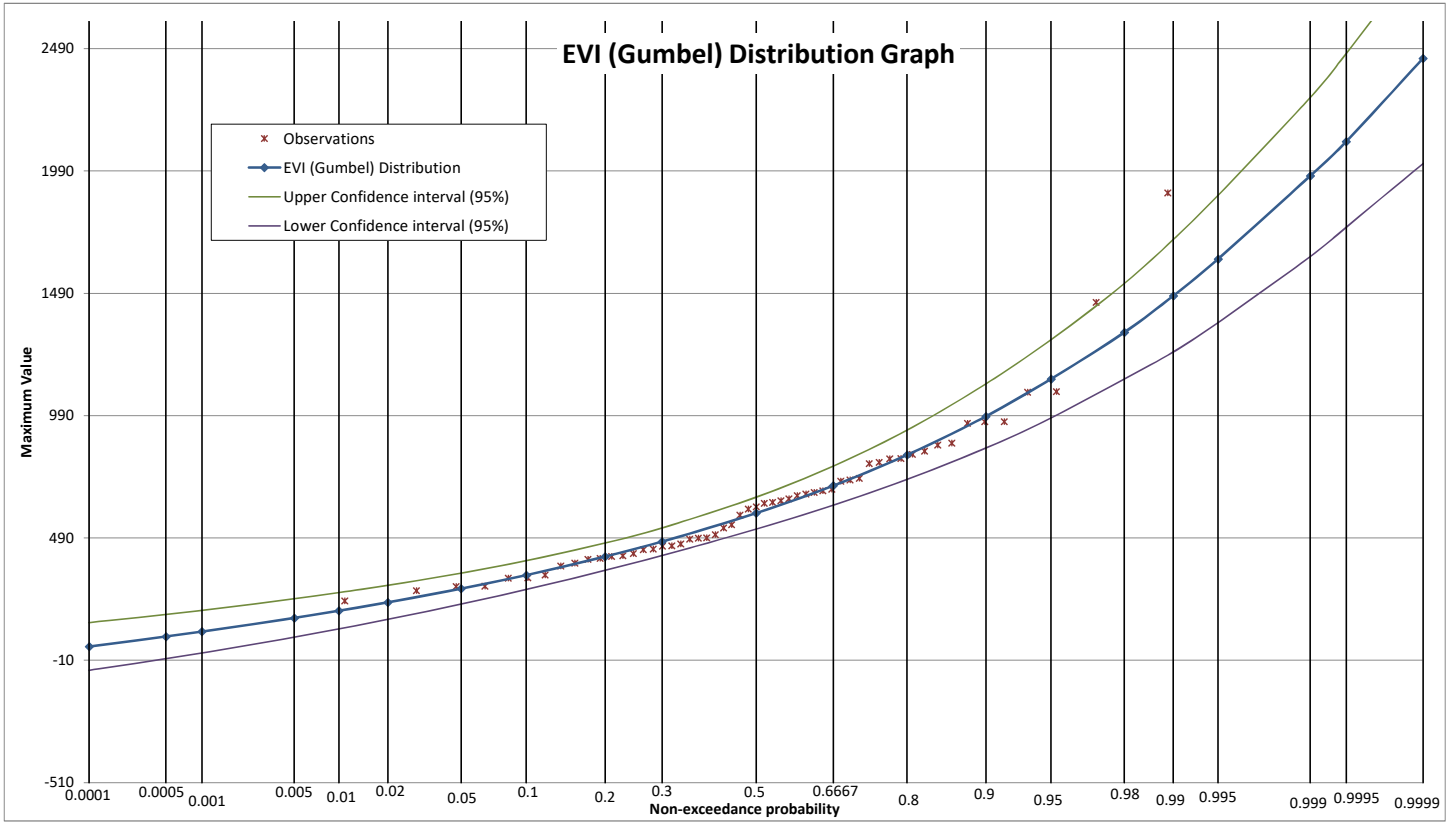
Pearson III Distribution
Visual Goodness-of-Fit Test Notes:



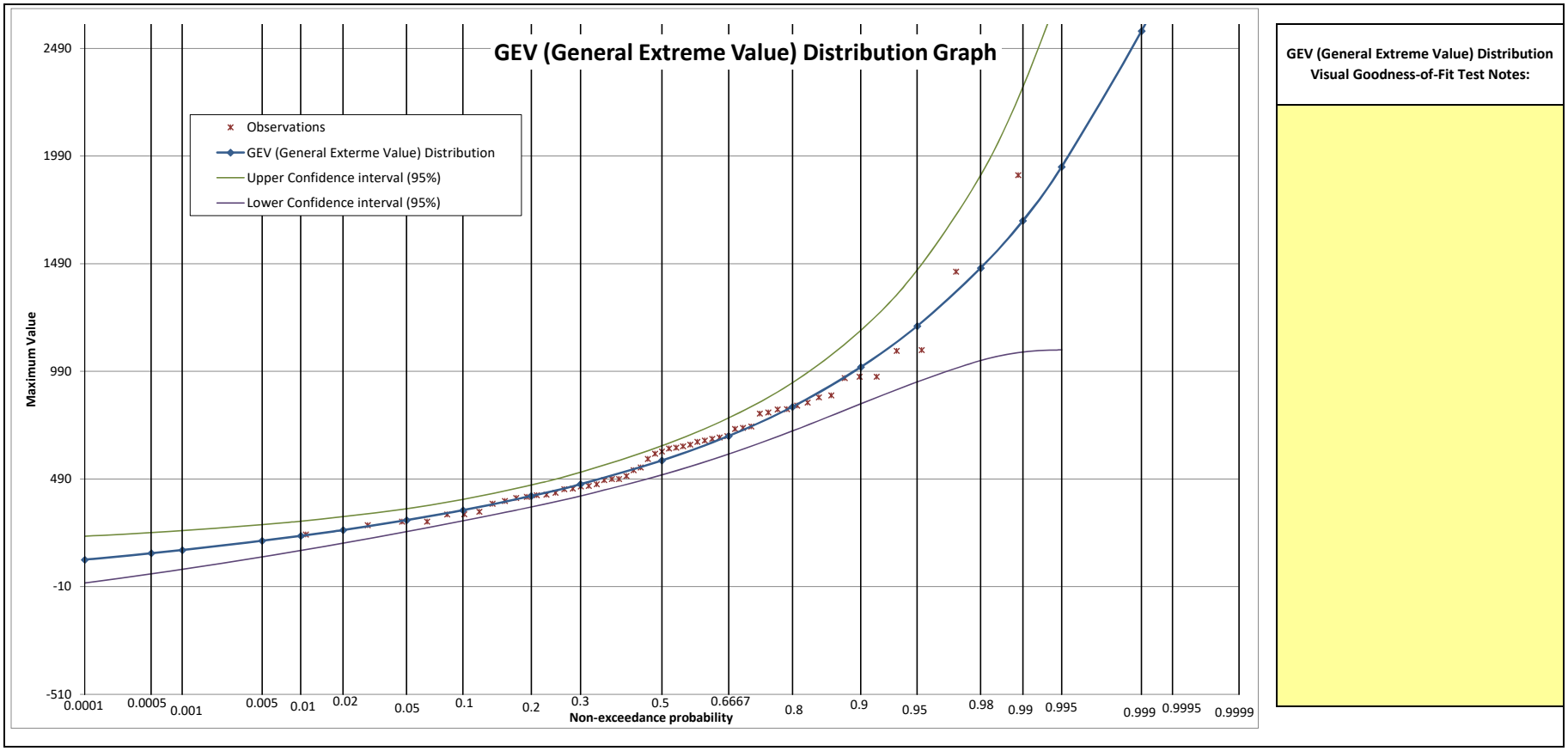
Log Pearson III Distribution Visual Goodness-of-Fit Test Notes:

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

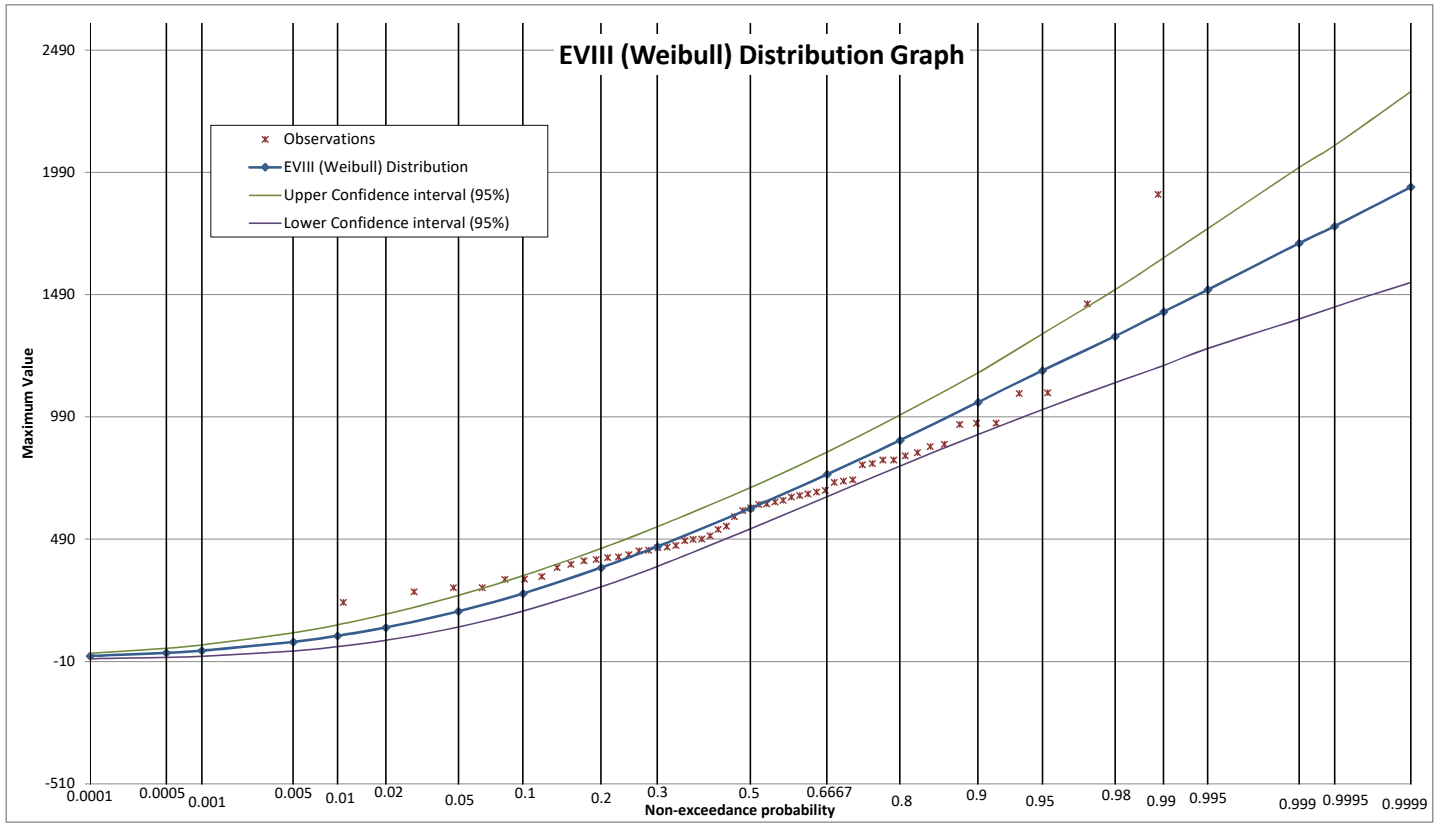
Lambda shape test
Pass
Alpha shape test
Pass



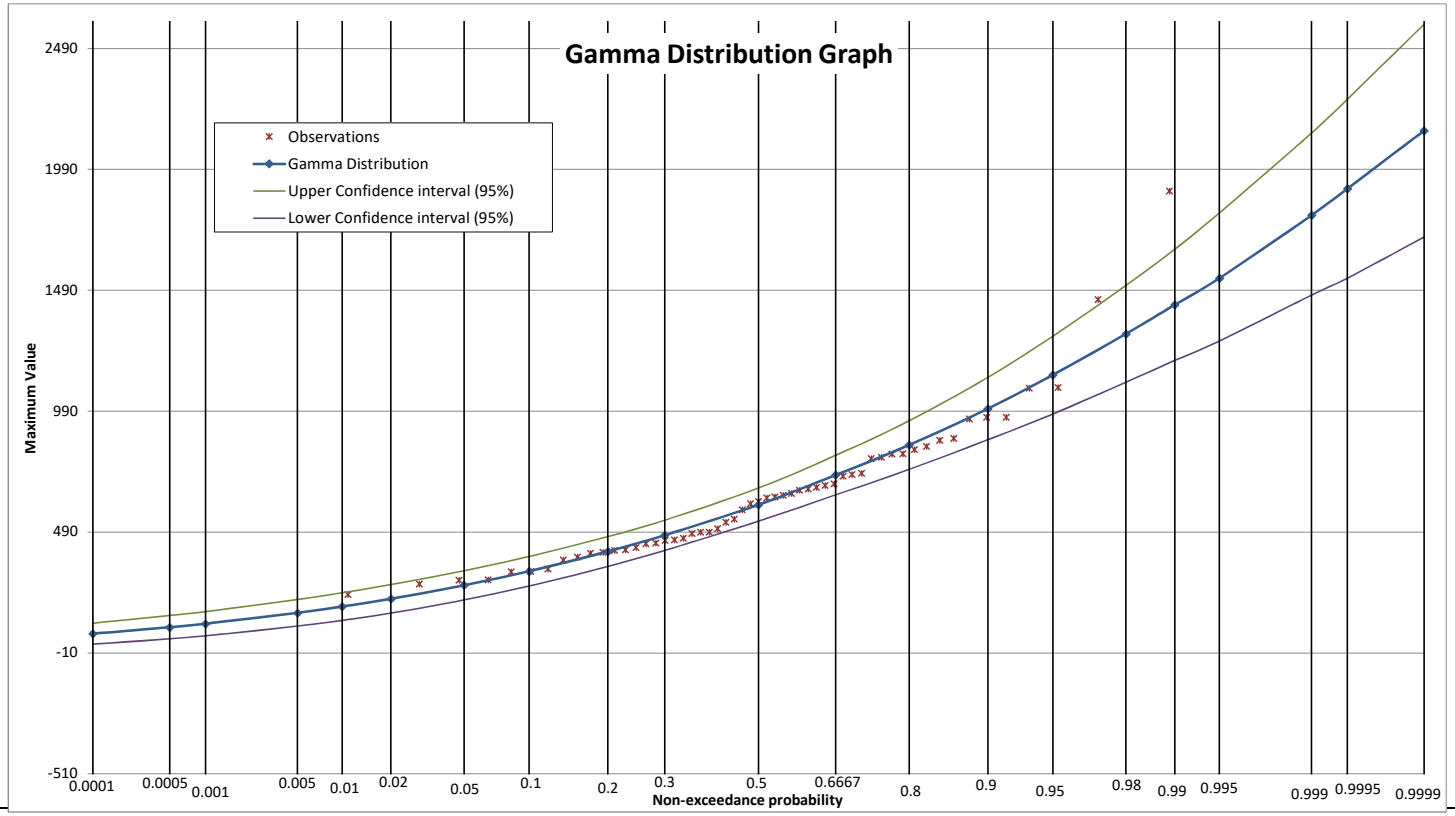
EVI (Gumbel) Distribution
Visual Goodness-of-Fit Test Notes:



