ASCENSION

STAGED MASTER DRAINAGE PLAN

Prepared for:

HIGHFIELD
LAND MANAGEMENT

Prepared by:

LGN Consulting Engineering Ltd.
stormwater and water resources management

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TABLE OF CONTENTS

LIST OF TABLES ... IV

LIST OF FIGURES ... V

1.0 INTRODUCTION ... 1
- 1.1 GENERAL ... 1
- 1.2 STUDY AREA ... 1
- 1.3 TOPOGRAPHY ... 1
- 1.4 SCOPE OF ANALYSIS ... 2

2.0 PRE-DEVELOPMENT HYDROLOGIC ASSESSMENT ... 3
- 2.1 METHODOLOGY ... 3
- 2.2 DATA SOURCES ... 3
- 2.3 PRE-DEVELOPMENT STUDY AREA ... 3
- 2.4 DRAINAGE PATTERNS ... 4
- 2.5 CLIMATE DATA AND DESIGN STORM ... 4
- 2.6 MODEL DEVELOPMENT ... 5
- 2.7 PCSWMM PEAK RUNOFF RATE ... 5
- 2.8 MODEL RESULTS ... 5
  - *Pre-development Peak Runoff Rate ... 5*

3.0 PROPOSED DRAINAGE STRATEGIES AND DESIGN CRITERIA ... 7
- 3.1 RELATED REPORTS ... 7
- 3.2 DRAINAGE STRATEGIES ... 7
- 3.3 GEOTECHNICAL CONSIDERATIONS ... 7
- 3.4 DESIGN CHARACTERISTICS FOR THE MAJOR AND MINOR SYSTEMS ... 8
  - *Minor System ... 9*
  - *Major System ... 9*
- 3.5 SOURCE CONTROL BEST MANAGEMENT PRACTICES ... 10
- 3.6 STORMWATER QUALITY ENHANCEMENT ... 10
- 3.7 BIOPHYSICAL IMPACT ASSESSMENT ... 11

4.0 POST-DEVELOPMENT HYDROLOGIC AND HYDRAULIC ANALYSIS ... 14
  - *Single Storm Event Analysis ... 14*
  - *Continuous Simulation ... 14*
- 4.1 COMPUTER MODEL ... 14
- 4.2 POST-DEVELOPMENT SUBCATCHMENTS ... 14
- 4.3 INFILTRATION ... 16
- 4.4 SNOW MELT ... 17
- 4.5 EVAPORATION ... 17
- 4.6 STORAGE ROUTING ... 17
- 4.7 SEDIMENT REMOVAL ANALYSIS ... 18
- 4.8 WATER FOR WETLAND TO BE RETAINED ... 19

5.0 DESIGN DETAILS ... 20
- 5.1 POND LAYOUT ... 20
- 5.2 OUTLET CONTROL STRUCTURE ... 21
- 5.3 EMERGENCY OVERFLOW ... 21
- 5.4 FREQUENCY OF PONDING ... 22

5.5 POST-DEVELOPMENT PEAK RUNOFF RATE 22
5.6 RUNOFF VOLUME DISCHARGES 23
5.7 WATER BALANCE 23
5.8 WATER QUALITY 23
5.9 STORM POND SEDIMENT REMOVAL 24
5.10 FOREBAY SIZING 24

6.0 CONCLUSIONS AND RECOMMENDATIONS 26

REFERENCES 28

APPENDICES

Appendix A Geotechnical Data

Appendix B PCSWMM Existing Conditions Analysis
- Schematic
- Input & Report Files

Appendix C PCSWMM Post-development Analysis
- Input Parameters
- Schematic
- Input & Report Files

Appendix D Frequency Analysis

Appendix E Oil/Grit Separator

LIST OF TABLES

Table 1 - Land Cover Imperviousness Values 3
Table 2 – Pre-development Sub-Catchment Parameters 4
Table 3 – Sandy Loam Infiltration Parameters 5
Table 4 - Peak Flow Results 6
Table 5 - Topsoil Composition 8
Table 6 – Sandy Loam Infiltration Parameters 8
Table 7 - Permissible Depths and Velocities for Overland Flows 9
Table 8 – Land Use Breakdown & Imperviousness 15
Table 9 – Post-development Sub-Catchment Shape Parameters 16
Table 10 – Existing Wetland Storage Rating Data 17
Table 11 – Proposed Dry Pond - Storage Rating Data 17
Table 12 – Proposed Constructed Wetland - Storage Rating Data 18
Table 13 - Pollutant Build-up Parameters 18
Table 14 - Pollutant Washoff Parameters 18
Table 15 - Settling Velocity Data 18
Table 16 – Dry Pond Characteristics 20
Table 17 – Constructed Wetland Characteristics 21
Table 18 – Frequency of Total Storage Volumes 22
Table 19 - Peak Flow Results 22
Table 20 - Average Annual Runoff Volumes 23
Table 21 – Water Balance 23
Table 22 - Pond Sediment Removal Efficiency 24
Table 23 - West Inlet Forebay Sizing 24
Table 24 – East inlet Forebay Sizing 25

LIST OF FIGURES

Figure 1 - Location Plan 29

Figure 2 - Study Area 30

Figure 3 – Land Use Concept Plan 31

Figure 4 – Pre-development Contours 32

Figure 5 – Pre-Development Sub-Catchments 33

Figure 6 – Regional Storm Plan 34

Figure 7 – Internal Storm Plan 35

Figure 8 – Post-development Catchments 36

Figure 9 – Dry Pond Design 37

Figure 10 – Dry Pond Preliminary Cross-Section 38

Figure 11 – Dry Pond Preliminary Outlet Control Structure 39

Figure 12 – Constructed Wetland Preliminary Design 40

Figure 13 – Constructed Wetland Preliminary Cross-section 41

Figure 14 – Constructed Wetland Preliminary Outlet Control Structure 42

Figure 15 - SWMFs Annual Water Levels 43

Figure 16 - SWMFs Frequency Distribution 44

Figure 17 - Pre vs Post-development Wetland hydroperiods 45

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.
- Westhoff Engineering Resources, Inc.; Master Drainage Plan for Watermark at Bearspaw; July 2010.
- Westhoff Engineering Resources, Inc.; Stormwater Pond Report for Watermark Phase 1 Ponds C and D; March 2011.
- Exp Services Inc.; Amendment Watermark Phase 1 Ponds C and D; May 2012.
- 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 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 and **Figure 3** shows the proposed Land Use Concept Plan provided by B&A Studios (**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 (±) in the north to 1182 (±) in 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 are also assessed. All these must meet Alberta ESRD and Rocky View County requirements.

Activities performed in preparation for this analysis:

- Outline pre-development sub-catchment boundaries.
- Hydrologic model to establish pre-development flows and wetland hydroperiods.
- Establish post-development drainage boundaries and catchment areas draining to each SWMF.
- Hydrologic modelling to estimate the runoff and water quality from the study catchment area utilizing both single and continuous computer simulation modelling.
- Hydraulic modelling to estimate stormwater storage volume required and anticipated operation of the SWMF.
- Estimate anticipated Post-development average annual 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 have 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. The main purpose was to establish the pre-development peak discharge from the Ascension lands into the Blueridge residential development.

The following basic steps were taken in the analysis:

- Gather and review relevant background data.
- Review Rocky View County, City of Calgary and Province Guidelines for appropriate modelling 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 modelling.
- Land cover data was determined 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 topographical data, the pre-development study area was divided into 4 sub-catchments; 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 sub-catchments and **Table 2** lists the model sub-catchments 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 sub-catchment 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 modelling. 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 and 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 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 by 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-sections extracted from cross-sections and a 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 the key results of the hydrological analysis. The subsections below discuss two primary aspects of the results, namely, drainage courses and overland flow paths.

The results are reflective of the most accurate modelling capabilities readily available from the PC-SWMM modelling 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**

The peak discharge of interest is the discharge from sub-catchment B, the analysis estimates a peak discharge from Area B of 0.253 m3/s.

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.
- Westhoff Engineering Resources, Inc.; Master Drainage Plan for Watermark at Bearspaw; July 2010.
- Westhoff Engineering Resources, Inc.; Stormwater Pond Report for Watermark Phase 1 Ponds C and D; March 2011.
- Exp Services Inc.; Amendment Watermark Phase 1 Ponds C and D; May 2012.
- 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.
- IBI Group; Morton Development Staged Master Drainage Plan; July 2020.

3.2 Drainage Strategies

The analysis is based on the following assumptions:

- 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.
- Discharge from the development to be conveyed via existing overland infrastructure in the residential developments of Blueridge and Watermark and then via 12 Mile Coulee Road into the Bow River. This discharge system uses existing outlet BO-1 to discharge into the Bow River.

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 5 - 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 67**.

Table 6 – 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 the 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 the 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 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 analyzed 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 7**.

Table 7 - 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.

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

3.5 Source Control Best Management Practices

In the interest of an environmentally sensitive development, there is a range of alternative storm servicing concepts that can be considered in new developments. These concepts require an 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 the 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 a 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 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 the 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 1960 – 2014 (inclusive). The output of the continuous simulation modelling is peak storage volumes for each year analyzed in the model. Following, a frequency analysis of these annual 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 7.5.3406 Professional. PCSWMM is a software developed by Computer Hydraulics International and is a comprehensive, GIS-based, spatial decision support system for urban drainage and watershed modelling. Integrating the US EPA SWMM5 engine Version 5.1.015, it accounts for various hydrologic processes that produce runoff from urban and rural areas. PCSWMM also contains a flexible set of hydraulic modelling 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.

4.2 Post-development Subcatchments

The land use composition of the study area is listed in **Table 8** and the proposed development land use composition is presented in **Figure 3**.

Table 8 – Land Use Breakdown & Imperviousness

Land Use	Area (ha)	Imperviousness (%)
To Dry Pond		
Single Family lots	2.14	35
Front of Lots	1.92	65
Back of Lots	0.89	0
Roads	0.73	72
Municipal Reserve (MR)	1.16	0
Environmental Reserve (ER)	0.74	0
Dry Pond at HWL	0.19	100
Sub-Total	**7.77**	**35**
To Existing Wetland		
MR	0.33	0
ER	0.69	0
Country Residential Road	0.32	25
Wetland @ HWL	1.13	100
Sub-Total	**2.47**	**49**
To Constructed Wetland		
Country Residential (OS-1)	3.78	6
Country Residential (OS-2)	1.74	9
Single Family lots	33.58	51
Front of Lots	6.37	76
Back of Lots	1.01	25
Multi-family	1.13	65
Commercial	19.42	85
Roads	17.55	72
MR	6.67	0
ER	0.89	0
Pond at HWL	2.44	65
Sub-Total	**94.58**	**54**
Existing Areas		
North	37.79	3.7
Middle	5.79	0
South	13.70	0
Sub-Total	**57.28**	**2.4**
Study Area Total	**162.10**	**35**

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 sub-catchments. **Table 9** lists the model sub-catchments and the parameters used in the computer model.

Table 9 – Post-development Sub-Catchment Shape Parameters

Sub-Catchment Model ID	Area (ha)	Imperviousness (%)	Length (m)	Width (m)	Slope (%)
To Dry Pond					
SF-1	7.77	35	125	622	3
Directly to Natural Drainage Course					
N1	37.79	3.7	412	917	5
N2	5.79	0	100	579	3
N3	13.7	0	100	1370	8
Sub-Total	57.28	2			
To Wet Pond					
OS-1	3.78	6	100	378	5
OS-2	1.74	9	50	348	5
SF-2	13.99	50	125	1119	3
SF-3	45.66	46	125	3653	5
MF-Com	25.52	82	125	2042	2
Pond-ER	3.89	41	40	973	2
Sub-Total	94.58	56			
To Existing Wetland					
Wetland-ER	2.47	49.1	120	206	2
Total Study Area	162.10	35			

The length of each sub-catchment 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 the 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 road's 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 at 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).

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 the solution is based on the conservation of mass. This command requires that the user provide the outflow-storage relationship of the reservoir. **Table 10** summarizes the storage rating for the existing wetland and **Tables 11 and 12** summarizes the storage-discharge rating for the proposed SWMFs and

Table 10 – 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

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	1,194.50	1,265	0	0	0
	1,195.00	1,897	790	0	0
	1,195.50	3,556	2,028	0	0
	1,196.00	5,728	4,440	0	0
	1,196.50	7,250	7,681	0	0
	1,197.00	8,882	11,711	0	0
	1,197.50	11,112	16,645	0	0
NWL	1,198.00	15,788	23,352	0	0
	1,198.50	18,721	32,081	8,729	0.044
	1,199.00	20,588	41,907	18,555	0.065
	1,199.50	22,493	52,676	29,325	0.081
HWL	1,200.00	24,432	64,407	41,055	0.094

* Elevations to be confirmed during detail design

4.7 Sediment Removal Analysis

Water Quality modelling requires input data for pollutant *built-up*, pollutant *washoff* and pond *settling velocities*. **Tables 13 and 14** 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 15** 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 13 - 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 14 - 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 15 - 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, discharge from the constructed wetland. Water quality will be achieved a chain of three (3) water quality improvement methods; they are:

1. Oil/grit separators located at the first manhole upstream of the constructed wetland inlets.
2. Settling forebays at each inlet and,
3. The main body of the constructed wetland.

5.0 DESIGN DETAILS

The ponds proposed to control the discharge of runoff 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 development. This pond will be finished as a constructed wetland, in a way that blends with the existing wetland and the 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 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 first manhole upstream of the pond inlet pipe. Water quality for the discharge from the constructed wetland will be achieved first, by two (2) OGS units, each one installed at the first manhole upstream of each pond inlet, then by the forebays at each inlet and finally by 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 16 and 17** summarize the characteristics of the proposed SWMFs.

Table 16 – Dry Pond Characteristics

Parameter		Value	Unit
General	Contributing Catchment Area	7.77	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	**1,170.94**	**m**
	Freeboard Elevation	1,171.50	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)	992	m^3
	1:100 Year Active Volume (Continuous simulation)	**1,020**	**m^3**
Discharge	Maximum Discharge @ HWL	7.7	l/s
	Preliminary ICD radius	27.6	mm
	1:100 Year Discharge	**6.1**	l/s

* Active Volume above NWL

Table 17 – Constructed Wetland Characteristics

Parameter		Value	Unit
General	Contributing Catchment Area	94.58	ha
	Side Slopes below UNWL	Varies	
	Side Slopes between UNWL & HWL	Varies	
	Side Slopes above HWL	4H:1V max	
Elevation	Pond Bottom Elevation	1,194.50	m
	NWL Elevation	1.198.00	m
	HWL Elevation	1,200.00	m
	1:100 Year Elevation	**1,199.52**	**m**
	Freeboard Elevation	1,200.30	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)	27,272*	m^3
	1:100 Year Active Volume (Continuous simulation)	**29,836***	**m^3**
Discharge	Maximum Allowable Discharge from proposed development	94	l/s
	Maximum Discharge at HWL	94	l/s
	Preliminary ICD radius	90.4	mm
	1:100 Year Discharge	**82**	**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 on the east side of the pond. The outlet pipe connects the pond to the outlet control structure which discharge to the existing wetland.

The outlet control structures are intended to control the pond discharge to the allowable rate described in **Section 3.4**. The 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 the natural drainage course. The overland escape route for the Constructed Wetland is located on the west side of the pond, also directed to the 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 18** summarizes the modelled frequency of Total Storage volumes.

Table 18 – Frequency of Total Storage Volumes

Return Period (Years)	Storage Volume (m^3)	
	Dry Pond	Constructed Wetland
2	378	32,700
5	531	37,500
10	639	40,900
20	748	44,400
50	898	49,100
100	1,020	52,800

For the Dry Pond, the 1:100 year volume calculated by the Frequency Analysis is higher than the single storm event and the maximum computed by the continuous simulation; therefore, this volume should be used in the detail design of the Dry Pond.

For the Constructed wetland, the maximum volume computed by the continuous simulation 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 detail 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 19 - Peak Flow Results

Discharge From	Single Event 24h-100y (m^3/s)
Dry Pond	0.006
Existing Wetland	0.084
TOTAL	**0.090**

The analysis in the Amendment Phase 1 Pond C and D report includes 24.88 ha at 2.5 L/s/ha coming from the Ascension lands, this equates to 0.062 m^3/s. Since Ascension is planning on discharging at 0.094 m3/s, some upgrades to the existing infrastructure will be required to accommodate the additional 32 L/s. A preliminary review of the existing infrastructure across the Blueridge and Watermark residential developments shows the following upgrades:

Drainage within the Blueridge is all overland with some culverts under the roads. We proposed to convey the discharge from Ascension on a new road ditch to be located along the west side of Blueridge View, from the existing wetland down to the south end of Blueridge View; at this point will cross the road with a new culvert and enter the Watermark storm system on the north end of the cascading ponds.

Preliminary review of the storm pond system within Watermark identifies to because the flow from Ascension is flow through no modifications are required to the storm ponds, the only adjustment is replacing the ICDs in the OCS of Ponds C and D. Initial analysis indicates that the required ICD for Pond C is a 530mm x 830mm rectangular opening and for Pond D a 528mm diameter ICD.

During detail design, all culverts downstream of Watermark will need to be surveyed to ensure appropriate capacity to accommodate this additional 32 L/s.

5.6 Runoff Volume Discharges

Table 20 summarizes the target runoff volume discharge and estimated average annual runoff volume resulting from the PCSWMM continuous simulation analysis presented in this report; the total discharge volume (55 years) is 746,366 m^3.

Table 20 - 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	162.10	81,052	50	73,532	45

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

Table 21 – Water Balance

	Depth (mm)
Total Precipitation	22903.400
Evaporation Loss	8965.694
Infiltration Loss	10906.102
Surface Runoff	3109.378
Snow Cover	2.600
Surface Storage	18.037
Continuity Error (%)	-0.393

5.8 Water Quality

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. And, from the constructed wetland, water quality will be achieved by a three (3) stage process;

1. Oil/grit separators located at the first manhole upstream of the constructed wetland inlets.
2. Settling forebays at each inlet and,
3. The main body of the constructed wetland.

Appendix E contains information on the proposed OGS units that will meet/exceed the water quality requirements imposed by the City of Calgary and Alberta Environment.

5.9 Storm Pond Sediment Removal

Sediment removal from 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 22** 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 22 - Pond Sediment Removal Efficiency

Particle size (µm)	% Removed
< 10	82.1
10 - 20	93.9
20 - 50	95.8
50 - 150	**97.1**
> 150	99.5
Totals	**94.1**

5.10 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 23 and 24** 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 23 - West Inlet Forebay Sizing

Sedimentation Forebay Characteristics			
Forebay Side Slopes below NWL	5	H to 1V	
Forebay Length at NWL	70.0		
Forebay Width at NWL	55.0		
Effective Forebay Width at NWL (m)	19.0		
Forebay Depth @ NWL (m)	3.5		
Maximum flow rate from pond (m^3/s)	0.094	94.58 ha @ 0.99 L/s/ha	
Design settling velocity for 50 µm (m/s)	0.00195		
Maximum inlet flow rate (m^3/s)	3.162	47.17 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	56.9
Forebay bottom width (m)	19.0	to be greater than or equal to	7.1
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	102.0	to be greater than or equal to	2.0
Calculated Hydraulic Parameters			
Minimum Forebay Settling Length (m)	57		
Minimum Forebay Dispersion Length (m)	14		
Minimum Bottom Width (m)	7		

Table 24 – East inlet Forebay Sizing

Sedimentation Forebay Characteristics			
Forebay Side Slopes below NWL	5	H to 1V	
Forebay Length at NWL	75.0		
Forebay Width at NWL	55.0		
Effective Forebay Width at NWL (m)	19.0		
Forebay Depth @ NWL (m)	3.5		
Maximum flow rate from pond (m^3/s)	0.094	94.58 ha @ 0.99 L/s/ha	
Design settling velocity for 50 μm (m/s)	0.00195		
Maximum inlet flow rate (m^3/s)	4.335	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	66.7
Forebay bottom width (m)	19.0	to be greater than or equal to	8.3
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	117.1	to be greater than or equal to	2.0
Calculated Hydraulic Parameters			
Minimum Forebay Settling Length (m)	67		
Minimum Forebay Dispersion Length (m)	20		
Minimum Bottom Width (m)	8		

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 87 L/s, which is well within the allowable 101 L/s as stipulated in the Bearspaw – Glenbow Master Drainage Plan, Worley Parsons; June 2010.

- 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 43 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 requirements for subcatchment SF-1 will be achieved by an OGS unit installed in the first manhole upstream of the Dry Pond inlet. And, from the constructed wetland, water quality will be achieved by a three (3) stage process;
    1. Oil/grit separators located at the first manhole upstream of the constructed wetland inlets.
    2. Settling forebays at each inlet and,
    3. The main body of the constructed wetland.

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 a 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 modelling to verify the performance and operation of the ultimate stormwater management facility.

- Existing infrastructure from Ascension to outlet BO-1 be surveyed and analysis for capacity, to determine all required upgrades to accommodate the additional 32 L/s of peak flow discharge.

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

Corporate Authorization

This document entitled, "Ascension – Staged Master Drainage Plan" was prepared by LGN Consulting Engineering Ltd. It is intended for the use of Highfield Land Management Inc., their consultants and contractors responsible for the development of noted property and approval authorities for which it has been prepared. The contents of the report represent LGN Consulting Engineering Ltd.'s best judgment based on available information at the time of preparation. Any use which a third party makes of the report, or reliance on or decisions made based on it, are the responsibilities of such third parties. LGN Consulting Engineering Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on the report.

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CORPORATE PERMIT

LUIS G. NARVAEZ

October 7, 2022
RESPONSIBLE ENGINEER
ID #55244

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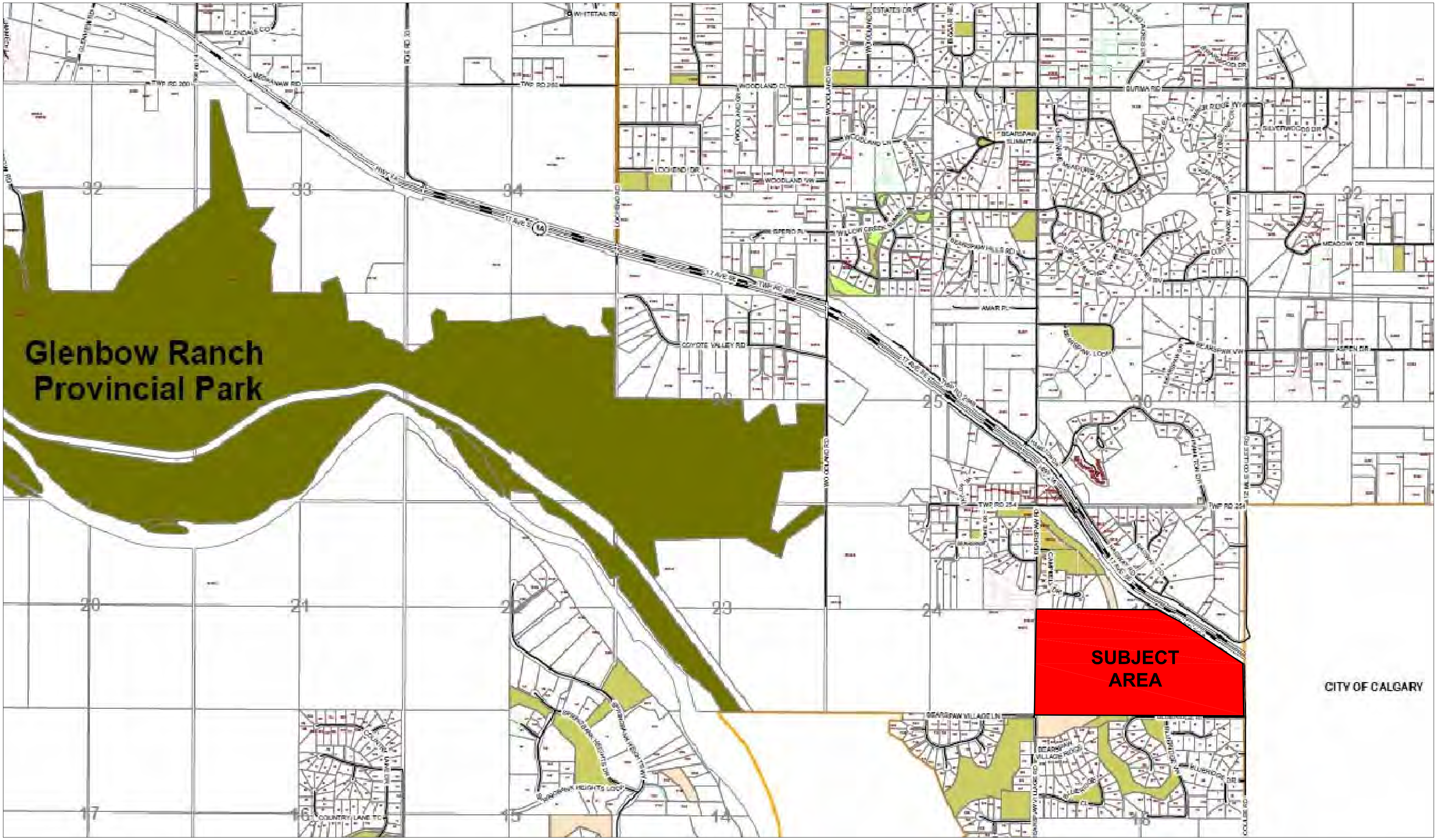
FIGURES



Scale: **NTS**

Client/Project

HIGHFIELD
LAND MANAGEMENT

ASCENSION

Title

Location Plan

Figure No. **1**

LGN Consulting Engineering Ltd.

Subject Land

Study Area

Municipal Boundary

Scale: **1:15,000**

LGN Consulting Engineering Ltd.

Client/Project

HIGHFIELD LAND MANAGEMENT

ASCENSION

Title

Study Area

Figure No. 2

NTS

0 100 200 400 600

metre

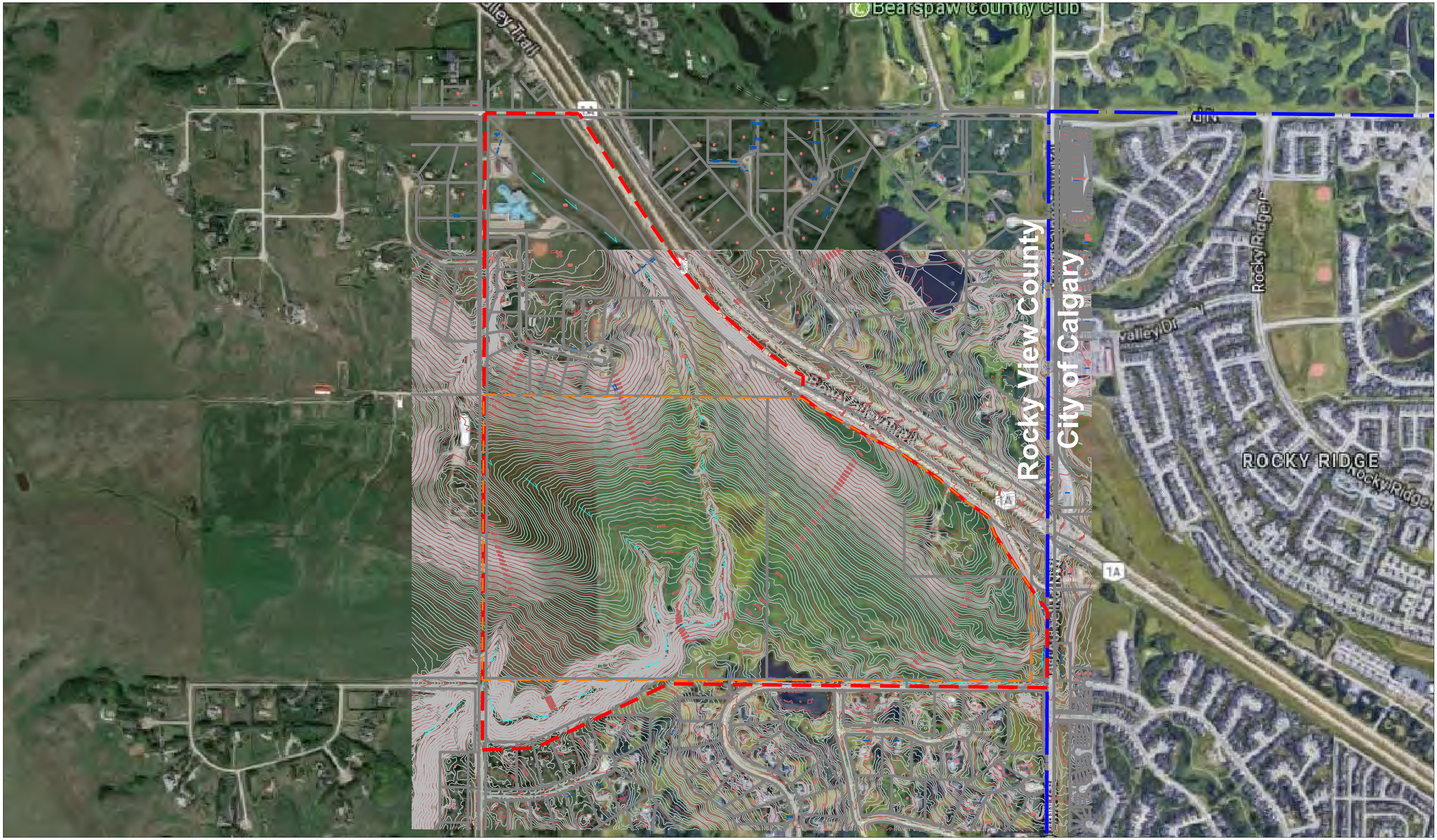
ASCENSION

Revised Concept Plan

September 2022

Figure 3

Sep 13, 2022 - 10:14am W:\2021-177_Highfield Land_Ascension_LUR\5.0 Technical\5.1 Technical Production\5.1.1 AutoCAD\2021-177- Revised option_2021 Nov 16.dwg Fig-Revised Concept



Legend

- - - - Subject Land
▬ ▬ ▬ Sudy Area
▬ · ▬ Municipal Boundary
0.5m Countours
2.5m Contours
Major Flow Paths

Scale: **1:15,000**

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HIGHFIELD LAND MANAGEMENT

ASCENSION

Title

Existing Topography

Figure No. 4

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HIGHFIELD
LAND MANAGEMENT

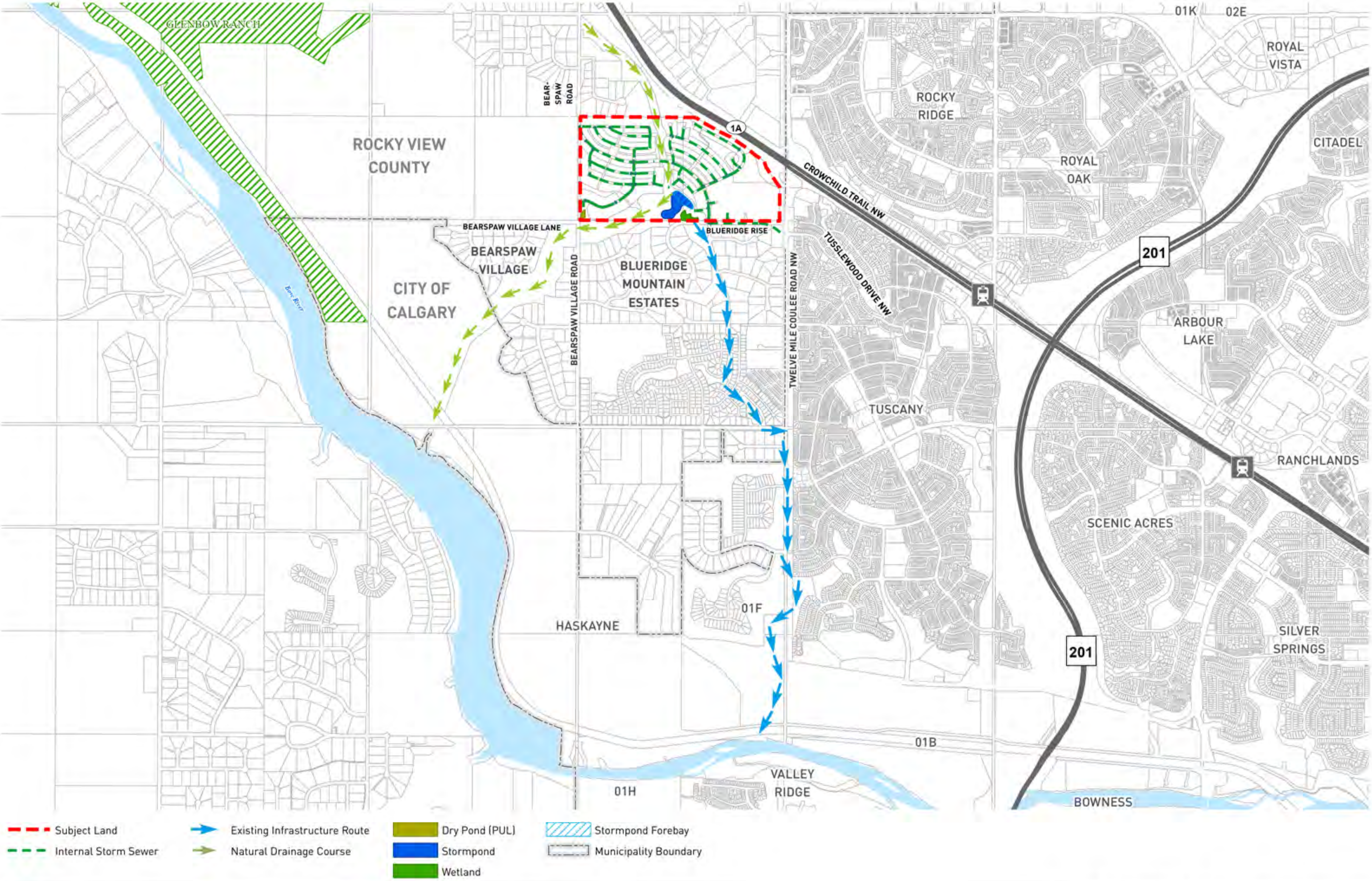
ASCENSION

Title

Pre-development Subcatchments

Figure No.

5



1:40,000

0 0.5 1 2 kilometre

ASCENSION

Figure 6 Regional Stormwater Utilities

Highfield Land Management

October 2022

NTS

0 100 200 400 600

metre

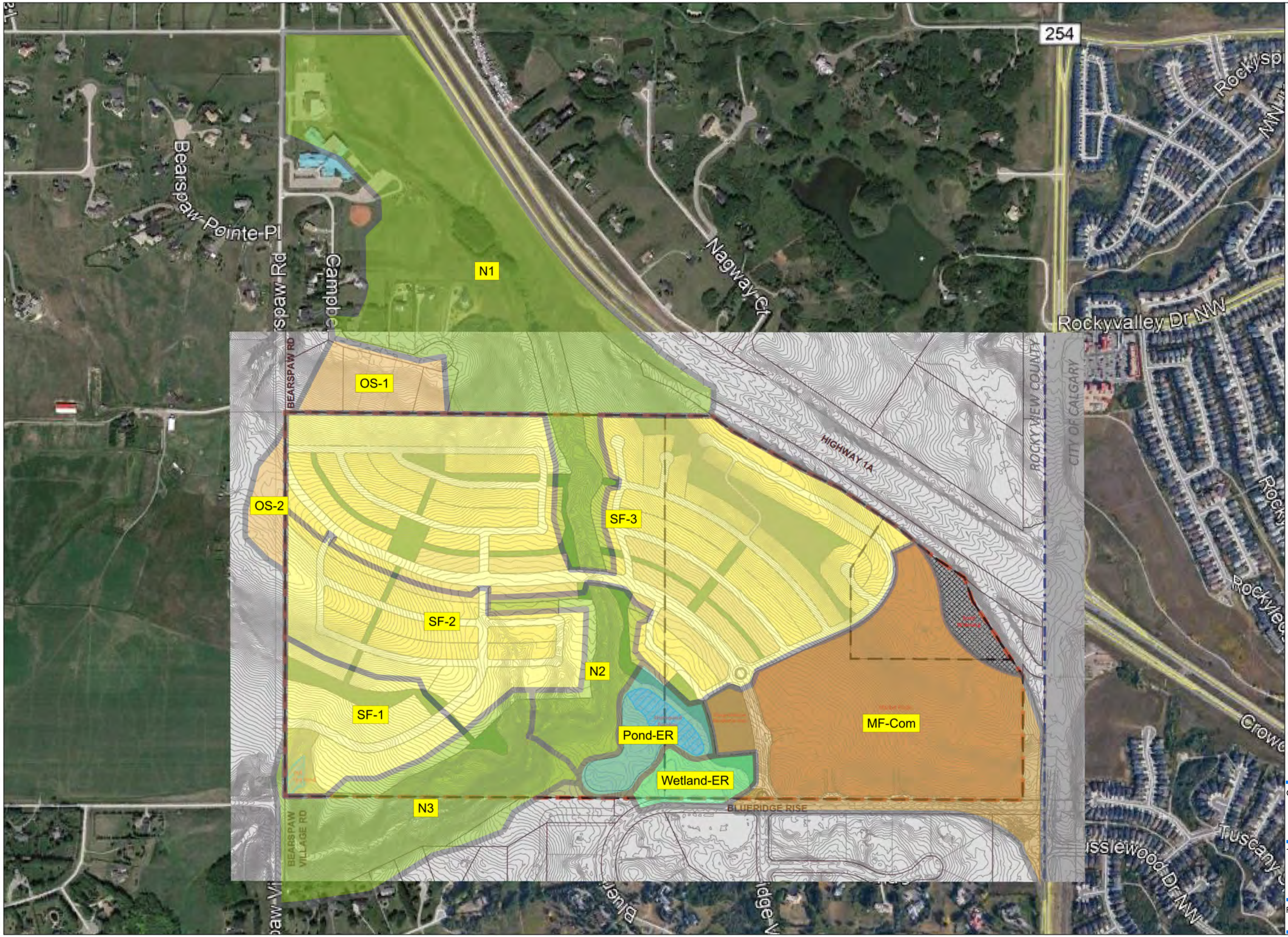
ASCENSION

Figure 7 Internal Storm Water Servicing Plan

September 2022

B&A

Oct 05, 2022 - 9:01am W:\2021-177_Highfield Land_Ascension_LUR\5.0 Technical\5.1 Technical Production\5.1.1 AutoCAD\2021-177- Revised option_2022SEPT27.dwg Fig-storm



Legend

Subcatchments

- 🟨 Residential
- 🟧 Commercial-Multifamily
- 🟧 Offsite
- 🟦 Pond
- 🟩 Wetland
- 🟩 Natural Drainage Course

N

300 m

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Title

Post-development Subcatchments

Figure No.

8

Scale: **1:750**

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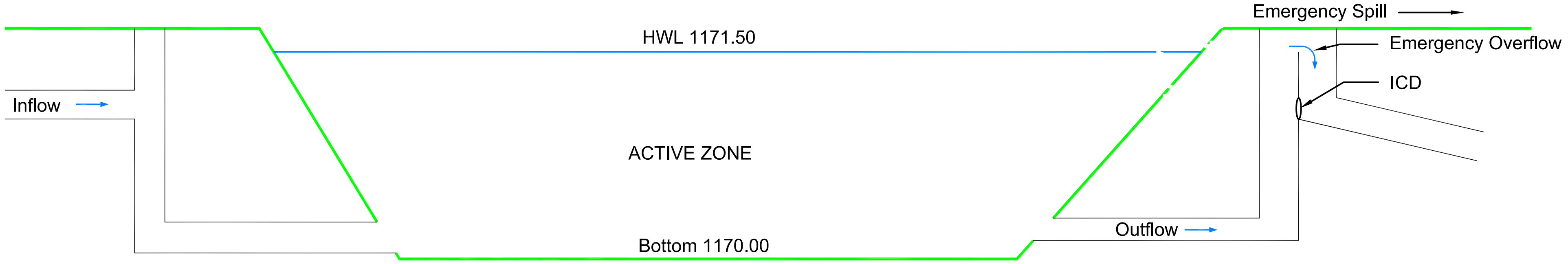
HIGHFIELD
LAND MANAGEMENT

ASCENSION

Title

Dry Pond Design

Figure No. **9**



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Client/Project

ASCENSION

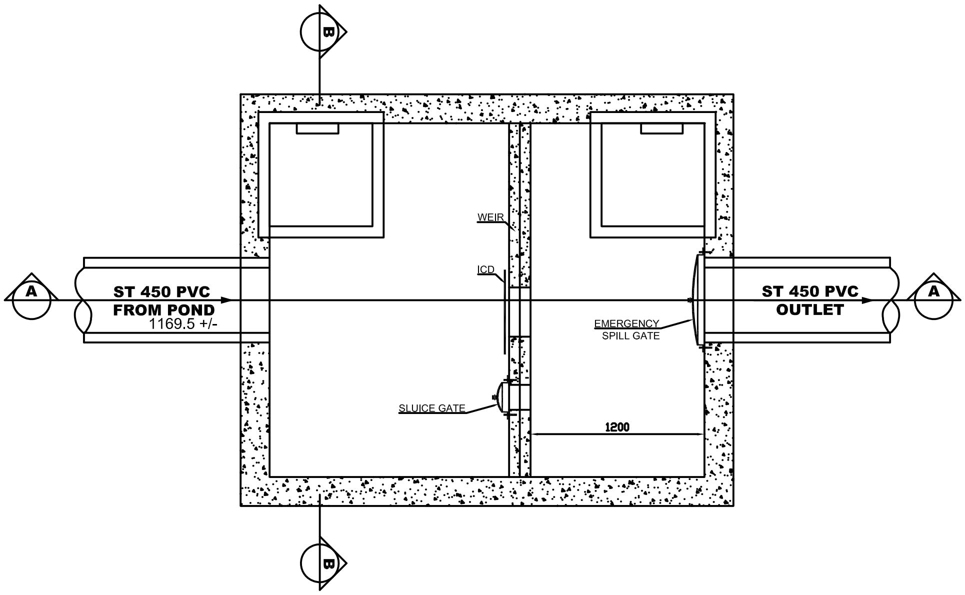
Title

Dry Pond

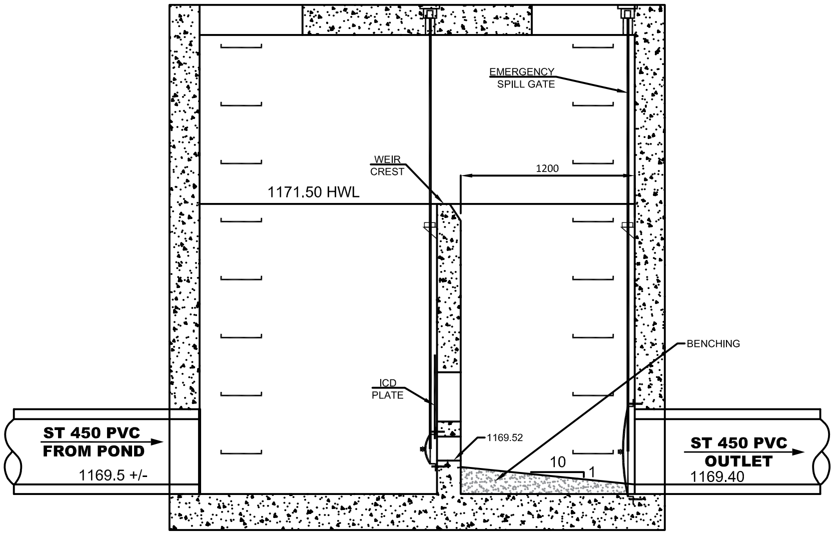
Preliminary Cross-Section

Figure No. **10**

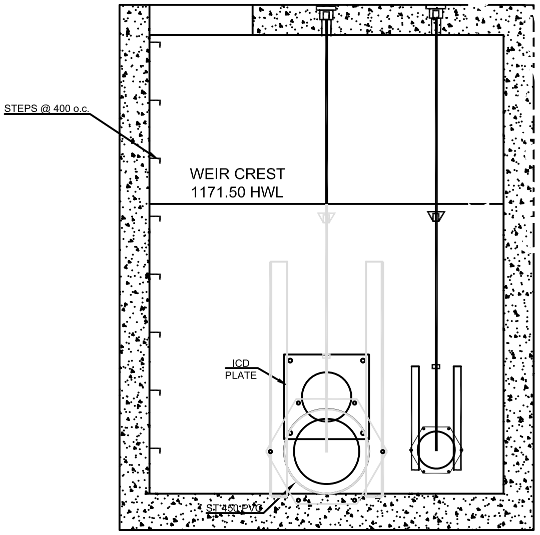
LGN Consulting Engineering Ltd.



PLAN VIEW



SECTION A-A



SECTION B-B

NOTE: CONTROL STRUCTURE GEOMETRY, PIPE SIZES AND INVERTS ARE SUBJECT TO CHANGE AT DETAIL DESIGN

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Engineering Ltd.

Scale: **N.T.S.**

Client/Project

HIGHFIELD
LAND MANAGEMENT

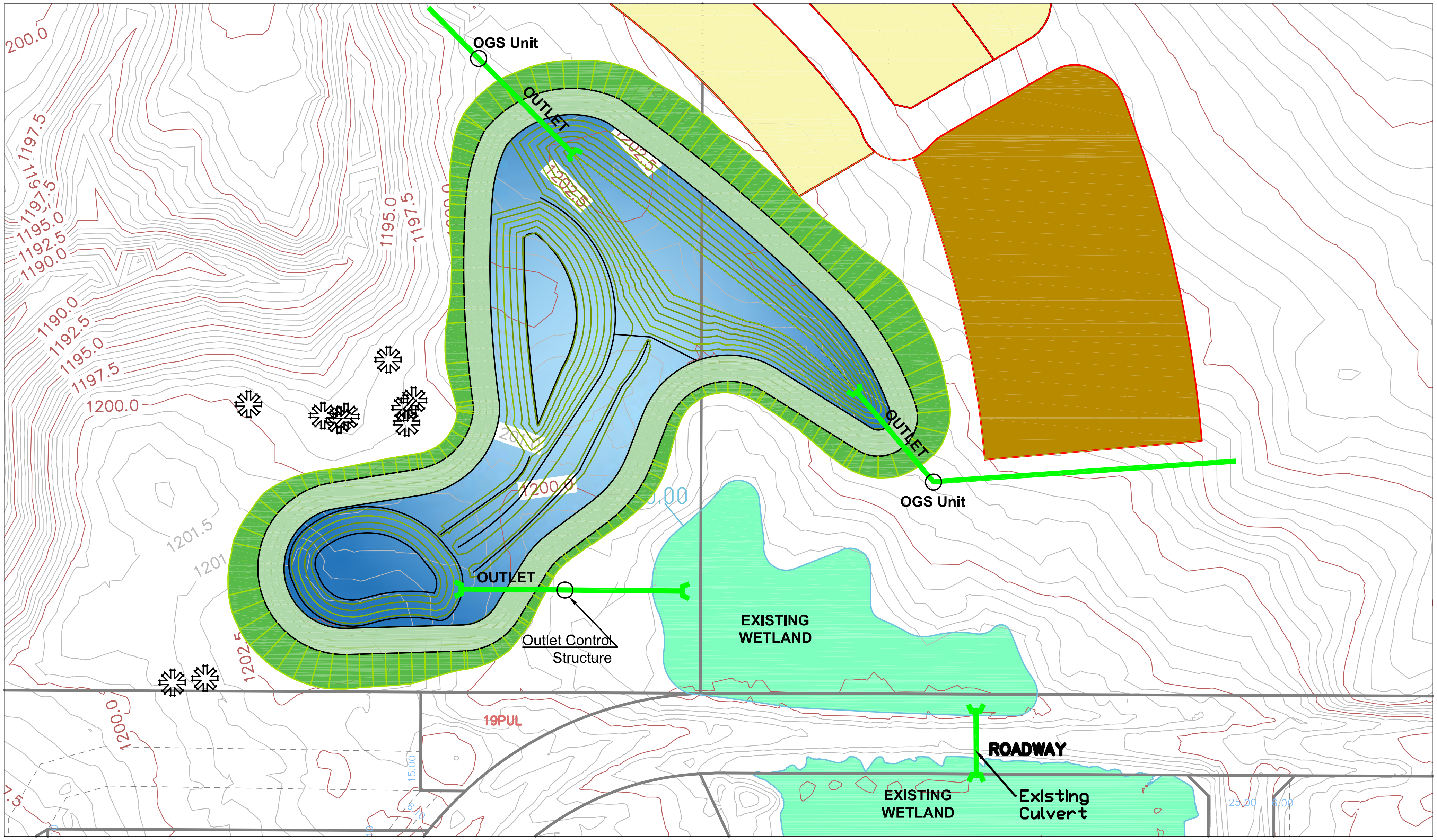
ASCENSION

Title

Dry Pond Preliminary Outlet Control Structure

Figure No.

11



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Client/Project

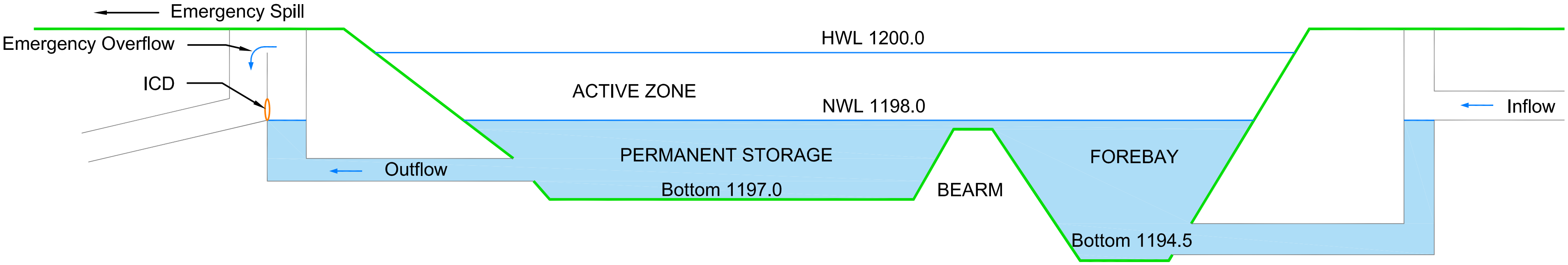
HIGHFIELD LAND MANAGEMENT

ASCENSION

Title

Constructed Wetland Preliminary Design

Figure No. 12



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Client/Project

HIGHFIELD
LAND MANAGEMENT

ASCENSION

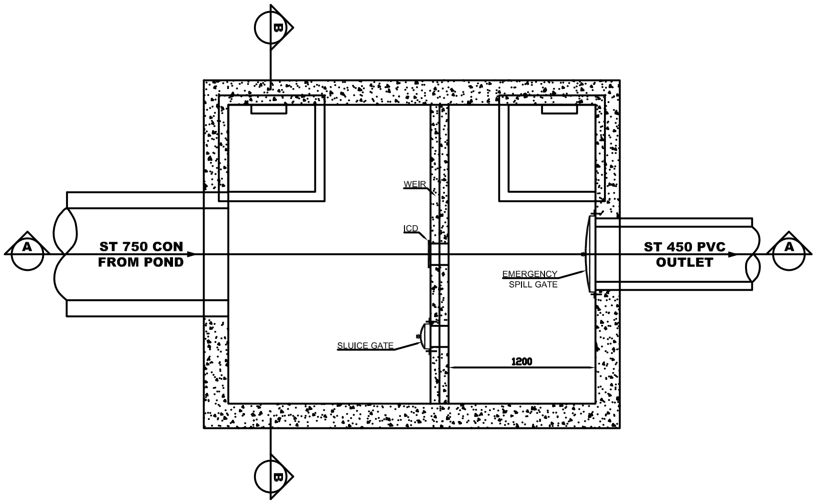
Title

Constructed Wetland

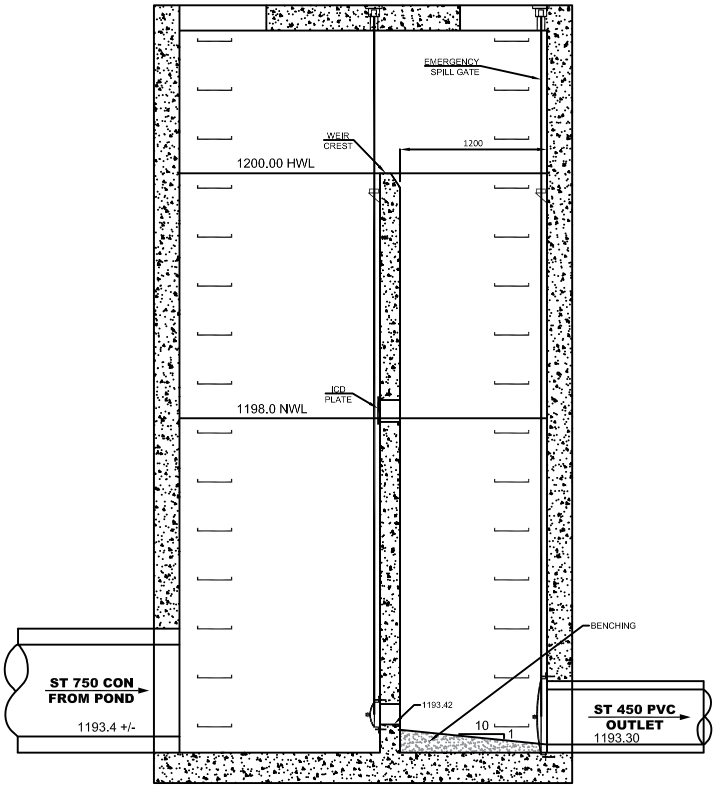
Preliminary Cross-Section

Figure No.