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	1.325	Accept H0	9
Lognormal	1.929	2.502	3.907	0.218	Accept H0	1
Lognormal III	1.929	2.502	3.907	0.242	Accept H0	4
Exponential	1.929	2.502	3.907	2.734	Reject H0	10
Pearson III	1.929	2.502	3.907	0.240	Accept H0	3
Log Pearson III	1.929	2.502	3.907	0.234	Accept H0	2
Gumbel	1.929	2.502	3.907	0.252	Accept H0	5
GEV	1.929	2.502	3.907	0.256	Accept H0	6
Weibull	1.929	2.502	3.907	1.002	Accept H0	8
Gamma	1.929	2.502	3.907	0.333	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	0.092	Accept H0	9
Lognormal	0.165	0.183	0.220	0.064	Accept H0	3
Lognormal III	0.165	0.183	0.220	0.078	Accept H0	6
Exponential	0.165	0.183	0.220	0.184	Reject H0	10
Pearson III	0.165	0.183	0.220	0.070	Accept H0	4
Log Pearson III	0.165	0.183	0.220	0.076	Accept H0	5
Gumbel	0.165	0.183	0.220	0.057	Accept H0	1
GEV	0.165	0.183	0.220	0.079	Accept H0	7
Weibull	0.165	0.183	0.220	0.087	Accept H0	8
Gamma	0.165	0.183	0.220	0.060	Accept H0	2

Least Squares Ranking

Distribution Type:	Standard Error	Rank
Normal	113	9
Lognormal	58	5
Lognormal III	51	3
Exponential	121	10
Pearson III	55	4
Log Pearson III	50	2
Gumbel	70	6
GEV	47	1
Weibull	92	8
Gamma	78	7

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

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**

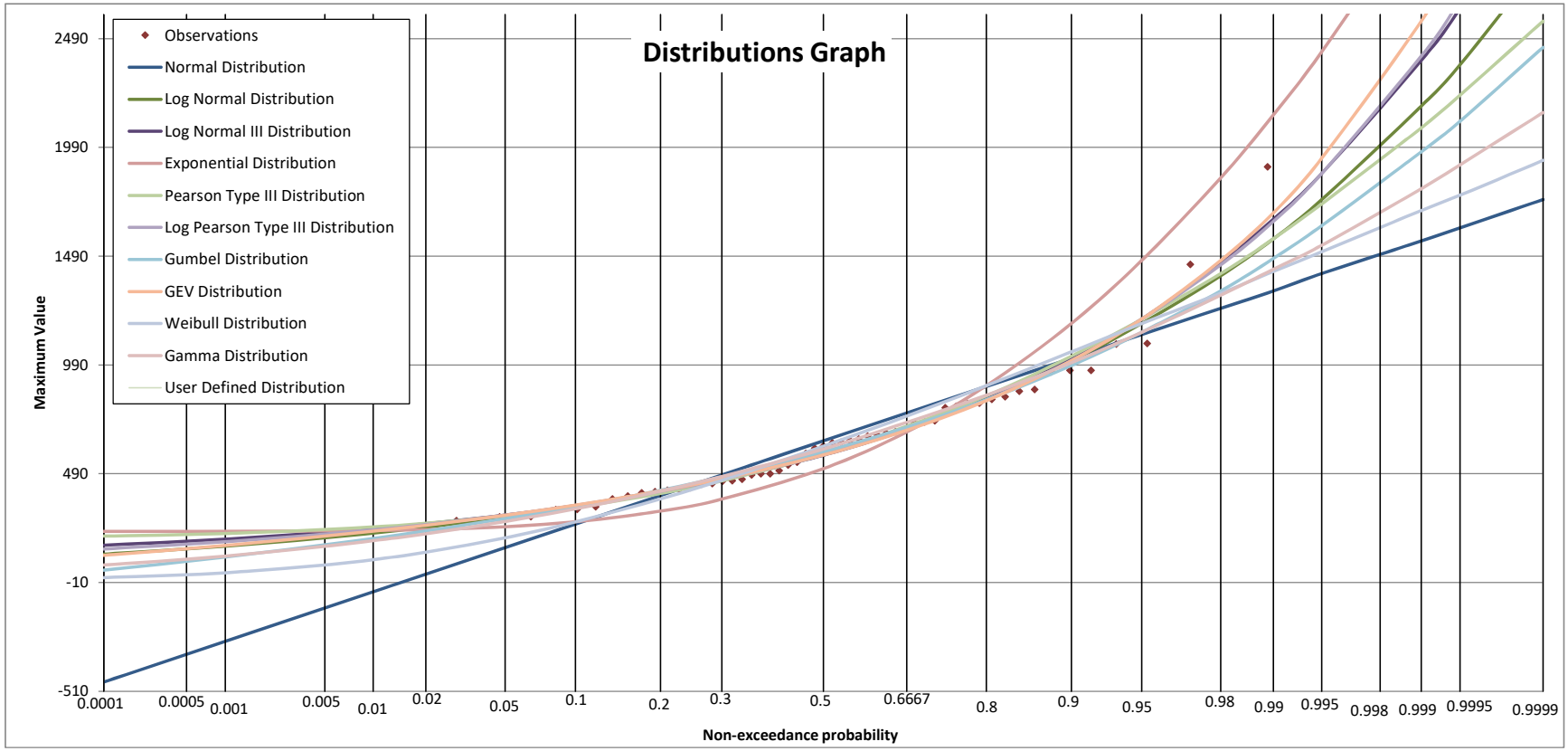
Sampling and Distribution Uncertainty

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	891

Sampling Uncertainty at (95%) Confidence Interval ±	92
Distribution Uncertainty ±	3.13
Total Uncertainty ±	95.1



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:	Ascension Development
Project Description:	Residential Development - Dry Pond
Location:	Rocky View County
Date:	2020-08-22
Designed by:	Luis Gerardo 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	9	9.00	9			
Lognormal	1	3	5	3.00	1			
Lognormal III	4	6	3	4.33	5			
Exponential	10	10	10	10.00	10			
Pearson III	3	4	4	3.67	3			
Log Pearson III	2	5	2	3.00	1			
Gumbel	5	1	6	4.00	4			
GEV	6	7	1	4.67	6			
Weibull	8	8	8	8.00	8			
Gamma	7	2	7	5.33	7			

Selected Distribution and Results

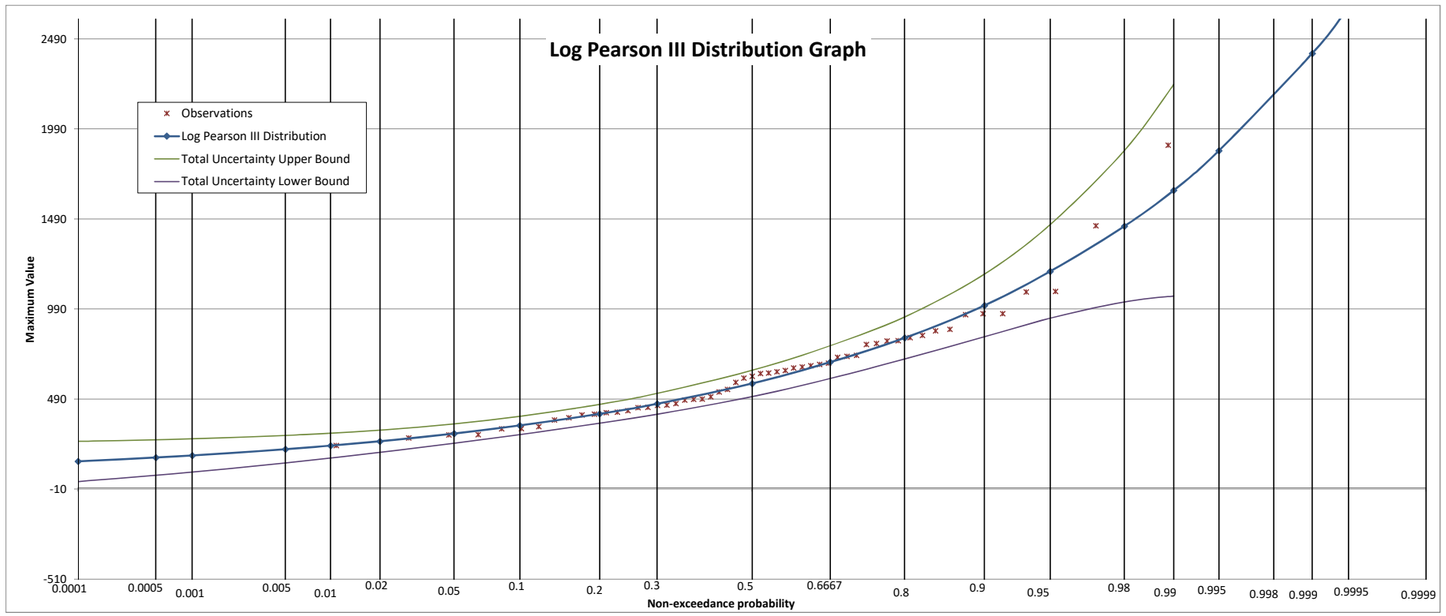
Instructions:

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

- 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	3330	#N/A	#N/A
2000	0.9995	2670	#N/A	#N/A
1000	0.9990	2410	#N/A	#N/A
500	0.9980	2190	#N/A	#N/A
200	0.9950	1870	2660	1090
100	0.9900	1650	2240	1060
50	0.9800	1450	1870	1030
20	0.9500	1200	1460	940
10	0.9000	1010	1180	836
5	0.8000	830	947	713
3	0.6667	696	787	605
2	0.5000	577	650	504
1.4286	0.3000	464	522	406
1.25	0.2000	409	461	357
1.1111	0.1000	344	395	293
1.0526	0.0500	299	353	245
1.0204	0.0200	256	318	195
1.0101	0.0100	232	301	163
1.005	0.0050	212	289	135
1.001	0.0010	177	269	84.8
1.0005	0.0005	166	265	67.3
1.0001	0.0001	144	256	32.3

*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:	Ascension Development
Project Description:	Residential Development - Constructed Wetland
Location:	Rocky View County
Date:	2020-08-26
Designed by:	Luis Gerardo 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	28310	0.138
2	1961	36220	0.899
3	1962	28010	0.120
4	1963	33230	0.736
5	1964	32480	0.663
6	1965	35120	0.826
7	1966	34260	0.808
8	1967	27240	0.065
9	1968	30880	0.500
10	1969	31500	0.554
11	1970	39010	0.935
12	1971	28750	0.192
13	1972	33500	0.754
14	1973	27890	0.101
15	1974	35810	0.862
16	1975	26590	0.011
17	1976	30340	0.428
18	1977	29570	0.373
19	1978	34110	0.790
20	1979	29010	0.246
21	1980	32020	0.609
22	1981	30480	0.464
23	1982	27740	0.083
24	1983	30170	0.409
25	1984	30390	0.446
26	1985	49710	0.971
27	1986	33760	0.772
28	1987	29430	0.337
29	1988	35260	0.844
30	1989	27130	0.047
31	1990	29550	0.355
32	1991	29390	0.319
33	1992	32780	0.699
34	1993	31670	0.591
35	1994	29280	0.301
36	1995	28330	0.156
37	1996	28770	0.210
38	1997	37410	0.917
39	1998	36150	0.880
40	1999	32880	0.717
41	2000	30030	0.391
42	2001	30770	0.482
43	2002	26910	0.029
44	2003	30890	0.518
45	2004	31500	0.572
46	2005	39870	0.953
47	2006	29270	0.283
48	2007	51880	0.989
49	2008	28580	0.174
50	2009	28900	0.228
51	2010	32700	0.681
52	2011	32250	0.645
53	2012	31140	0.536
54	2013	32220	0.627
55	2014	29240	0.264

Clear All Input Data

Basic Characteristics	
Number of Data Entries	55
Maximum Value	51900
Minimum Value	26600
Average (Mean) Value	32000
Median Value	30900
Standard Deviation	4790
Variance	22900000
Variation coefficient (Cv)	0.15
Skewness coefficient (Cs)	2.37
Kurtosis	9.27

*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:	-0.002

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

When there are no ties in rankings: based on t: **No Significant Trend at 0.05 Significance Level**

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

Spearman Correlation Coefficient:	-0.002
t-distribution value	-0.018
Degrees of freedom	53

T (Adjustment for ties) =	0.5
Standard Normal (z)=	-0.016

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)

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

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=	620.5
Total of Ranking in sample 2 R_2=	
U_1=	368

No Jump at 0.05 Significance Level

$$U_1 + U_2 = n_1 n_2.$$

U_2=	358.5
U (Minimum of U_1 and U_2)=	358.5
Standard Normal (z)=	-0.077

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 =	29

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

Mean =	28.0
Variance =	13.2

No Jump at 0.05 Significance Level

Standard Normal (z)=	0.1

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=	789.5
Total of Ranking in sample 1 R_2=	
U_1=	384

$$U_1 + U_2 = n_1 n_2.$$

U_2=	372.5
U (Minimum of U_1 and U_2)=	372.5
Standard Normal (z)=	-0.093

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 =	0.390
z =	0.107

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:	-0.25

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:	-0.25
t-distribution value	-1.88
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	56200000000
Mean	56300000000
Variance	2.32E+16

H_0= Data is independent

Data is independent at 0.05 Significance Level

Standard Normal (z)=	-1.1

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	-0.148
Mean	-0.019
Variance	0.018

H_0= Data is independent

Data is independent at 0.05 Significance Level

Standard Normal (z)=	-1.0

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=	45900	< Any value higher than X_h is considered a high outlier
Maximum Value	51900	
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=	21900	< Any value lower than X_h is considered a low outlier
Minimum Value	26600	
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) =	-0.158	No Serial Correlation at 0.05 Significance Level
t-distribution values for one time period offset	t =	-1.166	

Two Time Periods Offset			
Autocorrelation coefficient offset by two time periods	r(2) =	0.081	No Serial Correlation at 0.05 Significance Level
t-distribution values for two time periods offset	t =	0.594	

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)

Ascension Constructed Wetland

Results of the fitting

Normal (Maximum Likelihood)

Number of observations 55

Parameters

mu	32005.0909
sigma	4785.41839

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

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	4.98E+04	1.83E+03	4.62E+04	5.34E+04	
2000	0.9995	4.78E+04	1.65E+03	4.45E+04	5.10E+04	
1000	0.999	4.68E+04	1.56E+03	4.37E+04	4.99E+04	
200	0.995	4.43E+04	1.35E+03	4.17E+04	4.70E+04	
100	0.99	4.31E+04	1.25E+03	4.07E+04	4.56E+04	
50	0.98	4.18E+04	1.15E+03	3.96E+04	4.41E+04	
20	0.95	3.99E+04	995	3.79E+04	4.18E+04	
10	0.9	3.81E+04	874	3.64E+04	3.99E+04	
5	0.8	3.60E+04	753	3.46E+04	3.75E+04	
3	0.6667	3.41E+04	675	3.27E+04	3.54E+04	
2	0.5	3.20E+04	645	3.07E+04	3.33E+04	
1.4286	0.3	2.95E+04	689	2.81E+04	3.08E+04	
1.25	0.2	2.80E+04	753	2.65E+04	2.95E+04	
1.1111	0.1	2.59E+04	874	2.42E+04	2.76E+04	
1.0526	0.05	2.41E+04	995	2.22E+04	2.61E+04	
1.0204	0.02	2.22E+04	1.15E+03	1.99E+04	2.44E+04	
1.0101	0.01	2.09E+04	1.25E+03	1.84E+04	2.33E+04	
1.005	0.005	1.97E+04	1.35E+03	1.70E+04	2.23E+04	
1.001	0.001	1.72E+04	1.56E+03	1.42E+04	2.03E+04	
1.0005	0.0005	1.63E+04	1.65E+03	1.30E+04	1.95E+04	
1.0001	0.0001	1.42E+04	1.83E+03	1.06E+04	1.78E+04	

Lognormal Distribution:

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

Ascension Constructed Wetland

Results of the fitting

Lognormal (Maximum Likelihood)

Number of observations 55

Parameters

mu	10.364374
sigma	0.132262

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

T = 1/(1-q)

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	5.19E+04	2.62E+03	4.67E+04	5.70E+04	
2000	0.9995	4.90E+04	2.23E+03	4.46E+04	5.34E+04	
1000	0.999	4.77E+04	2.06E+03	4.37E+04	5.18E+04	
200	0.995	4.46E+04	1.66E+03	4.13E+04	4.78E+04	
100	0.99	4.31E+04	1.49E+03	4.02E+04	4.61E+04	
50	0.98	4.16E+04	1.32E+03	3.90E+04	4.42E+04	
20	0.95	3.94E+04	1.08E+03	3.73E+04	4.15E+04	
10	0.9	3.76E+04	9.08E+02	3.58E+04	3.93E+04	
5	0.8	3.54E+04	7.37E+02	3.40E+04	3.69E+04	
3	0.6667	3.36E+04	626	3.23E+04	3.48E+04	
2	0.5	3.17E+04	566	3.06E+04	3.28E+04	
1.4286	0.3	2.96E+04	563	2.85E+04	3.07E+04	
1.25	0.2	2.84E+04	590	2.72E+04	2.95E+04	
1.1111	0.1	2.68E+04	647	2.55E+04	2.80E+04	
1.0526	0.05	2.55E+04	702	2.41E+04	2.69E+04	
1.0204	0.02	2.42E+04	765	2.27E+04	2.57E+04	
1.0101	0.01	2.33E+04	806	2.17E+04	2.49E+04	
1.005	0.005	2.26E+04	842	2.09E+04	2.42E+04	
1.001	0.001	2.11E+04	910	1.93E+04	2.29E+04	
1.0005	0.0005	2.05E+04	934	1.87E+04	2.24E+04	
1.0001	0.0001	1.94E+04	981	1.75E+04	2.13E+04	

Lognormal III Distribution

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

Ascension Constructed Wetland

Results of the fitting

3-parameter lognormal (Maximum Likelihood)

Number of observations 55

Parameters

m	25460.7519
mu	8.581705
sigma	0.635841

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

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	8.22E+04	1.88E+04	4.53E+04	1.19E+05	
2000	0.9995	6.87E+04	1.24E+04	4.43E+04	9.30E+04	
1000	0.999	6.35E+04	1.02E+04	4.36E+04	8.35E+04	
200	0.995	5.29E+04	5.98E+03	4.12E+04	6.46E+04	
100	0.99	4.89E+04	4.58E+03	3.99E+04	5.79E+04	
50	0.98	4.52E+04	3.40E+03	3.85E+04	5.18E+04	
20	0.95	4.06E+04	2.15E+03	3.64E+04	4.49E+04	
10	0.9	3.75E+04	1.43E+03	3.47E+04	4.03E+04	
5	0.8	3.46E+04	909	3.28E+04	3.63E+04	
3	0.6667	3.25E+04	639	3.12E+04	3.37E+04	
2	0.5	3.08E+04	482	2.98E+04	3.17E+04	
1.4286	0.3	2.93E+04	368	2.86E+04	3.00E+04	
1.25	0.2	2.86E+04	319	2.80E+04	2.92E+04	
1.1111	0.1	2.78E+04	273	2.73E+04	2.84E+04	
1.0526	0.05	2.73E+04	260	2.68E+04	2.78E+04	
1.0204	0.02	2.69E+04	272	2.64E+04	2.74E+04	
1.0101	0.01	2.67E+04	292	2.61E+04	2.72E+04	
1.005	0.005	2.65E+04	316	2.59E+04	2.71E+04	
1.001	0.001	2.62E+04	3.71E+02	2.55E+04	2.69E+04	
1.0005	0.0005	2.61E+04	3.93E+02	2.53E+04	2.69E+04	
1.0001	0.0001	2.60E+04	4.38E+02	2.51E+04	2.68E+04	

Exponential and Pearson type of distributions:

Exponential Distribution

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

Ascension Constructed Wetland

Results of the fitting

Exponential (Maximum Likelihood)

Number of observations 55

Parameters

alpha	5515.37037
m	26489.7205

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

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	7.73E+04	6.90E+03	6.38E+04	9.08E+04	
2000	0.9995	6.84E+04	5.69E+03	5.73E+04	7.96E+04	
1000	0.999	6.46E+04	5.17E+03	5.44E+04	7.47E+04	
200	0.995	5.57E+04	3.96E+03	4.79E+04	6.35E+04	
100	0.99	5.19E+04	3.44E+03	4.51E+04	5.86E+04	
50	0.98	4.81E+04	2.92E+03	4.23E+04	5.38E+04	
20	0.95	4.30E+04	2.24E+03	3.86E+04	4.74E+04	
10	0.9	3.92E+04	1.72E+03	3.58E+04	4.26E+04	
5	0.8	3.54E+04	1.20E+03	3.30E+04	3.77E+04	
3	0.6667	3.25E+04	8.17E+02	3.09E+04	3.42E+04	
2	0.5	3.03E+04	516	2.93E+04	3.13E+04	
1.4286	0.3	2.85E+04	273	2.79E+04	2.90E+04	
1.25	0.2	2.77E+04	184	2.74E+04	2.81E+04	
1.1111	0.1	2.71E+04	120	2.68E+04	2.73E+04	
1.0526	0.05	2.68E+04	103	2.66E+04	2.70E+04	
1.0204	0.02	2.66E+04	100	2.64E+04	2.68E+04	
1.0101	0.01	2.65E+04	100	2.63E+04	2.67E+04	
1.005	0.005	2.65E+04	101	2.63E+04	2.67E+04	
1.001	0.001	2.65E+04	101	2.63E+04	2.67E+04	
1.0005	0.0005	2.65E+04	101	2.63E+04	2.67E+04	
1.0001	0.0001	2.65E+04	101	2.63E+04	2.67E+04	

Pearson Type III Distribution

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

Ascension Constructed Wetland

Results of the fitting

Pearson type III (Conditional maximum likelihood)

Number of observations 55

Parameters

alpha	0.000225
lambda	1.455958
m	26590

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

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	7.30E+04	6.51E+03	6.02E+04	8.58E+04	
2000	0.9995	6.55E+04	5.35E+03	5.50E+04	7.60E+04	
1000	0.999	6.23E+04	4.85E+03	5.28E+04	7.18E+04	
200	0.995	5.47E+04	3.69E+03	4.75E+04	6.19E+04	
100	0.99	5.14E+04	3.20E+03	4.51E+04	5.77E+04	
50	0.98	4.81E+04	2.71E+03	4.28E+04	5.34E+04	
20	0.95	4.36E+04	2.07E+03	3.96E+04	4.77E+04	
10	0.9	4.02E+04	1.60E+03	3.70E+04	4.33E+04	
5	0.8	3.66E+04	1140	3.44E+04	3.89E+04	
3	0.6667	3.40E+04	828	3.24E+04	3.56E+04	
2	0.5	3.17E+04	589	3.05E+04	3.28E+04	
1.4286	0.3	2.96E+04	424	2.88E+04	3.04E+04	
1.25	0.2	2.87E+04	361	2.80E+04	2.94E+04	
1.1111	0.1	2.78E+04	289	2.72E+04	2.84E+04	
1.0526	0.05	2.73E+04	230	2.69E+04	2.78E+04	
1.0204	0.02	2.70E+04	1.53E+02	2.67E+04	2.73E+04	
1.0101	0.01	2.68E+04	8.18E+01	2.66E+04	2.70E+04	
1.005	0.005	2.67E+04	N/D	N/D	N/D	
1.001	0.001	2.66E+04	N/D	N/D	N/D	
1.0005	0.0005	2.66E+04	N/D	N/D	N/D	
1.0001	0.0001	2.65E+04	N/D	N/D	N/D	

Log-Pearson Type III Distribution

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

Ascension Constructed Wetland

Results of the fitting

Log-Pearson type III (Méthode SAM)

Number of observations 55

Parameters

alpha	20.686089
lambda	1.385115
m	4.434232

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

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	8.52E+04	3.39E+04	N/D	N/D	
2000	0.9995	7.07E+04	2.13E+04	N/D	N/D	
1000	0.999	6.52E+04	1.70E+04	N/D	N/D	
200	0.995	5.40E+04	9.26E+03	N/D	N/D	
100	0.99	4.98E+04	6.74E+03	N/D	N/D	
50	0.98	4.58E+04	4.66E+03	3.67E+04	5.50E+04	
20	0.95	4.11E+04	2.59E+03	3.60E+04	4.61E+04	
10	0.9	3.77E+04	1.56E+03	3.46E+04	4.08E+04	
5	0.8	3.46E+04	1.08E+03	3.25E+04	3.67E+04	
3	0.6667	3.24E+04	920	3.06E+04	3.42E+04	
2	0.5	3.06E+04	746	2.92E+04	3.21E+04	
1.4286	0.3	2.91E+04	405	2.83E+04	2.99E+04	
1.25	0.2	2.85E+04	324	2.79E+04	2.92E+04	
1.1111	0.1	2.79E+04	633	N/D	N/D	
1.0526	0.05	2.76E+04	978	N/D	N/D	
1.0204	0.02	2.74E+04	1340	N/D	N/D	
1.0101	0.01	2.73E+04	1550	N/D	N/D	
1.005	0.005	2.72E+04	1710	N/D	N/D	
1.001	0.001	2.72E+04	1980	N/D	N/D	
1.0005	0.0005	2.72E+04	2050	N/D	N/D	
1.0001	0.0001	2.72E+04	2170	N/D	N/D	

Extreme Value type of distributions:

EVI (Gumbel) Distribution

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

Ascension Constructed Wetland

Results of the fitting

Gumbel (Maximum Likelihood)

Number of observations 55

Parameters

u	30136.1139
alpha	2912.67248

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

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	5.70E+04	3.01E+03	5.11E+04	6.29E+04	
2000	0.9995	5.23E+04	2.52E+03	4.73E+04	5.72E+04	
1000	0.999	5.03E+04	2.31E+03	4.57E+04	5.48E+04	
200	0.995	4.56E+04	1.81E+03	4.20E+04	4.91E+04	
100	0.99	4.35E+04	1.60E+03	4.04E+04	4.67E+04	
50	0.98	4.15E+04	1.39E+03	3.88E+04	4.42E+04	
20	0.95	3.88E+04	1.12E+03	3.66E+04	4.10E+04	
10	0.9	3.67E+04	9.14E+02	3.49E+04	3.85E+04	
5	0.8	3.45E+04	710	3.31E+04	3.59E+04	
3	0.6667	3.28E+04	565	3.17E+04	3.39E+04	
2	0.5	3.12E+04	460	3.03E+04	3.21E+04	
1.4286	0.3	2.96E+04	399	2.88E+04	3.04E+04	
1.25	0.2	2.88E+04	393	2.80E+04	2.95E+04	
1.1111	0.1	2.77E+04	415	2.69E+04	2.85E+04	
1.0526	0.05	2.69E+04	448	2.61E+04	2.78E+04	
1.0204	0.02	2.62E+04	493	2.52E+04	2.71E+04	
1.0101	0.01	2.57E+04	525	2.47E+04	2.67E+04	
1.005	0.005	2.53E+04	555	2.42E+04	2.64E+04	
1.001	0.001	2.45E+04	616	2.33E+04	2.57E+04	
1.0005	0.0005	2.42E+04	640	2.30E+04	2.55E+04	
1.0001	0.0001	2.37E+04	688	2.23E+04	2.50E+04	

GEV (General Extreme Value) Distribution

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

Ascension Constructed Wetland

Results of the fitting

GEV (Maximum Likelihood)

Number of observations 55

Parameters

alpha	2528.46323
k	-0.235657
u	29805.391

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

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	1.13E+05	5.74E+04	N/D	N/D	
2000	0.9995	8.34E+04	2.95E+04	N/D	N/D	
1000	0.999	7.37E+04	2.17E+04	N/D	N/D	
200	0.995	5.65E+04	9.85E+03	N/D	N/D	
100	0.99	5.08E+04	6.74E+03	3.76E+04	6.40E+04	
50	0.98	4.60E+04	4.46E+03	3.72E+04	5.47E+04	
20	0.95	4.07E+04	2.44E+03	3.59E+04	4.55E+04	
10	0.9	3.73E+04	1480	3.44E+04	4.02E+04	
5	0.8	3.44E+04	882	3.26E+04	3.61E+04	
3	0.6667	3.23E+04	613	3.11E+04	3.36E+04	
2	0.5	3.08E+04	462	2.99E+04	3.17E+04	
1.4286	0.3	2.93E+04	354	2.87E+04	3.00E+04	
1.25	0.2	2.87E+04	315	2.80E+04	2.93E+04	
1.1111	0.1	2.79E+04	294	2.73E+04	2.85E+04	
1.0526	0.05	2.74E+04	306	2.68E+04	2.80E+04	
1.0204	0.02	2.69E+04	343	2.62E+04	2.75E+04	
1.0101	0.01	2.66E+04	377	2.58E+04	2.73E+04	
1.005	0.005	2.63E+04	4.12E+02	2.55E+04	2.71E+04	
1.001	0.001	2.59E+04	4.89E+02	2.49E+04	2.68E+04	
1.0005	0.0005	2.57E+04	5.19E+02	2.47E+04	2.67E+04	
1.0001	0.0001	2.54E+04	5.85E+02	2.43E+04	2.66E+04	