13



PLAN VIEW



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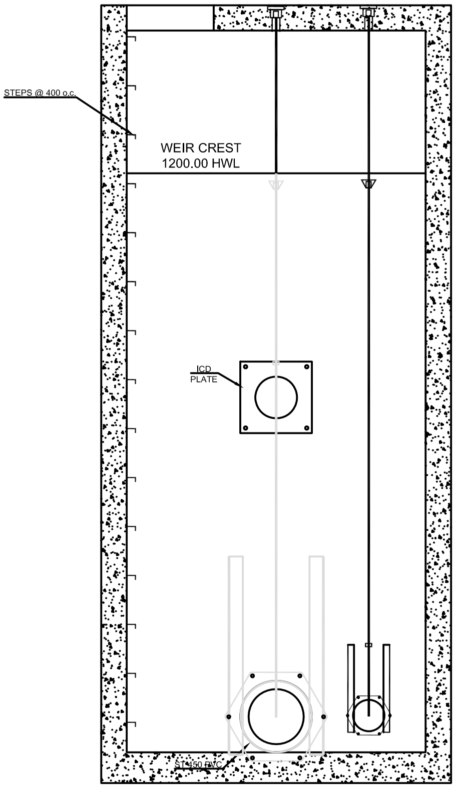

SECTION B-B

NOTE: CONTROL STRUCTURE GEOMETRY, PIPE SIZES AND INVERTS ARE SUBJECT TO CHANGE AT DETAIL DESIGN

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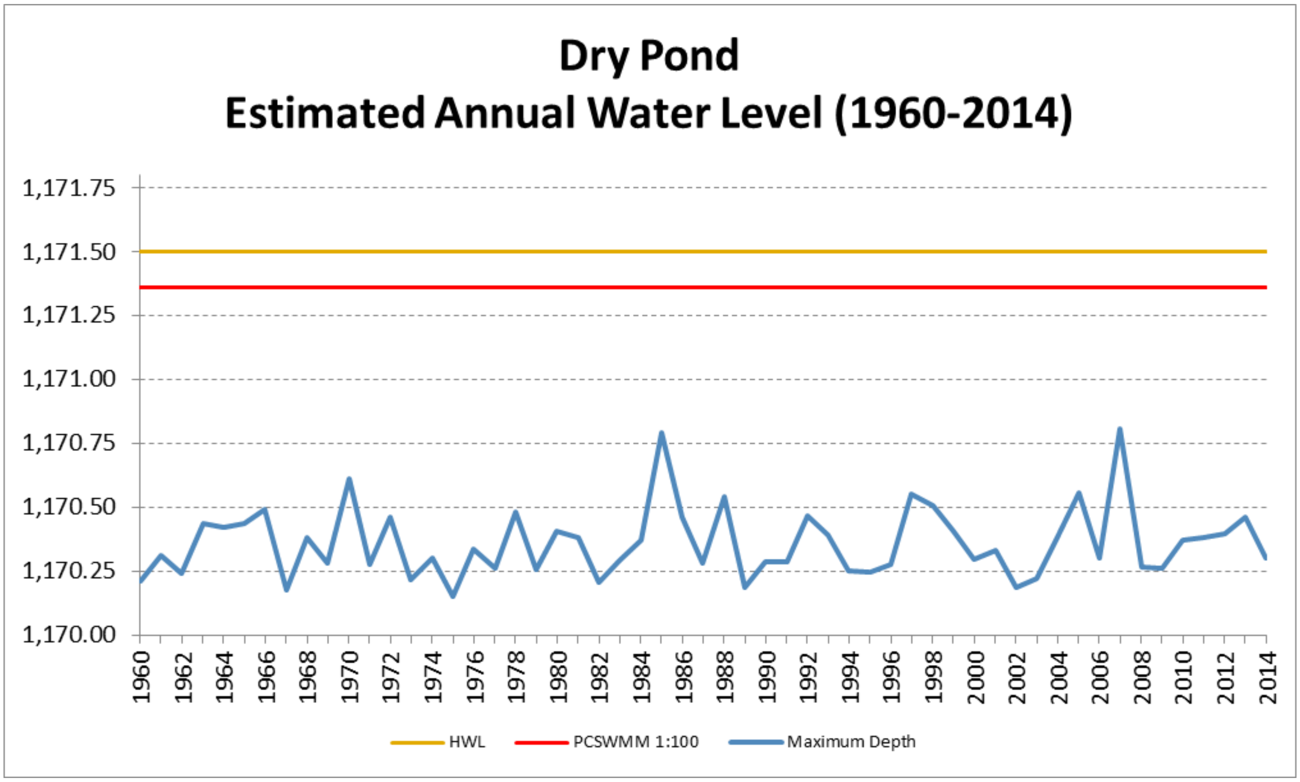
Client/Project

HIGHFIELD
LAND MANAGEMENT

ASCENSION

Title **Constructed Wetland Preliminary Outlet Control Structure**

Figure No. **14**



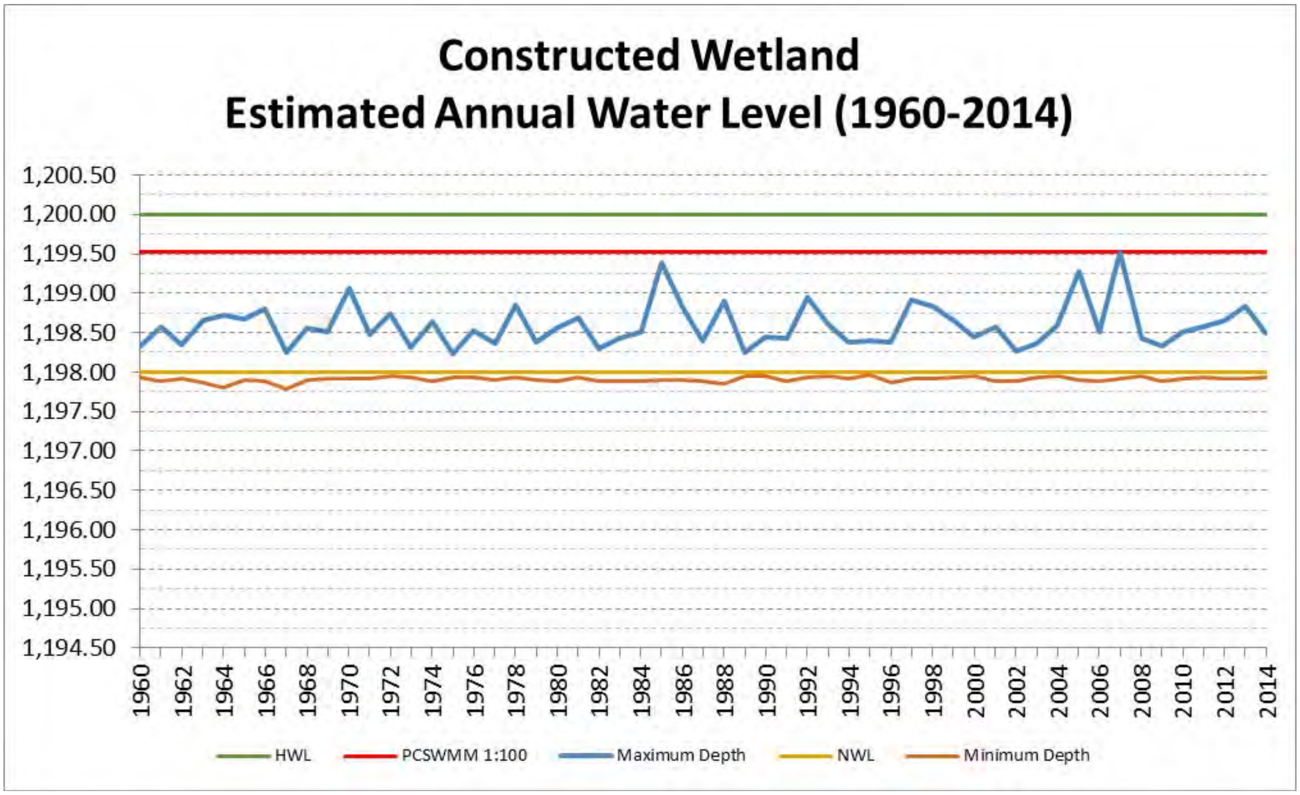
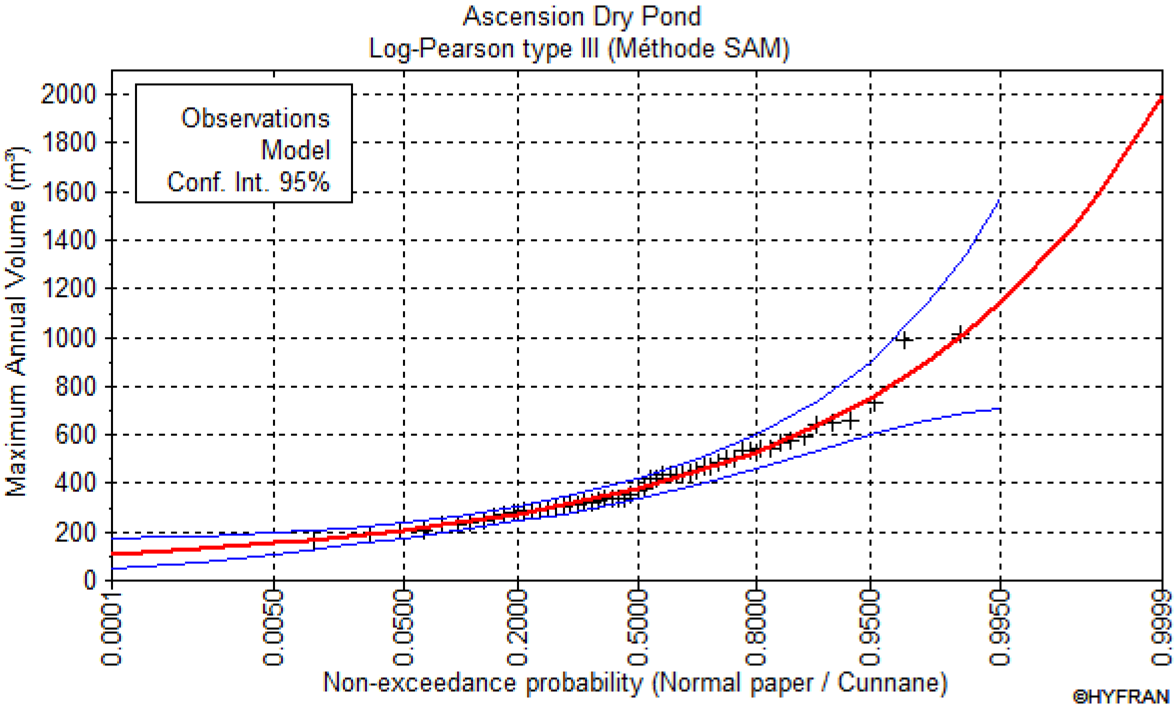


Figure 15 - SWMFs Annual Water Levels



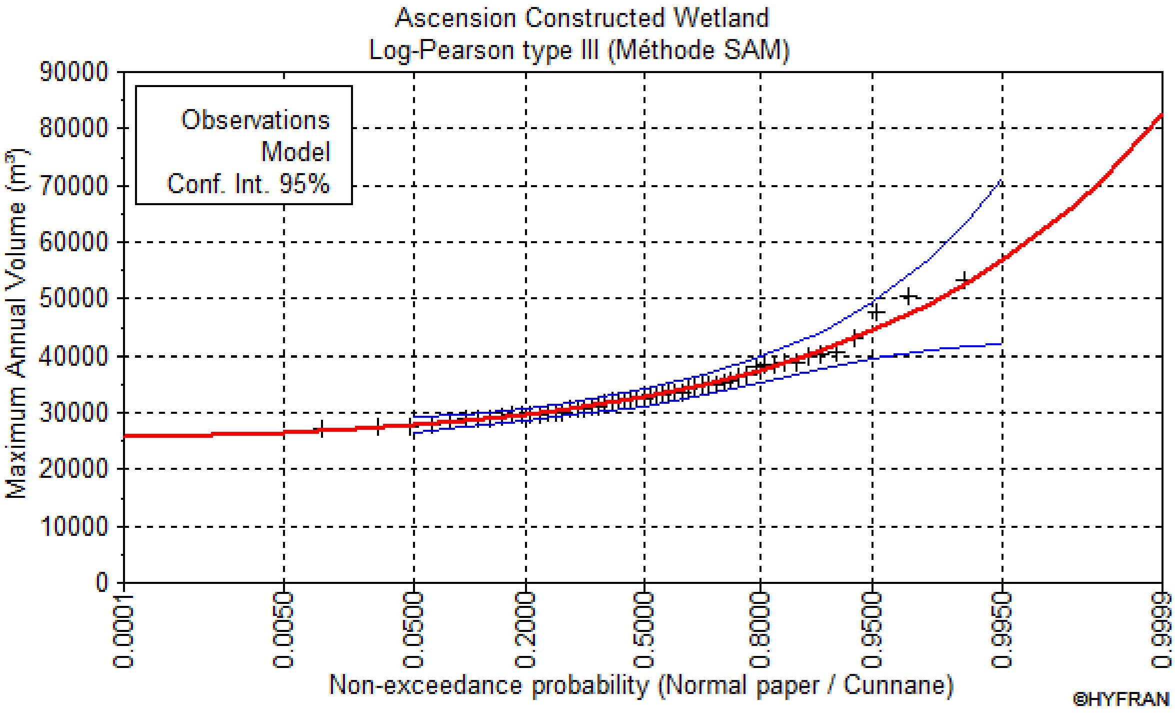
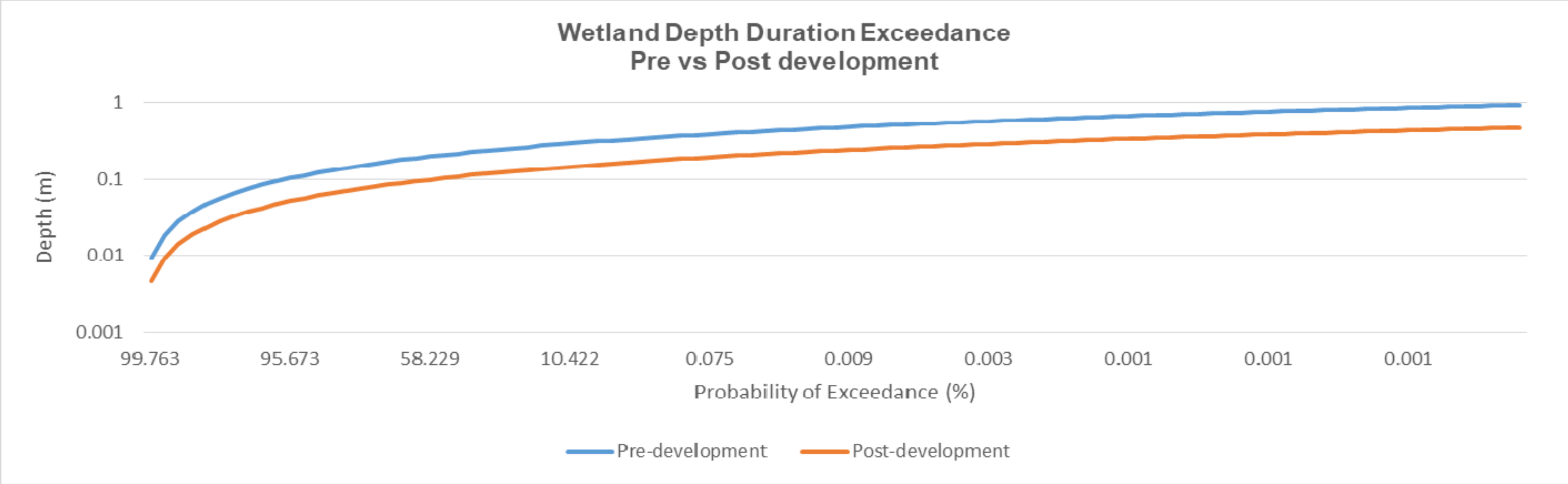


Figure 16 - SWMFs Frequency Distribution



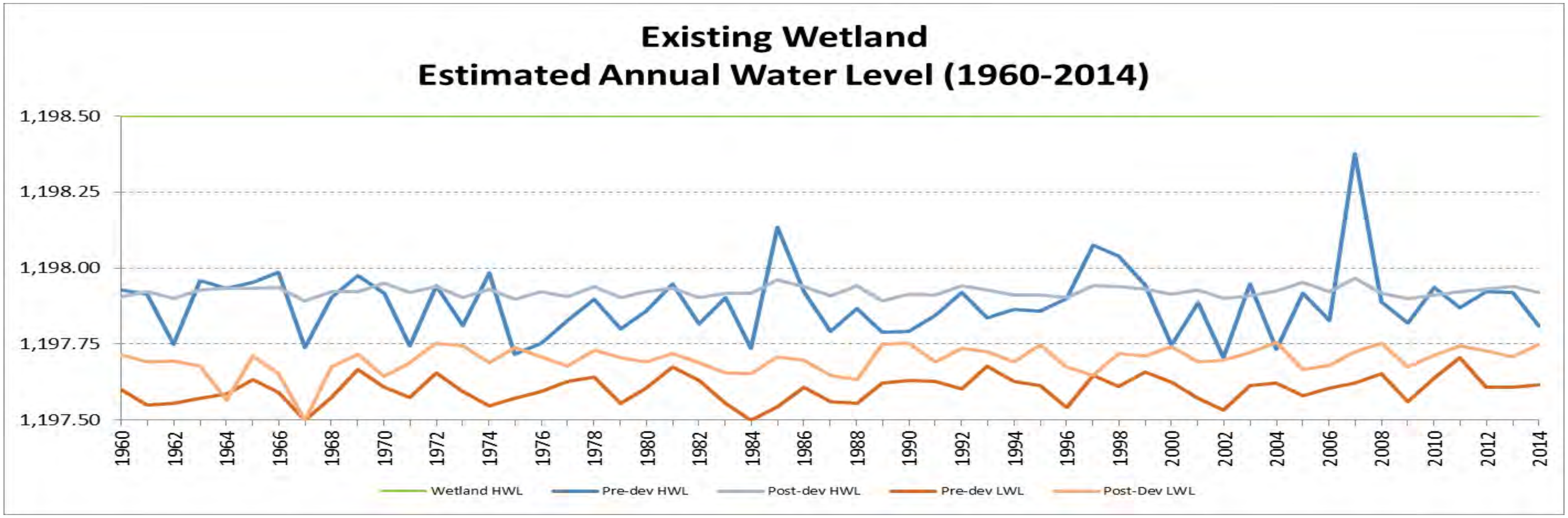


Figure 17 - Pre vs Post-development Wetland hydroperiods

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.

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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

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Nov 18, 2016

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PERMIT TO PRACTICE
EXP SERVICES INC.
Signature
Date Nov 18, 2016
PERMIT NUMBER: P 05437
The Association of Professional Engineers, Geologists and Geophysicists of Alberta

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.

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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.

Table of Contents

Legal Notification i

Table of Contents ii

1.0 Introduction 1

2.0 Proposed Development 1

3.0 Site Description 1

4.0 Site Exploration Program 2
4.1 Field Exploration 2
4.2 Laboratory Testing 2

5.0 Subsurface Conditions 3
5.1 General 3
5.2 Topsoil-Like Materials 3
5.3 Clay Fill 3
5.4 Sand 4
5.5 Lacustrine Clay 4
5.6 Clay Till 4
5.7 Bedrock 4
5.8 Groundwater 4

6.0 Slope Stability Analysis 6

7.0 Discussions and Recommendations 8
7.1 Geotechnical Considerations 8
  7.1.1 General 8
  7.1.2 Frost Susceptibility 8
  7.1.3 High Plastic Clay Soils 9
  7.1.4 Erodible Soils 9
  7.1.5 Shallow Bedrock 9
7.2 Site Preparation and Grading 9
7.3 Backfill Materials and Compaction 10
7.4 Construction Excavation and Temporary Dewatering 11
7.5 Pipe Support 12

7.6 Weeping Tile 12
7.7 Foundations 12
7.8 Seismic Class 13
7.9 Concrete Type 13
7.10 Further Work and Geotechnical Review 13

8.0 Closure 14

Appendix A – Interpretation and Use of Study & Report 15

Appendix B – Figures 16

Appendix C – Borehole Logs 17

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

Plot Date: Nov 17, 2016 - 01:38:13pm Plotted by:MeszarosR
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exp.

LEGEND:

🟥 CITY LIMITS BOUNDARY LINE

🟩 HAWKWOOD LANDS

PROJECT NAME:

HAWKWOOD LANDS

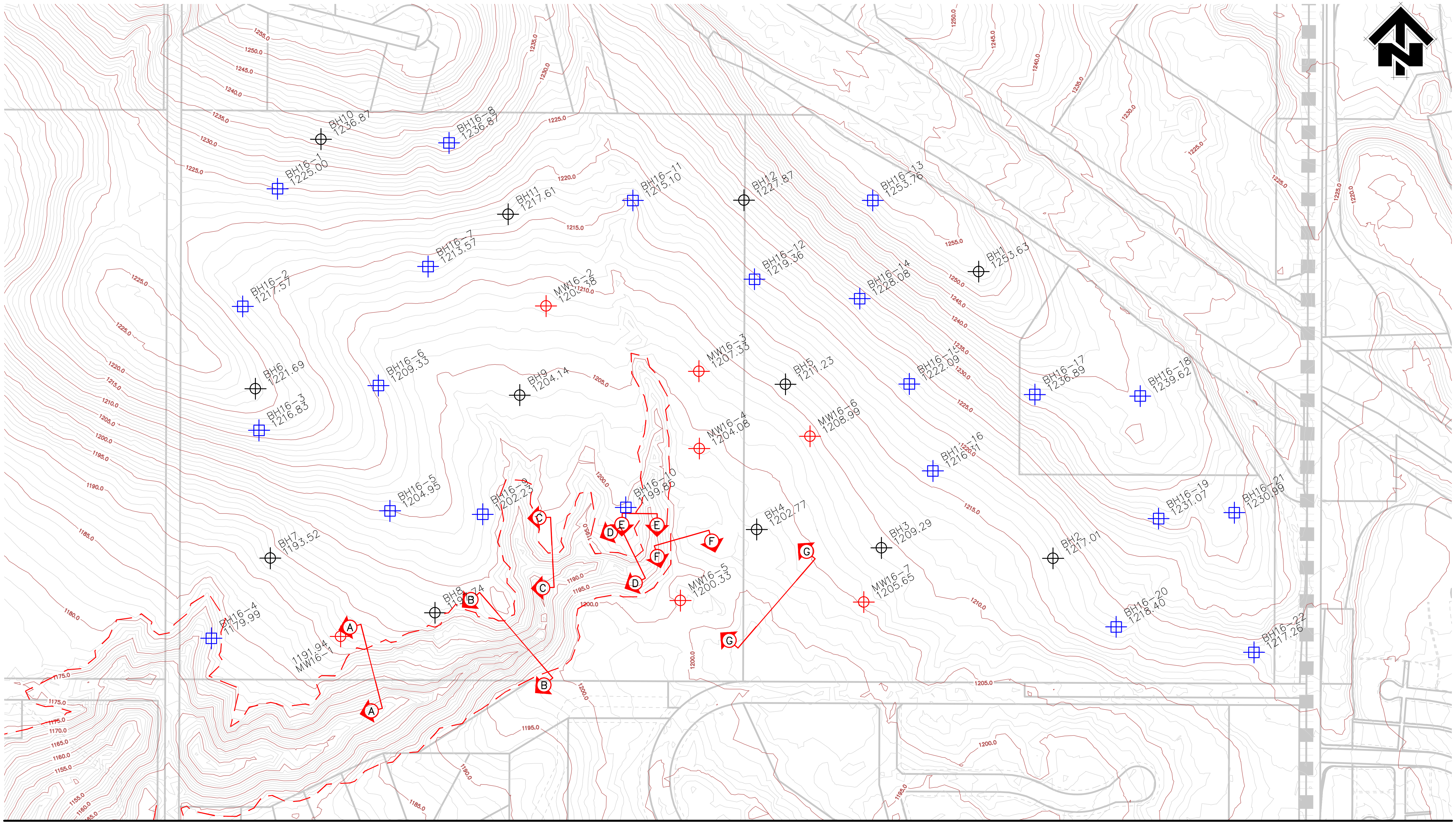
DATE: **2016.08.25** SCALE: **NTS**

TITLE:

SITE LOCATION PLAN

FIGURE NO.:

01



Plot Date: Nov 17, 2016 – 01:53:29pm Plotted by:MeszarosR
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LEGEND:

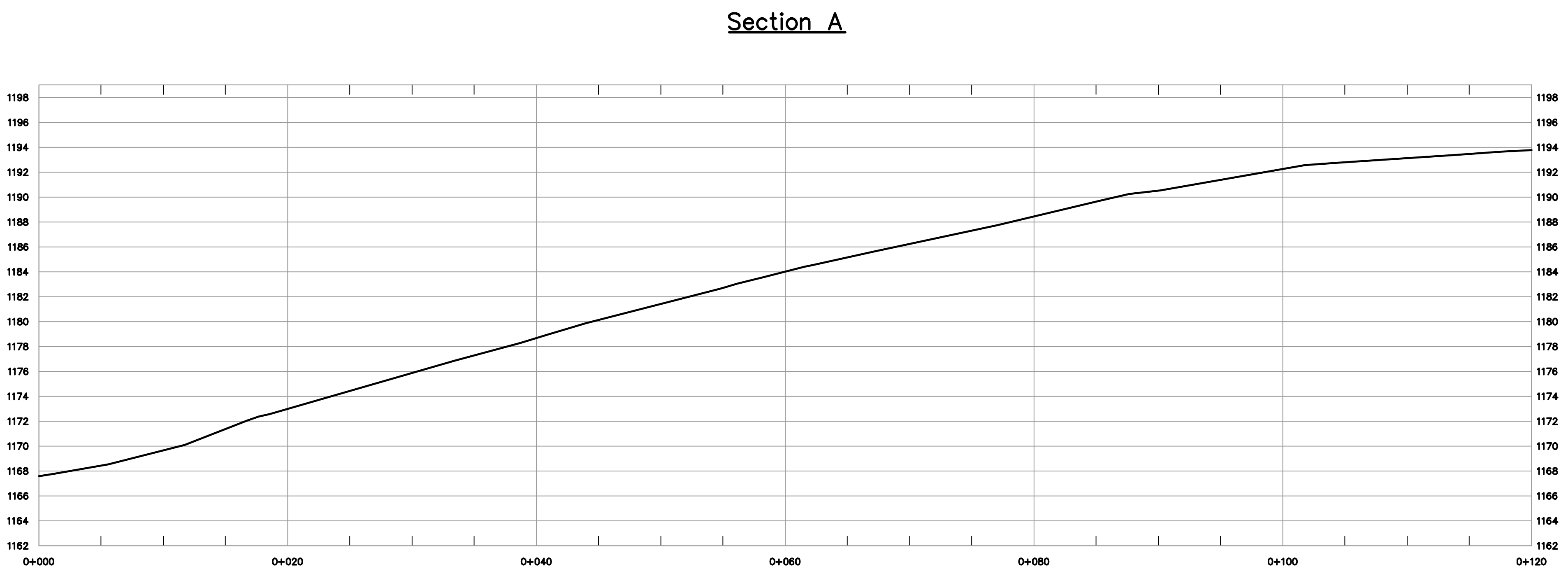
⊕ BH8 1197.741	EXISTING MCINTOSH LALANI TEST HOLE (AUGUST 2007)
⊞	EXP GEOTECHNICAL TEST HOLE
⊕	EXP MONITORING WELL
— — —	CREST OF SLOPE (20%)

PROJECT NAME:
HAWKWOOD LANDS

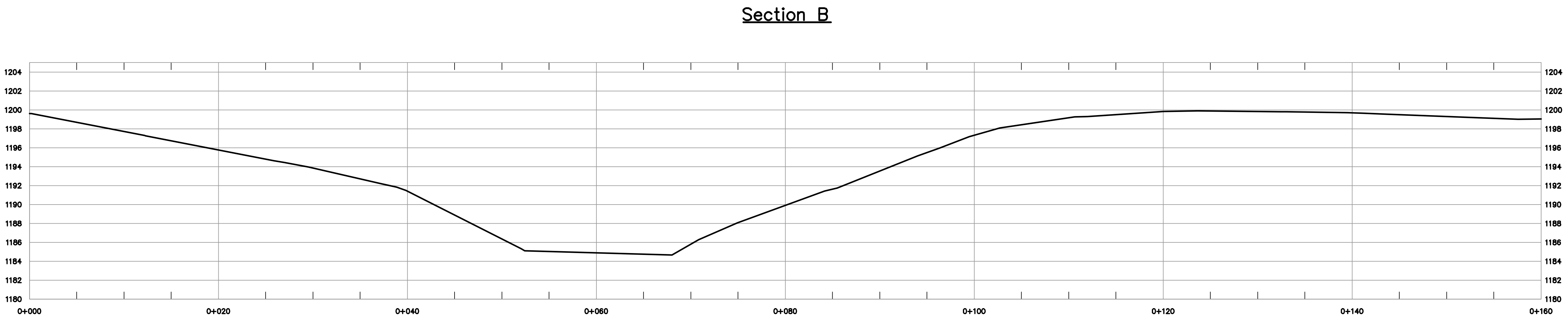
PROJECT NO.: **CGY-00092055-00** DATE: **2016.11.15** SCALE: **1:5000**

TITLE:
BOREHOLE & CROSS SECTION LOCATION PLAN

FIGURE NO.:
02



Section A



Section B

Plot Date: Nov 17, 2016 – 01:53:35pm Plotted by: MeszarosR
O:\CGY-00092055-00\60 Project Execution\2 Design Data\Concept\2016-11-03-OG Sections for Geo\CGY-00092055-00-OG Sections.dwg XREFS: CGY-00092055-00 – Legal (3TM).dwg

exp.

LEGEND:

— ORIGINAL GROUND

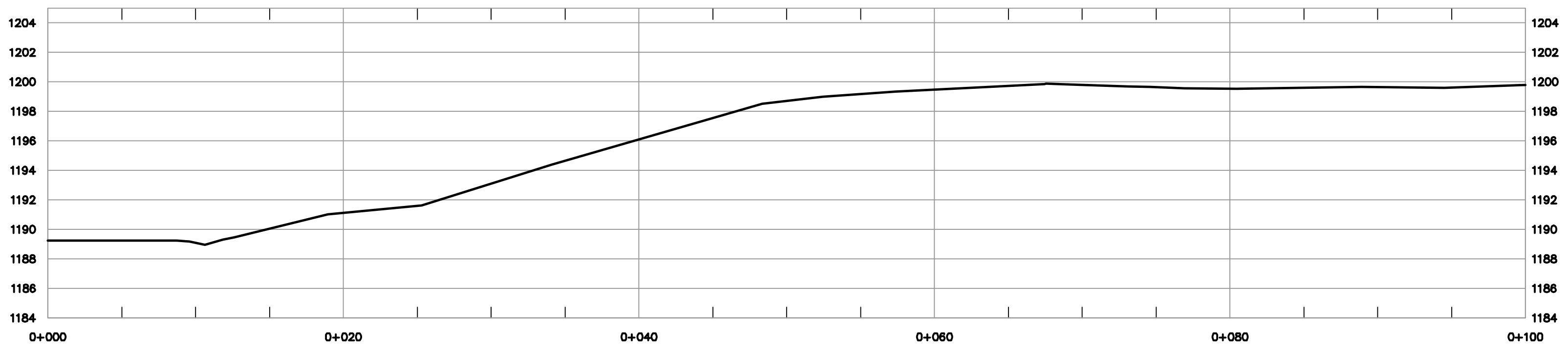
PROJECT NAME:
HAWKWOOD LANDS

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

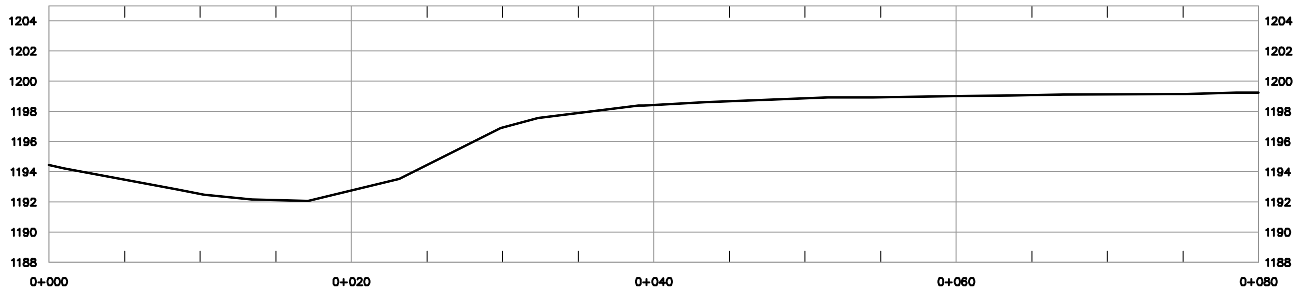
TITLE:
CROSS SECTIONS (A and B)

FIGURE NO.:
03

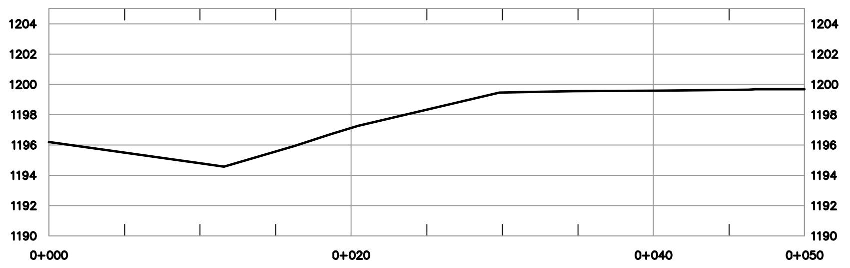
Section C



Section D



Section E



Plot Date: Nov 17, 2016 – 01:53:40pm Plotted by: MeszarosR
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exp.

LEGEND:

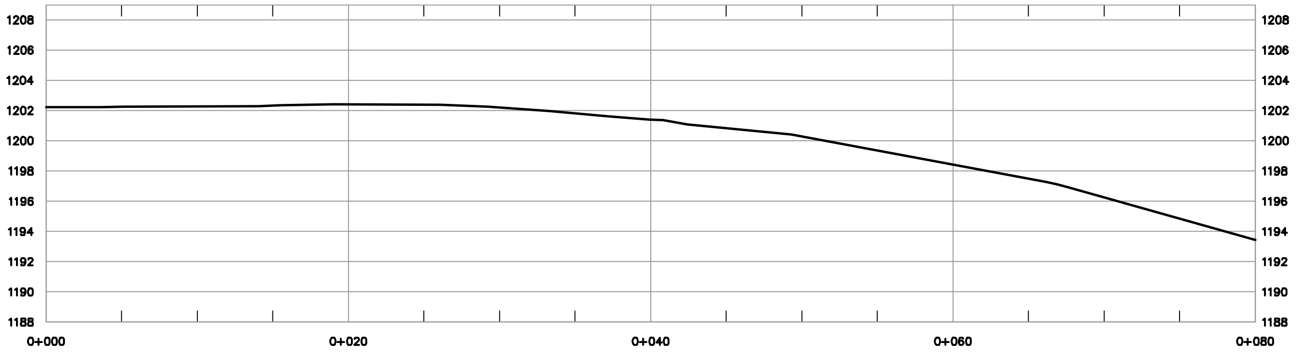
～ ORIGINAL GROUND

PROJECT NAME:
HAWKWOOD LANDS

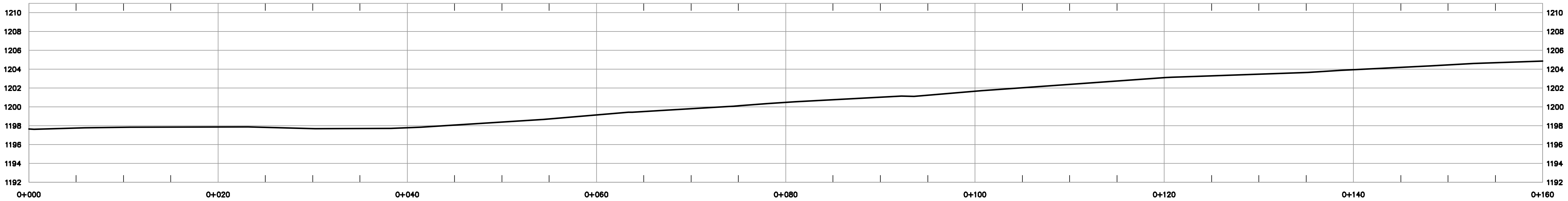
PROJECT NO.: **CGY-00092055-00** DATE: **2016.11.15** SCALE: **1:500**
TITLE:
CROSS SECTIONS (C, D, and E)

FIGURE NO.:
04

Section F



Section G



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exp.

LEGEND:

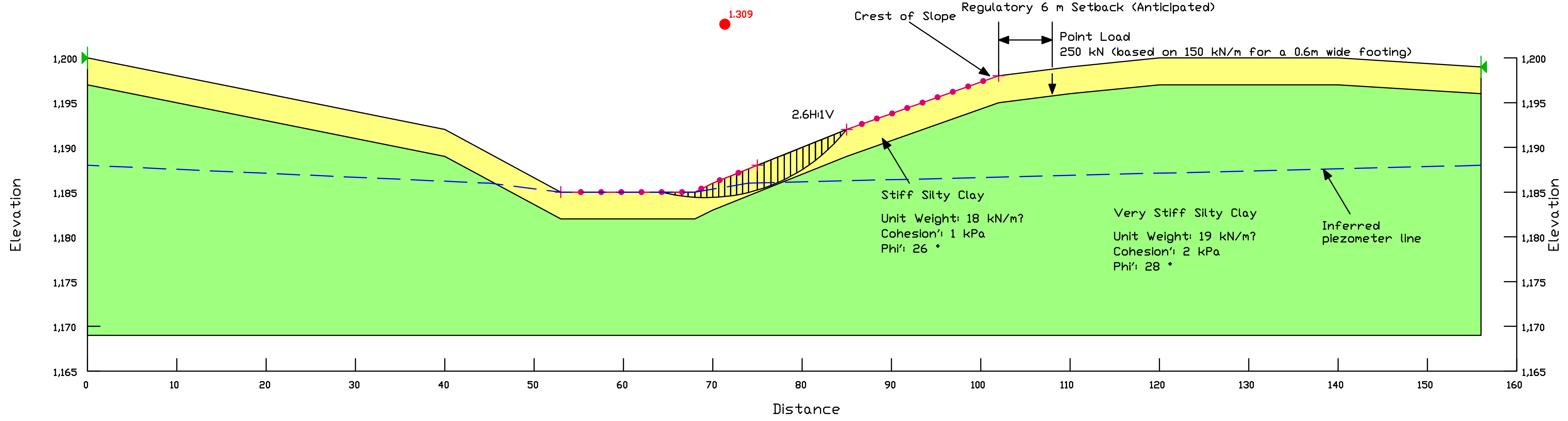
ORIGINAL GROUND

PROJECT NAME:
HAWKWOOD LANDS

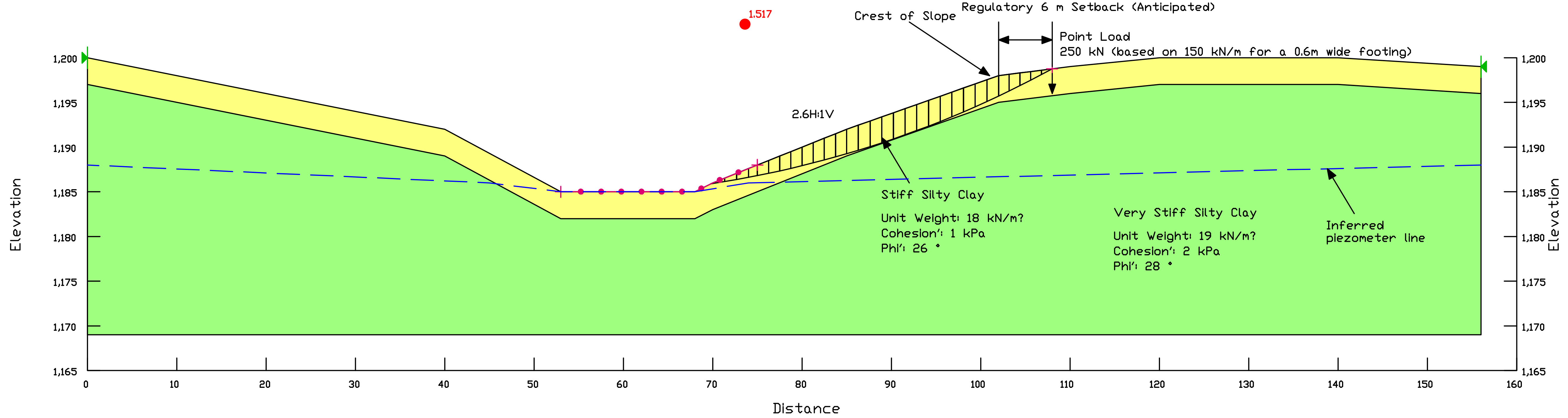
PROJECT NO.: **CGY-00092055-00** DATE: **2016.11.15** SCALE: **1:500**

TITLE:
CROSS SECTIONS (F and G)

FIGURE NO.:
05



SECTION B
SLOPE STABILITY ANALYSIS



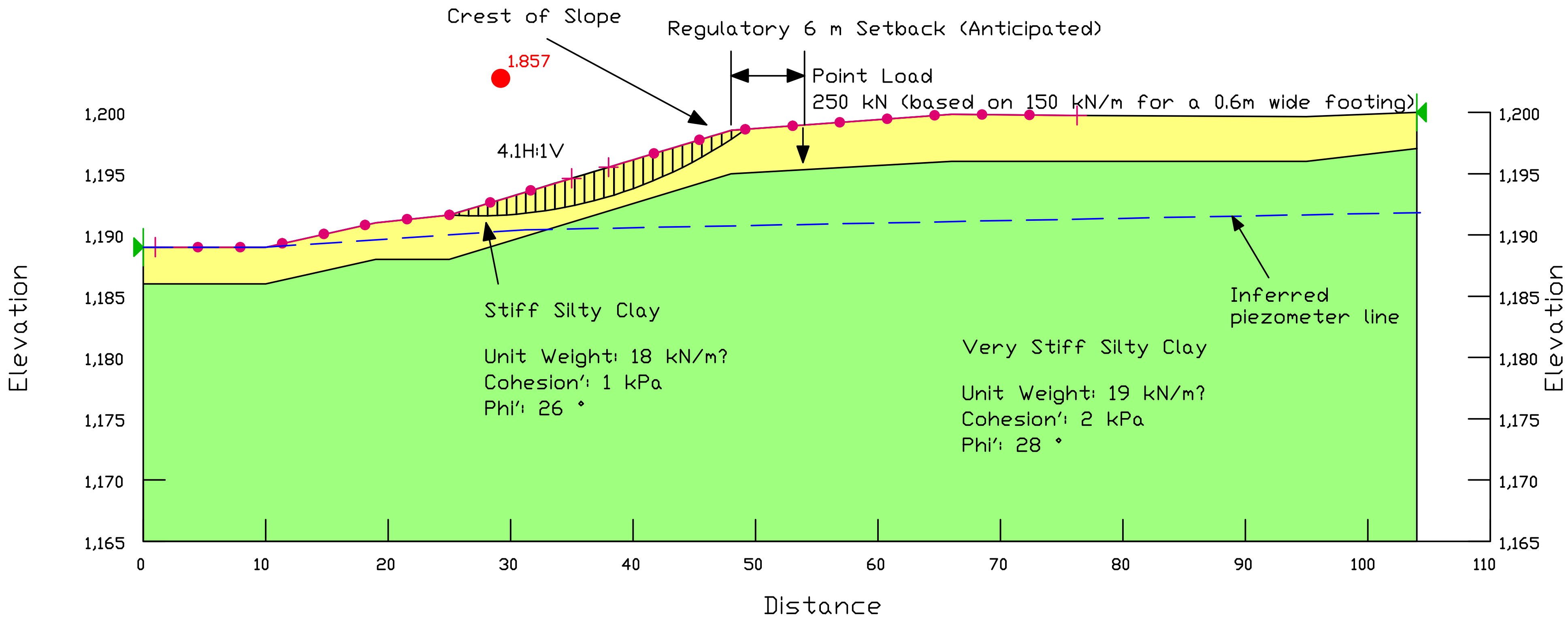
SECTION B
(FORCED SLIP SURFACE AT 6m SETBACK)
SLOPE STABILITY ANALYSIS

Plot Date: Nov 17, 2016 - 02:10:38pm Plotted by: MeszarosR
O:\CGY-00092055-00\60 Project Execution\3 Reports\Geotechnical\Slope Stability\CGY-00092055-00-Stability Sections.dwg
XREFS:

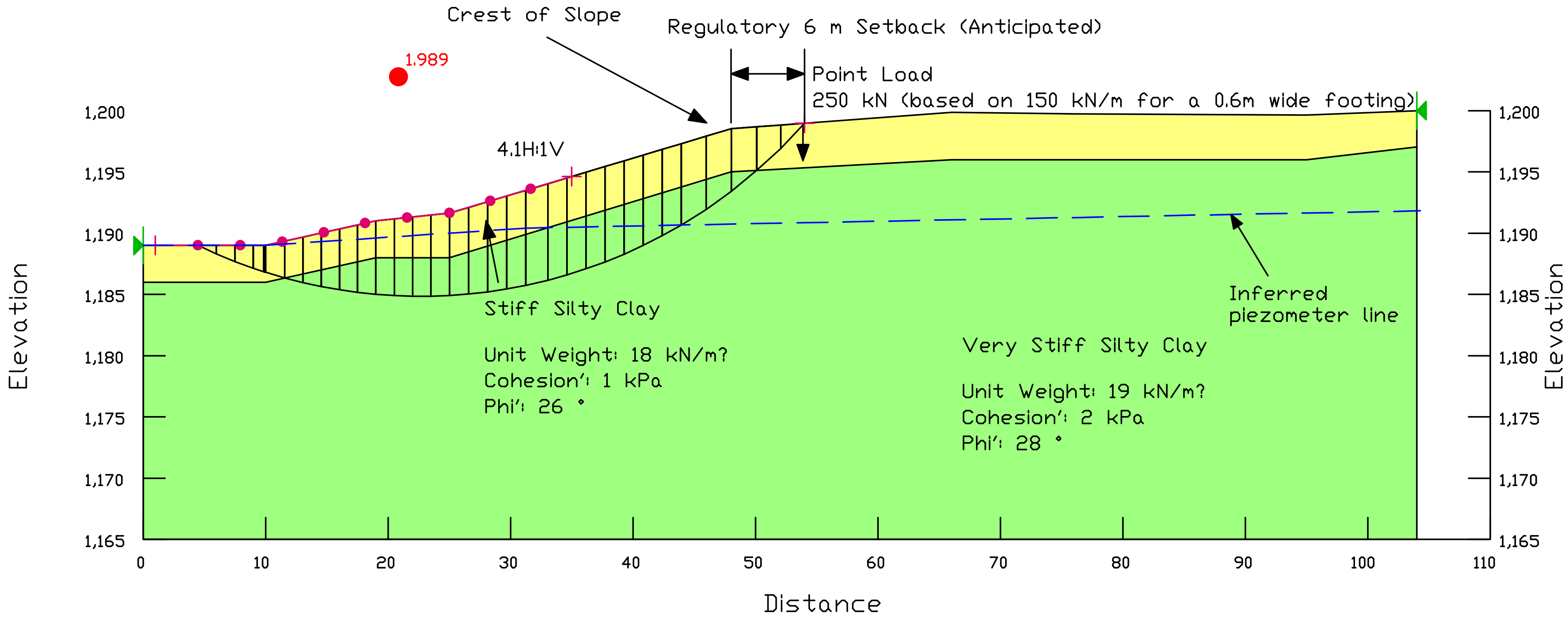
exp.

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

Plot Date: Nov 17, 2016 – 02:10:41pm Plotted by: MeszarosR
O:\CGY-00092055-00\60 Project Execution\3 Reports\Geotechnical\Slope Stability\CGY-00092055-00-Stability Sections.dwg XREFS:

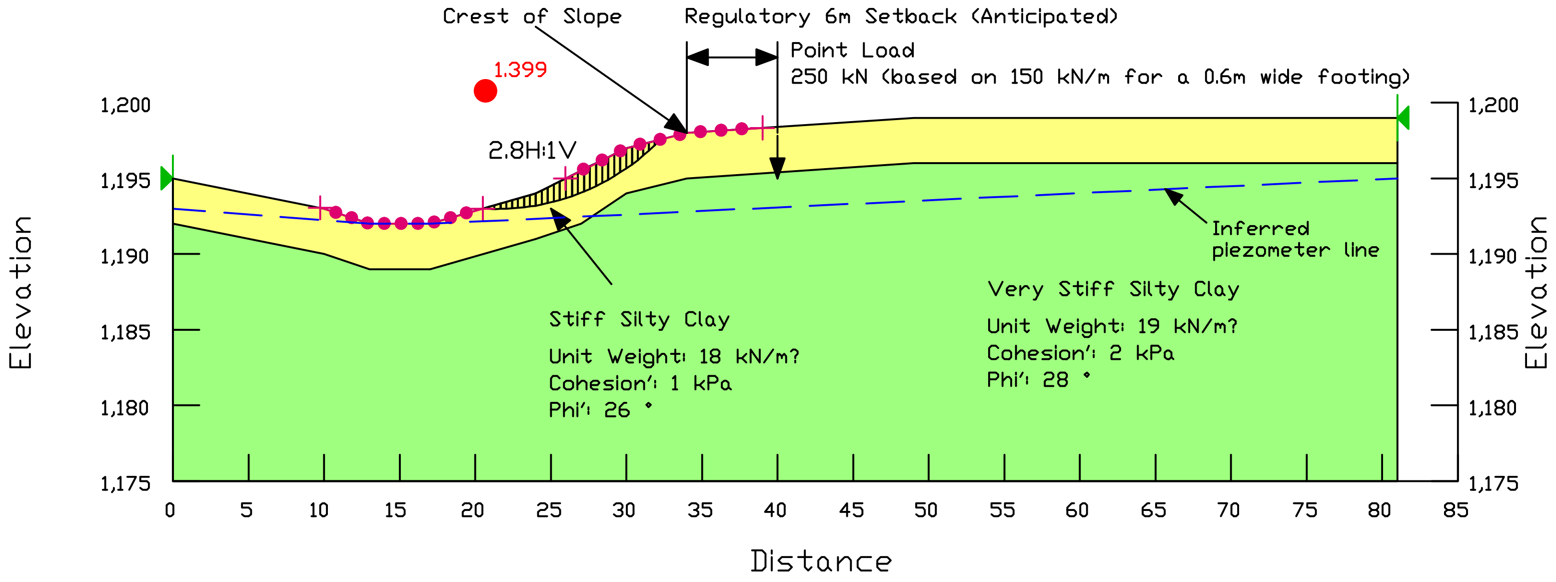
exp.