EVIII (Weibull) Distribution

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

Ascension Constructed Wetland

Results of the fitting

Weibull (Maximum Likelihood)

Number of observations 55

Parameters

alpha	34167.7205
c	5.523027

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

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	5.11E+04	2.15E+03	4.69E+04	5.53E+04	
2000	0.9995	4.93E+04	1.93E+03	4.55E+04	5.31E+04	
1000	0.999	4.85E+04	1.83E+03	4.49E+04	5.21E+04	
200	0.995	4.62E+04	1.57E+03	4.31E+04	4.93E+04	
100	0.99	4.51E+04	1.45E+03	4.22E+04	4.79E+04	
50	0.98	4.37E+04	1.32E+03	4.11E+04	4.63E+04	
20	0.95	4.17E+04	1.15E+03	3.94E+04	4.39E+04	
10	0.9	3.97E+04	1.02E+03	3.77E+04	4.17E+04	
5	0.8	3.72E+04	910	3.55E+04	3.90E+04	
3	0.6667	3.48E+04	876	3.30E+04	3.65E+04	
2	0.5	3.20E+04	917	3.02E+04	3.38E+04	
1.4286	0.3	2.83E+04	1050	2.63E+04	3.04E+04	
1.25	0.2	2.60E+04	1150	2.38E+04	2.83E+04	
1.1111	0.1	2.27E+04	1280	2.02E+04	2.52E+04	
1.0526	0.05	2.00E+04	1380	1.73E+04	2.27E+04	
1.0204	0.02	1.69E+04	1450	1.40E+04	1.97E+04	
1.0101	0.01	1.49E+04	1470	1.20E+04	1.77E+04	
1.005	0.005	1.31E+04	1460	1.02E+04	1.60E+04	
1.001	0.001	9.78E+03	1390	7.07E+03	1.25E+04	
1.0005	0.0005	8.63E+03	1330	6.01E+03	1.12E+04	
1.0001	0.0001	6.45E+03	1190	4.11E+03	8.79E+03	

Gamma type of distributions:

Gamma Distribution

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

Ascension Constructed Wetland

Results of the fitting

Gamma (Maximum Likelihood)

Number of observations 55

Parameters

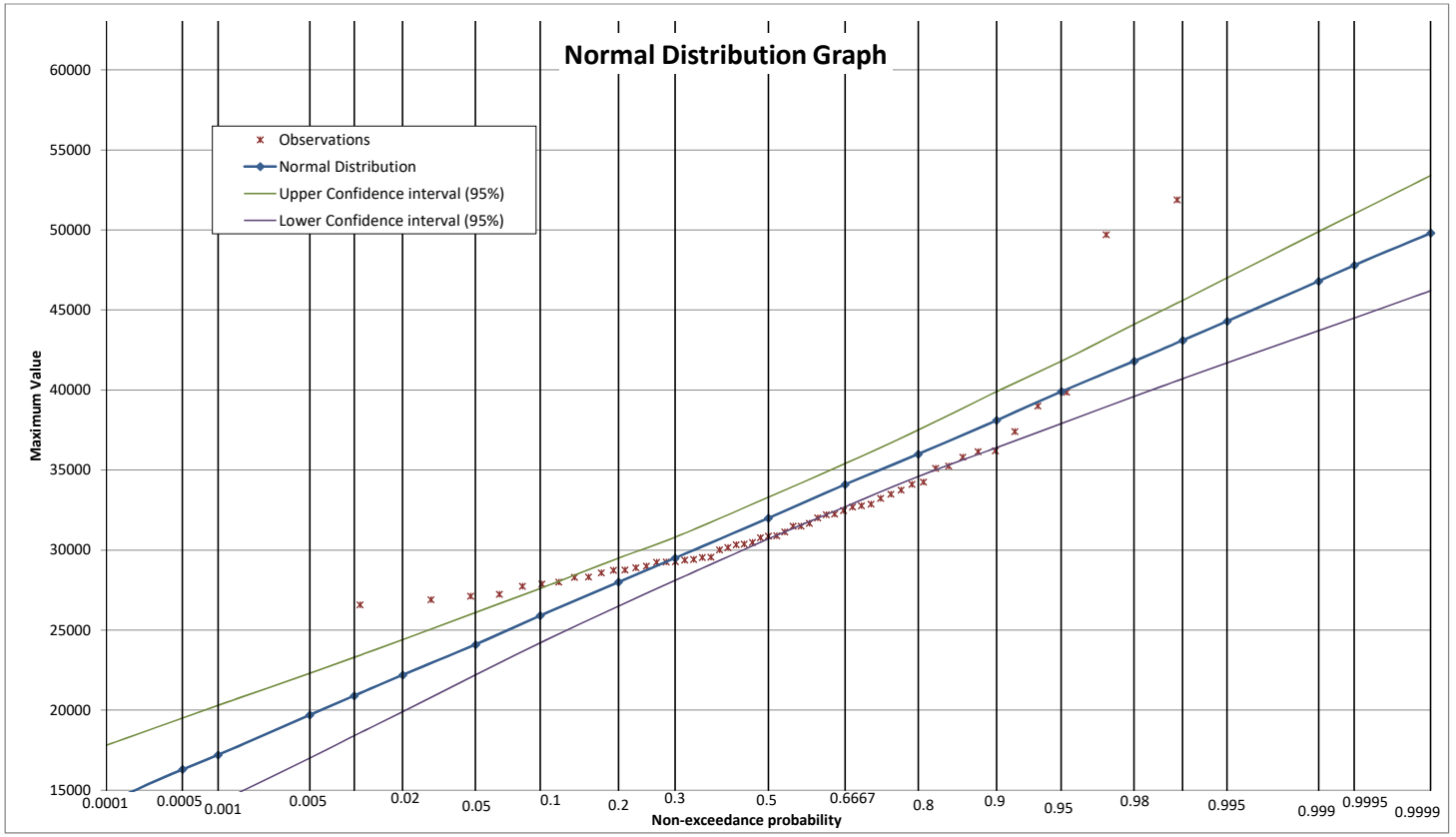
alpha	0.001689
lambda	54.068748

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

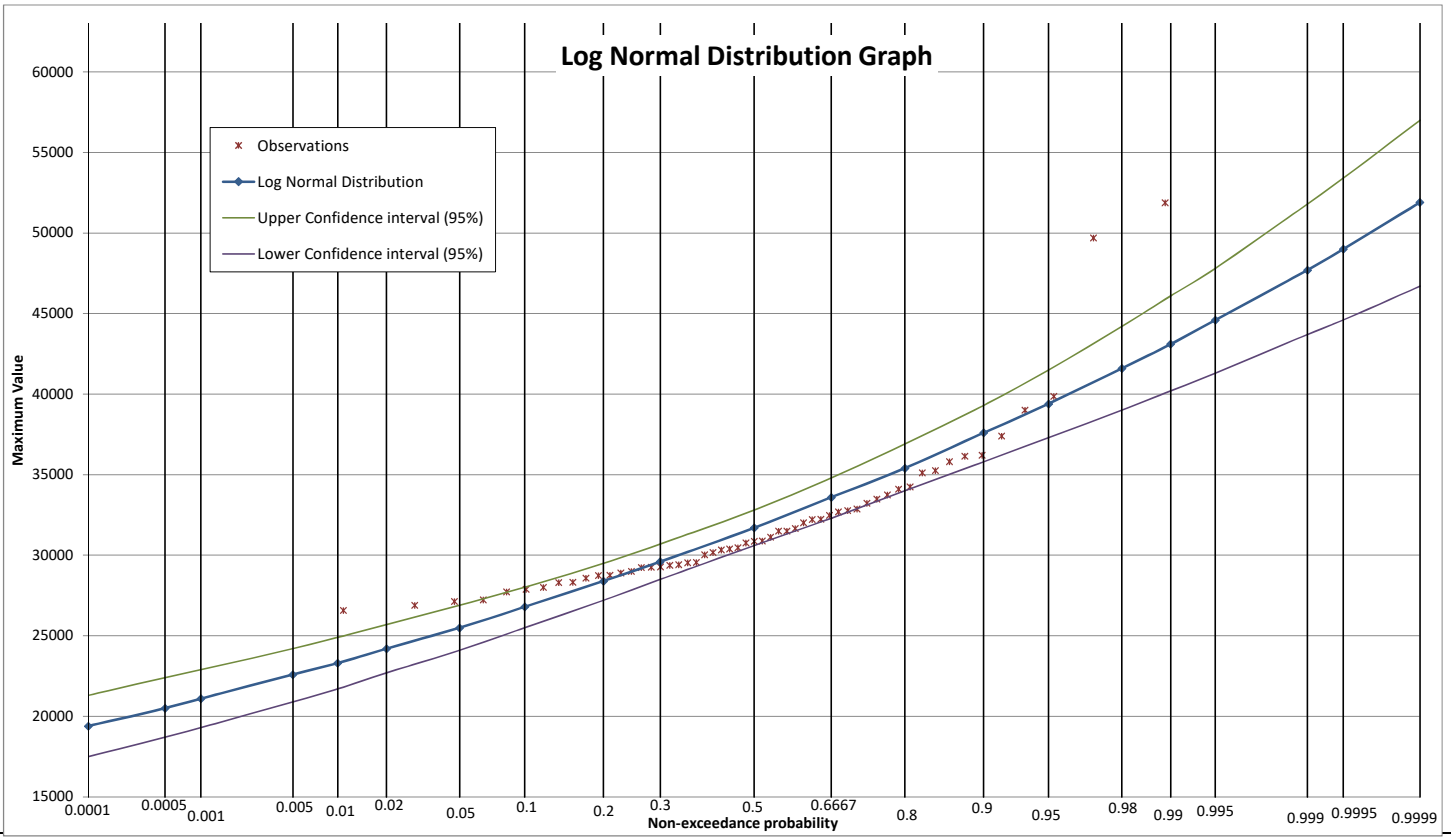
T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	5.08E+04	2.24E+03	4.64E+04	5.52E+04	
2000	0.9995	4.83E+04	1.95E+03	4.45E+04	5.21E+04	
1000	0.999	4.72E+04	1.82E+03	4.36E+04	5.07E+04	
200	0.995	4.43E+04	1.51E+03	4.14E+04	4.73E+04	
100	0.99	4.30E+04	1.37E+03	4.03E+04	4.57E+04	
50	0.98	4.16E+04	1.23E+03	3.92E+04	4.40E+04	
20	0.95	3.95E+04	1.04E+03	3.75E+04	4.15E+04	
10	0.9	3.77E+04	8.83E+02	3.60E+04	3.94E+04	
5	0.8	3.56E+04	733	3.42E+04	3.70E+04	
3	0.6667	3.37E+04	637	3.25E+04	3.50E+04	
2	0.5	3.18E+04	584	3.07E+04	3.30E+04	
1.4286	0.3	2.96E+04	594	2.84E+04	3.08E+04	
1.25	0.2	2.83E+04	629	2.71E+04	2.95E+04	
1.1111	0.1	2.66E+04	700	2.52E+04	2.79E+04	
1.0526	0.05	2.52E+04	769	2.37E+04	2.67E+04	
1.0204	0.02	2.37E+04	847	2.20E+04	2.54E+04	
1.0101	0.01	2.28E+04	898	2.10E+04	2.45E+04	
1.005	0.005	2.19E+04	942	2.01E+04	2.38E+04	
1.001	0.001	2.02E+04	1030	1.82E+04	2.23E+04	
1.0005	0.0005	1.96E+04	1050	1.76E+04	2.17E+04	
1.0001	0.0001	1.84E+04	1110	1.62E+04	2.05E+04	

Visual Goodness of Fit

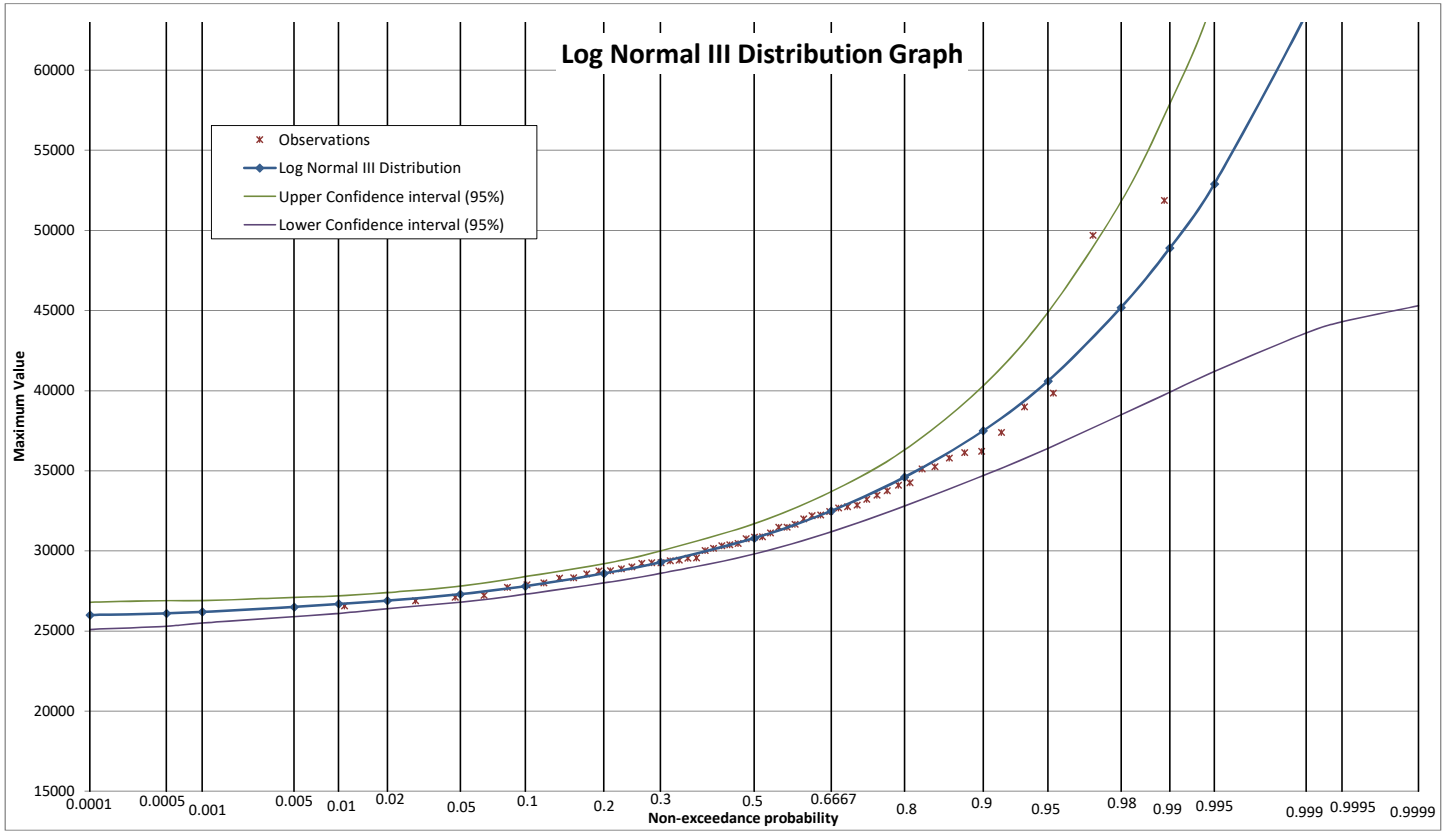
Clear All Note Data



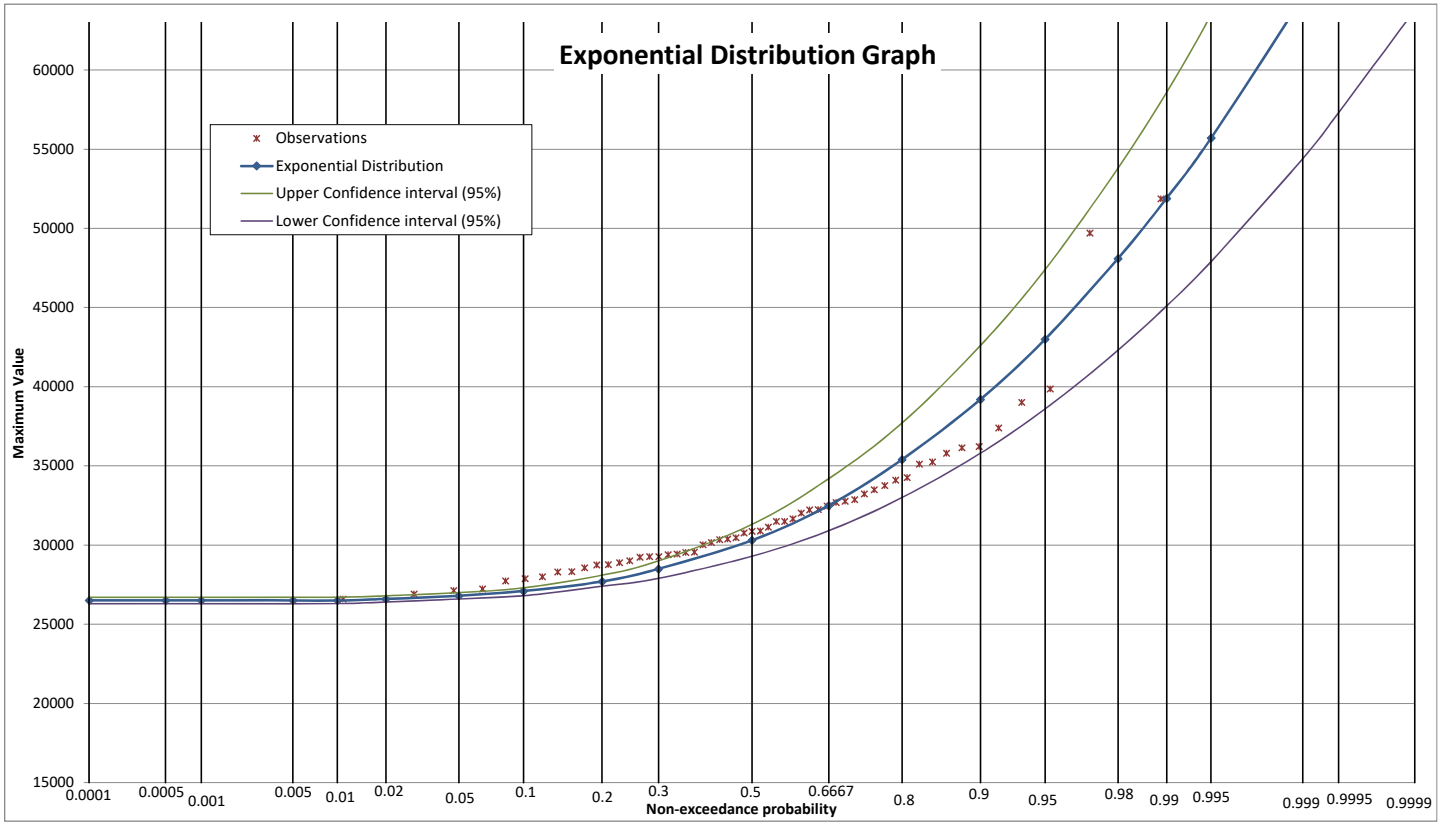
Normal Distribution
Visual Goodness-of-Fit Test Notes:



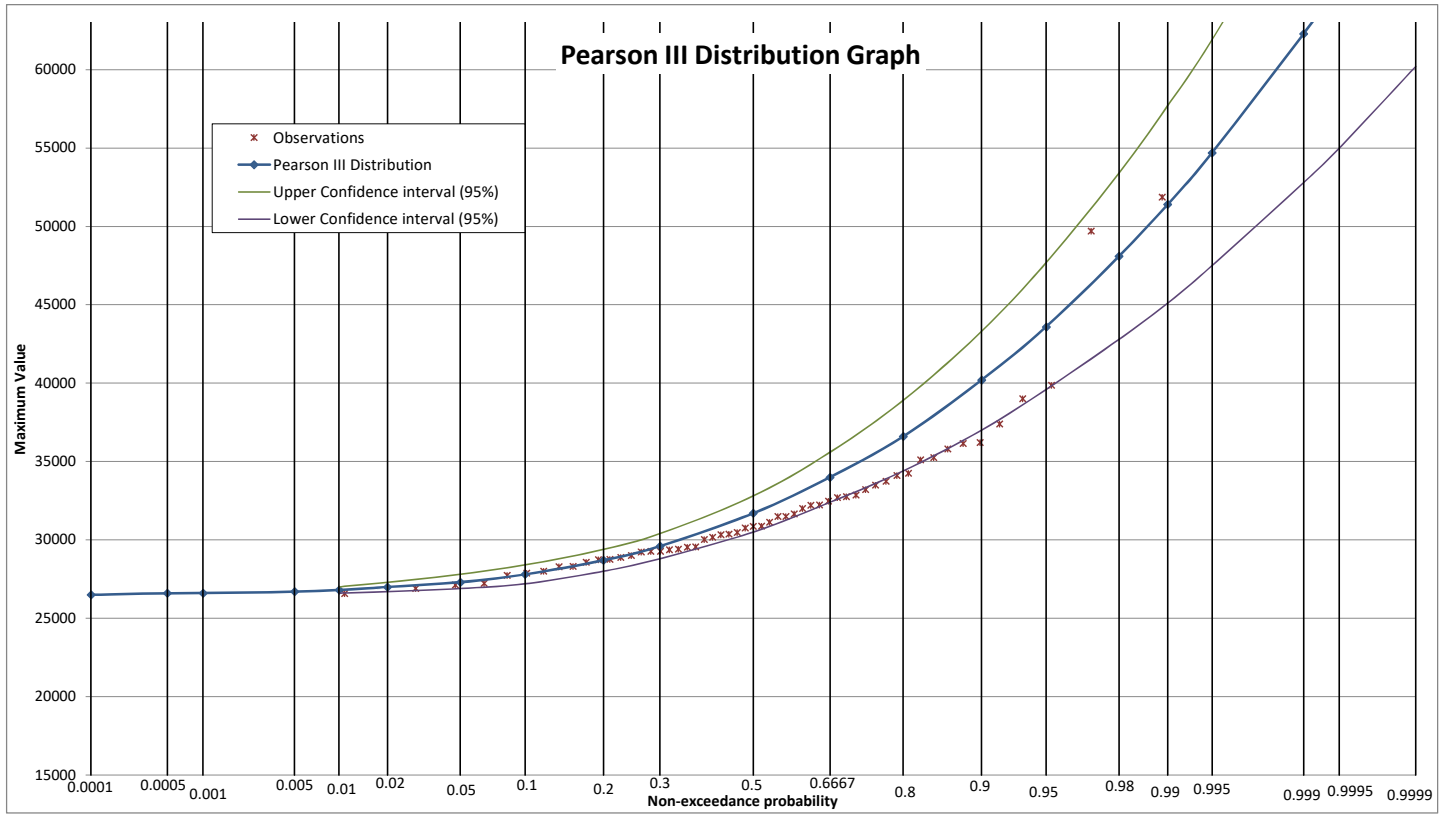
Log Normal Distribution
Visual Goodness-of-Fit Test Notes:



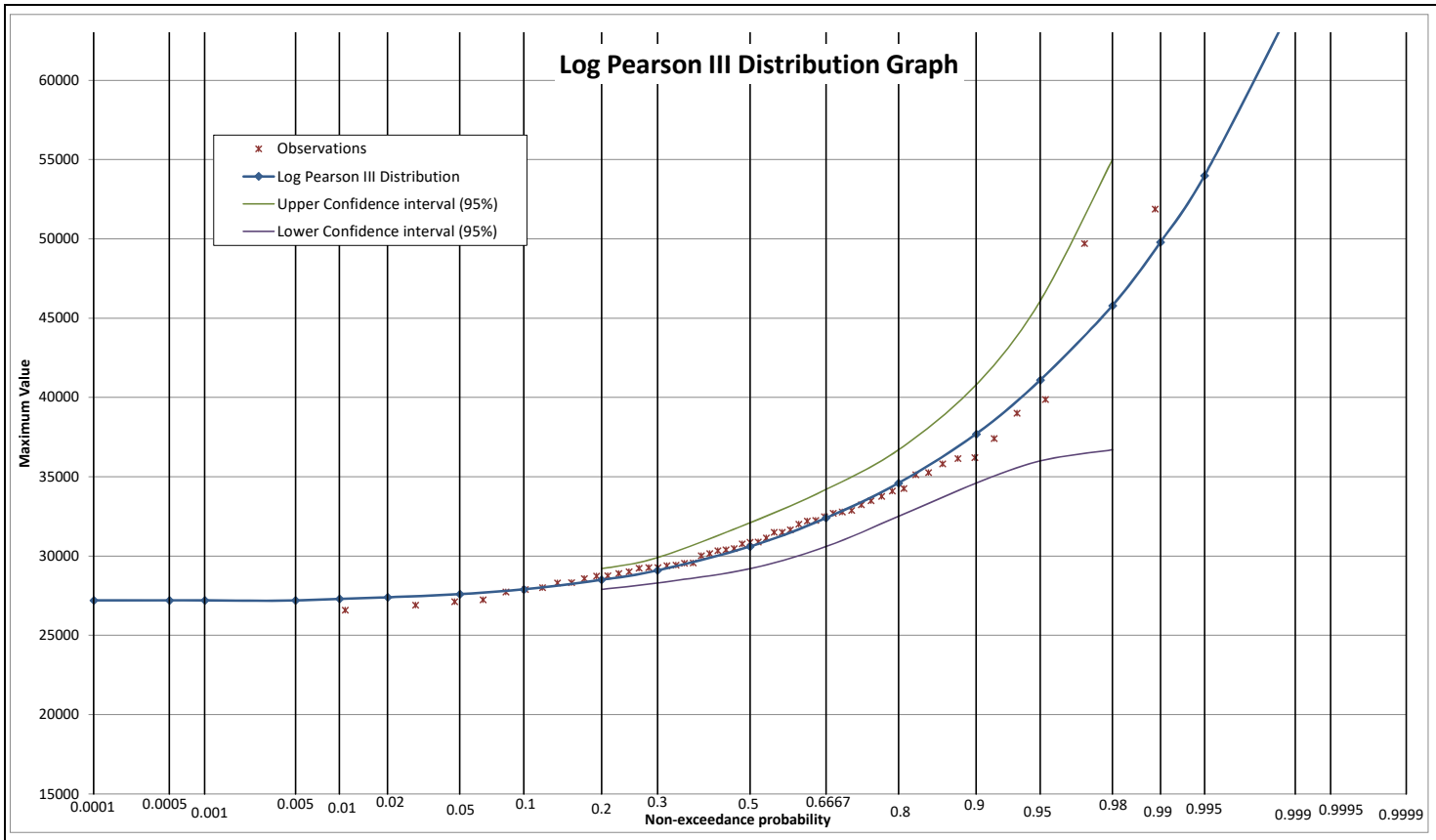
Log Normal III Distribution
Visual Goodness-of-Fit Test Notes:



Exponential Distribution
Visual Goodness-of-Fit Test Notes:



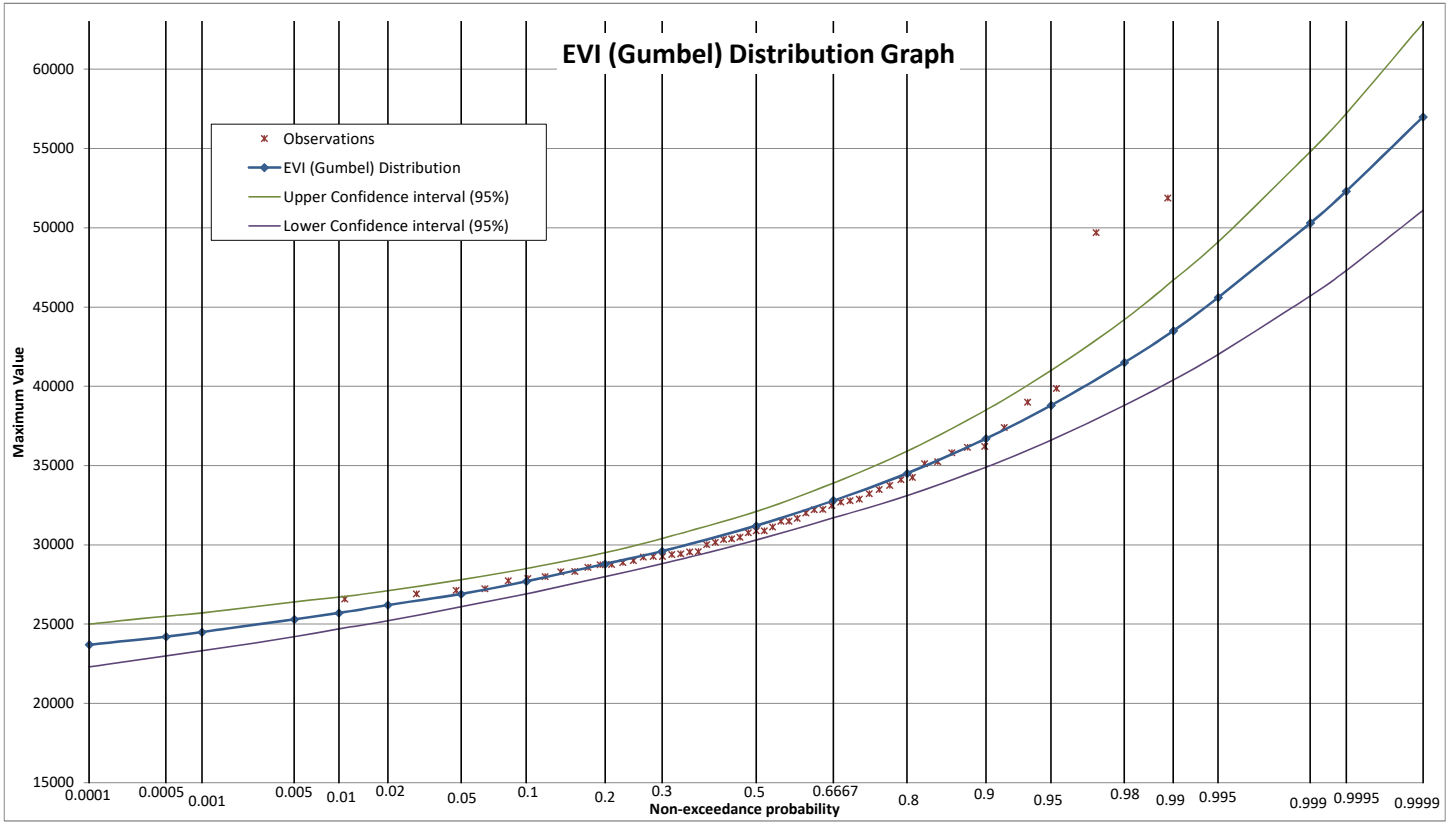
Pearson III Distribution
Visual Goodness-of-Fit Test Notes:



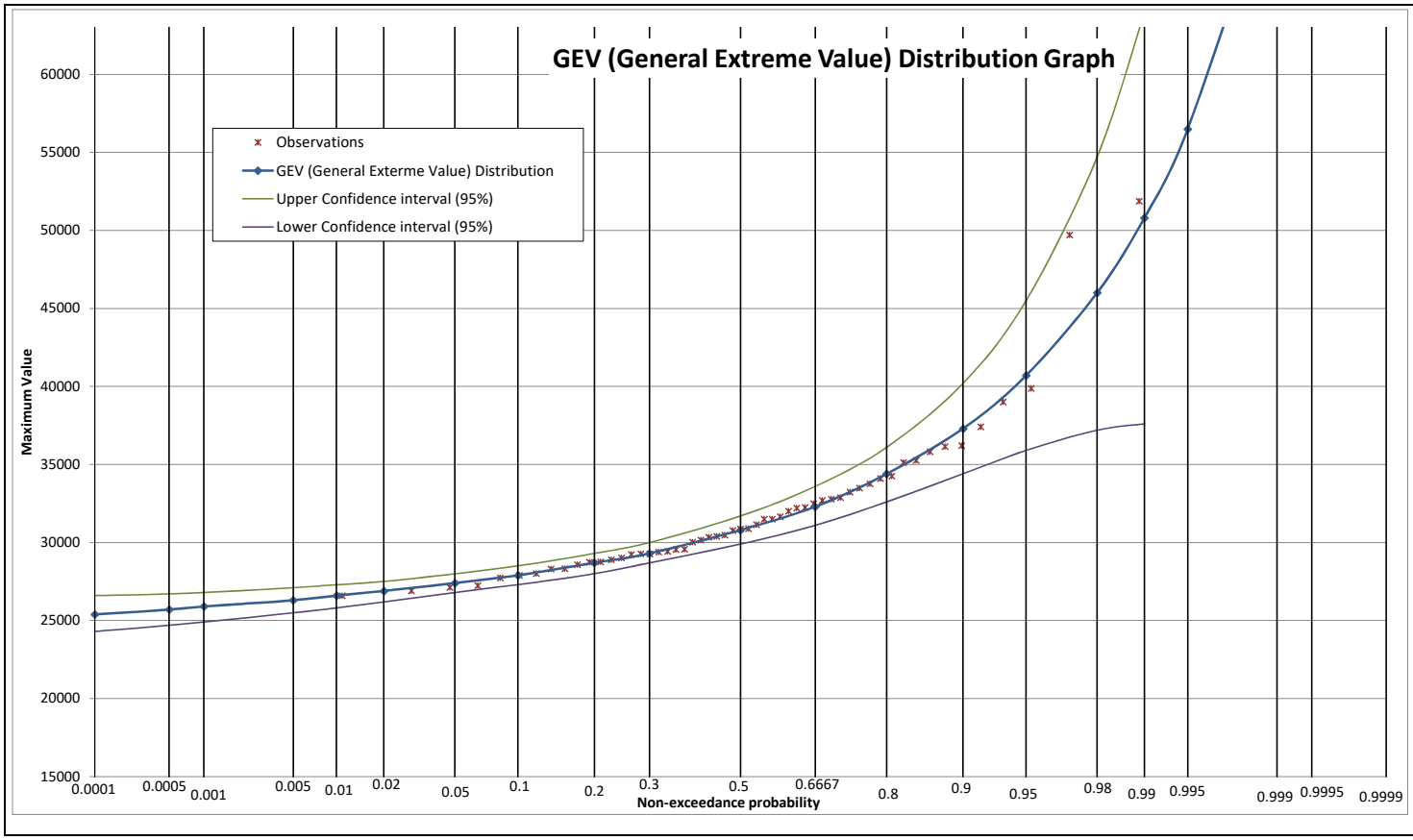
Log Pearson III Distribution Visual Goodness-of-Fit Test Notes:

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

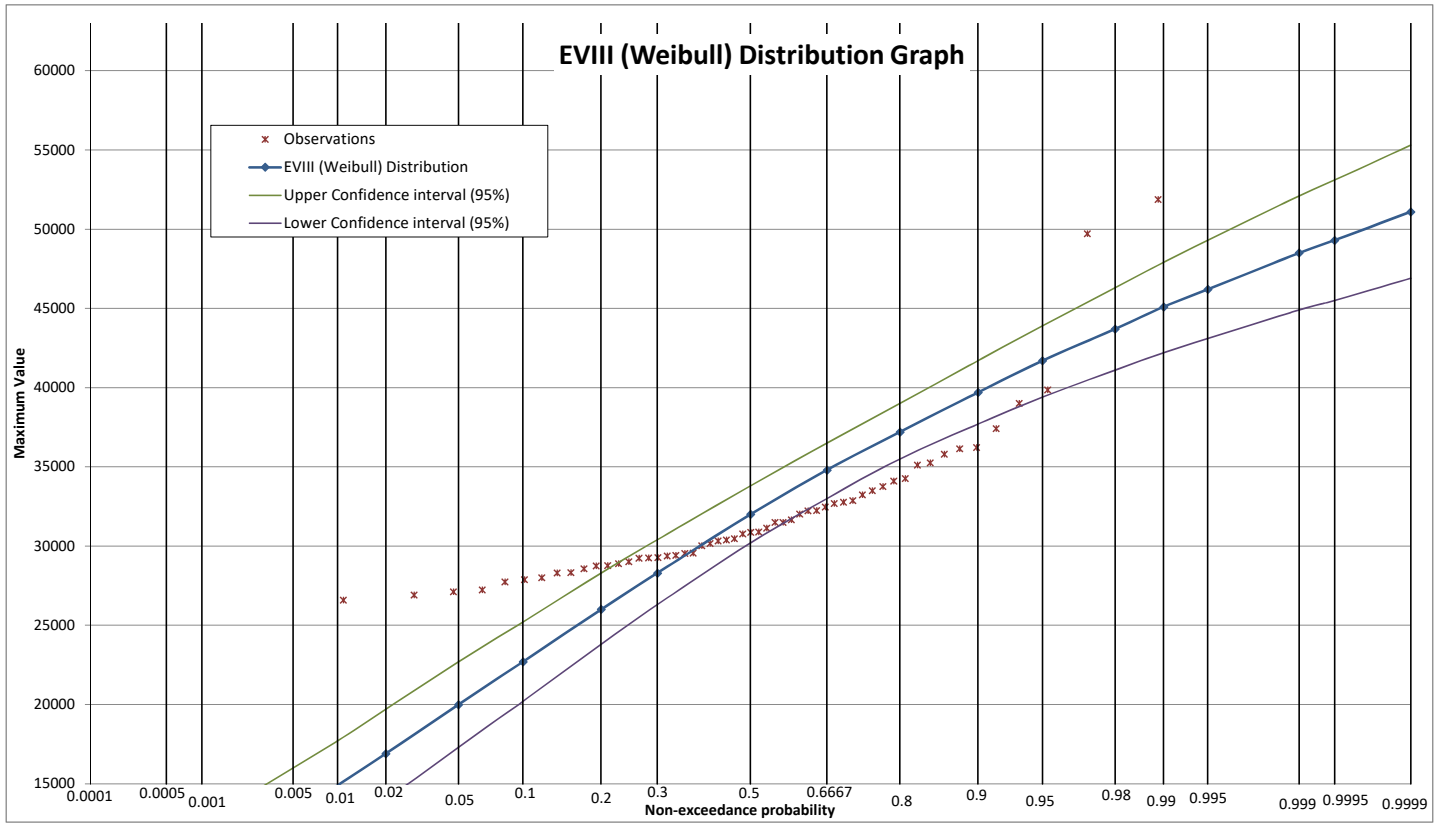
Lambda shape test
Pass
Alpha shape test
Pass



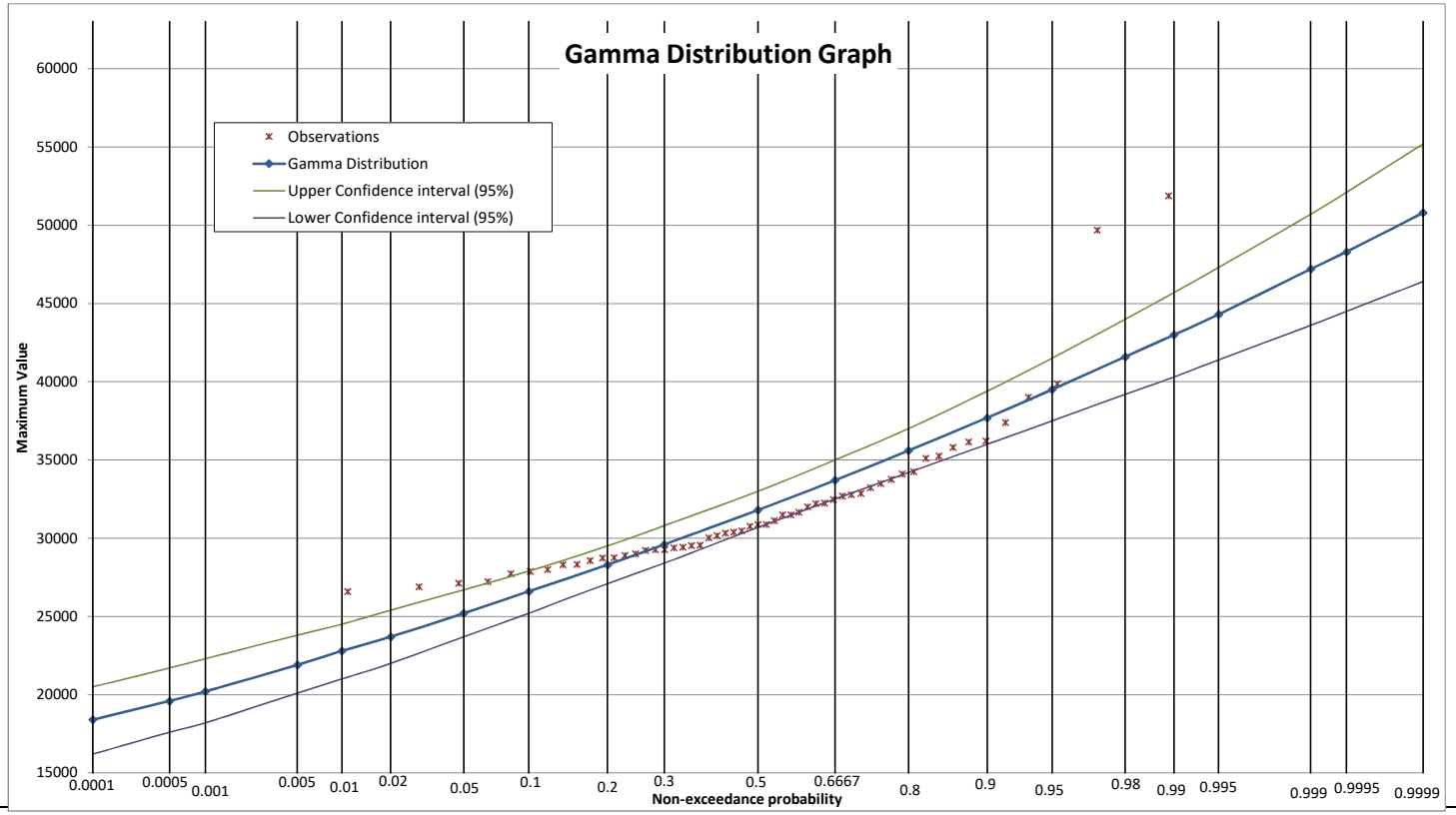
EVI (Gumbel) Distribution
Visual Goodness-of-Fit Test Notes:



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	2.830	Reject H0	9
Lognormal	1.929	2.502	3.907	1.683	Accept H0	6
Lognormal III	1.929	2.502	3.907	0.146	Accept H0	2
Exponential	1.929	2.502	3.907	1.776	Accept H0	7
Pearson III	1.929	2.502	3.907	1.273	Accept H0	5
Log Pearson III	1.929	2.502	3.907	1.172	Accept H0	4
Gumbel	1.929	2.502	3.907	0.436	Accept H0	3
GEV	1.929	2.502	3.907	0.109	Accept H0	1
Weibull	1.929	2.502	3.907	4.944	Reject H0	10
Gamma	1.929	2.502	3.907	2.016	Accept H0	8