PROJECT NAME:
HAWKWOOD LANDS

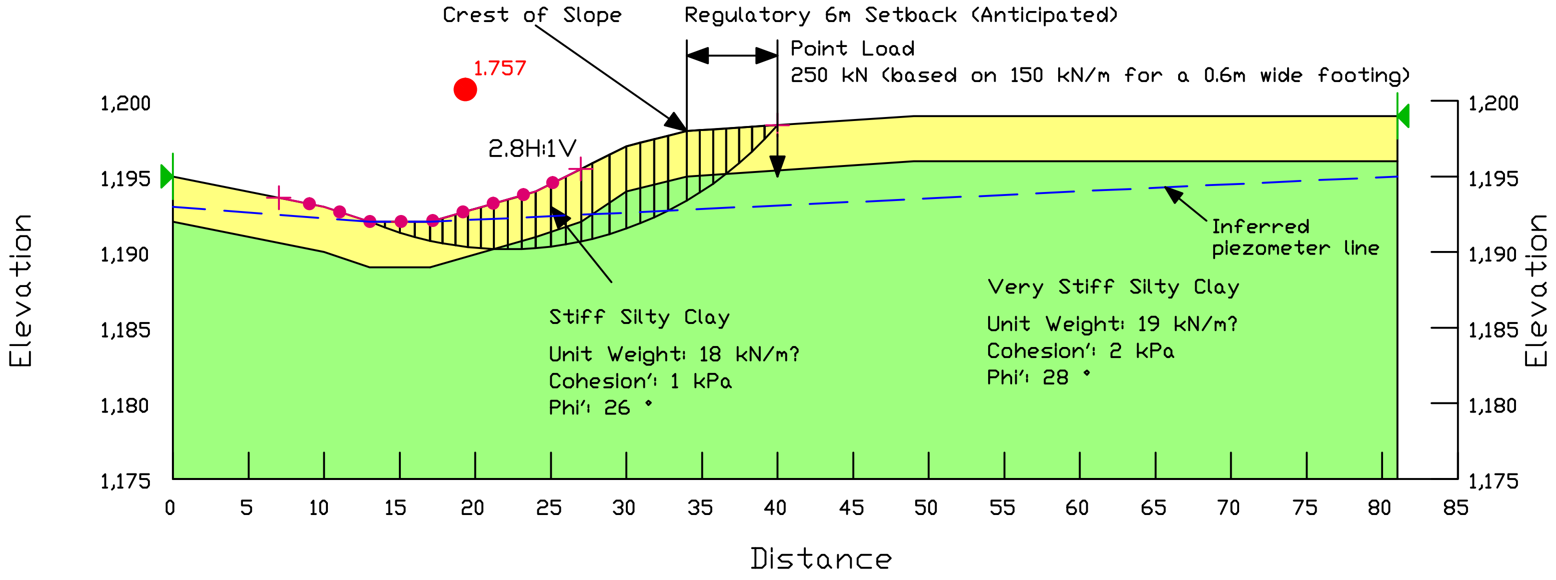
PROJECT NO.: **CGY-00092055-00** DATE: **2016.11.15** SCALE: **1:500**

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

Plot Date: Nov 17, 2016 – 02:10:46pm Plotted by: MeszarosR
O:\CGY-00092055-00\60 Project Execution\3 Reports\Geotechnical\Slope Stability\CGY-00092055-00-Stability Sections.dwg XREFS:

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

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RECORD OF BOREHOLE : BH16-01

PAGE 1 OF 1

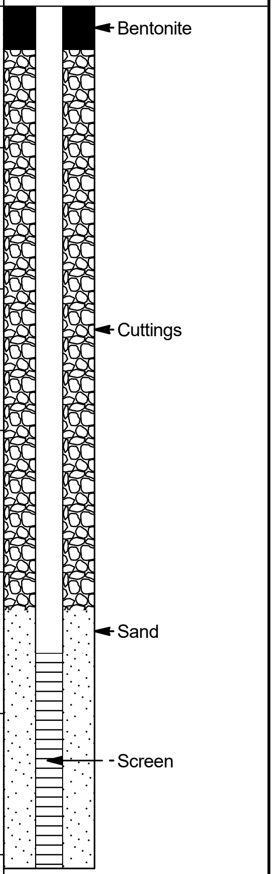
PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-20
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1225.05m
GROUND WATER LEVELS: ▽ **AT TIME OF DRILLING** ---
▼ **AT END OF DRILLING** --- Dry
▼ **AFTER DRILLING** --- 28/10/2016 Dry

SOIL DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m ▲	POCKET PEN. (kPa) ⊙	FINES CONTENT (%) ☐ / MOISTURE CONTENT ⬠
TOPSOIL, some clay, trace silt, sandy, some organics, dark brown, moist	1224.7 0.3	1	GB				
CLAY, silty, trace sand, medium plasticity, stiff, greyish brown, damp to moist		2	GB				18
	1223.2	3	SS	100	12	335	14
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				
-some angular gravel fragments, occasional cobbles		5	SS	100	50/140mm		11
-some gravel		6	GB				
-trace to some gravel, hard		7	SS	100	36	431	
-some gravel		8	GB				7
	1218.5	9	SS	30	30	431	

Bottom of hole at 6.6m.

WELL DIAGRAM
Casing Top Elev: m



exp Services Inc.

RECORD OF BOREHOLE : BH16-02

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

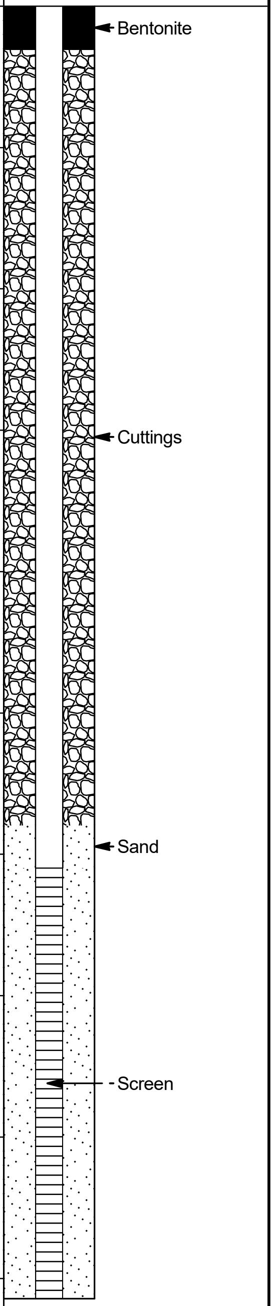
CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1217.57m
GROUND WATER LEVELS: ▽ **AT TIME OF DRILLING** ---
▼ **AT END OF DRILLING** --- Dry
▼ **AFTER DRILLING** --- 28/10/2016 Dry

SOIL DESCRIPTION	ELEV. DEPTH (m)
TOPSOIL, some clay, trace silt, sandy, some rootlets/organics, dark brown, moist	1217.1
CLAY (TILL), silty, trace fine rounded to sub-rounded gravel, trace sand, trace sulphates, medium plasticity, firm, greyish brown, moist	0.5 1216.0
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 1213.0
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 -very stiff -occasional cobbles -occasional silt layers	4.6 1208.0

Bottom of hole at 9.6m.

NUMBER	TYPE	RECOVERY %	SPT N VALUE BLOWS/0.3m	POCKET PEN. (kPa)	MC	PL	LL
1	GB						
2	GB				22		
3	SS	100	9	239	23		
4	GB				29	22	48
5	SS	100	9	192	32		
6	GB						
7	SS	100	13	335	16		
8	GB				14		
9	SS						
10	GB				16		
11	SS	50	24	335			
12	GB				14		
13	SS	100	30	431	20		

WELL DIAGRAM
Casing Top Elev: m



exp Services Inc.

RECORD OF BOREHOLE : BH16-03

PAGE 1 OF 1

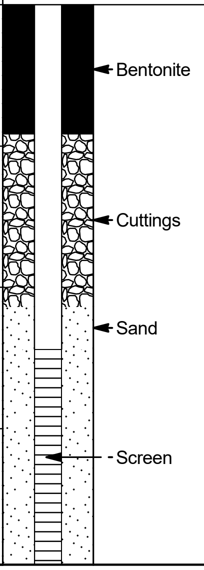
PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-20
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1216.27m
GROUND WATER LEVELS: ▽ **AT TIME OF DRILLING** ---
▼ **AT END OF DRILLING** --- Dry
▼ **AFTER DRILLING** --- 28/10/2016 Dry

DEPTH (m)	SOIL DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m ▲	POCKET PEN. (kPa) ⊙	MOISTURE CONTENT (PL ⬠ LL)
	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%		1	GB				
		1215.8 0.5	2	GB				26
1	CLAY, silty, trace to some sand, trace sulfates, medium plasticity, firm, light brown, moist							
	-stiff, trace fine to coarse sub-rounded gravel		3	SS	100	9	192	27
2			4	GB				24
	-greyish brown, occasional coal fragments							
3		1213.1						
	SANDSTONE, extremely weak to very weak, highly to moderately weathered, brown, dry	3.2	5	SS	100	50 50/150mm		
		1212.3	6	GB				

Refusal at 4.0m.

WELL DIAGRAM
Casing Top Elev: m



exp Services Inc.

RECORD OF BOREHOLE : BH16-04

PAGE 1 OF 1

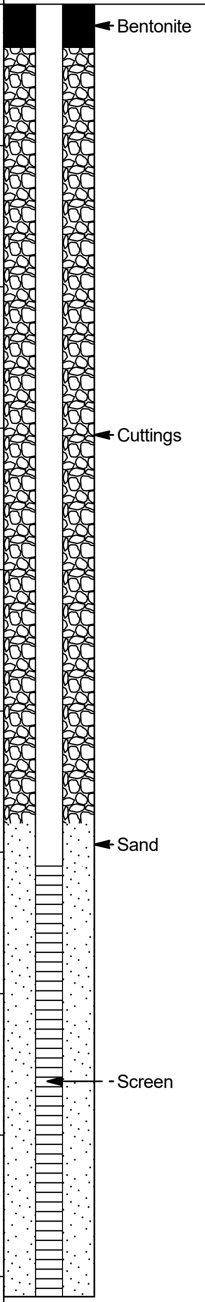
PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-20
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

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

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
TOPSOIL, some clay, some silt, sandy, some organics, dark brown, moist	1183.5 0.3	1	GB				
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
-sand seams -Sulphate Content = 0.3%		4	GB				
-some sand to sandy, minor oxidation, occasional grey mottling		5	SS	100	11	383	30
-medium to high plasticity, occasional quartz crystals Grain Size Analysis: Gravel = 5.7% Sand = 25.7% Silt = 57.6% Clay = 11.0%		6	GB				26 20 ⊢⬠⊣ 50
-trace fine sand, very stiff		7	SS	100	16	383	21
-occasional sandy seams -occasional trace coarse rounded gravel		8	GB				
-occasional silt seams and lenses -grey		9	SS		17		16
-occasional coal fragments	1176.5	10	GB				
CLAY (TILL), silty, some sand, trace rounded to sub-rounded gravel, occasional cobbles, medium plastic, very stiff, greyish brown, moist -trace bedrock fragments	7.3	11	SS	100	25	383	19
		12	GB				
-occasional silt and fine sand seams	1174.2	13	SS	100	24		23

Bottom of hole at 9.6m.

WELL DIAGRAM
Casing Top Elev: m



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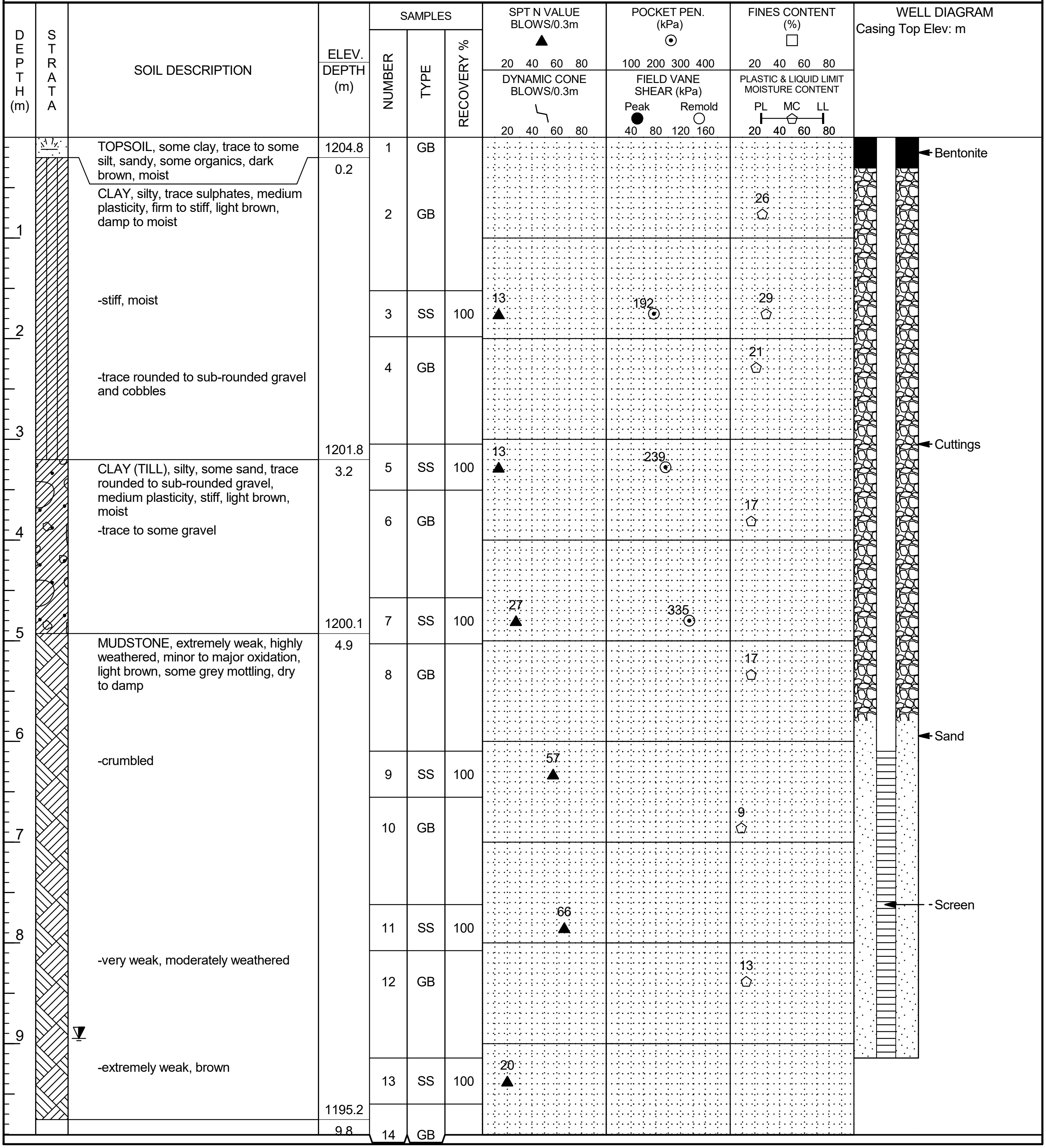
RECORD OF BOREHOLE : BH16-05

PAGE 1 OF 1

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 1204.99m
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** 8.9m 28/10/2016



SOIL DESCRIPTION	ELEV. DEPTH (m)
TOPSOIL, some clay, trace to some silt, sandy, some organics, dark brown, moist	1204.8 0.2
CLAY, silty, trace sulphates, medium plasticity, firm to stiff, light brown, damp to moist -stiff, moist -trace rounded to sub-rounded gravel and cobbles	1201.8 3.2
CLAY (TILL), silty, some sand, trace rounded to sub-rounded gravel, medium plasticity, stiff, light brown, moist -trace to some gravel	1200.1 4.9
MUDSTONE, extremely weak, highly weathered, minor to major oxidation, light brown, some grey mottling, dry to damp -crumbled -very weak, moderately weathered -extremely weak, brown	1195.2 9.8

NUMBER	TYPE	RECOVERY %	SPT N VALUE BLOWS/0.3m	POCKET PEN. (kPa)	MOISTURE CONTENT
1	GB				
2	GB				26
3	SS	100	13	192	29
4	GB				21
5	SS	100	13	239	
6	GB				17
7	SS	100	27	335	
8	GB				17
9	SS	100	57		
10	GB				9
11	SS	100	66		
12	GB				13
13	SS	100	20		
14	GB				

Refusal at 9.9m.

exp Services Inc.

RECORD OF BOREHOLE : BH16-06

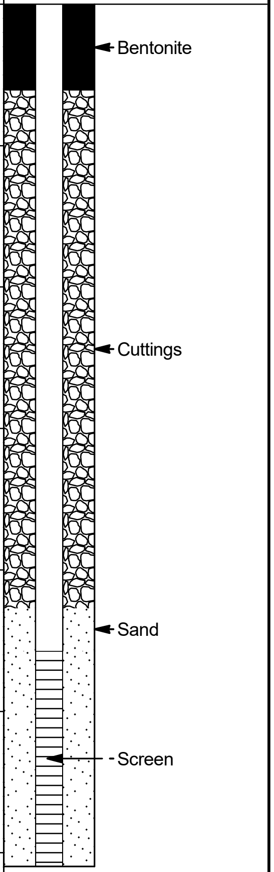
PAGE 1 OF 1

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 1209.41m
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)
		TOPSOIL, some clay, sandy, trace silt, some rootlets, dark brown, moist	1209.2 0.2	1	GB				
1		CLAY, silty, trace fine sand, medium plasticity, stiff, light brown, moist		2	GB			192	29
2		-occasional fine to medium sand seams		3	SS	60	11	287	26
		-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%		4	GB				20 31 51
3		-minor oxidation		5	SS	80	9	287	29
4		-occasional sand seams with trace gravel from 3.0 to 4.5m	1204.8	6	GB				
5		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 4.9	7	SS	100	26	335	16
6		MUDSTONE, extremely weak, highly weathered, light brown, dry		8	GB				17
			1202.9	9	SS	100	50		

WELL DIAGRAM
Casing Top Elev: m



Bottom of hole at 6.6m.

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RECORD OF BOREHOLE : BH16-07

PAGE 1 OF 1

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

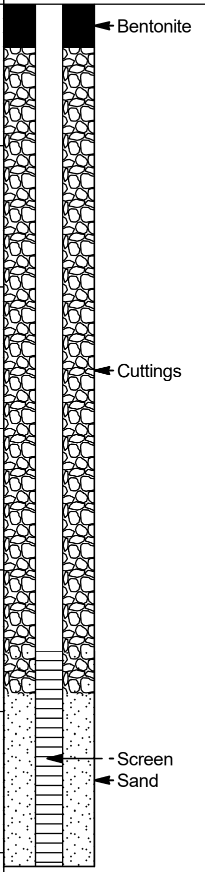
CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1213.57m
GROUND WATER LEVELS: ∇ **AT TIME OF DRILLING** ---
▼ **AT END OF DRILLING** --- Dry
▼ **AFTER DRILLING** --- 28/10/2016 Dry

SOIL DESCRIPTION	ELEV. DEPTH (m)
TOPSOIL, some clay, trace silt, sandy, some rootlets, dark brown, moist	1213.4 0.2
CLAY (FILL), silty, trace sand, medium plasticity, light brown, damp to moist -Sulphate Content <0.1%	1211.7
TOPSOIL, trace organics and rootlets, dark brown, moist	1.8 1211.4
CLAY, silty, trace sand, medium plasticity, stiff, brown, moist -grey -stiff to very stiff, occasional silt seams -minor oxidation, brown -trace gravel	2.1 1207.4
CLAY (TILL), silty, trace to some sand, trace gravel, medium plasticity, very stiff, brown, moist	6.1 1207.0

Bottom of hole at 6.6m.

SAMPLES NUMBER	TYPE	RECOVERY %	SPT N VALUE BLOWS/0.3m ▲	POCKET PEN. (kPa) ⊙	PLASTIC & LIQUID LIMIT MOISTURE CONTENT (MC)
1	GB				
2	GB				20
3	SS	100	5		
4	GB				25
5	SS	100	9	144	26
6	GB				
7	SS	100	15	239	22
8	GB				
9	SS	100	16	287	15

WELL DIAGRAM
Casing Top Elev: m



exp Services Inc.

RECORD OF BOREHOLE : BH16-08

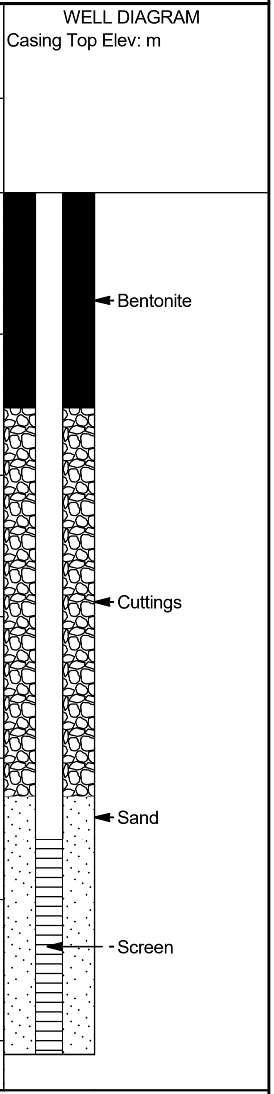
PAGE 1 OF 1

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

SOIL DESCRIPTION	ELEV. DEPTH (m)	NUMBER	TYPE	RECOVERY %	SPT N VALUE BLOWS/0.3m ▲	FINES CONTENT (%) ☐ / PLASTIC & LIQUID LIMIT MOISTURE CONTENT (PL, MC, LL)
TOPSOIL, some clay, trace silt, sandy, trace cobbles, some organics, dark brown, moist	1236.9 0.3	1	GB			
CLAY, silty, trace sulphates, medium plasticity, stiff, brown with oxidation, moist		2	GB			19
-very stiff -Sulphate Content <0.1% -grey, minor oxidation, dry		3	SS	50	29	
-light brown, dry	1234.4 2.7	4	GB			16
MUDSTONE, completely weathered to residual soil, extremely weak, trace to some sand, greyish brown, dry to damp		5	SS	90	50/150mm	14
		6	GB			
-minor oxidation		7	SS	100	50/75mm	12
		8	GB			
	1230.8	9	SS	100	50/50mm	

Bottom of hole at 6.3m.



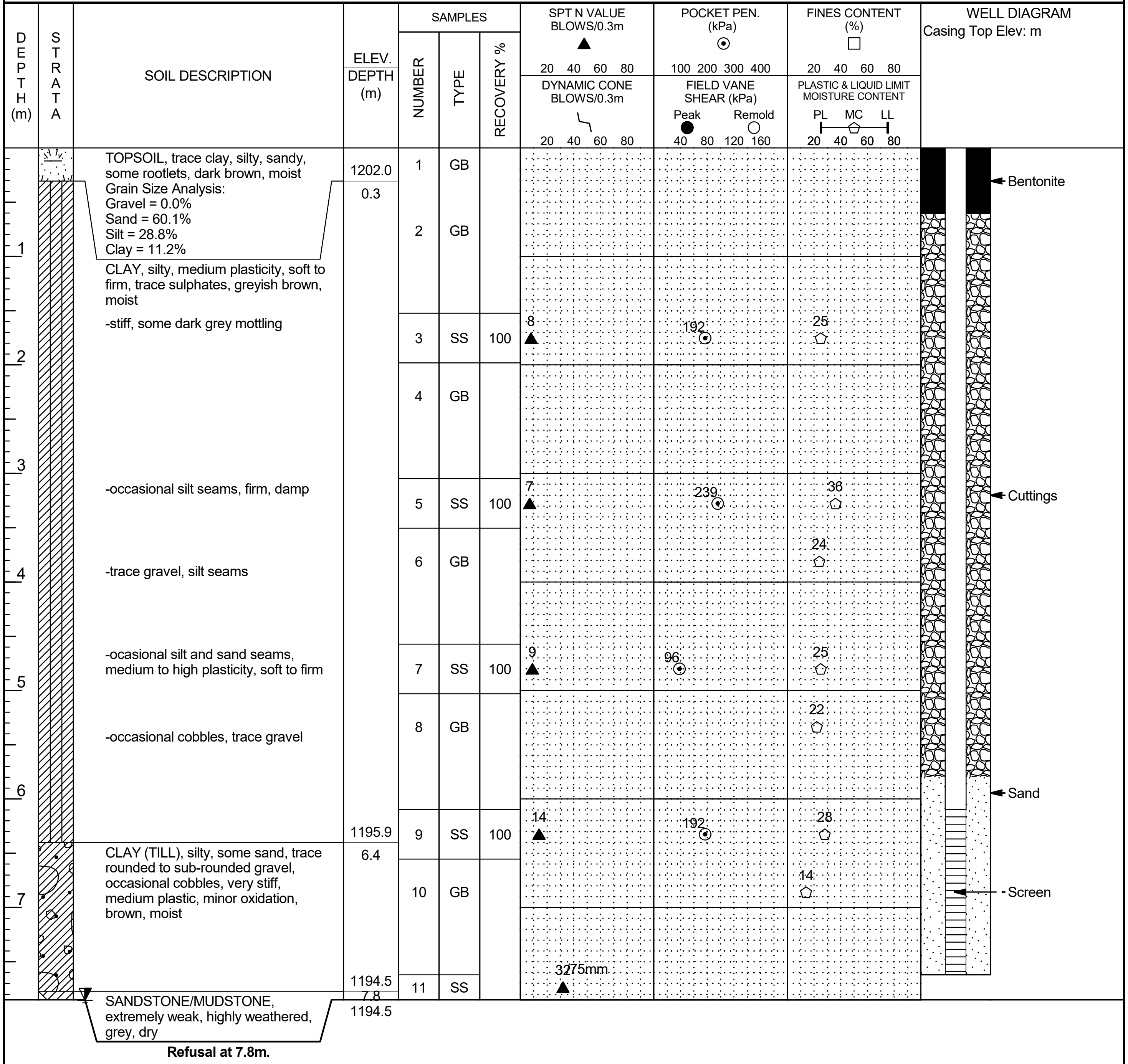
exp Services Inc.

RECORD OF BOREHOLE : BH16-09

PAGE 1 OF 1

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



SOIL DESCRIPTION	ELEV. DEPTH (m)	NUMBER	TYPE	RECOVERY %	SPT N VALUE BLOWS/0.3m	POCKET PEN. (kPa)	MOISTURE CONTENT
TOPSOIL, trace clay, silty, sandy, some rootlets, dark brown, moist	1202.0 0.3	1	GB				
Grain Size Analysis: Gravel = 0.0% Sand = 60.1% Silt = 28.8% Clay = 11.2%		2	GB				
CLAY, silty, medium plasticity, soft to firm, trace sulphates, greyish brown, moist							
-stiff, some dark grey mottling		3	SS	100	8	192	25
		4	GB				
-occasional silt seams, firm, damp		5	SS	100	7	239	36
-trace gravel, silt seams		6	GB				24
-ocasional silt and sand seams, medium to high plasticity, soft to firm		7	SS	100	9	96	25
-occasional cobbles, trace gravel		8	GB				22
	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	10	GB				14
	1194.5 7.8	11	SS		32/75mm		
SANDSTONE/MUDSTONE, extremely weak, highly weathered, grey, dry	1194.5						

Refusal at 7.8m.

RECORD OF BOREHOLE : BH16-10

exp Services Inc.

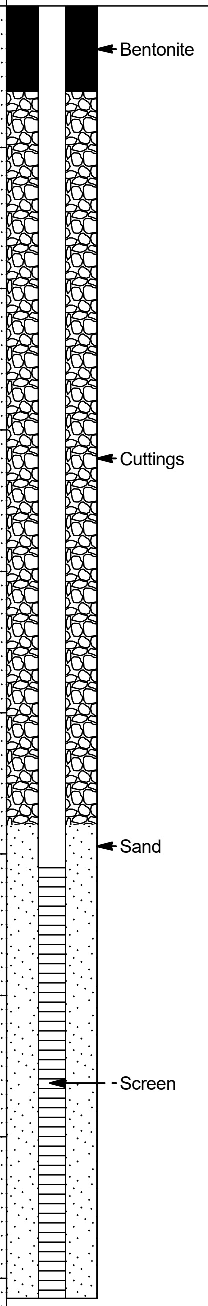
PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-19
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

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

SOIL DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	RECOVERY %	SPT N VALUE BLOWS/0.3m ▲	POCKET PEN. (kPa) ⊙	FINES CONTENT (%) ☐ / PL MC LL
TOPSOIL, some clay, sandy, trace silt, dark brown, moist	1199.6 0.3	1	GB				
CLAY, silty, trace sand, medium plasticity, trace sand, brown, damp to moist, firm		2	GB				31
		3	SS	67	7	192	
CLAY (TILL), silty, trace to some sand, trace rounded to sub-rounded gravel, medium plasticity, stiff, brown, damp to moist	1197.7 2.1	4	GB				14
Grain Size Analysis: Gravel = 0.9% Sand = 5.5% Silt = 84.2% Clay = 9.4%		5	SS	100	11	239	16 25 38
-trace grey mottling, moist		6	GB				19
-silt seams, damp		7	SS	100	10	239	26
		8	GB				24
-very stiff		9	SS	100	18	192	
-trace fine to coarse rounded gravel		10	GB				23
-trace coal fragments		11	SS	100	15	287	21
		12	GB				
	1190.2	13	GB	100	21	287	21

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

WELL DIAGRAM
Casing Top Elev: m



Bottom of hole at 9.6m.

RECORD OF BOREHOLE : BH16-11

PAGE 1 OF 1

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

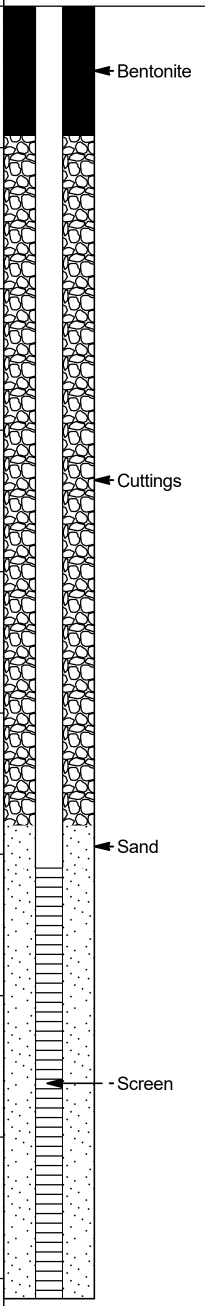
CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1217.42m
GROUND WATER LEVELS: ∇ **AT TIME OF DRILLING** ---
▼ **AT END OF DRILLING** 9.45m
∇ **AFTER DRILLING** 8.6m 28/10/2016

SOIL DESCRIPTION	ELEV. DEPTH (m)
TOPSOIL, some rootlets, trace to some clay, silty, sandy, dark brown, moist	1217.1 0.3
Grain Size Analysis: Gravel = 0.2% Sand = 61.7% Silt = 24.4% Clay = 13.7%	
CLAY, silty, medium plasticity, trace sand, brown, damp to moist, firm	
-trace fine rounded gravel, moist	1215.6 1.8
CLAY (TILL), silty, some sand, trace rounded to sub-rounded gravel, occasional cobbles, medium plasticity, stiff, brown, damp to moist	
-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	
-trace gravel, moist	
-trace subangular to rounded gravel, some sand layers, dry to moist	
-occasional coal fragments	
-some coarse rounded gravel	
-trace gravel	
-some gravel (rock in SPT), wet	1207.8

Bottom of hole at 9.6m.

SAMPLES NUMBER	TYPE	RECOVERY %	SPT N VALUE BLOWS/0.3m	POCKET PEN. (kPa)	MOISTURE CONTENT (PL / MC / LL)
1	GB				
2	GB				25
3	SS	100	15	287	
4	GB				17
5	SS	100	36	311	18 / 15 / 43
6	GB				15
7	SS	100	15	311	
8	GB				14
9	SS	100	31	359	
10	GB				15
11	SS	100	19	335	
12	GB				14
13	SS	50	50/150mm		

WELL DIAGRAM
Casing Top Elev: m



exp Services Inc.

RECORD OF BOREHOLE : BH16-12

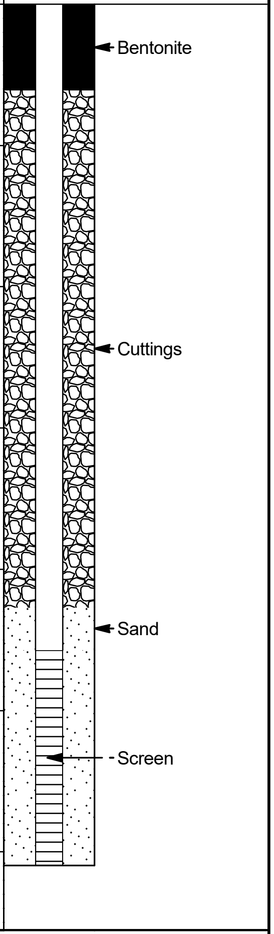
PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-19
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

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

SOIL DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	RECOVERY %	SPT N VALUE BLOWS/0.3m ▲ (20 40 60 80) / DYNAMIC CONE BLOWS/0.3m	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)
TOPSOIL, some rootlets, trace to some clay, trace to some silt, sandy, dark brown, moist	1219.2 0.3	1	GB				
CLAY, silty, trace sand, medium plasticity, stiff, brown, damp to moist	1217.9 1.5	2	GB				26
SAND, silty, trace clay, fine to medium, light brown, dry to damp, compact	1217.7 1.7	3	SS	90	17	239	
CLAY (TILL), silty, some sand, trace fine to coarse sub-rounded gravel, medium plasticity, stiff to very stiff, light brown, moist -minor oxidation		4	GB				15
-very stiff		5	SS	0	16		
-trace to some rounded gravel, occasional cobbles		6	GB				16
-hard		7	SS	80	33	431	
		8	GB				15
▼ -very stiff	1212.9	9	SS	100	26	431	15

Bottom of hole at 6.6m.

WELL DIAGRAM
Casing Top Elev: m



exp Services Inc.

RECORD OF BOREHOLE : BH16-13

PAGE 1 OF 1

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** ---

SOIL DESCRIPTION	ELEV. DEPTH (m)
TOPSOIL, some clay, trace to some silt, sandy, some organics, dark brown, moist	1263.4 0.3
CLAY (TILL), silty, some sand to sandy, trace to some angular gravel, medium plasticity, stiff, brown, damp to moist	
-layers of well graded sand and gravel, cobbles, some silt, occasional boulders, very stiff	
-some cobbles	
	1257.0

SAMPLES NUMBER	TYPE	RECOVERY %	SPT N VALUE BLOWS/0.3m	MOISTURE CONTENT (%)
1	GB			
2	GB			8
3	SS	100	39	13
4	GB			
	SS	0		
	GB			
5	SS	0	23	
6	SS	2933	0 50/125mm	

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

Refusal at 6.7m.

exp Services Inc.

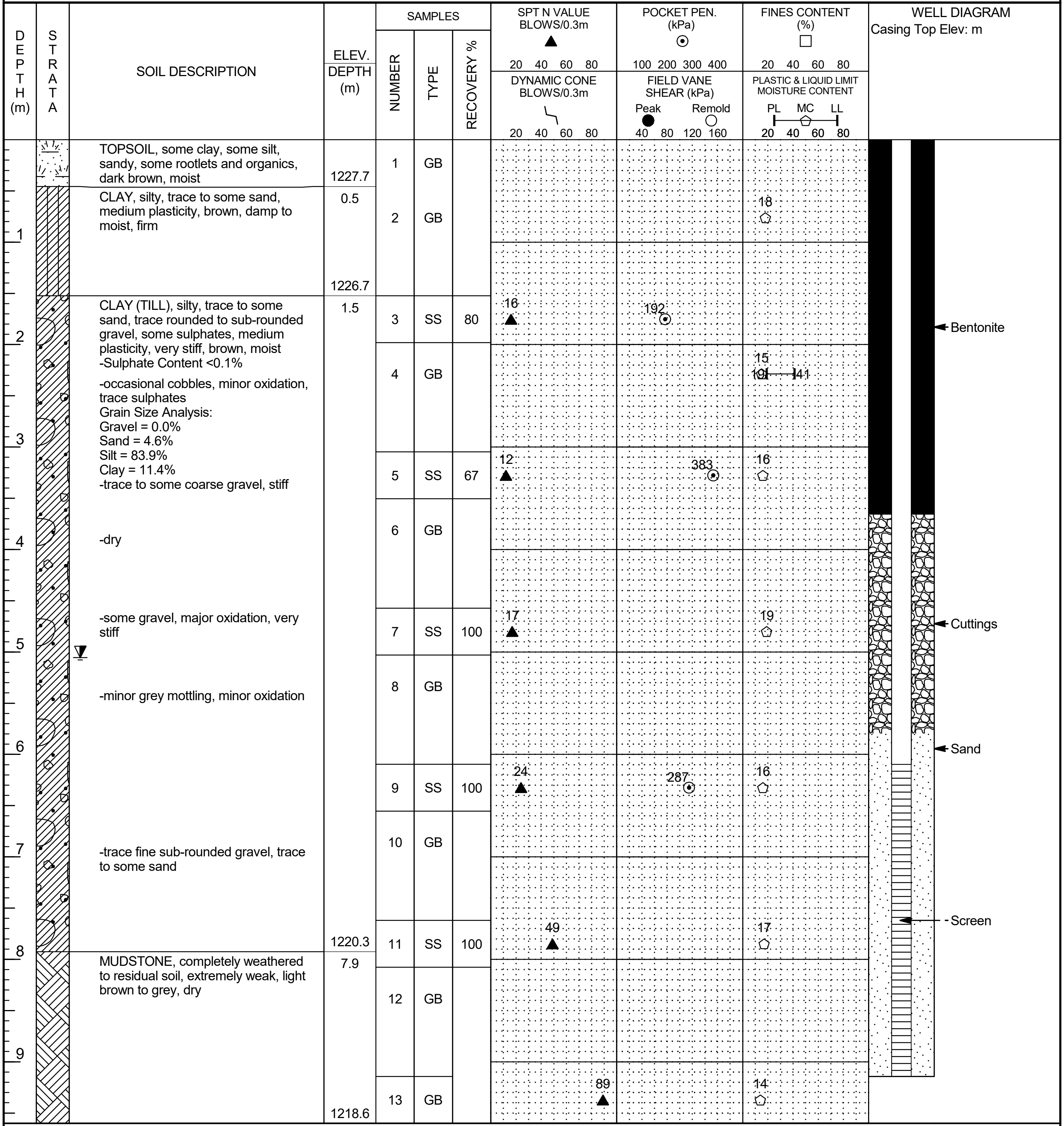
RECORD OF BOREHOLE : BH16-14

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

SOIL DESCRIPTION	ELEV. DEPTH (m)
TOPSOIL, some clay, some silt, sandy, some rootlets and organics, dark brown, moist	1227.7 0.5
CLAY, silty, trace to some sand, medium plasticity, brown, damp to moist, firm	1226.7 1.5
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% -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 -dry -some gravel, major oxidation, very stiff -minor grey mottling, minor oxidation -trace fine sub-rounded gravel, trace to some sand	1220.3 7.9
MUDSTONE, completely weathered to residual soil, extremely weak, light brown to grey, dry	1218.6

NUMBER	TYPE	RECOVERY %	SPT N VALUE BLOWS/0.3m	POCKET PEN. (kPa)	FINES CONTENT (%) / MOISTURE CONTENT
1	GB				
2	GB				18
3	SS	80	16	192	
4	GB				15 PL 19, LL 41
5	SS	67	12	383	16
6	GB				
7	SS	100	17		19
8	GB				
9	SS	100	24	287	16
10	GB				
11	SS	100	49		17
12	GB				
13	GB		89		14



Bottom of hole at 9.6m.

exp Services Inc.

RECORD OF BOREHOLE : BH16-15

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

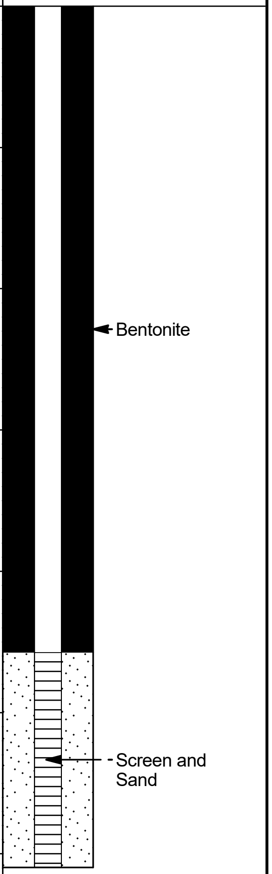
DEPTH (m)	SOIL DESCRIPTION	ELEV. DEPTH (m)
0.0	TOPSOIL, some clay, trace silt, sandy, some organics, dark brown, moist	1221.5 0.6
0.6	CLAY, silty, trace sand, medium plasticity, stiff, brown, damp to moist -occasional silt seams, minor oxidation -trace coarse sand, trace cobbles, trace gravel	1219.3 2.7
2.7	CLAY (TILL), silty, some sand, trace rounded to sub-rounded gravel, minor oxidation, low to medium plasticity, very stiff, brown, damp to moist -light brown, dry	1217.3 4.7
4.7	MUDSTONE, completely weathered to residual soil, extremely weak, light brown, minor oxidation, dry ▽ -extremely weak, highly weathered	1215.5

Bottom of hole at 6.6m.

SAMPLES; 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)

NUMBER	TYPE	RECOVERY %	SPT N VALUE	POCKET PEN. (kPa)	MOISTURE CONTENT
1	GB				
2	GB				21
3	SS	80	7	192	
4	GB				23
5	SS	100	17		
6	GB				15
7	SS	100	51		
8	GB				12
9	SS		82		

WELL DIAGRAM
Casing Top Elev: m



RECORD OF BOREHOLE : BH16-16

PAGE 1 OF 1

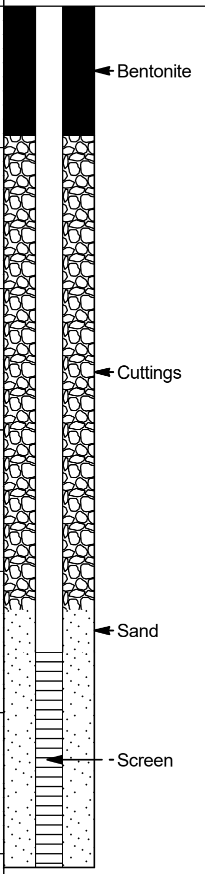
exp Services Inc.

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 1216.30m
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

SOIL DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY %	SPT N VALUE BLOWS/0.3m ▲	POCKET PEN. (kPa) ⊙	PLASTIC & LIQUID LIMIT MOISTURE CONTENT MC ⬠
TOPSOIL, some clay, sandy, trace silt, some organics, dark brown, moist	1216.0	1	GB				
CLAY, silty, trace sand, trace rootlets, medium plasticity, stiff, light brown, damp	0.3	2	GB				
-trace gravel	1214.6						
CLAY (TILL), silty, trace sand, trace fine to coarse rounded to sub-rounded gravel, medium plasticity, stiff, brown, damp -moist	1.7	3	SS	100	8	192	23
		4	GB				
		5	SS	90	13	239	18
-trace rounded gravel		6	GB				
-silt seams, trace gravel, damp to moist		7	SS	100	19	287	16
-trace fine to coarse rounded to sub-rounded gravel, sand seams		8	GB				
-damp to moist	1209.7	9	SS	100	25	335	16

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



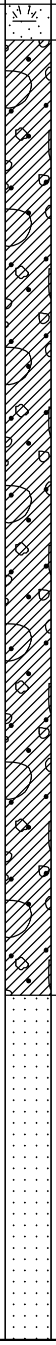
Bottom of hole at 6.6m.

exp Services Inc.

RECORD OF BOREHOLE : BH16-17

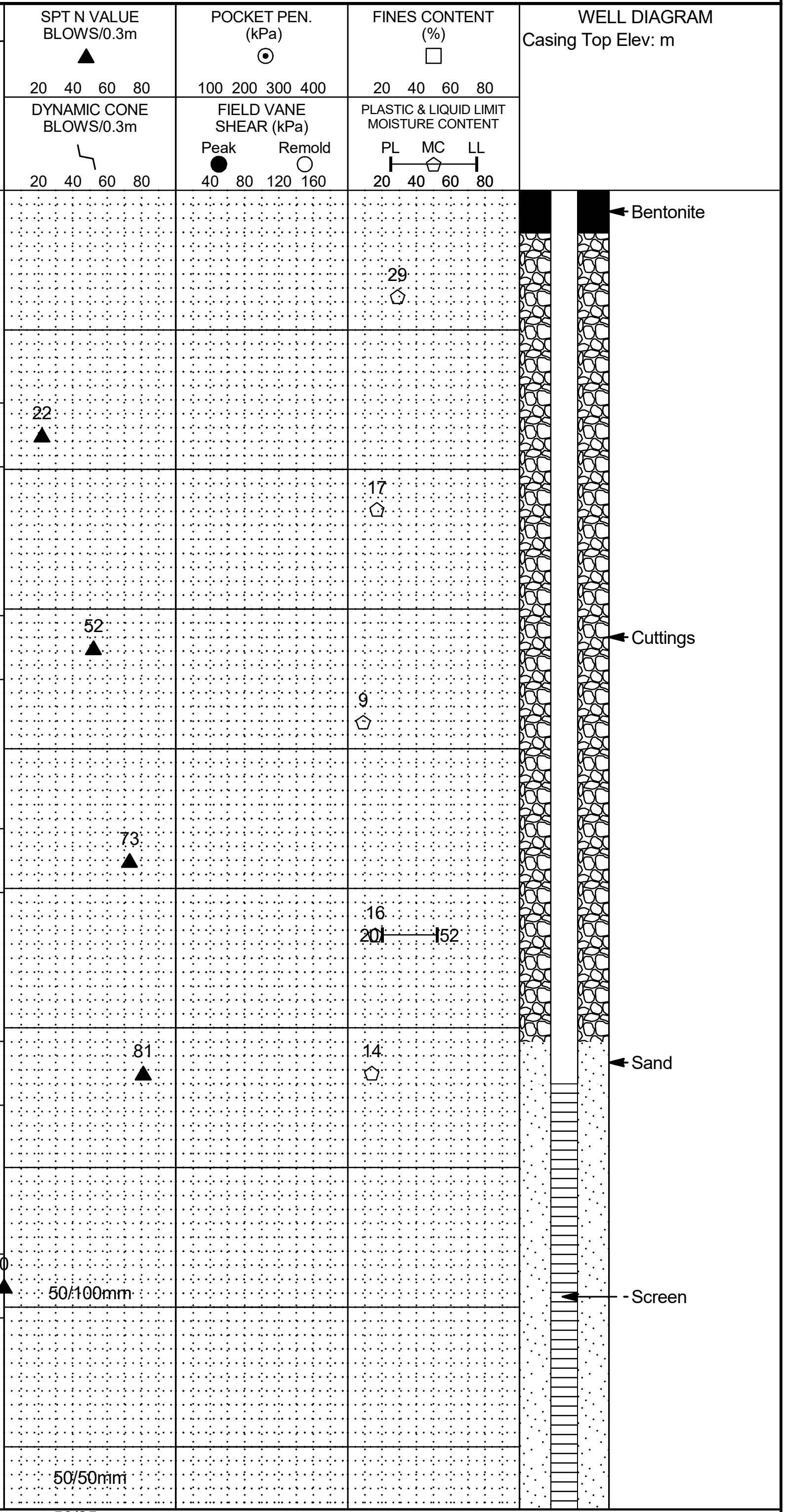
PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-17
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

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



SOIL DESCRIPTION	ELEV. DEPTH (m)
TOPSOIL, some clay, trace silt, sandy, some organics, dark brown, moist	1236.7 0.3
CLAY (TILL), silty, some sand, trace fine sub-rounded to sub-angular gravel, trace sulphates, trace organics, medium plasticity, stiff, light brown, moist	
-some fine to coarse sub-rounded to sub-angular gravel, occasional sulphates, minor oxidation, very stiff -Sulphate Content <0.1%	
-trace fine gravel, light brown/light grey with major oxidation, damp	
-sulphates, rust stains, hard	
-some angular gravel, minor oxidation	
-trace to some sand, trace gravel, occasional oxidation seams	
-some sand, medium to high plastic Grain Size Analysis: Gravel = 0.4% Sand = 18.4% Silt = 61.7% Clay = 19.5%	
-some sand to sandy, trace fine angular gravel,	1230.0 7.0
SANDSTONE, extremely weak, highly weathered, brown, dry	
-very weak, moderately weathered	1227.5
Refusal at 9.4m.	

SAMPLES NUMBER	TYPE	RECOVERY %	SPT N VALUE BLOWS/0.3m	FINES CONTENT / MOISTURE CONTENT (%)
1	GB			
2	GB			29
3	SS	100	22	
4	GB			17
5	SS	100	52	
6	GB			9
7	SS	100	73	
8	GB			16 PL 20, LL 52
9	SS	67	81	14
10	GB			
11	SS	100	0 50/100mm	
12	GB			
13	SS		50/50mm	
14	GB			
15	SS		50/25mm	



RECORD OF BOREHOLE : BH16-18

PAGE 1 OF 1

exp Services Inc.

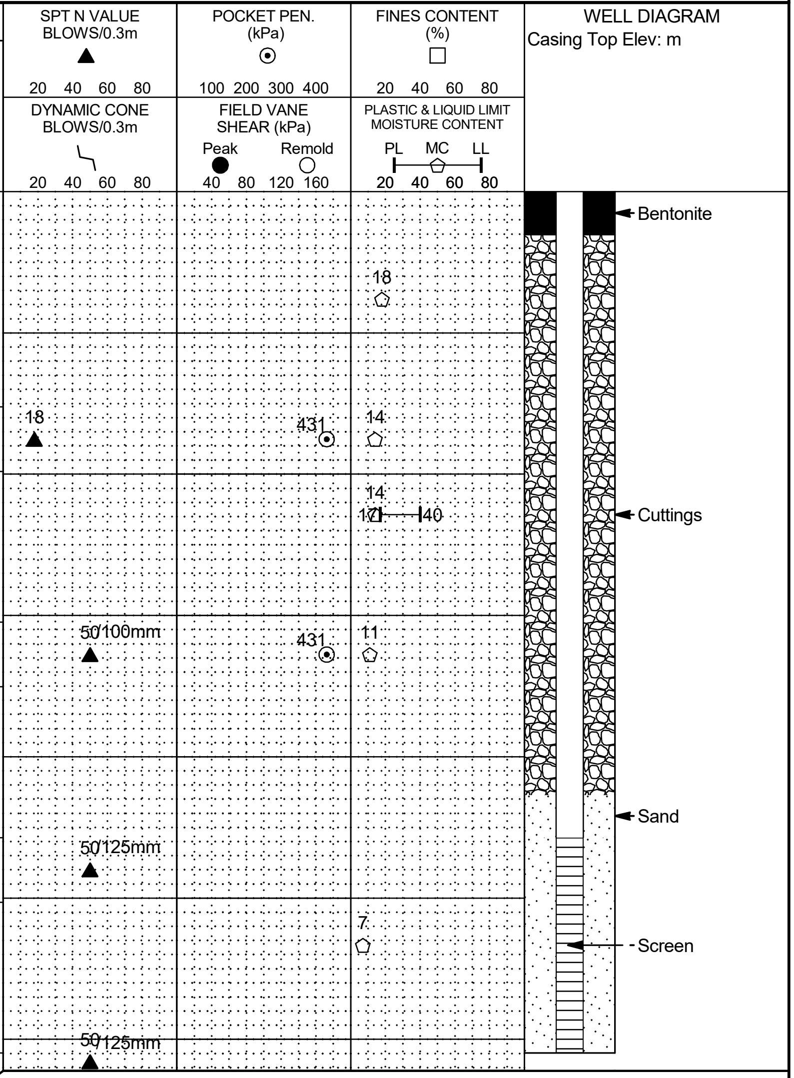
PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-17
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1239.18m
GROUND WATER LEVELS: ▽ **AT TIME OF DRILLING** ---
▼ **AT END OF DRILLING** --- Dry
▼ **AFTER DRILLING** --- 28/10/2016 Dry

SOIL DESCRIPTION	ELEV. DEPTH (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
CLAY, silty, some sulphates, trace sand, low to medium plasticity, stiff, greyish brown, dry	1237.7 1.5
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%	1235.8 3.4
SILT, sandy, (fine sand), trace to some clay, non to low plasticity, light brown, minor oxidation, dry	1235.2 4.0
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 -trace sand, occasional mudstone fragments	1233.0

Refusal at 6.2m.

SAMPLES NUMBER	TYPE	RECOVERY %	SPT N VALUE BLOWS/0.3m	POCKET PEN. (kPa)	FINES CONTENT (%) / PLASTIC & LIQUID LIMIT MOISTURE CONTENT
1	GB				
2	GB				18
3	SS	100	18	431	14
4	GB				14 17 40
5	SS	100	50/100mm	431	11
6	GB				
7	SS	100	50/125mm		
8	GB				7
9	SS	100	50/125mm		



exp Services Inc.

RECORD OF BOREHOLE : BH16-19

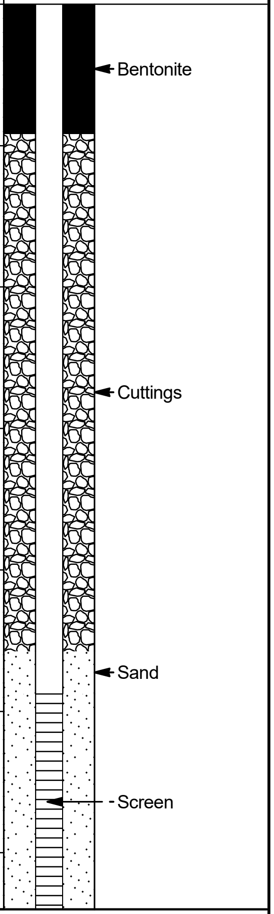
PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-17
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

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)	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)
	TOPSOIL, clayey, silty, some sand, some organics and rootlets, trace gravel, dark brown, dry to moist	1230.9 0.3	1	GB				
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	1229.6	2	GB			383	18
2	CLAY, silty, low to medium plasticity, hard, light brown to brownish grey, damp -major oxidation from 1.8m	1.5	3	SS	100	42		
	-trace mudstone fragments	1228.4	4	GB				15
3	MUDSTONE, extremely weak, highly to completely weathered, occasional black lenses, grey to brownish grey, minor oxidation	2.7	5	SS	100	62		
4			6	GB				12
5			7	SS		86		
6	▼		8	GB				14
	-grey, occasional oxidation seams, extremely to very weak, highly weathered	1224.7	9 10	SS GB		50/100mm		

Refusal at 6.4m.

WELL DIAGRAM
Casing Top Elev: m



exp Services Inc.

RECORD OF BOREHOLE : BH16-20

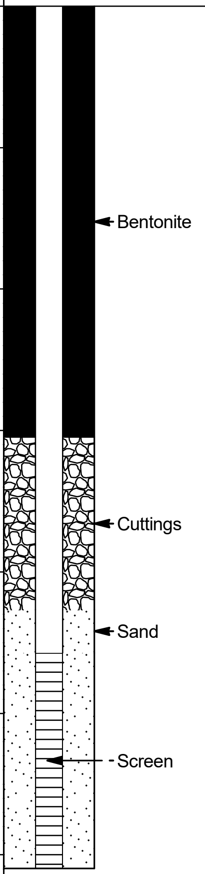
PAGE 1 OF 1

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)	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
	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
	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				
2			4	GB				13
3	-coarse sand, trace to some gravel		5	GB				
4	-some gravel		6	GB				7
5			7	SS	0	19		
	-well graded sand		8	GB				9
6		1211.8	9	SS	40	20		

Bottom of hole at 6.6m.

WELL DIAGRAM
Casing Top Elev: m



exp Services Inc.

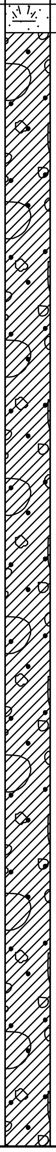
RECORD OF BOREHOLE : BH16-21

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

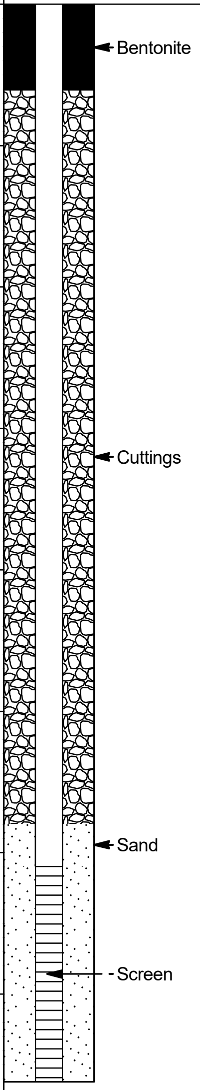
CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1231.00m
GROUND WATER LEVELS: ∇ **AT TIME OF DRILLING** ---
▼ **AT END OF DRILLING** --- Dry
▼ **AFTER DRILLING** --- 28/10/2016 Dry

DEPTH (m)	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)
	TOPSOIL, clayey, silty, some sand, some organics, trace gravel, dark brown, moist	1230.8 0.2	1	GB				
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				
			3	SS	0	16		
2	-trace gravel, occasional sulphates		4	GB				14
3	-sand layers from 3.0 to 4.6m		5	SS	25	8		
4	-some gravel to gravelly, moist		6	GB				9
5	-some sand to sandy, very stiff		7	SS	60	30	335	
6			8	GB				11
	-cobbles and boulders		9	SS	32	22		
7	-cobbles		10	GB				9
8		1222.9	11	SS	25	26		

Bottom of hole at 8.1m.



WELL DIAGRAM
Casing Top Elev: m



RECORD OF BOREHOLE : BH16-22

exp. 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

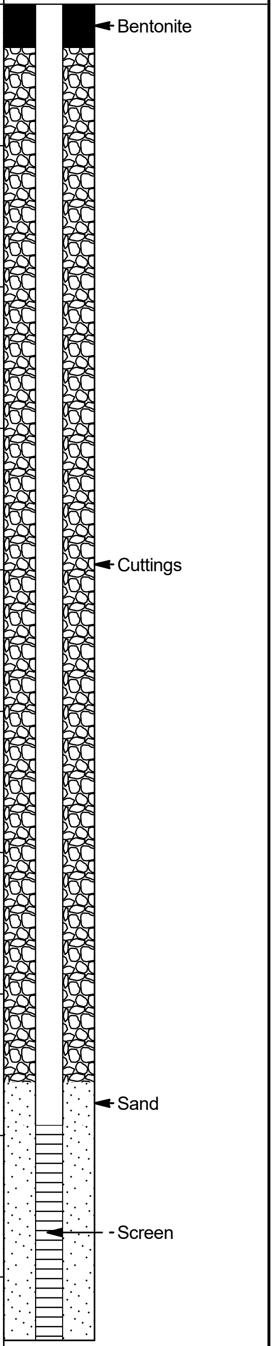
CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1217.32m
GROUND WATER LEVELS: ▽ **AT TIME OF DRILLING** ---
▼ **AT END OF DRILLING** 6.55m
▼ **AFTER DRILLING** 6.6m 28/10/2016

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

SOIL DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	RECOVERY %	SPT N VALUE	MC
TOPSOIL, trace to some clay, trace to some silt, , some sand to sandy, some organics, dark brown, moist	1216.7	1	GB			
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	
-gravelly, light brown, moist		4	GB			9
-minor oxidation		5	SS	25	20	
-some gravel to gravelly, occasional coal fragments		6	GB			
		7	SS	100	22	15
-trace to some rounded to sub-rounded gravel		8	GB			15
		9	SS		22	
▼ -gravelly -cobbly, gravelly, grey, wet		10	GB			19
		11	SS	50	47	
		12	GB			
-some gravel	1207.7	13	SS	50	26	17

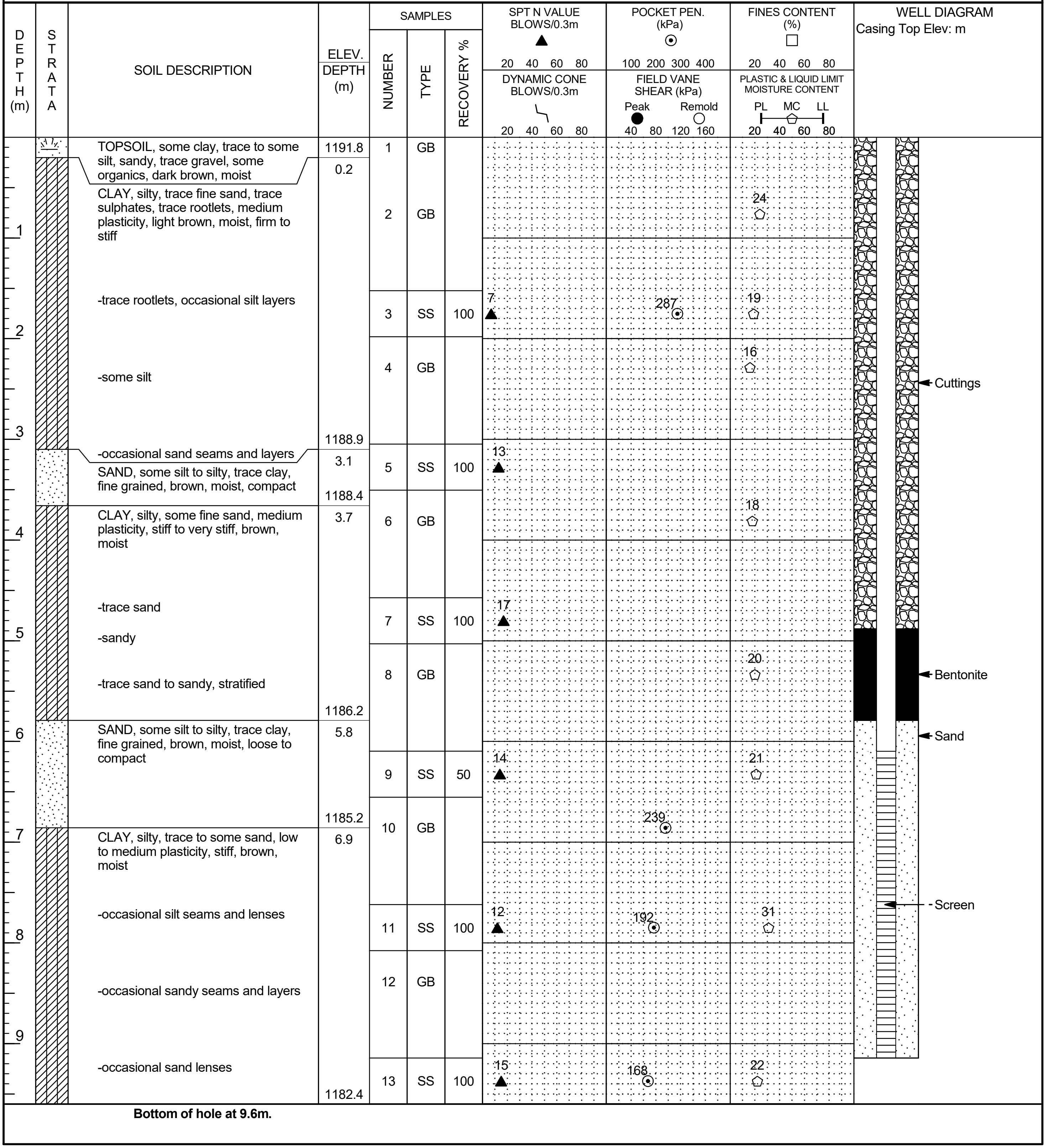
Bottom of hole at 9.6m.

WELL DIAGRAM
Casing Top Elev: m



RECORD OF TESTHOLE : MW16-01

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 1192.03m
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



SOIL DESCRIPTION	ELEV. DEPTH (m)
TOPSOIL, some clay, trace to some silt, sandy, trace gravel, some organics, dark brown, moist	1191.8 0.2
CLAY, silty, trace fine sand, trace sulphates, trace rootlets, medium plasticity, light brown, moist, firm to stiff -trace rootlets, occasional silt layers -some silt -occasional sand seams and layers	1188.9 3.1
SAND, some silt to silty, trace clay, fine grained, brown, moist, compact	1188.4 3.7
CLAY, silty, some fine sand, medium plasticity, stiff to very stiff, brown, moist -trace sand -sandy -trace sand to sandy, stratified	1186.2 5.8
SAND, some silt to silty, trace clay, fine grained, brown, moist, loose to compact	1185.2 6.9
CLAY, silty, trace to some sand, low to medium plasticity, stiff, brown, moist -occasional silt seams and lenses -occasional sandy seams and layers -occasional sand lenses	1182.4

Bottom of hole at 9.6m.

SAMPLES NUMBER	TYPE	RECOVERY %	SPT N VALUE	POCKET PEN. (kPa)	MOISTURE CONTENT
1	GB				
2	GB				24
3	SS	100	7	287	19
4	GB				16
5	SS	100	13		
6	GB				18
7	SS	100	17		
8	GB				20
9	SS	50	14		21
10	GB			239	
11	SS	100	12	192	31
12	GB				
13	SS	100	15	168	22

exp Services Inc.

RECORD OF TESTHOLE : MW16-02

PAGE 1 OF 1

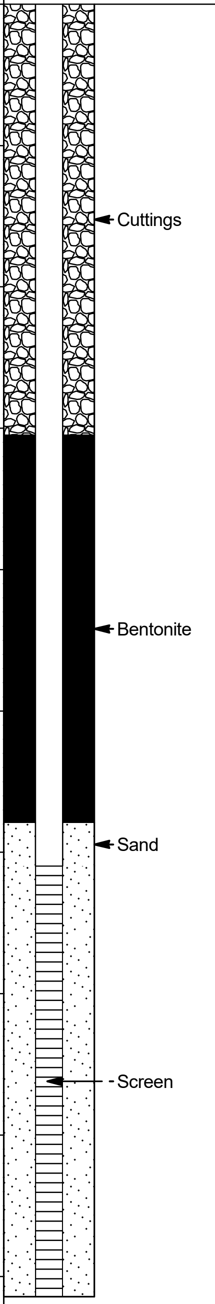
PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-19
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

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

SOIL DESCRIPTION	ELEV. DEPTH (m)	NUMBER	TYPE	RECOVERY %	SPT N VALUE BLOWS/0.3m ▲	POCKET PEN. (kPa) ⊙	PL	MC	LL
TOPSOIL, some rootlets, trace to some clay, trace to some silt, sandy, dark brown, moist	1208.1	1	GB						
CLAY, silty, trace sand, trace rootlets, medium plasticity, stiff, brown, moist Grain Size Analysis: Gravel = 0.0% Sand = 22.1% Silt = 67.0% Clay = 10.9%	0.3	2	GB				26	33	41
-trace to some sand, trace sulphates	1206.5	3	SS	100	10	239		23	
CLAY (TILL), silty, some sand, trace rounded to sub-rounded gravel, medium plastic, stiff, brown, moist	1.8	4	GB						
	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	
-some clay, low to medium plasticity		6	GB					26	
	1203.8								
CLAY, silty, trace to some sand, medium plasticity, stiff, light brown, damp to moist	4.6	7	SS	40	12	144		24	
-trace fine rounded to sub-rounded gravel		8	GB						
	1202.2								
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	
		10	GB						
		11	SS	33	15	239		19	
-trace coarse gravel		12	GB						
-cobble in SPT	1198.7	13	SS	100	56	287		19	

Bottom of hole at 9.6m.

WELL DIAGRAM
Casing Top Elev: m



exp Services Inc.

RECORD OF TESTHOLE : MW16-03

PAGE 1 OF 1

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

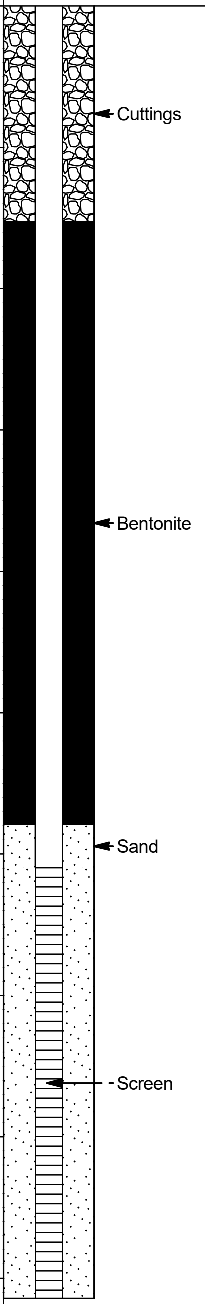
CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1208.90m
GROUND WATER LEVELS: ▽ **AT TIME OF DRILLING** ---
▼ **AT END OF DRILLING** 1.22m
⊻ **AFTER DRILLING** 2.2m 28/10/2016

ELEV. DEPTH (m)	SOIL DESCRIPTION
1208.7 0.2	TOPSOIL, clayey, some silt, sandy, some organics and rootlets, low/medium plasticity, dark brown, moist
	CLAY, some silt to silty, trace sand, medium to high plasticity, brown, moist, firm -occasional silt seams, stratified layers of clay -Sulphate Content <0.1% -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
1204.3 4.6	CLAY (TILL), silty, some sand, trace gravel, medium plasticity, very stiff, brown, moist -occasional coal fragments - some sand to sandy - sand seam, dark brown
1199.3	**Bottom of hole at 9.6m.**

NUMBER	TYPE	RECOVERY %	SPT N VALUE BLOWS/0.3m ▲	POCKET PEN. (kPa) ⊙	PL	MC	LL
1	GB						
2	GB					35	
3	SS	100	6	96		35	
4	GB						
5	SS	100	9	120	20	17	32
6	GB						
7	SS	50	11	239		20	
8	GB						
9	SS	67	15	287		18	
10	GB						
11	SS	33	20	239		16	
12	GB						
13	SS	60	25	287		18	

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



exp Services Inc.

RECORD OF TESTHOLE : MW16-04

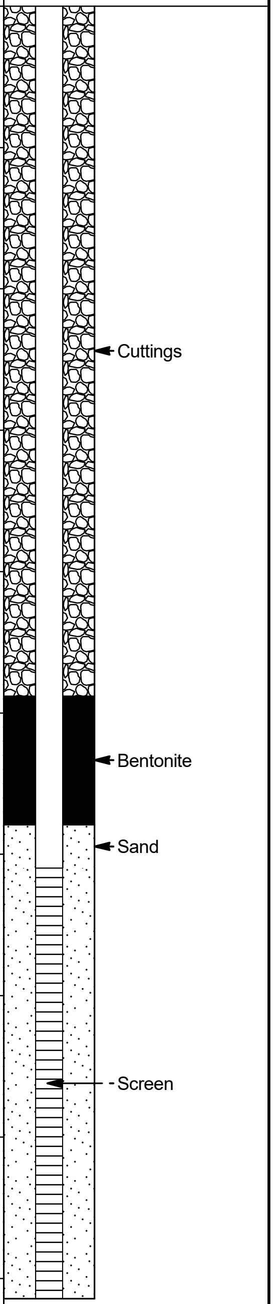
PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-18
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

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

SOIL DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	RECOVERY %	SPT N VALUE BLOWS/0.3m ▲	POCKET PEN. (kPa) ⊙	FINES CONTENT (%) ☐ / PLASTIC & LIQUID LIMIT MOISTURE CONTENT (MC)
TOPSOIL, some clay, trace silt, sandy, some organics, dark brown, moist	1204.0 0.0	1	GB				
CLAY, silty, trace fine sand, trace sulphates, medium plasticity, stiff, light brown, moist -occasional grey mottling, trace rootlets to 1.8m		2	GB				
		3	SS	100	8	287	27
		4	GB				
-occasional silt seams, wet		5	SS	100	8	96	32
	1199.5	6	GB				
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				
-occasional silt seams		9	SS	100	12	239	26
	1197.2	10	GB				
CLAY, some silt to silty, medium plasticity, stiff, brown, moist	6.9						
	1196.3	11	SS	100	11	287	20
CLAY (TILL), silty, some sand, trace fine to coarse rounded to sub-rounded gravel, medium plasticity, stiff, brown, moist	7.8	12	GB				
-some gravel	1194.4	13	SS	100	19	335	19

Bottom of hole at 9.6m.

WELL DIAGRAM
Casing Top Elev: m



exp Services Inc.

RECORD OF TESTHOLE : MW16-05

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

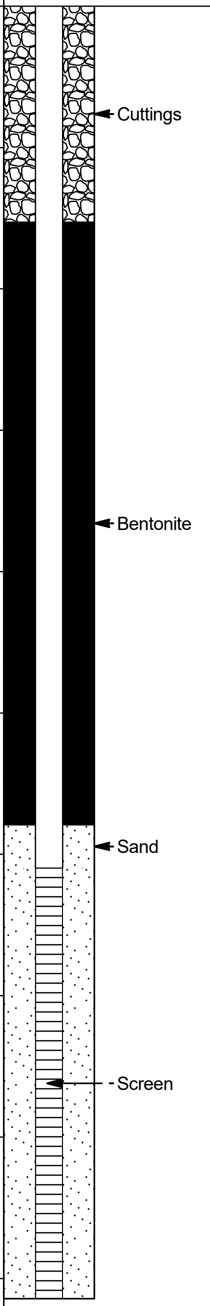
CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1200.60m
GROUND WATER LEVELS: ∇ **AT TIME OF DRILLING** ---
▼ **AT END OF DRILLING** 4.88m
∇ **AFTER DRILLING** 4.6m 28/10/2016

SOIL DESCRIPTION	ELEV. DEPTH (m)
TOPSOIL, some clay, trace silt, sandy, some organics, dark brown, moist	1200.5 0.1
CLAY (TILL), silty, some sand, trace fine to coarse sub-rounded gravel, trace rootlets, trace sulphates, low to medium plasticity, stiff, brown, damp	
Grain Size Analysis: Gravel = 3.7% Sand = 16.4% Silt = 67.1% Clay = 12.8%	
-trace fine gravel, very stiff	
-light brown	
-grey	
-sandy, gravelly, medium plasticity, stiff	
-brown	1192.8 7.8
CLAY, some silt, trace coarse sand, medium plasticity, light brown, moist, stiff	
- silty	
- occasional silt seams, grey, occasional oxidation	1191.0

Bottom of hole at 9.6m.

SAMPLES NUMBER	TYPE	RECOVERY %	SPT N VALUE BLOWS/0.3m	POCKET PEN. (kPa)	PL	MOISTURE CONTENT (%)	LL
1	GB						
2	GB						
3	SS	100	13	311		13	
4	GB				18	15	40
5	SS	100	17	335		14	
6	GB						
7	SS	100	18	263		14	
8	GB						
9	SS	80	14	192		15	
10	GB					16	
11	SS	100	13	192		25	
12	GB					23	
13	SS	90	17			22	

WELL DIAGRAM
Casing Top Elev: m



RECORD OF TESTHOLE : MW16-06

PAGE 1 OF 1

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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

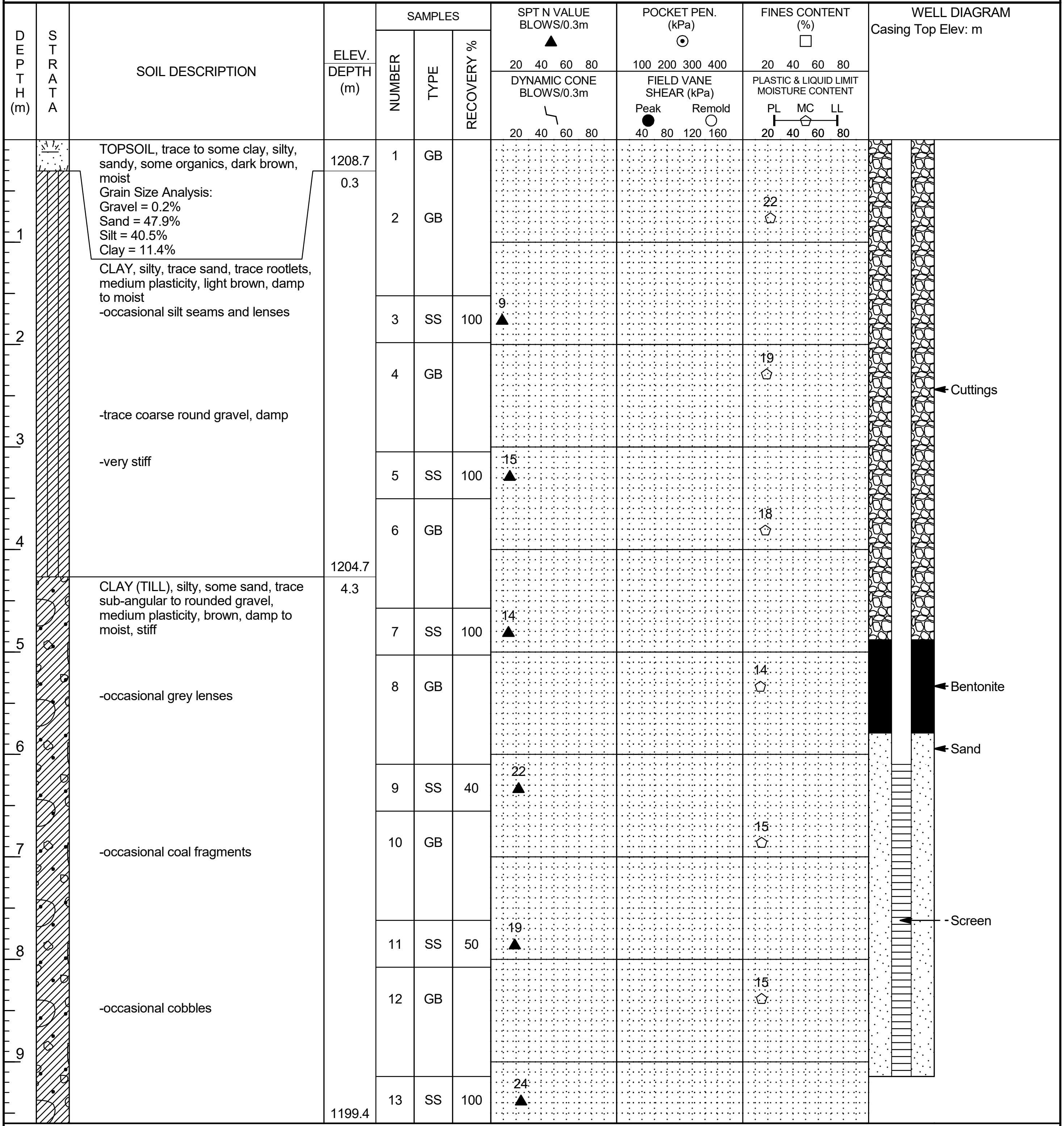
BOREHOLE LOCATION

ELEVATION 1209.00m

GROUND WATER LEVELS: ∇ **AT TIME OF DRILLING** ---

▼ **AT END OF DRILLING** --- Dry

▼ **AFTER DRILLING** --- 28/10/2016 Dry



SOIL DESCRIPTION	ELEV. DEPTH (m)
TOPSOIL, trace to some clay, silty, sandy, some organics, dark brown, moist	1208.7 0.3
Grain Size Analysis: Gravel = 0.2% Sand = 47.9% Silt = 40.5% Clay = 11.4%	
CLAY, silty, trace sand, trace rootlets, medium plasticity, light brown, damp to moist -occasional silt seams and lenses -trace coarse round gravel, damp -very stiff	1204.7 4.3
CLAY (TILL), silty, some sand, trace sub-angular to rounded gravel, medium plasticity, brown, damp to moist, stiff -occasional grey lenses -occasional coal fragments -occasional cobbles	1199.4

SAMPLES NUMBER	TYPE	RECOVERY %	SPT N VALUE BLOWS/0.3m	MOISTURE CONTENT (%)
1	GB			
2	GB			22
3	SS	100	9	
4	GB			19
5	SS	100	15	
6	GB			18
7	SS	100	14	
8	GB			14
9	SS	40	22	
10	GB			15
11	SS	50	19	
12	GB			15
13	SS	100	24	

Bottom of hole at 9.6m.

exp Services Inc.

RECORD OF TESTHOLE : MW16-07

PAGE 1 OF 1

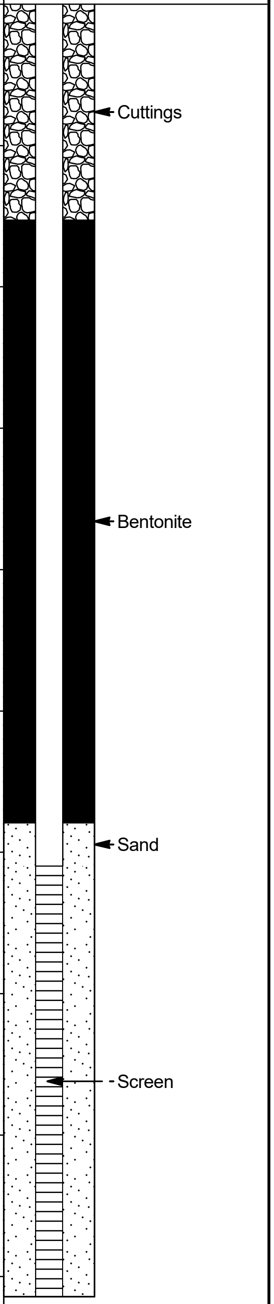
PROJECT NUMBER CGY-00092055-00
PROJECT NAME Hawkwood Lands
DRILLING DATE 2016-10-18
DRILLING CONTRACTOR Earth Drilling Co. Ltd.
DRILLING METHOD Solid Stem Auger
EQUIPMENT TYPE Truck Mounted Auger Drill
LOGGED BY CS **CHECKED BY** MT

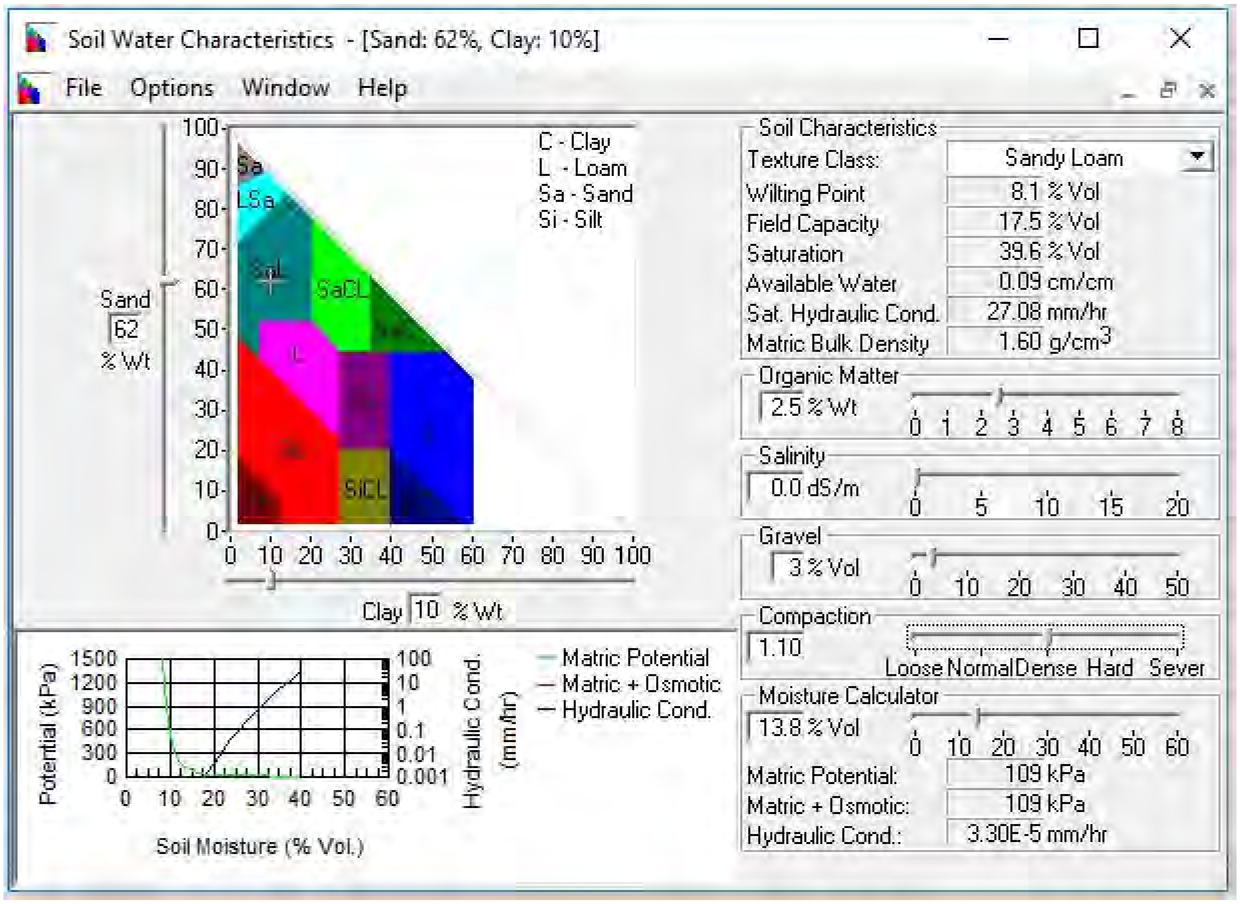
CLIENT Highfield Land Management Inc.
PROJECT LOCATION Calgary, Alberta
BOREHOLE LOCATION
ELEVATION 1205.68m
GROUND WATER LEVELS: ∇ **AT TIME OF DRILLING** ---
▼ **AT END OF DRILLING** --- Dry
▼ **AFTER DRILLING** 4.8m 28/10/2016

SOIL DESCRIPTION	ELEV. DEPTH (m)	NUMBER	TYPE	RECOVERY %	SPT N VALUE BLOWS/0.3m ▲	POCKET PEN. (kPa) ⊙	FINES CONTENT (%) ☐ / PLASTIC & LIQUID LIMIT MOISTURE CONTENT PL MC LL
TOPSOIL, some clay, trace to some silt, sandy, some organics, dark brown, moist	1205.4 0.2	1	GB				
CLAY (TILL), silty, some sand to sandy, some rounded to angular gravel, medium plasticity, very stiff, brown, damp to moist		2	GB				11
-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%	1202.6	4	GB				13 14 — 36
CLAY, silty, sandy, low to medium plasticity, brown, occasional grey mottling, moist, very stiff	3.0 1202.2	5	SS	50	19		18
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
▼		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
-occasional cobbles and boulders		9	SS	0	50		
-some gravel		10	GB				12
-occasional coal fragments		11	SS	10	19		
	1196.5	12	GB				
CLAY, silty, trace sand, medium plasticity, light brown, occasional oxidation, moist, stiff -grey	9.1 1196.1	13	SS	90	13		27

Bottom of hole at 9.6m.

WELL DIAGRAM
Casing Top Elev: m





Soil Water Characteristics - [Sand: 62%, Clay: 10%]

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/cm^3

Organic Matter 2.5 % Wt

Salinity 0.0 dS/m

Gravel 3 % Vol

Compaction 1.10

Moisture Calculator 13.8 % Vol

Matric Potential: 109 kPa
Matric + Osmotic: 109 kPa
Hydraulic Cond.: 3.30E-5 mm/hr

APPENDIX B

PCSWMM
Existing Conditions Analysis

- Schematic
- Input and Report Files

Legend

● Junctions

▲ Outfalls

🟩 Storages

Conduits

- Culvert
- Natural Channel

▨ Subcatchments

N

350 m

Client/Project

HIGHFIELD LAND MANAGEMENT

ASCENSION

Title

Pre-development PCSWMM Model Schematic

Figure No.

B-1

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

```
-------------------------------------------------------------------------------------------------
                                Maximum  Maximum                  Lateral       Total        Flow
                                Lateral    Total  Time of Max      Inflow      Inflow     Balance
                                 Inflow   Inflow   Occurrence      Volume      Volume       Error
Node                 Type           CMS      CMS  days hr:min    10^6 ltr    10^6 ltr     Percent
-------------------------------------------------------------------------------------------------
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.
---------------------------------------------------------------------
                                             Max. Height   Min. Depth
                                 Hours       Above Crown    Below Rim
Node                 Type      Surcharged         Meters       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
**********************

--------------------------------------------------------------------------------------------------
                       Average      Avg  Evap Exfil       Maximum     Max    Time of Max   Maximum
                        Volume     Pcnt  Pcnt  Pcnt        Volume    Pcnt     Occurrence   Outflow
Storage Unit           1000 m3     Full  Loss  Loss       1000 m3    Full    days hr:min       CMS
--------------------------------------------------------------------------------------------------
Ex-Wetland               2.475       32     0     0         4.800      61      0   09:33     0.337


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

-----------------------------------------------------------
                        Flow       Avg       Max      Total
                        Freq      Flow      Flow     Volume
Outfall Node            Pcnt       CMS       CMS   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
********************

-----------------------------------------------------------------------------
                                Maximum  Time of Max   Maximum   Max/    Max/
                                 |Flow|   Occurrence   |Veloc|   Full    Full
Link                 Type           CMS  days hr:min     m/sec   Flow   Depth
-----------------------------------------------------------------------------
1                    CONDUIT      0.337     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
***************************

-------------------------------------------------------------------------------------
                    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   0.00  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
*************************

----------------------------------------------------------------------------
                                                           Hours        Hours 
                         --------- Hours Full --------   Above Full   Capacity
Conduit                  Both Ends  Upstream  Dnstream   Normal Flow   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
*******************

-------------------------------------------------------------------------------------------------
                                Maximum  Maximum                  Lateral       Total        Flow
                                Lateral    Total  Time of Max      Inflow      Inflow     Balance
                                 Inflow   Inflow   Occurrence      Volume      Volume       Error
Node                 Type           CMS      CMS  days hr:min    10^6 ltr    10^6 ltr     Percent
-------------------------------------------------------------------------------------------------
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.
---------------------------------------------------------------------
                                             Max. Height   Min. Depth
                                 Hours       Above Crown    Below Rim
Node                 Type      Surcharged         Meters       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.
--------------------------------------------------------------------------
                                                           Total   Maximum
                               Maximum   Time of Max       Flood    Ponded
                      Hours       Rate    Occurrence      Volume     Depth
Node                 Flooded       CMS   days hr:min    10^6 ltr    Meters
--------------------------------------------------------------------------
J2                      0.46     2.611   17322  19:04       1.916   100.000


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

--------------------------------------------------------------------------------------------------
                       Average     Avg  Evap Exfil       Maximum     Max    Time of Max    Maximum
                        Volume    Pcnt  Pcnt  Pcnt        Volume    Pcnt     Occurrence    Outflow
Storage Unit           1000 m3    Full  Loss  Loss       1000 m3    Full    days hr:min        CMS
--------------------------------------------------------------------------------------------------
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
***********************

-----------------------------------------------------------
                       Flow       Avg       Max       Total
                       Freq      Flow      Flow      Volume
Outfall Node           Pcnt       CMS       CMS    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

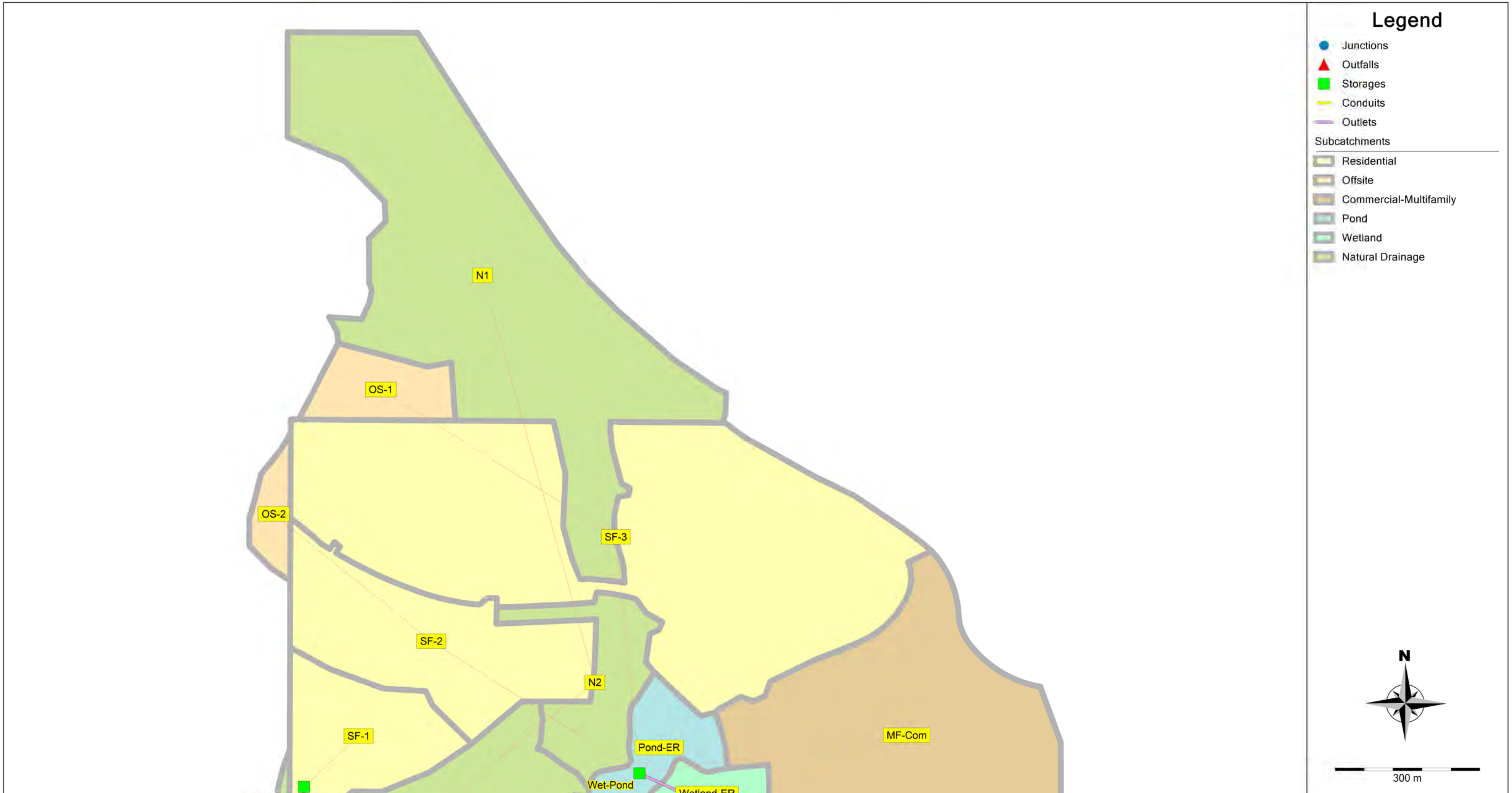
PCSWMM
Post-development Analysis

- 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)
MF-Com	25.52	81.6	20.82	70	14.58	30	6.25
N1*	37.79	3.7	1.40	0	0.00	100	1.40
N2*	5.79	0	0.00	0	0.00	100	0.00
N3*	13.7	0	0.00	0	0.00	100	0.00
OS-1	3.78	6	0.23	0	0.00	100	0.23
OS-2	1.74	9	0.16	0	0.00	100	0.16
Pond-ER	3.89	41	1.59	100	1.59	0	0.00
SF-1	7.77	34.9	2.71	52	1.41	48	1.30
SF-2	13.99	50.4	7.05	51	3.60	49	3.45
SF-3	45.66	46.3	21.14	53	11.20	47	9.94
Wetland-ER	2.47	49.1	1.21	93	1.13	7	0.08
	162.1	34.7	56.32	59.5	33.51	40.5	22.81

* Exiting Areas (Natural Drainage Course)



Client/Project

HIGHFIELD LAND MANAGEMENT

ASCENSION

Title **Post-development PCSWMM Model Schematic**

Figure No. **B-2**

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

---------------------------------------------------------------------------------
                               Average  Maximum  Maximum  Time of Max     Reported
                                 Depth    Depth      HGL   Occurrence    Max Depth
Node                 Type       Meters   Meters   Meters  days hr:min       Meters
---------------------------------------------------------------------------------
J1                   JUNCTION     0.00     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
*******************

-------------------------------------------------------------------------------------------------
                                Maximum  Maximum                  Lateral       Total        Flow
                                Lateral    Total  Time of Max      Inflow      Inflow     Balance
                                 Inflow   Inflow   Occurrence      Volume      Volume       Error
Node                 Type           CMS      CMS  days hr:min    10^6 ltr    10^6 ltr     Percent
-------------------------------------------------------------------------------------------------
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
**********************

--------------------------------------------------------------------------------------------------
                       Average     Avg  Evap Exfil       Maximum     Max    Time of Max    Maximum
                        Volume    Pcnt  Pcnt  Pcnt        Volume    Pcnt     Occurrence    Outflow
Storage Unit           1000 m3    Full  Loss  Loss       1000 m3    Full    days hr:min        CMS
--------------------------------------------------------------------------------------------------
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
***********************

-----------------------------------------------------------
```

```
                       Flow       Avg       Max       Total
                       Freq      Flow      Flow      Volume
Outfall Node           Pcnt       CMS       CMS    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
********************

-----------------------------------------------------------------------------
                               Maximum  Time of Max   Maximum    Max/    Max/
                                |Flow|   Occurrence   |Veloc|    Full    Full
Link                 Type          CMS  days hr:min     m/sec    Flow   Depth
-----------------------------------------------------------------------------
1                    CONDUIT     0.041     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
***************************

-------------------------------------------------------------------------------------
                    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   0.02  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
*************************

----------------------------------------------------------------------------
                                                           Hours        Hours
                       --------- Hours Full --------    Above Full   Capacity
Conduit                Both Ends  Upstream  Dnstream    Normal Flow   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
************
                                         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


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


**************************        Volume         Depth
Runoff Quantity Continuity     hectare-m            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


**************************        TSS010        TSS020        TSS050        TSS150        TSS500
Runoff Quality Continuity             kg            kg            kg            kg            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


**************************        Volume        Volume
Flow Routing Continuity        hectare-m      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


**************************        TSS010        TSS020        TSS050        TSS150        TSS500
Quality Routing Continuity            kg            kg            kg            kg            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
******************

---------------------------------------------------------------------------------
                               Average  Maximum  Maximum  Time of Max    Reported
                                 Depth    Depth      HGL   Occurrence   Max Depth
Node                 Type       Meters   Meters   Meters  days hr:min      Meters
---------------------------------------------------------------------------------
J1                   JUNCTION     0.00     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
*******************

-------------------------------------------------------------------------------------------------
                                Maximum  Maximum                  Lateral       Total        Flow
                                Lateral    Total  Time of Max      Inflow      Inflow     Balance
                                 Inflow   Inflow   Occurrence      Volume      Volume       Error
Node                 Type           CMS      CMS  days hr:min    10^6 ltr    10^6 ltr     Percent
-------------------------------------------------------------------------------------------------
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
**********************

--------------------------------------------------------------------------------------------------
                       Average     Avg  Evap Exfil       Maximum     Max    Time of Max    Maximum
                        Volume    Pcnt  Pcnt  Pcnt        Volume    Pcnt     Occurrence    Outflow
Storage Unit           1000 m3    Full  Loss  Loss       1000 m3    Full    days hr:min        CMS
```

```
  --------------------------------------------------------------------------------------------------
  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
  ***********************

  ------------------------------------------------------------------------------------------------------------------------
---------
                         Flow       Avg       Max       Total         Total         Total         Total         Total
Total
                         Freq      Flow      Flow      Volume        TSS010        TSS020        TSS050        TSS150
TSS500
  Outfall Node           Pcnt       CMS       CMS    10^6 ltr            kg            kg            kg            kg
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
  ********************

  -----------------------------------------------------------------------------
                                 Maximum  Time of Max   Maximum    Max/    Max/
                                  |Flow|   Occurrence   |Veloc|    Full    Full
  Link                 Type          CMS  days hr:min     m/sec    Flow   Depth
  -----------------------------------------------------------------------------
  1                    CONDUIT     0.005  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
  ***************************

  -------------------------------------------------------------------------------------
                      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   0.99  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:	2022-10-01
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	230.3	0.101
2	1961	351.6	0.482
3	1962	265.7	0.156
4	1963	503.6	0.754
5	1964	483.4	0.717
6	1965	502.2	0.736
7	1966	573.1	0.862
8	1967	192.1	0.029
9	1968	433.2	0.591
10	1969	314.7	0.319
11	1970	734.7	0.953
12	1971	306	0.283
13	1972	535	0.772
14	1973	235.4	0.120
15	1974	335.9	0.428
16	1975	166.1	0.011
17	1976	379.3	0.518
18	1977	290.1	0.246
19	1978	565.6	0.844
20	1979	285.1	0.210
21	1980	469.8	0.699
22	1981	433.1	0.572
23	1982	227.9	0.083
24	1983	329.3	0.391
25	1984	422.4	0.554
26	1985	991.8	0.971
27	1986	538.2	0.790
28	1987	316.2	0.337
29	1988	643.4	0.899
30	1989	204.9	0.047
31	1990	321.7	0.373
32	1991	320	0.355
33	1992	541.5	0.826
34	1993	448.7	0.645
35	1994	280.3	0.192
36	1995	271.7	0.174
37	1996	306.7	0.301
38	1997	653.9	0.917
39	1998	594.2	0.880
40	1999	465.5	0.681
41	2000	333.8	0.409
42	2001	373.4	0.500
43	2002	206.2	0.065
44	2003	246.5	0.138
45	2004	436.7	0.609
46	2005	659	0.935
47	2006	341.2	0.464
48	2007	1014	0.989
49	2008	293.8	0.264
50	2009	289.9	0.228
51	2010	421.9	0.536
52	2011	438.9	0.627
53	2012	456.4	0.663
54	2013	539.6	0.808
55	2014	340.8	0.446

Clear All Input Data

Basic Characteristics	
Number of Data Entries	55
Maximum Value	1010
Minimum Value	166
Average (Mean) Value	416
Median Value	373
Standard Deviation	177
Variance	31200
Variation coefficient (Cv)	0.425
Skewness coefficient (Cs)	1.41
Kurtosis	5.21

*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:	0.101

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

When there are no ties in rankings:

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

Spearman Correlation Coefficient:	0.101
t-distribution value	0.742
Degrees of freedom	53

T (Adjustment for ties) =	0
Standard Normal (z)=	0.735

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=	583
Total of Ranking in sample 2 R_2=	
U_1=	330

No Jump at 0.05 Significance Level

$$U_1 + U_2 = n_1 n_2.$$

U_2=	396
U (Minimum of U_1 and U_2)=	330
Standard Normal (z)=	-0.567

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 =	30

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)=	0.4

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=	758
Total of Ranking in sample 1 R_2=	
U_1=	352

$$U_1 + U_2 = n_1 n_2.$$

U_2=	404
U (Minimum of U_1 and U_2)=	352
Standard Normal (z)=	-0.438

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 =	2.269
z =	0.621

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:	-0.06

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:	-0.06
t-distribution value	-0.47
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	9410000
Mean	9470000
Variance	47300000000

H_0= Data is independent

Data is independent at 0.05 Significance Level

Standard Normal (z)=	-0.3

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	-0.053
Mean	-0.019
Variance	0.018

H_0= Data is independent

Data is independent at 0.05 Significance Level

Standard Normal (z)=	-0.3

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=	1160
Maximum Value	1010
High Outliers	No High Outliers Present

< Any value higher than X_h is considered a high outlier

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=	127
Minimum Value	166
Low Outliers	No Low Outliers Present

< Any value lower than X_h is considered a low outlier

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) =	-0.062
t-distribution values for one time period offset	t =	-0.454

No Serial Correlation at 0.05 Significance Level

Two Time Periods Offset		
Autocorrelation coefficient offset by two time periods	r(2) =	0.059
t-distribution values for two time periods offset	t =	0.433

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	415.570909
sigma	176.695895

Quantiles

q = F(X) : non-exceedance probability

T = 1/(1-q)

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	1.07E+03	6.76E+01	9.40E+02	1.21E+03	
2000	0.9995	9.97E+02	6.08E+01	8.78E+02	1.12E+03	
1000	0.999	9.62E+02	5.77E+01	8.49E+02	1.07E+03	
200	0.995	8.71E+02	4.99E+01	7.73E+02	9.69E+02	
100	0.99	8.27E+02	4.62E+01	7.36E+02	9.17E+02	
50	0.98	7.79E+02	4.23E+01	6.96E+02	8.61E+02	
20	0.95	7.06E+02	36.7	6.34E+02	7.78E+02	
10	0.9	6.42E+02	32.3	5.79E+02	7.05E+02	
5	0.8	5.64E+02	27.8	5.10E+02	6.19E+02	
3	0.6667	4.92E+02	24.9	4.43E+02	5.40E+02	
2	0.5	4.16E+02	23.8	3.69E+02	4.62E+02	
1.4286	0.3	3.23E+02	25.4	2.73E+02	3.73E+02	
1.25	0.2	2.67E+02	27.8	2.12E+02	3.21E+02	
1.1111	0.1	1.89E+02	32.3	1.26E+02	2.52E+02	
1.0526	0.05	1.25E+02	36.7	5.28E+01	1.97E+02	
1.0204	0.02	5.26E+01	4.23E+01	-3.03E+01	1.35E+02	
1.0101	0.01	4.44E+00	4.62E+01	-8.61E+01	9.50E+01	
1.005	0.005	-3.96E+01	4.99E+01	-1.37E+02	5.81E+01	
1.001	0.001	-1.31E+02	5.77E+01	-2.44E+02	-1.74E+01	
1.0005	0.0005	-1.66E+02	6.08E+01	-2.85E+02	-4.67E+01	
1.0001	0.0001	-2.42E+02	6.76E+01	-3.74E+02	-1.09E+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	5.950989
sigma	0.394951

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

T = 1/(1-q)

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	1.67E+03	2.52E+02	1.17E+03	2.16E+03	
2000	0.9995	1.41E+03	1.92E+02	1.03E+03	1.78E+03	
1000	0.999	1.30E+03	1.68E+02	9.73E+02	1.63E+03	
200	0.995	1.06E+03	1.18E+02	8.30E+02	1.29E+03	
100	0.99	9.63E+02	9.94E+01	7.68E+02	1.16E+03	
50	0.98	8.65E+02	8.17E+01	7.04E+02	1.02E+03	
20	0.95	7.36E+02	6.04E+01	6.17E+02	8.54E+02	
10	0.9	6.37E+02	4.60E+01	5.47E+02	7.27E+02	
5	0.8	5.36E+02	3.33E+01	4.70E+02	6.01E+02	
3	0.6667	4.55E+02	25.4	4.06E+02	5.05E+02	
2	0.5	3.84E+02	20.5	3.44E+02	4.24E+02	
1.4286	0.3	3.12E+02	17.8	2.78E+02	3.47E+02	
1.25	0.2	2.76E+02	17.1	2.42E+02	3.09E+02	
1.1111	0.1	2.32E+02	16.7	1.99E+02	2.64E+02	
1.0526	0.05	2.01E+02	16.5	1.68E+02	2.33E+02	
1.0204	0.02	1.71E+02	16.1	1.39E+02	2.02E+02	
1.0101	0.01	1.53E+02	15.8	1.22E+02	1.84E+02	
1.005	0.005	1.39E+02	15.5	1.09E+02	1.69E+02	
1.001	0.001	1.13E+02	14.6	8.47E+01	1.42E+02	
1.0005	0.0005	1.05E+02	14.2	7.68E+01	1.33E+02	
1.0001	0.0001	8.84E+01	13.4	6.22E+01	1.15E+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	76.842353
mu	5.702429
sigma	0.498168

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

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	1.99E+03	5.36E+02	9.37E+02	3.04E+03	
2000	0.9995	1.62E+03	3.71E+02	8.94E+02	2.35E+03	
1000	0.999	1.47E+03	3.10E+02	8.66E+02	2.08E+03	
200	0.995	1.16E+03	1.92E+02	7.81E+02	1.54E+03	
100	0.99	1.03E+03	1.51E+02	7.36E+02	1.33E+03	
50	0.98	9.10E+02	1.15E+02	6.85E+02	1.14E+03	
20	0.95	7.57E+02	7.61E+01	6.08E+02	9.06E+02	
10	0.9	6.44E+02	5.29E+01	5.40E+02	7.48E+02	
5	0.8	5.32E+02	35.6	4.63E+02	6.02E+02	
3	0.6667	4.48E+02	26.7	3.96E+02	5.00E+02	
2	0.5	3.76E+02	21.4	3.34E+02	4.18E+02	
1.4286	0.3	3.08E+02	17.4	2.73E+02	3.42E+02	
1.25	0.2	2.74E+02	15.7	2.43E+02	3.05E+02	
1.1111	0.1	2.35E+02	14.4	2.07E+02	2.63E+02	
1.0526	0.05	2.09E+02	14.5	1.80E+02	2.37E+02	
1.0204	0.02	1.85E+02	16.1	1.53E+02	2.16E+02	
1.0101	0.01	1.71E+02	17.7	1.36E+02	2.06E+02	
1.005	0.005	1.60E+02	19.5	1.22E+02	1.98E+02	
1.001	0.001	1.41E+02	2.36E+01	9.48E+01	1.87E+02	
1.0005	0.0005	1.35E+02	2.52E+01	8.55E+01	1.84E+02	
1.0001	0.0001	1.24E+02	2.87E+01	6.76E+01	1.80E+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	254.090741
m	161.480168

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

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	2.50E+03	3.18E+02	1.88E+03	3.12E+03	
2000	0.9995	2.09E+03	2.62E+02	1.58E+03	2.61E+03	
1000	0.999	1.92E+03	2.38E+02	1.45E+03	2.38E+03	
200	0.995	1.51E+03	1.83E+02	1.15E+03	1.87E+03	
100	0.99	1.33E+03	1.59E+02	1.02E+03	1.64E+03	
50	0.98	1.16E+03	1.35E+02	8.91E+02	1.42E+03	
20	0.95	9.23E+02	1.03E+02	7.21E+02	1.12E+03	
10	0.9	7.47E+02	7.91E+01	5.91E+02	9.02E+02	
5	0.8	5.70E+02	5.52E+01	4.62E+02	6.79E+02	
3	0.6667	4.41E+02	3.76E+01	3.67E+02	5.14E+02	
2	0.5	3.38E+02	23.8	2.91E+02	3.84E+02	
1.4286	0.3	2.52E+02	12.6	2.27E+02	2.77E+02	
1.25	0.2	2.18E+02	8.46	2.02E+02	2.35E+02	
1.1111	0.1	1.88E+02	5.52	1.77E+02	1.99E+02	
1.0526	0.05	1.75E+02	4.76	1.65E+02	1.84E+02	
1.0204	0.02	1.67E+02	4.62	1.58E+02	1.76E+02	
1.0101	0.01	1.64E+02	4.63	1.55E+02	1.73E+02	
1.005	0.005	1.63E+02	4.64	1.54E+02	1.72E+02	
1.001	0.001	1.62E+02	4.66	1.53E+02	1.71E+02	
1.0005	0.0005	1.62E+02	4.66	1.52E+02	1.71E+02	
1.0001	0.0001	1.62E+02	4.66	1.52E+02	1.71E+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	0.008894
lambda	2.388004
m	147.06549

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

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	1.57E+03	2.06E+02	1.16E+03	1.97E+03	
2000	0.9995	1.36E+03	1.68E+02	1.04E+03	1.69E+03	
1000	0.999	1.28E+03	1.51E+02	9.78E+02	1.57E+03	
200	0.995	1.07E+03	1.14E+02	8.42E+02	1.29E+03	
100	0.99	9.73E+02	9.84E+01	7.80E+02	1.17E+03	
50	0.98	8.78E+02	8.29E+01	7.16E+02	1.04E+03	
20	0.95	7.50E+02	6.30E+01	6.26E+02	8.73E+02	
10	0.9	6.48E+02	4.86E+01	5.53E+02	7.44E+02	
5	0.8	5.41E+02	35.4	4.71E+02	6.10E+02	
3	0.6667	4.57E+02	27.1	4.04E+02	5.11E+02	
2	0.5	3.79E+02	21.5	3.37E+02	4.21E+02	
1.4286	0.3	3.05E+02	17.8	2.70E+02	3.40E+02	
1.25	0.2	2.70E+02	16.2	2.38E+02	3.02E+02	
1.1111	0.1	2.31E+02	14.1	2.03E+02	2.58E+02	
1.0526	0.05	2.06E+02	12.3	1.82E+02	2.30E+02	
1.0204	0.02	1.85E+02	1.08E+01	1.64E+02	2.06E+02	
1.0101	0.01	1.75E+02	1.01E+01	1.55E+02	1.94E+02	
1.005	0.005	1.67E+02	9.84E+00	1.47E+02	1.86E+02	
1.001	0.001	1.55E+02	1.02E+01	1.35E+02	1.75E+02	
1.0005	0.0005	1.52E+02	1.05E+01	1.31E+02	1.73E+02	
1.0001	0.0001	1.47E+02	1.15E+01	1.24E+02	1.70E+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	51.316846
lambda	75.797722
m	1.107428

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

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	2.00E+03	7.47E+02	N/D	N/D	
2000	0.9995	1.61E+03	4.80E+02	N/D	N/D	
1000	0.999	1.46E+03	3.88E+02	N/D	N/D	
200	0.995	1.14E+03	2.21E+02	7.11E+02	1.58E+03	
100	0.99	1.02E+03	1.66E+02	6.92E+02	1.34E+03	
50	0.98	8.98E+02	1.21E+02	6.60E+02	1.14E+03	
20	0.95	7.48E+02	7.59E+01	6.00E+02	8.97E+02	
10	0.9	6.39E+02	5.13E+01	5.39E+02	7.40E+02	
5	0.8	5.31E+02	3.47E+01	4.63E+02	5.99E+02	
3	0.6667	4.50E+02	26.6	3.98E+02	5.02E+02	
2	0.5	3.78E+02	21.6	3.36E+02	4.21E+02	
1.4286	0.3	3.10E+02	17.5	2.75E+02	3.44E+02	
1.25	0.2	2.76E+02	16	2.44E+02	3.07E+02	
1.1111	0.1	2.35E+02	15.2	2.05E+02	2.65E+02	
1.0526	0.05	2.07E+02	16	1.76E+02	2.39E+02	
1.0204	0.02	1.81E+02	18.2	1.45E+02	2.16E+02	
1.0101	0.01	1.65E+02	20.2	1.26E+02	2.05E+02	
1.005	0.005	1.53E+02	22.3	1.09E+02	1.96E+02	
1.001	0.001	1.31E+02	26.8	7.80E+01	1.83E+02	
1.0005	0.0005	1.23E+02	28.5	6.71E+01	1.79E+02	
1.0001	0.0001	1.09E+02	32	4.61E+01	1.72E+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	338.5398
alpha	127.555943

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

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	1.51E+03	1.32E+02	1.25E+03	1.77E+03	
2000	0.9995	1.31E+03	1.10E+02	1.09E+03	1.52E+03	
1000	0.999	1.22E+03	1.01E+02	1.02E+03	1.42E+03	
200	0.995	1.01E+03	7.95E+01	8.58E+02	1.17E+03	
100	0.99	9.25E+02	7.02E+01	7.88E+02	1.06E+03	
50	0.98	8.36E+02	6.11E+01	7.17E+02	9.56E+02	
20	0.95	7.17E+02	4.90E+01	6.21E+02	8.14E+02	
10	0.9	6.26E+02	4.00E+01	5.47E+02	7.04E+02	
5	0.8	5.30E+02	31.1	4.69E+02	5.91E+02	
3	0.6667	4.54E+02	24.7	4.05E+02	5.02E+02	
2	0.5	3.85E+02	20.1	3.46E+02	4.25E+02	
1.4286	0.3	3.15E+02	17.5	2.81E+02	3.49E+02	
1.25	0.2	2.78E+02	17.2	2.44E+02	3.12E+02	
1.1111	0.1	2.32E+02	18.2	1.97E+02	2.68E+02	
1.0526	0.05	1.99E+02	19.6	1.60E+02	2.37E+02	
1.0204	0.02	1.65E+02	21.6	1.22E+02	2.07E+02	
1.0101	0.01	1.44E+02	23	9.86E+01	1.89E+02	
1.005	0.005	1.26E+02	24.3	7.82E+01	1.74E+02	
1.001	0.001	9.20E+01	27	3.91E+01	1.45E+02	
1.0005	0.0005	7.98E+01	28	2.49E+01	1.35E+02	
1.0001	0.0001	5.53E+01	30.1	-3.71E+00	1.14E+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	119.59119
k	-0.114666
u	331.76208

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

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	2.29E+03	1.06E+03	N/D	N/D	
2000	0.9995	1.78E+03	6.36E+02	N/D	N/D	
1000	0.999	1.59E+03	4.98E+02	N/D	N/D	
200	0.995	1.20E+03	2.62E+02	6.90E+02	1.72E+03	
100	0.99	1.06E+03	1.91E+02	6.83E+02	1.43E+03	
50	0.98	9.20E+02	1.34E+02	6.57E+02	1.18E+03	
20	0.95	7.55E+02	8.02E+01	5.98E+02	9.12E+02	
10	0.9	6.39E+02	52.6	5.36E+02	7.42E+02	
5	0.8	5.27E+02	34.6	4.60E+02	5.95E+02	
3	0.6667	4.46E+02	26.1	3.94E+02	4.97E+02	
2	0.5	3.77E+02	20.9	3.35E+02	4.18E+02	
1.4286	0.3	3.10E+02	17	2.76E+02	3.43E+02	
1.25	0.2	2.76E+02	15.7	2.46E+02	3.07E+02	
1.1111	0.1	2.37E+02	15.4	2.06E+02	2.67E+02	
1.0526	0.05	2.08E+02	16.5	1.76E+02	2.41E+02	
1.0204	0.02	1.81E+02	19	1.44E+02	2.18E+02	
1.0101	0.01	1.64E+02	21	1.23E+02	2.05E+02	
1.005	0.005	1.50E+02	2.31E+01	1.05E+02	1.96E+02	
1.001	0.001	1.24E+02	2.77E+01	7.01E+01	1.79E+02	
1.0005	0.0005	1.15E+02	2.96E+01	5.74E+01	1.73E+02	
1.0001	0.0001	9.73E+01	3.36E+01	3.16E+01	1.63E+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	469.033401
c	2.476658

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

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	1.15E+03	1.08E+02	9.38E+02	1.36E+03	
2000	0.9995	1.06E+03	9.28E+01	8.82E+02	1.25E+03	
1000	0.999	1.02E+03	8.61E+01	8.55E+02	1.19E+03	
200	0.995	9.20E+02	6.98E+01	7.83E+02	1.06E+03	
100	0.99	8.69E+02	6.24E+01	7.47E+02	9.91E+02	
50	0.98	8.14E+02	5.49E+01	7.06E+02	9.21E+02	
20	0.95	7.30E+02	4.49E+01	6.42E+02	8.19E+02	
10	0.9	6.57E+02	3.76E+01	5.83E+02	7.30E+02	
5	0.8	5.68E+02	31	5.08E+02	6.29E+02	
3	0.6667	4.87E+02	27.4	4.34E+02	5.41E+02	
2	0.5	4.05E+02	25.9	3.54E+02	4.55E+02	
1.4286	0.3	3.09E+02	25.5	2.59E+02	3.59E+02	
1.25	0.2	2.56E+02	25.1	2.07E+02	3.05E+02	
1.1111	0.1	1.89E+02	23.8	1.42E+02	2.36E+02	
1.0526	0.05	1.41E+02	21.8	9.87E+01	1.84E+02	
1.0204	0.02	9.70E+01	18.6	6.06E+01	1.33E+02	
1.0101	0.01	7.32E+01	16.1	4.16E+01	1.05E+02	
1.005	0.005	5.53E+01	13.8	2.83E+01	8.22E+01	
1.001	0.001	2.88E+01	9.11	1.10E+01	4.67E+01	
1.0005	0.0005	2.18E+01	7.52	7.06E+00	3.65E+01	
1.0001	0.0001	1.14E+01	4.69	2.18E+00	2.06E+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

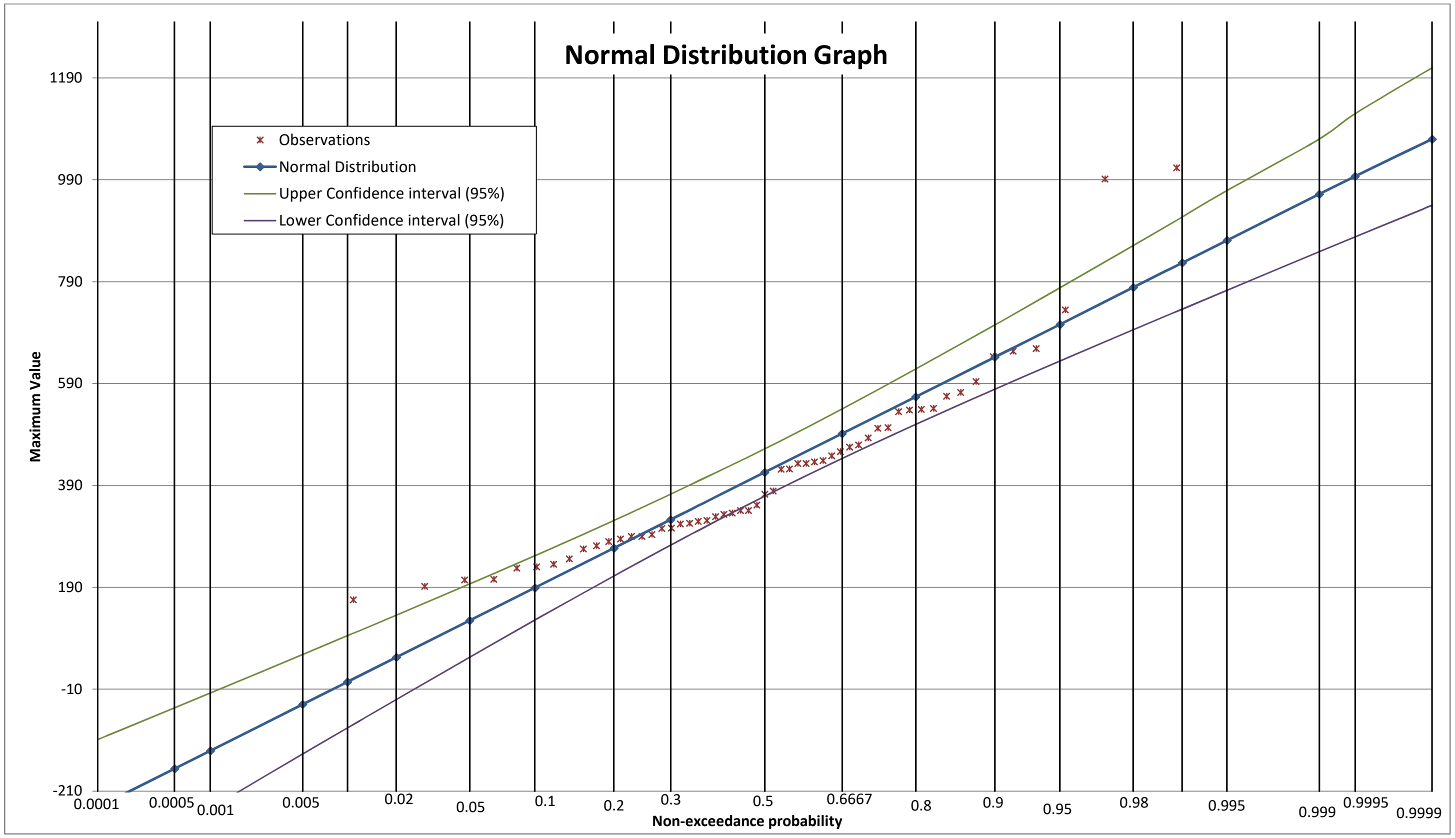
alpha	0.015686
lambda	6.518618

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

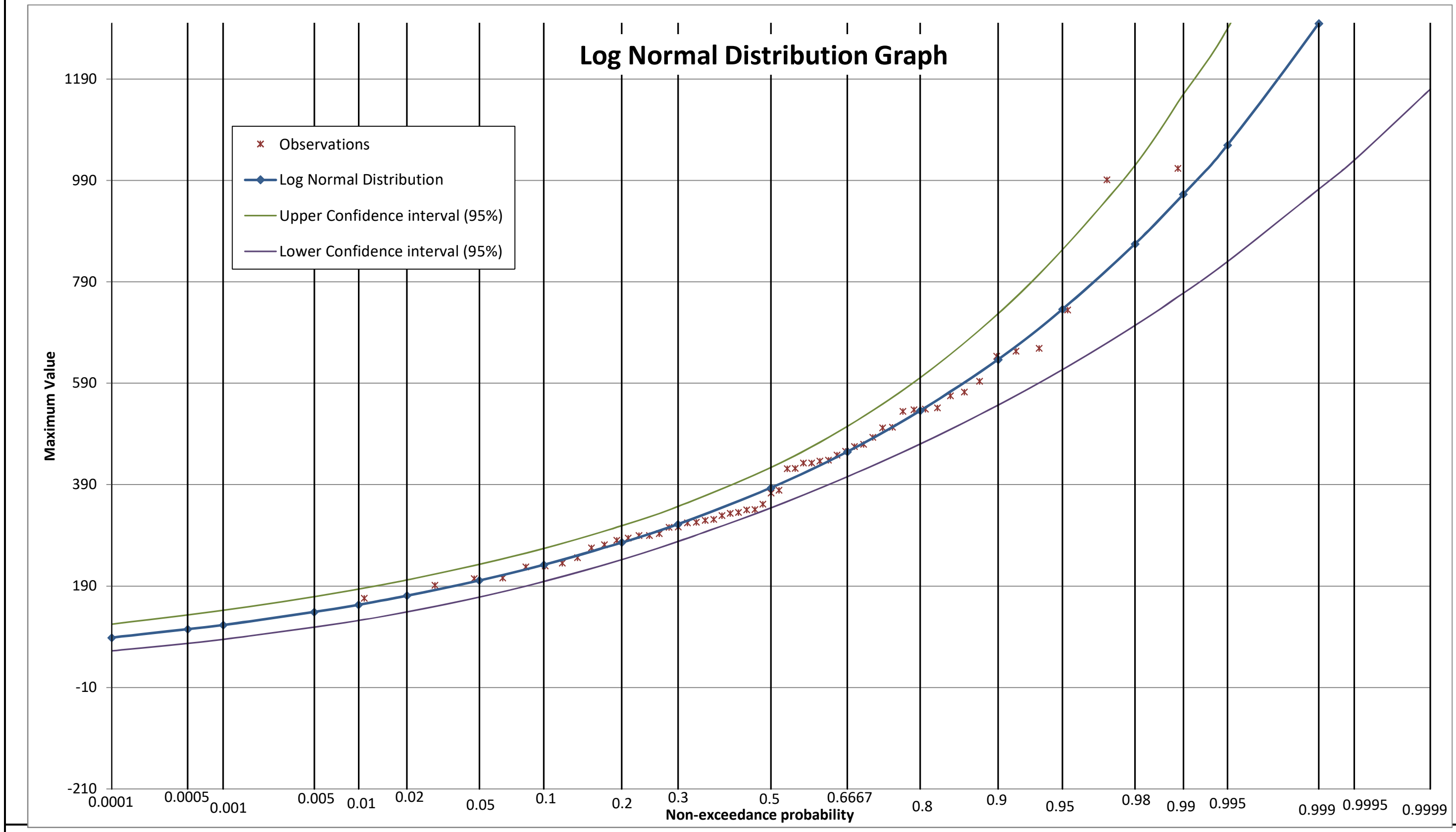
T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	1.30E+03	1.29E+02	1.05E+03	1.56E+03	
2000	0.9995	1.16E+03	1.09E+02	9.52E+02	1.38E+03	
1000	0.999	1.10E+03	9.97E+01	9.07E+02	1.30E+03	
200	0.995	9.52E+02	7.87E+01	7.98E+02	1.11E+03	
100	0.99	8.84E+02	6.96E+01	7.48E+02	1.02E+03	
50	0.98	8.14E+02	6.04E+01	6.95E+02	9.32E+02	
20	0.95	7.14E+02	4.83E+01	6.20E+02	8.09E+02	
10	0.9	6.33E+02	3.93E+01	5.56E+02	7.10E+02	
5	0.8	5.43E+02	30.6	4.83E+02	6.03E+02	
3	0.6667	4.68E+02	24.9	4.20E+02	5.17E+02	
2	0.5	3.95E+02	21.2	3.53E+02	4.36E+02	
1.4286	0.3	3.17E+02	19.6	2.79E+02	3.56E+02	
1.25	0.2	2.76E+02	19.4	2.38E+02	3.14E+02	
1.1111	0.1	2.25E+02	19.5	1.87E+02	2.63E+02	
1.0526	0.05	1.88E+02	19.6	1.50E+02	2.27E+02	
1.0204	0.02	1.53E+02	19.3	1.15E+02	1.91E+02	
1.0101	0.01	1.32E+02	19	9.47E+01	1.69E+02	
1.005	0.005	1.15E+02	18.6	7.85E+01	1.51E+02	
1.001	0.001	8.50E+01	17.3	5.11E+01	1.19E+02	
1.0005	0.0005	7.52E+01	16.8	4.23E+01	1.08E+02	
1.0001	0.0001	5.68E+01	15.4	2.66E+01	8.70E+01	

Visual Goodness of Fit

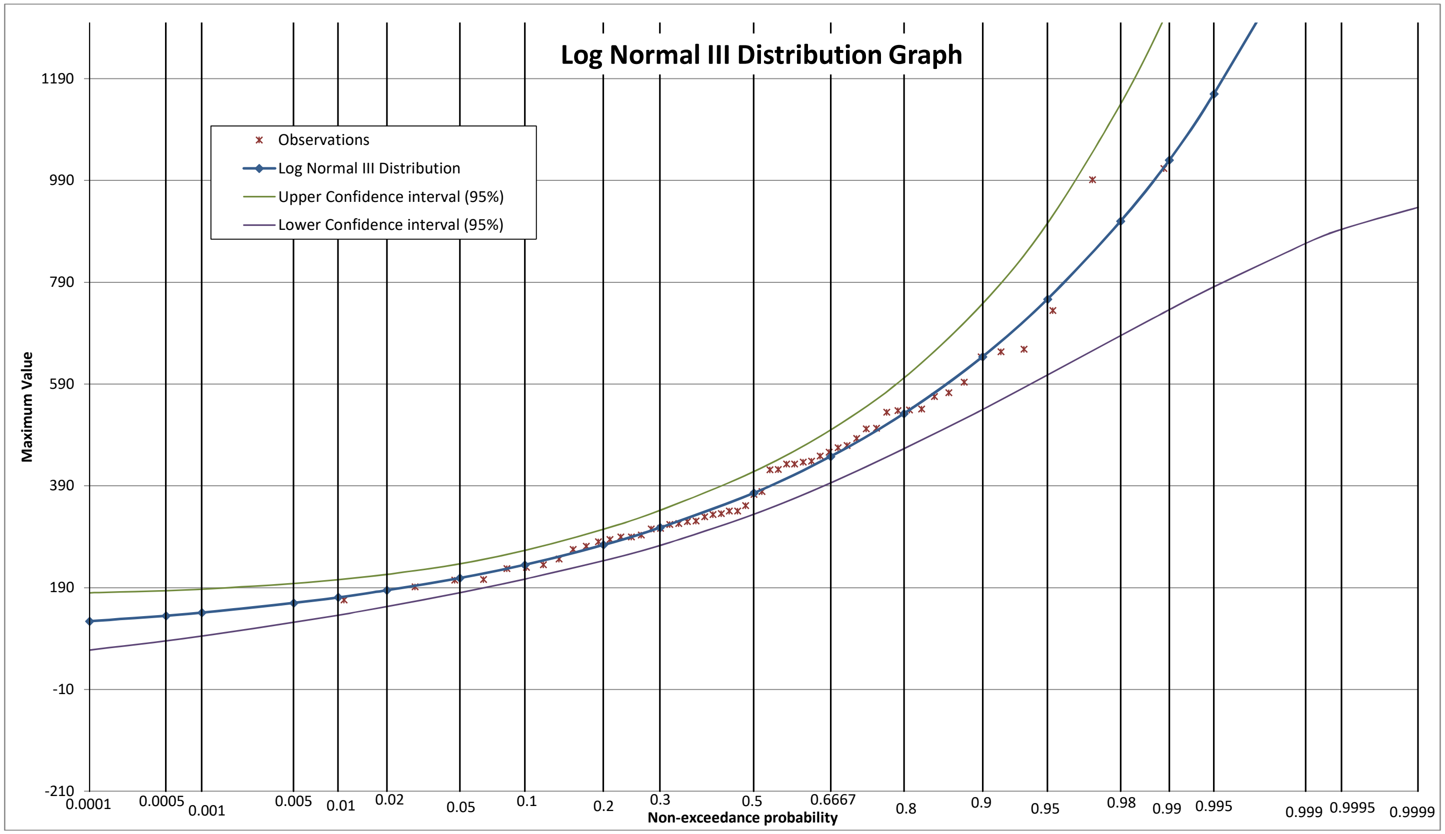
Clear All Note Data



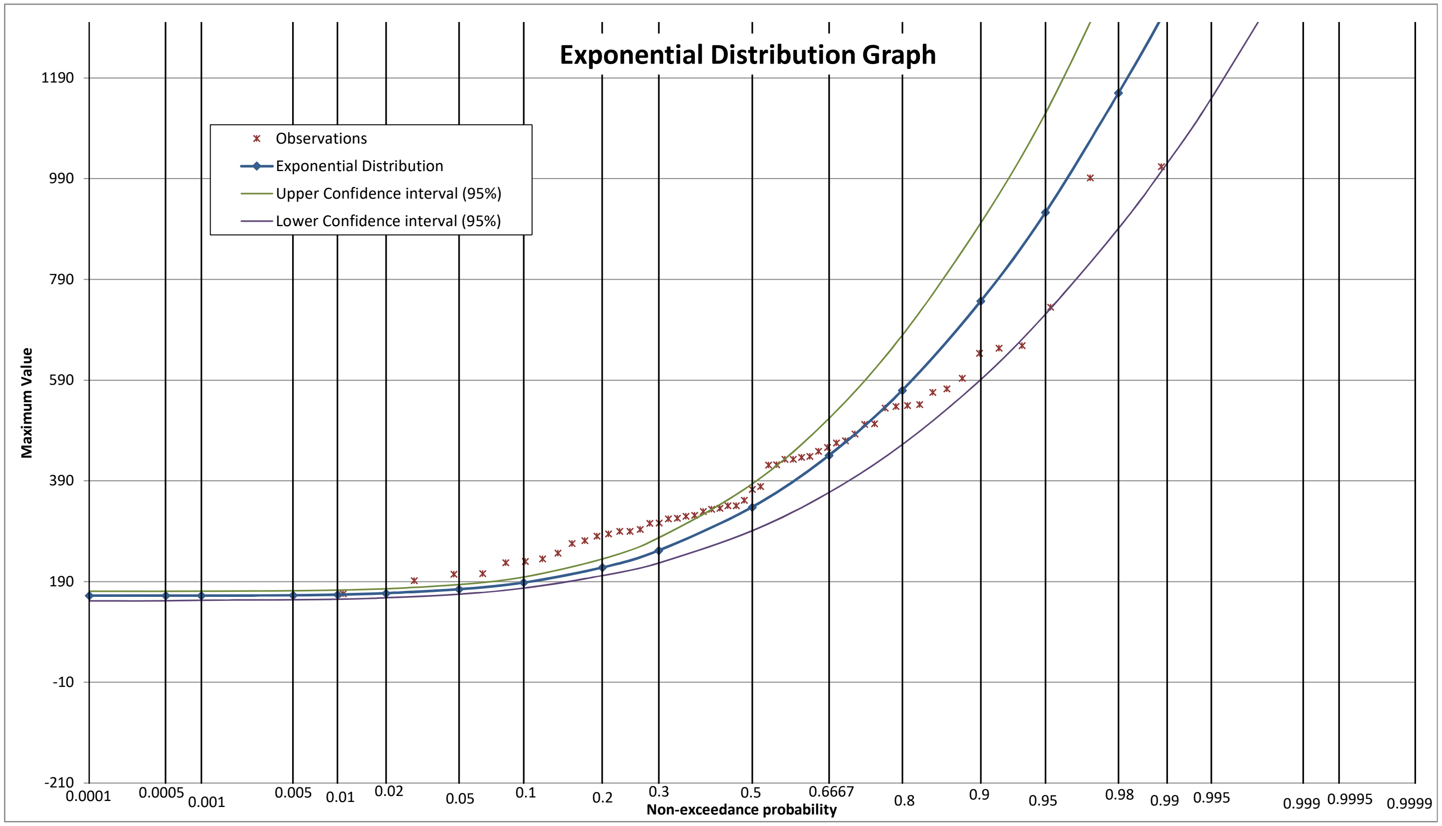
Normal Distribution
Visual Goodness-of-Fit Test Notes:



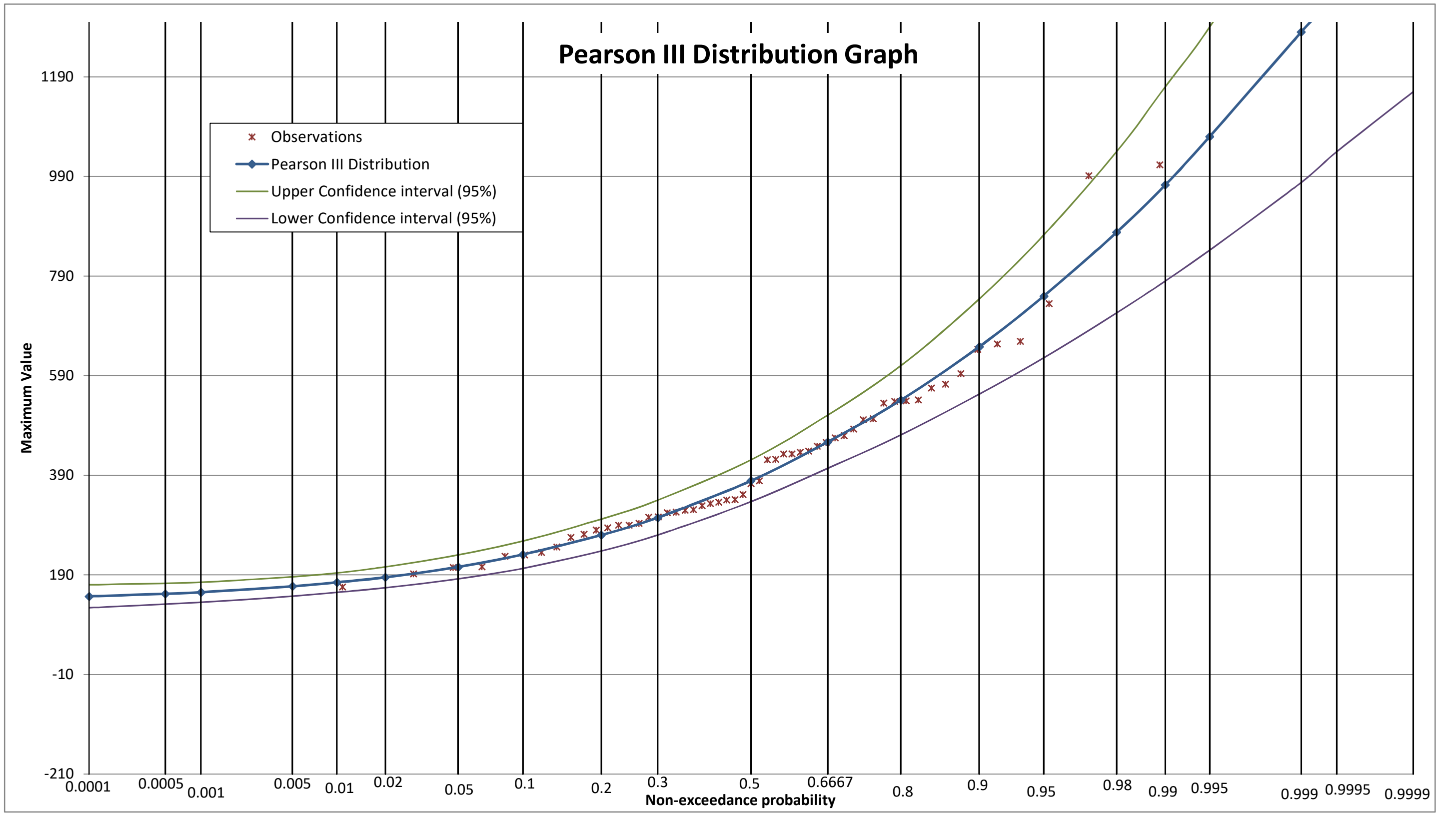
Log Normal Distribution
Visual Goodness-of-Fit Test Notes:



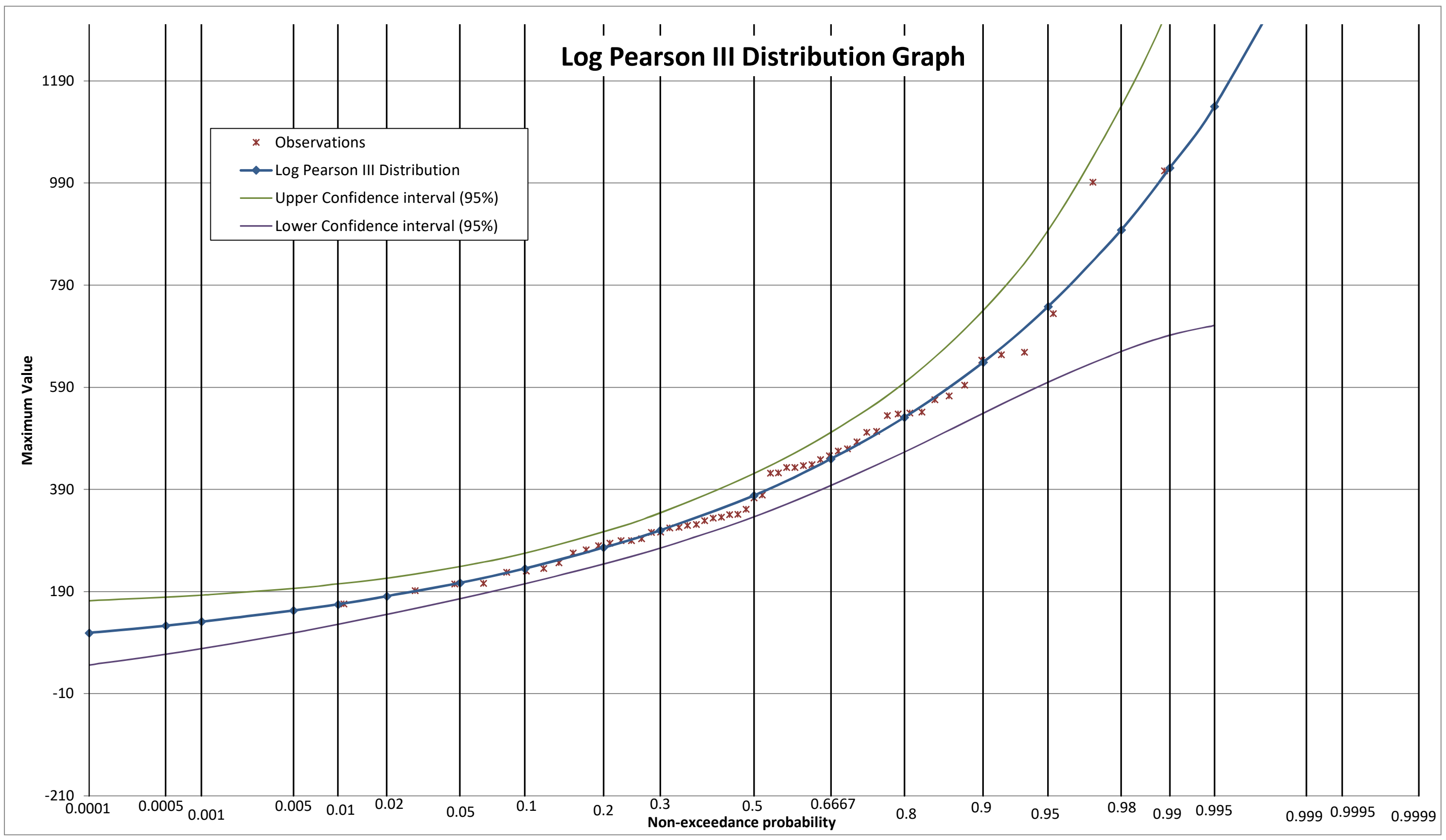
Log Normal III Distribution
Visual Goodness-of-Fit Test Notes:



Exponential Distribution
Visual Goodness-of-Fit Test Notes:



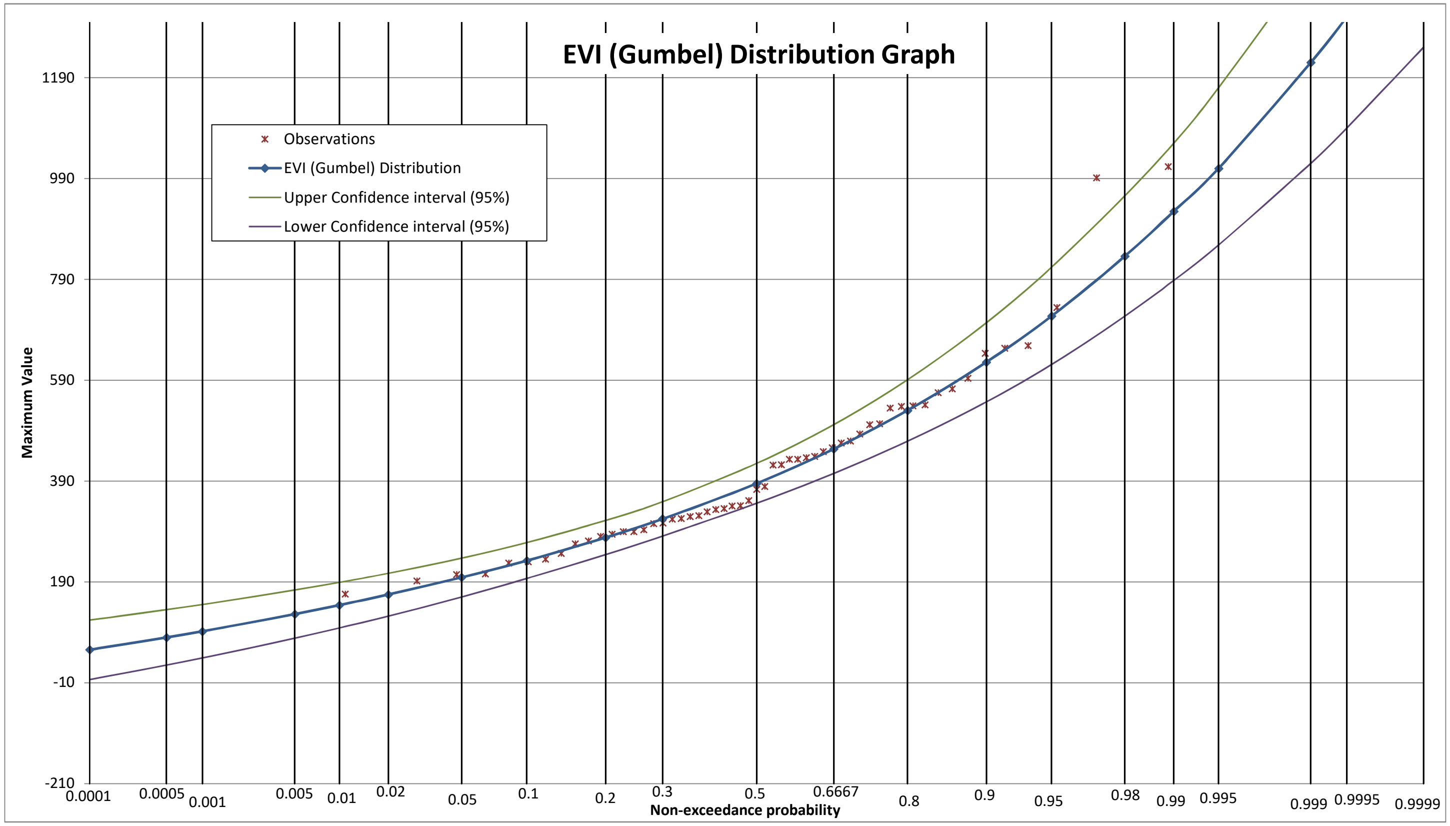
Pearson III Distribution
Visual Goodness-of-Fit Test Notes:



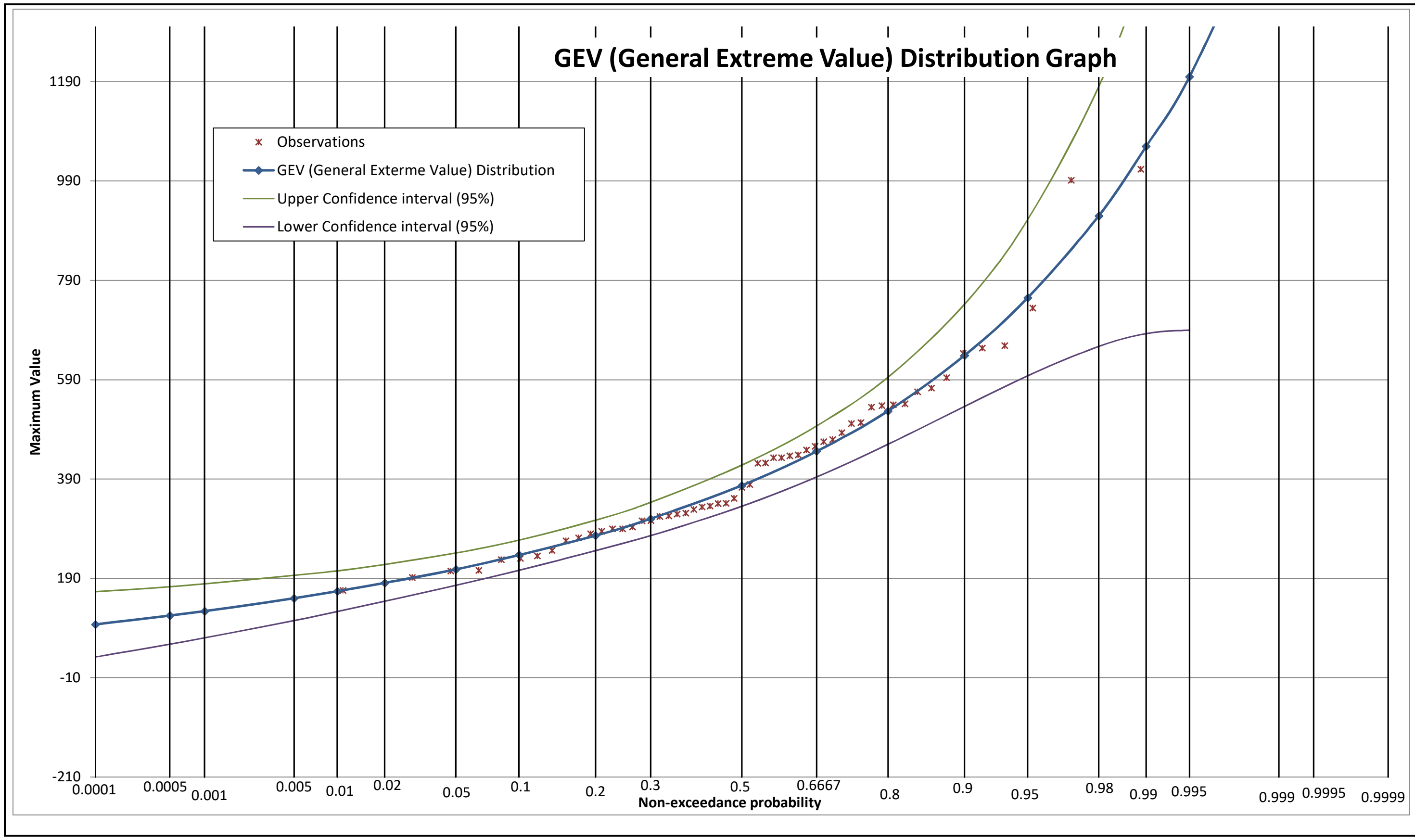
Log Pearson III Distribution
Visual Goodness-of-Fit Test Notes:

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

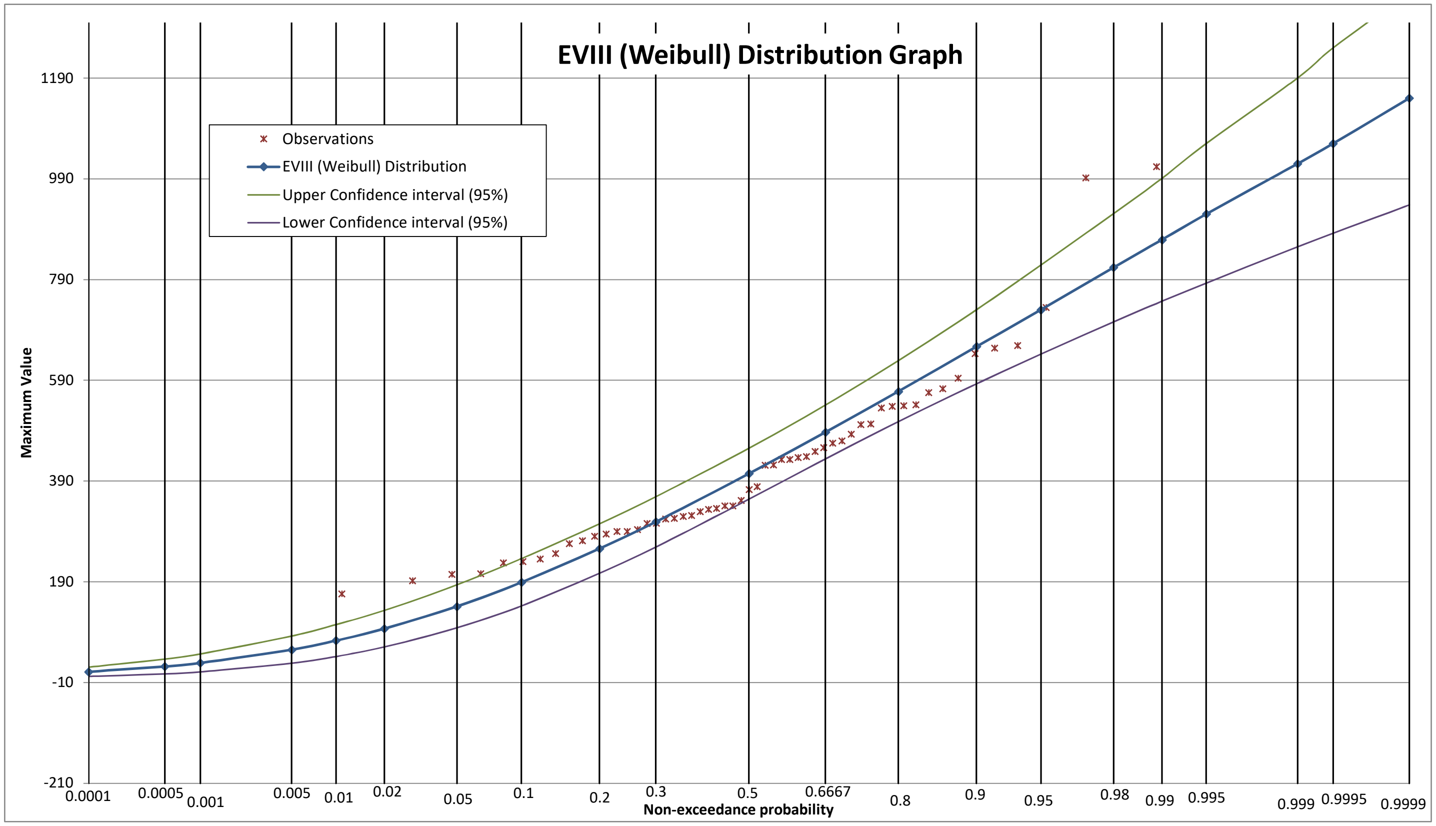
Lambda shape test
Pass
Alpha shape test
Pass



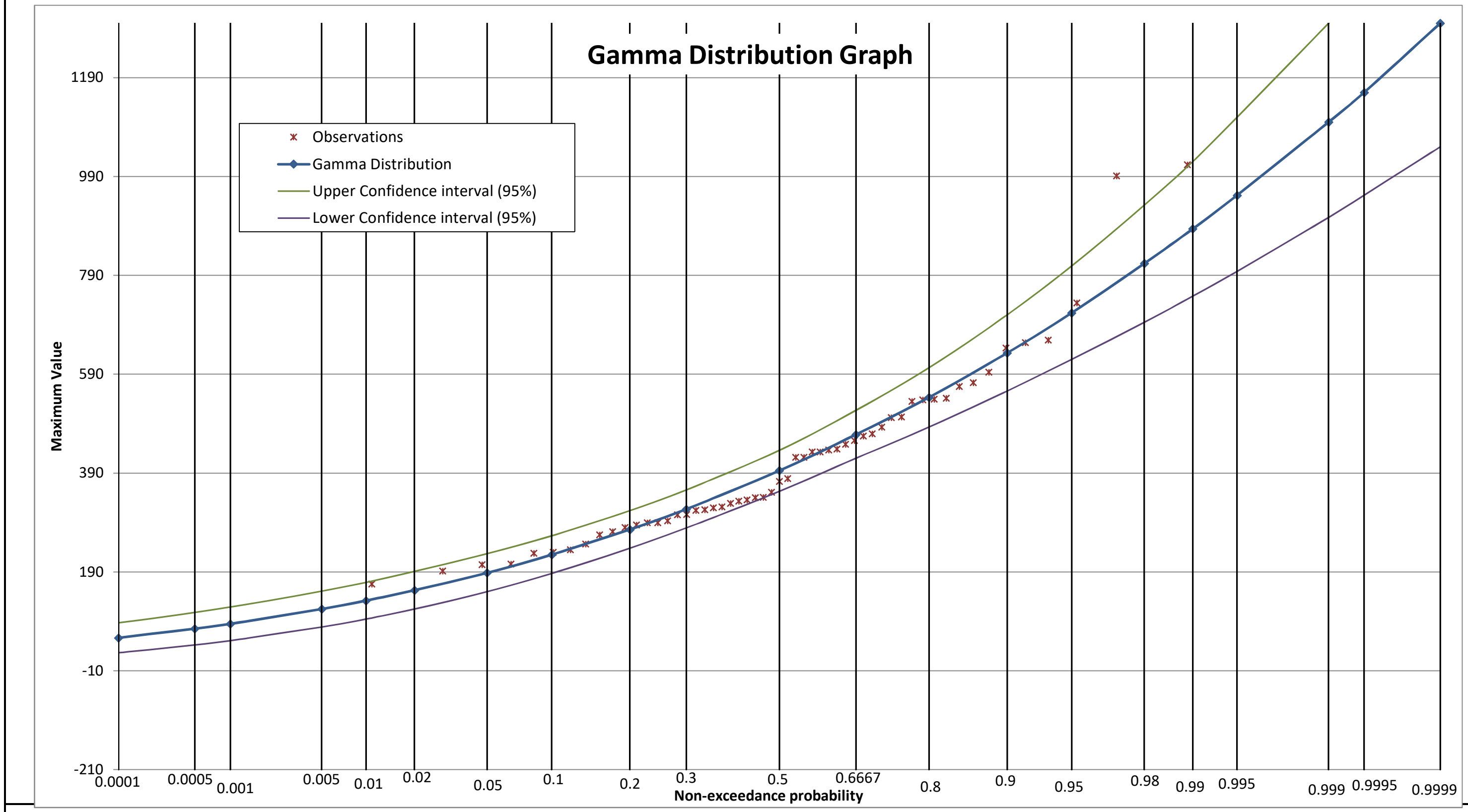
EVI (Gumbel) Distribution
Visual Goodness-of-Fit Test Notes:



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



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



Gamma Distribution
Visual Goodness-of-Fit Test Notes:

Numerical Tests

Choose Significance Level (alpha) : **5%**

1) Anderson-Darling Test (1952)

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

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

Distribution Type:	Critical Value at 10%	Critical Value at 5%	Critical Value at 1%	A2	Hypothesis	Rank (1 = best fit)
Normal	1.929	2.502	3.907	1.351	Accept H0	9
Lognormal	1.929	2.502	3.907	0.256	Accept H0	5
Lognormal III	1.929	2.502	3.907	0.228	Accept H0	2
Exponential	1.929	2.502	3.907	2.793	Reject H0	10
Pearson III	1.929	2.502	3.907	0.230	Accept H0	3
Log Pearson III	1.929	2.502	3.907	0.226	Accept H0	1
Gumbel	1.929	2.502	3.907	0.310	Accept H0	6
GEV	1.929	2.502	3.907	0.250	Accept H0	4
Weibull	1.929	2.502	3.907	1.085	Accept H0	8
Gamma	1.929	2.502	3.907	0.443	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	0.118	Accept H0	9
Lognormal	0.165	0.183	0.220	0.072	Accept H0	1
Lognormal III	0.165	0.183	0.220	0.084	Accept H0	5
Exponential	0.165	0.183	0.220	0.192	Reject H0	10
Pearson III	0.165	0.183	0.220	0.073	Accept H0	2
Log Pearson III	0.165	0.183	0.220	0.081	Accept H0	4
Gumbel	0.165	0.183	0.220	0.079	Accept H0	3
GEV	0.165	0.183	0.220	0.088	Accept H0	6
Weibull	0.165	0.183	0.220	0.089	Accept H0	7
Gamma	0.165	0.183	0.220	0.093	Accept H0	8

Least Squares Ranking

Distribution Type:	Standard Error	Rank
Normal	60	9
Lognormal	29	5
Lognormal III	25	3
Exponential	76	10
Pearson III	27	4
Log Pearson III	25	2
Gumbel	34	6
GEV	25	1
Weibull	49	8
Gamma	39	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**

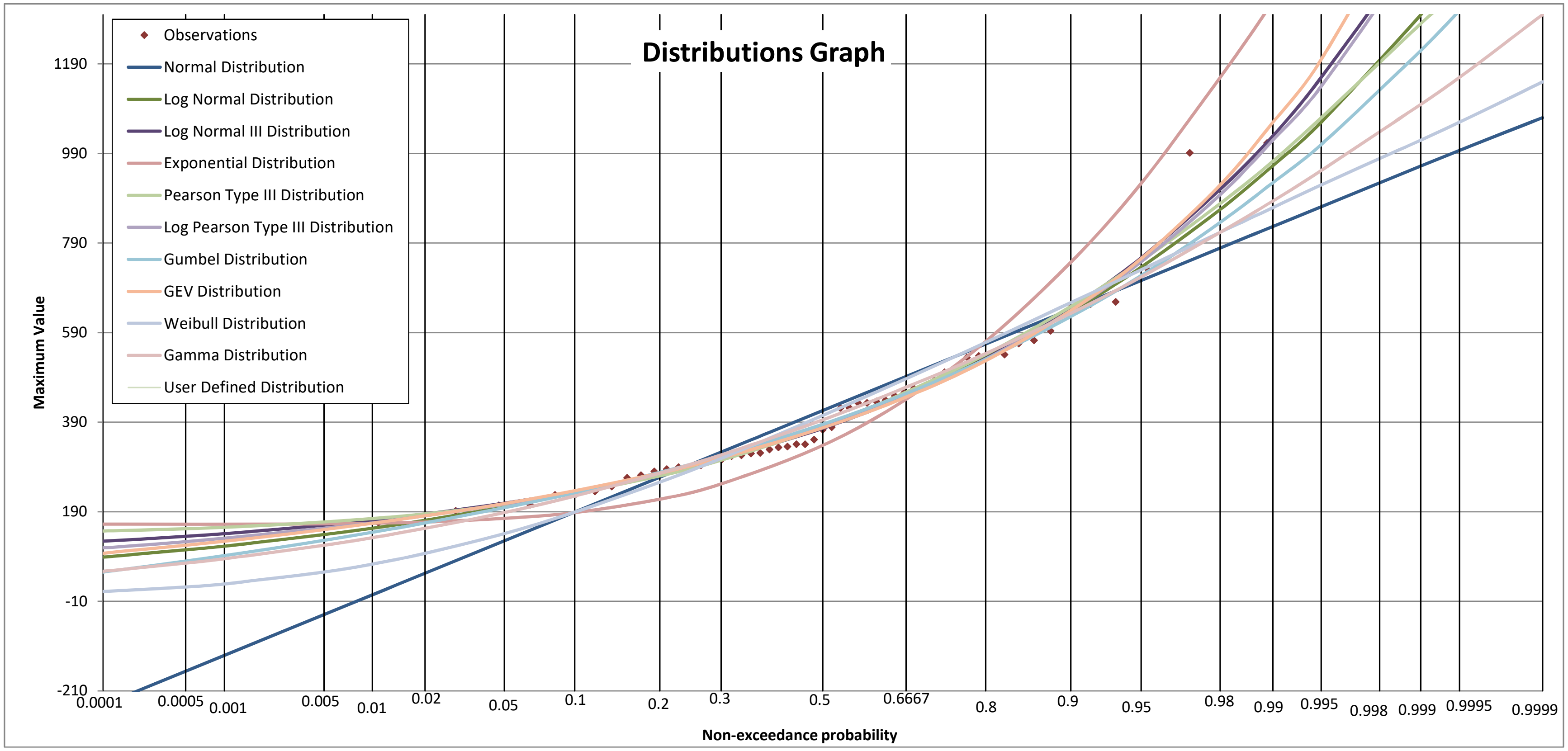
Sampling and Distribution Uncertainty

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	564

Sampling Uncertainty at (95%) Confidence Interval ±	54.5
Distribution Uncertainty ±	2
Total Uncertainty ±	56.5



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: 2022-10-01

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	5	1	5	3.67	4			
Lognormal III	2	5	3	3.33	3			
Exponential	10	10	10	10.00	10			
Pearson III	3	2	4	3.00	2			
Log Pearson III	1	4	2	2.33	1			
Gumbel	6	3	6	5.00	6			
GEV	4	6	1	3.67	4			
Weibull	8	7	8	7.67	8			
Gamma	7	8	7	7.33	7			

Selected Distribution and Results

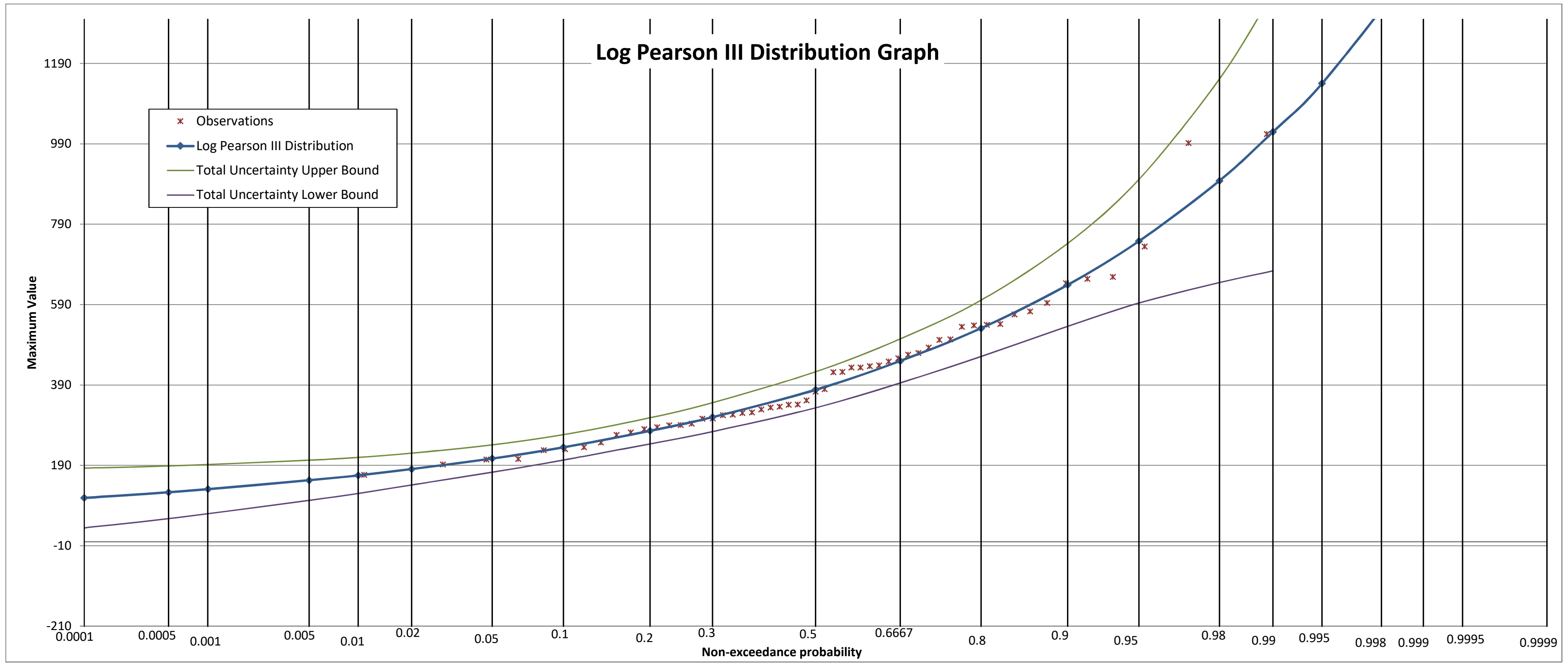
Instructions:

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

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

Return Period	Probability	Magnitude	Total Uncertainty (Upper Bound)	Total Uncertainty (Lower Bound)
10000	0.9999	2000	#N/A	#N/A
2000	0.9995	1610	#N/A	#N/A
1000	0.9990	1460	#N/A	#N/A
500	0.9980	1330	#N/A	#N/A
200	0.9950	1140	1610	675
100	0.9900	1020	1370	674
50	0.9800	898	1150	645
20	0.9500	748	902	594
10	0.9000	639	742	536
5	0.8000	531	601	461
3	0.6667	450	505	395
2	0.5000	378	423	333
1.4286	0.3000	310	346	274
1.25	0.2000	276	309	244
1.1111	0.1000	235	267	204
1.0526	0.0500	207	241	173
1.0204	0.0200	181	221	142
1.0101	0.0100	165	210	120
1.005	0.0050	153	203	103
1.001	0.0010	131	192	69.8
1.0005	0.0005	123	189	57.5
1.0001	0.0001	109	183	34.6

*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:	2022-10-01
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	29050	0.138
2	1961	33530	0.572
3	1962	29230	0.156
4	1963	34950	0.663
5	1964	36420	0.754
6	1965	35400	0.717
7	1966	37950	0.790
8	1967	27470	0.029
9	1968	33250	0.536
10	1969	32370	0.482
11	1970	43200	0.935
12	1971	31610	0.391
13	1972	36530	0.772
14	1973	28800	0.101
15	1974	34640	0.645
16	1975	27150	0.011
17	1976	32510	0.500
18	1977	29660	0.192
19	1978	39000	0.862
20	1979	29790	0.228
21	1980	33010	0.518
22	1981	35700	0.736
23	1982	28530	0.083
24	1983	30850	0.337
25	1984	32240	0.428
26	1985	50310	0.971
27	1986	38680	0.844
28	1987	30060	0.283
29	1988	39900	0.880
30	1989	27660	0.047
31	1990	30990	0.355
32	1991	30630	0.301
33	1992	40700	0.917
34	1993	34230	0.627
35	1994	29890	0.246
36	1995	30020	0.264
37	1996	29740	0.210
38	1997	40120	0.899
39	1998	38410	0.808
40	1999	35030	0.681
41	2000	31160	0.373
42	2001	33600	0.591
43	2002	27870	0.065
44	2003	29590	0.174
45	2004	33700	0.609
46	2005	47730	0.953
47	2006	32350	0.464
48	2007	53160	0.989
49	2008	30690	0.319
50	2009	28900	0.120
51	2010	32250	0.446
52	2011	33320	0.554
53	2012	35090	0.699
54	2013	38470	0.826
55	2014	31990	0.409

Clear All Input Data

Basic Characteristics	
Number of Data Entries	55
Maximum Value	53200
Minimum Value	27200
Average (Mean) Value	34000
Median Value	32500
Standard Deviation	5510
Variance	30400000
Variation coefficient (Cv)	0.162
Skewness coefficient (Cs)	1.56
Kurtosis	5.3

*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

H_0= Data has no trend

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

Spearman Correlation Coefficient:	0.068

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

When there are no ties in rankings:

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

Spearman Correlation Coefficient:	0.068
t-distribution value	0.498
Degrees of freedom	53

T (Adjustment for ties) =	0
Standard Normal (z)=	0.494

Tests for Jump:

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

Index number of subsample divide	22

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

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

No Jump at 0.05 Significance Level

Number of values in sample 1 n_1=	22
Number of values in sample 2 n_2=	33
Total of Ranking in sample 1 R_1=	601
Total of Ranking in sample 2 R_2=	
U_1=	348

$$U_1 + U_2 = n_1 n_2.$$

U_2=	378
U (Minimum of U_1 and U_2)=	348
Standard Normal (z)=	-0.258

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 =	34

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)=	1.5

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=	766
Total of Ranking in sample 1 R_2=	
U_1=	360

$$U_1 + U_2 = n_1 n_2.$$

U_2=	396
U (Minimum of U_1 and U_2)=	360
Standard Normal (z)=	-0.303

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 =	2.001
z =	0.548

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:	-0.12

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:	-0.12
t-distribution value	-0.87
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	63400000000
Mean	63500000000
Variance	4.47E+16

H_0= Data is independent

Data is independent at 0.05 Significance Level

Standard Normal (z)=	-0.5

2) Anderson Test

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

Statistic r	-0.078
Mean	-0.019
Variance	0.018

H_0= Data is independent

Data is independent at 0.05 Significance Level

Standard Normal (z)=	-0.4

Outliers

Significance Level (alpha):	10%

Grubbs and Beck test for Outliers

1) High Outliers

Assumption: logarithms of sample are normally distributed

X_h = exp (xmean+K_nS)

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

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

Sample Size (n) =	55	
K(n) =	2.80	
K(n) for 5<n<150 =	2.80	
X_h=	51000	< Any value higher than X_h is considered a high outlier
Maximum Value	53200	
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=	22100	< Any value lower than X_h is considered a low outlier
Minimum Value	27200	
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) =	-0.085
t-distribution values for one time period offset	t =	-0.623

No Serial Correlation at 0.05 Significance Level

Two Time Periods Offset		
Autocorrelation coefficient offset by two time periods	r(2) =	0.070
t-distribution values for two time periods offset	t =	0.510

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 Constructed Wetland

Results of the fitting

Normal (Maximum Likelihood)

Number of observations 55

Parameters

mu	33983.2727
sigma	5513.2692

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

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	5.45E+04	2.11E+03	5.04E+04	5.86E+04	
2000	0.9995	5.21E+04	1.90E+03	4.84E+04	5.58E+04	
1000	0.999	5.10E+04	1.80E+03	4.75E+04	5.46E+04	
200	0.995	4.82E+04	1.56E+03	4.51E+04	5.12E+04	
100	0.99	4.68E+04	1.44E+03	4.40E+04	4.96E+04	
50	0.98	4.53E+04	1.32E+03	4.27E+04	4.79E+04	
20	0.95	4.31E+04	1150	4.08E+04	4.53E+04	
10	0.9	4.10E+04	1010	3.91E+04	4.30E+04	
5	0.8	3.86E+04	867	3.69E+04	4.03E+04	
3	0.6667	3.64E+04	778	3.48E+04	3.79E+04	
2	0.5	3.40E+04	743	3.25E+04	3.54E+04	
1.4286	0.3	3.11E+04	794	2.95E+04	3.27E+04	
1.25	0.2	2.93E+04	867	2.76E+04	3.10E+04	
1.1111	0.1	2.69E+04	1010	2.49E+04	2.89E+04	
1.0526	0.05	2.49E+04	1150	2.27E+04	2.72E+04	
1.0204	0.02	2.27E+04	1.32E+03	2.01E+04	2.52E+04	
1.0101	0.01	2.12E+04	1.44E+03	1.83E+04	2.40E+04	
1.005	0.005	1.98E+04	1.56E+03	1.67E+04	2.28E+04	
1.001	0.001	1.69E+04	1.80E+03	1.34E+04	2.05E+04	
1.0005	0.0005	1.58E+04	1.90E+03	1.21E+04	1.96E+04	
1.0001	0.0001	1.35E+04	2.11E+03	9.35E+03	1.76E+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	10.422123
sigma	0.149051

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

T = 1/(1-q)

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	5.85E+04	3.33E+03	5.19E+04	6.50E+04	
2000	0.9995	5.49E+04	2.81E+03	4.93E+04	6.04E+04	
1000	0.999	5.33E+04	2.59E+03	4.82E+04	5.83E+04	
200	0.995	4.93E+04	2.07E+03	4.53E+04	5.34E+04	
100	0.99	4.75E+04	1.85E+03	4.39E+04	5.12E+04	
50	0.98	4.56E+04	1.63E+03	4.24E+04	4.88E+04	
20	0.95	4.29E+04	1.33E+03	4.03E+04	4.55E+04	
10	0.9	4.07E+04	1.11E+03	3.85E+04	4.28E+04	
5	0.8	3.81E+04	8.93E+02	3.63E+04	3.98E+04	
3	0.6667	3.58E+04	753	3.43E+04	3.73E+04	
2	0.5	3.36E+04	675	3.23E+04	3.49E+04	
1.4286	0.3	3.11E+04	667	2.98E+04	3.24E+04	
1.25	0.2	2.96E+04	695	2.83E+04	3.10E+04	
1.1111	0.1	2.78E+04	756	2.63E+04	2.92E+04	
1.0526	0.05	2.63E+04	815	2.47E+04	2.79E+04	
1.0204	0.02	2.47E+04	882	2.30E+04	2.65E+04	
1.0101	0.01	2.37E+04	925	2.19E+04	2.56E+04	
1.005	0.005	2.29E+04	962	2.10E+04	2.48E+04	
1.001	0.001	2.12E+04	1030	1.92E+04	2.32E+04	
1.0005	0.0005	2.06E+04	1060	1.85E+04	2.26E+04	
1.0001	0.0001	1.93E+04	1100	1.71E+04	2.15E+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	25418.1441
mu	8.870894
sigma	0.614484

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

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	9.54E+04	2.27E+04	5.10E+04	1.40E+05	
2000	0.9995	7.92E+04	1.51E+04	4.96E+04	1.09E+05	
1000	0.999	7.30E+04	1.24E+04	4.87E+04	9.73E+04	
200	0.995	6.01E+04	7.35E+03	4.57E+04	7.45E+04	
100	0.99	5.52E+04	5.65E+03	4.41E+04	6.63E+04	
50	0.98	5.06E+04	4.21E+03	4.23E+04	5.88E+04	
20	0.95	4.50E+04	2.68E+03	3.97E+04	5.02E+04	
10	0.9	4.11E+04	1.80E+03	3.75E+04	4.46E+04	
5	0.8	3.74E+04	1150	3.51E+04	3.96E+04	
3	0.6667	3.47E+04	818	3.31E+04	3.63E+04	
2	0.5	3.25E+04	623	3.13E+04	3.38E+04	
1.4286	0.3	3.06E+04	481	2.96E+04	3.15E+04	
1.25	0.2	2.97E+04	419	2.88E+04	3.05E+04	
1.1111	0.1	2.87E+04	363	2.79E+04	2.94E+04	
1.0526	0.05	2.80E+04	348	2.73E+04	2.87E+04	
1.0204	0.02	2.74E+04	367	2.67E+04	2.82E+04	
1.0101	0.01	2.71E+04	396	2.63E+04	2.79E+04	
1.005	0.005	2.69E+04	430	2.60E+04	2.77E+04	
1.001	0.001	2.65E+04	5.07E+02	2.55E+04	2.75E+04	
1.0005	0.0005	2.64E+04	5.38E+02	2.53E+04	2.74E+04	
1.0001	0.0001	2.61E+04	6.02E+02	2.50E+04	2.73E+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	6959.81482
m	27023.4579

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

T	q	XT	Standard deviation	Confidence interval (95%)	
10000	0.9999	9.11E+04	8.71E+03	7.41E+04	1.08E+05
2000	0.9995	7.99E+04	7.18E+03	6.58E+04	9.40E+04
1000	0.999	7.51E+04	6.53E+03	6.23E+04	8.79E+04
200	0.995	6.39E+04	5.00E+03	5.41E+04	7.37E+04
100	0.99	5.91E+04	4.35E+03	5.06E+04	6.76E+04
50	0.98	5.43E+04	3.69E+03	4.70E+04	6.15E+04
20	0.95	4.79E+04	2.82E+03	4.23E+04	5.34E+04
10	0.9	4.30E+04	2.17E+03	3.88E+04	4.73E+04
5	0.8	3.82E+04	1.51E+03	3.53E+04	4.12E+04
3	0.6667	3.47E+04	1.03E+03	3.26E+04	3.67E+04
2	0.5	3.18E+04	652	3.06E+04	3.31E+04
1.4286	0.3	2.95E+04	345	2.88E+04	3.02E+04
1.25	0.2	2.86E+04	232	2.81E+04	2.90E+04
1.1111	0.1	2.78E+04	151	2.75E+04	2.81E+04
1.0526	0.05	2.74E+04	130	2.71E+04	2.76E+04
1.0204	0.02	2.72E+04	127	2.69E+04	2.74E+04
1.0101	0.01	2.71E+04	127	2.68E+04	2.73E+04
1.005	0.005	2.71E+04	127	2.68E+04	2.73E+04
1.001	0.001	2.70E+04	128	2.68E+04	2.73E+04
1.0005	0.0005	2.70E+04	128	2.68E+04	2.73E+04
1.0001	0.0001	2.70E+04	128	2.68E+04	2.73E+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 (Maximum Likelihood)

Number of observations 55

Parameters

alpha	0.000233
lambda	1.640274
m	26952.6051

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

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	7.37E+04	6.63E+03	6.07E+04	8.67E+04	
2000	0.9995	6.64E+04	5.43E+03	5.57E+04	7.70E+04	
1000	0.999	6.32E+04	4.92E+03	5.35E+04	7.28E+04	
200	0.995	5.57E+04	3.74E+03	4.84E+04	6.31E+04	
100	0.99	5.25E+04	3.24E+03	4.61E+04	5.88E+04	
50	0.98	4.92E+04	2.74E+03	4.38E+04	5.45E+04	
20	0.95	4.47E+04	2.09E+03	4.06E+04	4.88E+04	
10	0.9	4.13E+04	1.61E+03	3.81E+04	4.44E+04	
5	0.8	3.77E+04	1150	3.55E+04	4.00E+04	
3	0.6667	3.51E+04	852	3.34E+04	3.67E+04	
2	0.5	3.26E+04	625	3.14E+04	3.38E+04	
1.4286	0.3	3.05E+04	472	2.95E+04	3.14E+04	
1.25	0.2	2.95E+04	411	2.87E+04	3.03E+04	
1.1111	0.1	2.85E+04	337	2.78E+04	2.91E+04	
1.0526	0.05	2.79E+04	273	2.74E+04	2.85E+04	
1.0204	0.02	2.75E+04	1.91E+02	2.71E+04	2.79E+04	
1.0101	0.01	2.73E+04	1.23E+02	2.70E+04	2.75E+04	
1.005	0.005	2.71E+04	N/D	N/D	N/D	
1.001	0.001	2.70E+04	N/D	N/D	N/D	
1.0005	0.0005	2.69E+04	N/D	N/D	N/D	
1.0001	0.0001	2.69E+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	29.262087
lambda	3.518463
m	4.406031

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

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	8.27E+04	2.33E+04	N/D	N/D	
2000	0.9995	7.11E+04	1.55E+04	N/D	N/D	
1000	0.999	6.65E+04	1.27E+04	N/D	N/D	
200	0.995	5.67E+04	7.45E+03	4.21E+04	7.13E+04	
100	0.99	5.28E+04	5.66E+03	4.17E+04	6.39E+04	
50	0.98	4.91E+04	4.14E+03	4.10E+04	5.72E+04	
20	0.95	4.44E+04	2.53E+03	3.94E+04	4.94E+04	
10	0.9	4.09E+04	1.65E+03	3.77E+04	4.42E+04	
5	0.8	3.75E+04	1.11E+03	3.53E+04	3.97E+04	
3	0.6667	3.50E+04	908	3.32E+04	3.68E+04	
2	0.5	3.27E+04	781	3.12E+04	3.43E+04	
1.4286	0.3	3.06E+04	586	2.95E+04	3.18E+04	
1.25	0.2	2.96E+04	478	2.87E+04	3.06E+04	
1.1111	0.1	2.85E+04	516	2.75E+04	2.95E+04	
1.0526	0.05	2.78E+04	746	2.63E+04	2.92E+04	
1.0204	0.02	2.71E+04	1090	N/D	N/D	
1.0101	0.01	2.68E+04	1340	N/D	N/D	
1.005	0.005	2.65E+04	1560	N/D	N/D	
1.001	0.001	2.61E+04	1980	N/D	N/D	
1.0005	0.0005	2.59E+04	2140	N/D	N/D	
1.0001	0.0001	2.57E+04	2450	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	31640.2378
alpha	3756.73015

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

T	q	XT	Standard deviation	Confidence interval (95%)	
10000	0.9999	6.62E+04	3.89E+03	5.86E+04	7.39E+04
2000	0.9995	6.02E+04	3.25E+03	5.38E+04	6.66E+04
1000	0.999	5.76E+04	2.97E+03	5.18E+04	6.34E+04
200	0.995	5.15E+04	2.34E+03	4.69E+04	5.61E+04
100	0.99	4.89E+04	2.07E+03	4.49E+04	5.30E+04
50	0.98	4.63E+04	1.80E+03	4.28E+04	4.98E+04
20	0.95	4.28E+04	1.44E+03	4.00E+04	4.56E+04
10	0.9	4.01E+04	1.18E+03	3.78E+04	4.24E+04
5	0.8	3.73E+04	916	3.55E+04	3.91E+04
3	0.6667	3.50E+04	729	3.36E+04	3.65E+04
2	0.5	3.30E+04	593	3.19E+04	3.42E+04
1.4286	0.3	3.09E+04	514	2.99E+04	3.20E+04
1.25	0.2	2.99E+04	507	2.89E+04	3.08E+04
1.1111	0.1	2.85E+04	535	2.75E+04	2.96E+04
1.0526	0.05	2.75E+04	578	2.64E+04	2.87E+04
1.0204	0.02	2.65E+04	636	2.53E+04	2.78E+04
1.0101	0.01	2.59E+04	678	2.46E+04	2.72E+04
1.005	0.005	2.54E+04	716	2.40E+04	2.68E+04
1.001	0.001	2.44E+04	795	2.28E+04	2.59E+04
1.0005	0.0005	2.40E+04	825	2.24E+04	2.56E+04
1.0001	0.0001	2.33E+04	887	2.16E+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	3342.8699
k	-0.205787
u	31273.7257

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

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	1.23E+05	6.00E+04	N/D	N/D	
2000	0.9995	9.27E+04	3.21E+04	N/D	N/D	
1000	0.999	8.23E+04	2.39E+04	N/D	N/D	
200	0.995	6.33E+04	1.13E+04	N/D	N/D	
100	0.99	5.69E+04	7.85E+03	4.15E+04	7.23E+04	
50	0.98	5.13E+04	5.28E+03	4.09E+04	6.16E+04	
20	0.95	4.50E+04	2.95E+03	3.92E+04	5.07E+04	
10	0.9	4.08E+04	1820	3.73E+04	4.44E+04	
5	0.8	3.71E+04	1110	3.50E+04	3.93E+04	
3	0.6667	3.46E+04	790	3.30E+04	3.61E+04	
2	0.5	3.25E+04	605	3.14E+04	3.37E+04	
1.4286	0.3	3.07E+04	470	2.97E+04	3.16E+04	
1.25	0.2	2.98E+04	422	2.89E+04	3.06E+04	
1.1111	0.1	2.87E+04	399	2.79E+04	2.95E+04	
1.0526	0.05	2.80E+04	418	2.72E+04	2.88E+04	
1.0204	0.02	2.73E+04	472	2.64E+04	2.82E+04	
1.0101	0.01	2.69E+04	519	2.59E+04	2.79E+04	
1.005	0.005	2.66E+04	5.68E+02	2.54E+04	2.77E+04	
1.001	0.001	2.59E+04	6.76E+02	2.46E+04	2.73E+04	
1.0005	0.0005	2.57E+04	7.19E+02	2.43E+04	2.71E+04	
1.0001	0.0001	2.53E+04	8.11E+02	2.37E+04	2.69E+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	36412.5819
c	5.594443

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

T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	5.42E+04	2.25E+03	4.97E+04	5.86E+04	
2000	0.9995	5.23E+04	2.02E+03	4.84E+04	5.63E+04	
1000	0.999	5.14E+04	1.91E+03	4.77E+04	5.52E+04	
200	0.995	4.91E+04	1.65E+03	4.58E+04	5.23E+04	
100	0.99	4.78E+04	1.52E+03	4.49E+04	5.08E+04	
50	0.98	4.65E+04	1.39E+03	4.37E+04	4.92E+04	
20	0.95	4.43E+04	1.21E+03	4.19E+04	4.67E+04	
10	0.9	4.23E+04	1.07E+03	4.02E+04	4.44E+04	
5	0.8	3.96E+04	956	3.78E+04	4.15E+04	
3	0.6667	3.70E+04	921	3.52E+04	3.88E+04	
2	0.5	3.41E+04	965	3.22E+04	3.60E+04	
1.4286	0.3	3.03E+04	1100	2.81E+04	3.24E+04	
1.25	0.2	2.78E+04	1210	2.55E+04	3.02E+04	
1.1111	0.1	2.44E+04	1360	2.17E+04	2.70E+04	
1.0526	0.05	2.14E+04	1460	1.86E+04	2.43E+04	
1.0204	0.02	1.81E+04	1540	1.51E+04	2.11E+04	
1.0101	0.01	1.60E+04	1560	1.29E+04	1.91E+04	
1.005	0.005	1.41E+04	1560	1.11E+04	1.72E+04	
1.001	0.001	1.06E+04	1480	7.69E+03	1.35E+04	
1.0005	0.0005	9.36E+03	1430	6.56E+03	1.22E+04	
1.0001	0.0001	7.02E+03	1280	4.51E+03	9.53E+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	0.001284
lambda	43.643041

Quantiles

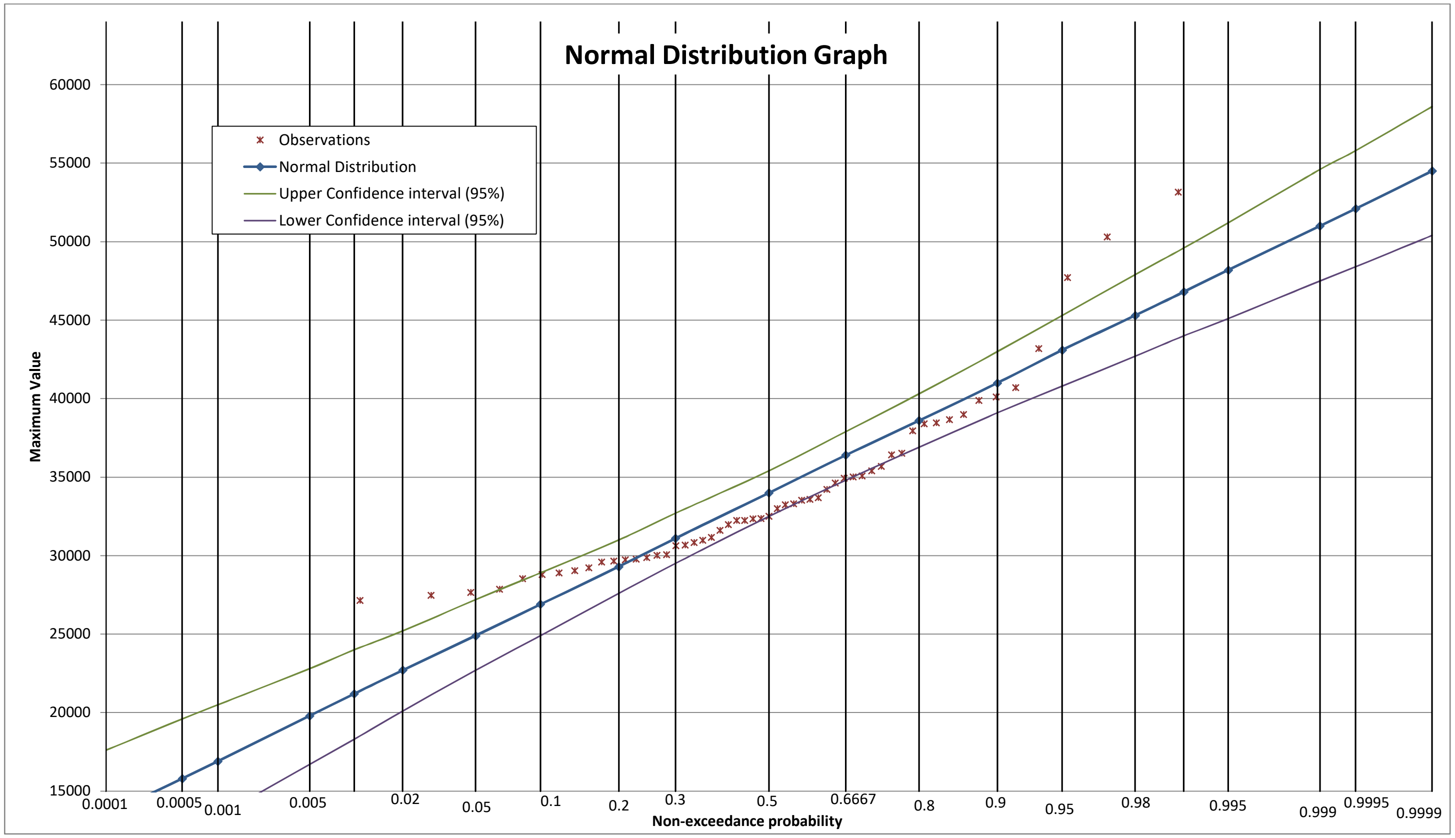
q = F(X) : non-exceedance probability

T = 1/(1-q)

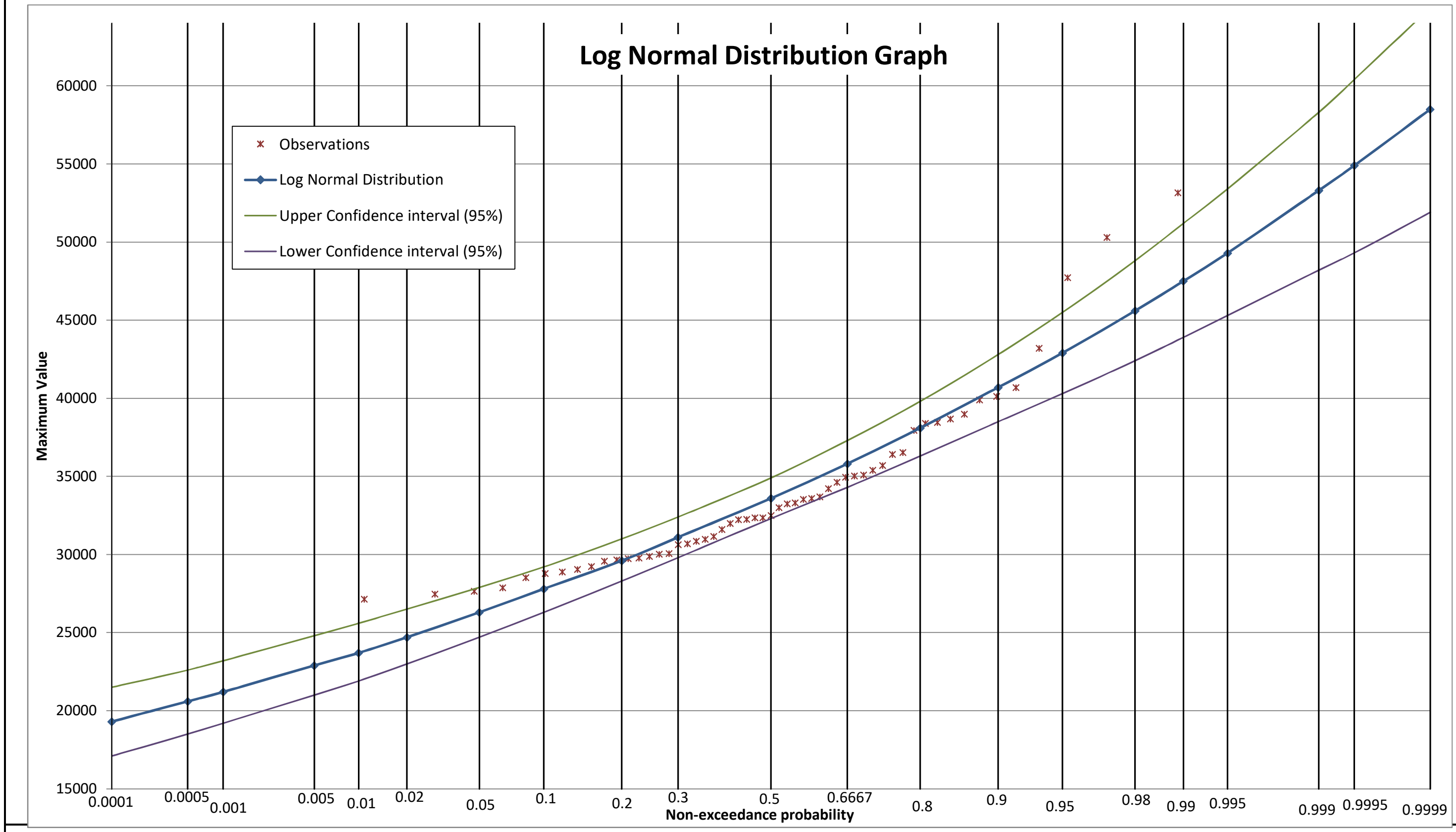
T	q	XT	Standard deviation	Confidence interval (95%)		
10000	0.9999	5.65E+04	2.73E+03	5.12E+04	6.19E+04	
2000	0.9995	5.35E+04	2.37E+03	4.89E+04	5.81E+04	
1000	0.999	5.21E+04	2.21E+03	4.78E+04	5.65E+04	
200	0.995	4.87E+04	1.83E+03	4.51E+04	5.23E+04	
100	0.99	4.71E+04	1.66E+03	4.38E+04	5.03E+04	
50	0.98	4.54E+04	1.48E+03	4.25E+04	4.83E+04	
20	0.95	4.29E+04	1.24E+03	4.04E+04	4.53E+04	
10	0.9	4.07E+04	1.06E+03	3.86E+04	4.28E+04	
5	0.8	3.82E+04	873	3.65E+04	3.99E+04	
3	0.6667	3.60E+04	755	3.45E+04	3.75E+04	
2	0.5	3.37E+04	690	3.24E+04	3.51E+04	
1.4286	0.3	3.11E+04	697	2.97E+04	3.25E+04	
1.25	0.2	2.96E+04	736	2.82E+04	3.10E+04	
1.1111	0.1	2.76E+04	815	2.60E+04	2.92E+04	
1.0526	0.05	2.60E+04	891	2.42E+04	2.77E+04	
1.0204	0.02	2.43E+04	977	2.23E+04	2.62E+04	
1.0101	0.01	2.32E+04	1030	2.11E+04	2.52E+04	
1.005	0.005	2.22E+04	1080	2.01E+04	2.43E+04	
1.001	0.001	2.03E+04	1160	1.80E+04	2.26E+04	
1.0005	0.0005	1.96E+04	1190	1.73E+04	2.20E+04	
1.0001	0.0001	1.82E+04	1250	1.57E+04	2.06E+04	

Visual Goodness of Fit

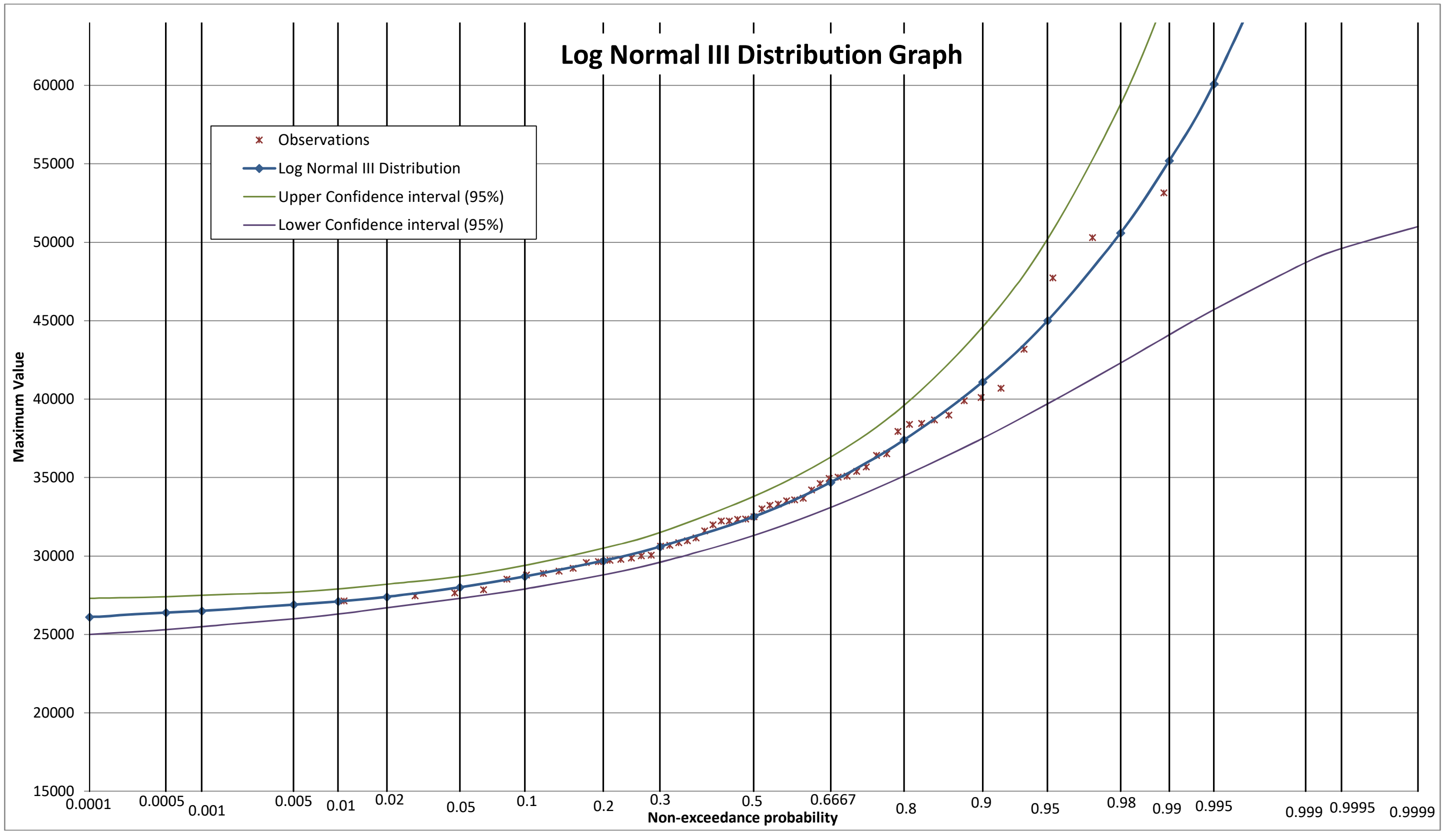
Clear All Note Data



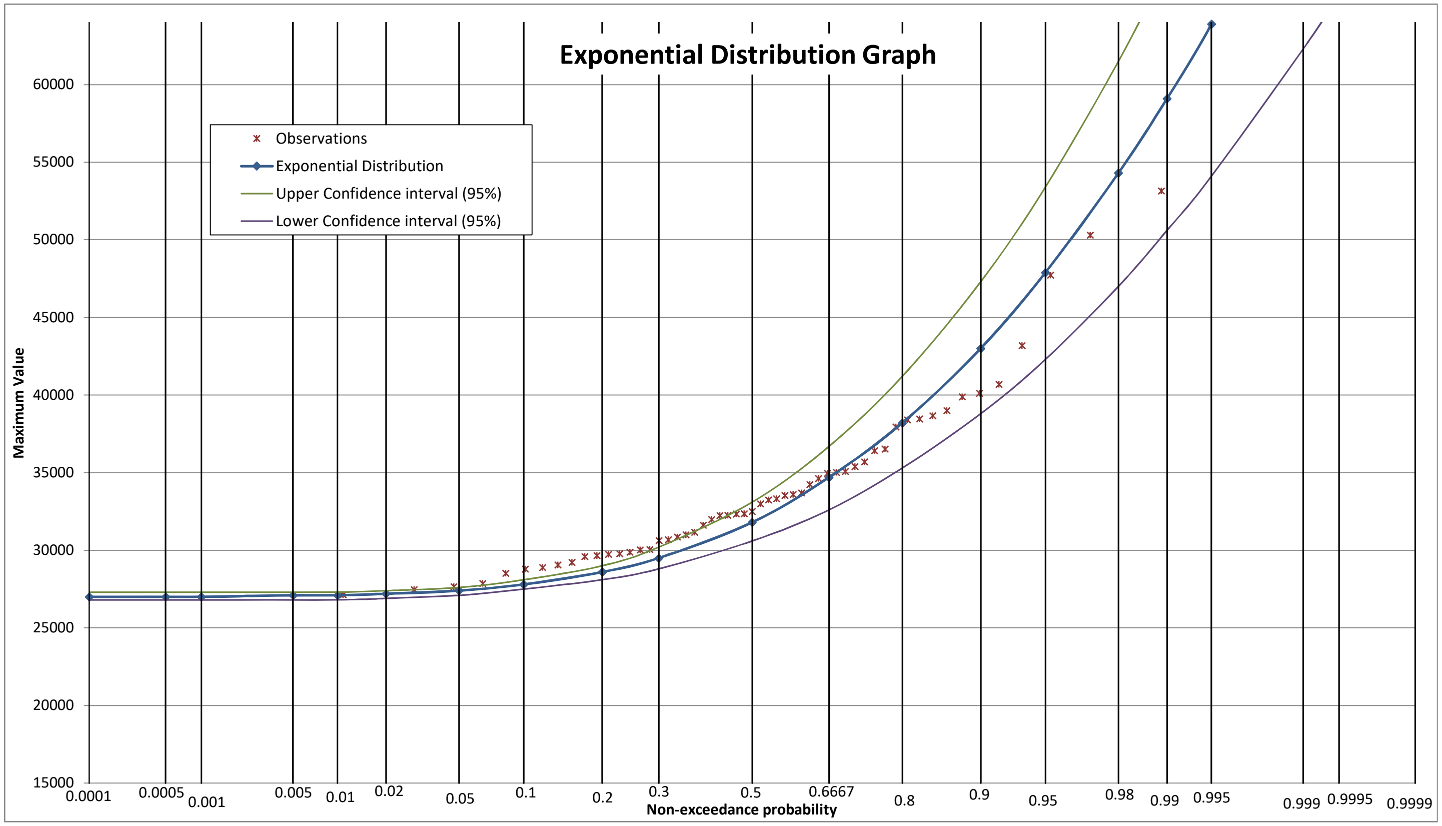
Normal Distribution
Visual Goodness-of-Fit Test Notes:



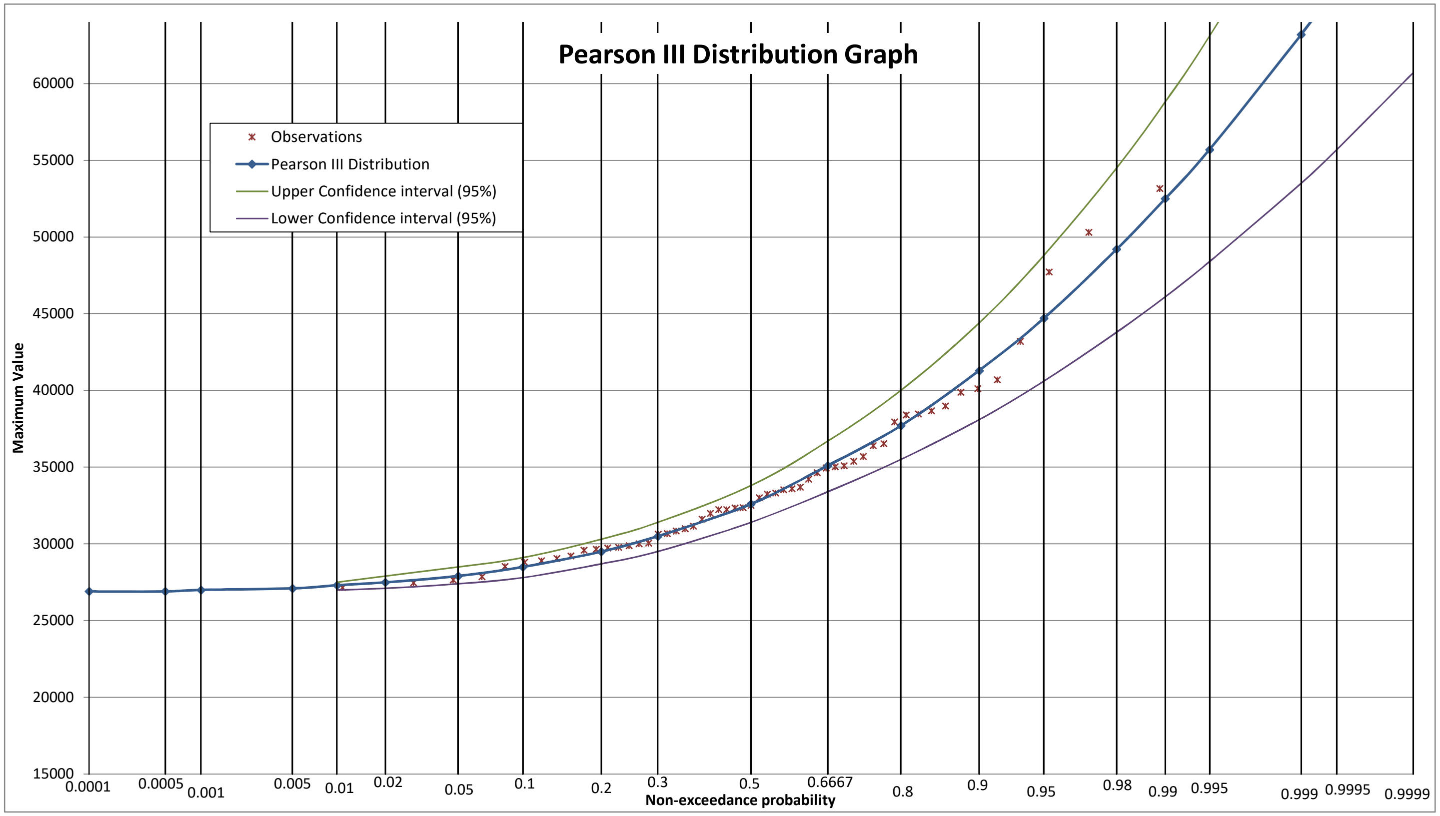
Log Normal Distribution
Visual Goodness-of-Fit Test Notes:



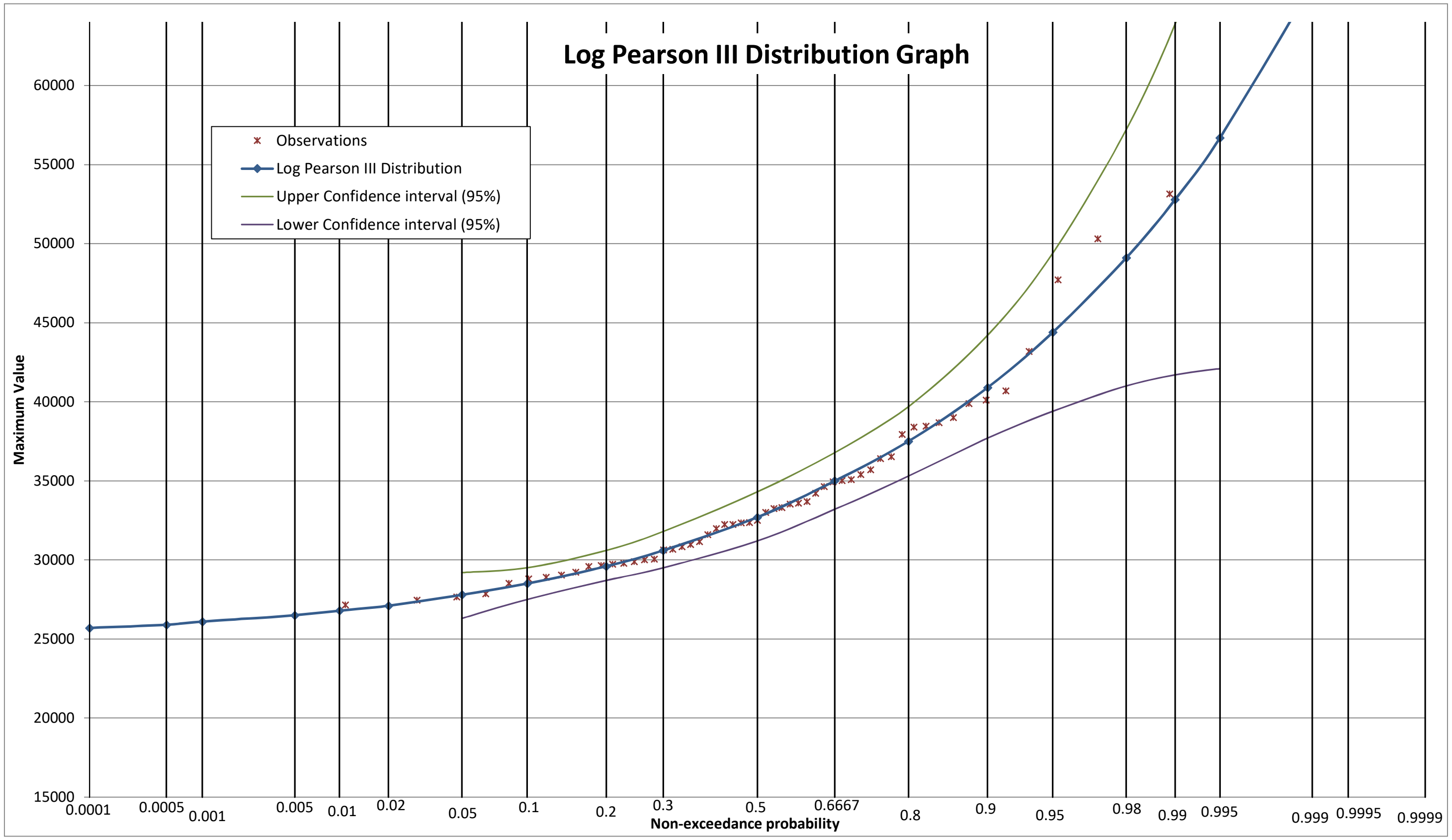
Log Normal III Distribution
Visual Goodness-of-Fit Test Notes:



Exponential Distribution
Visual Goodness-of-Fit Test Notes:



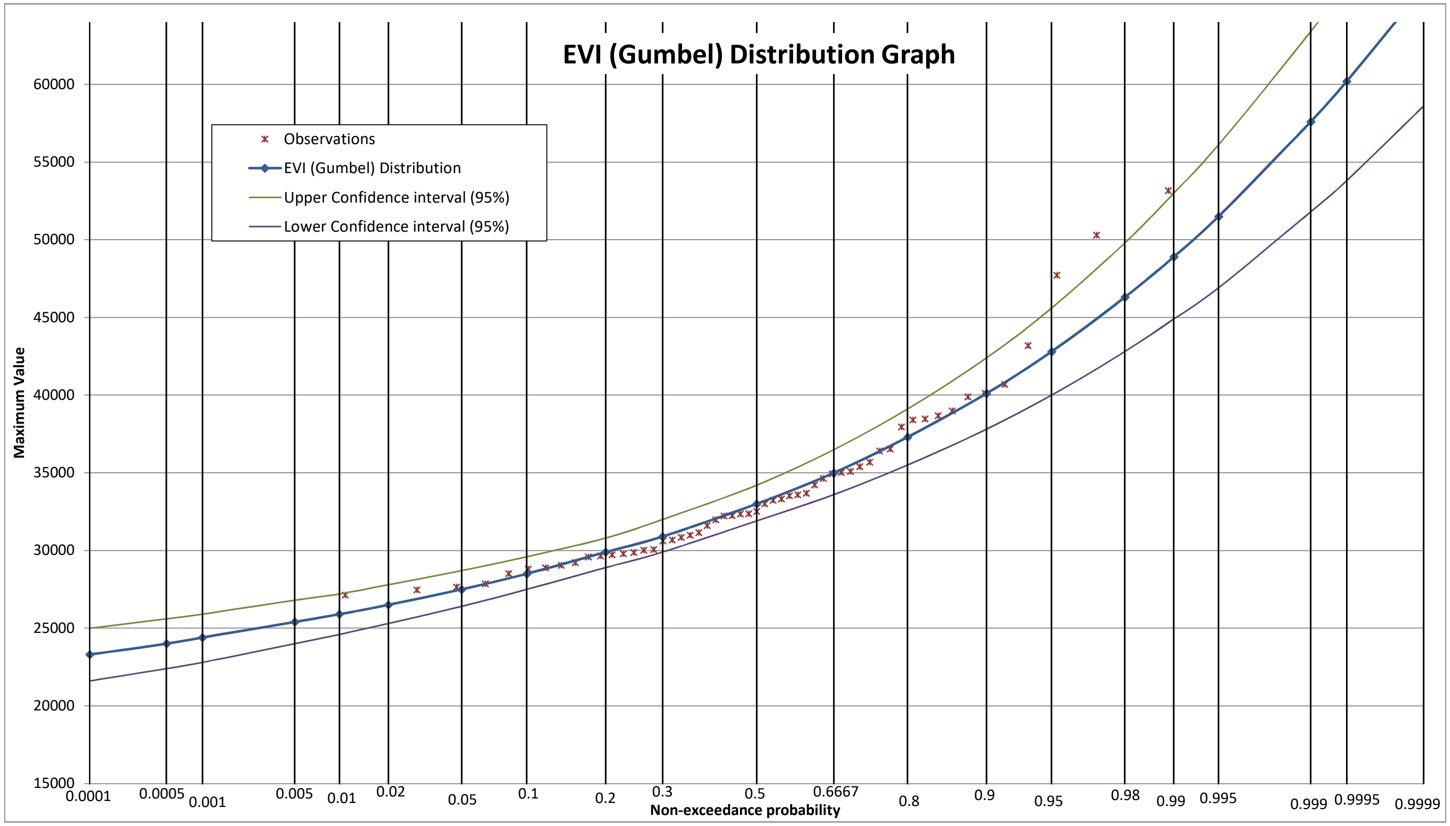
Pearson III Distribution
Visual Goodness-of-Fit Test Notes:



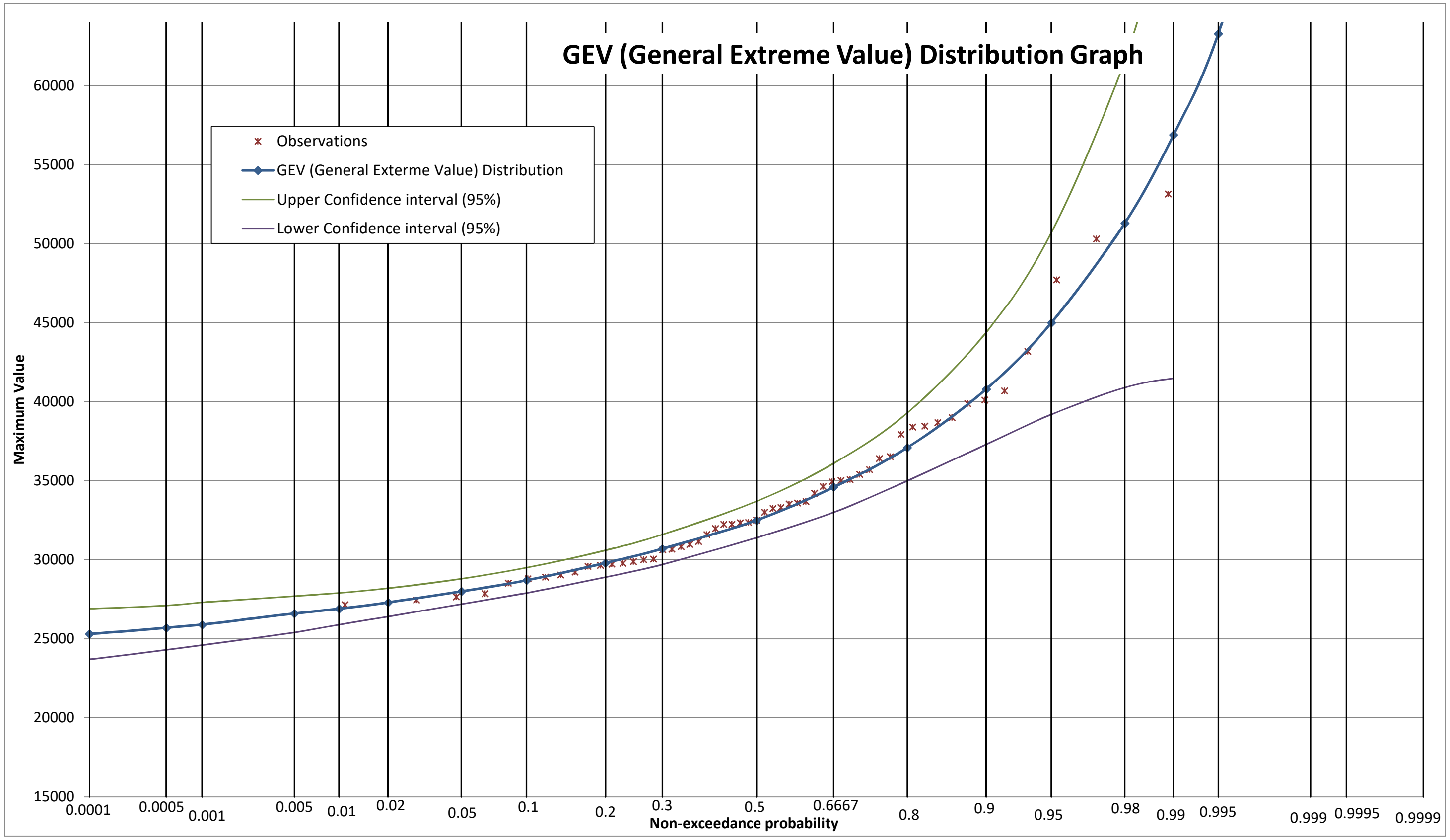
Log Pearson III Distribution
Visual Goodness-of-Fit Test Notes:

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

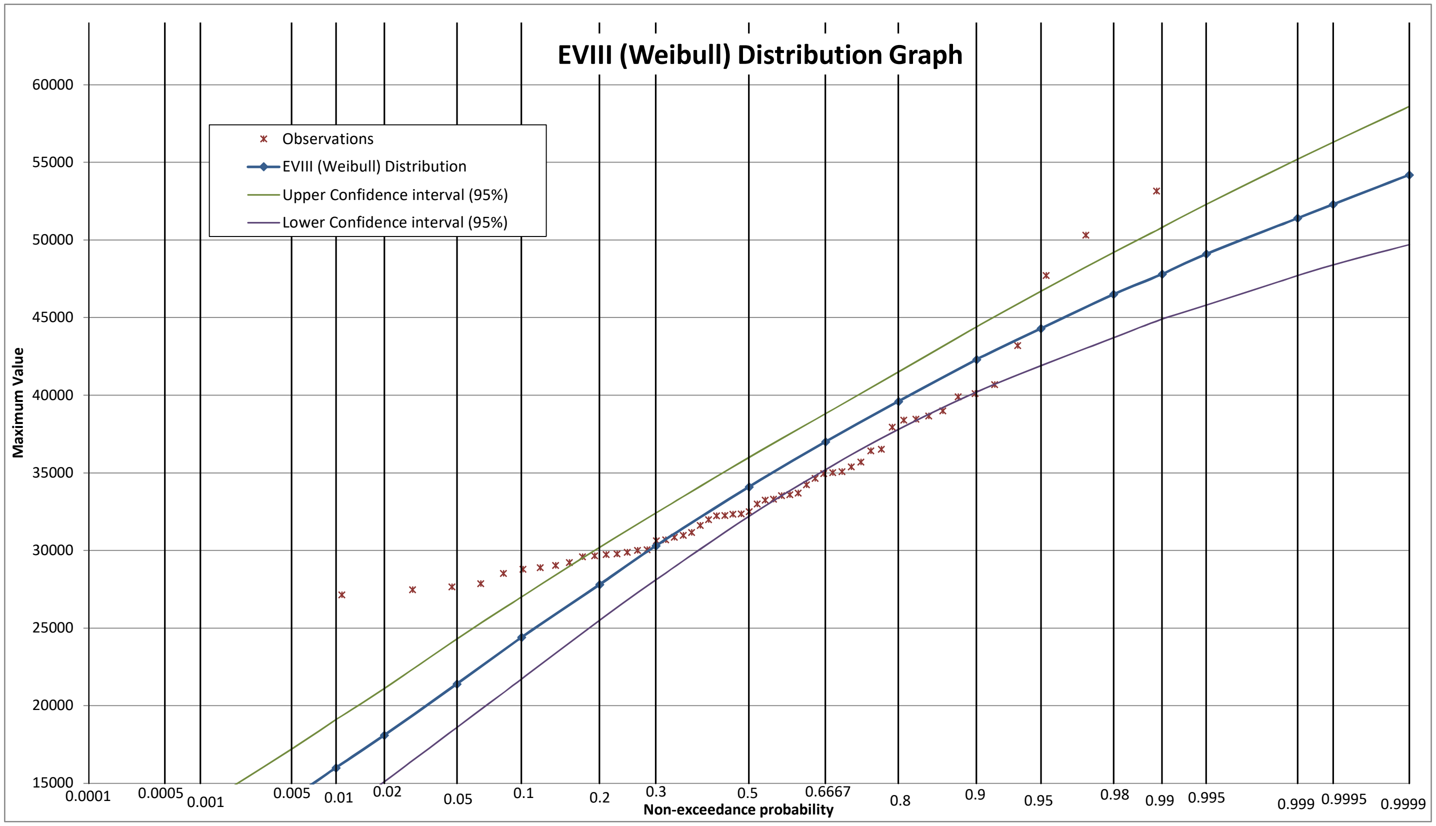
Lambda shape test
Pass
Alpha shape test
Pass



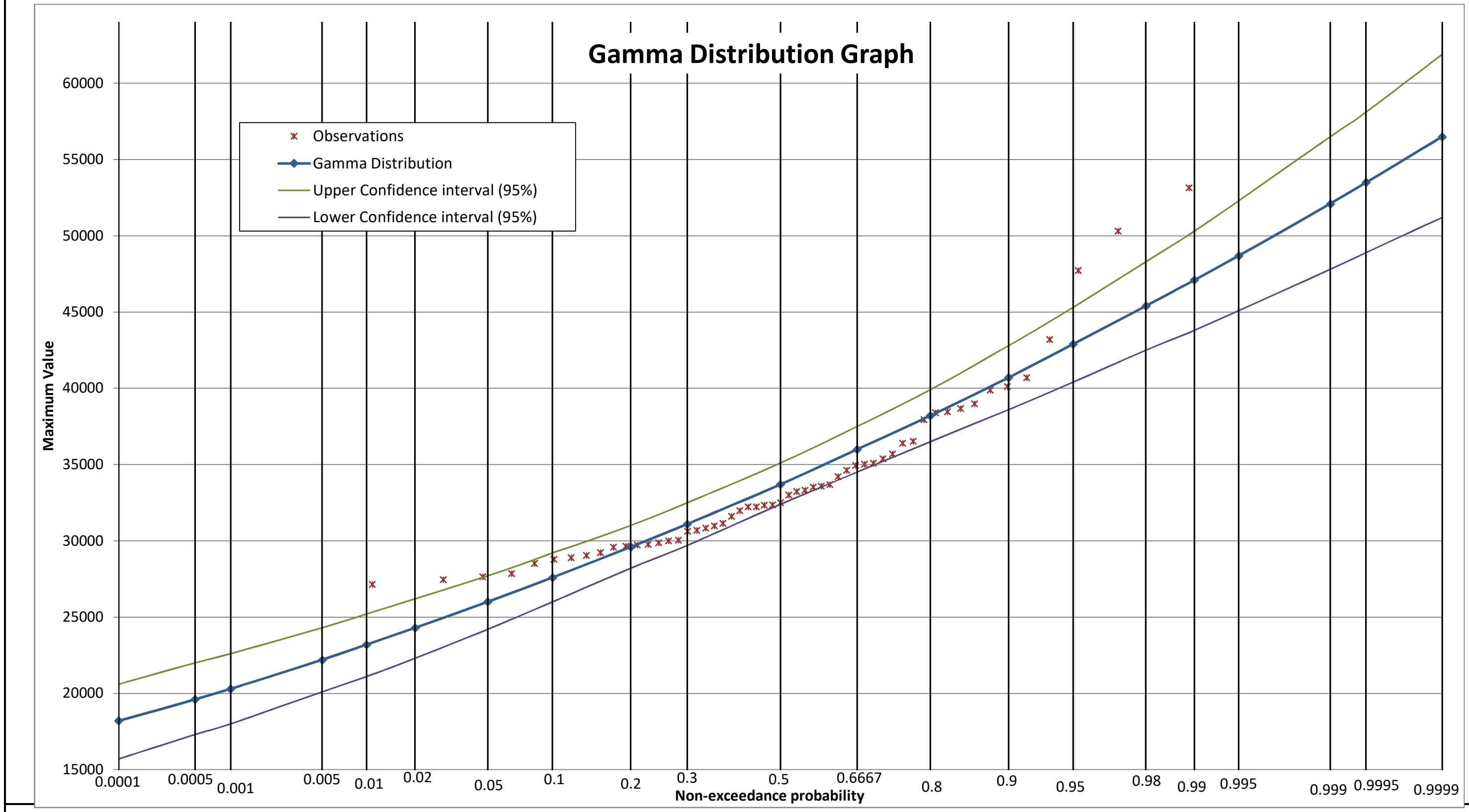
EVI (Gumbel) Distribution
Visual Goodness-of-Fit Test Notes:



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	1.867	Accept H0	9
Lognormal	1.929	2.502	3.907	1.057	Accept H0	6
Lognormal III	1.929	2.502	3.907	0.126	Accept H0	1
Exponential	1.929	2.502	3.907	1.471	Accept H0	8
Pearson III	1.929	2.502	3.907	0.164	Accept H0	4
Log Pearson III	1.929	2.502	3.907	0.138	Accept H0	2
Gumbel	1.929	2.502	3.907	0.359	Accept H0	5
GEV	1.929	2.502	3.907	0.143	Accept H0	3
Weibull	1.929	2.502	3.907	3.097	Reject H0	10
Gamma	1.929	2.502	3.907	1.299	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	0.120	Accept H0	8
Lognormal	0.165	0.183	0.220	0.092	Accept H0	6
Lognormal III	0.165	0.183	0.220	0.054	Accept H0	4
Exponential	0.165	0.183	0.220	0.145	Accept H0	9
Pearson III	0.165	0.183	0.220	0.049	Accept H0	2
Log Pearson III	0.165	0.183	0.220	0.044	Accept H0	1
Gumbel	0.165	0.183	0.220	0.055	Accept H0	5
GEV	0.165	0.183	0.220	0.052	Accept H0	3
Weibull	0.165	0.183	0.220	0.176	Accept H0	10
Gamma	0.165	0.183	0.220	0.102	Accept H0	7

Least Squares Ranking

Distribution Type:	Standard Error	Rank
Normal	2065	9
Lognormal	1606	7
Lognormal III	590	1
Exponential	1361	6
Pearson III	677	3
Log Pearson III	655	2
Gumbel	1253	5
GEV	683	4
Weibull	3114	10
Gamma	1740	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**

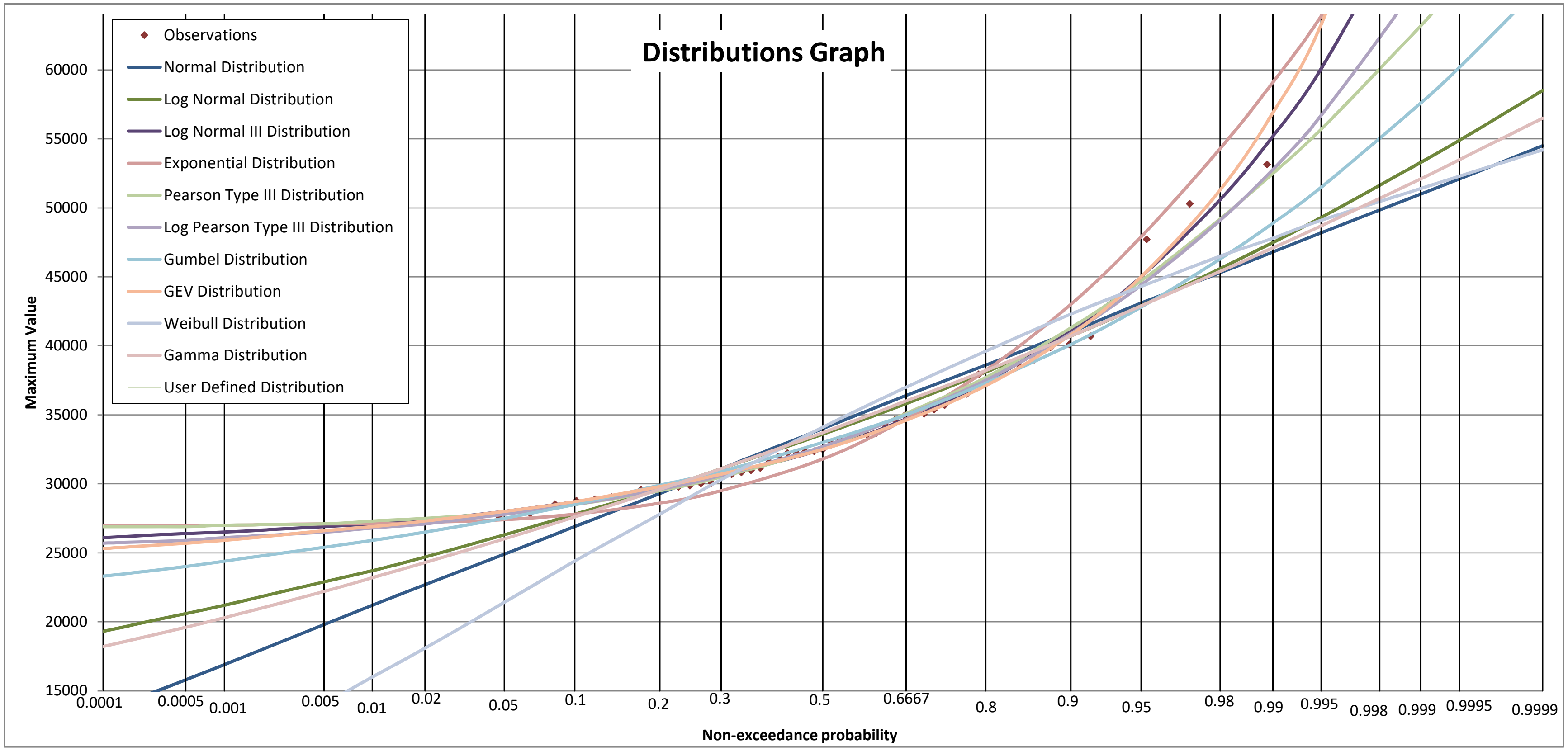
Sampling and Distribution Uncertainty

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	38600

Sampling Uncertainty at (95%) Confidence Interval ±	1700
Distribution Uncertainty ±	138
Total Uncertainty ±	1840



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:	2022-10-01
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	6	7	6.33	6			
Lognormal III	1	4	1	2.00	2			
Exponential	8	9	6	7.67	8			
Pearson III	4	2	3	3.00	3			
Log Pearson III	2	1	2	1.67	1			
Gumbel	5	5	5	5.00	5			
GEV	3	3	4	3.33	4			
Weibull	10	10	10	10.00	10			
Gamma	7	7	8	7.33	7			

Selected Distribution and Results

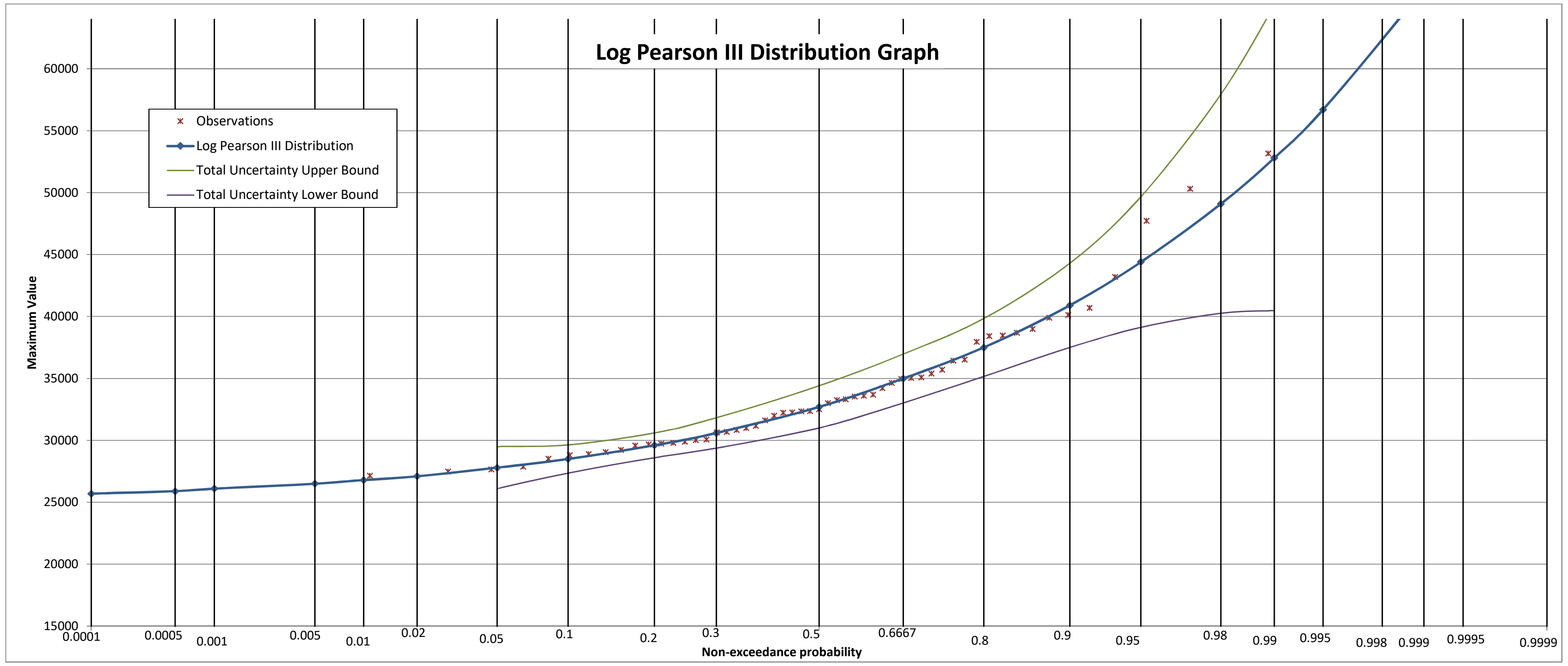
Instructions:

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

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

Return Period	Probability	Magnitude	Total Uncertainty (Upper Bound)	Total Uncertainty (Lower Bound)
10000	0.9999	82700	#N/A	#N/A
2000	0.9995	71100	#N/A	#N/A
1000	0.9990	66500	#N/A	#N/A
500	0.9980	62500	#N/A	#N/A
200	0.9950	56700	73100	40300
100	0.9900	52800	65100	40500
50	0.9800	49100	57900	40300
20	0.9500	44400	49700	39100
10	0.9000	40900	44300	37500
5	0.8000	37500	39800	35200
3	0.6667	35000	37000	33000
2	0.5000	32700	34400	31000
1.4286	0.3000	30600	31800	29400
1.25	0.2000	29600	30600	28600
1.1111	0.1000	28500	29600	27400
1.0526	0.0500	27800	29500	26100
1.0204	0.0200	27100	#N/A	#N/A
1.0101	0.0100	26800	#N/A	#N/A
1.005	0.0050	26500	#N/A	#N/A
1.001	0.0010	26100	#N/A	#N/A
1.0005	0.0005	25900	#N/A	#N/A
1.0001	0.0001	25700	#N/A	#N/A

*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

To: LGN Consulting Engineers
From: Rainwater Management
Date: 5-Oct-22

Project City: Calgary
Designation: Dry Pond
Revision: 1

Re: Ascension Lands

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
7.77	35%	RWM-DM-1800	89%	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)
544	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 (Concrete/PVC) and for 90 Deg. pipe configuration is 750mm/750mm.

* ETV particle size distribution utilized, or in part, shown on Page 4.

City of Calgary Checklist

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

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

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

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

Drainage Area (ha)	Conversion Factor	Agv. Annual Precipitation (mm)	Total Imperviousness (%)	Avg. % Volume Treated as per p.8	Avg. Volume Treated (m3)
7.77	10	400	35%	91%	9,850

Average annual sediment removed = Avg. Volume Treated x Avg. Removal Efficiency 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
9,850	89%	0.444	3,901	7,367	Condition Met

11) The allowable treatment flow:

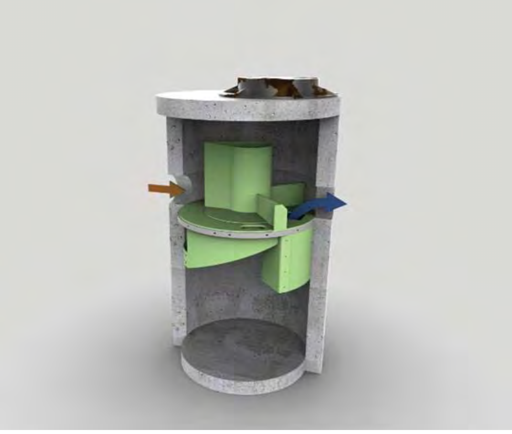
Manhole Diameter (mm)	Max Hydraulic Loading Rate (l/s/m2)	Allowable Treatable Flow (l/s)	Allowable Treatment Flow Condition
1,829	27	70.9	Condition Met

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.

RWM-DM Technology Summary

The Rainwater Management RWM-DM Stormwater Treatment System is a hydrodynamic oil/grit separator (OGS) that provides a unique flow path inside the treatment chamber to enhance gravity settling to remove solids from stormwater runoff. The RWM-DM is unique in that it does not back up the water significantly so it captures the sediment in the sump rather than settling the majority in the inlet pipe system.



This technology is the first technology to go through the latest ETV Protocol test program which ensures that total suspended solids (TSS) removals occur inside the OGS and not in the upstream piping. All previously tested OGS units were allowed to settle TSS in the inlet pipe and count it towards their overall TSS removal. The RWM-DM unit is the first design on the market to minimize settling in the upstream piping system.

The RWM-DM unit has been fully third party tested and verified by an ETV approved laboratory and is currently listed on the ETV Canada product list (https://etvcanada.ca/wp-content/uploads/2022/09/ISO-14034-ETV-Verification-Statement_RWM-DM-1200_2022-2025.pdf).

The RWM-DM Stormwater Treatment System can be installed as a bend structure, can accommodate multiple inlets, and does not require an elevation difference between the inlet and outlet pipes.

Maintenance is a key to any oil/grit separator system for proper long-term effectiveness. RWM-DM allows for unobstructed access without confined space requirements. Rainwater Management is available to train a maintenance crew or to provide regular inspection services.

Rainwater Management is happy to provide further information if required.

Kind Regards,
Peter Law P.Eng.

PETER LAW

Permit to Practice
Rainwater Management Ltd.
RM Signature
RM APEGA ID: 92487
Date [illegible]
Permit Number: P11426
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

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

Canadian ETV - ISO 14034 Information

Canadian ETV Testing - NEW REQUIREMENTS

The Canadian ETV (ISO 14034) testing protocol was recently updated with the intent of eliminating OGS systems that settle the pollutants in the inlet (upstream) pipe. Technologies undergoing testing must now report the amount of sediment that is captured in the Inlet pipe. The reason for the change is that they found that Vendors were enhancing the removal rates by designing systems that would back the water up in the pipe and settle out significant quantities of sediment in the inlet pipe.

The Rainwater Management RWM-DM and RWM-DM-OS units are the first units to be tested under the new protocol and have been specifically designed to capture the sediment in the OGS manhole. Technologies that were tested under the old protocol may be depositing large amounts of sediment in the piping systems rather than capturing it in the manhole.

Particle Size Distribution

The ISO 14034 (Canadian ETV) Particle Size Distribution that is utilized for testing all OGS units is shown below. This is the particle size distribution utilized in whole or in part for this sizing.

Particle Size (µm)	Percent Less Than	Particle size Fraction (µm)	Percent
1000	100	500-1000	5
500	95	250-500	5
250	90	150-250	15
150	75	100-150	15
100	60	75-100	10
75	50	50-75	5
50	45	20-50	10
20	35	8-20	15
8	20	5-8	10
5	10	2-5	5
2	5	<2	5

Third-Party Testing and Verification

The RWM-DM and RWM-DM-OS units are the latest development by Rainwater Management that are designed to capture a wide range of pollutants. The technology has been tested following the latest ISO 14034 (Canadian ETV) Procedure for Laboratory Testing of Oil/Grit Separators and is currently being verified. An important feature of the latest Canadian ETV testing requirements is that the inlet pipe diameter and length is now limited and any sediment that settles in the inlet pipe must be recorded to show the sediment that is actually captured in the OGS manhole. Previously tested OGS units (everything aside from RWM-DM unit as Rainwater Management is the first to go through the new protocol) could utilize designs that backed up the flow in the system to enhance removals by utilizing the inlet pipe as a settling chamber. Rainwater Management does not do that. Rainwater Management did multiple testing of various configurations and made a clone of an existing system sold frequently in British Columbia and found it removed 85% of total captured sediment in the inlet pipe during lab testing. This is the equivalent of using the upstream municipal pipe system to settle out the pollutants rather than capturing it on the OGS unit.

Scour Testing

RWM-DM and RWM-DM-OS units have an internal bypass that directs the treatment flows into the treatment/storage chamber and bypasses the peak events without scouring previously capture pollutants. This has been third-party verified during the Canadian ETV (ISO-14034) testing. The RWM-DM OGS units can be installed in an inline configuration knowing that the scour prevention technology is second to none.

Oil Capture and Scour

The RWM-DM-OS unit effectively achieved 100 % oil capture and retention for all flows during the third-party testing of the Light Liquid Retention Simulation Test Protocol of the ISO 14034 Procedure for Laboratory Testing of Oil/Grit Separator. Note that this test originally was simply a re-entrainment test and the oil test sample was pre-loaded into the storage chamber then it was checked for oil scour. All of the current OGS units listed on the ETV website did not capture the simulated oil, they only retained it as shown. The RWM-DM-OS unit had to capture, remove and prevent scour of the oil test sample.

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	102	64	53	64	101	127	57	75	101	114	74	104	1
2	282	168	142	185	247	413	231	161	202	279	236	257	2
3	145	161	153	149	306	454	243	196	267	422	227	216	3
4	380	127	137	327	480	727	390	100	219	328	247	337	4
5	141	243	98	259	252	447	214	113	257	394	196	334	5
6	139	60	132	239	217	462	355	59	139	294	336	117	6
7	161	69	116	303	327	322	356	237	161	235	188	305	7
8	84	0	160	187	163	271	325	83	82	275	267	187	8
9	94	119	122	249	246	244	248	91	153	121	61	179	9
10	136	70	34	238	169	205	345	102	170	236	137	33	10
11	114	113	39	150	152	228	338	77	192	647	38	190	11
12	124	210	41	82	163	205	40	124	207	248	120	123	12
13	44	177	134	91	275	45	44	45	364	181	0	182	13
14	97	0	98	50	98	488	146	146	340	344	0	99	14
15	158	104	53	105	107	208	107	104	104	207	157	54	15
18	651	239	422	486	242	352	230	419	119	419	423	529	18
20	685	272	342	267	343	276	340	137	280	341	0	279	20
25	1162	332	235	500	305	964	474	89	230	585	88	1062	25
30	662	770	0	581	389	1074	203	194	501	103	194	305	30
35	120	959	354	807	330	229	1774	227	472	463	240	122	35
40	134	273	141	794	131	253	272	127	415	986	283	0	40
45	156	156	305	454	147	0	0	0	154	144	294	149	45
50	0	345	0	0	167	360	171	165	178	0	0	0	50
55	0	560	368	0	373	0	388	0	0	0	0	190	55
60	0	0	0	212	201	420	0	0	0	0	202	216	60
69	468	458	0	233	0	681	0	0	0	0	458	471	69
71	0	251	0	0	0	0	0	0	0	0	253	0	71
75	0	0	521	0	0	0	0	0	0	0	0	0	75
168	0	771	0	1168	0	733	0	279	401	307	306	307	168
261	0	764	0	0	778	929	0	0	0	0	1444	0	261
354	0	0	0	0	0	0	0	0	0	0	996	0	354
447	0	0	0	0	0	0	0	0	0	0	0	0	447
540	0	0	0	0	0	0	0	0	0	0	0	0	540
540 +	0	0	0	0	0	0	0	0	0	0	0	0	540 +
Total Runoff	**6242**	**7835**	**4202**	**8177**	**6707**	**11117**	**7290**	**3352**	**5708**	**7674**	**7465**	**6344**	**Total Runoff**

Annual Runoff/Year in Cubic Meters

1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	Flow l/s
122	119	79	101	121	116	150	46	88	153	113	79	141	1
263	242	205	291	249	245	285	200	281	210	269	154	205	2
317	278	133	278	360	313	389	107	186	340	241	231	322	3
171	323	327	209	285	278	275	150	197	366	145	80	223	4
373	241	222	278	358	242	371	184	188	347	383	113	373	5
175	195	136	292	234	297	540	82	256	211	160	98	315	6
94	210	375	282	188	185	192	144	160	273	440	93	165	7
452	189	171	160	246	319	318	105	240	209	185	191	81	8
216	119	95	303	212	276	464	88	302	217	242	148	90	9
171	69	35	139	239	170	273	0	237	550	172	139	69	10
154	150	75	226	301	191	416	0	191	232	149	73	149	11
377	82	80	163	286	166	575	126	126	414	0	164	371	12
90	268	91	91	46	270	314	89	91	224	269	403	133	13
145	243	48	147	47	193	436	0	0	97	98	50	196	14
159	209	104	52	104	54	361	0	159	103	211	0	53	15
186	652	117	239	574	354	696	243	545	345	304	351	695	18
417	546	69	132	67	72	267	67	200	816	271	69	416	20
696	574	828	238	227	621	1064	561	726	393	502	177	477	25
791	297	279	305	489	491	385	387	488	391	874	396	481	30
225	242	0	338	447	0	122	120	704	461	361	223	347	35
534	139	268	0	792	408	269	129	561	1374	142	269	137	40
0	0	152	0	457	162	146	294	316	301	0	147	319	45
0	343	510	0	337	0	0	171	494	496	0	0	0	50
195	0	378	195	0	0	0	0	189	376	0	0	0	55
0	0	0	216	0	415	0	202	405	0	0	0	0	60
475	0	0	0	0	675	0	242	476	248	245	236	0	69
0	0	0	0	0	0	0	251	0	0	0	0	0	71
0	0	0	0	0	0	0	0	0	0	0	0	0	75
1509	0	938	619	0	279	290	0	0	343	914	0	0	168
0	0	0	0	0	0	0	0	0	0	0	0	0	261
0	0	0	0	0	0	0	0	0	0	0	0	0	354
0	0	0	0	0	0	0	0	0	0	0	0	0	447
0	0	0	0	0	0	0	0	0	0	0	0	0	540
0	0	0	0	0	0	0	0	0	0	0	0	0	540 +
8307	**5727**	**5712**	**5294**	**6664**	**6793**	**8597**	**3987**	**7806**	**9493**	**6690**	**3886**	**5759**	**Total Runoff**

Annual Runoff/Year in Cubic Meters

1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	Flow l/s
131	106	110	127	163	116	72	157	123	143	133	145	119	1
319	219	204	357	282	315	237	333	230	245	300	429	202	2
212	214	203	128	426	163	209	518	271	303	452	627	264	3
136	258	207	259	213	250	123	295	306	357	359	200	228	4
313	280	135	194	192	264	223	288	413	357	292	322	300	5
260	613	119	94	233	115	179	178	705	525	273	440	118	6
273	406	165	161	186	187	242	214	268	142	120	116	558	7
133	194	265	79	137	107	192	83	165	131	646	241	245	8
120	61	218	339	212	150	123	273	246	301	217	277	244	9
175	140	244	176	102	136	241	280	206	133	342	337	103	10
78	192	78	152	152	184	150	229	148	115	228	0	189	11
42	165	249	290	124	205	83	332	204	162	167	83	331	12
179	135	134	184	90	176	47	313	44	0	412	91	222	13
194	96	293	244	49	195	145	196	97	0	142	50	247	14
159	157	105	156	51	103	105	205	205	105	210	0	414	15
239	420	359	346	531	345	418	513	301	358	115	124	346	18
132	131	279	419	349	544	403	341	806	135	0	265	211	20
259	706	571	700	150	338	85	802	495	299	157	301	394	25
587	501	413	881	505	388	692	511	303	285	0	301	772	30
233	836	347	563	117	0	235	468	231	347	0	111	571	35
395	534	272	137	0	544	670	409	128	133	0	269	268	40
301	1321	147	615	0	0	146	146	158	157	0	157	160	45
517	353	0	501	341	169	509	167	338	0	167	172	0	50
194	192	0	369	370	0	195	0	574	0	372	0	0	55
0	210	205	0	0	209	201	200	0	0	0	0	0	60
219	0	0	0	0	248	231	243	228	0	0	0	0	69
0	0	0	0	0	252	0	0	0	0	0	0	0	71
0	257	0	0	0	257	0	0	0	0	0	0	266	75
1071	0	757	0	276	0	656	884	598	614	1187	0	295	168
0	0	0	0	0	0	0	0	0	0	0	0	790	261
0	0	0	0	0	0	0	0	0	0	0	0	0	354
0	0	0	0	0	0	0	0	0	0	0	0	0	447
0	0	0	0	0	0	0	0	0	0	0	0	0	540
0	0	0	0	0	0	0	0	0	0	0	0	0	540 +
6871	**8696**	**6078**	**7470**	**5250**	**5961**	**6812**	**8576**	**7789**	**5351**	**6291**	**5058**	**7858**	**Total Runoff**

Annual Runoff/Year in Cubic Meters

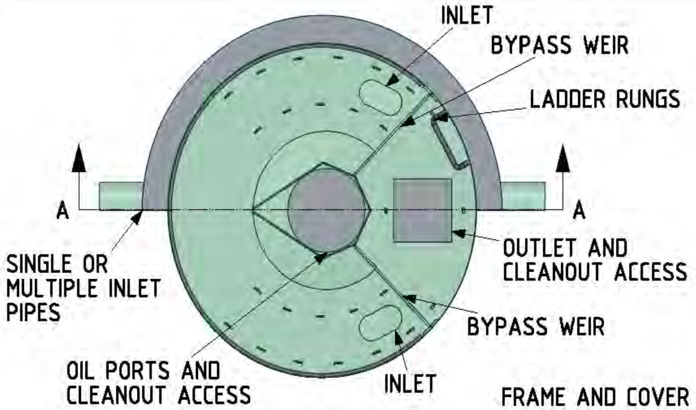
1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
100	110	120	70	102	91	95	83	101	118	117	71
302	416	169	220	287	280	215	276	228	243	294	285
291	394	351	388	264	234	204	222	203	233	532	154
402	481	259	134	203	233	230	155	264	398	469	243
190	643	135	183	260	355	180	147	175	300	528	195
344	668	252	180	174	420	141	257	279	264	374	341
239	95	201	281	189	540	236	298	71	287	378	96
295	266	237	188	188	189	106	162	220	189	299	80
183	91	92	180	184	92	248	211	95	121	214	92
133	237	206	202	202	413	176	239	103	238	206	137
184	152	490	114	76	231	303	452	37	151	300	113
365	163	205	123	81	331	203	248	82	368	201	82
133	45	180	135	270	44	90	358	136	226	226	135
196	0	194	98	196	147	195	146	194	50	144	94
155	0	156	260	0	105	105	212	156	105	159	53
533	305	410	124	227	235	296	417	709	418	237	64
680	457	196	280	211	206	71	210	269	348	71	0
1684	827	746	385	424	495	393	989	494	806	651	84
583	500	91	198	187	281	97	492	419	585	1195	0
242	0	579	111	112	351	113	217	696	241	366	0
131	0	139	275	0	0	129	134	275	410	129	0
314	1178	291	153	153	312	0	0	320	159	435	154
862	0	0	0	337	342	171	864	169	509	0	0
575	192	191	0	0	387	372	585	187	769	0	184
199	0	209	211	0	409	613	0	212	198	0	614
473	0	217	0	0	242	714	1622	0	0	236	242
0	0	0	251	0	0	0	0	0	0	0	0
260	0	0	269	0	0	0	0	0	0	0	0
613	598	830	0	666	277	373	586	1566	838	697	531
0	0	0	652	0	0	0	1389	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	1776	0	0
0	0	0	0	0	0	0	0	0	0	0	0
10660	**7818**	**7146**	**5666**	**4992**	**7243**	**6068**	**10971**	**7662**	**10349**	**8458**	**4046**

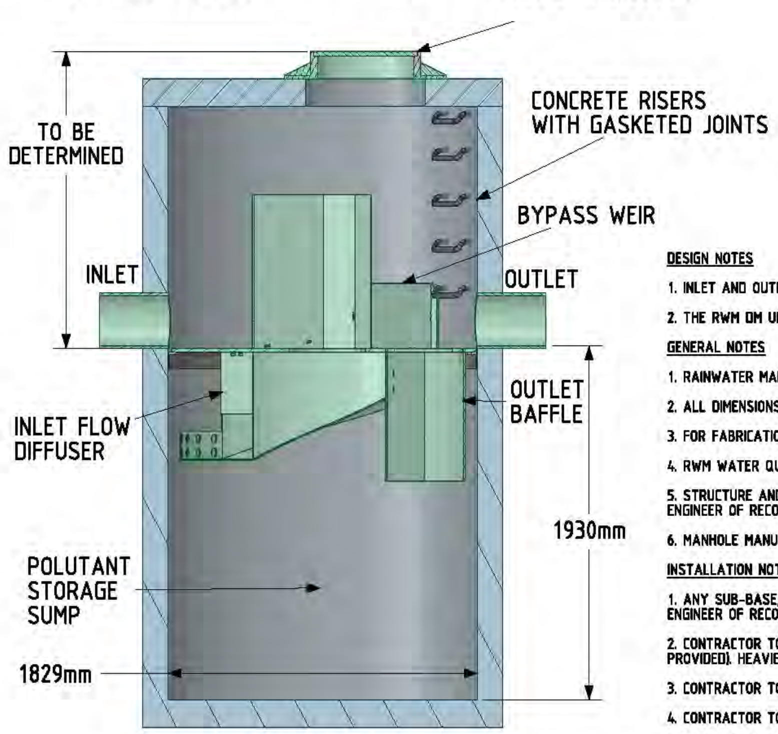
TSS Removal

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

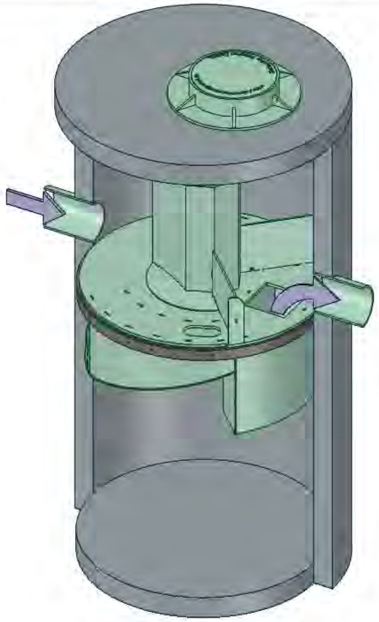
Runoff Treated

Year	Treated
1960	100%
1961	80%
1962	88%
1963	86%
1964	88%
1965	85%
1966	100%
1967	92%
1968	93%
1969	96%
1970	63%
1971	95%
1972	82%
1973	100%
1974	84%
1975	88%
1976	100%
1977	96%
1978	97%
1979	100%
1980	100%
1981	96%
1982	86%
1983	100%
1984	100%
1985	84%
1986	97%
1987	88%
1988	100%
1989	95%
1990	96%
1991	90%
1992	90%
1993	92%
1994	89%
1995	81%
1996	100%
1997	83%
1998	92%
1999	92%
2000	88%
2001	84%
2002	87%
2003	96%
2004	94%
2005	82%
2006	80%
2007	75%
2008	92%
2009	87%
Average	**91%**





SECTION A-A



SCALE 1:46

DESIGN NOTES

1. INLET AND OUTLET PIPE CAN BE UP TO 90 DEGREES APART DEPENDING ON PIPE AND MANHOLE SIZE. IF IN DOUBT, PLEASE CONTACT RAINWATER MANAGEMENT
2. THE RWM DM UNIT CAN HANDLE MULTIPLE INLET PIPES AS WELL AS A TOP INLET.

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, CONTACT RAINWATER MANAGEMENT. www.rainwatermanagement.ca
4. RWM WATER QUALITY STRUCTURE SHALL BE IN ACCORDANCE WITH ALL DESIGN DATA AND INFORMATION CONTAINED IN THIS DRAWING.
5. STRUCTURE AND CASTINGS SHALL MEET REQUIRED 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 LOCAL SPECIFICATIONS.

INSTALLATION NOTES

1. ANY SUB-BASE, BACKFILL DEPTH, AND/OR ANTI-FLOTATION PROVISIONS ARE SITE-SPECIFIC DESIGN CONSIDERATIONS AND SHALL BE SPECIFIED BY THE ENGINEER OF RECORD.
2. CONTRACTOR TO PROVIDE EQUIPMENT WITH SUFFICIENT LIFTING AND REACH CAPACITY TO LIFT AND SET THE MANHOLE STRUCTURE (LIFTING DEVICES NOT PROVIDED). HEAVIEST LIFT DEPENDS ON RISER HEIGHTS.
3. CONTRACTOR TO ADD GASKETS OR JOINT SEALANT BETWEEN ALL STRUCTURE SECTIONS, AND ASSEMBLE STRUCTURE AS REQUIRED.
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. IT IS SUGGESTED THAT ALL JOINTS BELOW PIPE INVERTS ARE GROUTED.

rainwater
MANAGEMENT
www.rainwatermanagment.ca
604-944-9265

FILE RWM-DM-1800 TYPDRW		MODEL RWM-DM-1800		
JOB / IDENTIFIER DM	REV	CREATOR AG	APPROVED	SHEET 1 of 1
MATERIAL --	THICKNESS	SCALE 1:38	CREATED 8/10/2022	LAST SAVED 8/10/2022 11:13:18 AM

rainwater
MANAGEMENT

To: LGN Consulting Engineers
From: Rainwater Management
Date: 5-Oct-22

City: Calgary

Project City: Calgary
Designation: West Inlet
Revision: **0**

Re: Ascension Lands

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
45.17	35%	329-5m Ultra	94%	92%

3) EPA SWWM Design Criteria:

Flow (l/s)	Slope	Imperv/Perv Depression Storage	Imperv/Perv Manning's n	Min/Max Infiltration Rate (mm/hr)	Decay Rate	Daily Evaporation Rate
3162	2%	1.6/3.2 mm	0.015/0.25	75/7.5	0.00115	2.54 mm

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.

* 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 CF x Avg Annual Precipitation x Total Impreviousness x Avg. Vol. Treated from Page 8.

Drainage Area (ha)	Conv Factor	Agv. Annual Percip (mm)	Total Imperviou-sness %	Avg. Vol Treated as per p.8	Avg. Vol Treated (m3)
45.17	10	400	35%	92%	57,931

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

Avg. Vol Treated (m3)	Avg. Removal Efficiency as per p.8	Sediment Concentration (kg/m3)	Avg. Annual Sediment Removed (kg)	Bottom Box Length (m)	RWM Models Sump Capacity (kg)	Sump Capacity Condition
57,931	94%	0.444	24,274	5	32,330	Contition Met

11) The allowable treatment flow:

RWM Ultra Model	Box Unit Width (mm)	Max Hyd. Laoding Rate (l/s/m2)	Alowable Treatable Flow (l/s)	Allowable Treatment Flow Condition
329-5m	2440	27	329.4	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.

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.

PROFESSIONAL ENGINEER ALBERTA
PETER LAW

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
10	2645	1634	1383	1954	2354	3434	1948	1575	1972	2504	2038	2778	10
15	1636	1221	1122	1258	2132	3763	1703	837	1639	2216	1633	1431	15
20	1534	795	727	1315	2444	3185	1548	1053	1139	2437	1671	2056	20
25	1141	872	799	1894	2219	3090	2322	430	1373	2838	1421	1116	25
30	1170	1496	1104	1572	1667	2280	1887	679	1003	2404	1279	1479	30
35	1146	1148	712	1049	344	2166	929	936	1053	1178	1638	1678	35
40	1717	418	393	2005	815	1740	2299	531	1317	1103	516	2559	40
45	1323	1062	464	1371	1518	1517	1228	904	298	1675	1235	1218	45
50	687	506	875	1354	1346	1017	858	704	692	1021	846	694	50
55	556	563	753	1139	185	1333	2463	569	740	2441	751	565	55
60	626	1029	1242	1030	1254	1238	1845	410	1443	2442	412	613	60
65	669	457	217	1108	669	1337	1108	1340	681	895	897	686	65
70	1455	991	727	502	0	240	957	0	717	235	244	236	70
75	1046	1044	529	526	528	1314	526	0	1590	1553	0	780	75
80	845	566	550	287	1385	1697	554	0	2213	1949	281	559	80
85	1479	1474	592	902	878	1768	290	594	296	0	304	0	85
90	631	635	632	318	312	316	0	1247	625	933	633	632	90
95	0	0	0	333	336	1011	0	342	670	0	0	990	95
100	1394	346	0	1427	349	1063	1057	710	708	0	356	1402	100
125	6014	2865	838	4080	2441	4177	2670	872	1575	3648	785	3529	125
150	917	3051	1523	2919	2014	3324	496	1445	472	1455	1901	1908	150
200	1174	4328	2514	5218	4305	4778	10636	612	4492	4615	1774	1262	200
250	876	2299	885	3091	1677	1546	1515	781	2400	2462	866	1741	250
300	0	4008	1006	2053	2062	922	948	0	0	0	912	1028	300
330	0	0	2234	0	0	2237	0	0	0	0	1127	1141	330
400	1353	2426	0	0	0	3671	0	1376	0	1318	4008	1318	400
420	0	1492	0	0	0	0	0	0	0	0	0	0	420
440	0	0	0	0	0	0	0	0	0	0	0	0	440
985	0	2079	0	5809	0	2112	0	0	1838	0	3446	0	985
1530	0	3924	0	0	3902	4873	0	0	0	0	8457	0	1530
2075	0	0	0	0	0	0	0	0	0	0	0	0	2075
2620	0	0	0	0	0	0	0	0	0	0	0	0	2620
3165	0	0	0	0	0	0	0	0	0	0	0	0	3165
3165 +	0	0	0	0	0	0	0	0	0	0	0	0	3165 +
Total Runoff	**32034**	**42731**	**21821**	**44513**	**37137**	**61148**	**39789**	**17947**	**30947**	**41324**	**39431**	**33400**	**Total Runoff**

Annual Runoff/Year in Cubic Meters

1972	**1973**	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**	**Flow l/s**
2812	2611	1875	2568	2619	2359	3128	1569	2245	2983	2731	1377	1835	10
1725	1991	1097	1944	1944	2060	2619	1031	2053	1763	1902	1152	1507	15
2006	1286	1679	1915	2017	1980	1988	1013	1233	2411	1279	861	2090	20
1421	1398	1308	1716	2291	1565	2300	788	1467	1889	1676	906	1968	25
1325	1365	1186	2157	1490	2072	2154	790	1569	2314	1197	776	1385	30
1883	1382	1187	1280	1038	1028	2700	465	1648	1066	1513	579	1532	35
1903	933	1467	939	1636	1492	949	662	1487	2838	1490	1078	839	40
1100	909	1348	1390	1981	1821	2624	621	1677	2022	1686	782	1051	45
1021	1733	532	679	676	676	2200	846	343	1028	1011	854	1200	50
752	1152	565	941	1140	0	1682	372	1131	1489	759	561	1326	55
1216	1233	1033	1241	1247	1040	1457	212	1844	1437	422	1044	1648	60
675	1142	0	669	1126	2251	2449	0	926	879	221	668	1108	65
2897	1192	236	488	735	952	1960	479	984	736	1227	976	0	70
527	1041	268	260	0	1320	2104	528	511	521	1277	529	260	75
549	0	287	280	563	834	1677	287	841	1118	565	0	1109	80
880	882	298	1175	886	1493	885	0	882	892	602	0	589	85
961	1255	632	637	627	0	1253	1234	1238	1565	1571	620	940	90
664	989	0	0	336	675	329	0	0	654	1000	339	662	95
1418	695	352	0	0	359	1040	1049	705	0	1059	350	1057	100
4797	2863	4067	1651	1950	3307	4035	1158	3148	4347	2781	844	3295	125
1503	1476	945	1432	3010	1493	3009	1946	2953	1964	3481	2008	2884	150
1310	2071	2463	0	5835	1865	2573	1197	5742	5732	1288	2517	2614	200
1486	832	1621	1590	2236	1619	0	2357	4156	6445	0	756	749	250
0	0	1961	0	0	1949	0	981	2952	3908	1010	1069	0	300
1120	0	0	0	0	1105	0	1140	0	0	0	0	0	330
5142	0	0	1194	0	0	1330	0	0	0	4031	0	0	400
0	0	0	1474	0	0	0	0	0	0	0	0	0	420
3083	0	0	0	0	1548	0	0	0	0	0	0	0	440
0	0	4451	0	0	0	0	0	0	1690	0	0	0	985
0	0	0	0	0	0	0	0	0	0	0	0	0	1530
0	0	0	0	0	0	0	0	0	0	0	0	0	2075
0	0	0	0	0	0	0	0	0	0	0	0	0	2620
0	0	0	0	0	0	0	0	0	0	0	0	0	3165
0	0	0	0	0	0	0	0	0	0	0	0	0	3165 +
44179	**30430**	**30858**	**27622**	**35384**	**36861**	**46447**	**20722**	**41733**	**51691**	**35780**	**20648**	**31647**	**Total Runoff**

Annual Runoff/Year in Cubic Meters

1985	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**Flow l/s**
2529	1785	1790	2691	2693	2565	2299	3212	2600	2440	2352	3237	1993	10
1626	1879	1372	1273	2465	1511	1279	1650	2076	1945	2200	3070	1455	15
1413	1638	885	1379	1473	1453	1338	3239	1714	1789	2733	2241	1975	20
1341	1332	1127	1129	1707	1356	971	1372	1764	2121	1932	1613	1292	25
1491	2423	892	986	1502	890	955	1722	3860	1804	1796	2530	1192	30
937	3149	1361	1614	1176	1124	465	1053	2728	2844	1047	1315	1411	35
667	1606	1356	527	1218	1203	1498	947	923	919	1346	824	4047	40
1055	1061	1068	1231	452	921	1384	1524	619	1074	2941	455	2000	45
534	1347	860	691	676	1369	1012	1705	688	668	516	1367	846	50
369	385	1517	933	956	1106	1322	1346	1301	751	1907	1673	934	55
627	830	1678	635	1041	401	824	824	633	202	820	0	428	60
448	684	1145	889	666	678	1133	1130	663	677	1117	228	677	65
716	967	470	1680	484	727	236	1235	0	493	1222	245	1702	70
515	520	254	532	776	775	521	2069	517	528	1300	538	1562	75
283	1119	1128	1672	280	838	834	2219	1106	0	555	279	1400	80
602	1196	1179	895	0	898	892	882	906	0	0	297	1482	85
926	936	320	1245	620	1258	318	1581	629	629	314	323	641	90
672	1004	0	1341	989	0	328	0	325	2006	0	0	665	95
345	1054	708	697	0	1754	0	349	1036	705	695	0	0	100
1202	2544	3618	2454	742	2966	3284	2839	5868	1558	751	2904	4020	125
4445	4872	1458	2567	990	491	3933	3964	1495	537	495	1460	2992	150
1925	3806	2946	7972	3177	3258	4540	3007	1965	592	1401	1241	1843	200
3330	9033	1492	4168	1599	0	2426	772	2485	734	825	1500	0	250
2872	1022	921	1855	0	3070	936	2976	3852	959	0	0	0	300
1094	0	0	0	0	1170	1097	1155	0	0	0	0	2217	330
0	1367	0	0	1202	0	1435	0	0	1347	0	0	0	400
1458	0	0	0	0	0	0	0	0	0	0	0	0	420
0	0	0	0	0	0	0	0	0	0	0	0	0	440
4012	0	3430	0	0	0	1632	4143	2972	1590	5523	0	1587	985
0	0	0	0	0	0	0	0	0	0	0	0	4109	1530
0	0	0	0	0	0	0	0	0	0	0	0	0	2075
0	0	0	0	0	0	0	0	0	0	0	0	0	2620
0	0	0	0	0	0	0	0	0	0	0	0	0	3165
0	0	0	0	0	0	0	0	0	0	0	0	0	3165 +
37433	**47556**	**32978**	**41057**	**26883**	**31782**	**36891**	**46915**	**42726**	**28911**	**33788**	**27340**	**42470**	**Total Runoff**

Annual Runoff/Year in Cubic Meters

1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
2782	3471	2087	1952	2600	2381	2195	2190	2375	2802	2931	2253
2581	2221	1919	1516	1992	2128	1525	1683	1486	1736	2424	1254
1889	2529	1593	1840	1248	2267	1540	1219	1602	2075	3522	1212
2461	2735	1415	1253	1040	2113	1199	1799	1364	1576	2581	1272
1477	3160	997	1177	1291	2249	1581	1197	963	1611	2119	785
1535	2787	1416	939	1071	1892	1172	684	1161	1417	2537	1454
668	1368	675	1481	946	2582	542	1088	1226	2578	1472	136
1194	905	1391	458	1072	1368	1368	1653	302	1194	1959	1058
1710	858	845	1547	1033	1353	853	850	514	854	1378	687
1889	758	1699	375	367	740	1511	933	764	1133	1489	382
1877	423	2500	1237	1031	213	821	2284	833	422	828	209
873	690	1781	679	456	1111	1128	1111	1118	1320	2015	221
1464	251	1685	240	726	978	1476	1461	1210	724	245	246
1305	269	792	1550	259	520	780	2086	1046	1319	771	270
0	839	569	0	553	1949	548	1661	0	553	277	287
592	0	897	0	600	0	292	900	595	868	1187	0
944	0	320	0	933	0	637	1564	944	308	1570	0
1331	992	667	330	1338	332	341	675	1690	1334	669	660
691	697	0	703	345	355	0	346	1749	1046	706	0
5590	4355	2802	4053	1244	3131	446	3298	2409	2389	2085	389
8440	2460	3527	978	469	939	0	2904	1959	2875	944	0
5656	1136	1237	1247	1832	1847	1813	4954	4170	3686	5233	1825
3081	7537	2538	1735	720	4173	1584	2494	1670	2524	2384	2431
4019	0	1071	1026	0	1921	2937	6945	2955	2882	951	981
1080	0	0	1117	0	2251	3425	3411	0	2252	0	1106
1336	1246	0	0	0	0	0	1389	0	0	0	0
1474	0	0	0	1442	0	0	0	0	0	1474	0
0	1569	0	0	1573	0	0	0	0	0	0	0
0	0	4111	3259	0	0	1679	6046	7588	4221	1616	2714
0	0	0	0	0	0	0	3832	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	8818	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
57941	**43253**	**38533**	**30694**	**26178**	**38793**	**31391**	**60658**	**41692**	**54516**	**45367**	**21829**

TSS Removal

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

Runoff Treated

Year	Treated
1960	96%
1961	77%
1962	100%
1963	87%
1964	89%
1965	83%
1966	100%
1967	92%
1968	94%
1969	97%
1970	60%
1971	96%
1972	81%
1973	100%
1974	86%
1975	90%
1976	100%
1977	96%
1978	97%
1979	100%
1980	100%
1981	97%
1982	89%
1983	100%
1984	100%
1985	85%
1986	97%
1987	90%
1988	100%
1989	96%
1990	100%
1991	92%
1992	91%
1993	93%
1994	90%
1995	84%
1996	100%
1997	87%
1998	95%
1999	93%
2000	89%
2001	89%
2002	88%
2003	100%
2004	95%
2005	81%
2006	82%
2007	76%
2008	93%
2009	88%
Average	**92%**

ETV Particle Size Distribution:

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

rainwater MANAGEMENT

To: LGN Consulting Engineers
From: Rainwater Management
Date: 5-Oct-22

City: Calgary

Project City: Calgary
Designation: East Inlet
Revision: **0**

Re: Ascension Lands

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
45.52	35%	329-5m Ultra	94%	92%

3) EPA SWWM Design Criteria:

Flow (l/s)	Slope	Imperv/Perv Depression Storage	Imperv/Perv Manning's n	Min/Max Infiltration Rate (mm/hr)	Decay Rate	Daily Evaporation Rate
4335	2%	1.6/3.2 mm	0.015/0.25	75/7.5	0.00115	2.54 mm

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.

* 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 CF x Avg Annual Precipitation x Total Impreviousness x Avg. Vol. Treated from Page 8.

Drainage Area (ha)	Conv Factor	Agv. Annual Percip (mm)	Total Imperviou-sness %	Avg. Vol Treated as per p.8	Avg. Vol Treated (m3)
45.52	10	400	35%	92%	58,363

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

Avg. Vol Treated (m3)	Avg. Removal Efficiency as per p.8	Sediment Concentration (kg/m3)	Avg. Annual Sediment Removed (kg)	Bottom Box Length (m)	RWM Models Sump Capacity (kg)	Sump Capacity Condition
58,363	94%	0.444	24,446	5	32,330	Contition Met

11) The allowable treatment flow:

RWM Ultra Model	Box Unit Width (mm)	Max Hyd. Laoding Rate (l/s/m2)	Alowable Treatable Flow (l/s)	Allowable Treatment Flow Condition
329-5m	2440	27	329.4	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.

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.

PROFESSIONAL ENGINEER ALBERTA
PETER LAW

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
10	2674	1618	1373	1940	2342	3409	1979	1591	1992	2532	2037	2808	10
15	1597	1163	1116	1253	2131	3760	1719	736	1600	2235	1628	1443	15
20	1602	912	787	1382	2371	3245	1343	1169	1129	2311	1739	2074	20
25	968	882	806	1640	2288	3095	2377	433	1366	2825	1343	1124	25
30	1360	1400	1114	1853	1770	2278	2081	577	993	2385	1269	1490	30
35	1030	1140	590	1056	346	2291	810	1053	1168	1149	1758	1561	35
40	1857	404	522	1876	822	1754	2443	536	1330	1220	520	2706	40
45	1332	1214	305	1365	1529	1531	1235	910	300	1669	1082	1228	45
50	691	512	1044	1525	1357	1023	863	707	695	1188	1014	697	50
55	561	568	756	1147	186	1145	2282	571	748	2456	756	568	55
60	411	1038	1248	1039	1044	1228	1842	412	1237	2460	414	616	60
65	889	460	218	1117	654	1326	1332	1348	668	901	901	690	65
70	1208	997	729	0	236	478	963	0	957	236	246	236	70
75	1301	1051	535	1035	262	1325	528	0	1330	1560	0	785	75
80	561	573	555	0	1664	1420	557	0	2501	1673	285	563	80
85	1777	1481	595	1197	883	2070	293	597	297	290	0	0	85
90	308	639	636	320	315	318	0	1257	627	938	622	635	90
95	326	0	0	334	339	674	0	0	675	0	324	996	95
100	1400	348	0	1072	351	1412	1061	1060	353	0	359	1408	100
125	6049	2879	843	4013	2459	3753	2687	877	1945	3671	788	3553	125
150	921	3073	1534	3392	2028	3797	498	1452	475	1464	1913	1922	150
200	1180	4355	2526	4529	4337	4811	10710	616	4522	4643	1783	1269	200
250	879	2311	890	3836	1686	1558	1524	785	2415	2481	870	1748	250
300	0	4033	1013	2063	2076	926	954	0	0	0	920	1034	300
330	0	0	2243	0	0	2250	0	0	0	0	1133	1147	330
400	1362	2441	0	0	0	3692	0	1384	0	1323	4033	1323	400
420	0	1499	0	0	0	0	0	0	0	0	0	0	420
440	0	0	0	0	0	0	0	0	0	0	0	0	440
1219	0	6036	0	5842	3925	2123	0	0	1847	0	7201	0	1219
1998	0	0	0	0	0	4905	0	0	0	0	4774	0	1998
2777	0	0	0	0	0	0	0	0	0	0	0	0	2777
3556	0	0	0	0	0	0	0	0	0	0	0	0	3556
4335	0	0	0	0	0	0	0	0	0	0	0	0	4335
4335 +	0	0	0	0	0	0	0	0	0	0	0	0	4335 +
Total Runoff	**32244**	**43030**	**21977**	**44826**	**37403**	**61597**	**40083**	**18071**	**31167**	**41612**	**39710**	**33624**	**Total Runoff**

Annual Runoff/Year in Cubic Meters

1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	Flow l/s
2820	2638	1896	2618	2658	2362	3160	1550	2274	2981	2688	1318	1853	10
1777	2006	1106	1908	1854	2115	2642	1022	1964	1815	1882	1180	1521	15
2026	1296	1694	1983	1996	1996	1931	1005	1281	2432	1327	922	2036	20
1430	1229	1228	1638	2270	1486	2209	867	1553	1812	1580	912	1965	25
1335	1556	1286	2153	1683	2177	2132	795	1473	2312	1385	783	1377	30
1519	1393	1195	1399	1048	1035	2935	468	1642	930	1527	583	1400	35
2299	939	1333	944	1358	1216	954	667	1622	2966	1499	939	955	40
1109	917	1345	1236	2120	2124	2475	625	1525	1694	1537	768	1041	45
848	1562	516	846	661	681	2377	852	507	1519	1002	1022	1370	50
738	943	749	948	1329	0	1693	375	941	1498	943	566	1333	55
1422	1637	1040	1249	1040	1046	1251	214	1840	1447	208	1052	1658	60
679	679	0	673	1350	2265	2681	0	682	883	440	673	1116	65
2916	1667	236	491	486	960	1975	482	1462	487	1236	984	0	70
529	1048	269	262	254	787	2119	260	515	779	1286	261	261	75
552	0	0	283	565	1383	1399	559	845	836	568	272	1116	80
888	887	589	1181	893	1196	1182	0	886	1188	300	0	593	85
641	1263	634	642	631	307	1263	1239	1243	1251	1888	623	622	90
996	995	0	0	338	334	330	0	0	986	1007	341	990	95
704	700	355	0	0	344	1048	694	709	0	1064	353	1065	100
5093	2880	4096	1659	1963	3690	4059	1527	3163	4372	2797	848	3316	125
1965	1486	950	1439	2486	1501	2487	1957	2973	1978	2961	1478	2903	150
1317	2082	2476	0	6408	1875	2413	1201	5774	5041	1836	3075	2628	200
1494	836	1628	1596	2250	1624	720	2371	4181	7214	0	762	754	250
0	0	1975	0	0	1958	0	984	2965	3933	1014	1074	0	300
1126	0	0	0	0	1111	0	1145	0	0	0	0	0	330
5167	0	0	1199	0	0	1337	0	0	0	4049	0	0	400
0	0	0	1480	0	0	0	0	0	0	0	0	0	420
3102	0	0	0	0	1559	0	0	0	0	0	0	0	440
0	0	4473	0	0	0	0	0	0	1699	0	0	0	1219
0	0	0	0	0	0	0	0	0	0	0	0	0	1998
0	0	0	0	0	0	0	0	0	0	0	0	0	2777
0	0	0	0	0	0	0	0	0	0	0	0	0	3556
0	0	0	0	0	0	0	0	0	0	0	0	0	4335
0	0	0	0	0	0	0	0	0	0	0	0	0	4335 +
44493	**30638**	**31071**	**27826**	**35639**	**37129**	**46771**	**20859**	**42020**	**52055**	**36024**	**20790**	**31873**	**Total Runoff**

Annual Runoff/Year in Cubic Meters

1985	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**Flow l/s**
2551	1807	1810	2728	2633	2592	2288	3208	2640	2393	2314	3193	2002	10
1638	1843	1277	1232	2593	1525	1217	1648	2093	1978	2181	3111	1504	15
1423	1561	1001	1444	1485	1394	1388	3174	1727	1857	2789	2240	1920	20
1171	1487	1139	1137	1629	1438	961	1528	1686	2137	1928	1697	1372	25
1682	2009	899	991	1494	897	1053	1737	3978	1707	1899	2223	1094	30
692	2975	1371	1502	1292	1005	470	1061	2369	2849	1055	1649	1404	35
923	2251	1365	512	1225	1195	1364	954	1309	1052	1355	829	4060	40
1063	1068	1076	1382	456	1073	1540	1533	461	1081	2961	296	1995	45
177	1357	865	517	679	1199	1020	1716	854	672	340	1361	1016	50
734	387	1528	1120	763	1292	1132	956	1311	756	2100	1863	940	55
631	835	1259	640	1246	402	1028	1227	422	202	827	0	430	60
450	691	1354	894	671	449	671	1136	884	682	889	230	680	65
720	975	707	1695	487	965	708	483	0	495	1213	246	1715	70
518	524	256	535	779	780	525	2572	520	261	1562	0	1574	75
285	838	557	1686	281	844	840	2221	1113	270	558	823	1410	80
298	878	1766	901	0	903	592	1175	607	0	0	299	1493	85
1240	1556	320	1254	624	941	627	1590	942	632	315	0	645	90
679	1010	0	1349	995	325	329	0	327	1335	0	325	666	95
348	1058	351	702	0	1766	0	351	1041	1397	701	0	0	100
1210	2106	4005	2469	745	2083	3308	2860	5909	1565	760	2469	4045	125
3930	5352	1467	2042	995	1395	3956	3986	1505	540	499	1922	3011	150
2480	3828	2965	7848	3195	3277	4565	3029	1980	596	1406	1250	1853	200
3357	9094	1502	4916	1607	0	1536	778	2501	740	830	1508	0	250
2889	1028	925	1868	0	3083	1842	2999	3876	966	0	0	0	300
1102	0	0	0	0	1175	1105	1161	0	0	0	0	2233	330
0	1376	0	0	1207	0	0	0	0	1353	0	0	0	400
1465	0	0	0	0	0	1442	0	0	0	0	0	0	420
0	0	0	0	0	0	0	0	0	0	0	0	0	440
4040	0	3446	0	0	0	1639	4163	2989	1599	5550	0	5732	1219
0	0	0	0	0	0	0	0	0	0	0	0	0	1998
0	0	0	0	0	0	0	0	0	0	0	0	0	2777
0	0	0	0	0	0	0	0	0	0	0	0	0	3556
0	0	0	0	0	0	0	0	0	0	0	0	0	4335
0	0	0	0	0	0	0	0	0	0	0	0	0	4335 +
37698	**47895**	**33211**	**41362**	**27081**	**31999**	**37148**	**47248**	**43041**	**29113**	**34033**	**27532**	**42792**	**Total Runoff**

Annual Runoff/Year in Cubic Meters

1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
2717	3467	2133	1900	2564	2398	2230	2155	2388	2797	2889	2237
2607	2219	1880	1547	1971	2146	1540	1717	1536	1786	2407	1299
1940	2458	1590	1837	1367	2143	1550	1286	1616	2092	3656	1149
2376	2449	1407	1244	1047	2181	1208	1813	1284	1318	2332	1353
1672	3634	985	1168	1193	2357	1487	1209	1062	1894	2405	682
1292	2806	1536	928	1063	1902	1289	691	1045	1427	2557	1448
925	1233	682	1618	930	2600	544	951	1218	2450	1481	264
1203	894	1240	462	1224	1216	1213	1811	450	1346	1973	1064
1545	1029	1015	1378	1041	1524	1020	855	518	860	1388	691
1886	762	1707	558	369	744	1522	940	568	942	1502	385
1653	209	1866	1247	1036	213	609	2084	1039	621	833	211
1313	678	2446	686	460	1121	1350	1336	1126	1328	2027	222
1223	235	1697	243	731	732	1485	1219	1218	729	247	248
1571	522	795	1561	261	773	784	1813	781	1325	775	0
0	554	570	0	556	1963	555	1928	271	559	278	272
596	291	598	0	603	0	293	890	291	876	1194	290
950	0	628	0	940	0	316	1560	931	309	1582	0
1341	999	671	332	1348	336	324	659	998	1343	671	666
696	700	0	708	347	358	342	691	2792	692	710	0
5625	3933	2820	4080	1250	3149	447	3322	1971	2765	1643	393
8500	2927	3544	986	472	946	0	2926	1878	2893	1402	0
5687	1144	1247	1254	1840	1857	1824	4989	4739	3703	5269	1839
3094	7591	2550	1745	723	4193	1591	2507	1683	2542	2401	2441
4036	0	1079	1030	0	1931	2948	6985	2974	2900	954	984
1088	0	0	1121	0	2263	3449	2237	0	2269	0	1113
1343	1251	0	0	0	0	0	2595	0	0	0	0
1480	0	0	0	1449	0	0	0	0	0	1480	0
0	1578	0	0	1581	0	0	0	0	0	0	0
0	0	4134	3278	0	0	1687	9939	7629	4251	1623	2730
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	8874	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
58358	**43565**	**38822**	**30907**	**26364**	**39046**	**31608**	**61109**	**42007**	**54891**	**45679**	**21980**

TSS Removal

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

Runoff Treated

Year	Treated
1960	96%
1961	77%
1962	100%
1963	87%
1964	90%
1965	83%
1966	100%
1967	92%
1968	94%
1969	97%
1970	60%
1971	96%
1972	81%
1973	100%
1974	86%
1975	90%
1976	100%
1977	96%
1978	97%
1979	100%
1980	100%
1981	97%
1982	89%
1983	100%
1984	100%
1985	85%
1986	97%
1987	90%
1988	100%
1989	96%
1990	100%
1991	92%
1992	91%
1993	93%
1994	90%
1995	84%
1996	100%
1997	87%
1998	95%
1999	94%
2000	89%
2001	89%
2002	89%
2003	100%
2004	95%
2005	79%
2006	82%
2007	76%
2008	93%
2009	88%
Average	**92%**

ETV Particle Size Distribution:

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

LGN Consulting Engineering Ltd.
stormwater and water resources management

P6400

July 19, 2023

Rocky View County
Capital and Engineering Services
262075 Rocky View Point
Rocky View County, AB   T4A 0X2

Attention: **Mr. Milan Patel, P.Eng.**
Municipal Engineer

Re: Ascension - Stormwater

LGN Consulting Engineering Ltd. (LGN) was requested, to analyse the existing Tuscany Storm Trunk from Pond 34WPA to the Bow River outfall B115A, under the following conditions:

1. Existing conditions, flows from Tuscany and Haskayne.
2. Existing conditions plus flows from the Watermark ponds and Ascension.
3. Existing conditions plus Ascension flows only.

The flows from the different contributing subcatchments are:

Table 1 – Land Use Characteristics

Subcatchment	Flow (m^3/s)
Tuscany	5.57
Haskayne	0.75
Watermark	0.564
Ascension	0.094

The first analysis was provided by the City of Calgary and was used as the base for the other two analysis. Profiles showing the High Water Level in the storm trunk are attached.

Conclusion

- The existing Tuscany Storm Trunk can accommodate the flows from Ascension only, without surcharging.

Should you require additional information or clarification to the above information, please do not hesitate to contact me.

Yours sincerely,

LGN Consulting Engineering Ltd.

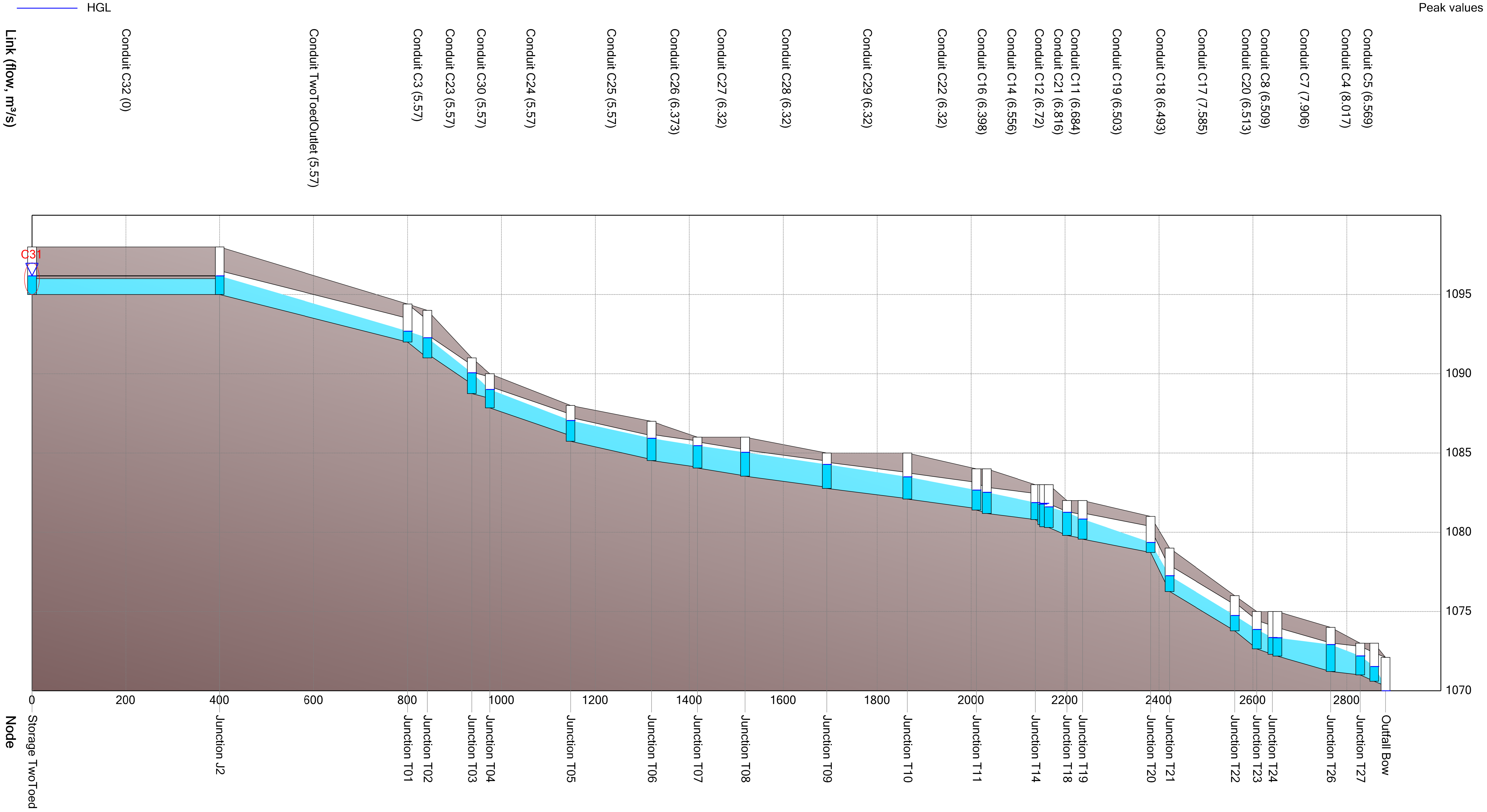
Luis G. Narvaez, B.Sc., P.Eng.
Senior Stormwater Engineer

PROFESSIONAL ENGINEER ALBERTA
LUIS G. NARVAEZ
July 19, 2023
ID #55244

APPENDIX A

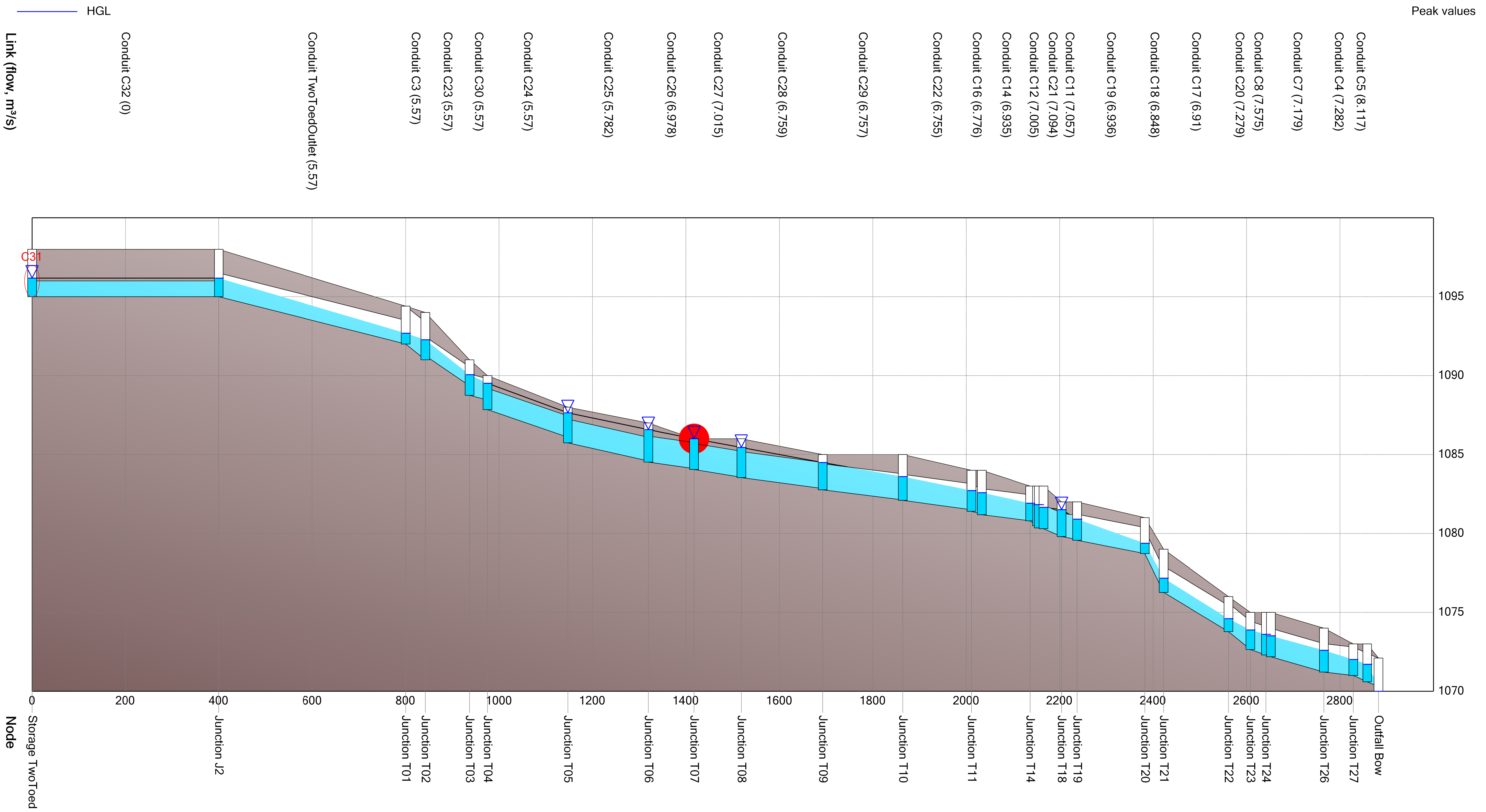
HGL Profile from Pond 34WPA to Bow River Outfall B115A

5.57 cms from Tuscany & 0.75 cms from Haskayne



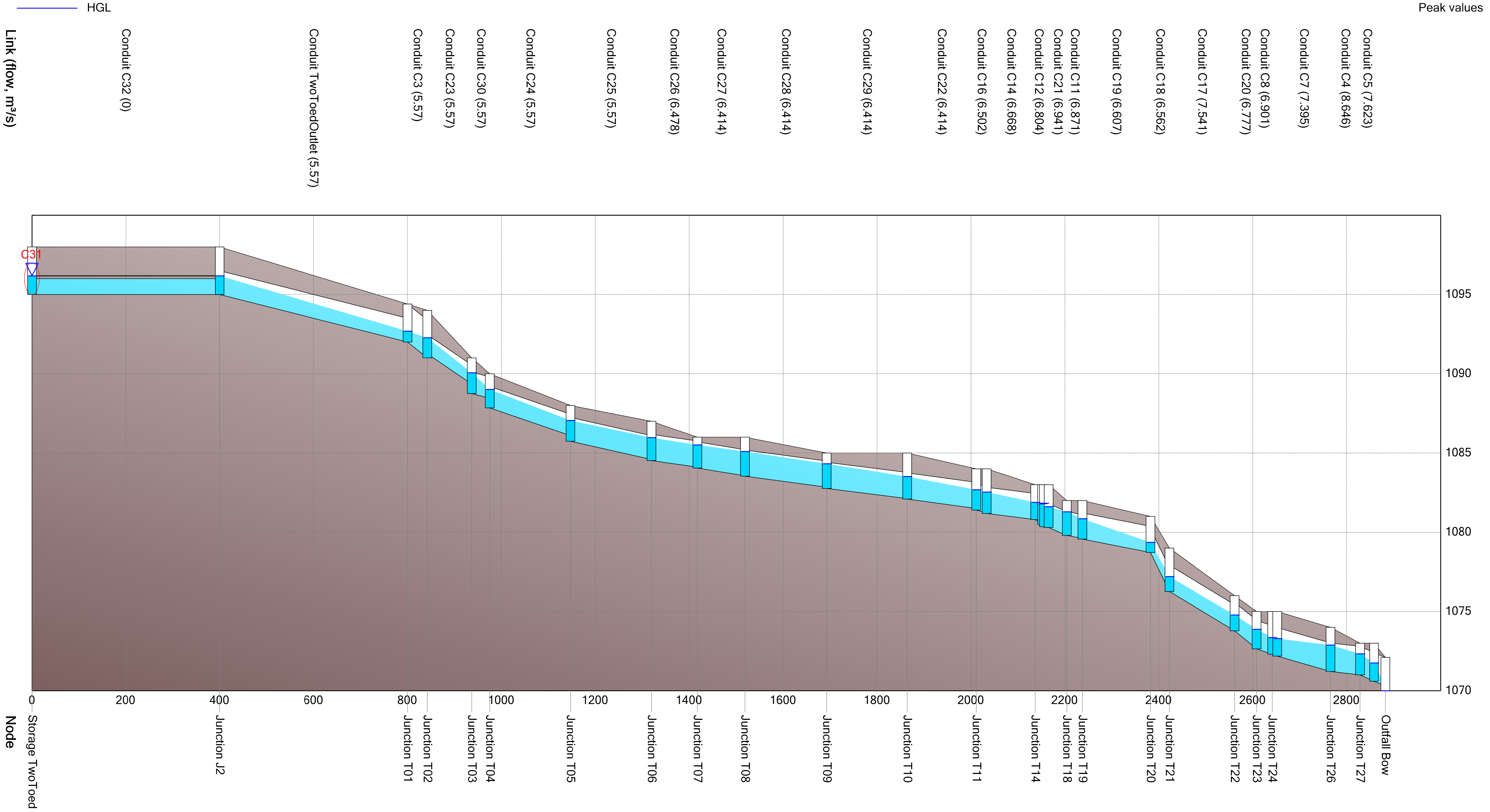
HGL Profile from Pond 34WPA to Bow River Outfall B115A

5.57 cms from Tuscany + 0.75 cms from Haskayne + 0.658 cms from Watermark & Ascension



HGL Profile from Pond 34WPA to Bow River Outfall B115A

5.57 cms from Tuscany + 0.75 cms from Haskayne + 0.094 cms from Ascension



LGN Consulting Engineering Ltd.
stormwater and water resources management

P6400

October 25, 2023

Rocky View County
Capital and Engineering Services
262075 Rocky View Point
Rocky View County, AB   T4A 0X2

Attention: **Mr. Milan Patel, P.Eng.**
Municipal Engineer

Re: Ascension – Offsite Infrastructure

Following is the offsite infrastructure to service the convey the Ascension Stormwater runoff from the Ascension Pond to the Bow River outfall B115:

1. Ascension wetland to Blueridge wetland – existing culvert, to be located and replaced or twinned if necessary.
2. Blueridge wetland to Watermark cascading ponds – new overland ditch along west side of Blueridge View to be designed in conjunction with Ascension pond and offsite utility extensions.
3. North end of cascading ponds to Watermark Pond C – existing overland system, no upgrades required.
4. Watermark Pond C – change the ICD to accommodate flow-through flows from Ascension will be required; preliminary design indicates that the ICD needs to be changed from 500mm x 800mm to 530mm x 830mm.
5. Pipes connecting Watermark Pond C and Watermark Pond D – no upgrade required.
6. Watermark Pond D – change the ICD to accommodate flow-through flows from Ascension will be required; preliminary design indicates that the ICD needs to be changed from 475mm Ø to 528mm Ø.
7. Watermark Pond D to 750 mm Storm trunk along Nose Hill Drive –Utilizing a City of Calgary topographical map, we generated key cross-sections of the existing ditch and flow capacity at each section was calculated; cross-sections location plan and calculations are attached in Appendix A. The calculations indicate that the lowest flow capacity is at Section 2, 3.39 m^3/s. The estimated flow from Watermark and Ascension combined is 0.658 m^3/s; this indicates that no upgrades is expected to be required on the existing ditch. However, a survey of the entire ditch is recommended to confirm that no upgrades are required.
8. Diversion chamber to direct Ascension flows to the Tuscany storm trunk – to be designed in conjunction with the Ascension pond detail design.

9. Diversion chamber to Bow River outfall B115A (100 m downstream of water intake RAW2) – existing storm trunk has been analysed with the additional 94 L/s from Ascension and this pipe system does not need any upgrades.

Should you require additional information or clarification to the above information, please do not hesitate to contact me.

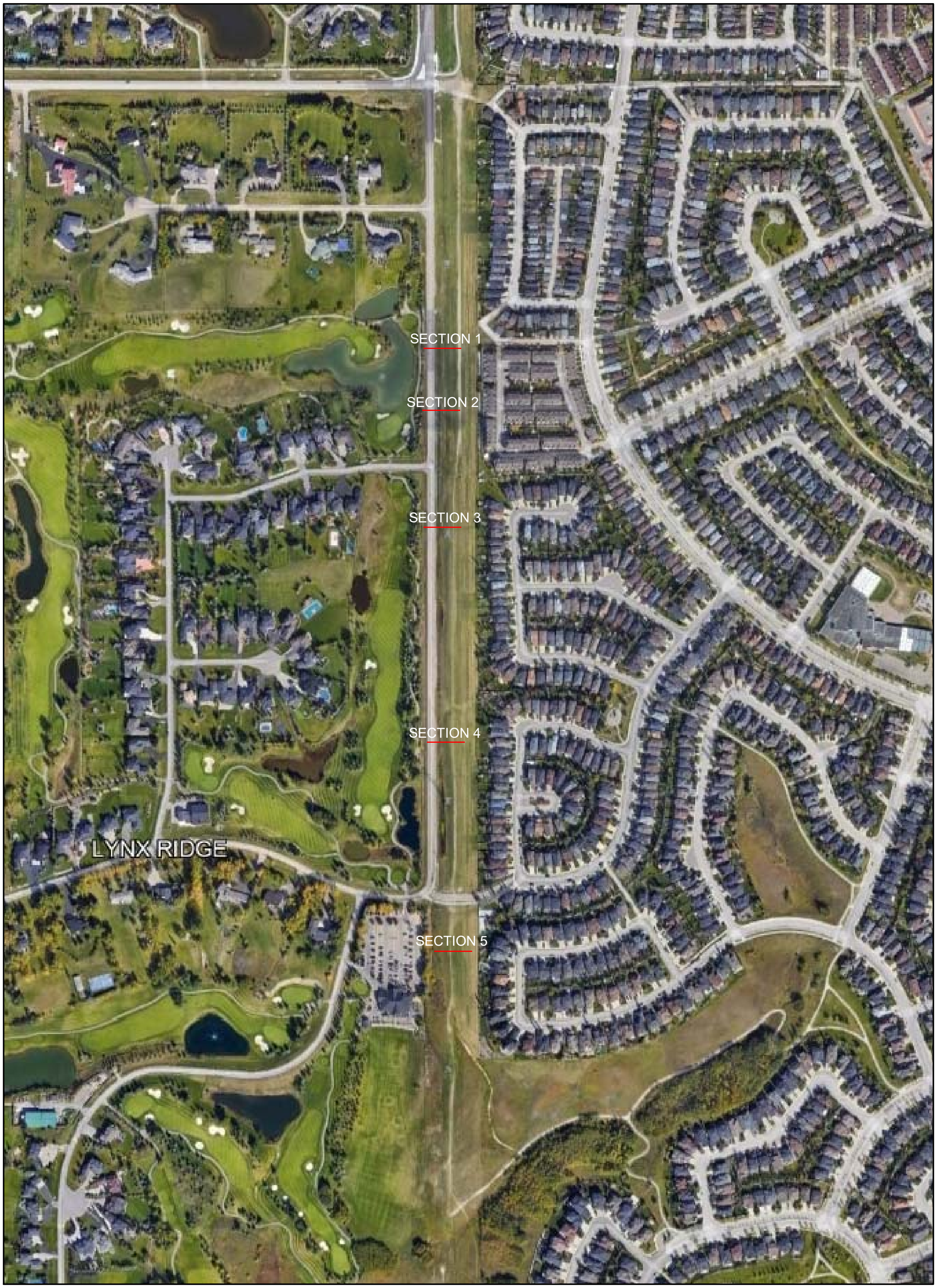
Yours sincerely,

LGN Consulting Engineering Ltd.

Luis G. Narvaez, B.Sc., P.Eng.
Senior Stormwater Engineer

PROFESSIONAL ENGINEER ALBERTA
LUIS G. NARVAEZ
Oct. 25, 2023
ID #55244

APPENDIX A



LGN Consulting Engineering Ltd.

Scale: **NTS**

Client/Project

HIGHFIELD LAND MANAGEMENT

ASCENSION

Title

Location of Ditch Cross-Sections

Figure No. **1**

Worksheet for Irregular Section - 1

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.51	%
Normal Depth	0.50	m

Section Definitions

Station (m)	Elevation (m)
0+00	1156.50
0+08	1156.50
0+11	1156.00
0+18	1156.00
0+20	1156.50
0+22	1157.00
0+23	1157.50
0+24	1158.00
0+26	1158.50

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 1156.50)	(0+11, 1156.00)	0.016
(0+11, 1156.00)	(0+26, 1158.50)	0.050

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Discharge	4.18	m³/s
Elevation Range	1156.00 to 1158.50 m	
Flow Area	4.77	m²

Worksheet for Irregular Section - 1

Results

Wetted Perimeter	12.10	m
Hydraulic Radius	0.39	m
Top Width	11.99	m
Normal Depth	0.50	m
Critical Depth	0.31	m
Critical Slope	0.02972	m/m
Velocity	0.88	m/s
Velocity Head	0.04	m
Specific Energy	0.54	m
Froude Number	0.44	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.50	m
Critical Depth	0.31	m
Channel Slope	0.51	%
Critical Slope	0.02972	m/m

Worksheet for Irregular Section - 2

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	1.30	%
Normal Depth	0.50	m

Section Definitions

Station (m)	Elevation (m)
0+00	1156.00
0+12	1156.00
0+14	1155.50
0+18	1155.50
0+20	1156.00
0+22	1156.50

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 1156.00)	(0+12, 1156.00)	0.016
(0+12, 1156.00)	(0+22, 1156.50)	0.050

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Discharge	3.39	m³/s
Elevation Range	1155.50 to 1156.50 m	
Flow Area	2.89	m²
Wetted Perimeter	7.84	m
Hydraulic Radius	0.37	m
Top Width	7.71	m

Worksheet for Irregular Section - 2

Results

Normal Depth	0.50	m
Critical Depth	0.38	m
Critical Slope	0.03753	m/m
Velocity	1.17	m/s
Velocity Head	0.07	m
Specific Energy	0.57	m
Froude Number	0.61	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.50	m
Critical Depth	0.38	m
Channel Slope	1.30	%
Critical Slope	0.03753	m/m

Worksheet for Irregular Section - 3

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	0.83	%
Normal Depth	0.50	m

Section Definitions

Station (m)	Elevation (m)
0+00	1155.50
0+11	1155.50
0+13	1155.00
0+19	1155.00
0+22	1155.50
0+24	1156.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 1155.50)	(0+11, 1155.50)	0.016
(0+11, 1155.50)	(0+24, 1156.00)	0.050

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Discharge	4.01	m³/s
Elevation Range	1155.00 to 1156.00 m	
Flow Area	4.17	m²
Wetted Perimeter	10.86	m
Hydraulic Radius	0.38	m
Top Width	10.75	m

Worksheet for Irregular Section - 3

Results

Normal Depth	0.50	m
Critical Depth	0.33	m
Critical Slope	0.03829	m/m
Velocity	0.96	m/s
Velocity Head	0.05	m
Specific Energy	0.55	m
Froude Number	0.49	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	0.50	m
Critical Depth	0.33	m
Channel Slope	0.83	%
Critical Slope	0.03829	m/m

Worksheet for Irregular Section - 4

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	1.28	%
Normal Depth	1.00	m
Section Definitions		

Station (m)	Elevation (m)
0+00	1154.00
0+09	1154.00
0+11	1153.50
0+14	1153.00
0+15	1153.00
0+19	1153.50
0+20	1154.00
0+21	1154.50
0+23	1155.00
0+26	1155.50
0+31	1155.50

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 1154.00)	(0+09, 1154.00)	0.016
(0+09, 1154.00)	(0+31, 1155.50)	0.050

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Discharge	10.58	m³/s

Worksheet for Irregular Section - 4

Results

Elevation Range	1153.00 to 1155.50 m	
Flow Area	6.64	m²
Wetted Perimeter	11.21	m
Hydraulic Radius	0.59	m
Top Width	10.99	m
Normal Depth	1.00	m
Critical Depth	0.82	m
Critical Slope	0.03170	m/m
Velocity	1.59	m/s
Velocity Head	0.13	m
Specific Energy	1.13	m
Froude Number	0.66	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	1.00	m
Critical Depth	0.82	m
Channel Slope	1.28	%
Critical Slope	0.03170	m/m

Worksheet for Irregular Section - 5

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Channel Slope	2.49	%
Normal Depth	1.00	m
Section Definitions		

Station (m)	Elevation (m)
0+00	1152.50
0+03	1153.00
0+06	1153.00
0+08	1152.50
0+10	1152.00
0+11	1152.00
0+12	1152.50
0+26	1153.00
0+32	1153.00

Roughness Segment Definitions

Start Station	Ending Station	Roughness Coefficient
(0+00, 1152.50)	(0+32, 1153.00)	0.050

Options

Current Roughness Weighted Method	Pavlovskii's Method
Open Channel Weighting Method	Pavlovskii's Method
Closed Channel Weighting Method	Pavlovskii's Method

Results

Discharge	12.52	m³/s
Elevation Range	1152.00 to 1153.00 m	
Flow Area	7.99	m²
Wetted Perimeter	22.82	m

Worksheet for Irregular Section - 5

Results

Hydraulic Radius	0.35	m
Top Width	22.01	m
Normal Depth	1.00	m
Critical Depth	0.95	m
Critical Slope	0.03684	m/m
Velocity	1.57	m/s
Velocity Head	0.13	m
Specific Energy	1.13	m
Froude Number	0.83	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	m
Length	0.00	m
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	m
Profile Description		
Profile Headloss	0.00	m
Downstream Velocity	Infinity	m/s
Upstream Velocity	Infinity	m/s
Normal Depth	1.00	m
Critical Depth	0.95	m
Channel Slope	2.49	%
Critical Slope	0.03684	m/m

LGN Consulting Engineering Ltd.
stormwater and water resources management

P6400

January 10, 2024

Rocky View County
Capital and Engineering Services
262075 Rocky View Point
Rocky View County, AB   T4A 0X2

Attention: **Mr. Milan Patel, P.Eng.**
Municipal Engineer

Reference: **Ascension – Watermark Infrastructure**

Following is our response to the Watermark Home Owners Association comments. In italic letters are the comments and in blue our response:

- *Whether reliance on overland surface flow from Ascension through Blueridge to the east cascading ponds in Watermark and from the outlet of Pond D down to the Bow River is a viable longer-term solution for stormwater management, as opposed to installation of underground infrastructure which would be the norm for stormwater handling in most communities of this nature?*

  Storm runoff from most of the communities in Rocky View County are handle by an overland storm system. It is a proven infrastructure and in this case is a viable longer-term solution with a minimum impact in the existing Watermark storm system. Because it is a flow through situation, no storage is required within Watermark; therefore, the ponds don't need change.

- Whether the proposed installation of oil/grit separators located at Ascension will provide the necessary assurances regarding the water quality of discharge leaving Ascension and ultimately entering the ponds in Watermark?

  The propose water quality control for Ascension is a treatment train composed of structural and non-structural components. They go from source control to natural controls, they are: oil/grit separators at the multi-family and commercial sites, oil/grit separators prior to runoff discharge into the storm pond, sedimentation forebay and constructed wetland. This proposed treatment train system will exceed Alberta Environment requirements.

- *Who will be responsible for ongoing regular monitoring of water quality of the discharge leaving Ascension and ensuring that water quality requirements are met or exceeded on an ongoing basis?*

Monitoring will be done in accordance with Provincial requirements and will be the responsibility of the pond owner, which will ultimately be Rocky View County.

- *What is the plan to maintain the integrity of the ditches in Blueridge through which the Ascension discharge is being surface transported over the longer term?*

  The proposal is to utilize the existing ditch and modify in specific locations as required, along the west side of Blueridge View, this will convey Ascension flows from the existing wetland in Blueridge to the top of the cascading ponds in Watermark.

  Please note that the pre-development 1:100 peak runoff is 253 L/s compared to 94 L/s for post-development. Therefore, impacts to downstream stormwater conveyance routes are not expected to be negatively impacted.

- *What assurances can be provided that the small culvert at the base of Blueridge View that runs under the Watermark pathway system before entering the cascading ponds system has enough capacity to handle the projected volumes during a major storm event (if not, there is risk of damage to the Watermark pathway system and landscaping, both of which are the maintenance responsibility of the Watermark HOA)?*

  During detail design, the capacity of all ditches and culverts will be surveyed and analysed to ensure the appropriate operation and, if necessary replaced with an appropriate size.

- *What analysis has been done to provide assurance that peak water flows are in fact manageable, particularly as they relate to the eastern cascading ponds - acknowledging that there is an in/out balance on the overall system, there is likely to be a temporal/transient effect at the cascading ponds that are in very close proximity to the back yards of the residences in Watermark bordering the eastern cascading ponds (our experience is that even a relatively modest increase in the flow entering the cascading pond system can appreciably increase water levels in these relatively small ponds)?*

  Because of the cascading nature of these ponds, the water levels are self-controlled and the additional 94 L/s flow from Ascension should approximately produce an additional 5 cm head during a peak flow, ignoring the pre-development flow that would normally be entering into the pond. These will also be assessed during detail design.

- *Given the importance of the aesthetic value of the stormwater ponds to residents of Watermark and the ongoing challenges associated with managing weed and algae growth in these ponds during the Summer months, what analysis has been done and what assurances can be provided to ensure that this additional run-off and related water quality impacts does not exacerbate these issues in the eastern cascades and in Ponds C and D (for example, increased concentrations of fertilizer associated with the run-off)?*

  Post development runoff is expected to exceed the quality of pre-development runoff.

- *In addition to the aesthetic impacts arising from increased run-off into these ponds, have potential functional issues (such as increased turbidity levels) been considered in the analysis conducted to date?*

  Based on the proposed water quality treatment train, flows from Ascension should not increase turbidity levels in the existing ponds.

- *Is the Ascension developer prepared to make an ongoing financial contribution toward maintaining the water quality in the stormwater ponds in Watermark and, if not, is the County prepared to require such a commitment as a condition of approval?*

  As described above, since there is no negative impact to the water quality within Watermark due to the Ascension runoff, no financial contribution is warranted.

Should you require additional information or clarification to the above information, please do not hesitate to contact me.

Yours sincerely,

LGN Consulting Engineering Ltd.

Luis G. Narvaez, B.Sc., P.Eng.
Senior Stormwater Engineer

PROFESSIONAL ENGINEER ALBERTA
LUIS G. NARVAEZ
Jan. 10, 2024
ID #55244