*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	0.137	Accept H0	8
Lognormal	0.165	0.183	0.220	0.101	Accept H0	5
Lognormal III	0.165	0.183	0.220	0.042	Accept H0	2
Exponential	0.165	0.183	0.220	0.154	Accept H0	9
Pearson III	0.165	0.183	0.220	0.113	Accept H0	7
Log Pearson III	0.165	0.183	0.220	0.088	Accept H0	4
Gumbel	0.165	0.183	0.220	0.067	Accept H0	3
GEV	0.165	0.183	0.220	0.039	Accept H0	1
Weibull	0.165	0.183	0.220	0.221	Reject H0	10
Gamma	0.165	0.183	0.220	0.113	Accept H0	6

Least Squares Ranking

Distribution Type:	Standard Error	Rank
Normal	2371	9
Lognormal	2017	7
Lognormal III	1065	4
Exponential	1240	5
Pearson III	1020	3
Log Pearson III	957	2
Gumbel	1775	6
GEV	910	1
Weibull	3637	10
Gamma	2108	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**

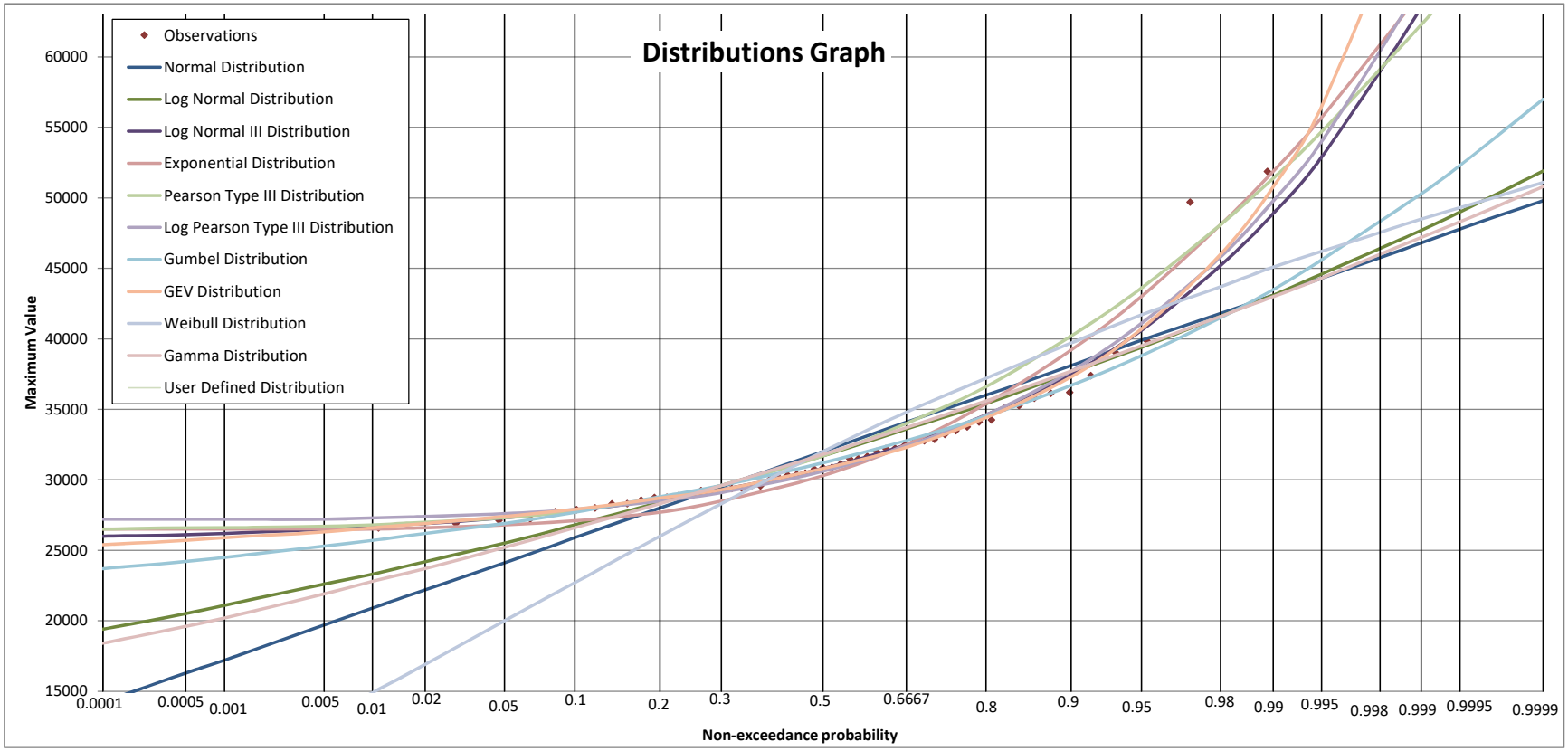
Sampling and Distribution Uncertainty

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	36000

Sampling Uncertainty at (95%) Confidence Interval ±	1450
Distribution Uncertainty ±	275
Total Uncertainty ±	1730



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:	Ascension Development
Project Description:	Residential Development - Constructed Wetland
Location:	Rocky View County
Date:	2020-08-26
Designed by:	Luis Gerardo 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	8	9	8.67	9			
Lognormal	6	5	7	6.00	6			
Lognormal III	2	2	4	2.67	2			
Exponential	7	9	5	7.00	7			
Pearson III	5	7	3	5.00	5			
Log Pearson III	4	4	2	3.33	3			
Gumbel	3	3	6	4.00	4			
GEV	1	1	1	1.00	1			
Weibull	10	10	10	10.00	10			
Gamma	8	6	8	7.33	8			

Selected Distribution and Results

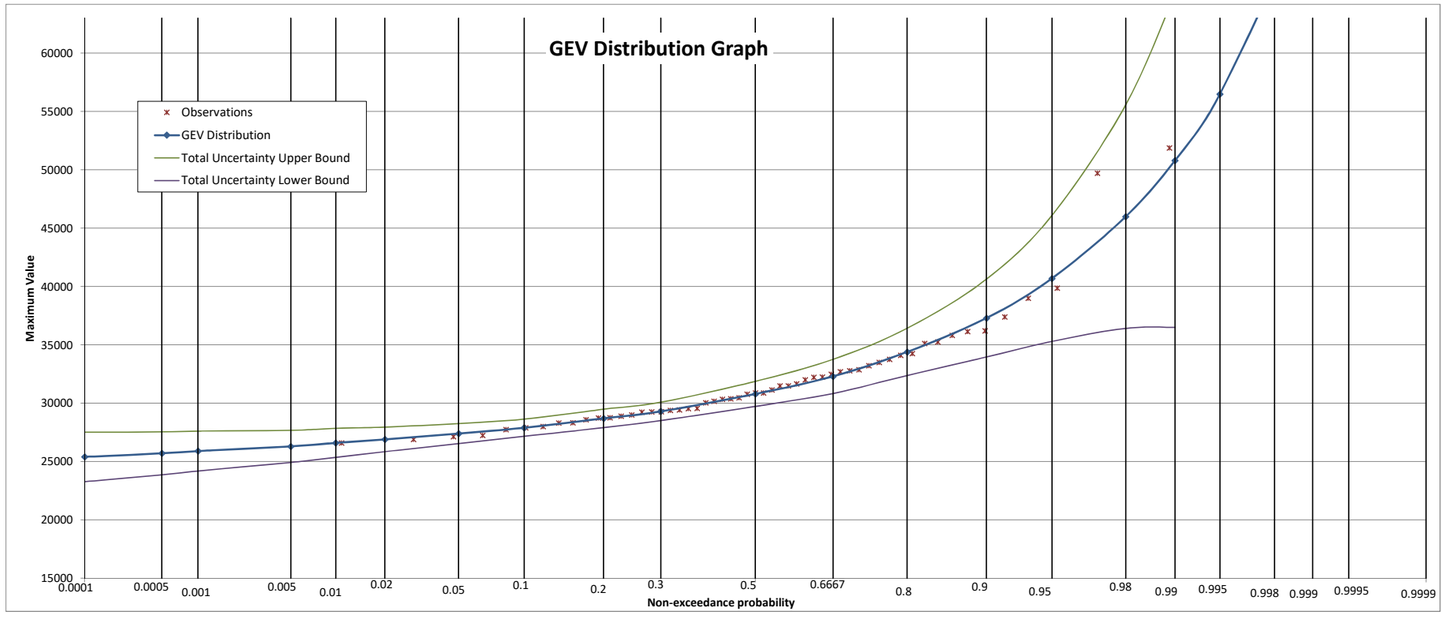
Distribution type chosen based on visual and numerical goodness-of-fit tests:	GEV

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

Return Period	Probability	Magnitude	Total Uncertainty (Upper Bound)	Total Uncertainty (Lower Bound)
10000	0.9999	113000	#N/A	#N/A
2000	0.9995	83400	#N/A	#N/A
1000	0.9990	73700	#N/A	#N/A
500	0.9980	65500	#N/A	#N/A
200	0.9950	56500	#N/A	#N/A
100	0.9900	50800	65100	36500
50	0.9800	46000	55600	36400
20	0.9500	40700	46100	35300
10	0.9000	37300	40600	34000
5	0.8000	34400	36400	32400
3	0.6667	32300	33800	30800
2	0.5000	30800	31900	29700
1.4286	0.3000	29300	30100	28500
1.25	0.2000	28700	29500	27900
1.1111	0.1000	27900	28600	27200
1.0526	0.0500	27400	28300	26500
1.0204	0.0200	26900	28000	25900
1.0101	0.0100	26600	27900	25400
1.005	0.0050	26300	27700	24900
1.001	0.0010	25900	27600	24200
1.0005	0.0005	25700	27500	23900
1.0001	0.0001	25400	27500	23300

*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
CDF based on parameters does not match Pearson III distribution
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 E

Oil/Grit Separators

rainwater MANAGEMENT

To: LGN Consulting Engineering
From: Rainwater Management
Date: 28-Aug-20

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

Re: Ascension Lands - SF-1

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
8.50	43%	3035-6	95%	91%

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)
595	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. 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)
8.50	10	400	43%	91%	13,342

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
13,342	95%	0.444	5,650	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
3035-6	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.

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.



28/08/2020

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	73	49	62	51	106	129	80	59	74	87	82	94	1
2	364	181	115	198	200	376	208	159	257	291	167	280	2
3	218	187	210	200	347	436	289	194	220	299	351	274	3
4	116	178	152	177	285	484	168	182	244	436	228	199	4
5	234	117	128	300	535	722	454	147	198	366	226	239	5
6	451	136	95	217	350	615	170	83	321	394	236	501	6
7	139	182	94	281	185	368	352	141	189	325	114	278	7
8	215	156	213	325	324	535	317	54	186	378	458	159	8
9	62	62	90	275	246	275	368	149	185	307	180	62	9
10	133	70	137	268	167	506	367	165	70	241	304	402	10
11	113	150	150	186	189	76	224	113	153	186	149	297	11
12	126	43	126	205	331	207	332	81	84	208	84	82	12
13	136	137	91	316	179	271	314	44	225	272	44	45	13
14	97	48	0	97	99	144	444	96	146	289	98	95	14
15	156	156	53	207	106	314	207	104	156	523	158	205	15
16	56	224	57	56	170	164	0	112	221	165	54	56	16
17	59	176	117	177	120	181	59	59	296	410	0	240	17
18	190	0	65	65	316	62	253	315	380	380	64	126	18
19	0	65	65	0	68	533	0	66	398	201	135	66	19
20	141	70	70	140	72	277	212	142	0	138	69	68	20
22	608	148	454	226	219	305	153	76	151	309	304	448	22
25	765	513	428	504	435	344	173	408	84	423	164	344	25
30	1587	198	290	495	595	713	884	95	582	399	0	898	30
40	1066	1232	111	1235	665	2215	544	374	793	694	369	1064	40
50	329	1433	459	1599	469	499	2084	461	482	601	653	160	50
60	198	381	579	966	196	0	363	0	758	1499	376	197	60
75	0	1200	490	0	978	460	723	218	231	0	263	251	75
100	617	935	680	585	0	1462	0	0	0	0	948	897	100
214	0	1017	0	760	0	964	0	370	528	400	403	400	214
328	0	1018	0	788	1031	0	0	0	0	0	1908	0	328
442	0	0	0	0	0	1229	0	0	0	0	1261	0	442
556	0	0	0	0	0	0	0	0	0	0	0	0	556
670	0	0	0	0	0	0	0	0	0	0	0	0	670
670 +	0	0	0	0	0	0	0	0	0	0	0	0	670 +
Total Runoff	**8247**	**10461**	**5581**	**10898**	**8982**	**14867**	**9742**	**4467**	**7612**	**10221**	**9849**	**8428**	**Total Runoff**

Annual Runoff/Year in Cubic Meters

1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	Flow l/s
116	95	77	97	92	79	137	76	98	95	123	56	101	1
287	294	174	272	287	281	308	150	196	335	280	178	261	2
344	288	216	315	317	241	339	199	343	236	282	112	192	3
265	233	175	272	317	374	433	179	198	341	224	316	266	4
146	340	247	300	319	258	386	64	232	321	223	83	338	5
217	298	318	140	333	294	242	120	195	392	234	79	325	6
489	211	136	468	371	304	520	182	213	402	278	185	420	7
183	240	264	157	243	242	428	106	219	211	270	53	243	8
154	248	368	341	153	152	277	187	152	302	397	124	209	9
342	68	166	203	309	413	238	103	275	235	271	104	134	10
187	260	115	228	225	227	304	112	340	190	230	228	77	11
366	81	83	285	250	368	493	82	328	294	120	165	40	12
136	45	92	90	137	44	266	0	272	223	268	88	176	13
48	245	148	344	292	191	393	0	146	628	247	143	49	14
154	0	104	153	311	157	574	160	51	363	0	159	209	15
503	336	56	113	163	227	498	56	223	279	55	223	383	16
176	176	122	60	177	176	419	60	0	176	296	413	177	17
125	192	64	126	64	375	629	0	126	188	63	0	189	18
265	132	0	0	134	66	267	0	134	131	134	68	201	19
0	280	139	138	210	69	281	0	70	139	70	0	283	20
0	531	0	225	224	304	446	153	309	230	374	302	381	22
421	673	176	251	339	163	514	254	592	603	342	86	257	25
1149	678	508	306	295	680	474	605	497	958	492	91	868	30
1268	730	933	679	778	864	1528	618	949	773	1477	768	859	40
668	316	164	152	1502	339	325	330	1229	627	470	463	461	50
183	185	379	0	587	394	374	386	1181	2278	187	376	597	60
250	447	1168	250	436	258	0	479	939	937	0	0	0	75
629	0	0	278	0	1161	0	643	891	322	318	311	0	100
1983	0	1240	809	0	374	382	0	0	455	1198	0	0	214
0	0	0	0	0	0	0	0	0	0	0	0	0	328
0	0	0	0	0	0	0	0	0	0	0	0	0	442
0	0	0	0	0	0	0	0	0	0	0	0	0	556
0	0	0	0	0	0	0	0	0	0	0	0	0	670
0	0	0	0	0	0	0	0	0	0	0	0	0	670 +
11053	**7622**	**7632**	**7052**	**8864**	**9073**	**11474**	**5303**	**10400**	**12664**	**8923**	**5171**	**7699**	**Total Runoff**

Annual Runoff/Year in Cubic Meters

1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	Flow l/s
100	93	94	115	163	92	70	112	97	103	100	149	73	1
322	218	212	342	261	355	201	372	290	304	371	243	265	2
274	260	230	305	541	256	325	383	289	237	232	751	168	3
250	175	192	115	253	108	167	276	245	356	472	378	269	4
209	330	207	196	243	342	128	559	385	446	489	385	258	5
121	196	138	316	195	195	201	319	158	197	258	237	329	6
392	569	114	143	333	208	161	254	789	419	374	499	235	7
242	445	187	190	166	214	189	190	540	602	192	236	187	8
306	534	218	61	184	187	183	151	352	150	91	307	95	9
170	171	267	66	208	104	306	171	103	170	372	137	863	10
74	187	77	303	153	192	187	227	262	150	546	224	191	11
124	82	290	251	166	121	122	209	206	410	167	292	249	12
134	137	269	138	134	269	320	90	225	0	443	264	136	13
48	145	146	244	196	98	96	342	195	146	390	142	196	14
158	260	212	260	52	104	53	467	208	206	155	107	53	15
110	110	224	167	54	223	166	283	56	0	114	54	277	16
240	240	238	118	118	120	0	295	119	60	236	0	359	17
126	0	127	187	0	126	126	189	125	0	497	64	318	18
65	67	199	464	201	269	201	270	200	66	0	66	401	19
0	282	142	142	0	68	0	418	69	142	352	0	415	20
368	152	150	147	443	454	292	302	152	79	72	0	156	22
341	501	343	340	423	515	668	337	683	497	0	413	165	25
0	826	573	1070	376	397	186	571	844	389	209	497	480	30
1125	751	1137	1401	673	739	1026	1340	989	360	0	252	1501	40
824	1783	493	754	151	528	812	961	331	628	0	634	811	50
403	1770	376	993	0	181	771	388	213	214	0	207	0	60
946	706	269	1150	921	217	972	489	1203	0	697	225	216	75
284	620	0	0	0	1263	299	322	294	0	0	0	345	100
1416	0	996	0	361	0	866	1168	0	812	1567	0	394	214
0	0	0	0	0	0	0	0	795	0	0	0	1047	328
0	0	0	0	0	0	0	0	0	0	0	0	0	442
0	0	0	0	0	0	0	0	0	0	0	0	0	556
0	0	0	0	0	0	0	0	0	0	0	0	0	670
0	0	0	0	0	0	0	0	0	0	0	0	0	670 +
9173	**11608**	**8121**	**9979**	**6970**	**7947**	**9095**	**11456**	**10417**	**7143**	**8395**	**6764**	**10453**	**Total Runoff**

Annual Runoff/Year in Cubic Meters

1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
92	118	124	77	103	105	95	95	79	92	114	63
279	435	184	137	254	200	215	212	263	286	321	286
344	321	264	326	387	347	263	280	250	296	303	229
336	441	409	372	212	252	191	274	186	286	503	142
348	324	147	213	193	275	268	181	250	247	579	289
339	781	234	120	273	339	200	155	280	445	479	236
257	648	210	164	210	281	135	190	240	254	524	187
162	643	267	303	134	376	107	300	189	161	408	359
366	59	302	217	181	644	149	90	90	274	335	31
373	276	171	136	169	335	308	380	68	366	408	135
191	151	74	298	222	190	185	228	188	188	223	37
292	247	207	287	248	211	246	167	167	165	250	167
180	176	135	135	224	311	273	268	175	182	274	134
97	199	341	48	98	340	198	343	98	343	243	98
420	106	512	210	51	157	314	359	0	208	315	51
168	164	171	55	57	167	109	165	57	275	167	56
116	0	176	120	356	235	120	533	236	119	178	178
126	0	315	190	248	63	127	126	62	0	192	188
266	0	135	199	0	134	135	135	135	201	0	65
211	72	69	72	72	0	139	210	211	70	141	0
223	76	381	149	149	223	224	525	524	378	298	0
773	862	409	85	257	424	169	83	675	521	175	0
1074	304	412	768	302	300	509	895	397	690	396	93
2423	1451	685	371	586	704	121	1627	1029	1213	2011	115
479	0	928	317	150	459	314	179	939	836	641	0
828	1584	381	392	408	414	0	0	611	638	582	202
1710	246	526	0	224	1225	701	1920	468	1515	0	769
949	0	280	949	0	585	1748	2130	281	0	306	588
807	787	1102	0	875	361	490	0	2073	1013	914	708
0	0	0	862	0	0	0	2586	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	2312	0	0
0	0	0	0	0	0	0	0	0	0	0	0
14229	**10471**	**9549**	**7571**	**6642**	**9658**	**8053**	**14635**	**10219**	**13572**	**11278**	**5406**

TSS Removal	
Year	Removal
1960	96%
1961	93%
1962	93%
1963	95%
1964	96%
1965	95%
1966	95%
1967	97%
1968	96%
1969	97%
1970	94%
1971	95%
1972	95%
1973	97%
1974	95%
1975	97%
1976	96%
1977	95%
1978	97%
1979	94%
1980	94%
1981	95%
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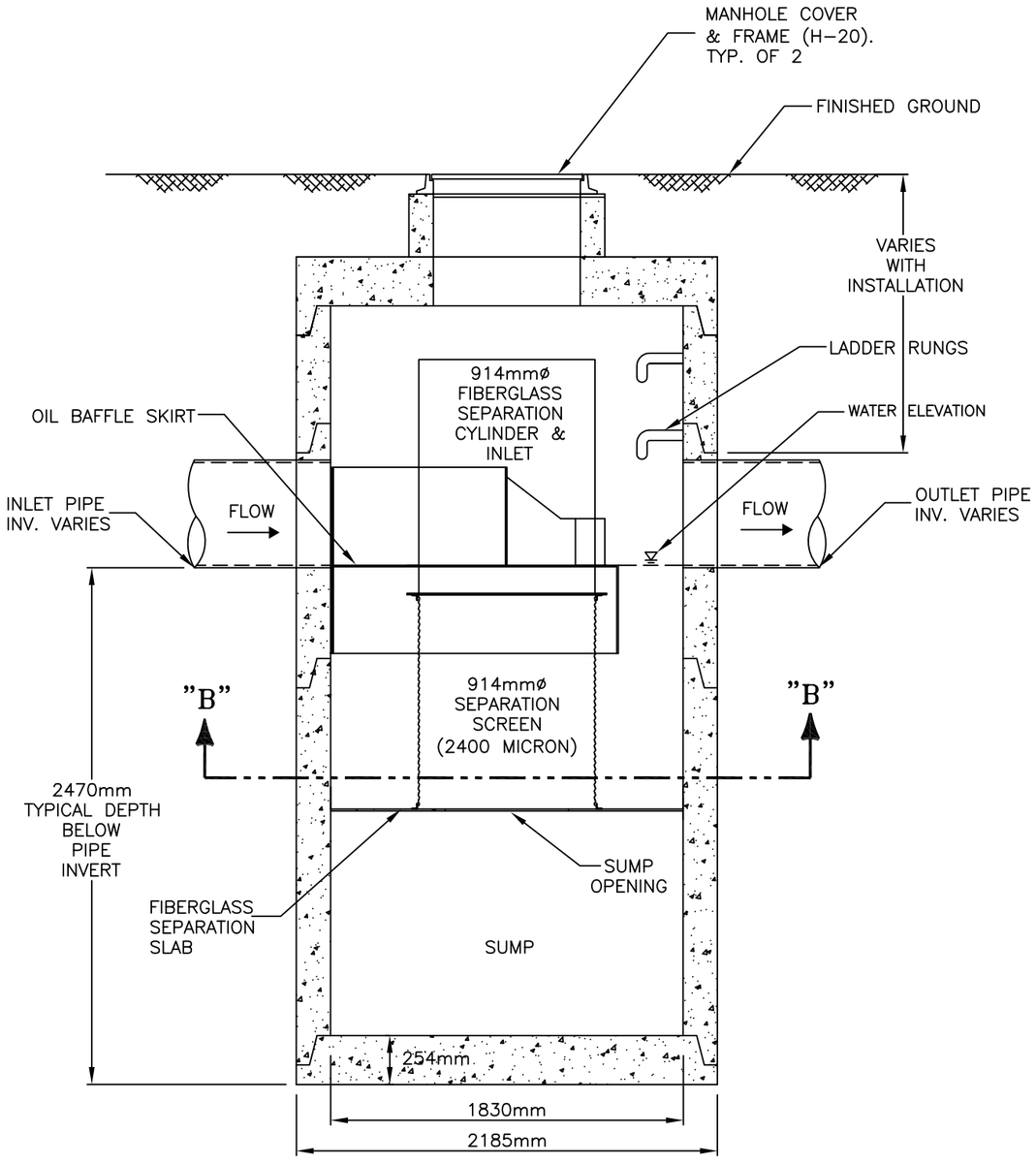
1995	98%
1996	97%
1997	96%
1998	94%
1999	96%
2000	96%
2001	95%
2002	97%
2003	95%
2004	94%
2005	93%
2006	95%
2007	95%
2008	96%
2009	94%
Average	**95%**

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	90%
1992	90%
1993	92%
1994	89%
1995	81%
1996	100%
1997	86%
1998	94%
1999	92%
2000	88%
2001	89%
2002	87%
2003	96%
2004	94%
2005	82%
2006	80%
2007	76%
2008	92%
2009	87%
Average	**91%**

ETV Particle Size Distribution:

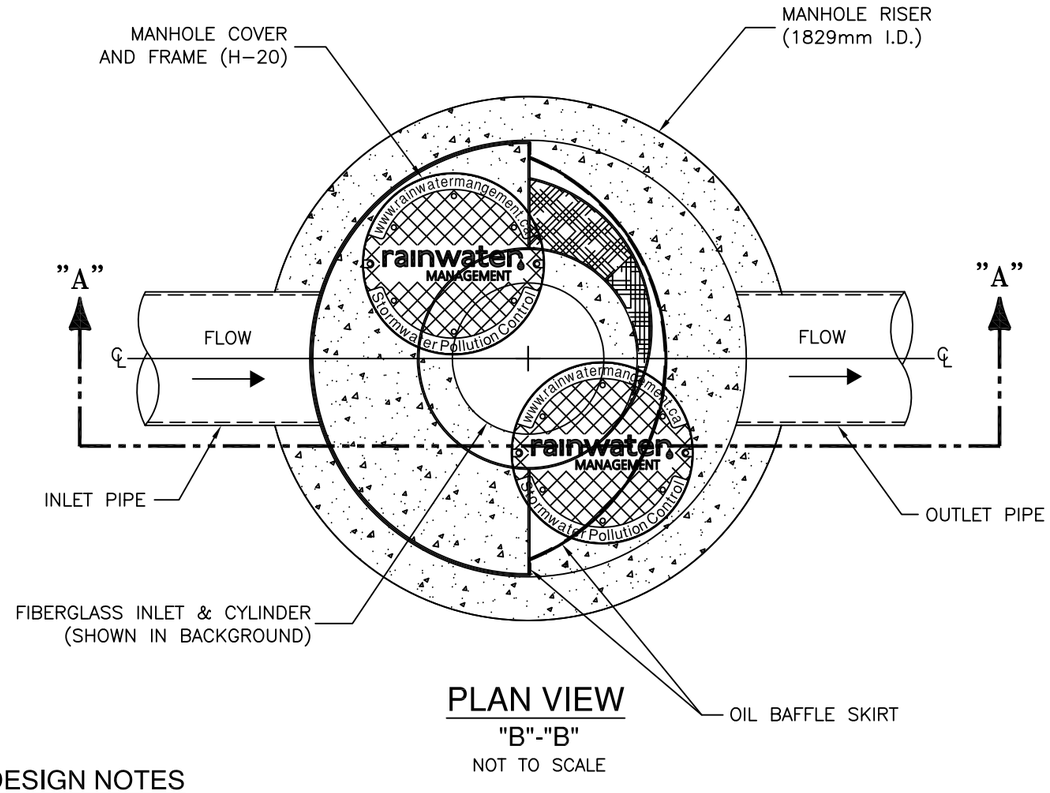
Particle Size Fraction (um)	Percent
500-1000	5
250-500	5
150-250	15
100-150	15
75-100	10
50-75	5
20-50	10
8-20	15
5-8	10
2-5	5
<2	5



ELEVATION VIEW

"A"-"A"

NOT TO SCALE



PLAN VIEW

"B"-"B"

NOT TO SCALE

DESIGN NOTES

1. THE STANDARD CDS3035 CONFIGURATION IS SHOWN. ALTERNATE CONFIGURATIONS ARE AVAILABLE, PLEASE CONTACT RAINWATER MANAGEMENT. SOME CONFIGURATIONS MAY BE COMBINED TO SUIT SITE REQUIREMENTS.
2. THE CDS UNIT CAN HANDLE MULTIPLE INLET PIPES AND CAN ACCOMODATE INLET PIPES AT AND 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. CDS 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 CDS 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.

CONTECH STORMWATER SOLUTIONS

CDS™ TECHNOLOGIES

SITE SPECIFIC DATA REQUIREMENTS FOR CDS3035

STRUCTURE ID		PIPE DATA:	I.E.	MATERIAL	DIAMETER	ANIT-FLOTATION BALLAST	WIDTH	HEIGHT
WATER QUALITY FLOW RATE (L/S)	*	INLET PIPE 1	*	*	*		*	*
PEAK FLOW RATE (L/S)	*	INLET PIPE 2	*	*	*	NOTES / SPECIAL REQUIREMENTS		
RETURN PERIOD OF PEAK FLOW (YRS)	*	OUTLET PIPE	*	*	*			
SCREEN APERTURE (2400)	*	RIM ELEVATION			*	* PER ENGINEER OF RECORD		

rainwater MANAGEMENT
www.rainwatermanagement.ca
TEL : 604–944–9265

CDS3035
INLINE CDS
STANDARD DETAIL

Plotted: