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STORMWATER MANAGEMENT REPORT
PROPOSED RESIDENTIAL SUBDIVISION
2050 DUNROBIN ROAD
CITY OF OTTAWA

Submitted to:

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PROJECT #: 200977

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1. INTRODUCTION

Mr. Zbigniew Hauderowicz retained Kollaard Associates Inc. to complete a Site Grading and Drainage Plan along with a Stormwater Management Report in support of the City of Ottawa Subdivision Approval Application for the proposed residential subdivision development at 2050 Dunrobin Road in the City of Ottawa, Ontario. The proposed subdivision will occupy a currently undeveloped parcel of land located along the northeast side of Dunrobin Road southeast of Constance Lake Road. The development will be accessed by extending a roadway northeast from Dunrobin Road. The proposed roadway will terminate with a cul-de-sac. The proposed development area will be divided into 8 single family residential estate lots with a block reserved for stormwater management.

For the remainder of this report Dunrobin Road will be considered to be on a north-south axis and the site is considered to be located on the east side of Dunrobin Road.

This report is intended to present the results of a stormwater management design in support of the application for subdivision approval. The report will summarize the stormwater management (SWM) design requirements and proposed works that will address stormwater flows arising from the site under post-development conditions on a level sufficient to ensure that stormwater management facility is adequately designed to meet the criteria for the site.

The total site development area is approximately 8.96 hectares (22 acres). A road will be extended through the development, east from Dunrobin Road, ending in a cul-de-sac on the site. Residential driveways will originate along both sides of the proposed development roadway. The single family dwellings will be serviced by wells, on-site septic leaching beds and side yard swales. The proposed residential development will affect an additional 0.11 hectare portion of City of Ottawa property, in the form of regarding of the roadside between the site and Dunrobin Road.

The report is to be read in conjunction with the stormwater management system design presented in the Kollaard Civil Drawings: 200977 - PRE, 200977 - POST, 200977 – GR-W, 200977 – GR-E, 200977 - ESC, 200977 - PP, 200977 – SVC, 200977 – FC, and 200977 - Details.

1.1. Background

The proposed development has in general a rectangular shape and extends from Dunrobin Road to the former CN railway tracks located along the east side of the site. A narrow portion of the site projects south from the southeast corner of the site along the CN railway. The projection has an average width of about 14.5 metres, a maximum width of about 26.5 metres and extends about 160 metres to the south side of Harwood Creek.

The proposed development site is part of the Harwood Creek watershed. Harwood Creek is a tributary to Constance Lake and is adjacent the southeastern extension of the site. Harwood Creek is a watercourse of record with sufficient size and capacity to receive the runoff from the proposed development. The initial design for the proposed development was completed in 2010 with various revision following. Conditions for Draft plan approval were received in 2015. At the time the initial design was completed and draft plan approval conditions were provided, flood plain mapping had not been completed for the Harwood Creek and no flood plain was identified on site. It is understood that the flood plain modeling for the Harwood Creek was completed in 2020 by MVCA. As a result of the mapping, a backwater flood plain was identified on the eastern portion of the site.

Modeling of the affect of the proposed development on the backwater flood plain was completed by J.F. Sabourin and Associates Inc. (JFSA) and has been presented in a separate report.

1.2. Summary

The proposed stormwater management design directs stormwater runoff to the southeast corner of the site by means of swales, the road side ditches and an outlet swale towards the Harwood Creek.

The proposed stormwater management plan for the subdivision will make use of best management practices in combination with a treatment train approach to meet the requirements for stormwater management on the site. Stormwater from the majority of the developed portion of each lot, including the driveways and dwelling footprints, and from the adjacent roadway will be collect by means of the roadside ditches and directed to the stormwater management swale. The stormwater management swale will consist of a flat bottomed low sloped swale complete with an enhanced topsoil layer on the bottom underlain by a clear stone layer.

The roadside ditches and stormwater management swale will provide stormwater storage and promote sedimentation and infiltration while the vegetated swales will promote infiltration and vegetative filtration in order to achieve the quantity and quality control parameters established by the City of Ottawa, Mississippi Valley Conservation Authority and the Ministry of Environment Conservation and Parks.

1.3. Governing Authorities

This Stormwater Management Report has been prepared to present the design information to satisfy conditions set by the following authorities:

City of Ottawa (City)
Mississippi Valley Conservation Authority (MVCA)
Ministry of Environment, Conservation and Parks (MECP) formerly Ministry of Environment (MOE)

1.4. Guidelines and Manuals

The following guidelines and manuals were utilized in the creation of the stormwater management design and the preparation of this report.

Ottawa Sewer Design Guildelines *(OSDG)*
City of Ottawa, October 2012 as amended.

Stormwater Management Planning and Design Manual *(MOE Manual)*
Ministry of the Environment, March 2003

Visual OTTHYMO V2.0: Reference Manual
Greenland International Consulting Inc., July 2002

CITY OF OTTAWA, Low Impact Development Technical Guidance Report
City of Ottawa, February 2021

MTO Drainage Management Manual
Ontario Ministry of Transportation

Part 650 Hydrology National Engineering Handbook – Chapter 15 Time of Concentration
United States Department of Agriculture (USDA Chapter 15)

Urban Hydrology for Small Watersheds Technical Release 55
United States Department of Agriculture (USDA TR55)

Storm Water Management Model Reference Manual Volume I – Hydrology (Revised)
United States Environmental Protection Agency (US EPA RM)

2. STORMWATER MANAGEMENT DESIGN

The subject lands are within the City of Ottawa and the Mississippi Valley Conservation Authority jurisdiction. Stormwater management criteria were established based on the nature and location of the development and on the nature of the receiving watercourse for the stormwater discharge from the site.

2.1. Design Criteria

2.1.1. Quantity Control Criteria

- Post-development peak runoff rates are to be equal to or less than pre-development levels for all design storm events up to and including the 100 year storm event,
- Onsite stormwater storage and flow shall be controlled as to not affect lands adjacent the development site,
- Surface runoff volumes are to be minimized through infiltration techniques,
- Incorporate low impact design techniques where possible.

2.1.2. Quality Control Criteria

- The design shall include enhanced quality treatment to 80% long-term suspended solids removal as recommended by the MOE Manual,
- Downstream sedimentation shall be mitigated at 2050 Dunrobin Road by increasing particle settlement along runoff flow paths within the development.

2.2. Best Management Practices

As indicated in the MOE Manual, the recommended strategy for stormwater management is to provide an integrated treatment train approach to stormwater management. Each element of the treatment train within the development when combined forms the stormwater management facility for the development.

In general, best management practices for stormwater management are divided into three categories: source control, conveyance control and end-of-pipe control. As indicated in the Ministry of Transportation Drainage Management Manual, the priority in applying these BMPs should follow the sequence presented with end of pipe measures applied as the last resort.

The proposed BMPs utilized in the proposed development will include both lot level and general BMPs. Lot level BMPs may include reduced lot grading, direction of roof drainage to the vegetated ground surfaces, reducing directly connected impervious areas, vegetative buffer strips and re-vegetating any surface areas of the lot disturbed during construction as soon as possible. The general BMPs will include reduced swale slopes and increased swale cross sections were possible to reduce flow rates and promote filtration and the removal of sediments.

3. PROPOSED HYDROLOGIC MODEL

3.1. Design Storm Intensity

Intensity-Duration-Frequency curves derived from Meteorological Services of Canada rainfall data for the MacDonald-Cartier Airport in Ottawa were used to determine the expected rainfall intensity for a given duration and storm frequency.

The IDF formulae obtained from the OSDG are as follows:

100 year Intensity = $1735.688 / (\text{Time in min} + 6.014)^{0.820}$
10 year Intensity = $1174.184 / (\text{Time in min} + 6.014)^{0.816}$
5 year Intensity = $998.071 / (\text{Time in min} + 6.053)^{0.814}$
2 year Intensity = $732.951 / (\text{Time in min} + 6.199)^{0.810}$

The data obtained from the IDF curves for the site was used to generate SCS Type II Design and Storms and Chicago Storms with select durations and return periods up to and including the 100 year storm event. The historical design storms from July 1, 1979 and August 4, 1988 were also included in the analysis to verify the sufficiency of the design. The 25 millimeter 4 hour Chicago storm is considered by the Ontario Ministry of Environment Conservation and Parks to be the design storm for quality control purposes and was also included in the analysis. *Table 3-1* summarizes the selected design storms included for analysis.

Table 3-1: Design Storms Considered

Quantity Control Storm Events	
Simulation 01.	SCS II 6 hr 5 yr
Simulation 02.	SCS II 6 hr 100 yr
Simulation 03.	SCS II 12 hr 5 yr
Simulation 04.	SCS II 12 hr 10 yr
Simulation 05.	SCS II 12 hr 100 yr
Simulation 06.	12 HR 2 YR Chicago
Simulation 07.	12 HR 100 YR Chicago
Simulation 08.	Historical July 1 1979
Simulation 09.	Historical Aug 4 1988
Quality Control Storm Events	
Simulation 10.	25mm 4 hr Chicago

3.2. Methodology

The hydrologic modeling software, Visual OTTHYMO (V6.2) was used to assess pre- and post-development stormwater conditions at the site.

The pre-development were calculated using the NASHYD watershed command. The post-development conditions were also calculated using the NASHYD watershed command as the average impervious ratio for the Subdivision is less than 20 percent.

The NASHYD hydrograph method uses the Nash instantaneous unit hydrograph which is made of a cascade of 'N' linear reservoirs and is used to model rural areas.

Both the Pre and Post-development conditions were modeled for quantity control purposes utilizing SCS Type II Storm Distributions and Chicago storm distributions listed for Simulations 1 to 9 in Table 3-1 above.

The post-development conditions were modeled using the 25 mm 4 hour Chicago storm for quality control purposes.

The SCS Type II storm data was given priority in the SWM design as the proposed development is a rural residential development. The 12 hour SCS storms are generally applicable to undeveloped or rural basins where peak flow rates are largely influenced by the total volume of rainfall. The SCS Type II storm distribution is generally preferred for both large and small rural areas (OSDG). The Chicago storm is more commonly used for urban areas.

3.3. OTTHYMO Storm Analysis Variables

As previously indicated, the stormwater runoff was calculated using the NASHYD watershed command. The NASHYD command uses the Nash instantaneous unit hydrograph which is made of a cascade of 'N' linear reservoirs and is used to model rural areas.

The NASHYD command uses the following inputs:
DT – Simulation time step increment (min) – must be shorter than TP
Area – Watershed or catchment area (hectares)
DWF – A constant Dry Weather Flow or Baseflow (m3/s) assumed to be 0 (doesn't change from pre to post development)
CN – SCS Modified Curve Number
IA – Initial Abstraction (mm)
N – Number of Linear reservoir used for derivation of the Nash Unit Hydrograph
TP – Unit hydrograph time to peak (hr)

The Storm Analysis Model Variables for each catchment used in the storm water management model are summarized in Appendix A of this report.

3.3.1. Runoff Curve Numbers

The NasHyd hydrograph method which uses the SCS loss method for pervious areas was used to model both the pre- and post development conditions of the proposed subdivision. Runoff Curve Numbers (CN) are utilized in the SCS hydrology method. The Curve Number is a function of soil type, ground cover, and antecedent moisture conditions. The Hydrologic soil type was chosen to be Group B for the site in keeping with the Hydrogeological Investigation and Terrain Evaluation Report prepared for the proposed development. The subsurface conditions were found to consist of sand, silty sand and glacial till underlying the topsoil at the site. A calculation of the CN values for both the pre- and post-development conditions is presented in Appendix A.

The CN values used for each catchment area consist of a weighted average value based on the conditions and cover of the ground surface in the catchment area. For the purposes of analysis presented in this report, the surface cover was considered to be Open Space (lawns) in good condition 61, Woods/brush in good condition (the woods/brush on site is recent re-growth with dense undergrowth) 55, Unmaintained and overgrown rear yards and Woods/brush in fair condition 60, and Impervious 98. The offsite contributing area to the northwest was considered to be a combination of unmaintained and overgrown rear yards and woods/brush in good condition resulting in a CN of 57.5. The CN values were taken from OSDG Table 5.9 and from the United States Department of Agriculture Urban Hydrology for Small Watersheds Technical Release 55 (USDA TR55).

3.3.2. Initial Abstraction and Potential Storage

The initial abstraction includes all losses before runoff begins, and includes water retained in surface depressions, water taken up by vegetation, evaporation, and infiltration. This value is related to characteristics of the soil and the soil cover. Initial abstraction is a function of the potential storage and is generally assumed to be equal to 0.2S where S is the potential storage.

It is considered that for lower CN values, the relationship IA = 0.2S tends to overestimate the initial abstraction resulting in underestimated peak runoff. As such suggested guidelines are as follows:

CN ≤ 70 IA = 0.075S
CN > 70 ≤ 80 IA = 0.10S
CN > 80 ≤ 90 IA = 0.15S

CN > 90 IA = 0.2S

The potential storage S is related to the runoff coefficient as follows:

S = (25400/CN) - 254

The initial abstraction IA and potential storage S values for both the pre- and post-development conditions are also presented in Appendix A.

3.3.3. Time of Concentration and Time to Peak

The time to peak is generally considered to be 2/3rds of the time of concentration of a catchment area. The calculation for the time of concentration of each catchment is summarized in Appendix B. The time of concentration of each catchment was determined using the Velocity method. The velocity method assumes that the time of concentration is the sum of travel times for segments along the hydraulically most distant flow path. The segments used in the velocity method may be of three types: sheet flow T_s, shallow concentrated (overland) flow T_{sc}, and open channel flow T_c. The open channel flow has been modelled using the route Channel Command in OTTHYMO.

3.3.3.1. Travel time for sheet flow

Sheet flow is defined as flow over plane surfaces. Sheet flow usually occurs at the upper end of each individual catchment and typically occurs for no more than 30 metres before transitioning to shallow concentrated flow. The Manning's roughness coefficients used for sheet flow only apply for flow depth of less than 3 cm and vary from those used in shallow concentrated flow and open channel flow.

The travel time for sheet flow is calculated using the simplified Manning's Kinematic solution as follows:

$$T_s = \frac{0.091(nl)^{0.8}}{(P_2)^{0.5}S^{0.4}}$$

Where T_s = travel time, h

n = Manning's roughness coefficient sheet flow

l = sheet flow length,

P_2 = 2-year 24-hour rainfall, = 48 mm

S = Slope of land surface m/m

The Manning's roughness coefficient for sheet flow includes the effects of roughness as well as the effects of raindrop impact, drag over the surface, obstacles such as litter and rocks and transportation of sediment.

The Manning's n for sheet flow ranges from 0.8 for Woods (with dense underbrush and no clearing of deadfall and other detritus) to 0.018 for bare hard packed earth. The Manning's n for grass ranges from 0.15 (short grass prairie or lawn grass with bare patches), 0.24 (dense prairie grasses (long stems grasses)) to 0.41 (Bermuda grass or dense lush lawn grass).

The ground surface conditions during pre-development beginning on the western portion of the site consist of meadow which transitions to deciduous shrub thickets through the center to woodland at the east end of the site. Since the sheet flow occurs at the upper end of the catchment area, the sheet flow during pre-development conditions on site will occur through the meadow portion of the site. As such a Manning's roughness coefficient of 0.24 corresponding to dense prairie grass cover was used for pre-development conditions for the site.

During post-development conditions, The runoff originating on each lot will be divided and will be either directed across the front yard to the roadside ditch or across the back yard to the swale along the rear property lines. Based on the proposed grading plan, it is anticipated that the front yards and the portion of the rear yard beside and immediately behind the proposed dwelling will be completely developed and regraded. These regraded portions of the lot will be surfaced with a maintained lawn upon completion of development. Since the sheet flow portion of the runoff for these catchment areas will occur over the regraded portions of each lot, a Manning's roughness coefficient of 0.4 was used for post-development conditions assuming a maintained lawn with lawn grass in good condition cut to not less than 3 cm in height (It is noted that the average recommended grass height for lawns subjected to cool weather varies from 1.5 to 3 inches or 3 to 7.5 cm).

Shallow concentrated flow was assumed to occur after a maximum of 30 metres on each catchment. The length of sheet flow is expected to end sooner in the catchments were a swale or ditch could intersect the flow.

3.3.3.2. Travel time for shallow concentrated flow

Shallow concentrated flow follows sheet flow and is expected to occur at depths of greater than 3 cm and less than 15 cm. The Manning's roughness coefficients for shallow concentrated or overland flow was obtained from Table 3-5 of the US EPA RM. The flow velocity used to calculate the time of travel for shallow concentrated flow was determined using Table 15-3 and

Figure 15-4 of Chapter 15 of the USDA handbook (Included in Appendix B of this Report). Since the ground surface cover descriptions provided on Table 15-3 are agricultural in nature, they do not readily relate to the expected ground surface cover to be encountered in the proposed development. As such, the corresponding Manning's n value provided in Table 15-3 was used to relate the ground surface cover description used in Figure 15-4. From US EPA RM Table 3-5, when considering shallow concentrated flow or overland flow, a Manning's n of 0.075 is used for parks and lawns, 0.09 for dense grass and 0.12 for shrubs and bushes. A Manning's n of 0.202 is used for forest with heavy ground litter and hay meadows.

As previously discussed, it is expected that the shallow concentrated flow during pre-development conditions will occur through shrubs and bushes which corresponds to a Manning's n of 0.12. This value is between the n values corresponding to the descriptions given in Table 15-3 for Minimum tillage and Forest. The flow velocity for both descriptions was obtained from Figure 15-4 for the average slope of the catchment and then liner interpolation was used to determine the flow velocity for a Manning's n of 0.12 as follows:.

Catchment Area C-PRE1 has a slope of 0.6%. From Figure 15-4 the flow velocity assuming minimum tillage n = 0.101 is 0.39 ft/s and for forest n = 0.202 is 0.196 ft/s. Using linear interpolation for n = 0.12 results in a flow velocity of 0.35 ft/s or 0.11 m/s.

During post development conditions, the shallow concentrated flow resulting from runoff generated in the front yards is expected to occur in the side yard swales where the ground surface will be covered with lawn corresponding to a Manning's n of 0.075. Referencing Table 15-4 this n value closely corresponds to the description of Short-grass pasture n = 0.073. The shallow concentrated flow in the rear yards is expected to occur along less defined flow paths than in the front completely regraded portion of each lot. As such, it expected that the grass growth less maintained, will be relatively higher in relation to the flow depth and there will be more litter on the ground surface obstruction the flows. Based on these expected conditions, the Manning's n for the rear yard catchments during post development conditions is expected to be between n = 0.09 and n =0.202. Referencing Table 15-4 an n value of 0.09 closely corresponds to the description of minimum tillage. Flow velocities for minimum tillage and for forest were obtained for each rear yard catchment and averaged to obtain the flow velocity for shallow concentrated flow during post development conditions in the rear yards.

As an example: The slope in Catchment C8 for shallow concentrated flow was determined to be 0.75 m over a distance of 58 m or 0.013. From Figure 15-4 of the USDA Handbook using a slope of 0.013 the velocity is estimated at 0.57 ft/s for minimum tillage and 0.29 ft/sec for forest. Averaging these two values results in a flow velocity of 0.40 ft/s or 0.12 m/s.

$$T_{sc} = \frac{l}{3600\ V}$$

Where T_{sc} = travel time, hrs

l = distance of shallow concentrated flow = 58 m

V = average velocity = 0.12 m/s

T_{sc} = 0.13 hrs

3.3.3.3. Travel time for open channel flow

The open channel flow will be modelled using the route Channel Command in OTTHYMO.

The main channels consist of the roadside ditches and drainage swales. The drainage swales and roadside ditches in the development are channels which were designed to be excavated channels in earth. Further discussion on these channels is included in sections 3.4, 6.2 and 6.3.

3.4. Open Channel Flow

Open Channel Flow will occur in the road side ditches and the storage and conveyance swale extending from the end of the cul-de-sac to Harwood Creek and in the proposed swales along the north, south and east sides of the site.

3.4.1. Conveyance of Offsite Runoff

Sheet flow and shallow concentrated flow from the offsite catchment north of the site will be collected by the proposed shallow swale located along the north side of the proposed development. This flow will be routed along the outside edge of the development to the proposed swale along the east side of the development which will discharge into the outlet swale for the proposed storm water storage facility.

3.4.2. Conveyance of Internal Site Runoff

Internal site runoff will be conveyed along roadside ditches and swales as illustrated on the proposed subdivision grading plans.

3.5. Watershed or Catchment Areas

The catchment areas contributing runoff to the stormwater management works consist of both onsite and offsite catchment areas. The catchment areas used in the design for the proposed subdivision are presented in the attached drawings 200977-PRE and 200977-POST.

3.5.1. Delineation of Offsite Catchment Areas

A review of watershed drainage patterns surrounding the subdivision was completed using the Ministry of Natural Resources and Forestry Ontario Flow Assessment Tool, large scale topographic mapping, the City of Ottawa geoOttawa tool, the Mississippi Valley Conservation Authority Flood Plain Mapping and LIDAR imagery. Based on the information obtained from the above sources it is apparent that runoff is generally directed parallel to the site from Dunrobin Road to the rail corridor east of the site. The flood plain mapping and topographical information provided indicates that there is a 100 year flood plain from the Hardwood Creek which extends onto the lower portion of the site. Runoff is directed towards the flood plain and towards the Harwood Creek. Due to these drainage patterns there are no offsite areas south of the site which contribute runoff to the site.

As indicated by the LIDAR image underlain on the pre-development drawing and topographic information obtained from contours of the adjacent site, a portion of the properties north of the site contribute runoff to the site. The north limit of the off-site catchment, as shown on the pre-development drawing, essentially passes through the high points indicated by the contour lines. Since the north limit is located on the high points, it represents a flow divide with runoff originating north of the line being directed towards Constance Lake Road. Runoff originating on this offsite area south of the high point will be directed towards the site. This offsite area has been delineated on the pre- and post-development drainage plans and is the same for both pre and post conditions.

3.5.2. Delineation of Onsite Catchment Areas

The onsite catchment areas were delineated based on the topography obtained for the site area and on the proposed development. Since the general flow direction during pre-development conditions is from west to east, the onsite pre-development catchment areas were simplified to 2 catchments divided by the approximate centerline of the future roadway.

The catchment areas used in the analysis during post-development conditions for the design of the stormwater management facility are presented in the attached drawing 200977-POST – Post-Development Drainage Plan. These catchment areas have been delineated based on the proposed lot grading and have been divided between front yard and rear yard grading.

4. RECEIVING WATER BODY - HARWOOD CREEK

The headwaters of the Harwood Creek adjacent to the site are located slightly east of the Village of Carp. The Harwood Creek passes through a double barrel box culvert beneath the railway adjacent to the east corner of the site immediately downstream of the site. The proposed stormwater management facility will outlet to the Harwood Creek about 35 metres upstream of the existing box culvert under the former railway. The Harwood Creek outlets to Constance Lake about 1.2 kilometres downstream of the railway culvert. The drainage area of Harwood Creek upstream of the railway culvert was estimated from National Resources Canada Topographic Maps in combination LIDAR imagery and the Ontario Flow Assessment Tool to be about 13 square kilometers.

4.1. Flow Rate and Water Level

The Mississippi Valley Conservation Authority developed a hydraulic (HEC-RAS) model of the Harwood Creek as part of the floodplain mapping works completed for the Harwood Creek. This model was used to determine flood levels at various stations along the Creek. The floodplain mapping shows that the railway culvert is located between River Stations 1023 and 1002 used in the model. The proposed stormwater management facility for the site will discharge into the Harwood Creek between River Stations 1075 and 1023

Flow rates in the Harwood Creek calculated by the model were provided to Kollaard Associates by MVCA for river stations upstream and downstream of the Culvert (Included in Appendix C for Reference). These results indicate that the 100 year flow rate in the Harwood Creek at River Station 1075, upstream of the proposed discharge point for the development, is 14.1 m^3/sec. The 100 year flow rate at River Station 1023, upstream of the railway culvert, is 14.9 m^3/sec and at River Station 1002, downstream of the culvert, is 14.9 m3/sec. The modeled flow depths during the 100 year storm event were 1.38 m, 1.45 m and 1.13 m for River Station 1075, River Station 1023 and River Station 1002 respectively.

The minimum channel depth determined at time of survey immediately upstream of the box culverts was 73.0 m. The above flow depths result in a water surface elevation of 74.41 m upstream of the culvert and 74.09 m downstream of the culvert during a 100 year flow event.

The minimum channel elevation considered in the HEC-RAS Model at River Stations 1023 and 1002 is 73.7 m which is 0.7 m higher than that measured during the topographic surveying. The actual channel elevation determined at determined at time of survey at River Station 1075 was 73.35 m compared to 73.95 m used in the model.

4.2. Railroad Culvert Capacity

The Harwood Creek passes under the Railroad Immediately east of the site between River Stations 1023 and 1002 by means of a double barrel cast-in-place concrete culvert. The existing culvert is a double barreled cast in place “box” culvert with wing walls. The side walls of the culvert are founded on bedrock. The bottom of the barrels consists of native material. The culvert has the following dimensions. Right (south) Barrel 1.6 m high x 2.8 m wide, invert of 72.76, Left (north) barrel 1.4 m high by 2.9 m wide, invert of 72.96, beveled entrance and exits, and 33 degree wing walls. The obverts of the barrels are at an elevation of 74.45 m. This results in an available flow depth of 1.69 m in the south Barrel and 1.49 m in the north Barrel. The centre of the railroad tracks above the culvert is at an elevation of 75.8 m.

Based on the above dimensions, the culvert has the following capacities depending on flow conditions. These capacities were determined using the Charts included in Appendix C.

Table 4-1: Capacity of Culvert Under Railroad Tracks

Elevation (m)	Capacity under inlet control conditions (no restriction at outlet) m^3/sec	Capacity under full flow conditions (tail water restricting flow) m^3/sec
73.5	4.0	5.6
73.6	4.6	6.3
73.7	5.1	6.8
73.8	6.3	7.3
73.9	8.0	7.7
74. 0	9.1	8.0
74.1	10.5	8.4
74.2	12.0	8.7
74.3	13.7	8.9
74.4	16.1	9.2
74.5	17.1	9.4
74.6	18.8	7.4
74.7	20.5	11.8
74.8	22.2	15.6

Since the flow depth immediately downstream of the culvert is 1.13 m during a 100 year flood event and the available flow depth through the box culvert is on average 1.59 m it is considered that the culverts will be operating under inlet control conditions. Referencing the above table, a flow rate of 14.9 m3/sec will result in a water surface elevation of between 74.3 m and 74.4

m , ate during a 100 year storm event is 14.9 m^3/sec resulting in an average headwater depth of between 1.44 and 1.54 m at the inlet of the culvert. This matches the flow depth expectation based on the HEC-RAS Modeling and demonstrates that the existing box culverts have sufficient capacity to accommodate the 100 year flow rate in the Harwood Creek without surcharge and the outlet from the proposed development will not be affected by flow restriction in the downstream box culverts.

4.3. Risk on Development from Flood Levels in the Harwood Creek

4.3.1. Existing Conditions

Information obtained from site reconnaissance and from residents in the surrounding areas indicates that, the lower elevations of the site are subject to flooding during the spring and as a result of damming of the creek by beavers. The existing ground surface elevation at the relatively level lower portion of the site ranges in elevation from about 74.9 to about 75.4 metres and extends southwest of the rear property line some 90 metres along the northeast side of the site and some 110 metres along the southeast side of the site. This lower area is also a backwater of Harwood Creek.

Flood plain mapping obtained from the MVCA indicates that the site is subject to a backwater flood plain from the Harwood Creek that has a 100 year flood plain elevation of 75.48 m. The extent of this flood plain on the site is illustrated on Kollaard Associates drawing 200977-PRE.

4.3.2. Mitigation of Flood Risk

In order to facilitate the proposed development of the two lots affected by the backwater flood plain, fill material will be placed to raise the ground surface to a minimum of 75.5 m within the area proposed for development. The proposed ground surface will slope upward from the minimum grade towards the proposed dwelling and septic area footprints resulting in elevations of 77.20 metres over the septic bed and 75.8 metres adjacent the proposed dwellings. This fill will remove the development area from the flood plain backwater. The existing flow through the flood plain backwater will be re-routed around the south east side of the fill to maintain the drainage of the property and the rear yards of the adjacent properties. A permit for placement of fill within the flood plain will be applied for as part of the development process in order to remove the developed portion of the subdivision from the flood plain.

The proposed dwellings will be constructed with a minimum underside of footing elevation of 75.80 metres. The proposed septic leaching beds should be constructed with a minimum tile elevation of 76.35 metres. The proposed area for development is above an elevation of 75.45 metres. It is intended that wells will be installed on the upslope side of the dwellings adjacent the lower level of the site.

4.4. Effect of Development on Flood Levels in Harwood Creek and Surrounding Area.

4.4.1. Placement of Fill in the Flood Plain

A detailed discussion of the effects of the removal of the backwater flood plain from the Harwood Creek by means of the proposed fill placement has been discussed by JFSA in a separate report and has been included in Appendix D.

In their report, JFSA provided the following conclusions:

> *"JFSA has assessed the potential impacts of filling the area within 2050Dunrobin Road, which is currently mapped as a floodplain in MVCA's recent floodplain mapping study. Based on updated HEC-RAS modelling, which assumes these lands are filled, JFSA has demonstrated that there is no increase in peak water level. It was noted that 1D HEC-RAS models are not well suited to assessing/simulating the complexities of lateral spills, and as such the floodplain storage lost due to filling these lands was approximated using 2020 LiDAR obtained from the City of Ottawa and the MVCA's simulated 100-year water surface elevation over these lands. Based on this analysis, it was found that filling the floodplain bulge on these lands will result in an approximate reduction in storage volume by 1,131 m³ or 0.36% of the Harwood Creek 100-year floodplain. As such JFSA concludes that the proposed filling within the subject property will have no adverse impacts on the existing hydraulic operations of Harwood Creek."*

Based on the modeling and calculations completed by JFSA, the placement of the fill within the backwater flood plain will have no negative impact to the Harwood Creek and surrounding properties including the existing wells and septic systems on the surrounding properties.

4.4.2. Affect of the Development During Storm Events

As demonstrated in the following Section 7 of this report, the post-development flow rates will be less than the calculated pre-development flow rates for all design storm events. In addition, as demonstrated in Section 8 of this report, the calculated stormwater runoff volume will be less than pre-development conditions during minor storm events and negligible higher than pre-development conditions during the 100 year storm event. As such, it is considered that the runoff from the proposed development will have no effect on the water level in the Harwood Creek during the design storm events.

Based on the above, it is considered that there will be no flood risk to the proposed development from the Harwood Creek during various storm events up to and including the 100 year storm events provided there are no extraneous circumstances such as damming of the creek downstream of the site. It is also considered that the proposed development will not affect adjacent landowners by increasing flood elevations.

5. PRE-DEVELOPMENT STORMWATER ANALYSIS

5.1. Adjacent Off Site Properties

5.1.1. Delineation of Catchments

As previously indicated, the site is located on the east side of Dunrobin Road in the City of Ottawa. The site is continuously sloped downward from the edge of Dunrobin Road towards the former railway along the east side of the development. The predominate slope is oriented perpendicular to Dunrobin Road. There is a slight cross slope towards the southeast such that the runoff at the east end of the site is directed to the Hardwood Creek located south of the site.

The existing road side ditch between the shoulder of Dunrobin Road and the site is poorly defined with minimal back slope at many locations. As a result, all of the runoff generated from the north bound lane of Dunrobin Road and from the ditch along the east side of the road is considered to travel across the site. Catchment areas C-A and C-B have been used to model the runoff contributed from Dunrobin Road during both pre- and post-development conditions. C-A includes the portion of the east lane and shoulder of Dunrobin Road as well as the east roadside ditch adjacent the site, north of the proposed site entrance. C-B includes the portion of the east lane and shoulder of Dunrobin Road as well as the east roadside ditch adjacent the site, south of the proposed site entrance. C-A and C-B are used to model the contribution to the site from Dunrobin Road during both pre- and post-development conditions.

As indicated by the LiDAR image underlain on the pre-development drawing and topographic information obtained from contours of the adjacent site, a portion of the properties north of the site contribute runoff to the site. The north limit of the off-site catchment as shown on the pre-development drawing essentially passes through the high points indicated by the contour lines. Since the north limit is located on the high points, it represents a flow divide with runoff originating north of the line being directed towards Constance Lake Road. Runoff originating on this offsite area south of the high point will be directed towards the site. This off site area has been delineated on the pre- and post-development drainage plans as catchment area C-OFF1 and is the same for both pre and post conditions.

During pre-development conditions, runoff from C-OFF1 is directed across the site by a shallow swale which outlets to the Harwood Creek. A review of aerial photographic images of this catchment indicates that C-OFF1 is predominately surfaced with a mixture of lawn, unmaintained rear yards (grass/brush) and woods/brush with the upper portion of the catchment consisting of unmaintained rear yards.

Runoff from the adjacent property to the south flows in a southeasterly direction to the Harwood Creek and does not contribute to the site.

5.1.2. Catchment Area Curve Numbers

As indicated in Section 3 of this report, the analysis was completed using Visual OTTHymo which uses the Runoff Curve Number CN as opposed to the runoff coefficient commonly used in combination with the Rational Method. Also as indicated in Section 3, the hydrologic soil group was considered to be Group B and the various ground surface covers and associated Curve Numbers are considered to be: Open Space (lawns) in good condition 61; Woods/brush in good condition (the woods/brush on site is recent re-growth with dense undergrowth) 55; Unmaintained and overgrown rear yards and Woods/brush in fair condition 60; and Impervious 98. These Runoff Curve Numbers would correspond to runoff coefficients as follows: CN of 61 ≈ n of 28; CN of 60 ≈ n of 25; CN of 55 ≈ n of 14; CN of 98 ≈ n of 0.99.

The Runoff Curve Number for each off site pre-development catchment area was calculated using a weighted average of the ground surface covers within each catchment as shown in the following Table 5-1.

Table 5-1 Pre-Development Runoff Curve Numbers – Offsite Areas

Catchment	Surface	Area Ha	CN	Weighted Average CN
C-OFF1 (1.68 ha)	Unmaintained Rear Yard	0.84	60	57.5
	Wood/brush good cond.	0.84	55	
C-A (0.17 ha)	Open Space (grass)	0.11	61	73.9
	Impervious	0.06	98	
C-A (0.17 ha)	Open Space (grass)	0.11	61	73.9
	Impervious	0.06	98	

5.2. On Site Pre-Development Catchments

5.2.1. Onsite Conditions

As previously indicated, the property is generally rectangular with an about 160 m long projection towards the southeast along the existing railway corridor.

Historical imagery available on the geoOttawa website indicates that the site was historically occupied by farmland with a dwelling and outbuildings. These images show that no significant agricultural activity was carried out on the site within the last 20 to 30 years or more and that the dwelling has been abandoned. The ground surface across the site has a general downward slope of about 0.3 to 2 percent from the southwest end of the property to the northeast. Current site drainage takes the form of sheet and shallow concentrated flow following the general slope of the site.

The vegetative communities on the southwest portion of the site predominately consisted of Forb Meadow which transitions to Buckthorn Deciduous Shrub Thickets through the central portion of the site. The northeast end of the site adjacent the railway corridor is occupied by fresh-moist poplar deciduous woodland.

Harwood Creek Crosses the eastern most portion of the 160 m long projection of the property. This projection is almost entirely occupied by the 100 year flood plain of the Harwood Creek. A tailwater section of the Flood Plain extends on the site covering a significant portion of the eastern about 100 metres of the site.

5.2.2. Onsite Delineation Catchments and Curve Numbers

As previously indicated, since the general flow direction during pre-development conditions is from west to east, the onsite pre-development catchment areas were simplified to 2 catchments divided by the approximate centerline of the future roadway. Based on the ground surface cover the Runoff Curve Numbers for the onsite pre-development conditions are as shown in Table 5-2.

Table 5-2 Pre-Development Runoff Curve Numbers – Onsite Areas

Catchment	Surface	Area Ha	CN	Weighted Average CN
C-PRE1 (4.31 ha)	Brush fair condition	1.44	60	58.7
	Wood/brush good cond.	1.44	55	
	Open Space (grass)	1.43	61	

C-PRE2 (4.65 ha)	Brush fair condition	1.55	60	58.7
	Wood/brush good cond.	1.55	55	
	Open Space (grass)	1.55	61	

5.3. Pre-Development Runoff

As previously indicated, the runoff criteria from a quantity control perspective were given as: post-development peak runoff rates are to be equal to or less than pre-development levels for all quantity control storms up to and including the 100 year storm event; and surface runoff volumes are to be minimized through infiltration techniques.

The pre-development peak runoff rate and runoff volume were calculated using the OTTHYMO model. Table 5-3 summarizes the pre-development peak runoff rate and runoff volumes calculated using the OTTHYMO model. Appendix E contains pre-development OTTHYMO summary output data as well as the detailed output data for the last link in the model. The detailed output data for the last link provides a summary of the predevelopment outflow from the proposed development including off site catchment areas.

Table 5-3: Pre-Development Runoff Rates and Runoff Volumes

Design Storm Event		Pre-Development Runoff Rate	Runoff Volume
		(m^3/s)	**(mm)**
Sim 1	6 hour 5 year SCS Type II	0.090	6.2
Sim 2	6 hour 100 year SCS Type II	0.335	21.3
Sim 3	12 hour 5 year SCS Type II	0.105	8.5
Sim 4	12 hour 10 year SCS Type II	0.158	12.3
Sim 5	12 hour 100 year SCS Type II	0.355	26.0
Sim 6	12 hour 2 year Chicago	0.037	3.9
Sim 7	12 hour 100 year Chicago	0.329	24.9
Sim 8	Historical Storm July 1, 1979	0.445	19.8
Sim 9	Historical Storm August 4, 1988	0.354	18.2
Sim 10	25mm 4 hour Chicago	0.008	0.6

6. POST-DEVELOPMENT MODEL

6.1. Post-Development Catchment Areas

6.1.1. Adjacent Off Site Properties

The offsite catchment areas delineated in section 5.1.1 will not be significantly altered as a result of the proposed development. As such, the offsite catchments delineated to model pre-development conditions were used without alteration in the post-development model.

6.1.2. Onsite Post-Development Catchment Areas

6.1.2.1. Post-development Conditions

The proposed development has a total site area of approximately 9.0 hectares and will be divided into eight residential lots with a minimum lot size of 0.8 hectares for a single family dwelling construction. During post-development conditions, the runoff originating on each lot will be divided and will be either directed across the front yard to the roadside ditch or across the back yard to the swale along the rear property lines. Based on the proposed grading plan, it is anticipated that the front yards and the portion of the rear yard beside and immediately behind the proposed dwelling will be completely developed and regraded. These regraded portions of the lot will be surfaced with a maintained lawn upon completion of development. The remaining areas of the rear yards are expected to be left in a more natural condition resulting in an unmaintained condition.

6.1.2.2. Delineation of Catchments and Runoff Curve Numbers

In order to model the post-development conditions onsite, the proposed development area was divided into a total of 16 catchment areas. These catchments were delineated on a lot by lot basis such that the area of each lot draining towards the proposed road was considered as one catchment and the lot area directing runoff to the rear of the lot was considered as a second catchment for each lot. It is considered that the runoff from the roofs of the proposed dwellings will be directed towards the front yard by means of downspouts. The half of the road allowance for the proposed roadway immediately adjacent each lot was also included within the front yard catchment.

Based on the ground surface cover the Runoff Curve Numbers for the onsite pre-development conditions are as shown in Table 6-1.

Table 6-1: Post-Development Runoff Curve Numbers – Onsite Areas

Catchment	Total Area (ha)	Maintained Lawn CN = 61	Impervious CN=98	Unmaintained Rear Yard CN = 60	Wood Good Cond. CN = 55	Weighted Average CN
		Area (ha)	Area (ha)	Area (ha)	Area (ha)	
C1	0.496	0.110	0.0	0.386	0.0	60.2
C2	0.503	0.110	0.0	0.393	0.0	60.2
C3	0.510	0.110	0.0	0.400	0.0	60.2
C4	1.676	0.575	0.0	0.851	0.250	59.6
C5	1.408	0.680	0.0	0.542	0.186	59.8
C6	0.501	0.150	0.0	0.351	0.0	60.3
C7	0.501	0.110	0.0	0.391	0.0	60.2
C8	0.493	0.110	0.0	0.383	0.0	60.2
C9	0.359	0.297	0.062	0.000	0.0	67.4
C10	0.376	0.314	0.062	0.000	0.0	67.1
C11	0.377	0.315	0.062	0.000	0.0	67.1
C12	0.295	0.223	0.072	0.000	0.0	70.0
C13	0.340	0.268	0.072	0.000	0.0	68.8
C14	0.363	0.301	0.062	0.000	0.0	67.3
C15	0.376	0.314	0.062	0.000	0.0	67.1
C16	0.387	0.325	0.062	0.000	0.0	66.9

6.1.2.3. Comparison of Pre- to Post- Development Onsite Conditions

As previously indicated, the pre-development onsite catchments were divided about the centre of the proposed roadway. The above catchments were combined into two post-development areas matching the pre-development catchments in order to directly compare the pre- and post- development runoff curve numbers to illustrate the affect of the proposed development on the Runoff Curve Numbers. This comparison is provided in Table 6-2.

Table 6-2: Comparison of Pre- to Post-Development Runoff Curve Numbers

Catchment	Total Area (ha)	Maintained Lawn CN = 61 Area (ha)	Impervious CN=98 Area (ha)	Unmain. Rear Yard CN = 60 Area (ha)	Wood Good Cond. CN = 55 Area (ha)	Weighted Average CN
North Side						
C-PRE1	4.311	1.437	0.000	1.437	1.437	58.7
Post	4.311	2.200	0.258	1.667	0.186	62.6
South side						
C-PRE2	4.650	1.550	0.000	1.550	1.550	58.7
Post	4.650	2.113	0.258	2.029	0.250	62.3

6.2. Stormwater Conveyance

6.2.1. Proposed Swales

Runoff for each lot will be managed as follows: Runoff originating from the front portion of each lot including all the impervious areas resulting from the construction of the proposed dwellings and driveways will be directed to the road side ditches along the subdivision roadway. This runoff will be conveyed to the stormwater management swale which extends east from the end of the cul-de-sac.

Any disturbed areas in the rear portion of the site will be rehabilitated and leveled to ensure any runoff is in the form of sheet flow. The sheet flow from the rear of the sites along the south side of the development will be directed to a proposed swale along the south side of the site. This swale will discharge into the stormwater management swale downstream of the outlet control. Runoff from the rear of the sites along the northwest side of the development as well as from the off-site area northwest of the development will be directed by means of a drainage swale constructed along the rear property lines of these lots. The swale will outlet to the stormwater management swale extended from the cul-de-sac downstream of the outlet control and will replace the existing swale currently directing this runoff to the Harwood Creek.

6.2.2. Limits to Longitudinal Slope of Swales

The swale along the north side of the proposed development is required to intersect and convey off site runoff occurring during the existing conditions. This means that the bottom of the swale plus a minimum swale depth must be below the existing ground surface. This results in a maximum elevation at the start of the channel section due to actual physical constraints which cannot be altered because the constraints are established by the ground surface elevation of the adjacent private property. The outlet elevation is fixed by the normal flow conditions and bottom elevation of the receiving water course. In a similar manner, the maximum bottom of swale elevation along the south side of the site is also fixed by existing conditions and is limited such that the bottom of the swale is below the existing ground surface in order to receive runoff from the adjacent surface areas.

Due to these limiting constraints there will be sections of the proposed swales with longitudinal slopes of 0.2% which is less than the minimum recommended longitudinal slope of 0.5%. It is considered that these low slopes in the swales will result in insufficient slope to ensure that there are no localized high or low spots within the swale channel. These localized high and low spots or undulations along the length of the channel bottom will result in ponded water in some sections along the bottom of the swales following a rainfall event. Assuming that the longitudinal grading of the channel bottom is completed in a manner which will provide as close to continuous positive drainage as possible, the height of the undulations is expected to be less than 0.1 metres. This ponding will occur during any rainfall event of with enough significance to generate runoff at the site.

Based on the sandy silt and glacial till materials encountered at the site, the coefficient of permeability k for the native soils at the site is expected to be in the order of $k=4x10^{-5}$ m/s. Based on this permeability, it is expected that the infiltration rate through the bottom of the swales will be in the order of 0.02 $m^3/hr/m^2$ of swale bottom. The duration of the localized ponding, assuming 0.1 metres of ponding depth and infiltration into the upper 0.3 metres below the swale bottom, can be estimated as follows:

$q = ki$; $k = 1 \times 10^{-3}$ cm/sec; $i = ((h+d/d) = 1.33$ where d is the upper 0.3 m of soil below the storage area and h is the ponding depth of 0.1 m. At a flow rate of 0.02 $m^3/hr/m^2$ it is estimated that a 0.1 m deep puddle would infiltrate in about 5 hours.

It is expected that seasonally high ground water levels may affect the rate of infiltration through the bottom of the swales. However it is also expected that any ponding within the swales will dissipate under normal conditions due to infiltration.

6.2.3. Description of Main Swales

There are five main swales proposed for the site. These swales consist of:

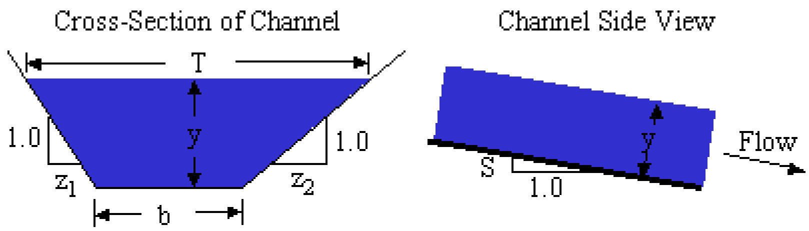
1. The north swale begins near Dunrobin Road and is located along the north side of the site. A review of the proposed grading plan indicates that the flow in the Dunrobin Road ditch adjacent the north half of the site is directed to the proposed roadside ditch along

the north side of the proposed roadway. Based on the proposed grading, the flow in the north swale will be negligible at the west end or beginning of the swale and will increase in magnitude to a maximum at the east end of the swale. The north swale has a bottom width of 1.0 m and a slope which ranges from 2.4% to 0.2%. With the exception of the first about 20 m, the swale depth ranges from about 0.4 m to 0.7 m.

2. The south swale begins near Dunrobin Road and is located along the south side of the site. A review of the proposed grading plan indicates that the flow in the Dunrobin Road ditch adjacent the south half of the site is directed to the proposed roadside ditch along the south side of the proposed roadway. Based on the proposed grading, the flow in the south swale will be negligible at the west end or beginning of the swale and will increase in magnitude to a maximum at the east end of the swale. The south swale has a bottom width of 1.0 m and a slope which ranges from 3.2% to 0.3%. With the exception of the first about 20 m, the swale depth ranges from about 0.32 m to 0.7 m.
3. The east swale continues from the north swale at the northeast corner of the site and discharges into the outlet swale at about the center of the east end of the site. The east swale swale has a bottom width of 1.0 m and a slope of 0.2%. The swale depth ranges from about 0.49 m to 0.7 m.
4. The stormwater storage swale begins at the east end of the cul-de-sac and discharges into the outlets swale near the east end of the site. The stormwater storage swale will be discussed in detail in Section 7.2.
5. The outlet swale begins at the east end of the storage swale, extends east to the east end of the site then south to discharge into Harwood Creek. The outlet swale receives flow from the storage swale, north swale and south swale at various points along its length. The outlet swale has a bottom width of 1.0 m and a slope which ranges from 1.5% to 0.4%. The swale depth ranges from 0.7 m to 1.5 m.

6.2.4. Capacity and Flow Level in the Main Swales

The capacity and flow depth were determined using the equations for open channel flow shown below. A Manning's roughness coefficient for open channel flow of n = 0.035 was obtained from the OSDG Appendix 6-C assuming an earth channel with a fairly uniform section that will not be maintained resulting in dense weeds and grass. The swales will in general have side slopes of 3H to 1V.



$$Q=VA \qquad V=\frac{k}{n}R^{2/3}S^{1/2} \qquad R=\frac{A}{P} \qquad A=\frac{y}{2}(b+T)$$

$$P=b+y\left(\sqrt{1+z_1^2}+\sqrt{1+z_2^2}\right) \qquad T=b+y(z_1+z_2)$$

$$F=V\sqrt{\frac{T}{gA\cos\theta}} \qquad \theta=Tan^{-1}(S)$$

The design storm events are listed below and abbreviated in the table as follows:
12 hour 10 year SCS Type II - 12-10
12 hour 100 year SCS Type II - 12-100

Swale sections are abbreviated in the table as follows:
North swale behind Lot 1 is North 1; South swale behind Lot 2 is South 2; Outlet Swale between Lot 7 and Lot 8 is Outlet 7/8 etc.

The following Table 6-3 provides a summary of the capacity and flow level along the above swales for the 10 year and 100 year SCS Type II design storms.

Table 6-3: Capacity and Flow Level in Main Swales

Swale Section	Storm Event	Contributing Catchment / Swale Section	Flow Rate	Flow Depth	Flow Vel.	Min. Slope	Min. Available Depth	Min Capacity
			m^3/sec	m	m/s	%	m	m^3/sec
North 1	12-10	C8	0.014	0.06	0.25	0.4	0.44	0.89
	12-100		0.030	0.08	0.29			
North 3	12-10	North 1 + C7	0.020	0.06	0.33	0.7	0.55	1.65
	12-100		0.044	0.09	0.42			
North 5	12-10	North 3 + C6	0.027	0.08	0.29	0.4	0.48	0.93
	12-100		0.061	0.12	0.37			
North 7	12-10	North 5 + C5	0.082	0.17	0.32	0.2	0.47	0.63
	12-100		0.187	0.26	0.40			

South 2	12-10	C1	0.015	0.04	0.42	1.8	0.59	3.08
	12-100		0.033	0.06	0.53			
South 4	12-10	South 2 + C2	0.025	0.07	0.36	0.7	0.61	2.07
	12-100		0.056	0.10	0.44			
South 6	12-10	South 4 + C3	0.033	0.10	0.29	0.3	0.47	0.77
	12-100		0.074	0.15	0.36			
South 8	12-10	South 6 + C4	0.049	0.12	0.32	0.3	0.32	0.34
	12-100		0.108	0.18	0.40			
East 7	12-10	North 7	0.082	0.17	0.32	0.2	0.51	0.75
	12-100		0.187	0.26	0.40			
Outlet 7/8	12-2	Storage Swale (SS)	0.005	0.02	0.25	1.5	0.7	4.12
	12-10		0.027	0.06	0.48			
	12-100		0.062	0.09	0.60			
Outlet 8	12-2	East 7 + SS	0.011	0.05	0.22	0.4	0.94	4.18
	12-10		0.091	0.15	0.42			
	12-100		0.227	0.24	0.54			
Outlet SE Corner	12-2	Outlet 8 + South 8	0.017	0.06	0.25	0.4	0.8	2.88
	12-10		0.137	0.19	0.48			
	12-100		0.332	0.29	0.60			

The above summary of results, which indicates the flow depth during various storm events as well as the available depth along each section of the swales, demonstrates that the flow from the 100 year storm event will be conveyed within the drainage swales without overflow.

6.3. Conveyance Along Roadside Ditches

6.3.1. Proposed and Existing Ditches

As previously indicated, the runoff from the front of each lot will be conveyed along the proposed roadside ditches to the stormwater storage swale extending east from the cul-de-sac. The ditch along the north side of the proposed roadway will receive runoff from the section of ditch along the east side of Dunrobin Road immediately west of Lot 1 and from the front of Lots 1, 3, 5 and 7. The ditch along the south side of the proposed roadway will receive runoff the section of ditch along the east side of Dunrobin Road immediately west of Lot 2 and from the front of Lots 2, 4, 6 and 8.

The existing ditch along the east side of Dunrobin Road adjacent the site has a discontinuous longitudinal slope. The height of the back slope along this section varies along the existing ditch from undefined to about 0.3 metres in height. In order to prevent stormwater runoff originating on public property from flowing across private land, the east ditch of Dunrobin Road will be re-sloped adjacent to Lot 1 and Lot 2 to direct the runoff to the ditches along the proposed roadway. The height of the back slope will be increased to a minimum of 0.5 metres to prevent runoff from the public road being directed onto private lands.

The ditches along the proposed roadway have been designed with a "V" shaped bottom and have 3H:1V side slopes. With the exception of the portion of the ditch along the north side of the proposed roadway to Station 0+080 and the ditches around the proposed cul-de-sac, the ditches for the proposed roadway have been designed to have a slope greater than 1%. The slope along the first section of the north ditch was reduced in order to facilitate continuous drainage of the ditch along the east side of Dunrobin Road adjacent to Lot 1. The slope of the ditch around the cul-de-sac has been reduced to between 0.9% and 0.2% in order to maintain a bottom elevation above the 100 year flood level of the backwater flood plain.

The proposed slope of the re-graded ditch bottom along Dunrobin road varies from 0.5% south of the proposed roadway to 0.3% north of the proposed roadway. The bottom slope of the ditch is limited by the existing grades.

6.3.2. Limits to Longitudinal Slope of Ditches

As discussed in Section 6.2.2 above, the constraints cause by existing conditions external to the proposed development will limit the slope of some sections of the ditch to less than 1% and less than 0.5% in some cases. As discussed above, this reduced slope will likely result in some discontinuous positive grading in the downstream direction which in turn will result in localized ponding at the bottom of the ditches. It is considered that the depth of this ponding will be limited by the relative difference between the undulations and that the ponding will occur during any rainfall event of significant magnitude to generate runoff. The duration of the ponding is expected to be limited.

6.3.3. Capacity and Flow Level in the Ditches

The capacity and flow depth were determined using the equations for open channel flow provided above. A Manning's roughness coefficient for open channel flow of n = 0.03 was obtained from the OSDG Appendix 6-C assuming an earth channel with a fairly uniform section that will be moderately maintained resulting in grass, some weeds.

The Ditch sections are abbreviated in the table as follows:
Ditch along the east side of Dunrobin Road west of Lot 1 is Dunrobin 1; The proposed ditch along the south side of the proposed road adjacent to Lot 2 is South 2; The proposed ditch along the north side of the proposed road adjacent to Lot 1 is North 1 etc.

The 25 mm 4 hour Chicago quality control design storm has been added to the table and is abbreviated in the table as 25mm.

The following Table 6-4 provides a summary of the capacity and flow level along the proposed and regraded ditches for the 10 year and 100 year SCS Type II design storms.

Table 6-4: Capacity and Flow Level in Proposed Ditches

Swale Section	Storm Event	Contributing Catchment / Swale Section	Flow Rate	Flow Depth	Flow Vel.	Min. Slope	Min. Avail. Depth	Min Capacity
			m^3/sec	m	m/s	%	m	m^3/sec
Dunrobin 1	12-10	CA	0.009	0.11	0.25	0.3	0.5	0.52
	12-100		0.017	0.14	0.30			
Dunrobin 2	12-10	CB	0.010	0.11	0.33	0.5	0.5	0.68
	12-100		0.017	0.13	0.37			
North 1	12-10	Dunrobin 1 + C9	0.022	0.16	0.33	0.3	0.81	1.89
	12-100		0.043	0.20	0.38			
North 3	12-10	North 1 + C10	0.035	0.14	0.57	1.1	0.82	3.76
	12-100		0.070	0.19	0.70			
North 5	25mm	North 3 + C11	0.002	0.05	0.28	1.0	0.80	3.35
	12-10		0.048	0.16	0.60			
	12-100		0.096	0.21	0.72			
North 7	25mm	North 5 + C12	0.004	0.09	0.18	0.2	0.81	1.55
	12-10		0.059	0.24	0.35			
	12-100		0.119	0.31	0.42			
South 2	12-10	Dunrobin 2 + C16	0.023	0.12	0.52	1.1	0.83	3.88
	12-100		0.044	0.16	0.63			
South 4	12-10	South 2 + C15	0.036	0.14	0.57	1.1	0.84	4.01
	12-100		0.071	0.19	0.70			
South 6	25mm	South 4 + C14	0.003	0.06	0.31	1.0	0.81	3.47
	12-10		0.048	0.16	0.60			
	12-100		0.097	0.21	0.72			
South 8	25mm	South 6 + C13	0.004	0.08	0.24	0.4	0.83	2.34
	12-10		0.062	0.22	0.47			
	12-100		0.124	0.28	0.55			

The above results, which indicate the flow depth for various storm events as well as the minimum available depth along each section of the ditches, demonstrate that the flow from the 100 year storm event is conveyed within the ditches.

6.4. Unmitigated Post-Development Runoff

The post-development peak runoff rate and runoff volume were calculated using the OTTHYMO model assuming no mitigation or detention and storage of the runoff. Table 6-5 summarizes the unmitigated post-development peak runoff rate and runoff volumes calculated using the OTTHYMO model.

Table 6-5: Unmitigated Post-Development Runoff Rates and Runoff Volumes

Design Storm Event		**Post-Development Runoff Rate**	**Runoff Volume**
		(m^3/s)	**(mm)**
Sim 1	6 hour 5 year SCS Type II	0.123	7.5
Sim 2	6 hour 100 year SCS Type II	0.446	24.3
Sim 3	12 hour 5 year SCS Type II	0.150	10.1
Sim 4	12 hour 10 year SCS Type II	0.227	14.3
Sim 5	12 hour 100 year SCS Type II	0.498	29.3
Sim 6	12 hour 2 year Chicago	0.055	4.9
Sim 7	12 hour 100 year Chicago	0.482	28.1
Sim 8	Historical Storm July 1, 1979	0.609	22.7
Sim 9	Historical Storm August 4, 1988	0.544	20.9
Sim 10	25mm 4 hour Chicago	0.011	1.0

Comparison of the OTTHYMO model results provided in Table 6-5 to the OTTHYMO model results provided in Table 5-3 indicate that the post-development runoff rates and volumes are higher than the pre-development runoff rates and volumes for all storm events if no stormwater management controls are provided during post-development conditions.

7. Post-Development Quantity Control – Flow Rate

As previously indicated, the post-development flow rate will be restricted such that the maximum runoff rate from the subdivision area during post-development conditions will be less than or equal to the pre-development flow rate for each storm event up to and including the 100 year design storm event.

Due to the increased impervious area and decreased time of concentration resulting from the proposed development, the post-development unrestricted runoff rates from the site will be much greater than the pre-development runoff rates. This is apparent when comparing the runoff rates provided in Table 6-5 to those provided in Table 5-3.

In order to meet the stormwater management criteria for the site with respect to runoff rate, temporary flow detention will be provided by means of directing the runoff from the front yards and proposed roadway to the proposed stormwater storage swale at the east end of the cul-de-sac and restricting the discharge rate from the storage swale.

7.1.1. Controlled and Uncontrolled Areas

The uncontrolled catchment areas consist of the catchment areas from which runoff exits the site without restriction to the runoff rate. For the purposes of the stormwater management design the uncontrolled areas consist of the rear yard catchments and the offsite catchment area C-OFF1 north of the proposed development. Even though the runoff is collected by the north and south swales, there is no restriction to the flow rate in the swales. As such, the discharge from these swales to the outlet swale is unrestricted and uncontrolled. The controlled areas are those areas from which the runoff is collected and directed to the proposed stormwater storage swale. These areas consist of the Dunrobin Road Catchments C-A and C-B as well as the front yard catchments.

7.1.2. Stormwater Storage Swale

Stormwater storage for the purposes of restricting the post-development runoff rate to the pre-development runoff rate for each storm event will be provided within the stormwater storage swale extending east from the cul-de-sac. The proposed storage swale has been designed in conjunction with the quality control criteria to ensure that both the quantity and quality control criteria will be met.

It is noted that the bottom of the stormwater storage swale will be constructed with no slope at an elevation of 75.45 m which is 3 cm below the 100 year flood level of the backwater flood plain of the Harwood Creek. The invert of the lower orifice in the outlet pipe from the storage swale has been set at 75.61 m or 16 cm above the bottom of the storage swale and 13 cm above the 100 year flood level. As such, the 100 year flood level will have no impact on the discharge from the storage swale.

Since the bottom of the storage swale is 16 cm below the lowest outlet elevation, outlet for the first 72.1 m^3 of stored water will be by infiltration only.

The stormwater storage swale has been designed as follows:

- The bottom of the storage swale extends downward from an elevation of 75.60 m at the bottom of the roadside ditch at the east end of the cul-de-sac at a slope of 1.1 percent for a distance of 14.1 m to the flat portion of the swale.
- The flat portion of the bottom of the storage swale has an elevation of 75.45 metres, a bottom width of 5 metres and a length of 76.5 m.
- The storage swale has been constructed with depth of 0.97 metres and side slopes of about 3 horizontal to 1 vertical.
- Discharge from the swale will be controlled by an outlet structure at the east end of the storage swale. Details of the outlet structure are provided in Section 7.3 of this report.
- Overflow from the storage swale will be over the north side of the swale and will be directed northeast to the east swale.
- The topsoil should be removed from below the footprint of the proposed storage swale and stockpiled on the upper third (west third) of the site.
- Once the topsoil has been removed, the bottom of the storage swale is expected to be between 0.4 and 0.8 metres above the subgrade surface. The subgrade should be further excavated as required to ensure a minimum of 0.45 m of separation between the bottom of the swale and the native subgrade.
- The subgrade surface should be scarified or ripped using the teeth of an excavator following removal of the topsoil.
- The subgrade should be built up to 0.45 metres below the bottom of the storage swale using a sandy material such as the native silty sand or silty sand glacial till present on site. Alternatively silty sands or sand-silt mixes identified as SM using the United Soils Classification System as illustrated in the Ontario Building Code Supplementary Standard SB-6 could be imported to raise the subgrade to the underside of the storage swale bottom soil structure.
- The storage bottom soil structure should consist of a layer of 150 mm thickness of 20mm clear stone placed on the fill materials used to raise the subgrade, topped with a 300 mm thickness of amended existing site topsoil.
- The existing site topsoil can be stripped and stock piled prior to amending. The site topsoil should be amended by mixing 1 part amendment material with 3 parts by volume of site topsoil. The amendment material shall consist of organic matter primarily leaf, yard and bark waste compost of 20 – 30% by dry weight as determined by Loss-on-ignition. No uncomposted manure should be used.
- The swale shall be seeded with deep rooted grasses and planted with vegetation that can tolerate both wet and dry soil conditions.
- Discharge from the swale below an elevation of 75.61 metres is by infiltration only.

The physical characteristics of the stormwater storage swale and outlet control will result in the storage - discharge relationship as indicated in Figure 7-1 in the following section.

7.1.3. Outlet Control and Allowable Release Rate

The flow rate from the storage swale will be restricted such that the maximum runoff rate from the proposed development including offsite catchment areas during post-development conditions will be less than or equal to the pre-development flow rate from the proposed development area including the offsite catchment areas during corresponding storm events up to and including the 100 year storm event. The release rate from the stormwater storage swale will be controlled by means of an outlet control structure.

The maximum flow rate that could be discharged from the stormwater storage swale during each storm event such that the total runoff rate from the site during post-development conditions is less than that for pre-development conditions would correspond to the allowable release rate from the controlled catchment areas of the development.

The outlet control structure will consist of a 525 mm diameter double wall HDPE (R320) outlet culvert complete with a concrete headwall placed at the east end of the storage swale. The culvert will have an inlet invert of 75.55 m. The culvert will be fitted with a cap across the inlet of the culvert through which two orifice openings will be cut. The lower orifice will have an invert of 75.61 m and a diameter of 100mm. The upper orifice will have an invert of 75.82 m and a diameter of 200 mm.

The discharge rates through the orifices were calculated using the equation:

$$Q = \frac{0.72\sqrt{2gD^5}}{[(C_w\eta^{1.98})^{-2.14} + (C_d\eta^{0.52})^{-2.14}]^{0.4673}}$$

This is a calculation that unifies flow through a partially full orifice as weir flow with flow through a fully submerged orifice as orifice flow.

Where
- Q = flow (cubic meters per second)
- C_d = Coefficient of Discharge for a sharp orifice = 0.60
- Cw = Coefficient of Discharge for a sharp crested weir = 0.62
- D = Orifice diameter (m)
- η = y/D
- Y = water-head relative to orifice invert (m)
- g = acceleration from gravity (9.81 m/s^2)

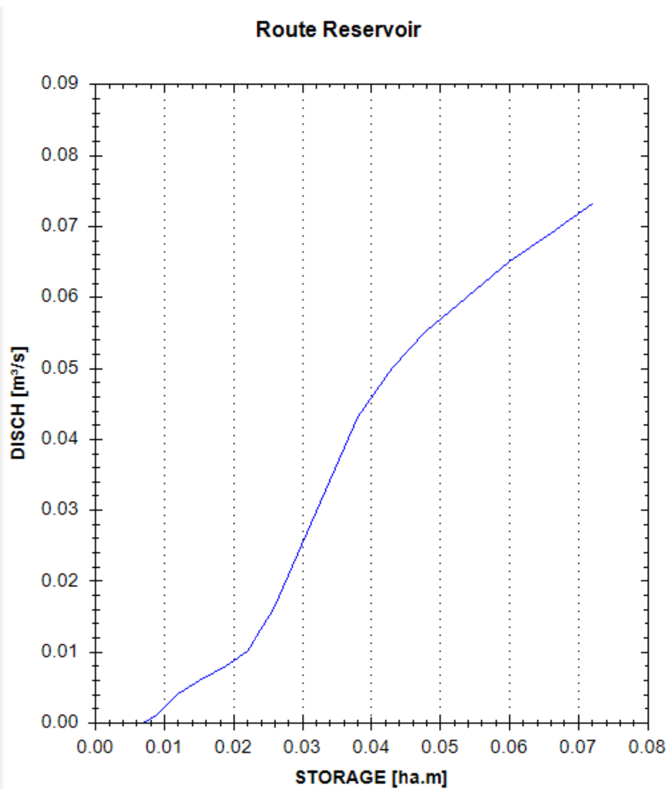
The size and elevation of the two orifices were determined by iteration. In a relatively large storm water storage facility, it is generally assumed that the hydraulic gradient is a function of the water surface elevation only. Since the discharge rate Q is a function of the depth of water-head relative to the orifice inverts, the discharge rate will be directly related to the water surface elevation relative to the orifice inverts. The volume of the storage swale is also directly related to the depth of water or water surface elevation. Since the discharge rate and storage swale volume are both related, a Discharge vs Storage curve can be developed. A discharge storage curve was developed in excel and was then programmed into the Route Reservoir block within the OTTHYMO hydrologic model. This process was repeated by varying the orifice sizes and/or inverts until the model produced post-development peak flow rates less than or equal to pre-development peak flow rates for each design storm up to and including the 100 year event.

The stormwater storage swale and outlet structure are modeled in the OTTHYMO program using a Route Reservoir Hydrograph command inserted between the proposed roadside ditch channels, receiving the runoff from the front yard catchments, and the outlet swale.

The detailed worksheet has been included in Appendix F. Figure 7-1 below illustrates the storage-discharge relationship that was copied into the Route Resevoir command (NHYD 29) within the OTTHYMO model to obtain the post-development results summarized in Table 7-1 below.

Figure 7-1: Wetland Storage-Discharge Relationship

	DISCH [m³/s]	STORAGE [ha.m]
1	0.00000	0.00000
2	0.00000	0.00200
3	0.00000	0.00400
4	0.00000	0.00700
5	0.00100	0.00900
6	0.00400	0.01200
7	0.00600	0.01500
8	0.00800	0.01900
9	0.01000	0.02200
10	0.01600	0.02600
11	0.02500	0.03000
12	0.03400	0.03400
13	0.04300	0.03800
14	0.05000	0.04300
15	0.05500	0.04800
16	0.06000	0.05400
17	0.06500	0.06000
18	0.06900	0.06600
19	0.07300	0.07200
20		



Discharge from the Outlet control structure will enter the outlet swale which in turn discharges to the Harwood Creek.

7.2. Mitigated or Controlled Post Development Runoff

The mitigated post-development runoff rate from the proposed development calculated using the OTTHYMO model after the insertion of the Route Reservoir Hydrograph command to control the runoff rate from the front yards and roadways is summarized in Table 7-1. This table also provides a comparison to the pre-development runoff rates.

Table 7-1: Mitigated Post-Development Runoff Rates and Runoff Volumes

Design Storm Event		**Post-Development Runoff**		**Pre-Development Runoff Rate**	**Post < Pre**
		Volume	**Rate**		
		(mm)	**(m^3/s)**	**(m^3/s)**	
Sim 1	6 hour 5 year SCS Type II	6.86	0.077	0.090	Yes
Sim 2	6 hour 100 year SCS Type II	23.59	0.309	0.335	Yes
Sim 3	12 hour 5 year SCS Type II	9.42	0.089	0.105	Yes
Sim 4	12 hour 10 year SCS Type II	13.69	0.137	0.158	Yes
Sim 5	12 hour 100 year SCS Type II	28.63	0.331	0.355	Yes
Sim 6	12 hour 2 year Chicago	4.21	0.028	0.090	Yes
Sim 7	12 hour 100 year Chicago	27.43	0.311	0.329	Yes
Sim 8	Historical Storm July 1, 1979	21.98	0.413	0.445	Yes
Sim 9	Historical Storm Aug. 4, 1988	20.18	0.350	0.354	Yes
Sim 10	25mm 4 hour Chicago	0.47	0.006	0.008	Yes

A review of the above table indicates that the proposed stormwater storage swale and outlet control configuration effectively mitigate the post-development runoff rate to less that occurring during pre-development conditions for all storm events.

Appendix G contains post-development OTTHYMO summary output data. Also included in Appendix G is the detailed output data for the last link in the model. The detailed output data for the last link provides a summary of the post-development outflow from the proposed development including off site catchment areas.

7.3. Storage Requirements

The OTTHYMO model Route Reservoir Report is provided in Appendix H. The storage requirements for the various storm events, obtained from the from the route reservoir block which models the stormwater storage swale, are shown in the following Table 7-2.

Table 7-2: Storage Requirements

Design Storm Event		Max. Storage	Max. Ponding Elev.	Storage Drawdown Time	Peak Discharge Rate
		m^3	m	hrs	m^3/s
Sim. 1	6 hour 5 year SCS Type II	230	75.86	36	0.012
Sim. 2	6 hour 100 year SCS Type II	540	76.20	52.5	0.060
Sim. 3	12 hour 5 year SCS Type II	244	75.88	37.5	0.014
Sim. 4	12 hour 10 year SCS Type II	310	75.96	42	0.027
Sim. 5	12 hour 100 yr SCS Type II	561	76.22	53.5	0.062
Sim. 6	12 hour 2 year Chicago	131	75.71	23.5	0.005
Sim. 7	12 hour 100 year Chicago	509	76.17	51.5	0.057
Sim. 8	Historical Storm July 1, 1979	650	76.29	57.5	0.068
Sim. 9	Historical August 4, 1988	511	76.17	51.5	0.058
Sim. 10	25mm 4 hour Chicago	55	75.57	9	0.000

The invert of the lowest orifice in the outlet pipe form the storage swale has been set at an elevation of 75.61 meters resulting in a storage volume of 72.1 cubic metres below the outlet. There is a total available quantity storage volume of 722.8 cubic metres within the storage swale below an elevation of 76.35 metres.

The maximum storage requirement of 650 cubic metres occurs during the July 1, 1979 historical storm. The maximum storage requirement during a 100 year storm event is 561 cubic metres. The minimum modeled storage requirement is 55 cubic meters during a 25 mm 4 hr Chicago storm. The maximum drawdown time is equal to 57.5 hours during a historical storm and 53.5 hours during a 100 year storm event.

Since the maximum storage requirement is less than the maximum available storage volume there is sufficient storage volume available within the proposed storage swale.

8. Quantity Control – Additional Criteria

The stormwater management criteria from a quantity control perspective also included the following imprecisely defined criteria: Surface runoff volumes are to be minimized through infiltration techniques and incorporate low impact design techniques where possible. Common low impact design practices include: bioretention cells, permeable pavement, infiltration trenches and chambers, enhanced swales, reduced swale slopes, rainwater harvesting and green roofs. Practices such as permeable pavement, rainwater harvesting and green roofs are not practical to enforce or design within the context of privately owned rural residential lots.

A Subwatershed Study was not identified for either the Harwood Creek or Constance Creek watersheds. A review of a number of available subwatershed studies for subwatersheds within Ottawa was completed to determine common goals and objectives of the recommendations for various subwatersheds. From this review of the studies, the common goals were divided into the following categories: 1) Surface/Groundwater Quantity; 2) Surface/Groundwater Quality; 3) Aquatic Resources; 4) Terrestrial Resources. Each category had its own objectives. Reviewing the objectives indicates that the majority of the objectives are centered on reducing flood risk and protecting groundwater supplies and groundwater base flow by reducing runoff, increasing infiltration and maintaining healthy aquatic and terrestrial communities.

8.1. Incorporation of Low Impact Design Techniques

The proposed development has incorporated elements of the common low impact design practices which will result in meeting some of the common objectives of the recommendations in the subwatershed studies. These elements include the low sloped swales along the north, south and east sides of the development. The low slope increases the travel time within the swale promoting infiltration. In addition, the localized shallow ponding caused by undulations along the channel bottoms results in additional infiltration as the ponded water will either infiltrate or evaporate.

The stormwater storage swale has been designed, in part, as a bioretention swale or infiltration basin and will retain stored water below the outlet to provide quality control by infiltration. As discussed in Section 9.3.2.6 below, the proposed seeding within the stormwater storage swale is intended for wet meadow or storm pond applications and can withstand emergent and flooding conditions. The vegetation will consist of a mix of native species designed to promote wildlife habitat and a healthy terrestrial community.

8.2. Reduction in Volume

Restricting the post-development flow rate to pre-development conditions controls the runoff rate to reduce the impact of the peak flow rate from the site to the receiving watercourse. This reduction in runoff rate is achieved by providing temporary storage on site, which is discharged at a restricted rate over a period of time during and following the storm event. The additional low impact design elements serve to increase the infiltration and reduce the post-development runoff volume from the site. The runoff volumes calculated using the OTTHYMO model during the various conditions of development are presented in the following Table 8-1

Table 8-1: Comparison of Pre- to Post-Development Runoff Volume

Design Storm Event	Pre-Dev. Volume		Mitigated * Post-Dev. Volume (2)		Difference Post- to Pre- (3)
	(mm) (1)	(m^3)	(mm) (1)	(m^3)	(m^3)
6 hour 5 year SCS Type II	6.2	681	6.86	754	73
6 hour 100 year SCS Type II	21.3	2340	23.59	2592	252
12 hour 5 year SCS Type II	8.5	934	9.42	1035	101
12 hour 10 year SCS Type II	12.3	1351	13.69	1504	153
12 hour 100 yr SCS Type II	26	2856	28.63	3145	289
12 hour 2 year Chicago	3.9	428	4.21	463	35
12 hour 100 year Chicago	24.9	2736	27.43	3013	277
Historical Storm July 1, 1979	19.8	2175	21.98	2415	240
Historical August 4, 1988	18.2	1999	20.18	2217	218
25mm 4 hour Chicago	0.6	66	0.47	52	-14

* Mitigated post-development volume is the result of the inclusion of the storage swale within the model.

1) The runoff volume is calculated by the model in terms of mm per-unit area. The runoff volume from the development area in terms of cubic metres is determined by multiplying the runoff volume in mm by the entire catchment area used in the model which equals 10.986 hectares including uncontrolled areas.

2) These two columns represent the runoff volume determined during post-development conditions using the OTTHYMO model.

3) This column represents the difference between the pre-development runoff volume and the post-development runoff volume in cubic metres from the total catchment area included in the model. Where the value is negative, the post-development runoff volume is less than the pre-development runoff volume.

Table 8-1 demonstrates that the proposed stormwater management design successfully reduces the post-development runoff volume such that there will be no additional runoff volume outlet to Harwood Creek as a result of the proposed development during normal rainfall events. There will be negligible additional runoff volume generated during minor storm events such as the 2 year and 5 year design storm events.

The greatest increase in runoff volume occurs during a 12 hour 100 year design storm and is 289 m^3. This runoff volume corresponds to a flow rate of 0.007 m^3/sec over the duration of the storm event. This flow rate when compared to the peak flow rate in the Harwood Creek of 14.1 m^3/sec at the river station in proximity to the development outlet is less than 0.05% of the 100 year flow in the Creek.

8.3. Summary

The reduced runoff volume from pre-development conditions during normal rainfall events and negligible increase during minor storm events as demonstrated by the model indicates that the proposed development successfully makes use of low impact design techniques to mitigate the results of the increased impervious area caused by the development. The reduced volume indicates that more runoff will infiltrate which will aid in achieving the general objectives of the recommendations within a subwatershed study. The increased infiltration will reduce flood risk and protect groundwater supplies and groundwater base flow.

9. Quality Control

As previously stated, an enhanced level of treatment is required for the runoff from the site. An enhanced level of treatment corresponds to 80 percent total suspended solids removal. The recommended strategy for stormwater management quality control is to provide an integrated treatment train approach. In general, best management practices for stormwater management quality control are divided into three categories: source control, conveyance control and end-of-pipe control.

9.1. Source Control

The primary source of total suspended solids and associated runoff pollution under post-development conditions is considered to the areas of a site subject to vehicle traffic. At the proposed development, this consists of the driveways and roadways. The vegetated landscaped surfaces and dwelling roofs are typically not considered to be significant sources of suspended solids following the completion of the development and establishment of the vegetation in landscaped areas.

The application of de-icing chemicals including salts and sand can be reduced with a best management plan for the application of these products. BMPs with respect to de-icing chemicals include such measures as timing of application, targeted application, and clearing of snow cover before application.

9.2. Conveyance Control

The proposed driveways and subdivision roadway are within the controlled area of the site. In general, runoff generated from the driveways will be directed across the grass surfaced front yards to the roadside ditch in front of the lots. The runoff from the roadways will also be conveyed along the roadside ditches to the storage swale east of the cul-de-sac. The roadside ditches have been designed with a longitudinal slope of which varies from 1.1% to 0.2% (north side) and 1.1% to 0.4% (south side). The low ditch slopes, in general, occur at the cul-de-sac. Due to the low slope and the vegetation within the ditches, the roadside ditches will provide preliminary treatment removing larger suspended solids.

Research has shown that vegetative filters can partially remove sediments and pollutants attached to sediment particles in runoff. Field experiments on vegetative filter strips showed average sediment removal varying from 50 to 98% as flow path length increases from 2.5 to 10 metres. The research indicates that almost all particles larger than 40 microns in diameter are captured within the first five meters of a filter strip provided the flow velocity is limited to less than 0.5 m/s during the quality control storm event. About 50% of the sediments are removed within the first 2.5 m of travel over the vegetative filter flow path. An additional 25% to 45% of sediments are removed within the next 2.5 m of the flow path depending on the flow rate and velocity. The removal efficiency of the vegetative filtration does not significantly increase with a flow path length beyond 10 m.

The MOE Manual considers the quality storm event to be the 4 hr 25 mm Chicago storm. From Table 6-5 Section 6.3.3 above, the flow rate and flow velocity during the 4 hr 25 mm Chicago storm in the eastern sections of the proposed roadside ditch are as summarized in the following Table 9-1:

Table 9-1: Flow Rate, Velocity and Depth along Roadside Ditches.

Ditch Section	Flow Rate (m^3/s)	Flow Velocity (m/s)	Flow Depth (m)
North 5	0.002	0.28	0.05
North 7	0.004	0.18	0.09
South 6	0.003	0.31	0.06
South 8	0.004	0.24	0.08

The results in the above table indicate that the flow velocity in the ditches will be well below the critical velocity of 0.5 m/s which means that the ditches will provide effective vegetative filtration.

Section 4.5.9 of the MOE Manual provides the design guidance with respect to the use of Grassed Swales to achieve quality control. The flow criteria has been summarized in the following Table 9-2. A column has been added to indicate how the proposed design conforms to the Criteria.

Table 9-2: Summary of MOE Flow Criteria for Grassed Swales and Conformance

Design Element	**Design Objective**	**Minimum Criteria**	**Maximum as Designed***
SWALES – OUTLET SWALE			
Flow Criteria	Required to Achieve Quality control		
Peak Flow Velocity	Facilitate Sedimentation and vegetative filtration	< 0.5 m/s	0.48 m/s during 10 year storm
Flow Depth	Promote Vegetative Filtration	< 0.5 m	0.19 m during 10 year storm
Flow Rate	Sedimentation and prevent re-suspension	≤ 0.15 m^3/s	0.137 m^3/s during 10 year storm
DITCHES			
Flow Criteria	Required to Achieve Quality control		
Peak Flow Velocity	Facilitate Sedimentation and vegetative filtration	< 0.5 m/s	0.28 m/s during quality control storm 0.44 m/s during 2 year storm 0.60 m/s during 10 year storm 0.72 m/s during 100 year storm
Flow Depth	Promote Vegetative Filtration	< 0.5 m	0.09 m during quality control storm 0.16 m during 2 year storm 0.24 m during 10 year storm 0.31 m during 100 year storm
Flow Rate	Sedimentation and prevent re-suspension	≤ 0.15 m^3/s	0.004 m^3/s during quality control storm 0.019 m^3/s during 2 year storm 0.062 m^3/s during 10 year storm 0.124 m^3/s during 100 year storm

* It is noted that the maximum velocity, maximum depth and maximum flow rate do not occur along the same section of ditch or swale. That is, a comparatively steeper ditch section will result in higher velocity and lower depth for the same flow rate.

All of the flow criteria are less than the required flow criteria needed to achieve an enhanced level of filtration during a quality control event.

Table 2.3 of the Ontario Ministry of Natural Resources Technical Guide – River and Stream Systems: Erosion Hazard Limit provides a maximum allowable flow velocity to prevent scour for a bare channel in sand and silt of 0.61 m/s. The allowable flow velocity increases to 0.91 m/s with fair vegetative cover.

The peak velocity during a 2 year storm event is less than 0.5 m/s ensuring that sedimentation will continue to occur during a 2 year design storm event. The peak flow velocities of 0.44 m/s and 0.60 m/s during the 2 year and 10 year storm events are less than the scour velocity assuming a bear channel. The peak flow of 0.72 m/s during a 100 year storm is less than 0.91 m/s ensuring scour will not occur once vegetation is established.

Since the flow velocity during a 2 year design storm is less than the scour velocity of a bare channel there will be no scour or re-suspension of sediment during a normal rainfall event. It is assumed that the vegetation will have a chance to grow through the sediment prior to successive 10 and 100 year storm events resulting in at least a fair vegetative condition in the ditches preventing resuspension of sediment.

9.3. End-of-Pipe Control – Stormwater Storage Swale

Final treatment and Quality Control will be provided by temporary detention of the entire quality control volume, generated from the surfaces in the controlled area, within the storage swale to be discharged by infiltration only. The quality storage swale has been designed to outlet the quality storage volume vertically through an amended topsoil layer into the underlying soils.

The quality control design is completed with the fundamental understanding that the majority of sediment and particulate pollutants are washed from the site surfaces during minor (frequent) storm events. Section 3.3.1 of the MOE Manual indicates that in most cases, quality control design storms range from 12.5 mm to 25 mm. The MOE Manual provides guidance on design for stormwater quality control using infiltration basins in Section 4.6.6 and using filtration in Section 4.6.7.

It is noted that the proposed stormwater storage swale does not meet all of the criteria for an infiltration basin as the stormwater storage swale is also used for quantity control and does not have a bypass for major storm events. Notwithstanding these discrepancies, guidance with respect to the design of the stormwater storage swale was taken from the MOE Manual Sections 4.6.6 and 4.6.7.

9.3.1. Summary of Design Guidance

Section 4.6.6 of the MOE Manual provides the design guidance with respect to the use of an infiltration basin as summarized in Table 9-3 below. A design conformance and a comment column have been added to indicate if the design conforms to the Criteria and to provide comment.

Table 9-3: Infiltration Basin Design Summary Table

Design Element	Design Objective	Minimum Criteria	Design Conformance	Comment
Drainage Area	Infiltration	< 5 hectares	Yes	3.22 hectares
Treatment Volume	Enhance Treatment	Table 3.2 21.2 m^3/ha x 3.22 = 68.3 m^3	Yes 8.3.2.1	72.1 m^3
Percolation Rate	Infiltration	≥ 60 mm/hr	8.3.2.2	Amended Topsoil Soil over a clear stone drainage layer followed by imported soil with a percolation rate of 8 to 20 min/cm
Depth to Water Table	Infiltration	> 1m	Yes	greater than 1 m based on bottom elevation above the existing ground surface.
Depth to Bedrock	Infiltration	> 1m	Yes	greater than 1.4 m
Length to Width Ratio	Spread Inflow	3:1 or greater	Yes	18:1
Storage Depth	Avoid Filter Compaction	< 0.6 m	8.3.2.3	0.77 m during a 100 year storm event for a duration of less than 8 hrs. 0.51 m during a 10 year storm event.
Pre-treatment	Longevity Groundwater protection	Required	8.3.2.4	Best management practices and Pre-treatment by vegetated filtration along ditch bottom, and side slopes
By-Pass	Winter / spring Operation	Required	8.3.2.5	By-Pass by overflow
Maintenance Access	Access for light discing equipment	Provided to approval of municipality	Yes	Maintenance Rd along length of Swale
Landscaping Plan	Enhanced Infiltration Increase porosity	Grasses, deep rooted legumes	8.3.2.6	Grasses, deep rooted legumes as well as other native vegetation

9.3.2. Conformance of Storage Swale

9.3.2.1. Treatment Volume

The water quality storage volume requirement to achieve an enhanced level of treatment using infiltration was determined from the MOE Manual Table 3.2 under infiltration. The impervious ratio for the controlled area of the site is 19.8%. The storage requirement was extrapolated from Table 3.2, considering a 19.8% impervious ratio at an enhanced level of treatment, to be 21.2 m^3/ha.

The total controlled area is 3.22ha. 3.22 ha x 21.2 m^3/ha gives a quality storage requirement of 68.3 m^3. An additional criterion with respect to treatment volume provided in the MOE Manual when considering the use of filtration for treatment is that there is no by-pass of the filter during a 4 hour 15 mm design storm. The 4 hour 15 mm design storm was not included in the OTTHYMO model. In order to ensure that by-pass would not occur below a 4 hr 15 mm design event, the runoff volume calculated for the 4 hr 25 mm quality design storm was considered. The runoff volume calculated during the 4 hr 25 mm design storm is equal to 0.47 mm of depth across the entire 10.986 ha catchment. The runoff volume generated across the combined area of 3.218 ha contributing runoff to the storage swale is 1.72 mm during a 4 hr 25 mm design storm. This runoff volume is greater per unit area than the volume averaged across the entire 10.986 ha catchment as this catchment contains the majority of the impervious area in the development.

A 4hr 25 mm quality storm event will result in a runoff volume of (3.218 ha x 1.72 mm) 55 m^3. This volumes is less than the quality storage requirement calculated using Table 3.2. As such the maximum quality storage requirement of was determined to be 68.3 m^3 using Table 3.2. There is a total volume of 72.1 m^3 below the lower outlet invert. As such a minimum of 72.1 m^3 will outlet by filtration only.

As such the entire quality control volume required by the MOE MANUAL as calculated by Table 3.2 will be stored below the outlet ICD and no by-pass or overtopping will occur during a 4 hr 15 mm storm event.

9.3.2.2. Percolation Rate

As specified in section 7.2 of this report, the bottom of the storm pond will be between 0.4 and 0.8 metres above the existing ground surface once the topsoil has been removed. In addition, the bottom structure will consist of amended topsoil overlying a clear stone drainage layer. The native and imported soils below the bottom structure are expected to have a percolation rate ranging from 30 to 75 mm/hr. The clear stone layer will distribute the infiltration to areas with a greater infiltration rate and will reduce the potential for surficial long term ponding.

9.3.2.3. Storage Depth

It is noted that the MEO Manual in section 4.6.6 under the heading Storage Configuration/ Depth provides the following:

> *"In an infiltration basin, surface storage is used to retain water for infiltration. In monitoring studies (Galli, 1990), one of the causal factors of failure was noted to be the depth of water retained in the basin. The weight of the water is thought to compact the basin decreasing its infiltration potential. The depth of storage should be limited to a maximum of 0.6 metres in order to minimize the compaction of the basin."*

In section 4.6.7 of the MOE manual, the maximum storage depth to prevent compaction of a sand filter is increased to 1.0 metres.

The maximum ponding depth in the proposed storage swale during a 100 year design storm event is 0.77 m. Using the rainfall data from the historical rainfall event of July 1, 1979, the maximum ponding depth would be 0.84 m. It is noted that the draw down time from a maximum ponding depth of 0.84 m to a depth of 0.6 m is about 11 hours. The maximum ponding depth during a 10 year storm event is 0.51 m. This means that the storage swale will only be subjected to ponding depths in excess of 0.6 m during infrequent events for a short duration. Since the excessive ponding depth will be of limited duration and infrequent in occurrence, it is considered that the excessive ponding depth will have minimal effect on the compaction of the soils below the storage swale. In addition, the proposed planting are intended to have a root structure which will aid in reducing the compaction of the soils.

9.3.2.4. Pre-Treatment

The majority of the pre-treatment for the storage swale will take the form of source control and conveyance control as described in sections 8.1 and 8.2 above. In addition to these, the first 14.1 metres of the bottom of the storage swale sloped downward at 1.1 percent. This first 14.1 metres will provide additional filtration prior to the runoff encountering the remainder of the swale. These measures will ensure that the coarse sediment is removed from the runoff prior to main infiltration portion of the storage swale.

9.3.2.5. By Pass

Since the storage swale is being used for quality control purposes, there is no proposed low level by-pass for major storm events. By-pass of the storage swale will result by overflow along the north side of the swale.

9.3.2.6. Landscaping Plan

The MOE Manual provides the following:

> *"The vegetation in an infiltration basin should be able to withstand periods of ponding and maintain or enhance the pore space in the underlying soils. There is much literature to suggest that deep rooted legumes increase porosity and enhance infiltration compared to other ground covers (e.g., rotation of oat and corn crops with alfalfa) (Bryant et al., 1986; Minnesota Pollution Control Agency, 1989). As such, the planting strategy should include grasses and deep rooted legumes."*

The bottom of the proposed storage swale should be lightly seeded sweet clover in combination with a mix such as Wet meadow or storm pond seed such as QS Wet Meadow Mixture as supplied by Quality Seeds or Stormpond Native Seed Mixture or Creek Bank Native Seed Mixtures supplied by OSC Seeds.. The sides slopes of the storage swale should be seeded with a meadow mix such as QS Meadow Mixture as supplied by Quality Seeds. The seed mixes should be sowed at the rates recommended by the supplier. The seed mixes should be sowed in combination with a nurse crop of annual rye or oats which is sowed at a rate of 22-25 kg/ha.

9.3.2.7. Detention Time

The normal recommended detention time for stormwater management facilities ranges from a minimum of 24 hours (12 hrs if in conflict with minimum orifice size) to a preferred time of 48 hours. The proposed storage swale will have a total drawdown time of about 55 hours following the completion of a 100 year storm event. The draw down time following the completion of a 5 year storm event and a 10 year storm event is about 37.5 hours and 42 hours respectively.

The amount of time for the entire storage volume below the lowest outlet invert to infiltrate will be about 17.5 hours.

9.3.2.8. Flow velocity

Due to the outlet restriction, the discharge rate during the various design storms will be limited to for the 5 year, 10 year and 100 year storm events. Based on a bottom width of 5 metres, these flow rates would result in flow depths and flow velocities in the storm pond assuming no backwater conditions as shown in the following Table 9-4:

Table 9-4: Flow Velocity and Depth in Storage Swale

Storm Event	Flow Rate (m^3/sec)	Flow Depth (m)	Flow Velocity (m/sec)
5 year	0.085	0.17	0.09
10 year	0.120	0.20	0.12
100 year	0.242	0.30	0.14

The above flow velocities and flow depths represent the theoretical velocity that would occur without the outlet restriction. The ponding caused by the outlet restriction will increase the ponding depth and reduce the flow velocity. Since the flow velocity is much lower than 0.5 m/s during all storm events, the proposed vegetation in the storage swale will effectively provide vegetative filtration and remove sediment. The minimal velocity will also prevent re-suspension and scour of fine sediment.

9.3.3. Summary

The proposed storage swale design meets the majority of the design criteria for an infiltration basin as illustrated above. The swale meets the critical criteria with respect to storage volume and detention time necessary to infiltrate the entire quality control volume. Further, due to the outflow restriction, the flow velocity is minimized such that vegetative filtration will be effective and scour and re-suspension of sediment is unlikely.

Based on the above, the proposed stormwater storage swale will ensure that an enhanced level of treatment will be attained for the proposed development.

10. Driveway Culverts

Table 6-4 above provides the maximum flow rates in the roadside ditches during the 10 year and 100 year design storm events. Table 6-4 also provides the minimum available ditch depth for each section considered.

The driveway culverts are specified as 500 mm diameter 1.6 mm thick (16 gauge) plain galvanized corrugated steel pipe with a 68 x 13 mm helical profile.

The headwater depth for each driveway culvert required to meet the flow demand for each respective ditch section was calculated using the Hydroflow Express extension for Autodesk AutoCAD Civil 3D. The results of the calculations are presented in Table 10-1 below. Summary reports are including in Appendix I.

Table 10-1: Culvert Flow Demand and Capacity

Culvert Number	Culvert Diameter / Embedment (m)	Culvert Capacity (gravity) (m^3/s)	10 year Storm		100 year storm	
			Flow Demand (m^3/s)	Headwater Depth (m)	Flow Demand (m^3/s)	Headwater Depth (m)
Lot 1 & 2	0.5 / 0.05	0.19	0.023	0.16	0.044	0.22
Lot 3 & 4			0.036	0.20	0.071	0.28
Lot 5 & 6			0.048	0.23	0.097	0.33
Lot 7 & 8			0.062	0.26	0.124	0.38

From the above analyses, there is sufficient capacity to convey the maximum flow rate generated during a 100 year design storm in the roadside ditches through the driveway culverts without exceeding the minimum available ditch depth and without surcharging the culverts.

11. Operation and Maintenance

The responsibility for the operation and maintenance of the stormwater management facility in the subdivision is that of the owner/developer until the subdivision is accepted by the City of Ottawa. Once the subdivision is accepted by the City of Ottawa, the operation and maintenance of the stormwater management facility in the subdivision is the responsibility of the City of Ottawa

11.1. Grassed Swales and Roadside Ditches

The grassed swales and ditches proposed for the development will require occasional maintenance. Periodic grass trimming along the drainage swales and ditches represents the bulk of the maintenance required. Temporary straw bale check dams should be used to trap the debris and sediment disrupted during ditch cleaning operations.

Should excavation be required during maintenance, re-vegetation of disturbed areas should be completed after maintenance operations have been completed.

11.2. Stormwater Management Swale

The stormwater management swale should be inspected on a weekly basis and after any rain fall event after construction until vegetation is well established. Once the vegetation is well established and during the first year of operation, the stormwater management swale should be visually inspected on a bi-monthly basis and following significant storm event. For inspection purposes, a rain fall event of more than 25 mm in 4 hours would be considered to be a significant event.

Cut the vegetation within the stormwater storage swale to a height of 20 cm twice during the first growing season and once early in the second growing season. Hand remove pockets of aggressive weeds during the establishment period. The specified native seed mixes are intended to grow without maintenance following their establishment in order to provide wildlife habitat.

If patches of weeds occur following the establishment of the seed mixture, the patch could be mechanically removed by excavator. The topsoil removed should be replaced with an amended topsoil mix and the area should be reseeded.

Removal of accumulated sediment from the stormwater management swale should be conducted when the accumulation of the sediment begins to significantly affect the quality of the vegetation growth within the storage swale and/or the drainage patterns along the bottom. If the drawdown time becomes significantly extended, the topsoil layer should be tilled or cultivated to reduce the compaction. Additional amending material can also be added at that time. Following tilling or cultivation, the bottom should be reseeded with the specified seed mixtures.

12. Mitigation Measures for Construction and Development

The following Mitigation Measures should be incorporated during the construction and development of the site to minimize the impact of the proposed development on the adjacent undeveloped areas:

1) To prevent the introduction and spread of invasive plant species into the study area, equipment utilized during construction should be inspected and cleaned in accordance with the *Clean Equipment Protocol for Industry*
   a) Inspect the vehicle thoroughly inside and out for where dirt, plant material and seeds may be lodged or adhering to interior and exterior surfaces prior to mobilizing equipment onto the site.
   b) Remove any guards, covers or plates that are easy to remove.
   c) Attention should be paid to the underside of the vehicle, radiators, spare tires, foot wells and bumper bars.

   d) If clods of dirt, seed or other plant material are found, removal should take place immediately, using the techniques outlined in the Clean Equipment Protocol For Industry.
2) Except as required to construct the outlet, a minimum of 30 m setback from Harwood Creek should be maintained where no development or clearing should occur.
3) In accordance with the City's of Ottawa's *Protocol for Wildlife Protection during Construction to* reduce potential wildlife usage of the Forb Meadow habitat by mowing/clearing outside of the breeding season (i.e., before April 15), then maintain as mowed grass until on-site work begins.
4) No clearing of any vegetation should occur between April 1 and September 15 of any year, unless a qualified biologist has determined that no bird nesting is occurring within five days of the vegetation clearing event.
5) Should any SAR be discovered during the project works, and/or should any SAR or their habitat be potentially impacted by on-site activities, the MECP shall be contacted immediately and operations modified to avoid any negative impacts to SAR or their habitat, until further direction is provided by the MECP;
6) Any excavation or heavy equipment use in the floodplain or near Harwood Creek within the study area, conducted between May 1 and September 15, has the potential to harm travelling Blanding's Turtles and other SAR turtles that utilize the watercourse. As such, mitigation measures should be employed to protect SAR and their habitat during construction and to maintain compliance with the ESA. Some common mitigations would include working outside the known timing window for active turtle movement from May 1 to September 15 of any year, unless the area has been cleared of turtles by a qualified biologist; as well as temporary turtle exclusion barriers should be installed by May 1, prior to the turtle nesting season surrounding the impacted watercourse or proposed works.

13. EROSION AND SEDIMENT CONTROL

The following Sediment and Erosion Control measures are recommended during the various stages of development of the proposed subdivision.

1) Prior to Start of Construction:
   a) Install silt fence, straw bale check dams and mud mat in location shown;
   b) Inspect measures immediately after installation.
2) In General:
   a) Do not locate topsoil piles or fill piles within 2.5 m from any paved or gravel surface area;
   b) Control dust off site by seeding topsoil and soil piles and other disturbed areas watering as necessary if they are to remain unfinished longer than 30 days;
   c) City Roadway to be cleaned of all sediment from vehicular tracking as required;

   d) Provide mud mat where ever vehicular traffic leaves the site from an unpaved egress point;
   e) All erosion control measures should be inspected within 24 hours of a storm event and should be cleaned / repaired / replaced as necessary;
3) During Placement of the Fill within the Flood Plain Area:
   a) Minimize the extend of the disturbed areas outside of the area immediately affected by the fill placement;
   b) Plan the placement of the fill to reduce the duration of exposure either by ensuring sufficient equipment or by placing the fill in stages;
   c) Install silt fence at the perimeter of the disturbed area or around the perimeter of each phase if not completing the fill placement all at once;
   d) Level the fill to finished grade immediately after placement;
   e) Cover fill with minimum 100 mm of topsoil then seed and mulch or hydro seed. The placement of the fill should be completed in a manner that will allow the placement of the topsoil and seeding and mulching / hydro seeding within 30 days of start of fill placement;
   f) Inspect silt fence within 24 hours of a storm event and clean / repair as necessary;
4) During Construction of the Storm water Management Facility.
   a) Minimize the extend of the disturbed areas outside of the area immediately affected by storm water management facility;
   b) Install silt fence at the perimeter of the disturbed area;
   c) Ensure straw bale check dams are in place downstream of the facility;
   d) Equipment used should be sufficient in size and quantity to ensure the construction time is minimized;
   e) Any excess soil material excavated during the construction should be stockpiled on the proposed lots outside of vulnerable areas and outside of the road allowance. The soil should be leveled to rough grade and should be stabilized by seeding;
   f) Cover disturbed areas with minimum 100 mm of topsoil then seed and mulch or hydro seed. The topsoil placement and seeding and mulching / hydro seeding should be completed within 30 days of start of the construction of the facilities;
5) During Construction of the Roadway:
   a) Minimize the extend of the disturbed areas outside of the area immediately affected by the road construction;
   b) Install silt fence at the perimeter of the disturbed area;
   c) Ensure straw bale check dams are in place at the discharge point from the Cul-de-Sac;
   d) Equipment used should be sufficient in size and quantity to ensure the construction time is minimized;
   e) Any excess soil material excavated during the construction should be stockpiled on the proposed lots outside of vulnerable areas and outside of the road allowance. The soil should be leveled to rough grade and should be stabilized by seeding;

   f) Cover disturbed areas with minimum 100 mm of topsoil then seed and mulch or hydro seed. The topsoil placement and seeding and mulching / hydro seeding should be completed within 30 days of start of the construction of the roadway;

6) During Development of Individual Lots
   a) Install silt fence at the perimeter of the disturbed area;
   b) Control dust off site by seeding topsoil and other disturbed areas watering as necessary if they are to remain unfinished longer than 30 days;
   c) Repair any erosion channels as they occur and redirect surface runoff with the use of berms to promote sheet flow;
   d) Cover disturbed areas with minimum 100 mm of topsoil then seed and mulch or hydro seed as soon as possible;

14. STORMWATER MANAGEMENT CONCLUSIONS

- The proposed Dunrobin subdivision covers a total of about 9 hectares. The subdivision will consist of 8 lots proposed for single family residential development.

- The property has been previously used for farming and currently drains to the eastern portion of the site. The proposed development will ensure that the existing overall drainage patterns of the site are not changed.

- Development of the Site and associated filling of the backwater flood plain will have no impact on the adjacent upstream or downstream properties including their wells and septic systems. The elimination of a portion of the backwater flood plain will have no effect on the flow regime in the Harwood Creek.

- The stormwater runoff will be treated using road side ditches, grassed swales and infiltration to ensure that an enhanced level of protection is achieved.

- Runoff will be managed from the site to ensure that the post-development runoff rate does not exceed the pre-development runoff rate for all storm events

- The proposed stormwater management facility will ensure that the development does not increase the runoff volume during normal rainfall events and only negligibly increases the runoff volume during minor storm events ensuring the development will have no measurable effect on the Hardwood Creek flow and flood elevations.

- The proposed stormwater management facility will promote infiltration and promote aquatic and terrain habitat on and adjacent to the site.

- Erosion measures will be placed prior to construction and during development and will remain in place until construction is complete. Disturbed areas will be topsoiled and seeded as soon as reasonably possible.

- Mitigation measures will reduce the impact of the proposed development to adjacent undeveloped areas.

We trust that this report provides sufficient information for your present purposes. If you have any questions concerning this report or if we can be of any further assistance to you on this project, please do not hesitate to contact our office.

Sincerely,
Kollaard Associates Inc.

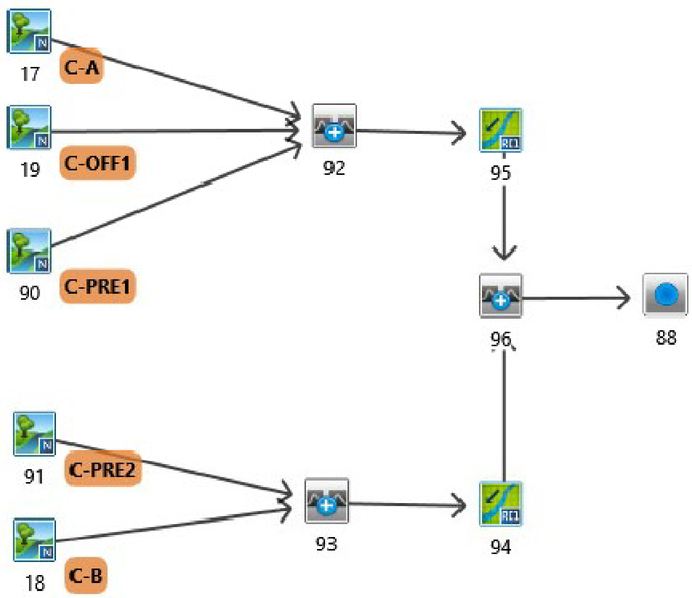
Steven deWit, P.Eng.

APPENDIX A: STORM ANALYSIS MODEL SCHEMATIC AND PARAMETERS

Pre-development OTTHYMO model Schematic and Summary Table

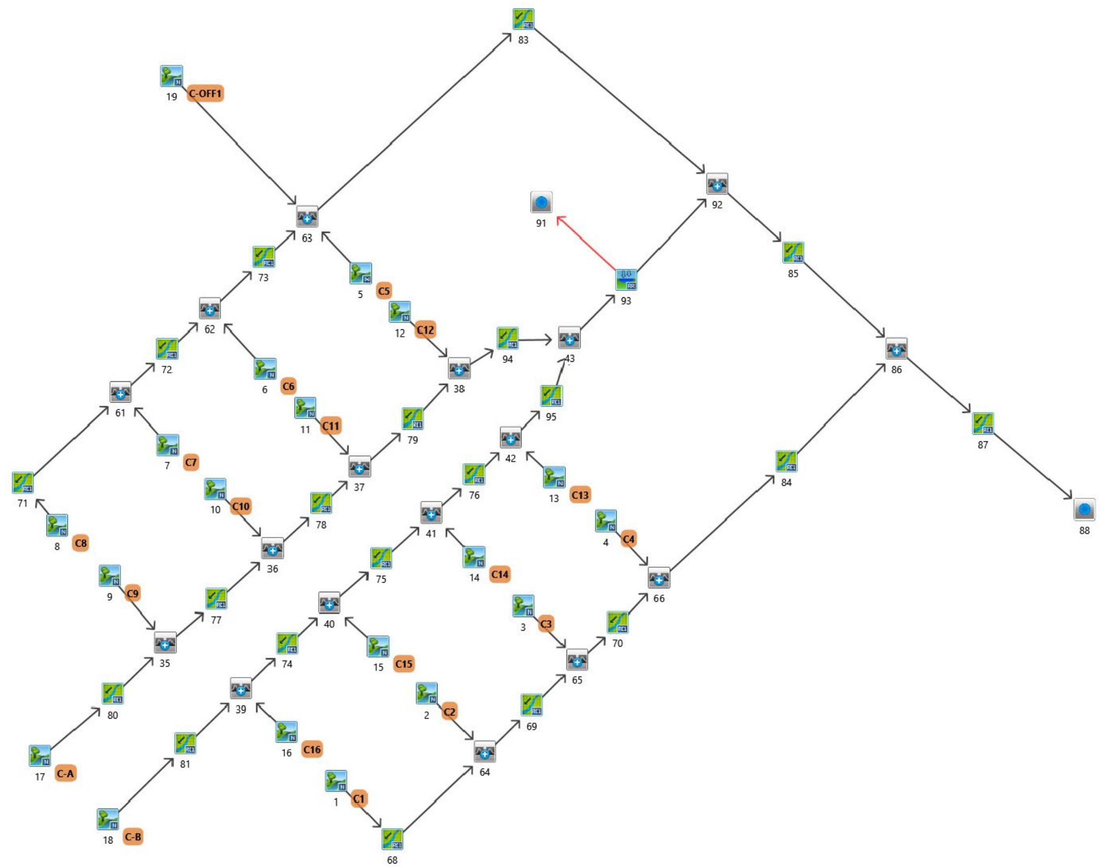
Post-development OTTHYMO model Schematic and Summary Table

Model Variables for Each Catchment



Pre-Development OTTHYMO model Schematic Summary Table

Hydrograph No.	Model Type	Item Represented	Comment
90	NASHYD	Sub-Catchment C-PRE1	Catchment represents north half of site.
91	NASHYD	Sub-Catchment C-PRE2	Catchment represents south half of site
17	NASHYD	Sub-Catchment C-A	Catchment includes west side of Lot 1 and east half of Dunrobin Road adjacent Lot 1
18	NASHYD	Sub-Catchment C-B	Catchment includes west side of Lot 2 and east half of Dunrobin Road adjacent Lot 2
19	NASHYD	Sub-Catchment C-OFF1	Catchment includes offsite area north of the proposed development
95,96	Route Channel	Open Channel Flow along grassed swale	Models the open channel flow component of the runoff during pre-development conditions along the north and south sides of the site
88	Node	Ends the Model	Ends the Model
30,31,33-46,49,50	NASHYD	Add Hydrograph	Used to add two hydrographs in the routing


83
19
C-OFF1
92
63
91
93
85
73
5
C5
62
12
C12
94
43
86
72
38
6
C6
95
61
11
C11
79
7
C7
42
87
71
37
76
13
C13
84
10
C10
8
C8
78
41
4
C4
88
36
9
C9
75
14
C14
66
77
40
3
C3
35
70
74
15
C15
65
80
39
2
C2
69
16
C16
17
C-A
81
64
1
C1
18
C-B
68

Post-Development OTTHYMO model Schematic Summary Table

Hydrograph No.	Model Type	Item Represented	Comment
1	NASHYD	Sub-Catchment C1	Catchment represents rear yard of Lot 2. Uncontrolled.
2	NASHYD	Sub-Catchment C2	Catchment represents rear yard of Lot 4. Uncontrolled.
3	NASHYD	Sub-Catchment C3	Catchment represents rear yard of Lot 6. Uncontrolled.
4	NASHYD	Sub-Catchment C4	Catchment represents rear yard of Lot 8. Uncontrolled.
5	NASHYD	Sub-Catchment C5	Catchment represents rear yard of Lot 7. Uncontrolled.
6	NASHYD	Sub-Catchment C6	Catchment represents rear yard of Lot 5. Uncontrolled.
7	NASHYD	Sub-Catchment C7	Catchment represents rear yard of Lot 3. Uncontrolled.
8	NASHYD	Sub-Catchment C8	Catchment represents rear yard of Lot 1. Uncontrolled.
9	NASHYD	Sub-Catchment C9	Catchment includes front yard of Lot 1 and contains dwelling, driveway and half of road. Controlled
10	NASHYD	Sub-Catchment C10	Catchment includes front yard of Lot 3 and contains dwelling, driveway and half of road. Controlled
11	NASHYD	Sub-Catchment C11	Catchment includes front yard of Lot 5 and contains dwelling, driveway and half of road. Controlled
12	NASHYD	Sub-Catchment C12	Catchment includes front yard of Lot 7 and contains dwelling, driveway and half of road. Controlled
13	NASHYD	Sub-Catchment C13	Catchment includes front yard of Lot 8 and contains dwelling, driveway and half of road. Controlled
14	NASHYD	Sub-Catchment C14	Catchment includes front yard of Lot 6 and contains dwelling, driveway and half of road. Controlled

15	NASHYD	Sub-Catchment C15	Catchment includes front yard of Lot 4 and contains dwelling, driveway and half of road. Controlled
16	NASHYD	Sub-Catchment C16	Catchment includes front yard of Lot 2 and contains dwelling, driveway and half of road. Controlled
17	NASHYD	Sub-Catchment C-A	Catchment includes northwest side of Lot 1 and southeast half of Dunrobin Road Controlled
18	NASHYD	Sub-Catchment C-B	Catchment includes southwest side of Lot 2 and southeast half of Dunrobin Road Controlled
19	NASHYD	Sub-Catchment C-OFF1	Catchment includes offsite area northwest of the proposed development Controlled
71, 72, 73, 83	Route Channel	Open Channel Flow along grassed swale	Models the open channel flow component of the runoff during post-dev. conditions along the north side of the development and along the east side of Lot 7
68, 69, 70, 84,	Route Channel	Open Channel Flow along grassed swale	Models the open channel flow component of the runoff during post-dev. conditions along the south side of the development
77, 78, 79, 94	Route Channel	Open Channel Flow, Road side ditches	Models the open channel flow component of the runoff during post-development conditions along the front of Lots 1, 3, 5 and 7 respectively.
74, 75, 76, 95	Route Channel	Open Channel Flow, Road side ditches	Models the open channel flow component of the runoff during post-development conditions along the front of Lots 2, 4, 6 and 8 respectively.
80, 81	Route Channel	Open Channel Flow, Road side ditches	Models the open channel flow component of the runoff in the ditches along Dunrobin Road.
85, 87	Route Channel	Open Channel Flow, Grassed Swales	Models the open channel flow component of the runoff during post-development conditions following the stormwater management swale to Harwood Creek
93	Route Reservoir	The stormwater management swale	Provides a model of the stormwater storage swale storage and release.
35-43, 61-66, 86, 92	NASHYD	Add Hydrograph	Used to add two hydrographs in the routing

Catchment Areas and Model Parameters

Refer to Drawing # 200977-PRECA and Drawing # 200977-POST for an illustration of the specified catchment areas.

	NASHYD CATCHMENT AREAS							
	TOTAL AREA m^2	OPEN SPACE (GOOD)	IMPERVIOUS (ROOFS ROADS)	UNMAINTAINED REAR YARD / WOOD (FAIR)	WOODS (GOOD)	Weighted Average CN	POTENTIAL STORAGE mm	TC min
POST	4955.01	1100.00	0	3855	0	60.2	157.77	15.49
POST	5031.69	1100.00	0	3932	0	60.2	157.80	27.53
POST	5095.33	1100.00	0	3995	0	60.2	157.82	40.80
POST	16758.44	5750.00	0	3508	2500	59.6	172.19	62.50
POST	14079.026	6800.00	0	5421	1858	59.8	170.58	31.01
POST	5010.94	1500.00	0	3511	0	60.3	157.23	45.02
POST	5006.55	1100.00	0	3907	0	60.2	157.79	43.69
POST	4933.72	1100.00	0	3834	0	60.2	157.77	17.56
POST	3589.55	2969.55	620	0	0	67.4	122.91	23.91
POST	3763.32	3143.32	620	0	0	67.1	124.56	23.91
POST	3767.48	3147.48	620	0	0	67.1	124.60	23.91
POST	2954.80	2234.80	720	0	0	70.0	108.78	19.97
POST	3399.84	2679.84	720	0	0	68.8	114.99	21.30
POST	3628.25	3008.25	620	0	0	67.3	123.29	23.91
POST	3756.20	3136.20	620	0	0	67.1	124.50	23.91
POST	3871.88	3251.88	620	0	0	66.9	125.53	23.91
PRE/POST	1726.19	1126.19	600	0	0	73.9	89.89	0.21
PRE/POST	1723.05	1123.05	600	0	0	73.9	89.78	0.21
PRE/POST	16801.01	0.00	0	8401	8401	57.5	187.74	36.82
PRE	43105.4	14368.0	0.0	14368.0	14369.4	58.7	178.96	46.47
PRE	46496.6	15499.0	0.0	15499.0	15498.6	58.7	178.95	56.01

OTTHYMO NASHYD PARAMETERS											
NHYD #	NAME	OUTLET NHYD#	DT [min]	AREA [ha]	DWF [m³/s]	CN	IA [mm]	N	TP [hr]	STORM INDEX	RAIN [mm/hr]
1	C1	68	5	0.496	0	60.2	13.4	3	0.17	1	0
2	C2	64	5	0.503	0	60.2	13.4	3	0.31	1	0
3	C3	65	5	0.510	0	60.2	13.4	3	0.45	1	0
4	C4	66	5	1.676	0	59.6	13.8	3	0.69	1	0
5	C5	63	5	1.408	0	59.8	13.6	3	0.34	1	0
6	C6	62	5	0.501	0	60.3	13.4	3	0.50	1	0
7	C7	61	5	0.501	0	60.2	13.4	3	0.49	1	0
8	C8	71	5	0.493	0	60.2	13.4	3	0.20	1	0
9	C9	35	5	0.359	0	67.4	9.8	3	0.27	1	0
10	C10	36	5	0.376	0	67.1	10.0	3	0.27	1	0
11	C11	37	5	0.377	0	67.1	10.0	3	0.27	1	0
12	C12	38	5	0.295	0	70.0	10.9	3	0.22	1	0
13	C13	42	5	0.340	0	68.8	9.2	3	0.24	1	0
14	C14	41	5	0.363	0	67.3	9.9	3	0.27	1	0
15	C15	40	5	0.376	0	67.1	10.0	3	0.27	1	0
16	C16	39	5	0.387	0	66.9	10.0	3	0.27	1	0
17	C-A	varies	5	0.173	0	73.9	9.0	3	0.17	1	0
18	C-B	varies	5	0.172	0	73.9	9.0	3	0.17	1	0
19	C-OFF1	varies	5	1.680	0	57.5	15.0	3	0.41	1	0
90	C-PRE1	92	5	4.311	0	58.7	14.3	3	0.52	1	0
91	C-PRE2	93	5	4.650	0	58.7	14.3	3	0.62	1	0

APPENDIX B: TIME OF CONCENTRATION AND TIME TO PEAK CALCULATION

Calculation Table

USDA Chapter 15 – Figure 15-4 and Table 15-3

Sheet Flow						Shallow Concentrated Flow					
NAME	Mannings n	length Sheet Flow (m)	2 yr 24 Hr Rainfall (mm)	Slope (m/m)	Time of Sheet Flow (hrs)	Flow Length to Major Channel (m)	Slope (m/m)	Velocity (m/s)	Time of Shallow Concentrated Flow (hr)	TC min	TP [hr]
C1	0.4	16	48	0.09	0.15	58	0.017	0.15	0.11	15	0.17
C2	0.4	27	48	0.057	0.28	58	0.006	0.09	0.18	28	0.31
C3	0.4	24	48	0.067	0.24	58	0.001	0.04	0.44	41	0.45
C4	0.4	30	48	0.027	0.41	83	0.001	0.04	0.63	62	0.69
C5	0.4	30	48	0.041	0.35	45	0.004	0.07	0.17	31	0.34
C6	0.4	25	48	0.038	0.31	58	0.001	0.04	0.44	45	0.50
C7	0.4	30	48	0.066	0.29	58	0.001	0.04	0.44	44	0.49
C8	0.4	18	48	0.1	0.16	58	0.013	0.12	0.13	18	0.20
C9	0.4	30	48	0.03	0.39	10	0.03	0.37	0.01	24	0.27
C10	0.4	30	48	0.03	0.39	10	0.03	0.37	0.01	24	0.27
C11	0.4	30	48	0.03	0.39	10	0.03	0.37	0.01	24	0.27
C12	0.4	30	48	0.047	0.33	10	0.047	0.46	0.01	20	0.22
C13	0.4	30	48	0.04	0.35	10	0.04	0.42	0.01	21	0.24
C14	0.4	30	48	0.03	0.39	10	0.03	0.37	0.01	24	0.27
C15	0.4	30	48	0.03	0.39	10	0.03	0.37	0.01	24	0.27
C16	0.4	30	48	0.03	0.39	10	0.03	0.37	0.01	24	0.27
C-A	0.011	3	48	0.03	0.00					0	0.17
C-B	0.011	3	48	0.03	0.00					0	0.17
C-OFF1	0.35	30	48	0.01	0.55	30	0.013	0.12	0.07	37	0.41
C-PRE1	0.24	30	48	0.01	0.40	147	0.006	0.11	0.37	46	0.52
C-PRE2	0.24	30	48	0.01	0.40	210	0.006	0.11	0.53	56	0.62

Figure 15–4 Velocity versus slope for shallow concentrated flow

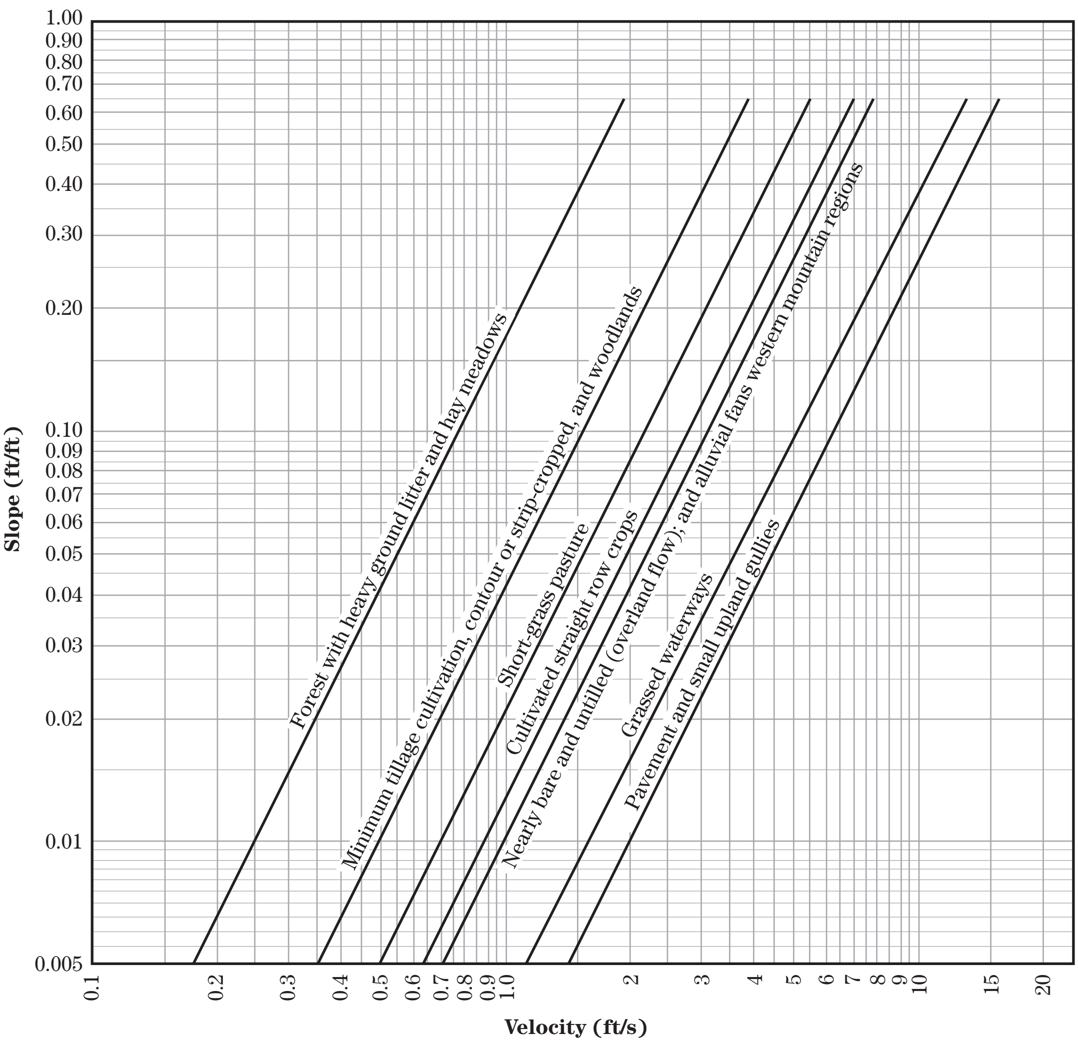


Table 15–3 Equations and assumptions developed from figure 15–4

Flow type	**Depth (ft)**	**Manning's *n***	**Velocity equation (ft/s)**
Pavement and small upland gullies	0.2	0.025	$V = 20.328(s)^{0.5}$
Grassed waterways	0.4	0.050	$V=16.135(s)^{0.5}$
Nearly bare and untilled (overland flow); and alluvial fans in western mountain regions	0.2	0.051	$V=9.965(s)^{0.5}$
Cultivated straight row crops	0.2	0.058	$V=8.762(s)^{0.5}$
Short-grass pasture	0.2	0.073	$V=6.962(s)^{0.5}$
Minimum tillage cultivation, contour or strip-cropped, and woodlands	0.2	0.101	$V=5.032(s)^{0.5}$
Forest with heavy ground litter and hay meadows	0.2	0.202	$V=2.516(s)^{0.5}$

Table 3-5 Estimates of Manning's roughness coefficient for overland flow

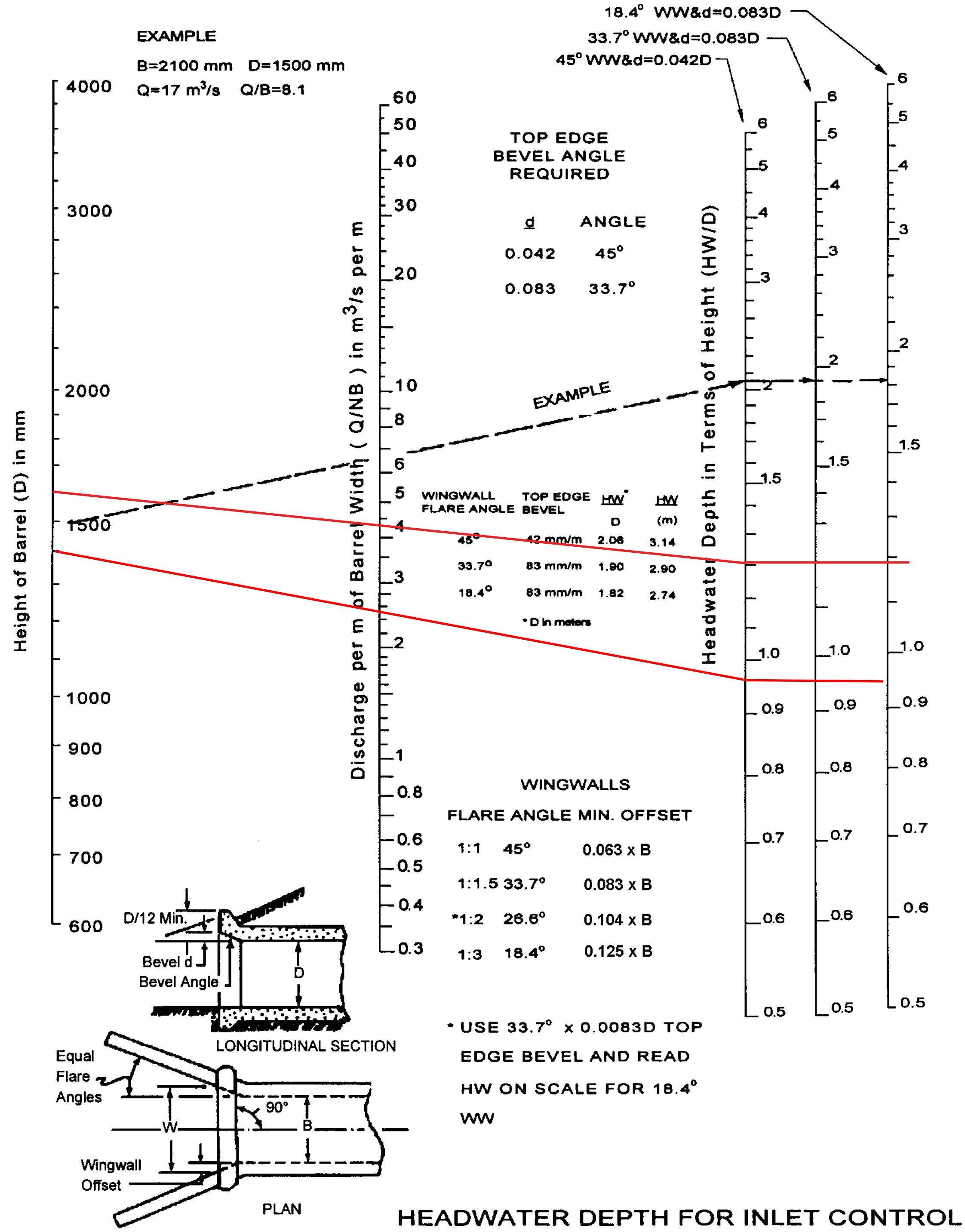
Source	Ground Cover	n	Range
Crawford and Linsley (1966)[a]	Smooth asphalt	0.01	
	Asphalt of concrete paving	0.014	
	Packed clay	0.03	
	Light turf	0.20	
	Dense turf	0.35	
	Dense shrubbery and forest litter	0.4	
Engman (1986)[b]	Concrete or asphalt	0.011	0.010-0.013
	Bare sand	0.010	0.01-0.016
	Graveled surface	0.02	0.012-0.03
	Bare clay-loam (eroded)	0.02	0.012-0.033
	Range (natural)	0.13	0.01-0.32
	Bluegrass sod	0.45	0.39-0.63
	Short grass prairie	0.15	0.10-0.20
	Bermuda grass	0.41	0.30-0.48
Yen (2001)[c]	Smooth asphalt pavement	0.012	0.010-0.015
	Smooth impervious surface	0.013	0.011-0.015
	Tar and sand pavement	0.014	0.012-0.016
	Concrete pavement	0.017	0.014-0.020
	Rough impervious surface	0.019	0.015-0.023
	Smooth bare packed soil	0.021	0.017-0.025
	Moderate bare packed soil	0.030	0.025-0.035
	Rough bare packed soil	0.038	0.032-0.045
	Gravel soil	0.032	0.025-0.045
	Mowed poor grass	0.038	0.030-0.045
	Average grass, closely clipped sod	0.050	0.040-0.060
	Pasture	0.055	0.040-0.070
	Timberland	0.090	0.060-0.120
	Dense grass	0.090	0.060-0.120
	Shrubs and bushes	0.120	0.080-0.180
	Business land use	0.022	0.014-0.035
	Semi-business land use	0.035	0.022-0.050
	Industrial land use	0.035	0.020-0.050
	Dense residential land use	0.040	0.025-0.060
	Suburban residential land use	0.055	0.030-0.080
	Parks and lawns	0.075	0.040-0.120

[a]Obtained by calibration of Stanford Watershed Model.
[b]Computed by Engman (1986) by kinematic wave and storage analysis of measured rainfall-runoff data.
[c]Computed on basis of kinematic wave analysis.

APPENDIX C: HARWOOD CREEK FLOOD LEVEL AND FLOW RATES

Reach	River Sta	Return Period (Yrs)	Q Total (m3/s)	W.S. Elev (m)	E.G. Elev (m)	Vel Left (m/s)	Vel Chnl (m/s)	Vel Right (m/s)
Main	1214	2	2.7	74.89	74.9	0.2	0.83	0.17
Main	1214	5	5.1	75.08	75.09	0.21	0.93	0.14
Main	1214	10	7	75.19	75.2	0.22	0.94	0.13
Main	1214	25	9.7	75.29	75.3	0.24	1.02	0.13
Main	1214	50	11.8	75.39	75.4	0.22	1.02	0.13
Main	1214	100	14.1	75.48	75.49	0.22	0.96	0.14
Main	1130	2	2.7	74.75	74.77	0.16	0.95	0.21
Main	1130	5	5.1	74.93	74.96	0.23	1.24	0.22
Main	1130	10	7	75.04	75.07	0.27	1.39	0.22
Main	1130	25	9.7	75.12	75.17	0.33	1.66	0.24
Main	1130	50	11.8	75.23	75.28	0.33	1.73	0.22
Main	1130	100	14.1	75.36	75.4	0.31	1.62	0.22
Main	1075	2	2.7	74.44	74.6	0.34	1.98	0.31
Main	1075	5	5.1	74.64	74.78	0.37	2.07	0.35
Main	1075	10	7	74.75	74.89	0.36	2.18	0.34
Main	1075	25	9.7	75	75.04	0.28	1.47	0.17
Main	1075	50	11.8	75.17	75.19	0.2	1.14	0.16
Main	1075	100	14.1	75.33	75.34	0.17	0.93	0.14
Main	1023	2	2.8	74.23	74.26	0.22	0.84	0.13
Main	1023	5	5.3	74.48	74.53	0.29	1.04	0.22
Main	1023	10	7.2	74.63	74.7	0.33	1.17	0.27
Main	1023	25	10.2	74.85	74.93	0.39	1.32	0.33
Main	1023	50	12.5	75	75.09	0.42	1.43	0.37
Main	1023	100	14.9	75.15	75.26	0.45	1.51	0.4
Main	1013		Culvert					
Main	1002	2	2.8	74.18	74.22	0.2	0.91	0.18
Main	1002	5	5.3	74.39	74.45	0.29	1.16	0.28
Main	1002	10	7.2	74.5	74.59	0.35	1.34	0.34
Main	1002	25	10.2	74.66	74.78	0.43	1.58	0.41
Main	1002	50	12.5	74.75	74.9	0.48	1.76	0.47
Main	1002	100	14.9	74.83	75.01	0.54	1.94	0.52
Main	900	2	2.8	74.04	74.06	0.15	0.72	0.1
Main	900	5	5.3	74.24	74.28	0.13	0.95	0.17
Main	900	10	7.2	74.36	74.4	0.17	1.06	0.2
Main	900	25	10.2	74.5	74.56	0.21	1.24	0.18
Main	900	50	12.5	74.6	74.66	0.24	1.32	0.21
Main	900	100	14.9	74.69	74.75	0.26	1.39	0.23

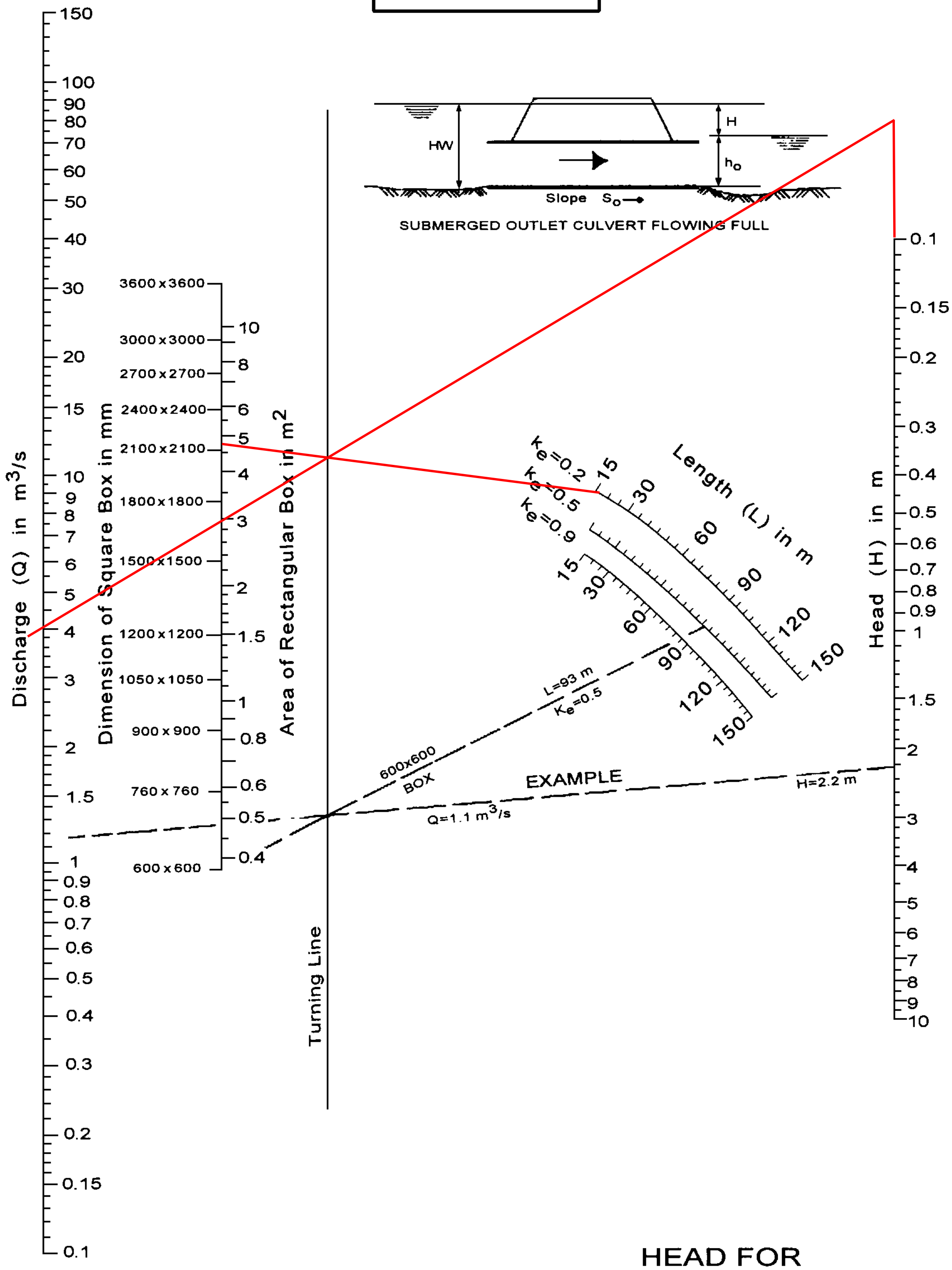
CHART 13A



Adapted from
Bureau of Public Roads Office of R & D
August 1968

HEADWATER DEPTH FOR INLET CONTROL RECTANGULAR BOX CULVERTS OFFSET FLARED WINGWALLS AND BEVELED EDGE AT TOP OF INLET

CHART 15A



HEAD FOR CONCRETE BOX CULVERTS FLOWING FULL

n=0.012

Adapted from
Burea of Public Roads Jan. 1963

APPENDIX D: JFSA – 2050 DUNROBIN ROAD FLOODPLAIN ANALYSIS

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jfsa.com

Ottawa. ON
Paris. ON
Gatineau. QC
Montréal. QC
Québec. QC

October 25, 2022 Project Number: 2363-22

Kollaard Associates Inc.
210 Prescot Street, Unit 1,
P.O. Box 189
Kemptville, ON
K0G 1J0

Attention: **William Kollaard, P.Eng.**

Subject: **2050 Dunrobin Road, City of Ottawa – Floodplain Analysis**

Overview

J.F. Sabourin and Associates Inc. (JFSA) has been retained by Kollaard Associates Inc. (Kollaard) to investigate the current floodplain extents on a site located at 2050 Dunrobin Road (hereon referred to as "the subject property"), adjacent to Harwood Creek. Based on the current floodplain mapping of Harwood Creek provided by the Mississippi Valley Conservation Authority (MVCA), as well as the information submitted by MVCA on their review of the Application for Zoning By-law Amendment on June 17, 2022, the subject property is partially located within the floodplain and regulation limit of Harwood Creek. Under proposed conditions, the development area of 8 rural residential lots will de raised to ensure there is no floodplain encroachment on any part of the residential envelope. Additionally, the floodplain is considered a backwater area that does not contribute to the effective conveyance of flows on Harwood Creek. **Figure 1** shows the extent of the floodplain within the subject property for the existing conditions. The following memo assesses the potential flooding on these lands and quantifies the impacts of raising the grades in this location to ensure no encroachment on the residential development envelopes.

Hydraulic Analysis

To support this analysis, JFSA has purchased a copy of the hydraulic (HEC-RAS) model of Harwood Creek developed by MVCA as part of the floodplain mapping works recently undertaken on this watercourse. In addition to this, LiDAR has been obtained from the City of Ottawa which was flown in 2020. **Figure 2** provides an overview of both the HEC-RAS model and the LiDAR obtained for this project.

From the topographic mapping underlaid in **Figure 2**, it is seen that the floodplain bulges out on this site as the product of a lateral spill from Harwood Creek located between model cross-sections (XS) **1130** and **1214**. As the flooding potential on these lands would occur due to lateral spill/backwater conditions, this area provides no benefit to flow conveyance and in turn, cannot impact the conveyance of flows along Harwood Creek. This concept is also proven by comparing the results of the pre- and post-development floodplain analysis, which demonstrates that there are no changes to the inundation boundary along Harwood Creek despite the reduction of the inundated area within the subject lands due to the proposed site alteration. **Figure 3** shows the floodplain overview under proposed conditions and **Figure 4** shows a comparison/overlay between the existing and proposed floodplain conditions, identifying the floodplain removal within the subject lands and showing that there are no changes to the existing floodplain limits along Harwood Creek. Note that from **Figure 3,** none of the proposed units are at risk of flooding.

JFSA has updated the HEC-RAS model with the 2020 LiDAR obtained from the City of Ottawa and the inclusion of the proposed development as per the detailed grading design provided by Kollaard, see **Figure 5** for the proposed details grading plan for this site. **Attachment A** provides a full summary of existing and proposed results, which shows that the filling of these lands has no impact and that the peak water level results are identical. Additionally, by comparing the 100-year water surface elevation of **75.48 m** on Harwood Creek at **XS 1214** with the proposed underside of footing elevation (USF) of **75.80 m** at **Unit 8**, it can be concluded that the USF is above the 100-year water level on Harwood Creek, with a freeboard of **0.32 m**.

It should be noted that 1D HEC-RAS models, although capable of simulating lateral spills, are not well suited to capture the complex hydraulic phenomenon under such situations. As a secondary check, the floodplain storage loss caused by filling these lands has been assessed using simple GIS tools and data available.

Floodplain Storage Volume

Based on MVCA's HEC-RAS modelling, the 100-year water surface elevation on Harwood Creek at **XS 1214** is **75.48 m**. Overlaying this water surface elevation onto the City of Ottawa LiDAR within the subject property and summing up the total depth of flooding in each cell (1.0m x 1.0m cell) determined that the total existing floodplain storage volume at this location is approximately **3,008 m³**. By doing the same process for the proposed condition where a portion of the development is filled, the floodplain storage volume within the subject property is approximately **1,877 m³**. As such, filling this land would reduce the total floodplain storage volume to Harwood Creek by approximately **1,131 m³**. To provide some context, based on MVCA's HEC-RAS model, the total floodplain storage volume within the Harwood Creek for the 100-year event is **312,000 m³**, therefore the floodplain storage volume loss due to the filling within the subject property at 2050 Dunrobin Road equates to a **0.36%** reduction in total floodplain storage within Harwood Creek. As such, it is determined that filling these lands will have no impact on the hydraulic operations of this watercourse.

Conclusion

Based on the above, JFSA has assessed the potential impacts of filling the area within 2050 Dunrobin Road, which is currently mapped as a floodplain in MVCA's recent floodplain mapping study. Based on updated HEC-RAS modelling, which assumes these lands are filled, JFSA has demonstrated that there is no increase in peak water level. It was noted that 1D HEC-RAS models are not well suited to assessing/simulating the complexities of lateral spills, and as such the floodplain storage lost due to filling these lands was approximated using 2020 LiDAR obtained from the City of Ottawa and the MVCA's simulated 100-year water surface elevation over these lands. Based on this analysis, it was found that filling the floodplain bulge on these lands will result in an approximate reduction in storage volume by **1,131 m³** or **0.36%** of the Harwood Creek 100-year floodplain. As such JFSA concludes that the proposed filling within the subject property will have no adverse impacts on the existing hydraulic operations of Harwood Creek.

Yours truly,
J.F Sabourin and Associates Inc.

J. Burnett

LICENSED PROFESSIONAL ENGINEER
J. J. BURNETT
100227734
PROVINCE OF ONTARIO

Jonathon Burnet, B.Eng, P.Eng
Water Resource Engineer

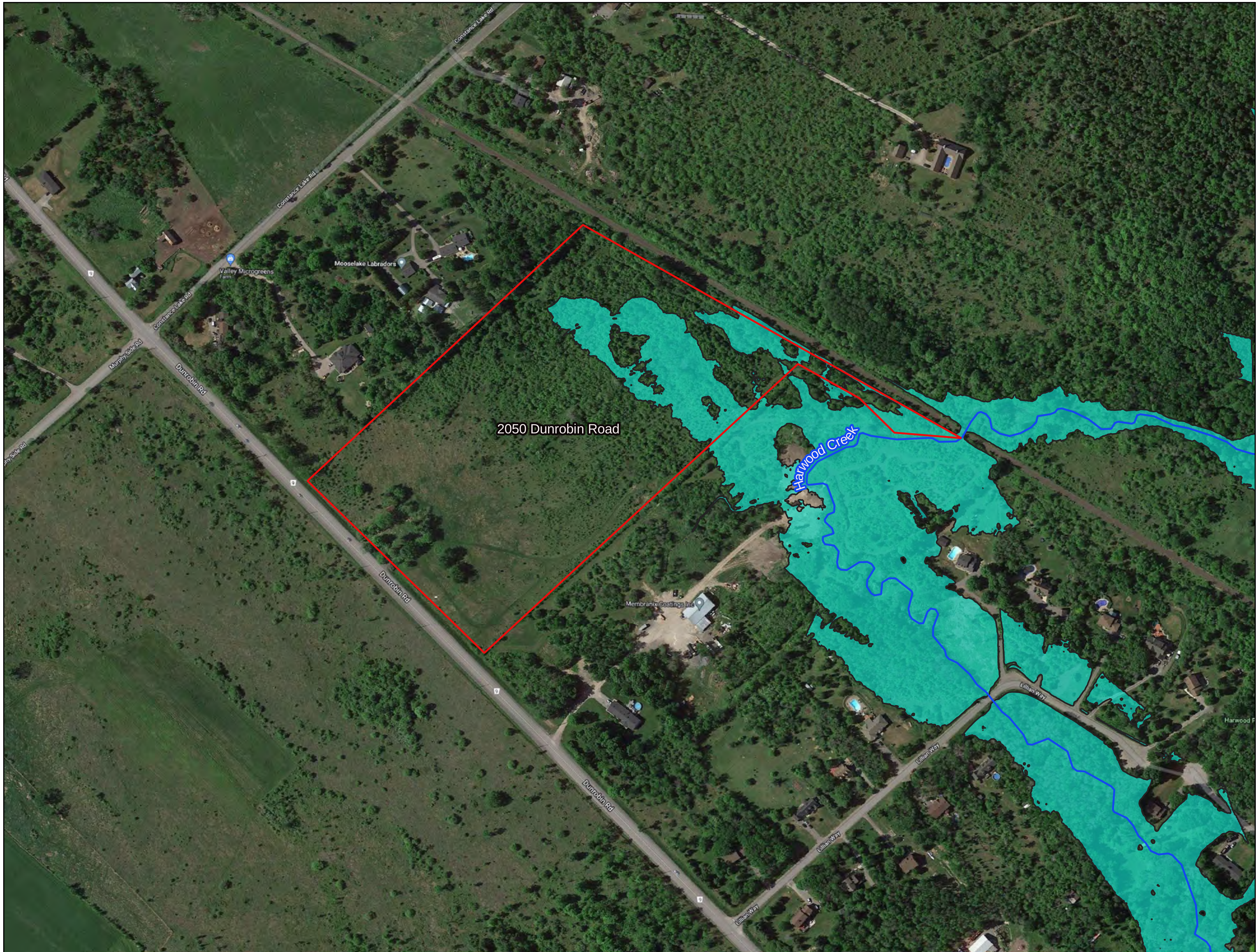
cc: J.F Sabourin, M.Eng, P.Eng
Director of Water Resources Projects

Figures

Figure 1: Existing Conditions 100-Year Floodplain Overview
Figure 2: HEC-RAS Model Overview
Figure 3: Proposed Conditions 100-Year Floodplain Overview
Figure 4: Existing & Proposed Conditions 100-Year Floodplain Comparison
Figure 5: Preliminary Grading Plan for Fill Placement (Kollaard, March 2022)

Attachments

Attachment A: Harwood Creek HEC-RAS Model Results



Legend

- Site Boundary
- Watercourse
- Existing Floodplain
  City of Ottawa Lidar (NRCan)

SCALE: 1:3500

0 100 200 m

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Kollaard Associates
Engineers

2050 Dunrobin Road
Harwood Creek
Floodplain Analysis

Figure 1: Existing Conditions
100-Year Floodplain Overview

PROJECT	2363-22
DRAWN	PP
DATE	October 2022

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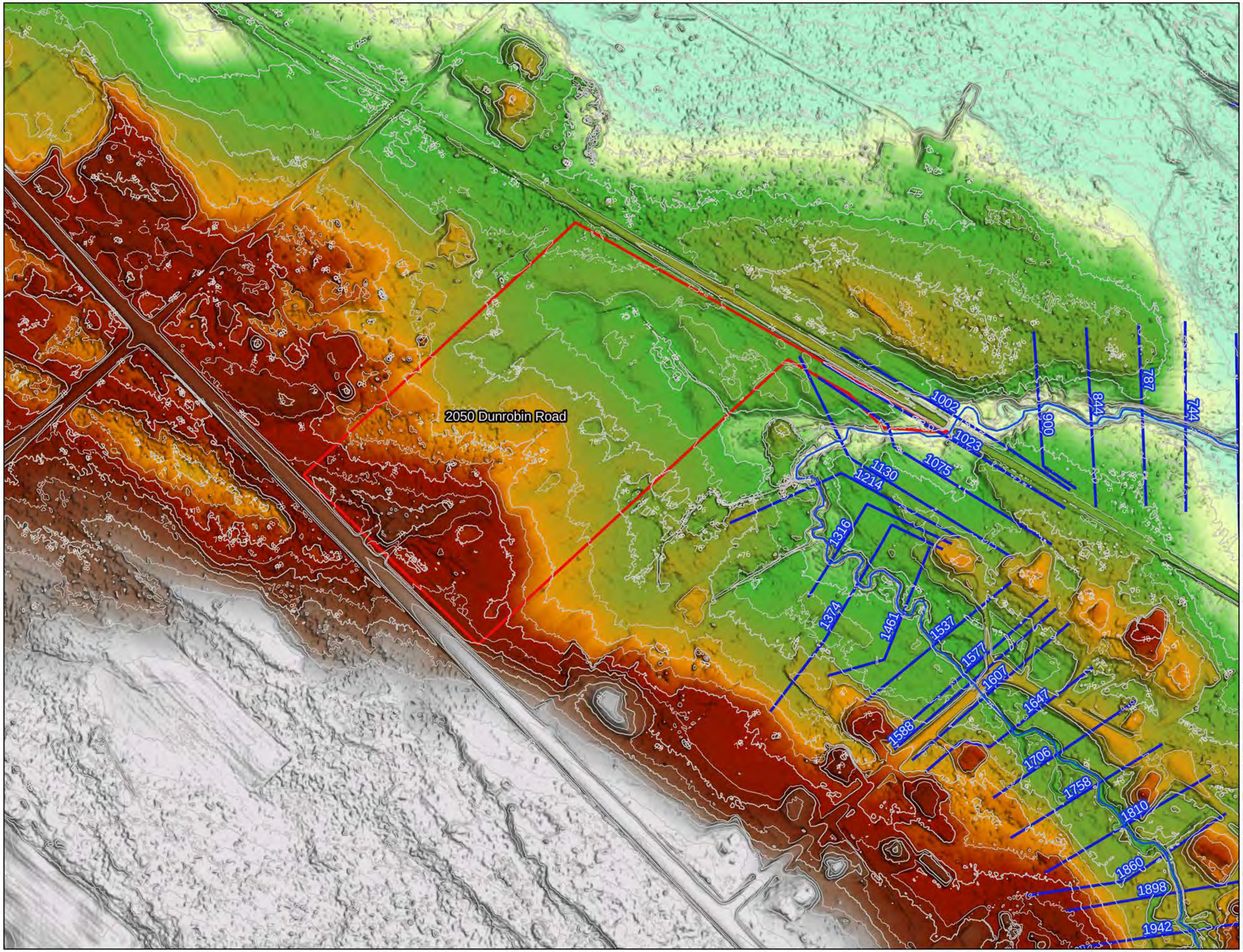

Legend

- Minor Contours (0.5m)
- Major Contours (1.0m)
- HEC-RAS XS
- Site Boundary
- Watercourse

Lidar (m)

- 73
- 74
- 75
- 76
- 77
- 78
- 79
- 80
- 81
- 82

N

SCALE: 1:3500

0 100 200 m

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Harwood Creek
Floodplain Analysis

Figure 2: HEC-RAS Model Overview

PROJECT	2363-22
DRAWN	PP
DATE	October 2022

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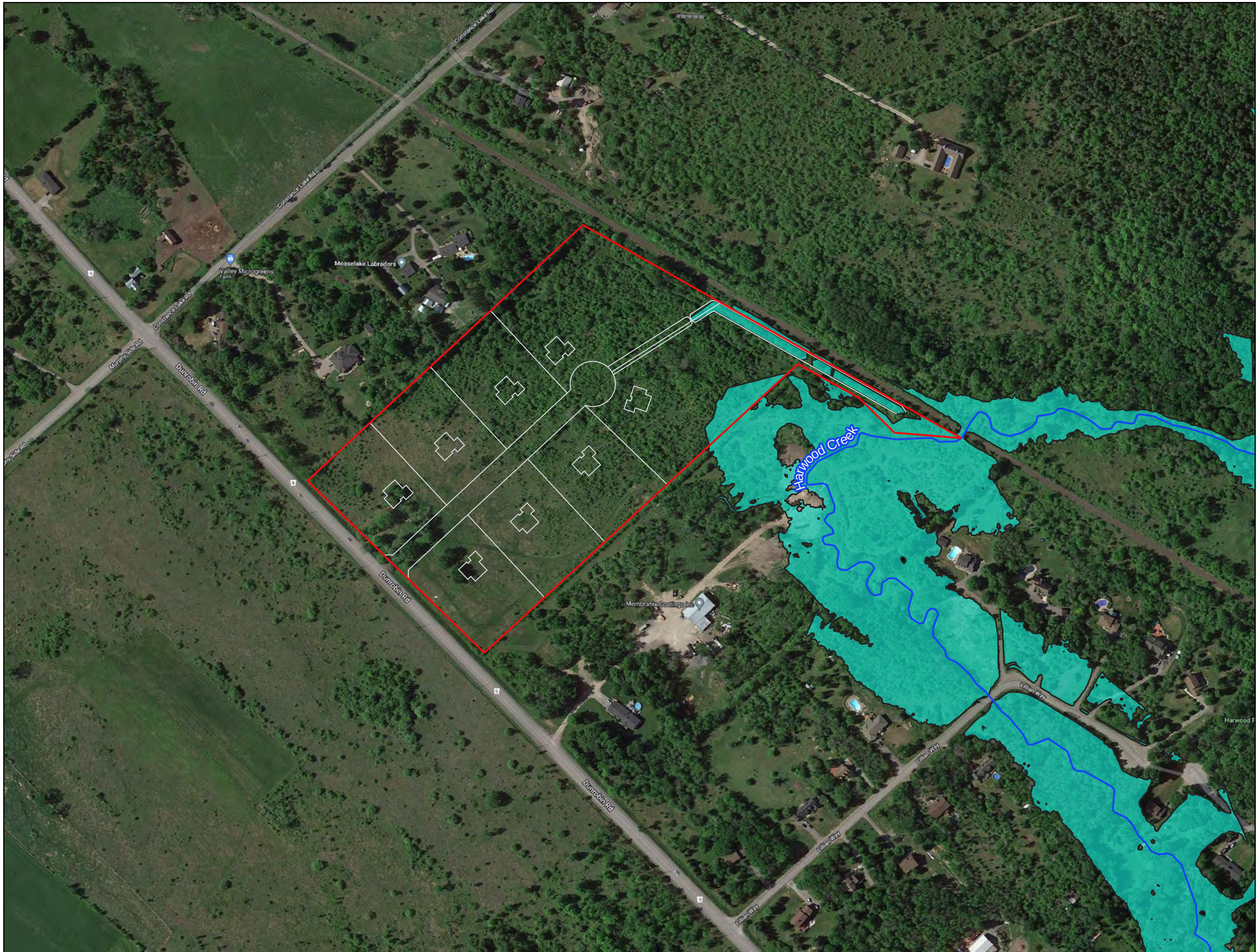

Legend

- Site Boundary
- SitePlan
- Watercourse
- 100-Year Floodplain

SCALE: 1:3500

0 100 200 m

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Harwood Creek
Floodplain Analysis

Figure 3: Proposed Conditions
100-Year Floodplain Overview

PROJECT	2363-22
DRAWN	PP
DATE	October 2022

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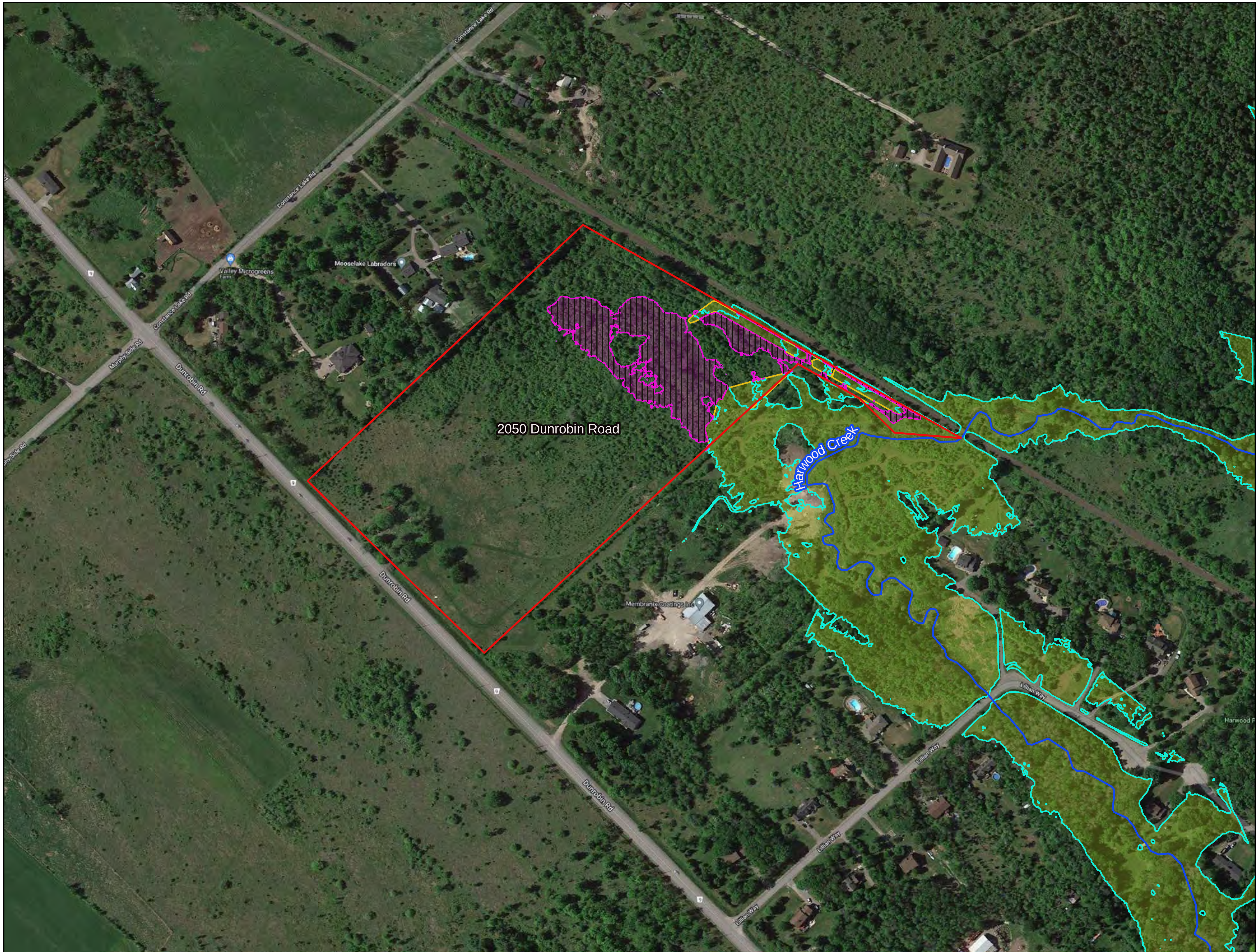

N

Legend

- Site Boundary
- Watercourse
- Floodplain Removal
- Existing Condition Floodplain
- Proposed Condition Floodplain

SCALE: 1:3500

0 100 200 m

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Harwood Creek
Floodplain Analysis

Figure 4: Existing & Proposed Conditions 100-Year Floodplain Comparison

PROJECT	2363-22
DRAWN	PP
DATE	October 2022

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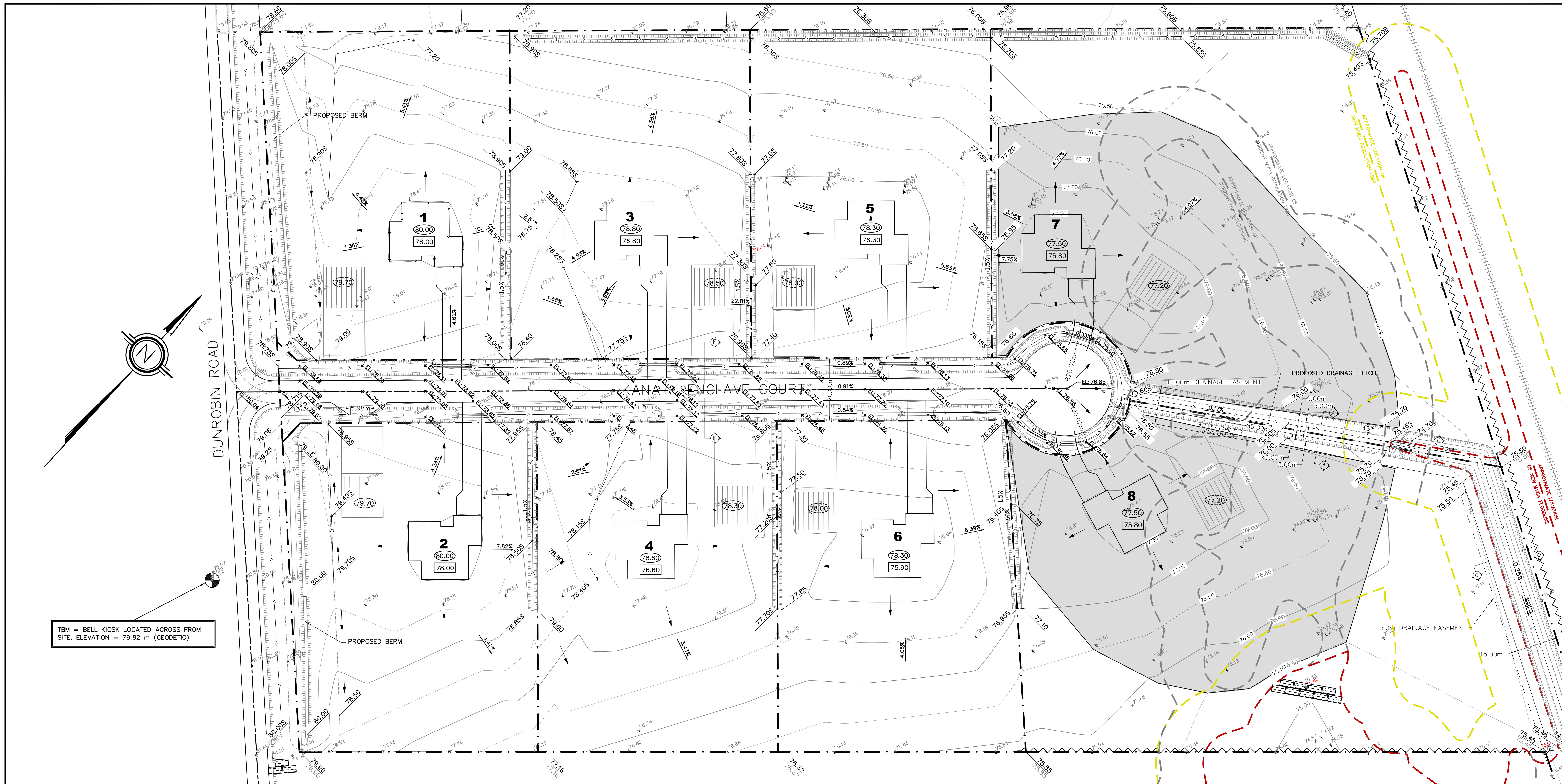
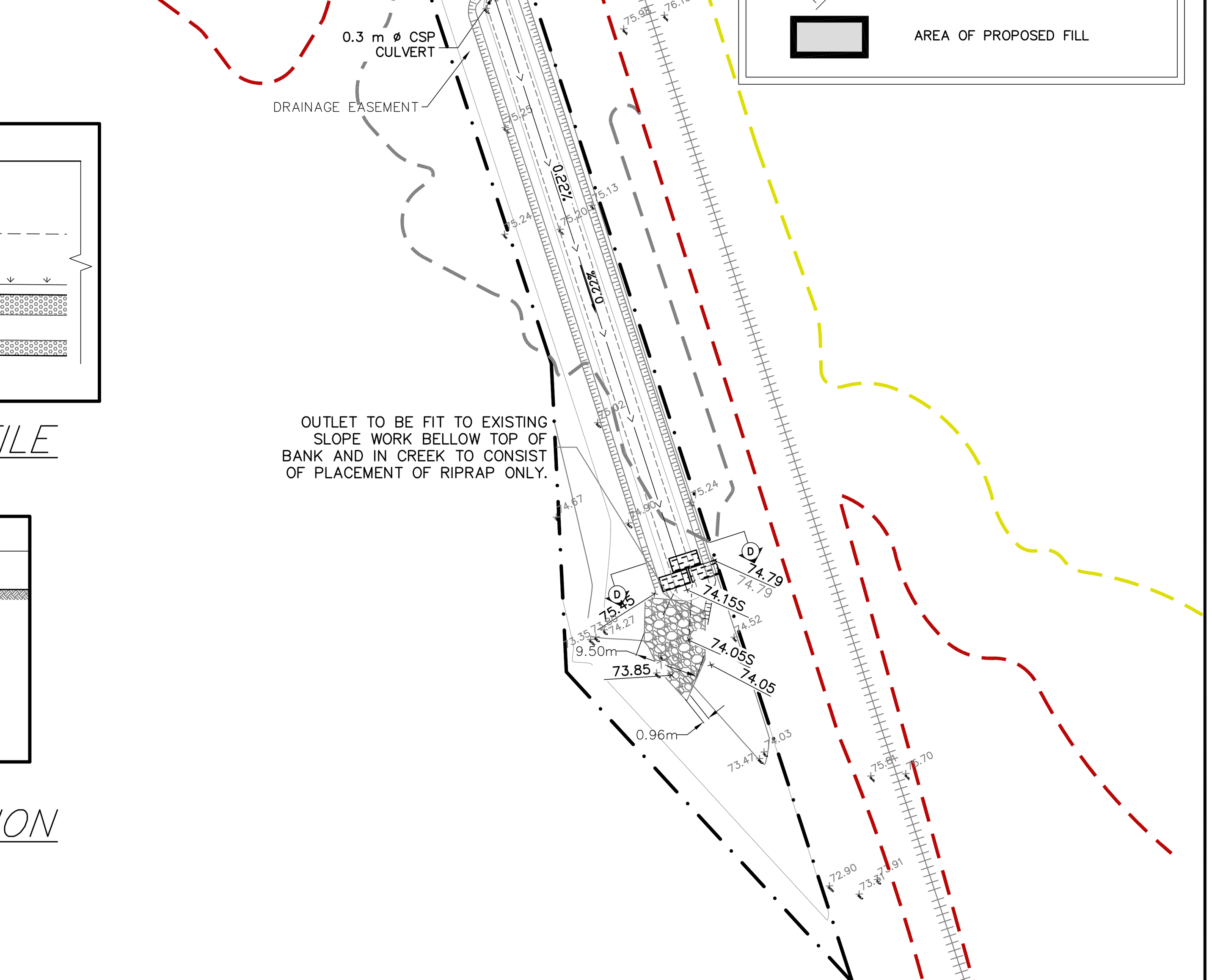
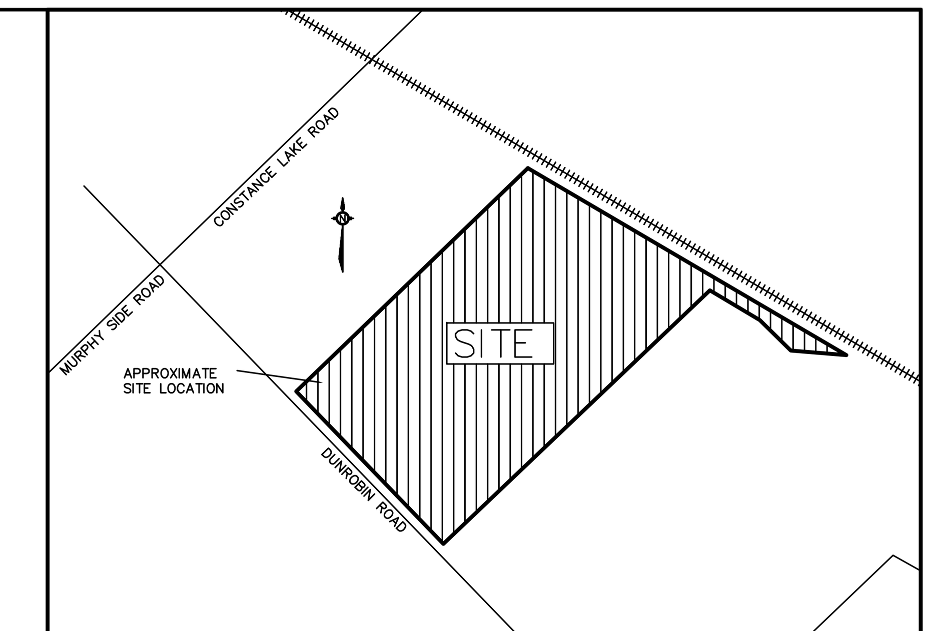


PRELIMINARY GRADING PLAN FOR FILL PLACEMENT

SCALE = 1:750





KEY PLAN

NOT TO SCALE

GENERAL LEGEND

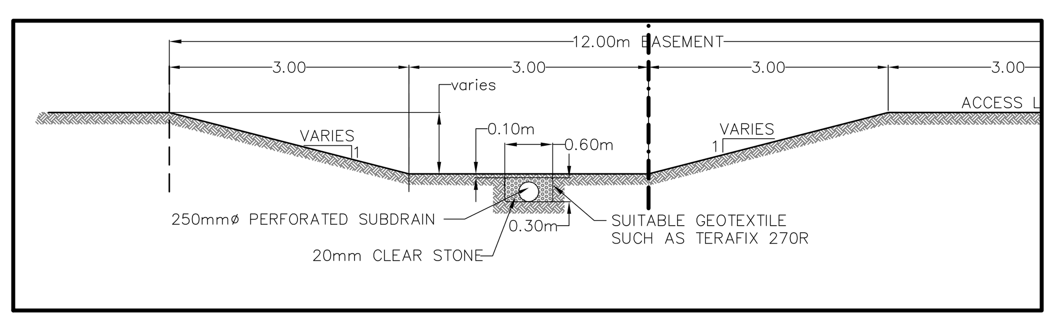
- EXISTING SPOT ELEVATION
- PROPOSED ELEVATION
- EXISTING ELEVATION
- PROPOSED DITCH ELEVATION
- GRADE AREA TO PROMOTE SURFACE RUNOFF
- PROPOSED TERRACING ELEVATION AROUND DWELLING
- PROPOSED UNDERSIDE OF FOOTING ELEVATION
- PROPOSED TOP OF SEPTIC LEACHING BED
- POTENTIAL WELL LOCATION
- NO-DEVELOPMENT AREA
- FENCELINE
- PROPERTY LINES
- PROPERTY SETBACKS
- EDGE OF ROAD
- POTENTIAL DWELLING LOCATION
- POTENTIAL SEPTIC BED LOCATION
- DIRECTION OF FLOW
- TOP OF TERRACING

LEGEND – EROSION & SEDIMENT

- PROPERTY LINES
- TOP OF TERRACING
- EDGE OF ROAD
- LIGHT DUTY SILT FENCE AS PER OPSD 219.110
- STRAWBALE FLOW BARRIER AS PER OPSD 219.180

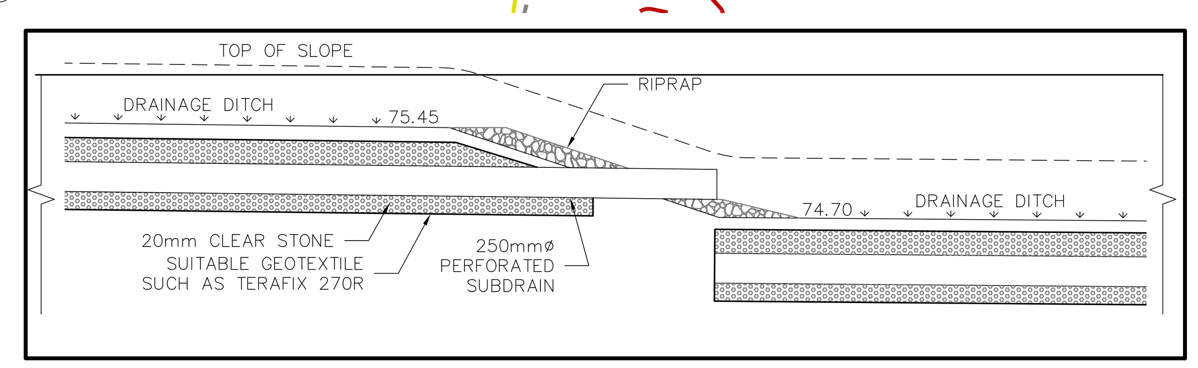
LEGEND – FILL PLACEMENT

- MVCA FLOODLINE
- MVCA REGULATION LIMIT
- PROPOSED GRADE ELEVATION
- AREA OF PROPOSED FILL



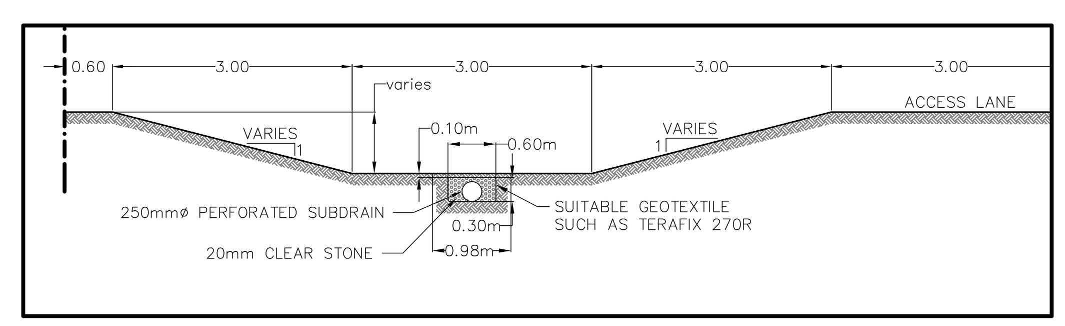
"A–A" PROPOSED DRAINAGE DITCH SECTION

NOT TO SCALE



"B–B" PROPOSED DRAINAGE DITCH PROFILE

NOT TO SCALE

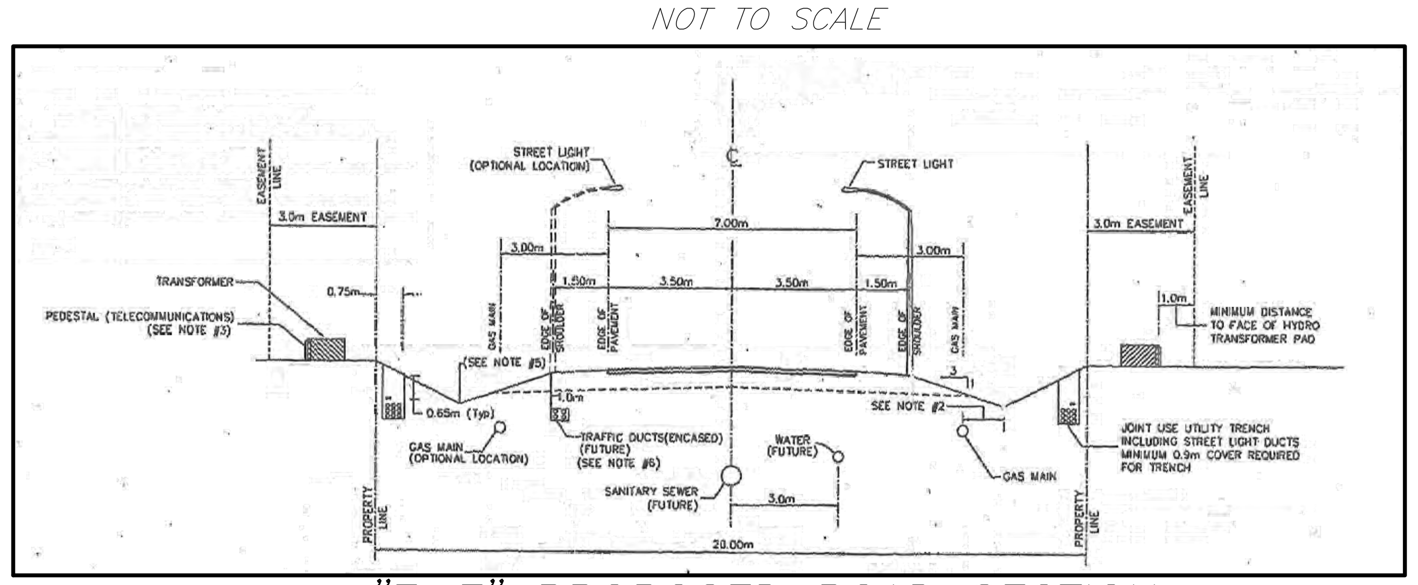


"C–C" PROPOSED DRAINAGE DITCH SECTION

NOT TO SCALE

GRADING & DRAINAGE NOTES

1. Finished grade to slope away from proposed and existing buildings at a minimum of 2% grade for the first 5.0 metres from building. Grade elevations are as indicated.
2. All roadside ditches, swales and exposed drainage channels to be treated with 75mm of topsoil and seeded/mulched or hydroseeded as soon as possible. (Unless noted otherwise)
3. All materials and construction methods to be in accordance with the City of Ottawa.
4. All disturbed areas to be reinstated to the satisfaction of the engineer and the City of Ottawa.
5. The owner (and/or Contractor) agrees to prepare and implement an erosion and sediment control plan at least equal to the stated minimum requirements and to the satisfaction of the City of Ottawa and the Mississippi Conservation, appropriate to the site conditions, prior to undertaking any site alterations (filling, grading, removal of vegetaiton, etc…) and during all phases of site preparation and construction in accordance with the current Best Management Practices for Erosion and Sediment Control such as but not limited to installing a light duty silt fence barrier as shown of Kollaard Associates Inc. dwg. No. 070415-3 (Erosion & Sediment Control Plan).
6. Match existing elevations at all exterior property lines. Ensure positive drainage whether indicated or not.
7. All lots to be graded to allow positive drainage away from tile beds and dwellings consistent with the drainage patterns outlined on this plan. All isolated low areas are to be eliminated.
8. Undersides of footing and terrace elevations have been set for grading drainage purposes only. Builders should consult the geotechnical report for the subdivision prior to construction. Builders should obtain a subgrade inspection report from qualified engineer prior to concrete placement.
9. Driveway entrance culverts to will consist of non-perforated 12.00 METRE ~ 600mm Ø Corragated Steel Pipel.
10. Roadway subgrade shall be inspected by a licensed Geotechnical engineer prior to the placement of granulars.
11. All drainage easements, road side ditches, and property line swales with slopes one percent (1%) or less require a subdrain (see typical detail).
12. Subdrain cover material to consist of a sand/peat mixture capable of supporting vegetative growth.



"F–F" PROPOSED ROAD SECTION

NOT TO SCALE

NOTE:

1. All dimensions are in metres.
2. All elevations are in metres and are based on a geodetic benchmark. TBM = Bell kiosk located sout/westh side of Dunrobin Road, across from proposed lot #2 , elevation = 79.82 m (geodetic)
3. This drawing does not represent a legal survey.
4. Finished grade to slope away from proposed building at a minimum of 2%. Grade elevations are as indicated.
5. All dimensions to be verified on site by contractor prior to construction.
6. All materials and construction methods to be in accordance with City of Ottawa Standards and Ontario Provincial Standards and Specifications.
7. All disturbed areas to be reinstated to the satisfaction of the engineer and the City of Ottawa.
8. The owner (and/or Contractor) agrees to prepare and implement an erosion and sediment control plan at least equal to the stated minimum requirements and to the satisfaction of the City of Ottawa, appropriate to the site conditions, prior to undertaking any site alterations (filling, grading, removal of vegetation, etc.) and during all phases of site preparation and construction in accordance with the current Best Management Practices for Erosion and Sediment Control
9. Any changes made to this plan must be verified and approved by Kollaard Associates Inc.

No.	REVISION	DATE	BY
1	ISSUED FOR MVCA PERMIT	MAY.06.2021	ML
0	ISSUED FOR CITY AND MVCA REVIEW	MAR.09.2021	ML

Kollaard Associates
Engineers

BOX 189
210 PRESCOTT STREET
KEMPTVILLE, ONTARIO
K0G 1J0
FACSIMILE (613) 258-0475

(613) 860-0923

DESIGN	KL/SD/WK
CHECKED	SD
DRAWN	PV/RR/ML
CHECKED	SD
APPROVED	SD

SCALE

1:750

PROJECT LOCATION	2050 DUNROBIN ROAD, CITY OF OTTAWA, ONTARIO
CLIENT NAME	ZBIGNIEW HAUDEROWICZ
PROJECT NAME	PROPOSED RESIDENTIAL SUBDIVISION
DRAWING	PRELIMARY GRADING PLAN FOR FILL PLACEMENT
PROJECT No.	200977
DRAWING No.	200977–GRF
DATE	MARCH 09, 2021
SHEET SET	FIGURE 5

APPENDIX E: PRE-DEVELOPMENT OTTHYMO MODEL RESULTS

Pre-development Summary Output

Detailed Output from Last Link

```
================================================================================

      V    V   I    SSSSS  U   U    A    L             (v 6.2.2011)
      V    V   I    SS     U   U   A A   L
       V  V    I     SS    U   U  AAAAA  L
       V  V    I      SS   U   U  A   A  L
        VV     I    SSSSS  UUUUU  A   A  LLLLL

       OOO   TTTTT  TTTTT  H   H  Y   Y  M   M   OOO    TM
      O   O    T      T    H   H   Y Y   MM MM  O   O
      O   O    T      T    H   H    Y    M   M  O   O
       OOO     T      T    H   H    Y    M   M   OOO

                  *****  S U M M A R Y   O U T P U T  *****


  ************************************************
  ** SIMULATION : 1. SCS II 6hr 5yr Ottawa      **
  ************************************************

  W/E COMMAND              HYD ID   DT    AREA  ' Qpeak Tpeak   R.V. R.C.
Qbase
                                   min     ha   '  cms   hrs     mm          cms

      START @  0.00 hrs
      --------------------
    READ STORM                  30.0
    [ Ptot= 50.41 mm ]
    remark: SCS II 6hr 5yr Ottawa
*
 ** CALIB NASHYD         0017  1  5.0    0.17    0.01  3.08  13.03 0.26   0.000
    [CN=73.9          ]
    [ N = 3.0:Tp 0.17]
*
    READ STORM                  30.0
    [ Ptot= 50.41 mm ]
    fname : C:\Users\hymo\AppData\Local\Temp\85e25ca1-449f-4356-8d20-
776d0a1a030c\efd79b53-4367-4bd5-a2ba-ef6554
    remark: SCS II 6hr 5yr Ottawa
*
 ** CALIB NASHYD         0019  1  5.0    1.68    0.01  3.58   5.62 0.11   0.000
    [CN=57.5          ]
    [ N = 3.0:Tp 0.41]
*
    READ STORM                  30.0
    [ Ptot= 50.41 mm ]
    remark: SCS II 6hr 5yr Ottawa
*
 ** CALIB NASHYD         0090  1  5.0    4.31    0.04  3.67   6.07 0.12   0.000
    [CN=58.7          ]
    [ N = 3.0:Tp 0.52]
*
    ADD [  0017+  0019]  0092  3  5.0    1.85    0.02  3.50   6.31  n/a   0.000
*
    ADD [  0092+  0090]  0092  1  5.0    6.16    0.05  3.58   6.14  n/a   0.000
*
    CHANNEL[ 2:  0092]   0095  1  5.0    6.16    0.05  3.75   6.14  n/a   0.000
*
    READ STORM                  30.0
    [ Ptot= 50.41 mm ]
```

```
    remark: SCS II 6hr 5yr Ottawa
*
 ** CALIB NASHYD         0018  1  5.0    0.17    0.01  3.08  13.03 0.26   0.000
    [CN=73.9         ]
    [ N = 3.0:Tp 0.17]
*
    READ STORM                 30.0
    [ Ptot= 50.41 mm ]
    remark: SCS II 6hr 5yr Ottawa
*
 ** CALIB NASHYD         0091  1  5.0    4.65    0.04  3.83   6.07 0.12   0.000
    [CN=58.7         ]
    [ N = 3.0:Tp 0.62]
*
    ADD [  0018+  0091]  0093  3  5.0    4.82    0.04  3.75   6.32  n/a   0.000
*
    CHANNEL[ 2:  0093]   0094  1  5.0    4.82    0.04  3.92   6.32  n/a   0.000
*
    ADD [  0094+  0095]  0096  3  5.0   10.99    0.09  3.75   6.22  n/a   0.000
*
===============================================================================
  ************************************************
  ** SIMULATION : 10. 25mm4hrChicago           **
  ************************************************

  W/E COMMAND             HYD ID   DT    AREA  ' Qpeak Tpeak   R.V. R.C.
Qbase
                                  min     ha   '  cms   hrs     mm          cms

      START @  0.00 hrs
      --------------------
    READ STORM                 10.0
    [ Ptot= 25.00 mm ]
    remark: twentyfive mm 4 hr chicago storm
*
 ** CALIB NASHYD         0017  1  5.0    0.17    0.00  1.75   2.41 0.10   0.000
    [CN=73.9         ]
    [ N = 3.0:Tp 0.17]
*
    READ STORM                 10.0
    [ Ptot= 25.00 mm ]
    remark: twentyfive mm 4 hr chicago storm
*
 ** CALIB NASHYD         0019  1  5.0    1.68    0.00  3.33   0.50 0.02   0.000
    [CN=57.5         ]
    [ N = 3.0:Tp 0.41]
*
    READ STORM                 10.0
    [ Ptot= 25.00 mm ]
    remark: twentyfive mm 4 hr chicago storm
*
 ** CALIB NASHYD         0090  1  5.0    4.31    0.00  3.42   0.60 0.02   0.000
    [CN=58.7         ]
    [ N = 3.0:Tp 0.52]
*
    ADD [  0017+  0019]  0092  3  5.0    1.85    0.00  3.08   0.68  n/a   0.000
*
    ADD [  0092+  0090]  0092  1  5.0    6.16    0.00  3.33   0.63  n/a   0.000
*
    CHANNEL[ 2:  0092]   0095  1  5.0    6.16    0.00  3.67   0.63  n/a   0.000
*
```

```
    READ STORM                10.0
    [ Ptot= 25.00 mm ]
    remark: twentyfive mm 4 hr chicago storm
*
 ** CALIB NASHYD         0018  1  5.0    0.17    0.00  1.75   2.41 0.10   0.000
    [CN=73.9         ]
    [ N = 3.0:Tp 0.17]
*
    READ STORM                10.0
    [ Ptot= 25.00 mm ]
    remark: twentyfive mm 4 hr chicago storm
*
 ** CALIB NASHYD         0091  1  5.0    4.65    0.00  3.75   0.60 0.02   0.000
    [CN=58.7         ]
    [ N = 3.0:Tp 0.62]
*
    ADD [  0018+  0091]  0093  3  5.0    4.82    0.00  3.67   0.67  n/a   0.000
*
    CHANNEL[ 2:  0093]   0094  1  5.0    4.82    0.00  3.92   0.67  n/a   0.000
*
    ADD [  0094+  0095]  0096  3  5.0   10.99    0.01  3.75   0.64  n/a   0.000
*
===============================================================================
  ************************************************
  ** SIMULATION : 2. SCS II 6hr 100yr Ottawa    **
  ************************************************

  W/E COMMAND             HYD ID   DT    AREA  ' Qpeak Tpeak   R.V. R.C.
Qbase
                                  min     ha   '  cms   hrs     mm          cms

      START @  0.00 hrs
      --------------------
    READ STORM                30.0
    [ Ptot= 87.00 mm ]
    remark: SCS II 6hr 100yr Ottawa
*
 ** CALIB NASHYD         0017  1  5.0    0.17    0.02  3.00  36.15 0.42   0.000
    [CN=73.9         ]
    [ N = 3.0:Tp 0.17]
*
    READ STORM                30.0
    [ Ptot= 87.00 mm ]
    remark: SCS II 6hr 100yr Ottawa
*
 ** CALIB NASHYD         0019  1  5.0    1.68    0.06  3.50  19.96 0.23   0.000
    [CN=57.5         ]
    [ N = 3.0:Tp 0.41]
*
    READ STORM                30.0
    [ Ptot= 87.00 mm ]
    remark: SCS II 6hr 100yr Ottawa
*
 ** CALIB NASHYD         0090  1  5.0    4.31    0.14  3.58  21.02 0.24   0.000
    [CN=58.7         ]
    [ N = 3.0:Tp 0.52]
*
    ADD [  0017+  0019]  0092  3  5.0    1.85    0.07  3.42  21.47  n/a   0.000
*
    ADD [  0092+  0090]  0092  1  5.0    6.16    0.20  3.58  21.16  n/a   0.000
*
```

```
    CHANNEL[ 2:  0092]   0095  1  5.0    6.16    0.20  3.58  21.16  n/a   0.000
*
    READ STORM               30.0
    [ Ptot= 87.00 mm ]
    remark: SCS II 6hr 100yr Ottawa
*
 ** CALIB NASHYD         0018  1  5.0    0.17    0.02  3.00  36.15 0.42   0.000
    [CN=73.9          ]
    [ N = 3.0:Tp 0.17]
*
    READ STORM               30.0
    [ Ptot= 87.00 mm ]
    remark: SCS II 6hr 100yr Ottawa
*
 ** CALIB NASHYD         0091  1  5.0    4.65    0.13  3.75  21.02 0.24   0.000
    [CN=58.7          ]
    [ N = 3.0:Tp 0.62]
*
    ADD [  0018+  0091]  0093  3  5.0    4.82    0.14  3.67  21.56  n/a   0.000
*
    CHANNEL[ 2:  0093]   0094  1  5.0    4.82    0.14  3.75  21.56  n/a   0.000
*
    ADD [  0094+  0095]  0096  3  5.0   10.99    0.34  3.67  21.33  n/a   0.000
*
===============================================================================
  ***********************************************
  ** SIMULATION : 3. SCS II 12hr 5yr Ottawa     **
  ***********************************************

  W/E COMMAND             HYD ID   DT    AREA  ' Qpeak Tpeak   R.V. R.C.
Qbase
                                  min     ha   '  cms   hrs     mm          cms

      START @  0.00 hrs
      --------------------
    READ STORM               30.0
    [ Ptot= 57.20 mm ]
    remark: SCS II 12hr 5yr Ottawa
*
 ** CALIB NASHYD         0017  1  5.0    0.17    0.01  6.00  16.78 0.29   0.000
    [CN=73.9          ]
    [ N = 3.0:Tp 0.17]
*
    READ STORM               30.0
    [ Ptot= 57.20 mm ]
    remark: SCS II 12hr 5yr Ottawa
*
 ** CALIB NASHYD         0019  1  5.0    1.68    0.02  6.42   7.74 0.14   0.000
    [CN=57.5          ]
    [ N = 3.0:Tp 0.41]
*
    READ STORM               30.0
    [ Ptot= 57.20 mm ]
    remark: SCS II 12hr 5yr Ottawa
*
 ** CALIB NASHYD         0090  1  5.0    4.31    0.04  6.58   8.30 0.15   0.000
    [CN=58.7          ]
    [ N = 3.0:Tp 0.52]
*
    ADD [  0017+  0019]  0092  3  5.0    1.85    0.02  6.25   8.59  n/a   0.000
*
```

```
    ADD [  0092+  0090]  0092  1  5.0    6.16    0.06  6.50   8.39  n/a   0.000
*
    CHANNEL[ 2:  0092]   0095  1  5.0    6.16    0.06  6.58   8.39  n/a   0.000
*
    READ STORM                30.0
    [ Ptot= 57.20 mm ]
    remark: SCS II 12hr 5yr Ottawa
*
 ** CALIB NASHYD         0018  1  5.0    0.17    0.01  6.00  16.78 0.29   0.000
    [CN=73.9          ]
    [ N = 3.0:Tp 0.17]
*
    READ STORM                30.0
    [ Ptot= 57.20 mm ]
    remark: SCS II 12hr 5yr Ottawa
*
 ** CALIB NASHYD         0091  1  5.0    4.65    0.04  6.67   8.30 0.15   0.000
    [CN=58.7          ]
    [ N = 3.0:Tp 0.62]
*
    ADD [  0018+  0091]  0093  3  5.0    4.82    0.04  6.67   8.61  n/a   0.000
*
    CHANNEL[ 2:  0093]   0094  1  5.0    4.82    0.04  6.75   8.61  n/a   0.000
*
    ADD [  0094+  0095]  0096  3  5.0   10.99    0.10  6.67   8.48  n/a   0.000
*
==============================================================================

  ************************************************
  ** SIMULATION : 4. SCS II 12hr 10yr Ottawa    **
  ************************************************

  W/E COMMAND             HYD ID   DT    AREA  ' Qpeak Tpeak   R.V. R.C.
Qbase
                                   min     ha   '  cms   hrs     mm          cms

      START @  0.00 hrs
      --------------------
    READ STORM                30.0
    [ Ptot= 67.20 mm ]
    remark: SCS II 12hr 10yr Ottawa
*
 ** CALIB NASHYD         0017  1  5.0    0.17    0.01  6.00  22.82 0.34   0.000
    [CN=73.9          ]
    [ N = 3.0:Tp 0.17]
*
    READ STORM                30.0
    [ Ptot= 67.20 mm ]
    remark: SCS II 12hr 10yr Ottawa
*
 ** CALIB NASHYD         0019  1  5.0    1.68    0.03  6.33  11.35 0.17   0.000
    [CN=57.5          ]
    [ N = 3.0:Tp 0.41]
*
    READ STORM                30.0
    [ Ptot= 67.20 mm ]
    remark: SCS II 12hr 10yr Ottawa
*
 ** CALIB NASHYD         0090  1  5.0    4.31    0.06  6.58  12.08 0.18   0.000
    [CN=58.7          ]
    [ N = 3.0:Tp 0.52]
```

```
*
    ADD [  0017+  0019]  0092  3  5.0    1.85    0.03  6.25  12.42  n/a   0.000
*
    ADD [  0092+  0090]  0092  1  5.0    6.16    0.09  6.50  12.18  n/a   0.000
*
    CHANNEL[ 2:  0092]   0095  1  5.0    6.16    0.09  6.58  12.18  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 67.20 mm ]
    remark: SCS II 12hr 10yr Ottawa
*
 ** CALIB NASHYD         0018  1  5.0    0.17    0.01  6.00  22.82 0.34   0.000
    [CN=73.9          ]
    [ N = 3.0:Tp 0.17]
*
    READ STORM                 30.0
    [ Ptot= 67.20 mm ]
    remark: SCS II 12hr 10yr Ottawa
*
 ** CALIB NASHYD         0091  1  5.0    4.65    0.06  6.67  12.08 0.18   0.000
    [CN=58.7          ]
    [ N = 3.0:Tp 0.62]
*
    ADD [  0018+  0091]  0093  3  5.0    4.82    0.07  6.58  12.46  n/a   0.000
*
    CHANNEL[ 2:  0093]   0094  1  5.0    4.82    0.07  6.67  12.46  n/a   0.000
*
    ADD [  0094+  0095]  0096  3  5.0   10.99    0.16  6.58  12.31  n/a   0.000
*
 FINISH

===============================================================================
  ***********************************************
  ** SIMULATION : 5. SCS II 12hr 100yr correct  **
  ***********************************************

  W/E COMMAND             HYD ID   DT    AREA  ' Qpeak Tpeak   R.V. R.C.
Qbase
                                  min     ha   '  cms   hrs     mm          cms

      START @  0.00 hrs
      --------------------
    READ STORM                 30.0
    [ Ptot= 96.00 mm ]
    remark: SCS II 12hr 100yr Ottawa
*
 ** CALIB NASHYD         0017  1  5.0    0.17    0.02  6.00  42.68 0.44   0.000
    [CN=73.9          ]
    [ N = 3.0:Tp 0.17]
*
    READ STORM                 30.0
    [ Ptot= 96.00 mm ]
    remark: SCS II 12hr 100yr Ottawa
*
 ** CALIB NASHYD         0019  1  5.0    1.68    0.06  6.33  24.41 0.25   0.000
    [CN=57.5          ]
    [ N = 3.0:Tp 0.41]
*
    READ STORM                 30.0
    [ Ptot= 96.00 mm ]
    remark: SCS II 12hr 100yr Ottawa
```

```
*
 ** CALIB NASHYD         0090  1  5.0    4.31    0.15  6.50  25.63 0.27   0.000
    [CN=58.7         ]
    [ N = 3.0:Tp 0.52]
*
    ADD [  0017+  0019]  0092  3  5.0    1.85    0.07  6.25  26.12  n/a   0.000
*
    ADD [  0092+  0090]  0092  1  5.0    6.16    0.21  6.42  25.78  n/a   0.000
*
    CHANNEL[ 2:  0092]   0095  1  5.0    6.16    0.21  6.50  25.78  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 96.00 mm ]
    remark: SCS II 12hr 100yr Ottawa
*
 ** CALIB NASHYD         0018  1  5.0    0.17    0.02  6.00  42.68 0.44   0.000
    [CN=73.9         ]
    [ N = 3.0:Tp 0.17]
*
    READ STORM                 30.0
    [ Ptot= 96.00 mm ]
    remark: SCS II 12hr 100yr Ottawa
*
 ** CALIB NASHYD         0091  1  5.0    4.65    0.14  6.58  25.63 0.27   0.000
    [CN=58.7         ]
    [ N = 3.0:Tp 0.62]
*
    ADD [  0018+  0091]  0093  3  5.0    4.82    0.15  6.58  26.24  n/a   0.000
*
    CHANNEL[ 2:  0093]   0094  1  5.0    4.82    0.15  6.67  26.24  n/a   0.000
*
    ADD [  0094+  0095]  0096  3  5.0   10.99    0.35  6.58  25.98  n/a   0.000
*
==============================================================================
  ************************************************
  ** SIMULATION : 6. Chi 12hr 2yr               **
  ************************************************

  W/E COMMAND             HYD ID   DT    AREA  ' Qpeak Tpeak   R.V. R.C.
Qbase
                                   min     ha   '  cms   hrs     mm          cms

      START @  0.00 hrs
      --------------------
    CHIC STORM                 10.0
    [ Ptot= 42.34 mm ]
*
 ** CALIB NASHYD         0017  1  5.0    0.17    0.00  4.17   9.00 0.21   0.000
    [CN=73.9         ]
    [ N = 3.0:Tp 0.17]
*
    CHIC STORM                 10.0
    [ Ptot= 42.34 mm ]
*
 ** CALIB NASHYD         0019  1  5.0    1.68    0.01  4.67   3.48 0.08   0.000
    [CN=57.5         ]
    [ N = 3.0:Tp 0.41]
*
    CHIC STORM                 10.0
    [ Ptot= 42.34 mm ]
*
```

```
 ** CALIB NASHYD         0090  1  5.0    4.31    0.02  4.83   3.80 0.09   0.000
    [CN=58.7          ]
    [ N = 3.0:Tp 0.52]
*
    ADD [  0017+  0019]  0092  3  5.0    1.85    0.01  4.50   3.99  n/a   0.000
*
    ADD [  0092+  0090]  0092  1  5.0    6.16    0.02  4.75   3.86  n/a   0.000
*
    CHANNEL[ 2:  0092]   0095  1  5.0    6.16    0.02  4.83   3.86  n/a   0.000
*
    CHIC STORM                 10.0
    [ Ptot= 42.34 mm ]
*
 ** CALIB NASHYD         0018  1  5.0    0.17    0.00  4.17   9.00 0.21   0.000
    [CN=73.9          ]
    [ N = 3.0:Tp 0.17]
*
    CHIC STORM                 10.0
    [ Ptot= 42.34 mm ]
*
 ** CALIB NASHYD         0091  1  5.0    4.65    0.01  5.00   3.80 0.09   0.000
    [CN=58.7          ]
    [ N = 3.0:Tp 0.62]
*
    ADD [  0018+  0091]  0093  3  5.0    4.82    0.02  4.92   3.99  n/a   0.000
*
    CHANNEL[ 2:  0093]   0094  1  5.0    4.82    0.02  5.08   3.99  n/a   0.000
*
    ADD [  0094+  0095]  0096  3  5.0   10.99    0.04  4.92   3.92  n/a   0.000
*
================================================================================
  ************************************************
  ** SIMULATION : 7. Chi 12hr 100yr             **
  ************************************************

  W/E COMMAND              HYD ID   DT    AREA  ' Qpeak Tpeak   R.V. R.C.
Qbase
                                    min     ha   '  cms   hrs     mm          cms

      START @  0.00 hrs
      --------------------
    CHIC STORM                 10.0
    [ Ptot= 93.90 mm ]
*
 ** CALIB NASHYD         0017  1  5.0    0.17    0.02  4.08  41.13 0.44   0.000
    [CN=73.9          ]
    [ N = 3.0:Tp 0.17]
*
    CHIC STORM                 10.0
    [ Ptot= 93.90 mm ]
*
 ** CALIB NASHYD         0019  1  5.0    1.68    0.06  4.50  23.34 0.25   0.000
    [CN=57.5          ]
    [ N = 3.0:Tp 0.41]
*
    CHIC STORM                 10.0
    [ Ptot= 93.90 mm ]
*
 ** CALIB NASHYD         0090  1  5.0    4.31    0.14  4.58  24.53 0.26   0.000
    [CN=58.7          ]
    [ N = 3.0:Tp 0.52]
```

```
*
    ADD [  0017+  0019]  0092  3  5.0    1.85    0.07  4.42  25.00  n/a   0.000
*
    ADD [  0092+  0090]  0092  1  5.0    6.16    0.20  4.58  24.67  n/a   0.000
*
    CHANNEL[ 2:  0092]   0095  1  5.0    6.16    0.20  4.58  24.67  n/a   0.000
*
    CHIC STORM                 10.0
    [ Ptot= 93.90 mm ]
*
 ** CALIB NASHYD         0018  1  5.0    0.17    0.02  4.08  41.13 0.44   0.000
    [CN=73.9          ]
    [ N = 3.0:Tp 0.17]
*
    CHIC STORM                 10.0
    [ Ptot= 93.90 mm ]
*
 ** CALIB NASHYD         0091  1  5.0    4.65    0.13  4.75  24.53 0.26   0.000
    [CN=58.7          ]
    [ N = 3.0:Tp 0.62]
*
    ADD [  0018+  0091]  0093  3  5.0    4.82    0.14  4.75  25.12  n/a   0.000
*
    CHANNEL[ 2:  0093]   0094  1  5.0    4.82    0.13  4.83  25.12  n/a   0.000
*
    ADD [  0094+  0095]  0096  3  5.0   10.99    0.33  4.67  24.87  n/a   0.000
*
===============================================================================
  ***********************************************
  ** SIMULATION : 8. Historical July 1 1979     **
  ***********************************************

  W/E COMMAND             HYD ID   DT    AREA  ' Qpeak Tpeak   R.V. R.C.
Qbase
                                   min     ha   '  cms   hrs     mm          cms

      START @  0.00 hrs
      --------------------
    READ STORM                  5.0
    [ Ptot= 83.99 mm ]
    remark: Ottawa July 1 1979
*
 ** CALIB NASHYD         0017  1  5.0    0.17    0.02  1.67  34.02 0.41   0.000
    [CN=73.9          ]
    [ N = 3.0:Tp 0.17]
*
    READ STORM                  5.0
    [ Ptot= 83.99 mm ]
    remark: Ottawa July 1 1979
*
 ** CALIB NASHYD         0019  1  5.0    1.68    0.08  2.00  18.54 0.22   0.000
    [CN=57.5          ]
    [ N = 3.0:Tp 0.41]
*
    READ STORM                  5.0
    [ Ptot= 83.99 mm ]
    remark: Ottawa July 1 1979
*
 ** CALIB NASHYD         0090  1  5.0    4.31    0.18  2.08  19.55 0.23   0.000
    [CN=58.7          ]
    [ N = 3.0:Tp 0.52]
```

```
*
    ADD [  0017+  0019]  0092  3  5.0    1.85    0.09  1.92  19.98  n/a   0.000
*
    ADD [  0092+  0090]  0092  1  5.0    6.16    0.27  2.08  19.68  n/a   0.000
*
    CHANNEL[ 2:  0092]   0095  1  5.0    6.16    0.27  2.08  19.68  n/a   0.000
*
    READ STORM                    5.0
    [ Ptot= 83.99 mm ]
    remark: Ottawa July 1 1979
*
 ** CALIB NASHYD         0018  1  5.0    0.17    0.02  1.67  34.02 0.41   0.000
    [CN=73.9          ]
    [ N = 3.0:Tp 0.17]
*
    READ STORM                    5.0
    [ Ptot= 83.99 mm ]
    remark: Ottawa July 1 1979
*
 ** CALIB NASHYD         0091  1  5.0    4.65    0.18  2.17  19.55 0.23   0.000
    [CN=58.7          ]
    [ N = 3.0:Tp 0.62]
*
    ADD [  0018+  0091]  0093  3  5.0    4.82    0.18  2.17  20.07  n/a   0.000
*
    CHANNEL[ 2:  0093]   0094  1  5.0    4.82    0.18  2.25  20.07  n/a   0.000
*
    ADD [  0094+  0095]  0096  3  5.0   10.99    0.44  2.17  19.85  n/a   0.000
*
===============================================================================
  ***********************************************
  ** SIMULATION : 9. Historical Aug 4 1988      **
  ***********************************************

  W/E COMMAND             HYD ID   DT    AREA  ' Qpeak Tpeak   R.V. R.C.
Qbase
                                   min     ha   '  cms   hrs     mm          cms

      START @  0.00 hrs
      --------------------
    READ STORM                    5.0
    [ Ptot= 80.57 mm ]
    remark: Ottawa Aug 4 1988
*
 ** CALIB NASHYD         0017  1  5.0    0.17    0.02  2.08  31.64 0.39   0.000
    [CN=73.9          ]
    [ N = 3.0:Tp 0.17]
*
    READ STORM                    5.0
    [ Ptot= 80.57 mm ]
    remark: Ottawa Aug 4 1988
*
 ** CALIB NASHYD         0019  1  5.0    1.68    0.07  2.25  16.97 0.21   0.000
    [CN=57.5          ]
    [ N = 3.0:Tp 0.41]
*
    READ STORM                    5.0
    [ Ptot= 80.57 mm ]
    remark: Ottawa Aug 4 1988
*
 ** CALIB NASHYD         0090  1  5.0    4.31    0.15  2.33  17.92 0.22   0.000
```

```
    [CN=58.7         ]
    [ N = 3.0:Tp 0.52]
*
    ADD [  0017+  0019]  0092  3  5.0    1.85    0.08  2.17  18.34  n/a   0.000
*
    ADD [  0092+  0090]  0092  1  5.0    6.16    0.22  2.25  18.05  n/a   0.000
*
    CHANNEL[ 2:  0092]   0095  1  5.0    6.16    0.22  2.33  18.05  n/a   0.000
*
    READ STORM                  5.0
    [ Ptot= 80.57 mm ]
    remark: Ottawa Aug 4 1988
*
 ** CALIB NASHYD         0018  1  5.0    0.17    0.02  2.08  31.64 0.39   0.000
    [CN=73.9         ]
    [ N = 3.0:Tp 0.17]
*
    READ STORM                  5.0
    [ Ptot= 80.57 mm ]
    remark: Ottawa Aug 4 1988
*
 ** CALIB NASHYD         0091  1  5.0    4.65    0.14  2.42  17.92 0.22   0.000
    [CN=58.7         ]
    [ N = 3.0:Tp 0.62]
*
    ADD [  0018+  0091]  0093  3  5.0    4.82    0.14  2.42  18.41  n/a   0.000
*
    CHANNEL[ 2:  0093]   0094  1  5.0    4.82    0.14  2.42  18.41  n/a   0.000
*
    ADD [  0094+  0095]  0096  3  5.0   10.99    0.35  2.33  18.21  n/a   0.000
*
```

```
*****************************************
** SIMULATION:1. SCS II 6hr 5yr Ottawa **
*****************************************

  --------------------------
  | Junction Command(0088) |
  --------------------------

                             AREA     QPEAK   TPEAK     R.V.
                             (ha)     (cms)    (hrs)    (mm)
  INFLOW : ID= 1(  0096)    10.99      0.09    3.75     6.22
  OUTFLOW: ID= 2(  0088)    10.99      0.09    3.75     6.22

  ------------------------------------------------------------------------------
--
***********************************
** SIMULATION:10. 25mm4hrChicago **
***********************************

  --------------------------
  | Junction Command(0088) |
  --------------------------

                             AREA     QPEAK   TPEAK     R.V.
                             (ha)     (cms)    (hrs)    (mm)
  INFLOW : ID= 1(  0096)    10.99      0.01    3.75     0.64
  OUTFLOW: ID= 2(  0088)    10.99      0.01    3.75     0.64

  ------------------------------------------------------------------------------
--
*******************************************
** SIMULATION:2. SCS II 6hr 100yr Ottawa **
*******************************************

  --------------------------
  | Junction Command(0088) |
  --------------------------

                             AREA     QPEAK   TPEAK     R.V.
                             (ha)     (cms)    (hrs)    (mm)
  INFLOW : ID= 1(  0096)    10.99      0.34    3.67    21.33
  OUTFLOW: ID= 2(  0088)    10.99      0.34    3.67    21.33

  ------------------------------------------------------------------------------
--
******************************************
** SIMULATION:3. SCS II 12hr 5yr Ottawa **
******************************************

  --------------------------
  | Junction Command(0088) |
  --------------------------

                             AREA     QPEAK   TPEAK     R.V.
                             (ha)     (cms)    (hrs)    (mm)
  INFLOW : ID= 1(  0096)    10.99      0.10    6.67     8.48
  OUTFLOW: ID= 2(  0088)    10.99      0.10    6.67     8.48

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

```
*******************************************
** SIMULATION:4. SCS II 12hr 10yr Ottawa **
*******************************************

  --------------------------
  | Junction Command(0088) |
  --------------------------

                           AREA     QPEAK   TPEAK     R.V.
                           (ha)     (cms)    (hrs)     (mm)
  INFLOW : ID= 1(  0096)   10.99     0.16    6.58    12.31
  OUTFLOW: ID= 2(  0088)   10.99     0.16    6.58    12.31

  ------------------------------------------------------------------------------
--
*********************************************
** SIMULATION:5. SCS II 12hr 100yr correct **
*********************************************

  --------------------------
  | Junction Command(0088) |
  --------------------------

                           AREA     QPEAK   TPEAK     R.V.
                           (ha)     (cms)    (hrs)     (mm)
  INFLOW : ID= 1(  0096)   10.99     0.35    6.58    25.98
  OUTFLOW: ID= 2(  0088)   10.99     0.35    6.58    25.98

  ------------------------------------------------------------------------------
--
************************************
** SIMULATION:6. Chi 12hr 2yr     **
************************************

  --------------------------
  | Junction Command(0088) |
  --------------------------

                           AREA     QPEAK   TPEAK     R.V.
                           (ha)     (cms)    (hrs)     (mm)
  INFLOW : ID= 1(  0096)   10.99     0.04    4.92     3.92
  OUTFLOW: ID= 2(  0088)   10.99     0.04    4.92     3.92

  ------------------------------------------------------------------------------
--
************************************
** SIMULATION:7. Chi 12hr 100yr   **
************************************

  --------------------------
  | Junction Command(0088) |
  --------------------------

                           AREA     QPEAK   TPEAK     R.V.
                           (ha)     (cms)    (hrs)     (mm)
  INFLOW : ID= 1(  0096)   10.99     0.33    4.67    24.87
  OUTFLOW: ID= 2(  0088)   10.99     0.33    4.67    24.87

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

```
******************************************
** SIMULATION:8. Historical July 1 1979 **
******************************************

  --------------------------
  | Junction Command(0088) |
  --------------------------

                            AREA     QPEAK   TPEAK     R.V.
                            (ha)     (cms)    (hrs)    (mm)
  INFLOW : ID= 1(  0096)   10.99      0.44    2.17    19.85
  OUTFLOW: ID= 2(  0088)   10.99      0.44    2.17    19.85

  -------------------------------------------------------------------------------
--
*****************************************
** SIMULATION:9. Historical Aug 4 1988 **
*****************************************

  --------------------------
  | Junction Command(0088) |
  --------------------------

                            AREA     QPEAK   TPEAK     R.V.
                            (ha)     (cms)    (hrs)    (mm)
  INFLOW : ID= 1(  0096)   10.99      0.35    2.33    18.21
  OUTFLOW: ID= 2(  0088)   10.99      0.35    2.33    18.21

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

APPENDIX F: STAGE STORAGE WORKSHEET

APPENDIX F: STORMWATER STORAGE SWALE

Stage Storage Discharge Worksheet

Client: Hauderowicz, Zbigniew and Teresa
Job No.: 200977
Location: 2050 Dunrobin Road
Date: May 5, 2023

Orifice 1 Information	
Dia (m):	0.100
Area (m2.):	0.0079
Orifice Coeff, C_d:	0.60
Orifice Coeff , C_w:	0.62
Orifice Top (m):	75.71
Orifice Cen (m):	75.66
Orifice Inv (m):	75.61

Orifice 2 Information	
Dia (m):	0.200
Area (m2.):	0.0314
Orifice Coeff, C_d:	0.60
Orifice Coeff , C_w:	0.62
Orifice Top (m):	76.02
Orifice Cen (m):	75.92
Orifice Inv (m):	75.82

Stage, WSE Elev (m)	Comment	Layer Thickness [m]	Incremental [m^3]	Orifice 1 Flow			Orifice 2 Flow			Total Outflow (m^3/sec)	Storage (Ha.m)
				Flow Depth (m)	n	Orifice 1 Flow (m^3/sec)	Flow Depth (m)	n	Orifice 1 Flow (m^3/sec)		
76.35		0.05	65.31	0.740	7.40	0.017	0.530	2.65	0.056	0.073	0.072
76.30		0.05	61.58	0.690	6.90	0.017	0.480	2.40	0.052	0.069	0.066
76.25		0.05	57.95	0.640	6.40	0.016	0.430	2.15	0.049	0.065	0.060
76.20		0.05	54.47	0.590	5.90	0.015	0.380	1.90	0.045	0.060	0.054
76.15		0.05	51.15	0.540	5.40	0.015	0.330	1.65	0.041	0.055	0.048
76.10		0.05	48.05	0.490	4.90	0.014	0.280	1.40	0.036	0.050	0.043
76.05		0.05	45.10	0.440	4.40	0.013	0.230	1.15	0.030	0.043	0.038
76.00		0.05	42.28	0.390	3.90	0.012	0.180	0.90	0.022	0.034	0.034
75.95		0.05	39.63	0.340	3.40	0.011	0.130	0.65	0.013	0.025	0.030
75.90		0.05	37.12	0.290	2.90	0.010	0.080	0.40	0.006	0.016	0.026
75.85		0.05	34.75	0.240	2.40	0.009	0.030	0.15	0.001	0.010	0.022
75.80		0.05	32.54	0.190	1.90	0.008	#N/A	#N/A	#N/A	0.008	0.019
75.75		0.05	30.50	0.140	1.40	0.006	#N/A	#N/A	#N/A	0.006	0.015
75.70		0.05	28.60	0.090	0.90	0.004	#N/A	#N/A	#N/A	0.004	0.012
75.65		0.05	26.84	0.040	0.40	0.001	#N/A	#N/A	#N/A	0.001	0.009
75.60		0.05	24.74	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0.000	0.007
75.55		0.05	22.24	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0.000	0.004
75.50		0.05	19.96	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0.000	0.002
75.45		0.00	0.00	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	0.000	0.000

APPENDIX G: POST-DEVELOPMENT OTTHYMO MODEL RESULTS

Post-Development OTTHYMO summary output file

Post-Development Detailed Output file Last Link before Harwood Creek

```
================================================================================

      V    V   I    SSSSS  U   U    A    L              (v 6.2.2011)
      V    V   I    SS     U   U   A A   L
       V  V    I     SS    U   U  AAAAA  L
       V  V    I      SS   U   U  A   A  L
        VV     I    SSSSS  UUUUU  A   A  LLLLL

       OOO   TTTTT  TTTTT  H   H  Y   Y  M   M   OOO    TM
      O   O    T      T    H   H   Y Y   MM MM  O   O
      O   O    T      T    H   H    Y    M   M  O   O
       OOO     T      T    H   H    Y    M   M   OOO

                  *****  S U M M A R Y   O U T P U T  *****


  ************************************************
  ** SIMULATION : 1. SCS II 6hr 5yr Ottawa      **
  ************************************************

  W/E COMMAND             HYD ID   DT    AREA  ' Qpeak Tpeak   R.V. R.C.
Qbase
                                  min     ha   '  cms   hrs     mm          cms

      START @  0.00 hrs
      --------------------
    READ STORM                 30.0
    [ Ptot= 50.41 mm ]
    remark: SCS II 6hr 5yr Ottawa
*
 ** CALIB NASHYD         0001  1  5.0    0.50    0.01  3.08   6.66 0.13   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0001]   0068  1  5.0    0.50    0.01  3.08   6.66  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 50.41 mm ]
    remark: SCS II 6hr 5yr Ottawa
*
 ** CALIB NASHYD         0002  1  5.0    0.50    0.01  3.33   6.68 0.13   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.31]
*
    ADD [  0002+  0068]  0064  3  5.0    1.00    0.01  3.17   6.67  n/a   0.000
*
    CHANNEL[ 2:  0064]   0069  1  5.0    1.00    0.01  3.25   6.67  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 50.41 mm ]
    remark: SCS II 6hr 5yr Ottawa
*
 ** CALIB NASHYD         0003  1  5.0    0.51    0.01  3.58   6.68 0.13   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.45]
*
    ADD [  0003+  0069]  0065  3  5.0    1.51    0.02  3.33   6.67  n/a   0.000
*
    CHANNEL[ 2:  0065]   0070  1  5.0    1.51    0.02  3.42   6.67  n/a   0.000
*
```

```
    READ STORM                  30.0
    [ Ptot= 50.41 mm ]
    remark: SCS II 6hr 5yr Ottawa
*
 ** CALIB NASHYD         0004  1  5.0    1.68    0.01  3.92    6.42 0.13   0.000
    [CN=59.6        ]
    [ N = 3.0:Tp 0.69]
*
    ADD [  0004+  0070]  0066  3  5.0    3.18    0.03  3.67    6.54  n/a   0.000
*
    CHANNEL[ 2:  0066]   0084  1  5.0    3.18    0.03  3.75    6.54  n/a   0.000
*
    READ STORM                  30.0
    [ Ptot= 50.41 mm ]
    remark: SCS II 6hr 5yr Ottawa
*
 ** CALIB NASHYD         0005  1  5.0    1.41    0.02  3.50    6.53 0.13   0.000
    [CN=59.8        ]
    [ N = 3.0:Tp 0.34]
*
    READ STORM                  30.0
    [ Ptot= 50.41 mm ]
    remark: SCS II 6hr 5yr Ottawa
*
 ** CALIB NASHYD         0006  1  5.0    0.50    0.00  3.67    6.70 0.13   0.000
    [CN=60.3        ]
    [ N = 3.0:Tp 0.50]
*
    READ STORM                  30.0
    [ Ptot= 50.41 mm ]
    remark: SCS II 6hr 5yr Ottawa
*
 ** CALIB NASHYD         0008  1  5.0    0.49    0.01  3.08    6.67 0.13   0.000
    [CN=60.2        ]
    [ N = 3.0:Tp 0.20]
*
    CHANNEL[ 2:  0008]   0071  1  5.0    0.49    0.01  3.17    6.67  n/a   0.000
*
    READ STORM                  30.0
    [ Ptot= 50.41 mm ]
    remark: SCS II 6hr 5yr Ottawa
*
 ** CALIB NASHYD         0007  1  5.0    0.50    0.00  3.67    6.68 0.13   0.000
    [CN=60.2        ]
    [ N = 3.0:Tp 0.49]
*
    ADD [  0007+  0071]  0061  3  5.0    0.99    0.01  3.50    6.68  n/a   0.000
*
    CHANNEL[ 2:  0061]   0072  1  5.0    0.99    0.01  3.50    6.68  n/a   0.000
*
    ADD [  0006+  0072]  0062  3  5.0    1.49    0.02  3.58    6.68  n/a   0.000
*
    CHANNEL[ 2:  0062]   0073  1  5.0    1.49    0.01  3.58    6.68  n/a   0.000
*
    READ STORM                  30.0
    [ Ptot= 50.41 mm ]
    remark: SCS II 6hr 5yr Ottawa
*
 ** CALIB NASHYD         0019  1  5.0    1.68    0.01  3.58    5.62 0.11   0.000
    [CN=57.5        ]
    [ N = 3.0:Tp 0.41]
*
```

```
    ADD [  0019+  0005]  0063  3  5.0     3.09     0.03  3.50    6.03  n/a    0.000
*
    ADD [  0063+  0073]  0063  1  5.0     4.58     0.05  3.58    6.24  n/a    0.000
*
    CHANNEL[ 2:  0063]   0083  1  5.0     4.58     0.04  3.67    6.24  n/a    0.000
*
    READ STORM                  30.0
    [ Ptot= 50.41 mm ]
    remark: SCS II 6hr 5yr Ottawa
*
 ** CALIB NASHYD         0009  1  5.0     0.36     0.01  3.17   10.08 0.20    0.000
    [CN=67.4         ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                  30.0
    [ Ptot= 50.41 mm ]
    remark: SCS II 6hr 5yr Ottawa
*
 ** CALIB NASHYD         0017  1  5.0     0.17     0.01  3.08   13.03 0.26    0.000
    [CN=73.9         ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0017]   0080  1  5.0     0.17     0.01  3.17   12.94  n/a    0.000
*
    ADD [  0080+  0009]  0035  3  5.0     0.53     0.01  3.17   11.01  n/a    0.000
*
    CHANNEL[ 2:  0035]   0077  1  5.0     0.53     0.01  3.17   11.01  n/a    0.000
*
    READ STORM                  30.0
    [ Ptot= 50.41 mm ]
    remark: SCS II 6hr 5yr Ottawa
*
 ** CALIB NASHYD         0010  1  5.0     0.38     0.01  3.17    9.89 0.20    0.000
    [CN=67.1         ]
    [ N = 3.0:Tp 0.27]
*
    ADD [  0010+  0077]  0036  3  5.0     0.91     0.02  3.17   10.55  n/a    0.000
*
    CHANNEL[ 2:  0036]   0078  1  5.0     0.91     0.02  3.25   10.55  n/a    0.000
*
    READ STORM                  30.0
    [ Ptot= 50.41 mm ]
    remark: SCS II 6hr 5yr Ottawa
*
 ** CALIB NASHYD         0011  1  5.0     0.38     0.01  3.17    9.89 0.20    0.000
    [CN=67.1         ]
    [ N = 3.0:Tp 0.27]
*
    ADD [  0011+  0078]  0037  3  5.0     1.28     0.03  3.25   10.35  n/a    0.000
*
    CHANNEL[ 2:  0037]   0079  1  5.0     1.28     0.03  3.25   10.35  n/a    0.000
*
    READ STORM                  30.0
    [ Ptot= 50.41 mm ]
    remark: SCS II 6hr 5yr Ottawa
*
 ** CALIB NASHYD         0012  1  5.0     0.29     0.01  3.08   10.51 0.21    0.000
    [CN=70.0         ]
    [ N = 3.0:Tp 0.22]
*
    ADD [  0012+  0079]  0038  3  5.0     1.58     0.03  3.25   10.38  n/a    0.000
*
```

```
    CHANNEL[ 2:  0038]   0094  1  5.0    1.58    0.03  3.25  10.37  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 50.41 mm ]
    remark: SCS II 6hr 5yr Ottawa
*
 ** CALIB NASHYD         0013  1  5.0    0.34    0.01  3.17  10.85 0.22   0.000
    [CN=68.8         ]
    [ N = 3.0:Tp 0.24]
*
    READ STORM                 30.0
    [ Ptot= 50.41 mm ]
    remark: SCS II 6hr 5yr Ottawa
*
 ** CALIB NASHYD         0014  1  5.0    0.36    0.01  3.17  10.00 0.20   0.000
    [CN=67.3         ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                 30.0
    [ Ptot= 50.41 mm ]
    remark: SCS II 6hr 5yr Ottawa
*
 ** CALIB NASHYD         0015  1  5.0    0.38    0.01  3.17   9.89 0.20   0.000
    [CN=67.1         ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                 30.0
    [ Ptot= 50.41 mm ]
    remark: SCS II 6hr 5yr Ottawa
*
 ** CALIB NASHYD         0016  1  5.0    0.39    0.01  3.17   9.82 0.19   0.000
    [CN=66.9         ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                 30.0
    [ Ptot= 50.41 mm ]
    remark: SCS II 6hr 5yr Ottawa
*
 ** CALIB NASHYD         0018  1  5.0    0.17    0.01  3.08  13.03 0.26   0.000
    [CN=73.9         ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0018]   0081  1  5.0    0.17    0.01  3.17  12.97  n/a   0.000
*
    ADD [  0016+  0081]  0039  3  5.0    0.56    0.01  3.17  10.79  n/a   0.000
*
    CHANNEL[ 2:  0039]   0074  1  5.0    0.56    0.01  3.17  10.79  n/a   0.000
*
    ADD [  0015+  0074]  0040  3  5.0    0.94    0.02  3.17  10.43  n/a   0.000
*
    CHANNEL[ 2:  0040]   0075  1  5.0    0.94    0.02  3.25  10.43  n/a   0.000
*
    ADD [  0014+  0075]  0041  3  5.0    1.30    0.03  3.25  10.31  n/a   0.000
*
    CHANNEL[ 2:  0041]   0076  1  5.0    1.30    0.03  3.25  10.31  n/a   0.000
*
    ADD [  0013+  0076]  0042  3  5.0    1.64    0.04  3.25  10.42  n/a   0.000
*
    CHANNEL[ 2:  0042]   0095  1  5.0    1.64    0.04  3.25  10.42  n/a   0.000
*
    ADD [  0094+  0095]  0043  3  5.0    3.22    0.07  3.25  10.40  n/a   0.000
*
```

```
 ** Reservoir
    OUTFLOW:              0093  1  5.0     3.22    0.01  5.25   8.06  n/a   0.000
*
    ADD [  0083+  0093]   0092  3  5.0     7.80    0.05  3.75   6.99  n/a   0.000
*
    CHANNEL[ 2:  0092]    0085  1  5.0     7.80    0.05  3.75   6.99  n/a   0.000
*
    ADD [  0084+  0085]   0086  3  5.0    10.99    0.08  3.75   6.86  n/a   0.000
*
    CHANNEL[ 2:  0086]    0087  1  5.0    10.99    0.08  3.83   6.86  n/a   0.000
*
===============================================================================
  ************************************************
  ** SIMULATION : 10. 25mm4hrChicago            **
  ************************************************

  W/E COMMAND             HYD ID   DT    AREA  ' Qpeak Tpeak   R.V. R.C.
Qbase
                                   min     ha   '  cms   hrs     mm           cms

      START @  0.00 hrs
      --------------------
    READ STORM                 10.0
    [ Ptot= 25.00 mm ]
    remark: twentyfive mm 4 hr chicago storm
*
 ** CALIB NASHYD          0001  1  5.0     0.50    0.00  2.17   0.75 0.03   0.000
    [CN=60.2         ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0001]    0068  1  5.0     0.50    0.00  2.25   0.74  n/a   0.000
*
    READ STORM                 10.0
    [ Ptot= 25.00 mm ]
    remark: twentyfive mm 4 hr chicago storm
*
 ** CALIB NASHYD          0002  1  5.0     0.50    0.00  2.58   0.75 0.03   0.000
    [CN=60.2         ]
    [ N = 3.0:Tp 0.31]
*
    ADD [  0002+  0068]   0064  3  5.0     1.00    0.00  2.50   0.75  n/a   0.000
*
    CHANNEL[ 2:  0064]    0069  1  5.0     1.00    0.00  2.58   0.75  n/a   0.000
*
    READ STORM                 10.0
    [ Ptot= 25.00 mm ]
    remark: twentyfive mm 4 hr chicago storm
*
 ** CALIB NASHYD          0003  1  5.0     0.51    0.00  3.00   0.75 0.03   0.000
    [CN=60.2         ]
    [ N = 3.0:Tp 0.45]
*
    ADD [  0003+  0069]   0065  3  5.0     1.51    0.00  2.75   0.75  n/a   0.000
*
    CHANNEL[ 2:  0065]    0070  1  5.0     1.51    0.00  2.92   0.75  n/a   0.000
*
    READ STORM                 10.0
    [ Ptot= 25.00 mm ]
    remark: twentyfive mm 4 hr chicago storm
*
 ** CALIB NASHYD          0004  1  5.0     1.68    0.00  3.75   0.68 0.03   0.000
    [CN=59.6         ]
```

```
    [ N = 3.0:Tp 0.69]
*
    ADD [  0004+  0070]  0066  3  5.0    3.18    0.00  3.42    0.71  n/a    0.000
*
    CHANNEL[ 2:  0066]   0084  1  5.0    3.18    0.00  3.67    0.71  n/a    0.000
*
    READ STORM                 10.0
    [ Ptot= 25.00 mm ]
    remark: twentyfive mm 4 hr chicago storm
*
 ** CALIB NASHYD         0005  1  5.0    1.41    0.00  2.75    0.71 0.03   0.000
    [CN=59.8          ]
    [ N = 3.0:Tp 0.34]
*
    READ STORM                 10.0
    [ Ptot= 25.00 mm ]
    remark: twentyfive mm 4 hr chicago storm
*
 ** CALIB NASHYD         0006  1  5.0    0.50    0.00  3.17    0.75 0.03   0.000
    [CN=60.3          ]
    [ N = 3.0:Tp 0.50]
*
    READ STORM                 10.0
    [ Ptot= 25.00 mm ]
    remark: twentyfive mm 4 hr chicago storm
*
 ** CALIB NASHYD         0008  1  5.0    0.49    0.00  2.33    0.75 0.03   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.20]
*
    CHANNEL[ 2:  0008]   0071  1  5.0    0.49    0.00  2.33    0.75  n/a    0.000
*
    READ STORM                 10.0
    [ Ptot= 25.00 mm ]
    remark: twentyfive mm 4 hr chicago storm
*
 ** CALIB NASHYD         0007  1  5.0    0.50    0.00  3.08    0.75 0.03   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.49]
*
    ADD [  0007+  0071]  0061  3  5.0    0.99    0.00  2.83    0.75  n/a    0.000
*
    CHANNEL[ 2:  0061]   0072  1  5.0    0.99    0.00  2.92    0.75  n/a    0.000
*
    ADD [  0006+  0072]  0062  3  5.0    1.49    0.00  3.00    0.75  n/a    0.000
*
    CHANNEL[ 2:  0062]   0073  1  5.0    1.49    0.00  3.08    0.75  n/a    0.000
*
    READ STORM                 10.0
    [ Ptot= 25.00 mm ]
    remark: twentyfive mm 4 hr chicago storm
*
 ** CALIB NASHYD         0019  1  5.0    1.68    0.00  3.33    0.50 0.02   0.000
    [CN=57.5          ]
    [ N = 3.0:Tp 0.41]
*
    ADD [  0019+  0005]  0063  3  5.0    3.09    0.00  3.08    0.60  n/a    0.000
*
    ADD [  0063+  0073]  0063  1  5.0    4.58    0.00  3.08    0.65  n/a    0.000
*
    CHANNEL[ 2:  0063]   0083  1  5.0    4.58    0.00  3.67    0.64  n/a    0.000
*
```

```
    READ STORM                 10.0
    [ Ptot= 25.00 mm ]
    remark: twentyfive mm 4 hr chicago storm
*
 ** CALIB NASHYD         0009  1  5.0    0.36    0.00  2.00   1.67 0.07   0.000
    [CN=67.4         ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                 10.0
    [ Ptot= 25.00 mm ]
    remark: twentyfive mm 4 hr chicago storm
*
 ** CALIB NASHYD         0017  1  5.0    0.17    0.00  1.75   2.41 0.10   0.000
    [CN=73.9         ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0017]   0080  1  5.0    0.17    0.00  2.00   2.33  n/a   0.000
*
    ADD [  0080+  0009]  0035  3  5.0    0.53    0.00  2.00   1.89  n/a   0.000
*
    CHANNEL[ 2:  0035]   0077  1  5.0    0.53    0.00  2.08   1.89  n/a   0.000
*
    READ STORM                 10.0
    [ Ptot= 25.00 mm ]
    remark: twentyfive mm 4 hr chicago storm
*
 ** CALIB NASHYD         0010  1  5.0    0.38    0.00  2.08   1.61 0.06   0.000
    [CN=67.1         ]
    [ N = 3.0:Tp 0.27]
*
    ADD [  0010+  0077]  0036  3  5.0    0.91    0.00  2.08   1.77  n/a   0.000
*
    CHANNEL[ 2:  0036]   0078  1  5.0    0.91    0.00  2.17   1.77  n/a   0.000
*
    READ STORM                 10.0
    [ Ptot= 25.00 mm ]
    remark: twentyfive mm 4 hr chicago storm
*
 ** CALIB NASHYD         0011  1  5.0    0.38    0.00  2.08   1.61 0.06   0.000
    [CN=67.1         ]
    [ N = 3.0:Tp 0.27]
*
    ADD [  0011+  0078]  0037  3  5.0    1.28    0.00  2.17   1.72  n/a   0.000
*
    CHANNEL[ 2:  0037]   0079  1  5.0    1.28    0.00  2.17   1.72  n/a   0.000
*
    READ STORM                 10.0
    [ Ptot= 25.00 mm ]
    remark: twentyfive mm 4 hr chicago storm
*
 ** CALIB NASHYD         0012  1  5.0    0.29    0.00  2.00   1.61 0.06   0.000
    [CN=70.0         ]
    [ N = 3.0:Tp 0.22]
*
    ADD [  0012+  0079]  0038  3  5.0    1.58    0.00  2.17   1.70  n/a   0.000
*
    CHANNEL[ 2:  0038]   0094  1  5.0    1.58    0.00  2.25   1.70  n/a   0.000
*
    READ STORM                 10.0
    [ Ptot= 25.00 mm ]
    remark: twentyfive mm 4 hr chicago storm
*
```

```
 ** CALIB NASHYD         0013  1  5.0    0.34    0.00  1.92    1.90 0.08   0.000
    [CN=68.8          ]
    [ N = 3.0:Tp 0.24]
*
    READ STORM                 10.0
    [ Ptot= 25.00 mm ]
    remark: twentyfive mm 4 hr chicago storm
*
 ** CALIB NASHYD         0014  1  5.0    0.36    0.00  2.00    1.64 0.07   0.000
    [CN=67.3          ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                 10.0
    [ Ptot= 25.00 mm ]
    remark: twentyfive mm 4 hr chicago storm
*
 ** CALIB NASHYD         0015  1  5.0    0.38    0.00  2.08    1.61 0.06   0.000
    [CN=67.1          ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                 10.0
    [ Ptot= 25.00 mm ]
    remark: twentyfive mm 4 hr chicago storm
*
 ** CALIB NASHYD         0016  1  5.0    0.39    0.00  2.08    1.60 0.06   0.000
    [CN=66.9          ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                 10.0
    [ Ptot= 25.00 mm ]
    remark: twentyfive mm 4 hr chicago storm
*
 ** CALIB NASHYD         0018  1  5.0    0.17    0.00  1.75    2.41 0.10   0.000
    [CN=73.9          ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0018]   0081  1  5.0    0.17    0.00  1.92    2.35  n/a   0.000
*
    ADD [  0016+  0081]  0039  3  5.0    0.56    0.00  2.00    1.83  n/a   0.000
*
    CHANNEL[ 2:  0039]   0074  1  5.0    0.56    0.00  2.08    1.83  n/a   0.000
*
    ADD [  0015+  0074]  0040  3  5.0    0.94    0.00  2.08    1.74  n/a   0.000
*
    CHANNEL[ 2:  0040]   0075  1  5.0    0.94    0.00  2.17    1.74  n/a   0.000
*
    ADD [  0014+  0075]  0041  3  5.0    1.30    0.00  2.08    1.71  n/a   0.000
*
    CHANNEL[ 2:  0041]   0076  1  5.0    1.30    0.00  2.17    1.71  n/a   0.000
*
    ADD [  0013+  0076]  0042  3  5.0    1.64    0.00  2.17    1.75  n/a   0.000
*
    CHANNEL[ 2:  0042]   0095  1  5.0    1.64    0.00  2.17    1.75  n/a   0.000
*
    ADD [  0094+  0095]  0043  3  5.0    3.22    0.01  2.25    1.72  n/a   0.000
*
 ** Reservoir
    OUTFLOW:             0093  1  5.0    3.22    0.00  0.00    0.00  n/a   0.000
*
    ADD [  0083+  0093]  0092  3  5.0    7.80    0.00  3.67    0.38  n/a   0.000
*
    CHANNEL[ 2:  0092]   0085  1  5.0    7.80    0.00  3.67    0.38  n/a   0.000
```

```
*
    ADD [  0084+  0085]  0086  3  5.0   10.99    0.01  3.67   0.47  n/a   0.000
*
    CHANNEL[ 2:  0086]   0087  1  5.0   10.99    0.01  3.83   0.47  n/a   0.000
*
 FINISH

===============================================================================
  ***********************************************
  ** SIMULATION : 2. SCS II 6hr 100yr Ottawa    **
  ***********************************************

  W/E COMMAND             HYD ID   DT    AREA  ' Qpeak Tpeak   R.V. R.C.
Qbase
                                  min     ha   '  cms   hrs     mm          cms

      START @  0.00 hrs
      --------------------
    READ STORM                 30.0
    [ Ptot= 87.00 mm ]
    remark: SCS II 6hr 100yr Ottawa
*
 ** CALIB NASHYD         0001  1  5.0    0.50    0.03  3.08  22.35 0.26   0.000
    [CN=60.2         ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0001]   0068  1  5.0    0.50    0.03  3.08  22.35  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 87.00 mm ]
    remark: SCS II 6hr 100yr Ottawa
*
 ** CALIB NASHYD         0002  1  5.0    0.50    0.02  3.25  22.42 0.26   0.000
    [CN=60.2         ]
    [ N = 3.0:Tp 0.31]
*
    ADD [  0002+  0068]  0064  3  5.0    1.00    0.05  3.08  22.38  n/a   0.000
*
    CHANNEL[ 2:  0064]   0069  1  5.0    1.00    0.05  3.17  22.38  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 87.00 mm ]
    remark: SCS II 6hr 100yr Ottawa
*
 ** CALIB NASHYD         0003  1  5.0    0.51    0.02  3.50  22.42 0.26   0.000
    [CN=60.2         ]
    [ N = 3.0:Tp 0.45]
*
    ADD [  0003+  0069]  0065  3  5.0    1.51    0.06  3.17  22.40  n/a   0.000
*
    CHANNEL[ 2:  0065]   0070  1  5.0    1.51    0.06  3.25  22.40  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 87.00 mm ]
    remark: SCS II 6hr 100yr Ottawa
*
 ** CALIB NASHYD         0004  1  5.0    1.68    0.05  3.83  21.84 0.25   0.000
    [CN=59.6         ]
    [ N = 3.0:Tp 0.69]
*
    ADD [  0004+  0070]  0066  3  5.0    3.18    0.10  3.58  22.10  n/a   0.000
*
```

```
    CHANNEL[ 2:  0066]   0084  1  5.0    3.18    0.10  3.67  22.10  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 87.00 mm ]
    remark: SCS II 6hr 100yr Ottawa
*
 ** CALIB NASHYD         0005  1  5.0    1.41    0.06  3.25  22.06 0.25   0.000
    [CN=59.8          ]
    [ N = 3.0:Tp 0.34]
*
    READ STORM                 30.0
    [ Ptot= 87.00 mm ]
    remark: SCS II 6hr 100yr Ottawa
*
 ** CALIB NASHYD         0006  1  5.0    0.50    0.02  3.58  22.49 0.26   0.000
    [CN=60.3          ]
    [ N = 3.0:Tp 0.50]
*
    READ STORM                 30.0
    [ Ptot= 87.00 mm ]
    remark: SCS II 6hr 100yr Ottawa
*
 ** CALIB NASHYD         0008  1  5.0    0.49    0.03  3.08  22.38 0.26   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.20]
*
    CHANNEL[ 2:  0008]   0071  1  5.0    0.49    0.03  3.08  22.38  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 87.00 mm ]
    remark: SCS II 6hr 100yr Ottawa
*
 ** CALIB NASHYD         0007  1  5.0    0.50    0.02  3.58  22.42 0.26   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.49]
*
    ADD [  0007+  0071]  0061  3  5.0    0.99    0.04  3.17  22.40  n/a   0.000
*
    CHANNEL[ 2:  0061]   0072  1  5.0    0.99    0.04  3.17  22.40  n/a   0.000
*
    ADD [  0006+  0072]  0062  3  5.0    1.49    0.05  3.25  22.43  n/a   0.000
*
    CHANNEL[ 2:  0062]   0073  1  5.0    1.49    0.05  3.33  22.43  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 87.00 mm ]
    remark: SCS II 6hr 100yr Ottawa
*
 ** CALIB NASHYD         0019  1  5.0    1.68    0.06  3.50  19.96 0.23   0.000
    [CN=57.5          ]
    [ N = 3.0:Tp 0.41]
*
    ADD [  0019+  0005]  0063  3  5.0    3.09    0.11  3.33  20.92  n/a   0.000
*
    ADD [  0063+  0073]  0063  1  5.0    4.58    0.17  3.33  21.41  n/a   0.000
*
    CHANNEL[ 2:  0063]   0083  1  5.0    4.58    0.16  3.50  21.40  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 87.00 mm ]
    remark: SCS II 6hr 100yr Ottawa
*
```

```
 ** CALIB NASHYD         0009  1  5.0    0.36    0.02  3.17  29.77 0.34   0.000
    [CN=67.4          ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                 30.0
    [ Ptot= 87.00 mm ]
    remark: SCS II 6hr 100yr Ottawa
*
 ** CALIB NASHYD         0017  1  5.0    0.17    0.02  3.00  36.15 0.42   0.000
    [CN=73.9          ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0017]   0080  1  5.0    0.17    0.02  3.17  36.03  n/a   0.000
*
    ADD [  0080+  0009]  0035  3  5.0    0.53    0.04  3.17  31.81  n/a   0.000
*
    CHANNEL[ 2:  0035]   0077  1  5.0    0.53    0.04  3.17  31.81  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 87.00 mm ]
    remark: SCS II 6hr 100yr Ottawa
*
 ** CALIB NASHYD         0010  1  5.0    0.38    0.02  3.17  29.40 0.34   0.000
    [CN=67.1          ]
    [ N = 3.0:Tp 0.27]
*
    ADD [  0010+  0077]  0036  3  5.0    0.91    0.06  3.17  30.81  n/a   0.000
*
    CHANNEL[ 2:  0036]   0078  1  5.0    0.91    0.06  3.17  30.81  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 87.00 mm ]
    remark: SCS II 6hr 100yr Ottawa
*
 ** CALIB NASHYD         0011  1  5.0    0.38    0.02  3.17  29.40 0.34   0.000
    [CN=67.1          ]
    [ N = 3.0:Tp 0.27]
*
    ADD [  0011+  0078]  0037  3  5.0    1.28    0.09  3.17  30.39  n/a   0.000
*
    CHANNEL[ 2:  0037]   0079  1  5.0    1.28    0.09  3.17  30.39  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 87.00 mm ]
    remark: SCS II 6hr 100yr Ottawa
*
 ** CALIB NASHYD         0012  1  5.0    0.29    0.02  3.08  31.27 0.36   0.000
    [CN=70.0          ]
    [ N = 3.0:Tp 0.22]
*
    ADD [  0012+  0079]  0038  3  5.0    1.58    0.11  3.17  30.56  n/a   0.000
*
    CHANNEL[ 2:  0038]   0094  1  5.0    1.58    0.11  3.17  30.55  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 87.00 mm ]
    remark: SCS II 6hr 100yr Ottawa
*
 ** CALIB NASHYD         0013  1  5.0    0.34    0.02  3.08  31.33 0.36   0.000
    [CN=68.8          ]
    [ N = 3.0:Tp 0.24]
*
```

```
    READ STORM                30.0
    [ Ptot= 87.00 mm ]
    remark: SCS II 6hr 100yr Ottawa
*
 ** CALIB NASHYD         0014  1  5.0    0.36    0.02  3.17  29.63 0.34   0.000
    [CN=67.3          ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                30.0
    [ Ptot= 87.00 mm ]
    remark: SCS II 6hr 100yr Ottawa
*
 ** CALIB NASHYD         0015  1  5.0    0.38    0.02  3.17  29.40 0.34   0.000
    [CN=67.1          ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                30.0
    [ Ptot= 87.00 mm ]
    remark: SCS II 6hr 100yr Ottawa
*
 ** CALIB NASHYD         0016  1  5.0    0.39    0.02  3.17  29.24 0.34   0.000
    [CN=66.9          ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                30.0
    [ Ptot= 87.00 mm ]
    remark: SCS II 6hr 100yr Ottawa
*
 ** CALIB NASHYD         0018  1  5.0    0.17    0.02  3.00  36.15 0.42   0.000
    [CN=73.9          ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0018]   0081  1  5.0    0.17    0.02  3.08  36.07  n/a   0.000
*
    ADD [  0016+  0081]  0039  3  5.0    0.56    0.04  3.17  31.34  n/a   0.000
*
    CHANNEL[ 2:  0039]   0074  1  5.0    0.56    0.04  3.17  31.34  n/a   0.000
*
    ADD [  0015+  0074]  0040  3  5.0    0.94    0.06  3.17  30.56  n/a   0.000
*
    CHANNEL[ 2:  0040]   0075  1  5.0    0.94    0.06  3.17  30.56  n/a   0.000
*
    ADD [  0014+  0075]  0041  3  5.0    1.30    0.09  3.17  30.30  n/a   0.000
*
    CHANNEL[ 2:  0041]   0076  1  5.0    1.30    0.09  3.17  30.29  n/a   0.000
*
    ADD [  0013+  0076]  0042  3  5.0    1.64    0.11  3.17  30.51  n/a   0.000
*
    CHANNEL[ 2:  0042]   0095  1  5.0    1.64    0.11  3.17  30.51  n/a   0.000
*
    ADD [  0094+  0095]  0043  3  5.0    3.22    0.22  3.17  30.53  n/a   0.000
*
 ** Reservoir
    OUTFLOW:             0093  1  5.0    3.22    0.06  4.25  28.20  n/a   0.000
*
    ADD [  0083+  0093]  0092  3  5.0    7.80    0.21  3.58  24.21  n/a   0.000
*
    CHANNEL[ 2:  0092]   0085  1  5.0    7.80    0.21  3.58  24.20  n/a   0.000
*
    ADD [  0084+  0085]  0086  3  5.0   10.99    0.31  3.58  23.59  n/a   0.000
*
    CHANNEL[ 2:  0086]   0087  1  5.0   10.99    0.31  3.67  23.59  n/a   0.000
```

```
*
===============================================================================

  ************************************************
  ** SIMULATION : 3. SCS II 12hr 5yr Ottawa     **
  ************************************************

  W/E COMMAND             HYD ID   DT    AREA  ' Qpeak Tpeak   R.V. R.C.
Qbase
                                  min     ha   '  cms   hrs     mm          cms

      START @  0.00 hrs
      --------------------
    READ STORM                 30.0
    [ Ptot= 57.20 mm ]
    remark: SCS II 12hr 5yr Ottawa
*
 ** CALIB NASHYD         0001  1  5.0    0.50    0.01  6.08   9.03 0.16   0.000
    [CN=60.2         ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0001]   0068  1  5.0    0.50    0.01  6.08   9.03  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 57.20 mm ]
    remark: SCS II 12hr 5yr Ottawa
*
 ** CALIB NASHYD         0002  1  5.0    0.50    0.01  6.25   9.06 0.16   0.000
    [CN=60.2         ]
    [ N = 3.0:Tp 0.31]
*
    ADD [  0002+  0068]  0064  3  5.0    1.00    0.02  6.08   9.04  n/a   0.000
*
    CHANNEL[ 2:  0064]   0069  1  5.0    1.00    0.02  6.17   9.04  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 57.20 mm ]
    remark: SCS II 12hr 5yr Ottawa
*
 ** CALIB NASHYD         0003  1  5.0    0.51    0.01  6.50   9.06 0.16   0.000
    [CN=60.2         ]
    [ N = 3.0:Tp 0.45]
*
    ADD [  0003+  0069]  0065  3  5.0    1.51    0.02  6.25   9.05  n/a   0.000
*
    CHANNEL[ 2:  0065]   0070  1  5.0    1.51    0.02  6.25   9.05  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 57.20 mm ]
    remark: SCS II 12hr 5yr Ottawa
*
 ** CALIB NASHYD         0004  1  5.0    1.68    0.02  6.75   8.74 0.15   0.000
    [CN=59.6         ]
    [ N = 3.0:Tp 0.69]
*
    ADD [  0004+  0070]  0066  3  5.0    3.18    0.03  6.42   8.88  n/a   0.000
*
    CHANNEL[ 2:  0066]   0084  1  5.0    3.18    0.03  6.58   8.88  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 57.20 mm ]
    remark: SCS II 12hr 5yr Ottawa
```

```
*
 ** CALIB NASHYD         0005  1  5.0    1.41    0.02  6.25    8.87 0.15   0.000
    [CN=59.8          ]
    [ N = 3.0:Tp 0.34]
*
    READ STORM                 30.0
    [ Ptot= 57.20 mm ]

    remark: SCS II 12hr 5yr Ottawa
*
 ** CALIB NASHYD         0006  1  5.0    0.50    0.01  6.50    9.09 0.16   0.000
    [CN=60.3          ]
    [ N = 3.0:Tp 0.50]
*
    READ STORM                 30.0
    [ Ptot= 57.20 mm ]

    remark: SCS II 12hr 5yr Ottawa
*
 ** CALIB NASHYD         0008  1  5.0    0.49    0.01  6.08    9.04 0.16   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.20]
*
    CHANNEL[ 2:  0008]   0071  1  5.0    0.49    0.01  6.08    9.04  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 57.20 mm ]

    remark: SCS II 12hr 5yr Ottawa
*
 ** CALIB NASHYD         0007  1  5.0    0.50    0.01  6.50    9.06 0.16   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.49]
*
    ADD [  0007+  0071]  0061  3  5.0    0.99    0.01  6.17    9.05  n/a   0.000
*
    CHANNEL[ 2:  0061]   0072  1  5.0    0.99    0.01  6.25    9.05  n/a   0.000
*
    ADD [  0006+  0072]  0062  3  5.0    1.49    0.02  6.25    9.06  n/a   0.000
*
    CHANNEL[ 2:  0062]   0073  1  5.0    1.49    0.02  6.33    9.06  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 57.20 mm ]

    remark: SCS II 12hr 5yr Ottawa
*
 ** CALIB NASHYD         0019  1  5.0    1.68    0.02  6.42    7.74 0.14   0.000
    [CN=57.5          ]
    [ N = 3.0:Tp 0.41]
*
    ADD [  0019+  0005]  0063  3  5.0    3.09    0.04  6.33    8.26  n/a   0.000
*
    ADD [  0063+  0073]  0063  1  5.0    4.58    0.05  6.33    8.52  n/a   0.000
*
    CHANNEL[ 2:  0063]   0083  1  5.0    4.58    0.05  6.50    8.51  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 57.20 mm ]

    remark: SCS II 12hr 5yr Ottawa
*
```

```
 ** CALIB NASHYD         0009  1  5.0    0.36    0.01  6.17  13.19 0.23   0.000
    [CN=67.4          ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                 30.0
    [ Ptot= 57.20 mm ]

    remark: SCS II 12hr 5yr Ottawa
*
 ** CALIB NASHYD         0017  1  5.0    0.17    0.01  6.00  16.78 0.29   0.000
    [CN=73.9          ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0017]   0080  1  5.0    0.17    0.01  6.08  16.71  n/a   0.000
*
    ADD [  0080+  0009]  0035  3  5.0    0.53    0.02  6.08  14.33  n/a   0.000
*
    CHANNEL[ 2:  0035]   0077  1  5.0    0.53    0.02  6.17  14.33  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 57.20 mm ]

    remark: SCS II 12hr 5yr Ottawa
*
 ** CALIB NASHYD         0010  1  5.0    0.38    0.01  6.17  12.96 0.23   0.000
    [CN=67.1          ]
    [ N = 3.0:Tp 0.27]
*
    ADD [  0010+  0077]  0036  3  5.0    0.91    0.02  6.17  13.76  n/a   0.000
*
    CHANNEL[ 2:  0036]   0078  1  5.0    0.91    0.02  6.17  13.76  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 57.20 mm ]

    remark: SCS II 12hr 5yr Ottawa
*
 ** CALIB NASHYD         0011  1  5.0    0.38    0.01  6.17  12.96 0.23   0.000
    [CN=67.1          ]
    [ N = 3.0:Tp 0.27]
*
    ADD [  0011+  0078]  0037  3  5.0    1.28    0.03  6.17  13.53  n/a   0.000
*
    CHANNEL[ 2:  0037]   0079  1  5.0    1.28    0.03  6.17  13.53  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 57.20 mm ]

    remark: SCS II 12hr 5yr Ottawa
*
 ** CALIB NASHYD         0012  1  5.0    0.29    0.01  6.08  13.80 0.24   0.000
    [CN=70.0          ]
    [ N = 3.0:Tp 0.22]
*
    ADD [  0012+  0079]  0038  3  5.0    1.58    0.04  6.17  13.58  n/a   0.000
*
    CHANNEL[ 2:  0038]   0094  1  5.0    1.58    0.04  6.25  13.57  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 57.20 mm ]

    remark: SCS II 12hr 5yr Ottawa
```

```
*
 ** CALIB NASHYD         0013  1  5.0    0.34    0.01  6.08  14.10 0.25   0.000
    [CN=68.8         ]
    [ N = 3.0:Tp 0.24]
*
    READ STORM                 30.0
    [ Ptot= 57.20 mm ]

    remark: SCS II 12hr 5yr Ottawa
*
 ** CALIB NASHYD         0014  1  5.0    0.36    0.01  6.17  13.10 0.23   0.000
    [CN=67.3         ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                 30.0
    [ Ptot= 57.20 mm ]

    remark: SCS II 12hr 5yr Ottawa
*
 ** CALIB NASHYD         0015  1  5.0    0.38    0.01  6.17  12.96 0.23   0.000
    [CN=67.1         ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                 30.0
    [ Ptot= 57.20 mm ]

    remark: SCS II 12hr 5yr Ottawa
*
 ** CALIB NASHYD         0016  1  5.0    0.39    0.01  6.17  12.88 0.23   0.000
    [CN=66.9         ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                 30.0
    [ Ptot= 57.20 mm ]

    remark: SCS II 12hr 5yr Ottawa
*
 ** CALIB NASHYD         0018  1  5.0    0.17    0.01  6.00  16.78 0.29   0.000
    [CN=73.9         ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0018]   0081  1  5.0    0.17    0.01  6.08  16.73  n/a   0.000
*
    ADD [  0016+  0081]  0039  3  5.0    0.56    0.02  6.08  14.06  n/a   0.000
*
    CHANNEL[ 2:  0039]   0074  1  5.0    0.56    0.02  6.17  14.06  n/a   0.000
*
    ADD [  0015+  0074]  0040  3  5.0    0.94    0.03  6.17  13.62  n/a   0.000
*
    CHANNEL[ 2:  0040]   0075  1  5.0    0.94    0.03  6.17  13.62  n/a   0.000
*
    ADD [  0014+  0075]  0041  3  5.0    1.30    0.03  6.17  13.47  n/a   0.000
*
    CHANNEL[ 2:  0041]   0076  1  5.0    1.30    0.03  6.17  13.47  n/a   0.000
*
    ADD [  0013+  0076]  0042  3  5.0    1.64    0.04  6.17  13.60  n/a   0.000
*
    CHANNEL[ 2:  0042]   0095  1  5.0    1.64    0.04  6.17  13.60  n/a   0.000
*
    ADD [  0094+  0095]  0043  3  5.0    3.22    0.08  6.17  13.59  n/a   0.000
*
 ** Reservoir
```

```
    OUTFLOW:              0093  1  5.0     3.22    0.01  8.00  11.25  n/a   0.000
*
    ADD [  0083+  0093]   0092  3  5.0     7.80    0.06  6.58   9.64  n/a   0.000
*
    CHANNEL[ 2:  0092]    0085  1  5.0     7.80    0.06  6.58   9.64  n/a   0.000
*
    ADD [  0084+  0085]   0086  3  5.0    10.99    0.09  6.58   9.42  n/a   0.000
*
    CHANNEL[ 2:  0086]    0087  1  5.0    10.99    0.09  6.67   9.42  n/a   0.000
*
===============================================================================
  ************************************************
  ** SIMULATION : 4. SCS II 12hr 10yr Ottawa    **
  ************************************************

  W/E COMMAND             HYD ID   DT    AREA  ' Qpeak Tpeak   R.V. R.C.
Qbase
                                  min     ha   '  cms   hrs     mm          cms

      START @  0.00 hrs
      --------------------
    READ STORM                 30.0
    [ Ptot= 67.20 mm ]
    remark: SCS II 12hr 10yr Ottawa
*
 ** CALIB NASHYD          0001  1  5.0     0.50    0.01  6.00  13.01 0.19   0.000
    [CN=60.2         ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0001]    0068  1  5.0     0.50    0.01  6.08  13.01  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 67.20 mm ]
    remark: SCS II 12hr 10yr Ottawa
*
 ** CALIB NASHYD          0002  1  5.0     0.50    0.01  6.17  13.05 0.19   0.000
    [CN=60.2         ]
    [ N = 3.0:Tp 0.31]
*
    ADD [  0002+  0068]   0064  3  5.0     1.00    0.03  6.08  13.03  n/a   0.000
*
    CHANNEL[ 2:  0064]    0069  1  5.0     1.00    0.03  6.17  13.03  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 67.20 mm ]
    remark: SCS II 12hr 10yr Ottawa
*
 ** CALIB NASHYD          0003  1  5.0     0.51    0.01  6.42  13.05 0.19   0.000
    [CN=60.2         ]
    [ N = 3.0:Tp 0.45]
*
    ADD [  0003+  0069]   0065  3  5.0     1.51    0.03  6.17  13.04  n/a   0.000
*
    CHANNEL[ 2:  0065]    0070  1  5.0     1.51    0.03  6.25  13.03  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 67.20 mm ]
    remark: SCS II 12hr 10yr Ottawa
*
 ** CALIB NASHYD          0004  1  5.0     1.68    0.02  6.75  12.64 0.19   0.000
    [CN=59.6         ]
    [ N = 3.0:Tp 0.69]
```

```
*
    ADD [  0004+  0070]  0066  3  5.0    3.18    0.05  6.33  12.83  n/a   0.000
*
    CHANNEL[ 2:  0066]   0084  1  5.0    3.18    0.05  6.50  12.83  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 67.20 mm ]
    remark: SCS II 12hr 10yr Ottawa
*
 ** CALIB NASHYD         0005  1  5.0    1.41    0.03  6.25  12.80 0.19   0.000
    [CN=59.8          ]
    [ N = 3.0:Tp 0.34]
*
    READ STORM                 30.0
    [ Ptot= 67.20 mm ]
    remark: SCS II 12hr 10yr Ottawa
*
 ** CALIB NASHYD         0006  1  5.0    0.50    0.01  6.50  13.09 0.19   0.000
    [CN=60.3          ]
    [ N = 3.0:Tp 0.50]
*
    READ STORM                 30.0
    [ Ptot= 67.20 mm ]
    remark: SCS II 12hr 10yr Ottawa
*
 ** CALIB NASHYD         0008  1  5.0    0.49    0.01  6.08  13.03 0.19   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.20]
*
    CHANNEL[ 2:  0008]   0071  1  5.0    0.49    0.01  6.08  13.03  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 67.20 mm ]
    remark: SCS II 12hr 10yr Ottawa
*
 ** CALIB NASHYD         0007  1  5.0    0.50    0.01  6.50  13.05 0.19   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.49]
*
    ADD [  0007+  0071]  0061  3  5.0    0.99    0.02  6.17  13.04  n/a   0.000
*
    CHANNEL[ 2:  0061]   0072  1  5.0    0.99    0.02  6.17  13.04  n/a   0.000
*
    ADD [  0006+  0072]  0062  3  5.0    1.49    0.03  6.25  13.06  n/a   0.000
*
    CHANNEL[ 2:  0062]   0073  1  5.0    1.49    0.03  6.33  13.06  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 67.20 mm ]
    remark: SCS II 12hr 10yr Ottawa
*
 ** CALIB NASHYD         0019  1  5.0    1.68    0.03  6.33  11.35 0.17   0.000
    [CN=57.5          ]
    [ N = 3.0:Tp 0.41]
*
    ADD [  0019+  0005]  0063  3  5.0    3.09    0.05  6.25  12.01  n/a   0.000
*
    ADD [  0063+  0073]  0063  1  5.0    4.58    0.08  6.25  12.35  n/a   0.000
*
    CHANNEL[ 2:  0063]   0083  1  5.0    4.58    0.08  6.50  12.35  n/a   0.000
*
    READ STORM                 30.0
```

```
    [ Ptot= 67.20 mm ]
    remark: SCS II 12hr 10yr Ottawa
*
 ** CALIB NASHYD         0009  1  5.0    0.36    0.01  6.08  18.27 0.27   0.000
    [CN=67.4         ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                 30.0
    [ Ptot= 67.20 mm ]
    remark: SCS II 12hr 10yr Ottawa
*
 ** CALIB NASHYD         0017  1  5.0    0.17    0.01  6.00  22.82 0.34   0.000
    [CN=73.9         ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0017]   0080  1  5.0    0.17    0.01  6.08  22.73  n/a   0.000
*
    ADD [  0080+  0009]  0035  3  5.0    0.53    0.02  6.08  19.72  n/a   0.000
*
    CHANNEL[ 2:  0035]   0077  1  5.0    0.53    0.02  6.17  19.72  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 67.20 mm ]
    remark: SCS II 12hr 10yr Ottawa
*
 ** CALIB NASHYD         0010  1  5.0    0.38    0.01  6.17  17.99 0.27   0.000
    [CN=67.1         ]
    [ N = 3.0:Tp 0.27]
*
    ADD [  0010+  0077]  0036  3  5.0    0.91    0.03  6.17  19.00  n/a   0.000
*
    CHANNEL[ 2:  0036]   0078  1  5.0    0.91    0.04  6.17  19.00  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 67.20 mm ]
    remark: SCS II 12hr 10yr Ottawa
*
 ** CALIB NASHYD         0011  1  5.0    0.38    0.01  6.17  17.99 0.27   0.000
    [CN=67.1         ]
    [ N = 3.0:Tp 0.27]
*
    ADD [  0011+  0078]  0037  3  5.0    1.28    0.05  6.17  18.70  n/a   0.000
*
    CHANNEL[ 2:  0037]   0079  1  5.0    1.28    0.05  6.17  18.70  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 67.20 mm ]
    remark: SCS II 12hr 10yr Ottawa
*
 ** CALIB NASHYD         0012  1  5.0    0.29    0.01  6.08  19.16 0.29   0.000
    [CN=70.0         ]
    [ N = 3.0:Tp 0.22]
*
    ADD [  0012+  0079]  0038  3  5.0    1.58    0.06  6.17  18.79  n/a   0.000
*
    CHANNEL[ 2:  0038]   0094  1  5.0    1.58    0.06  6.17  18.78  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 67.20 mm ]
    remark: SCS II 12hr 10yr Ottawa
*
 ** CALIB NASHYD         0013  1  5.0    0.34    0.01  6.08  19.40 0.29   0.000
```

```
    [CN=68.8         ]
    [ N = 3.0:Tp 0.24]
*
    READ STORM                 30.0
    [ Ptot= 67.20 mm ]
    remark: SCS II 12hr 10yr Ottawa
*
 ** CALIB NASHYD          0014  1  5.0    0.36    0.01  6.08  18.16 0.27   0.000
    [CN=67.3         ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                 30.0
    [ Ptot= 67.20 mm ]
    remark: SCS II 12hr 10yr Ottawa
*
 ** CALIB NASHYD          0015  1  5.0    0.38    0.01  6.17  17.99 0.27   0.000
    [CN=67.1         ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                 30.0
    [ Ptot= 67.20 mm ]
    remark: SCS II 12hr 10yr Ottawa
*
 ** CALIB NASHYD          0016  1  5.0    0.39    0.01  6.17  17.88 0.27   0.000
    [CN=66.9         ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                 30.0
    [ Ptot= 67.20 mm ]
    remark: SCS II 12hr 10yr Ottawa
*
 ** CALIB NASHYD          0018  1  5.0    0.17    0.01  6.00  22.82 0.34   0.000
    [CN=73.9         ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0018]    0081  1  5.0    0.17    0.01  6.08  22.75  n/a   0.000
*
    ADD [  0016+  0081]   0039  3  5.0    0.56    0.02  6.08  19.38  n/a   0.000
*
    CHANNEL[ 2:  0039]    0074  1  5.0    0.56    0.02  6.17  19.38  n/a   0.000
*
    ADD [  0015+  0074]   0040  3  5.0    0.94    0.04  6.17  18.82  n/a   0.000
*
    CHANNEL[ 2:  0040]    0075  1  5.0    0.94    0.04  6.17  18.82  n/a   0.000
*
    ADD [  0014+  0075]   0041  3  5.0    1.30    0.05  6.17  18.63  n/a   0.000
*
    CHANNEL[ 2:  0041]    0076  1  5.0    1.30    0.05  6.17  18.63  n/a   0.000
*
    ADD [  0013+  0076]   0042  3  5.0    1.64    0.06  6.17  18.79  n/a   0.000
*
    CHANNEL[ 2:  0042]    0095  1  5.0    1.64    0.06  6.17  18.79  n/a   0.000
*
    ADD [  0094+  0095]   0043  3  5.0    3.22    0.12  6.17  18.79  n/a   0.000
*
 ** Reservoir
    OUTFLOW:              0093  1  5.0    3.22    0.03  7.33  16.46  n/a   0.000
*
    ADD [  0083+  0093]   0092  3  5.0    7.80    0.09  6.67  14.04  n/a   0.000
*
    CHANNEL[ 2:  0092]    0085  1  5.0    7.80    0.09  6.67  14.04  n/a   0.000
*
```

```
    ADD [  0084+  0085]  0086  3  5.0    10.99    0.14  6.67  13.69  n/a   0.000
*
    CHANNEL[ 2:  0086]   0087  1  5.0    10.99    0.14  6.67  13.69  n/a   0.000
*
===============================================================================


                   *****  S U M M A R Y   O U T P U T  *****


  Input   filename: C:\Program Files (x86)\Visual OTTHYMO 6.2\VO2\voin.dat
  Output  filename: C:\Users\hymo\AppData\Local\Civica\VH5\1f7c7d87-7b37-46a9-
a1c7-473109835596\e68662c9-8287-4969-a7d0-6c1851ffd0b8\scenari
  Summary filename: C:\Users\hymo\AppData\Local\Civica\VH5\1f7c7d87-7b37-46a9-
a1c7-473109835596\e68662c9-8287-4969-a7d0-6c1851ffd0b8\scenari


DATE: 05-05-2023                          TIME: 01:59:25

USER:


COMMENTS: ____________________________________________________________


  ***********************************************
  ** SIMULATION : 5. SCS II 12hr 100yr correct  **
  ***********************************************

  W/E COMMAND             HYD ID   DT    AREA  ' Qpeak Tpeak   R.V. R.C.
Qbase
                                   min     ha   '  cms   hrs     mm          cms

      START @  0.00 hrs
      --------------------
    READ STORM                 30.0
    [ Ptot= 96.00 mm ]
    remark: SCS II 12hr 100yr Ottawa
*
 ** CALIB NASHYD          0001  1  5.0    0.50    0.03  6.00  27.14 0.28   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0001]   0068  1  5.0    0.50    0.03  6.08  27.14  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 96.00 mm ]
    remark: SCS II 12hr 100yr Ottawa
*
 ** CALIB NASHYD          0002  1  5.0    0.50    0.02  6.17  27.22 0.28   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.31]
*
    ADD [  0002+  0068]  0064  3  5.0    1.00    0.06  6.08  27.18  n/a   0.000
*
    CHANNEL[ 2:  0064]   0069  1  5.0    1.00    0.06  6.08  27.18  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 96.00 mm ]
    remark: SCS II 12hr 100yr Ottawa
*
 ** CALIB NASHYD          0003  1  5.0    0.51    0.02  6.33  27.23 0.28   0.000
```

```
    [CN=60.2         ]
    [ N = 3.0:Tp 0.45]
*
    ADD [  0003+  0069]  0065  3  5.0    1.51    0.07  6.17  27.20  n/a   0.000
*
    CHANNEL[ 2:  0065]   0070  1  5.0    1.51    0.07  6.17  27.20  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 96.00 mm ]
    remark: SCS II 12hr 100yr Ottawa
*
 ** CALIB NASHYD         0004  1  5.0    1.68    0.05  6.67  26.56 0.28   0.000
    [CN=59.6         ]
    [ N = 3.0:Tp 0.69]
*
    ADD [  0004+  0070]  0066  3  5.0    3.18    0.11  6.25  26.86  n/a   0.000
*
    CHANNEL[ 2:  0066]   0084  1  5.0    3.18    0.11  6.33  26.86  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 96.00 mm ]
    remark: SCS II 12hr 100yr Ottawa
*
 ** CALIB NASHYD         0005  1  5.0    1.41    0.06  6.17  26.81 0.28   0.000
    [CN=59.8         ]
    [ N = 3.0:Tp 0.34]
*
    READ STORM                 30.0
    [ Ptot= 96.00 mm ]
    remark: SCS II 12hr 100yr Ottawa
*
 ** CALIB NASHYD         0006  1  5.0    0.50    0.02  6.42  27.31 0.28   0.000
    [CN=60.3         ]
    [ N = 3.0:Tp 0.50]
*
    READ STORM                 30.0
    [ Ptot= 96.00 mm ]
    remark: SCS II 12hr 100yr Ottawa
*
 ** CALIB NASHYD         0008  1  5.0    0.49    0.03  6.08  27.18 0.28   0.000
    [CN=60.2         ]
    [ N = 3.0:Tp 0.20]
*
    CHANNEL[ 2:  0008]   0071  1  5.0    0.49    0.03  6.08  27.18  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 96.00 mm ]
    remark: SCS II 12hr 100yr Ottawa
*
 ** CALIB NASHYD         0007  1  5.0    0.50    0.02  6.42  27.23 0.28   0.000
    [CN=60.2         ]
    [ N = 3.0:Tp 0.49]
*
    ADD [  0007+  0071]  0061  3  5.0    0.99    0.04  6.17  27.21  n/a   0.000
*
    CHANNEL[ 2:  0061]   0072  1  5.0    0.99    0.05  6.17  27.21  n/a   0.000
*
    ADD [  0006+  0072]  0062  3  5.0    1.49    0.06  6.17  27.24  n/a   0.000
*
    CHANNEL[ 2:  0062]   0073  1  5.0    1.49    0.06  6.25  27.24  n/a   0.000
*
    READ STORM                 30.0
```

```
    [ Ptot= 96.00 mm ]
    remark: SCS II 12hr 100yr Ottawa
*
 ** CALIB NASHYD         0019  1  5.0    1.68    0.06  6.33  24.41 0.25   0.000
    [CN=57.5          ]
    [ N = 3.0:Tp 0.41]
*
    ADD [  0019+  0005]  0063  3  5.0    3.09    0.13  6.25  25.51  n/a   0.000
*
    ADD [  0063+  0073]  0063  1  5.0    4.58    0.19  6.25  26.07  n/a   0.000
*
    CHANNEL[ 2:  0063]   0083  1  5.0    4.58    0.18  6.33  26.06  n/a   0.000
*
    READ STORM                30.0
    [ Ptot= 96.00 mm ]
    remark: SCS II 12hr 100yr Ottawa
*
 ** CALIB NASHYD         0009  1  5.0    0.36    0.03  6.08  35.52 0.37   0.000
    [CN=67.4          ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                30.0
    [ Ptot= 96.00 mm ]
    remark: SCS II 12hr 100yr Ottawa
*
 ** CALIB NASHYD         0017  1  5.0    0.17    0.02  6.00  42.68 0.44   0.000
    [CN=73.9          ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0017]   0080  1  5.0    0.17    0.02  6.08  42.58  n/a   0.000
*
    ADD [  0080+  0009]  0035  3  5.0    0.53    0.04  6.08  37.81  n/a   0.000
*
    CHANNEL[ 2:  0035]   0077  1  5.0    0.53    0.04  6.17  37.81  n/a   0.000
*
    READ STORM                30.0
    [ Ptot= 96.00 mm ]
    remark: SCS II 12hr 100yr Ottawa
*
 ** CALIB NASHYD         0010  1  5.0    0.38    0.03  6.08  35.11 0.37   0.000
    [CN=67.1          ]
    [ N = 3.0:Tp 0.27]
*
    ADD [  0010+  0077]  0036  3  5.0    0.91    0.07  6.17  36.69  n/a   0.000
*
    CHANNEL[ 2:  0036]   0078  1  5.0    0.91    0.07  6.17  36.69  n/a   0.000
*
    READ STORM                30.0
    [ Ptot= 96.00 mm ]
    remark: SCS II 12hr 100yr Ottawa
*
 ** CALIB NASHYD         0011  1  5.0    0.38    0.03  6.08  35.11 0.37   0.000
    [CN=67.1          ]
    [ N = 3.0:Tp 0.27]
*
    ADD [  0011+  0078]  0037  3  5.0    1.28    0.10  6.17  36.23  n/a   0.000
*
    CHANNEL[ 2:  0037]   0079  1  5.0    1.28    0.10  6.17  36.22  n/a   0.000
*
    READ STORM                30.0
    [ Ptot= 96.00 mm ]
    remark: SCS II 12hr 100yr Ottawa
```

```
*
 ** CALIB NASHYD         0012  1  5.0    0.29    0.02  6.08  37.29 0.39   0.000
    [CN=70.0          ]
    [ N = 3.0:Tp 0.22]
*
    ADD [  0012+  0079]  0038  3  5.0    1.58    0.12  6.17  36.42  n/a   0.000
*
    CHANNEL[ 2:  0038]   0094  1  5.0    1.58    0.12  6.17  36.42  n/a   0.000
*
    READ STORM                 30.0
    [ Ptot= 96.00 mm ]
    remark: SCS II 12hr 100yr Ottawa
*
 ** CALIB NASHYD         0013  1  5.0    0.34    0.03  6.08  37.26 0.39   0.000
    [CN=68.8          ]
    [ N = 3.0:Tp 0.24]
*
    READ STORM                 30.0
    [ Ptot= 96.00 mm ]
    remark: SCS II 12hr 100yr Ottawa
*
 ** CALIB NASHYD         0014  1  5.0    0.36    0.03  6.08  35.36 0.37   0.000
    [CN=67.3          ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                 30.0
    [ Ptot= 96.00 mm ]
    remark: SCS II 12hr 100yr Ottawa
*
 ** CALIB NASHYD         0015  1  5.0    0.38    0.03  6.08  35.11 0.37   0.000
    [CN=67.1          ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                 30.0
    [ Ptot= 96.00 mm ]
    remark: SCS II 12hr 100yr Ottawa
*
 ** CALIB NASHYD         0016  1  5.0    0.39    0.03  6.08  34.92 0.36   0.000
    [CN=66.9          ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                 30.0
    [ Ptot= 96.00 mm ]
    remark: SCS II 12hr 100yr Ottawa
*
 ** CALIB NASHYD         0018  1  5.0    0.17    0.02  6.00  42.68 0.44   0.000
    [CN=73.9          ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0018]   0081  1  5.0    0.17    0.02  6.08  42.61  n/a   0.000
*
    ADD [  0016+  0081]  0039  3  5.0    0.56    0.04  6.08  37.28  n/a   0.000
*
    CHANNEL[ 2:  0039]   0074  1  5.0    0.56    0.04  6.08  37.28  n/a   0.000
*
    ADD [  0015+  0074]  0040  3  5.0    0.94    0.07  6.08  36.41  n/a   0.000
*
    CHANNEL[ 2:  0040]   0075  1  5.0    0.94    0.07  6.17  36.41  n/a   0.000
*
    ADD [  0014+  0075]  0041  3  5.0    1.30    0.10  6.17  36.11  n/a   0.000
*
    CHANNEL[ 2:  0041]   0076  1  5.0    1.30    0.10  6.17  36.11  n/a   0.000
```

```
*
    ADD [  0013+  0076]  0042  3  5.0     1.64    0.12  6.17  36.35  n/a   0.000
*
    CHANNEL[ 2:  0042]   0095  1  5.0     1.64    0.12  6.17  36.35  n/a   0.000
*
    ADD [  0094+  0095]  0043  3  5.0     3.22    0.24  6.17  36.38  n/a   0.000
*
 ** Reservoir
    OUTFLOW:             0093  1  5.0     3.22    0.06  7.08  34.05  n/a   0.000
*
    ADD [  0083+  0093]  0092  3  5.0     7.80    0.23  6.42  29.36  n/a   0.000
*
    CHANNEL[ 2:  0092]   0085  1  5.0     7.80    0.23  6.42  29.36  n/a   0.000
*
    ADD [  0084+  0085]  0086  3  5.0    10.99    0.33  6.42  28.63  n/a   0.000
*
    CHANNEL[ 2:  0086]   0087  1  5.0    10.99    0.33  6.50  28.63  n/a   0.000
*
================================================================================
  **************************************************
  ** SIMULATION : 6. Chi 12hr 2yr                **
  **************************************************

  W/E COMMAND              HYD ID   DT    AREA  ' Qpeak Tpeak   R.V. R.C.
Qbase
                                   min     ha   '  cms   hrs     mm          cms

      START @  0.00 hrs
      --------------------
    CHIC STORM                  10.0
    [ Ptot= 42.34 mm ]
*
 ** CALIB NASHYD         0001  1  5.0     0.50    0.00  4.25   4.24 0.10   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0001]   0068  1  5.0     0.50    0.00  4.25   4.24  n/a   0.000
*
    CHIC STORM                  10.0
    [ Ptot= 42.34 mm ]
*
 ** CALIB NASHYD         0002  1  5.0     0.50    0.00  4.42   4.25 0.10   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.31]
*
    ADD [  0002+  0068]  0064  3  5.0     1.00    0.01  4.33   4.25  n/a   0.000
*
    CHANNEL[ 2:  0064]   0069  1  5.0     1.00    0.01  4.42   4.25  n/a   0.000
*
    CHIC STORM                  10.0
    [ Ptot= 42.34 mm ]
*
 ** CALIB NASHYD         0003  1  5.0     0.51    0.00  4.67   4.25 0.10   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.45]
*
    ADD [  0003+  0069]  0065  3  5.0     1.51    0.01  4.42   4.25  n/a   0.000
*
    CHANNEL[ 2:  0065]   0070  1  5.0     1.51    0.01  4.50   4.25  n/a   0.000
*
    CHIC STORM                  10.0
    [ Ptot= 42.34 mm ]
```

```
*
 ** CALIB NASHYD         0004  1  5.0    1.68    0.01  5.08   4.06 0.10   0.000
    [CN=59.6          ]
    [ N = 3.0:Tp 0.69]
*
    ADD [  0004+  0070]  0066  3  5.0    3.18    0.01  4.67   4.15  n/a   0.000
*
    CHANNEL[ 2:  0066]   0084  1  5.0    3.18    0.01  4.92   4.15  n/a   0.000
*
    CHIC STORM                 10.0
    [ Ptot= 42.34 mm ]
*
 ** CALIB NASHYD         0005  1  5.0    1.41    0.01  4.50   4.14 0.10   0.000
    [CN=59.8          ]
    [ N = 3.0:Tp 0.34]
*
    CHIC STORM                 10.0
    [ Ptot= 42.34 mm ]
*
 ** CALIB NASHYD         0006  1  5.0    0.50    0.00  4.75   4.27 0.10   0.000
    [CN=60.3          ]
    [ N = 3.0:Tp 0.50]
*
    CHIC STORM                 10.0
    [ Ptot= 42.34 mm ]
*
 ** CALIB NASHYD         0008  1  5.0    0.49    0.00  4.25   4.25 0.10   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.20]
*
    CHANNEL[ 2:  0008]   0071  1  5.0    0.49    0.00  4.33   4.25  n/a   0.000
*
    CHIC STORM                 10.0
    [ Ptot= 42.34 mm ]
*
 ** CALIB NASHYD         0007  1  5.0    0.50    0.00  4.75   4.25 0.10   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.49]
*
    ADD [  0007+  0071]  0061  3  5.0    0.99    0.00  4.42   4.25  n/a   0.000
*
    CHANNEL[ 2:  0061]   0072  1  5.0    0.99    0.00  4.50   4.25  n/a   0.000
*
    ADD [  0006+  0072]  0062  3  5.0    1.49    0.01  4.58   4.26  n/a   0.000
*
    CHANNEL[ 2:  0062]   0073  1  5.0    1.49    0.01  4.67   4.25  n/a   0.000
*
    CHIC STORM                 10.0
    [ Ptot= 42.34 mm ]
*
 ** CALIB NASHYD         0019  1  5.0    1.68    0.01  4.67   3.48 0.08   0.000
    [CN=57.5          ]
    [ N = 3.0:Tp 0.41]
*
    ADD [  0019+  0005]  0063  3  5.0    3.09    0.01  4.58   3.78  n/a   0.000
*
    ADD [  0063+  0073]  0063  1  5.0    4.58    0.02  4.58   3.93  n/a   0.000
*
    CHANNEL[ 2:  0063]   0083  1  5.0    4.58    0.02  4.92   3.93  n/a   0.000
*
    CHIC STORM                 10.0
    [ Ptot= 42.34 mm ]
```

```
*
 ** CALIB NASHYD         0009  1  5.0    0.36    0.00  4.33   6.81 0.16   0.000
    [CN=67.4          ]
    [ N = 3.0:Tp 0.27]
*
    CHIC STORM                 10.0
    [ Ptot= 42.34 mm ]
*
 ** CALIB NASHYD         0017  1  5.0    0.17    0.00  4.17   9.00 0.21   0.000
    [CN=73.9          ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0017]   0080  1  5.0    0.17    0.00  4.33   8.94  n/a   0.000
*
    ADD [  0080+  0009]  0035  3  5.0    0.53    0.01  4.33   7.50  n/a   0.000
*
    CHANNEL[ 2:  0035]   0077  1  5.0    0.53    0.01  4.33   7.50  n/a   0.000
*
    CHIC STORM                 10.0
    [ Ptot= 42.34 mm ]
*
 ** CALIB NASHYD         0010  1  5.0    0.38    0.00  4.33   6.66 0.16   0.000
    [CN=67.1          ]
    [ N = 3.0:Tp 0.27]
*
    ADD [  0010+  0077]  0036  3  5.0    0.91    0.01  4.33   7.15  n/a   0.000
*
    CHANNEL[ 2:  0036]   0078  1  5.0    0.91    0.01  4.42   7.15  n/a   0.000
*
    CHIC STORM                 10.0
    [ Ptot= 42.34 mm ]
*
 ** CALIB NASHYD         0011  1  5.0    0.38    0.00  4.33   6.66 0.16   0.000
    [CN=67.1          ]
    [ N = 3.0:Tp 0.27]
*
    ADD [  0011+  0078]  0037  3  5.0    1.28    0.01  4.42   7.01  n/a   0.000
*
    CHANNEL[ 2:  0037]   0079  1  5.0    1.28    0.02  4.42   7.01  n/a   0.000
*
    CHIC STORM                 10.0
    [ Ptot= 42.34 mm ]
*
 ** CALIB NASHYD         0012  1  5.0    0.29    0.00  4.25   7.04 0.17   0.000
    [CN=70.0          ]
    [ N = 3.0:Tp 0.22]
*
    ADD [  0012+  0079]  0038  3  5.0    1.58    0.02  4.42   7.01  n/a   0.000
*
    CHANNEL[ 2:  0038]   0094  1  5.0    1.58    0.02  4.42   7.01  n/a   0.000
*
    CHIC STORM                 10.0
    [ Ptot= 42.34 mm ]
*
 ** CALIB NASHYD         0013  1  5.0    0.34    0.00  4.25   7.40 0.17   0.000
    [CN=68.8          ]
    [ N = 3.0:Tp 0.24]
*
    CHIC STORM                 10.0
    [ Ptot= 42.34 mm ]
*
 ** CALIB NASHYD         0014  1  5.0    0.36    0.00  4.33   6.75 0.16   0.000
```

```
    [CN=67.3          ]
    [ N = 3.0:Tp 0.27]
*
    CHIC STORM                 10.0
    [ Ptot= 42.34 mm ]
*
 ** CALIB NASHYD        0015  1  5.0     0.38     0.00  4.33    6.66 0.16    0.000
    [CN=67.1          ]
    [ N = 3.0:Tp 0.27]
*
    CHIC STORM                 10.0
    [ Ptot= 42.34 mm ]
*
 ** CALIB NASHYD        0016  1  5.0     0.39     0.00  4.33    6.61 0.16    0.000
    [CN=66.9          ]
    [ N = 3.0:Tp 0.27]
*
    CHIC STORM                 10.0
    [ Ptot= 42.34 mm ]
*
 ** CALIB NASHYD        0018  1  5.0     0.17     0.00  4.17    9.00 0.21    0.000
    [CN=73.9          ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0018]  0081  1  5.0     0.17     0.00  4.25    8.95  n/a    0.000
*
    ADD [  0016+  0081] 0039  3  5.0     0.56     0.01  4.33    7.33  n/a    0.000
*
    CHANNEL[ 2:  0039]  0074  1  5.0     0.56     0.01  4.33    7.33  n/a    0.000
*
    ADD [  0015+  0074] 0040  3  5.0     0.94     0.01  4.33    7.06  n/a    0.000
*
    CHANNEL[ 2:  0040]  0075  1  5.0     0.94     0.01  4.42    7.06  n/a    0.000
*
    ADD [  0014+  0075] 0041  3  5.0     1.30     0.02  4.33    6.98  n/a    0.000
*
    CHANNEL[ 2:  0041]  0076  1  5.0     1.30     0.02  4.42    6.97  n/a    0.000
*
    ADD [  0013+  0076] 0042  3  5.0     1.64     0.02  4.42    7.06  n/a    0.000
*
    CHANNEL[ 2:  0042]  0095  1  5.0     1.64     0.02  4.42    7.06  n/a    0.000
*
    ADD [  0094+  0095] 0043  3  5.0     3.22     0.04  4.42    7.04  n/a    0.000
*
 ** Reservoir
    OUTFLOW:            0093  1  5.0     3.22     0.00  7.58    4.70  n/a    0.000
*
    ADD [  0083+  0093] 0092  3  5.0     7.80     0.02  5.08    4.25  n/a    0.000
*
    CHANNEL[ 2:  0092]  0085  1  5.0     7.80     0.02  5.08    4.25  n/a    0.000
*
    ADD [  0084+  0085] 0086  3  5.0    10.99     0.03  5.00    4.22  n/a    0.000
*
    CHANNEL[ 2:  0086]  0087  1  5.0    10.99     0.03  5.17    4.22  n/a    0.000
*
===============================================================================
  ************************************************
  ** SIMULATION : 7. Chi 12hr 100yr             **
  ************************************************

  W/E COMMAND              HYD ID   DT    AREA  ' Qpeak Tpeak   R.V. R.C.
Qbase
```

```
                                                min      ha   '  cms   hrs     mm           cms

      START @  0.00 hrs
      ---------------------
    CHIC STORM                     10.0
    [ Ptot= 93.90 mm ]
*
 ** CALIB NASHYD          0001  1  5.0     0.50    0.03  4.17  25.99 0.28   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0001]    0068  1  5.0     0.50    0.03  4.17  25.99  n/a   0.000
*
    CHIC STORM                     10.0
    [ Ptot= 93.90 mm ]
*
 ** CALIB NASHYD          0002  1  5.0     0.50    0.02  4.33  26.07 0.28   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.31]
*
    ADD [  0002+  0068]   0064  3  5.0     1.00    0.05  4.25  26.03  n/a   0.000
*
    CHANNEL[ 2:  0064]    0069  1  5.0     1.00    0.06  4.25  26.03  n/a   0.000
*
    CHIC STORM                     10.0
    [ Ptot= 93.90 mm ]
*
 ** CALIB NASHYD          0003  1  5.0     0.51    0.02  4.50  26.08 0.28   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.45]
*
    ADD [  0003+  0069]   0065  3  5.0     1.51    0.07  4.25  26.05  n/a   0.000
*
    CHANNEL[ 2:  0065]    0070  1  5.0     1.51    0.07  4.33  26.05  n/a   0.000
*
    CHIC STORM                     10.0
    [ Ptot= 93.90 mm ]
*
 ** CALIB NASHYD          0004  1  5.0     1.68    0.05  4.83  25.43 0.27   0.000
    [CN=59.6          ]
    [ N = 3.0:Tp 0.69]
*
    ADD [  0004+  0070]   0066  3  5.0     3.18    0.10  4.42  25.72  n/a   0.000
*
    CHANNEL[ 2:  0066]    0084  1  5.0     3.18    0.10  4.58  25.72  n/a   0.000
*
    CHIC STORM                     10.0
    [ Ptot= 93.90 mm ]
*
 ** CALIB NASHYD          0005  1  5.0     1.41    0.06  4.33  25.68 0.27   0.000
    [CN=59.8          ]
    [ N = 3.0:Tp 0.34]
*
    CHIC STORM                     10.0
    [ Ptot= 93.90 mm ]
*
 ** CALIB NASHYD          0006  1  5.0     0.50    0.02  4.58  26.16 0.28   0.000
    [CN=60.3          ]
    [ N = 3.0:Tp 0.50]
*
    CHIC STORM                     10.0
    [ Ptot= 93.90 mm ]
```

```
*
 ** CALIB NASHYD         0008  1  5.0    0.49    0.03  4.17  26.03 0.28   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.20]
*
    CHANNEL[ 2:  0008]   0071  1  5.0    0.49    0.03  4.25  26.03  n/a   0.000
*
    CHIC STORM                 10.0
    [ Ptot= 93.90 mm ]
*
 ** CALIB NASHYD         0007  1  5.0    0.50    0.02  4.58  26.08 0.28   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.49]
*
    ADD [  0007+  0071]  0061  3  5.0    0.99    0.04  4.25  26.06  n/a   0.000
*
    CHANNEL[ 2:  0061]   0072  1  5.0    0.99    0.04  4.33  26.06  n/a   0.000
*
    ADD [  0006+  0072]  0062  3  5.0    1.49    0.06  4.33  26.09  n/a   0.000
*
    CHANNEL[ 2:  0062]   0073  1  5.0    1.49    0.06  4.42  26.09  n/a   0.000
*
    CHIC STORM                 10.0
    [ Ptot= 93.90 mm ]
*
 ** CALIB NASHYD         0019  1  5.0    1.68    0.06  4.50  23.34 0.25   0.000
    [CN=57.5          ]
    [ N = 3.0:Tp 0.41]
*
    ADD [  0019+  0005]  0063  3  5.0    3.09    0.12  4.42  24.41  n/a   0.000
*
    ADD [  0063+  0073]  0063  1  5.0    4.58    0.18  4.42  24.96  n/a   0.000
*
    CHANNEL[ 2:  0063]   0083  1  5.0    4.58    0.17  4.58  24.95  n/a   0.000
*
    CHIC STORM                 10.0
    [ Ptot= 93.90 mm ]
*
 ** CALIB NASHYD         0009  1  5.0    0.36    0.03  4.25  34.15 0.36   0.000
    [CN=67.4          ]
    [ N = 3.0:Tp 0.27]
*
    CHIC STORM                 10.0
    [ Ptot= 93.90 mm ]
*
 ** CALIB NASHYD         0017  1  5.0    0.17    0.02  4.08  41.13 0.44   0.000
    [CN=73.9          ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0017]   0080  1  5.0    0.17    0.02  4.25  41.04  n/a   0.000
*
    ADD [  0080+  0009]  0035  3  5.0    0.53    0.04  4.25  36.39  n/a   0.000
*
    CHANNEL[ 2:  0035]   0077  1  5.0    0.53    0.04  4.25  36.39  n/a   0.000
*
    CHIC STORM                 10.0
    [ Ptot= 93.90 mm ]
*
 ** CALIB NASHYD         0010  1  5.0    0.38    0.03  4.25  33.75 0.36   0.000
    [CN=67.1          ]
    [ N = 3.0:Tp 0.27]
*
```

```
    ADD [  0010+  0077]  0036  3  5.0    0.91    0.07  4.25  35.30  n/a   0.000
*
    CHANNEL[ 2:  0036]   0078  1  5.0    0.91    0.07  4.33  35.30  n/a   0.000
*
    CHIC STORM                 10.0
    [ Ptot= 93.90 mm ]
*
 ** CALIB NASHYD         0011  1  5.0    0.38    0.03  4.25  33.75 0.36   0.000
    [CN=67.1          ]
    [ N = 3.0:Tp 0.27]
*
    ADD [  0011+  0078]  0037  3  5.0    1.28    0.10  4.25  34.84  n/a   0.000
*
    CHANNEL[ 2:  0037]   0079  1  5.0    1.28    0.10  4.33  34.84  n/a   0.000
*
    CHIC STORM                 10.0
    [ Ptot= 93.90 mm ]
*
 ** CALIB NASHYD         0012  1  5.0    0.29    0.03  4.17  35.86 0.38   0.000
    [CN=70.0          ]
    [ N = 3.0:Tp 0.22]
*
    ADD [  0012+  0079]  0038  3  5.0    1.58    0.12  4.25  35.03  n/a   0.000
*
    CHANNEL[ 2:  0038]   0094  1  5.0    1.58    0.12  4.33  35.03  n/a   0.000
*
    CHIC STORM                 10.0
    [ Ptot= 93.90 mm ]
*
 ** CALIB NASHYD         0013  1  5.0    0.34    0.03  4.25  35.86 0.38   0.000
    [CN=68.8          ]
    [ N = 3.0:Tp 0.24]
*
    CHIC STORM                 10.0
    [ Ptot= 93.90 mm ]
*
 ** CALIB NASHYD         0014  1  5.0    0.36    0.03  4.25  34.00 0.36   0.000
    [CN=67.3          ]
    [ N = 3.0:Tp 0.27]
*
    CHIC STORM                 10.0
    [ Ptot= 93.90 mm ]
*
 ** CALIB NASHYD         0015  1  5.0    0.38    0.03  4.25  33.75 0.36   0.000
    [CN=67.1          ]
    [ N = 3.0:Tp 0.27]
*
    CHIC STORM                 10.0
    [ Ptot= 93.90 mm ]
*
 ** CALIB NASHYD         0016  1  5.0    0.39    0.03  4.25  33.57 0.36   0.000
    [CN=66.9          ]
    [ N = 3.0:Tp 0.27]
*
    CHIC STORM                 10.0
    [ Ptot= 93.90 mm ]
*
 ** CALIB NASHYD         0018  1  5.0    0.17    0.02  4.08  41.13 0.44   0.000
    [CN=73.9          ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0018]   0081  1  5.0    0.17    0.02  4.42  41.07  n/a   0.000
```

```
*
    ADD [  0016+  0081]  0039  3  5.0    0.56    0.04  4.25  35.88  n/a   0.000
*
    CHANNEL[ 2:  0039]   0074  1  5.0    0.56    0.04  4.25  35.88  n/a   0.000
*
    ADD [  0015+  0074]  0040  3  5.0    0.94    0.07  4.25  35.02  n/a   0.000
*
    CHANNEL[ 2:  0040]   0075  1  5.0    0.94    0.07  4.33  35.02  n/a   0.000
*
    ADD [  0014+  0075]  0041  3  5.0    1.30    0.10  4.25  34.73  n/a   0.000
*
    CHANNEL[ 2:  0041]   0076  1  5.0    1.30    0.10  4.33  34.73  n/a   0.000
*
    ADD [  0013+  0076]  0042  3  5.0    1.64    0.13  4.25  34.97  n/a   0.000
*
    CHANNEL[ 2:  0042]   0095  1  5.0    1.64    0.13  4.33  34.96  n/a   0.000
*
    ADD [  0094+  0095]  0043  3  5.0    3.22    0.24  4.33  35.00  n/a   0.000
*
 ** Reservoir
    OUTFLOW:             0093  1  5.0    3.22    0.06  5.25  32.66  n/a   0.000
*
    ADD [  0083+  0093]  0092  3  5.0    7.80    0.21  4.58  28.13  n/a   0.000
*
    CHANNEL[ 2:  0092]   0085  1  5.0    7.80    0.21  4.67  28.13  n/a   0.000
*
    ADD [  0084+  0085]  0086  3  5.0   10.99    0.31  4.58  27.43  n/a   0.000
*
    CHANNEL[ 2:  0086]   0087  1  5.0   10.99    0.31  4.67  27.43  n/a   0.000
*
===============================================================================
  ************************************************
  ** SIMULATION : 8. Historical July 1 1979     **
  ************************************************

  W/E COMMAND             HYD ID   DT    AREA  ' Qpeak Tpeak   R.V. R.C.
Qbase
                                  min     ha   '  cms   hrs     mm          cms

      START @  0.00 hrs
      --------------------
    READ STORM                 5.0
    [ Ptot= 83.99 mm ]
    remark: Ottawa July 1 1979
*
 ** CALIB NASHYD         0001  1  5.0    0.50    0.04  1.67  20.82 0.25   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0001]   0068  1  5.0    0.50    0.04  1.67  20.82  n/a   0.000
*
    READ STORM                 5.0
    [ Ptot= 83.99 mm ]
    remark: Ottawa July 1 1979
*
 ** CALIB NASHYD         0002  1  5.0    0.50    0.03  1.83  20.88 0.25   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.31]
*
    ADD [  0002+  0068]  0064  3  5.0    1.00    0.07  1.75  20.85  n/a   0.000
*
    CHANNEL[ 2:  0064]   0069  1  5.0    1.00    0.07  1.75  20.85  n/a   0.000
```

```
*
    READ STORM                    5.0
    [ Ptot= 83.99 mm ]
    remark: Ottawa July 1 1979
*
 ** CALIB NASHYD          0003  1  5.0    0.51    0.03  2.00  20.89 0.25   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.45]
*
    ADD [  0003+  0069]   0065  3  5.0    1.51    0.09  1.83  20.86  n/a   0.000
*
    CHANNEL[ 2:  0065]    0070  1  5.0    1.51    0.09  1.83  20.86  n/a   0.000
*
    READ STORM                    5.0
    [ Ptot= 83.99 mm ]
    remark: Ottawa July 1 1979
*
 ** CALIB NASHYD          0004  1  5.0    1.68    0.06  2.25  20.33 0.24   0.000
    [CN=59.6          ]
    [ N = 3.0:Tp 0.69]
*
    ADD [  0004+  0070]   0066  3  5.0    3.18    0.13  2.00  20.58  n/a   0.000
*
    CHANNEL[ 2:  0066]    0084  1  5.0    3.18    0.13  2.08  20.58  n/a   0.000
*
    READ STORM                    5.0
    [ Ptot= 83.99 mm ]
    remark: Ottawa July 1 1979
*
 ** CALIB NASHYD          0005  1  5.0    1.41    0.08  1.92  20.54 0.24   0.000
    [CN=59.8          ]
    [ N = 3.0:Tp 0.34]
*
    READ STORM                    5.0
    [ Ptot= 83.99 mm ]
    remark: Ottawa July 1 1979
*
 ** CALIB NASHYD          0006  1  5.0    0.50    0.02  2.08  20.95 0.25   0.000
    [CN=60.3          ]
    [ N = 3.0:Tp 0.50]
*
    READ STORM                    5.0
    [ Ptot= 83.99 mm ]
    remark: Ottawa July 1 1979
*
 ** CALIB NASHYD          0008  1  5.0    0.49    0.04  1.67  20.85 0.25   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.20]
*
    CHANNEL[ 2:  0008]    0071  1  5.0    0.49    0.04  1.75  20.85  n/a   0.000
*
    READ STORM                    5.0
    [ Ptot= 83.99 mm ]
    remark: Ottawa July 1 1979
*
 ** CALIB NASHYD          0007  1  5.0    0.50    0.02  2.08  20.89 0.25   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.49]
*
    ADD [  0007+  0071]   0061  3  5.0    0.99    0.05  1.75  20.87  n/a   0.000
*
    CHANNEL[ 2:  0061]    0072  1  5.0    0.99    0.05  1.83  20.87  n/a   0.000
```

```
*
    ADD [  0006+  0072]  0062  3  5.0    1.49    0.07  1.83  20.90  n/a   0.000
*
    CHANNEL[ 2:  0062]   0073  1  5.0    1.49    0.07  1.92  20.89  n/a   0.000
*
    READ STORM                    5.0
    [ Ptot= 83.99 mm ]
    remark: Ottawa July 1 1979
*
 ** CALIB NASHYD         0019  1  5.0    1.68    0.08  2.00  18.54 0.22   0.000
    [CN=57.5          ]
    [ N = 3.0:Tp 0.41]
*
    ADD [  0019+  0005]  0063  3  5.0    3.09    0.16  1.92  19.45  n/a   0.000
*
    ADD [  0063+  0073]  0063  1  5.0    4.58    0.23  1.92  19.92  n/a   0.000
*
    CHANNEL[ 2:  0063]   0083  1  5.0    4.58    0.22  2.08  19.91  n/a   0.000
*
    READ STORM                    5.0
    [ Ptot= 83.99 mm ]
    remark: Ottawa July 1 1979
*
 ** CALIB NASHYD         0009  1  5.0    0.36    0.03  1.75  27.91 0.33   0.000
    [CN=67.4          ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                    5.0
    [ Ptot= 83.99 mm ]
    remark: Ottawa July 1 1979
*
 ** CALIB NASHYD         0017  1  5.0    0.17    0.02  1.67  34.02 0.41   0.000
    [CN=73.9          ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0017]   0080  1  5.0    0.17    0.02  1.75  33.90  n/a   0.000
*
    ADD [  0080+  0009]  0035  3  5.0    0.53    0.05  1.75  29.86  n/a   0.000
*
    CHANNEL[ 2:  0035]   0077  1  5.0    0.53    0.05  1.75  29.86  n/a   0.000
*
    READ STORM                    5.0
    [ Ptot= 83.99 mm ]
    remark: Ottawa July 1 1979
*
 ** CALIB NASHYD         0010  1  5.0    0.38    0.03  1.75  27.56 0.33   0.000
    [CN=67.1          ]
    [ N = 3.0:Tp 0.27]
*
    ADD [  0010+  0077]  0036  3  5.0    0.91    0.08  1.75  28.91  n/a   0.000
*
    CHANNEL[ 2:  0036]   0078  1  5.0    0.91    0.08  1.83  28.90  n/a   0.000
*
    READ STORM                    5.0
    [ Ptot= 83.99 mm ]
    remark: Ottawa July 1 1979
*
 ** CALIB NASHYD         0011  1  5.0    0.38    0.03  1.75  27.56 0.33   0.000
    [CN=67.1          ]
    [ N = 3.0:Tp 0.27]
*
    ADD [  0011+  0078]  0037  3  5.0    1.28    0.11  1.75  28.51  n/a   0.000
```

```
*
    CHANNEL[ 2:  0037]   0079  1  5.0    1.28    0.11  1.83  28.51  n/a   0.000
*
    READ STORM                  5.0
    [ Ptot= 83.99 mm ]
    remark: Ottawa July 1 1979
*
 ** CALIB NASHYD         0012  1  5.0    0.29    0.03  1.75  29.32 0.35   0.000
    [CN=70.0          ]
    [ N = 3.0:Tp 0.22]
*
    ADD [  0012+  0079]  0038  3  5.0    1.58    0.14  1.83  28.66  n/a   0.000
*
    CHANNEL[ 2:  0038]   0094  1  5.0    1.58    0.14  1.83  28.65  n/a   0.000
*
    READ STORM                  5.0
    [ Ptot= 83.99 mm ]
    remark: Ottawa July 1 1979
*
 ** CALIB NASHYD         0013  1  5.0    0.34    0.03  1.75  29.41 0.35   0.000
    [CN=68.8          ]
    [ N = 3.0:Tp 0.24]
*
    READ STORM                  5.0
    [ Ptot= 83.99 mm ]
    remark: Ottawa July 1 1979
*
 ** CALIB NASHYD         0014  1  5.0    0.36    0.03  1.75  27.77 0.33   0.000
    [CN=67.3          ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                  5.0
    [ Ptot= 83.99 mm ]
    remark: Ottawa July 1 1979
*
 ** CALIB NASHYD         0015  1  5.0    0.38    0.03  1.75  27.56 0.33   0.000
    [CN=67.1          ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                  5.0
    [ Ptot= 83.99 mm ]
    remark: Ottawa July 1 1979
*
 ** CALIB NASHYD         0016  1  5.0    0.39    0.03  1.75  27.40 0.33   0.000
    [CN=66.9          ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                  5.0
    [ Ptot= 83.99 mm ]
    remark: Ottawa July 1 1979
*
 ** CALIB NASHYD         0018  1  5.0    0.17    0.02  1.67  34.02 0.41   0.000
    [CN=73.9          ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0018]   0081  1  5.0    0.17    0.02  1.75  33.94  n/a   0.000
*
    ADD [  0016+  0081]  0039  3  5.0    0.56    0.05  1.75  29.41  n/a   0.000
*
    CHANNEL[ 2:  0039]   0074  1  5.0    0.56    0.05  1.75  29.41  n/a   0.000
*
    ADD [  0015+  0074]  0040  3  5.0    0.94    0.08  1.75  28.67  n/a   0.000
```

```
*
    CHANNEL[ 2:  0040]   0075  1  5.0    0.94    0.08  1.75  28.66  n/a   0.000
*
    ADD [  0014+  0075]  0041  3  5.0    1.30    0.11  1.75  28.42  n/a   0.000
*
    CHANNEL[ 2:  0041]   0076  1  5.0    1.30    0.11  1.83  28.41  n/a   0.000
*
    ADD [  0013+  0076]  0042  3  5.0    1.64    0.14  1.83  28.62  n/a   0.000
*
    CHANNEL[ 2:  0042]   0095  1  5.0    1.64    0.15  1.83  28.62  n/a   0.000
*
    ADD [  0094+  0095]  0043  3  5.0    3.22    0.28  1.83  28.63  n/a   0.000
*
 ** Reservoir
    OUTFLOW:             0093  1  5.0    3.22    0.07  2.50  26.30  n/a   0.000
*
    ADD [  0083+  0093]  0092  3  5.0    7.80    0.28  2.08  22.55  n/a   0.000
*
    CHANNEL[ 2:  0092]   0085  1  5.0    7.80    0.28  2.08  22.55  n/a   0.000
*
    ADD [  0084+  0085]  0086  3  5.0   10.99    0.41  2.08  21.98  n/a   0.000
*
    CHANNEL[ 2:  0086]   0087  1  5.0   10.99    0.41  2.08  21.98  n/a   0.000
*
===============================================================================
  ************************************************
  ** SIMULATION : 9. Historical Aug 4 1988      **
  ************************************************

  W/E COMMAND             HYD ID   DT    AREA  ' Qpeak Tpeak   R.V. R.C.
Qbase
                                  min     ha   '  cms   hrs     mm          cms

      START @  0.00 hrs
      --------------------
    READ STORM                 5.0
    [ Ptot= 80.57 mm ]
    remark: Ottawa Aug 4 1988
*
 ** CALIB NASHYD         0001  1  5.0    0.50    0.04  2.08  19.12 0.24   0.000
    [CN=60.2        ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0001]   0068  1  5.0    0.50    0.04  2.08  19.12  n/a   0.000
*
    READ STORM                 5.0
    [ Ptot= 80.57 mm ]
    remark: Ottawa Aug 4 1988
*
 ** CALIB NASHYD         0002  1  5.0    0.50    0.03  2.17  19.18 0.24   0.000
    [CN=60.2        ]
    [ N = 3.0:Tp 0.31]
*
    ADD [  0002+  0068]  0064  3  5.0    1.00    0.06  2.08  19.15  n/a   0.000
*
    CHANNEL[ 2:  0064]   0069  1  5.0    1.00    0.06  2.17  19.15  n/a   0.000
*
    READ STORM                 5.0
    [ Ptot= 80.57 mm ]
    remark: Ottawa Aug 4 1988
*
 ** CALIB NASHYD         0003  1  5.0    0.51    0.02  2.25  19.19 0.24   0.000
```

```
    [CN=60.2          ]
    [ N = 3.0:Tp 0.45]
*
    ADD [  0003+  0069]  0065  3  5.0    1.51    0.08  2.17  19.16  n/a   0.000
*
    CHANNEL[ 2:  0065]   0070  1  5.0    1.51    0.08  2.17  19.16  n/a   0.000
*
    READ STORM                    5.0
    [ Ptot= 80.57 mm ]
    remark: Ottawa Aug 4 1988
*
 ** CALIB NASHYD         0004  1  5.0    1.68    0.05  2.50  18.66 0.23   0.000
    [CN=59.6          ]
    [ N = 3.0:Tp 0.69]
*
    ADD [  0004+  0070]  0066  3  5.0    3.18    0.12  2.25  18.90  n/a   0.000
*
    CHANNEL[ 2:  0066]   0084  1  5.0    3.18    0.12  2.33  18.89  n/a   0.000
*
    READ STORM                    5.0
    [ Ptot= 80.57 mm ]
    remark: Ottawa Aug 4 1988
*
 ** CALIB NASHYD         0005  1  5.0    1.41    0.07  2.17  18.86 0.23   0.000
    [CN=59.8          ]
    [ N = 3.0:Tp 0.34]
*
    READ STORM                    5.0
    [ Ptot= 80.57 mm ]
    remark: Ottawa Aug 4 1988
*
 ** CALIB NASHYD         0006  1  5.0    0.50    0.02  2.33  19.24 0.24   0.000
    [CN=60.3          ]
    [ N = 3.0:Tp 0.50]
*
    READ STORM                    5.0
    [ Ptot= 80.57 mm ]
    remark: Ottawa Aug 4 1988
*
 ** CALIB NASHYD         0008  1  5.0    0.49    0.04  2.08  19.15 0.24   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.20]
*
    CHANNEL[ 2:  0008]   0071  1  5.0    0.49    0.03  2.08  19.15  n/a   0.000
*
    READ STORM                    5.0
    [ Ptot= 80.57 mm ]
    remark: Ottawa Aug 4 1988
*
 ** CALIB NASHYD         0007  1  5.0    0.50    0.02  2.33  19.19 0.24   0.000
    [CN=60.2          ]
    [ N = 3.0:Tp 0.49]
*
    ADD [  0007+  0071]  0061  3  5.0    0.99    0.05  2.17  19.17  n/a   0.000
*
    CHANNEL[ 2:  0061]   0072  1  5.0    0.99    0.05  2.17  19.17  n/a   0.000
*
    ADD [  0006+  0072]  0062  3  5.0    1.49    0.07  2.17  19.19  n/a   0.000
*
    CHANNEL[ 2:  0062]   0073  1  5.0    1.49    0.07  2.25  19.19  n/a   0.000
*
    READ STORM                    5.0
```

```
    [ Ptot= 80.57 mm ]
    remark: Ottawa Aug 4 1988
*
 ** CALIB NASHYD          0019  1  5.0     1.68     0.07  2.25  16.97 0.21   0.000
    [CN=57.5          ]
    [ N = 3.0:Tp 0.41]
*
    ADD [  0019+  0005]   0063  3  5.0     3.09     0.14  2.17  17.83  n/a   0.000
*
    ADD [  0063+  0073]   0063  1  5.0     4.58     0.20  2.25  18.28  n/a   0.000
*
    CHANNEL[ 2:  0063]    0083  1  5.0     4.58     0.19  2.33  18.27  n/a   0.000
*
    READ STORM                     5.0
    [ Ptot= 80.57 mm ]
    remark: Ottawa Aug 4 1988
*
 ** CALIB NASHYD          0009  1  5.0     0.36     0.03  2.08  25.85 0.32   0.000
    [CN=67.4          ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                     5.0
    [ Ptot= 80.57 mm ]
    remark: Ottawa Aug 4 1988
*
 ** CALIB NASHYD          0017  1  5.0     0.17     0.02  2.08  31.64 0.39   0.000
    [CN=73.9          ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0017]    0080  1  5.0     0.17     0.02  2.17  31.51  n/a   0.000
*
    ADD [  0080+  0009]   0035  3  5.0     0.53     0.05  2.17  27.69  n/a   0.000
*
    CHANNEL[ 2:  0035]    0077  1  5.0     0.53     0.05  2.17  27.69  n/a   0.000
*
    READ STORM                     5.0
    [ Ptot= 80.57 mm ]
    remark: Ottawa Aug 4 1988
*
 ** CALIB NASHYD          0010  1  5.0     0.38     0.03  2.08  25.51 0.32   0.000
    [CN=67.1          ]
    [ N = 3.0:Tp 0.27]
*
    ADD [  0010+  0077]   0036  3  5.0     0.91     0.08  2.17  26.79  n/a   0.000
*
    CHANNEL[ 2:  0036]    0078  1  5.0     0.91     0.08  2.17  26.78  n/a   0.000
*
    READ STORM                     5.0
    [ Ptot= 80.57 mm ]
    remark: Ottawa Aug 4 1988
*
 ** CALIB NASHYD          0011  1  5.0     0.38     0.03  2.08  25.51 0.32   0.000
    [CN=67.1          ]
    [ N = 3.0:Tp 0.27]
*
    ADD [  0011+  0078]   0037  3  5.0     1.28     0.10  2.17  26.41  n/a   0.000
*
    CHANNEL[ 2:  0037]    0079  1  5.0     1.28     0.10  2.17  26.41  n/a   0.000
*
    READ STORM                     5.0
    [ Ptot= 80.57 mm ]
    remark: Ottawa Aug 4 1988
```

```
*
 ** CALIB NASHYD         0012  1  5.0    0.29    0.03  2.08  27.15 0.34   0.000
    [CN=70.0          ]
    [ N = 3.0:Tp 0.22]
*
    ADD [  0012+  0079]  0038  3  5.0    1.58    0.13  2.17  26.55  n/a   0.000
*
    CHANNEL[ 2:  0038]   0094  1  5.0    1.58    0.13  2.17  26.54  n/a   0.000
*
    READ STORM                  5.0
    [ Ptot= 80.57 mm ]
    remark: Ottawa Aug 4 1988
*
 ** CALIB NASHYD         0013  1  5.0    0.34    0.03  2.08  27.27 0.34   0.000
    [CN=68.8          ]
    [ N = 3.0:Tp 0.24]
*
    READ STORM                  5.0
    [ Ptot= 80.57 mm ]
    remark: Ottawa Aug 4 1988
*
 ** CALIB NASHYD         0014  1  5.0    0.36    0.03  2.08  25.71 0.32   0.000
    [CN=67.3          ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                  5.0
    [ Ptot= 80.57 mm ]
    remark: Ottawa Aug 4 1988
*
 ** CALIB NASHYD         0015  1  5.0    0.38    0.03  2.08  25.51 0.32   0.000
    [CN=67.1          ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                  5.0
    [ Ptot= 80.57 mm ]
    remark: Ottawa Aug 4 1988
*
 ** CALIB NASHYD         0016  1  5.0    0.39    0.03  2.08  25.36 0.31   0.000
    [CN=66.9          ]
    [ N = 3.0:Tp 0.27]
*
    READ STORM                  5.0
    [ Ptot= 80.57 mm ]
    remark: Ottawa Aug 4 1988
*
 ** CALIB NASHYD         0018  1  5.0    0.17    0.02  2.08  31.64 0.39   0.000
    [CN=73.9          ]
    [ N = 3.0:Tp 0.17]
*
    CHANNEL[ 2:  0018]   0081  1  5.0    0.17    0.02  2.08  31.56  n/a   0.000
*
    ADD [  0016+  0081]  0039  3  5.0    0.56    0.05  2.08  27.27  n/a   0.000
*
    CHANNEL[ 2:  0039]   0074  1  5.0    0.56    0.05  2.17  27.27  n/a   0.000
*
    ADD [  0015+  0074]  0040  3  5.0    0.94    0.08  2.17  26.56  n/a   0.000
*
    CHANNEL[ 2:  0040]   0075  1  5.0    0.94    0.08  2.17  26.56  n/a   0.000
*
    ADD [  0014+  0075]  0041  3  5.0    1.30    0.11  2.17  26.32  n/a   0.000
*
    CHANNEL[ 2:  0041]   0076  1  5.0    1.30    0.11  2.17  26.32  n/a   0.000
```

```
*
    ADD [  0013+  0076]  0042  3  5.0    1.64    0.13  2.17  26.52  n/a   0.000
*
    CHANNEL[ 2:  0042]   0095  1  5.0    1.64    0.13  2.17  26.51  n/a   0.000
*
    ADD [  0094+  0095]  0043  3  5.0    3.22    0.26  2.17  26.53  n/a   0.000
*
 ** Reservoir
    OUTFLOW:             0093  1  5.0    3.22    0.06  2.67  24.19  n/a   0.000
*
    ADD [  0083+  0093]  0092  3  5.0    7.80    0.24  2.33  20.71  n/a   0.000
*
    CHANNEL[ 2:  0092]   0085  1  5.0    7.80    0.24  2.33  20.71  n/a   0.000
*
    ADD [  0084+  0085]  0086  3  5.0   10.99    0.36  2.33  20.18  n/a   0.000
*
    CHANNEL[ 2:  0086]   0087  1  5.0   10.99    0.35  2.33  20.18  n/a   0.000
```

```
****************************************
** SIMULATION:1. SCS II 6hr 5yr Ottawa **
****************************************

  --------------------------
  | Junction Command(0088) |
  --------------------------

                            AREA     QPEAK   TPEAK     R.V.
                            (ha)     (cms)    (hrs)    (mm)
  INFLOW : ID= 1(  0087)    10.99     0.08    3.83     6.86
  OUTFLOW: ID= 2(  0088)    10.99     0.08    3.83     6.86

  -----------------------------------------------------------------------------
--
**********************************
** SIMULATION:10. 25mm4hrChicago **
**********************************

  --------------------------
  | Junction Command(0088) |
  --------------------------

                            AREA     QPEAK   TPEAK     R.V.
                            (ha)     (cms)    (hrs)    (mm)
  INFLOW : ID= 1(  0087)    10.99     0.01    3.83     0.47
  OUTFLOW: ID= 2(  0088)    10.99     0.01    3.83     0.47

  -----------------------------------------------------------------------------
--
******************************************
** SIMULATION:2. SCS II 6hr 100yr Ottawa **
******************************************

  --------------------------
  | Junction Command(0088) |
  --------------------------

                            AREA     QPEAK   TPEAK     R.V.
                            (ha)     (cms)    (hrs)    (mm)
  INFLOW : ID= 1(  0087)    10.99     0.31    3.67    23.59
  OUTFLOW: ID= 2(  0088)    10.99     0.31    3.67    23.59

  -----------------------------------------------------------------------------
--
*****************************************
** SIMULATION:3. SCS II 12hr 5yr Ottawa **
*****************************************

  --------------------------
  | Junction Command(0088) |
  --------------------------

                            AREA     QPEAK   TPEAK     R.V.
                            (ha)     (cms)    (hrs)    (mm)
  INFLOW : ID= 1(  0087)    10.99     0.09    6.67     9.42
  OUTFLOW: ID= 2(  0088)    10.99     0.09    6.67     9.42

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

```
*******************************************
** SIMULATION:4. SCS II 12hr 10yr Ottawa **
*******************************************

  --------------------------
  | Junction Command(0088) |
  --------------------------

                           AREA     QPEAK   TPEAK     R.V.
                           (ha)     (cms)    (hrs)    (mm)
  INFLOW : ID= 1(  0087)   10.99     0.14    6.67    13.69
  OUTFLOW: ID= 2(  0088)   10.99     0.14    6.67    13.69

  ------------------------------------------------------------------------------
--
*********************************************
** SIMULATION:5. SCS II 12hr 100yr correct **
*********************************************

  --------------------------
  | Junction Command(0088) |
  --------------------------

                           AREA     QPEAK   TPEAK     R.V.
                           (ha)     (cms)    (hrs)    (mm)
  INFLOW : ID= 1(  0087)   10.99     0.33    6.50    28.63
  OUTFLOW: ID= 2(  0088)   10.99     0.33    6.50    28.63

  ------------------------------------------------------------------------------
--
************************************
** SIMULATION:6. Chi 12hr 2yr     **
************************************

  --------------------------
  | Junction Command(0088) |
  --------------------------

                           AREA     QPEAK   TPEAK     R.V.
                           (ha)     (cms)    (hrs)    (mm)
  INFLOW : ID= 1(  0087)   10.99     0.03    5.17     4.22
  OUTFLOW: ID= 2(  0088)   10.99     0.03    5.17     4.22

  ------------------------------------------------------------------------------
--
************************************
** SIMULATION:7. Chi 12hr 100yr   **
************************************

  --------------------------
  | Junction Command(0088) |
  --------------------------

                           AREA     QPEAK   TPEAK     R.V.
                           (ha)     (cms)    (hrs)    (mm)
  INFLOW : ID= 1(  0087)   10.99     0.31    4.67    27.43
  OUTFLOW: ID= 2(  0088)   10.99     0.31    4.67    27.43

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

```
*****************************************
** SIMULATION:8. Historical July 1 1979 **
*****************************************

  --------------------------
  | Junction Command(0088) |
  --------------------------

                            AREA     QPEAK   TPEAK     R.V.
                            (ha)     (cms)    (hrs)    (mm)
  INFLOW : ID= 1(  0087)   10.99      0.41    2.08    21.98
  OUTFLOW: ID= 2(  0088)   10.99      0.41    2.08    21.98

  -----------------------------------------------------------------------------
--
****************************************
** SIMULATION:9. Historical Aug 4 1988 **
****************************************

  --------------------------
  | Junction Command(0088) |
  --------------------------

                            AREA     QPEAK   TPEAK     R.V.
                            (ha)     (cms)    (hrs)    (mm)
  INFLOW : ID= 1(  0087)   10.99      0.35    2.33    20.18
  OUTFLOW: ID= 2(  0088)   10.99      0.35    2.33    20.18

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

APPENDIX H: OTTHYMO MODEL ROUTE RESERVOIR REPORT

```
*****************************************
** SIMULATION:1. SCS II 6hr 5yr Ottawa **
*****************************************
--------------------
| RESERVOIR(  0093)|     OVERFLOW IS ON
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   0.0250     0.0300
                          0.0000     0.0020   |   0.0340     0.0340
                          0.0000     0.0040   |   0.0430     0.0380
                          0.0000     0.0070   |   0.0500     0.0430
                          0.0010     0.0090   |   0.0550     0.0480
                          0.0040     0.0120   |   0.0600     0.0540
                          0.0060     0.0150   |   0.0650     0.0600
                          0.0080     0.0190   |   0.0690     0.0660
                          0.0100     0.0220   |   0.0730     0.0720
                          0.0160     0.0260   |   0.0000     0.0000

                                AREA      QPEAK      TPEAK       R.V.
                                (ha)      (cms)      (hrs)       (mm)
   INFLOW : ID= 2 (  0043)      3.218      0.069      3.25      10.40
   OUTFLOW: ID= 1 (  0093)      3.218      0.012      5.25       8.06
   OVERFLOW:ID= 3 (  0003)      0.000      0.000      0.00       0.00

                     TOTAL NUMBER OF SIMULATION OVERFLOW  =     0
                     CUMULATIVE TIME OF OVERFLOW  (HOURS) =  0.00
                     PERCENTAGE OF TIME OVERFLOWING   (%) =  0.00

                     PEAK   FLOW   REDUCTION [Qout/Qin](%)= 16.58
                     TIME SHIFT OF PEAK FLOW         (min)=120.00
                     MAXIMUM  STORAGE   USED       (ha.m.)=  0.0230

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

```
**********************************
** SIMULATION:10. 25mm4hrChicago **
**********************************
--------------------
| RESERVOIR(  0093)|     OVERFLOW IS ON
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   0.0250      0.0300
                          0.0000     0.0020   |   0.0340      0.0340
                          0.0000     0.0040   |   0.0430      0.0380
                          0.0000     0.0070   |   0.0500      0.0430
                          0.0010     0.0090   |   0.0550      0.0480
                          0.0040     0.0120   |   0.0600      0.0540
                          0.0060     0.0150   |   0.0650      0.0600
                          0.0080     0.0190   |   0.0690      0.0660
                          0.0100     0.0220   |   0.0730      0.0720
                          0.0160     0.0260   |   0.0000      0.0000

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  0043)      3.218      0.007      2.25        1.72
   OUTFLOW: ID= 1 (  0093)      3.218      0.000      0.00        0.00
   OVERFLOW:ID= 3 (  0003)      0.000      0.000      0.00        0.00

                   TOTAL NUMBER OF SIMULATION OVERFLOW  =     0
                   CUMULATIVE TIME OF OVERFLOW  (HOURS) =  0.00
                   PERCENTAGE OF TIME OVERFLOWING   (%) =  0.00

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)=  0.00
                   TIME SHIFT OF PEAK FLOW         (min)=******
                   MAXIMUM  STORAGE   USED       (ha.m.)=  0.0055

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

```
*******************************************
** SIMULATION:2. SCS II 6hr 100yr Ottawa **
*******************************************
--------------------
| RESERVOIR(  0093)|     OVERFLOW IS ON
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   0.0250      0.0300
                          0.0000     0.0020   |   0.0340      0.0340
                          0.0000     0.0040   |   0.0430      0.0380
                          0.0000     0.0070   |   0.0500      0.0430
                          0.0010     0.0090   |   0.0550      0.0480
                          0.0040     0.0120   |   0.0600      0.0540
                          0.0060     0.0150   |   0.0650      0.0600
                          0.0080     0.0190   |   0.0690      0.0660
                          0.0100     0.0220   |   0.0730      0.0720
                          0.0160     0.0260   |   0.0000      0.0000

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  0043)      3.218      0.218      3.17      30.53
   OUTFLOW: ID= 1 (  0093)      3.218      0.060      4.25      28.20
   OVERFLOW:ID= 3 (  0003)      0.000      0.000      0.00       0.00

                   TOTAL NUMBER OF SIMULATION OVERFLOW  =     0
                   CUMULATIVE TIME OF OVERFLOW  (HOURS) =  0.00
                   PERCENTAGE OF TIME OVERFLOWING   (%) =  0.00

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)= 27.49
                   TIME SHIFT OF PEAK FLOW         (min)= 65.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  0.0540

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

```
*****************************************
** SIMULATION:3. SCS II 12hr 5yr Ottawa **
*****************************************
--------------------
| RESERVOIR(  0093)|     OVERFLOW IS ON
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   0.0250     0.0300
                          0.0000     0.0020   |   0.0340     0.0340
                          0.0000     0.0040   |   0.0430     0.0380
                          0.0000     0.0070   |   0.0500     0.0430
                          0.0010     0.0090   |   0.0550     0.0480
                          0.0040     0.0120   |   0.0600     0.0540
                          0.0060     0.0150   |   0.0650     0.0600
                          0.0080     0.0190   |   0.0690     0.0660
                          0.0100     0.0220   |   0.0730     0.0720
                          0.0160     0.0260   |   0.0000     0.0000

                                AREA      QPEAK      TPEAK       R.V.
                                (ha)      (cms)      (hrs)       (mm)
   INFLOW : ID= 2 (  0043)      3.218      0.085      6.17       13.59
   OUTFLOW: ID= 1 (  0093)      3.218      0.014      8.00       11.25
   OVERFLOW:ID= 3 (  0003)      0.000      0.000      0.00        0.00

                   TOTAL NUMBER OF SIMULATION OVERFLOW  =     0
                   CUMULATIVE TIME OF OVERFLOW  (HOURS) =  0.00
                   PERCENTAGE OF TIME OVERFLOWING   (%) =  0.00

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)= 16.12
                   TIME SHIFT OF PEAK FLOW         (min)=110.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  0.0244

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

```
******************************************
** SIMULATION:4. SCS II 12hr 10yr Ottawa **
******************************************
--------------------
| RESERVOIR(  0093)|     OVERFLOW IS ON
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   0.0250     0.0300
                          0.0000     0.0020   |   0.0340     0.0340
                          0.0000     0.0040   |   0.0430     0.0380
                          0.0000     0.0070   |   0.0500     0.0430
                          0.0010     0.0090   |   0.0550     0.0480
                          0.0040     0.0120   |   0.0600     0.0540
                          0.0060     0.0150   |   0.0650     0.0600
                          0.0080     0.0190   |   0.0690     0.0660
                          0.0100     0.0220   |   0.0730     0.0720
                          0.0160     0.0260   |   0.0000     0.0000

                                AREA     QPEAK     TPEAK      R.V.
                                (ha)     (cms)     (hrs)      (mm)
   INFLOW : ID= 2 (  0043)      3.218     0.120      6.17      18.79
   OUTFLOW: ID= 1 (  0093)      3.218     0.027      7.33      16.46
   OVERFLOW:ID= 3 (  0003)      0.000     0.000      0.00       0.00

                   TOTAL NUMBER OF SIMULATION OVERFLOW  =     0
                   CUMULATIVE TIME OF OVERFLOW  (HOURS) =  0.00
                   PERCENTAGE OF TIME OVERFLOWING   (%) =  0.00

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)= 22.56
                   TIME SHIFT OF PEAK FLOW        (min)= 70.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  0.0310

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

```
*********************************************
** SIMULATION:5. SCS II 12hr 100yr correct **
*********************************************
--------------------
| RESERVOIR(  0093)|     OVERFLOW IS ON
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   0.0250      0.0300
                          0.0000     0.0020   |   0.0340      0.0340
                          0.0000     0.0040   |   0.0430      0.0380
                          0.0000     0.0070   |   0.0500      0.0430
                          0.0010     0.0090   |   0.0550      0.0480
                          0.0040     0.0120   |   0.0600      0.0540
                          0.0060     0.0150   |   0.0650      0.0600
                          0.0080     0.0190   |   0.0690      0.0660
                          0.0100     0.0220   |   0.0730      0.0720
                          0.0160     0.0260   |   0.0000      0.0000

                                AREA     QPEAK      TPEAK       R.V.
                                (ha)     (cms)      (hrs)       (mm)
   INFLOW : ID= 2 (  0043)      3.218      0.242      6.17       36.38
   OUTFLOW: ID= 1 (  0093)      3.218      0.062      7.08       34.05
   OVERFLOW:ID= 3 (  0003)      0.000      0.000      0.00        0.00

                   TOTAL NUMBER OF SIMULATION OVERFLOW  =     0
                   CUMULATIVE TIME OF OVERFLOW  (HOURS) =  0.00
                   PERCENTAGE OF TIME OVERFLOWING   (%) =  0.00

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)= 25.46
                   TIME SHIFT OF PEAK FLOW         (min)= 55.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  0.0561

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

```
************************************
** SIMULATION:6. Chi 12hr 2yr     **
************************************
--------------------
| RESERVOIR(  0093)|     OVERFLOW IS ON
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   0.0250      0.0300
                          0.0000     0.0020   |   0.0340      0.0340
                          0.0000     0.0040   |   0.0430      0.0380
                          0.0000     0.0070   |   0.0500      0.0430
                          0.0010     0.0090   |   0.0550      0.0480
                          0.0040     0.0120   |   0.0600      0.0540
                          0.0060     0.0150   |   0.0650      0.0600
                          0.0080     0.0190   |   0.0690      0.0660
                          0.0100     0.0220   |   0.0730      0.0720
                          0.0160     0.0260   |   0.0000      0.0000

                                AREA     QPEAK      TPEAK       R.V.
                                (ha)     (cms)      (hrs)       (mm)
   INFLOW : ID= 2 (  0043)      3.218      0.038      4.42        7.04
   OUTFLOW: ID= 1 (  0093)      3.218      0.005      7.58        4.70
   OVERFLOW:ID= 3 (  0003)      0.000      0.000      0.00        0.00

                   TOTAL NUMBER OF SIMULATION OVERFLOW  =     0
                   CUMULATIVE TIME OF OVERFLOW  (HOURS) =  0.00
                   PERCENTAGE OF TIME OVERFLOWING   (%) =  0.00

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)= 12.53
                   TIME SHIFT OF PEAK FLOW         (min)=190.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  0.0131

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

```
************************************
** SIMULATION:7. Chi 12hr 100yr   **
************************************
--------------------
| RESERVOIR(  0093)|     OVERFLOW IS ON
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE    |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)    |   (cms)     (ha.m.)
                          0.0000     0.0000    |  0.0250      0.0300
                          0.0000     0.0020    |  0.0340      0.0340
                          0.0000     0.0040    |  0.0430      0.0380
                          0.0000     0.0070    |  0.0500      0.0430
                          0.0010     0.0090    |  0.0550      0.0480
                          0.0040     0.0120    |  0.0600      0.0540
                          0.0060     0.0150    |  0.0650      0.0600
                          0.0080     0.0190    |  0.0690      0.0660
                          0.0100     0.0220    |  0.0730      0.0720
                          0.0160     0.0260    |  0.0000      0.0000

                                AREA     QPEAK      TPEAK       R.V.
                                (ha)     (cms)      (hrs)       (mm)
   INFLOW : ID= 2 (  0043)      3.218      0.245      4.33       35.00
   OUTFLOW: ID= 1 (  0093)      3.218      0.057      5.25       32.66
   OVERFLOW:ID= 3 (  0003)      0.000      0.000      0.00        0.00

                   TOTAL NUMBER OF SIMULATION OVERFLOW  =     0
                   CUMULATIVE TIME OF OVERFLOW  (HOURS) =  0.00
                   PERCENTAGE OF TIME OVERFLOWING   (%) =  0.00

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)= 23.48
                   TIME SHIFT OF PEAK FLOW         (min)= 55.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  0.0509

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

```
*****************************************
** SIMULATION:8. Historical July 1 1979 **
*****************************************
--------------------
| RESERVOIR(  0093)|     OVERFLOW IS ON
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   0.0250     0.0300
                          0.0000     0.0020   |   0.0340     0.0340
                          0.0000     0.0040   |   0.0430     0.0380
                          0.0000     0.0070   |   0.0500     0.0430
                          0.0010     0.0090   |   0.0550     0.0480
                          0.0040     0.0120   |   0.0600     0.0540
                          0.0060     0.0150   |   0.0650     0.0600
                          0.0080     0.0190   |   0.0690     0.0660
                          0.0100     0.0220   |   0.0730     0.0720
                          0.0160     0.0260   |   0.0000     0.0000

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  0043)      3.218     0.285     1.83      28.63
   OUTFLOW: ID= 1 (  0093)      3.218     0.068     2.50      26.30
   OVERFLOW:ID= 3 (  0003)      0.000     0.000     0.00       0.00

                   TOTAL NUMBER OF SIMULATION OVERFLOW  =     0
                   CUMULATIVE TIME OF OVERFLOW  (HOURS) =  0.00
                   PERCENTAGE OF TIME OVERFLOWING   (%) =  0.00

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)= 24.00
                   TIME SHIFT OF PEAK FLOW         (min)= 40.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  0.0650

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

```
*****************************************
** SIMULATION:9. Historical Aug 4 1988 **
*****************************************
--------------------
| RESERVOIR(  0093)|     OVERFLOW IS ON
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |  0.0250      0.0300
                          0.0000     0.0020   |  0.0340      0.0340
                          0.0000     0.0040   |  0.0430      0.0380
                          0.0000     0.0070   |  0.0500      0.0430
                          0.0010     0.0090   |  0.0550      0.0480
                          0.0040     0.0120   |  0.0600      0.0540
                          0.0060     0.0150   |  0.0650      0.0600
                          0.0080     0.0190   |  0.0690      0.0660
                          0.0100     0.0220   |  0.0730      0.0720
                          0.0160     0.0260   |  0.0000      0.0000

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  0043)      3.218     0.263      2.17      26.53
   OUTFLOW: ID= 1 (  0093)      3.218     0.058      2.67      24.19
   OVERFLOW:ID= 3 (  0003)      0.000     0.000      0.00       0.00

                   TOTAL NUMBER OF SIMULATION OVERFLOW  =     0
                   CUMULATIVE TIME OF OVERFLOW  (HOURS) =  0.00
                   PERCENTAGE OF TIME OVERFLOWING   (%) =  0.00

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)= 21.88
                   TIME SHIFT OF PEAK FLOW         (min)= 30.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  0.0511

-------------------------------------------------------------------------------
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APPENDIX I: CULVERT ANALYSIS AND HYDRAFLOW EXPRESS ANALYSIS RESULTS

Culvert Report

LOT 1 & 2 - 10 Year

Invert Elev Dn (m)	=	77.8600
Pipe Length (m)	=	12.0000
Slope (%)	=	1.1666
Invert Elev Up (m)	=	78.0000
Rise (mm)	=	500.0
Shape	=	Circular
Span (mm)	=	500.0
No. Barrels	=	1
n-Value	=	0.024
Culvert Type	=	Circular Corrugate Metal Pipe
Culvert Entrance	=	Projecting
Coeff. K,M,c,Y,k	=	0.034, 1.5, 0.0553, 0.54, 0.9

Embankment

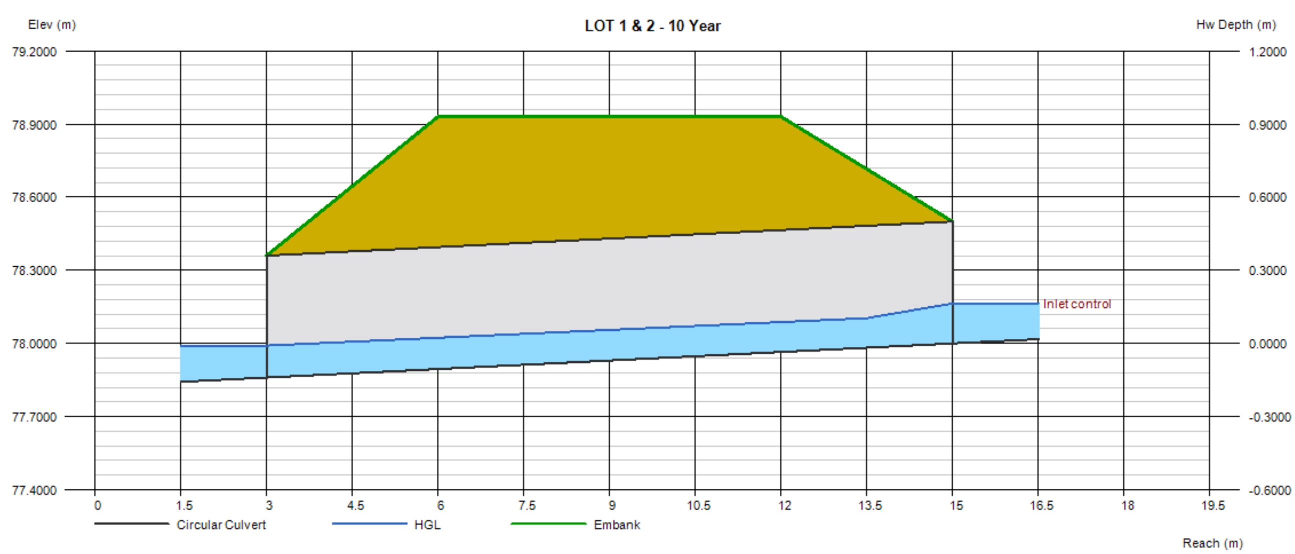
Top Elevation (m)	=	78.9300
Top Width (m)	=	6.0000
Crest Width (m)	=	3.0000

Calculations

Qmin (cms)	=	0.0330
Qmax (cms)	=	0.0330
Tailwater Elev (m)	=	Normal

Highlighted

Qtotal (cms)	=	0.0330
Qpipe (cms)	=	0.0330
Qovertop (cms)	=	0.0000
Veloc Dn (m/s)	=	0.8042
Veloc Up (m/s)	=	0.9128
HGL Dn (m)	=	77.9911
HGL Up (m)	=	78.1198
Hw Elev (m)	=	78.1642
Hw/D (m)	=	0.3284
Flow Regime	=	Inlet Control



Culvert Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Friday, May 5 2023

LOT 1 & 2 - 100 Year

Invert Elev Dn (m)	=	77.8600
Pipe Length (m)	=	12.0000
Slope (%)	=	1.1666
Invert Elev Up (m)	=	78.0000
Rise (mm)	=	500.0
Shape	=	Circular
Span (mm)	=	500.0
No. Barrels	=	1
n-Value	=	0.024
Culvert Type	=	Circular Corrugate Metal Pipe
Culvert Entrance	=	Projecting
Coeff. K,M,c,Y,k	=	0.034, 1.5, 0.0553, 0.54, 0.9

Embankment

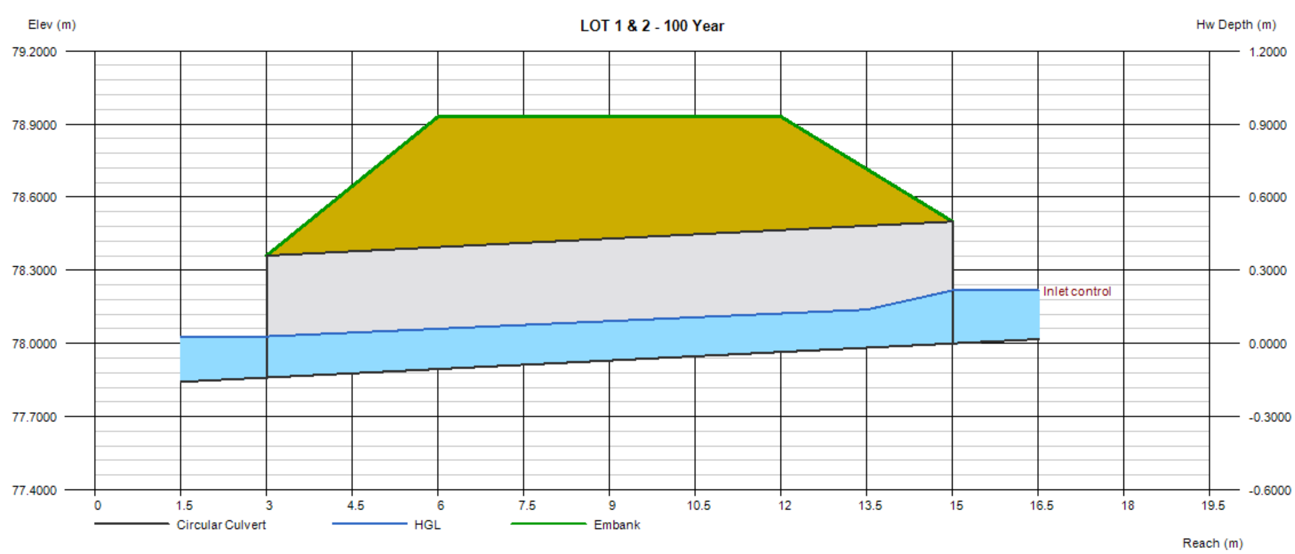
Top Elevation (m)	=	78.9300
Top Width (m)	=	6.0000
Crest Width (m)	=	3.0000

Calculations

Qmin (cms)	=	0.0540
Qmax (cms)	=	0.0540
Tailwater Elev (m)	=	Normal

Highlighted

Qtotal (cms)	=	0.0540
Qpipe (cms)	=	0.0540
Qovertop (cms)	=	0.0000
Veloc Dn (m/s)	=	0.9262
Veloc Up (m/s)	=	1.0480
HGL Dn (m)	=	78.0288
HGL Up (m)	=	78.1543
Hw Elev (m)	=	78.2175
Hw/D (m)	=	0.4349
Flow Regime	=	Inlet Control



Culvert Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Friday, May 5 2023

LOT 3 & 4 - 10 Year

Invert Elev Dn (m)	=	77.0500
Pipe Length (m)	=	12.0000
Slope (%)	=	1.8333
Invert Elev Up (m)	=	77.2700
Rise (mm)	=	500.0
Shape	=	Circular
Span (mm)	=	500.0
No. Barrels	=	1
n-Value	=	0.024
Culvert Type	=	Circular Corrugate Metal Pipe
Culvert Entrance	=	Projecting
Coeff. K,M,c,Y,k	=	0.034, 1.5, 0.0553, 0.54, 0.9

Embankment

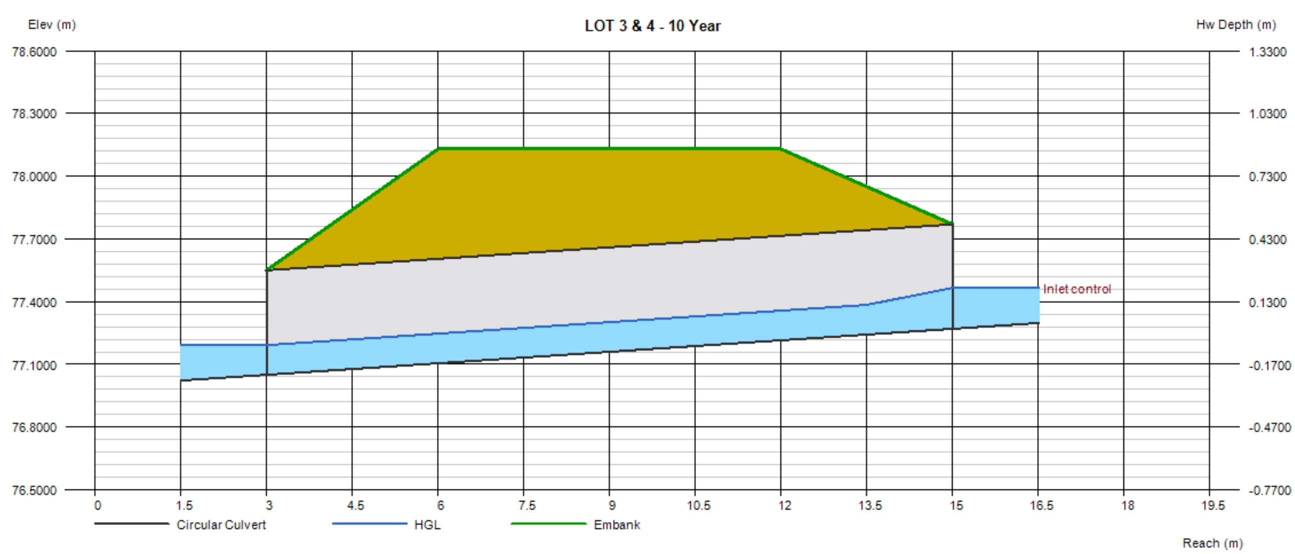
Top Elevation (m)	=	78.1300
Top Width (m)	=	6.0000
Crest Width (m)	=	3.0000

Calculations

Qmin (cms)	=	0.0460
Qmax (cms)	=	0.0460
Tailwater Elev (m)	=	Normal

Highlighted

Qtotal (cms)	=	0.0460
Qpipe (cms)	=	0.0460
Qovertop (cms)	=	0.0000
Veloc Dn (m/s)	=	1.0011
Veloc Up (m/s)	=	1.0011
HGL Dn (m)	=	77.1921
HGL Up (m)	=	77.4121
Hw Elev (m)	=	77.4665
Hw/D (m)	=	0.3931
Flow Regime	=	Inlet Control



Culvert Report

LOT 3 & 4 - 100 Year

Invert Elev Dn (m)	=	77.0500
Pipe Length (m)	=	12.0000
Slope (%)	=	1.8333
Invert Elev Up (m)	=	77.2700
Rise (mm)	=	500.0
Shape	=	Circular
Span (mm)	=	500.0
No. Barrels	=	1
n-Value	=	0.024
Culvert Type	=	Circular Corrugate Metal Pipe
Culvert Entrance	=	Projecting
Coeff. K,M,c,Y,k	=	0.034, 1.5, 0.0553, 0.54, 0.9

Embankment

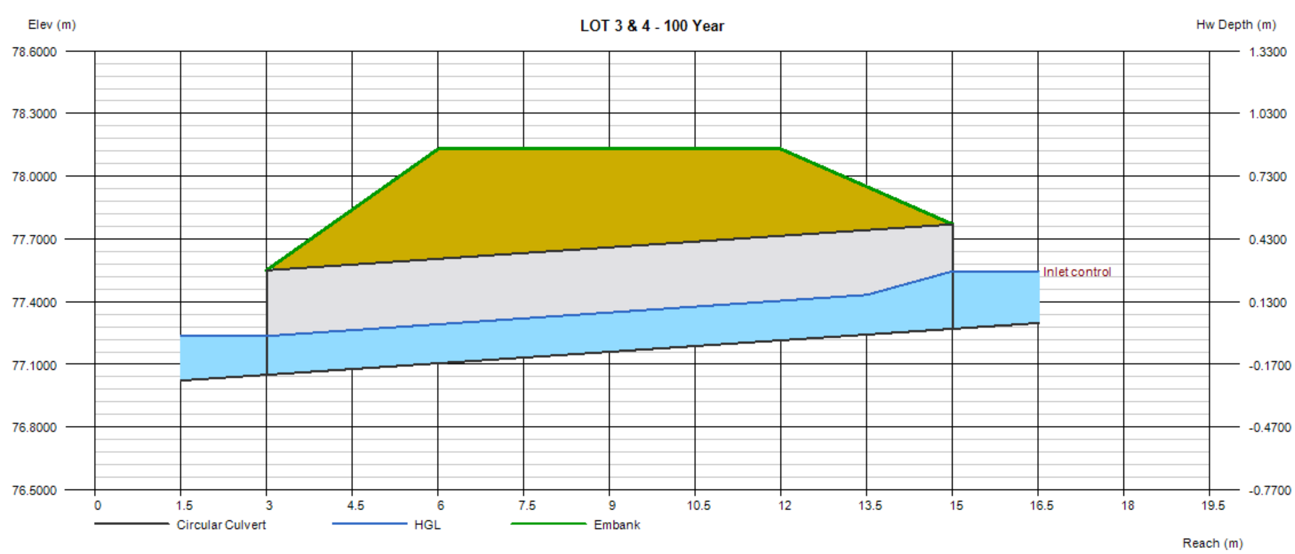
Top Elevation (m)	=	78.1300
Top Width (m)	=	6.0000
Crest Width (m)	=	3.0000

Calculations

Qmin (cms)	=	0.0810
Qmax (cms)	=	0.0810
Tailwater Elev (m)	=	Normal

Highlighted

Qtotal (cms)	=	0.0810
Qpipe (cms)	=	0.0810
Qovertop (cms)	=	0.0000
Veloc Dn (m/s)	=	1.2216
Veloc Up (m/s)	=	1.1799
HGL Dn (m)	=	77.2355
HGL Up (m)	=	77.4604
Hw Elev (m)	=	77.5453
Hw/D (m)	=	0.5506
Flow Regime	=	Inlet Control



Culvert Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Friday, May 5 2023

LOT 5 & 6 - 10 Year

Invert Elev Dn (m)	=	76.1100
Pipe Length (m)	=	12.0000
Slope (%)	=	0.9166
Invert Elev Up (m)	=	76.2200
Rise (mm)	=	500.0
Shape	=	Circular
Span (mm)	=	500.0
No. Barrels	=	1
n-Value	=	0.024
Culvert Type	=	Circular Corrugate Metal Pipe
Culvert Entrance	=	Projecting
Coeff. K,M,c,Y,k	=	0.034, 1.5, 0.0553, 0.54, 0.9

Embankment

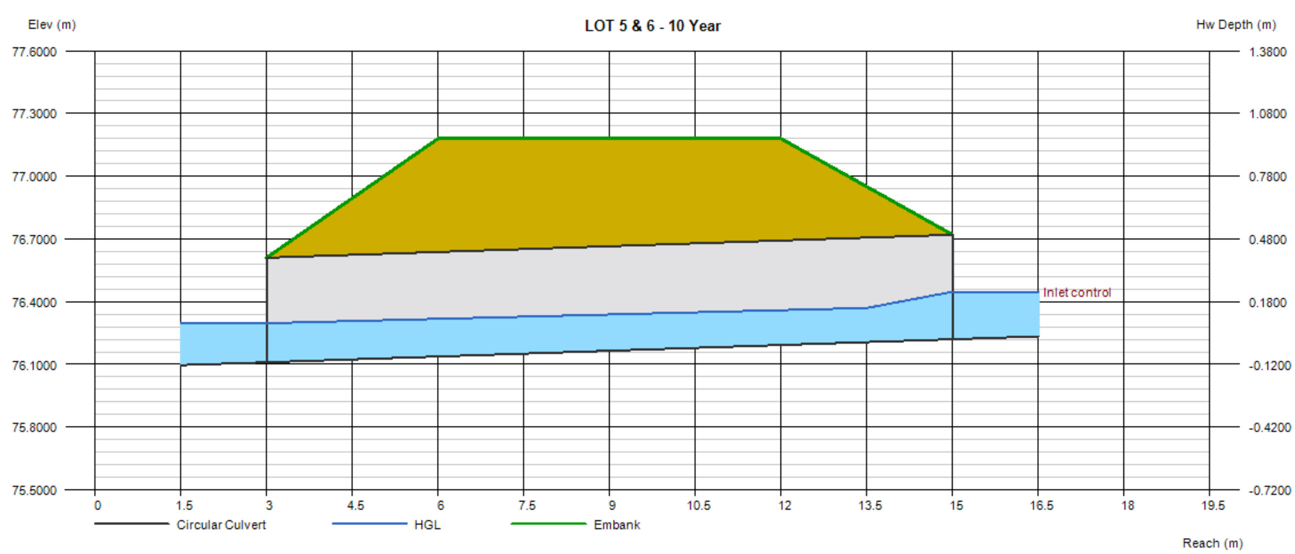
Top Elevation (m)	=	77.1800
Top Width (m)	=	6.0000
Crest Width (m)	=	3.0000

Calculations

Qmin (cms)	=	0.0580
Qmax (cms)	=	0.0580
Tailwater Elev (m)	=	Normal

Highlighted

Qtotal (cms)	=	0.0580
Qpipe (cms)	=	0.0580
Qovertop (cms)	=	0.0000
Veloc Dn (m/s)	=	0.8671
Veloc Up (m/s)	=	1.0697
HGL Dn (m)	=	76.2968
HGL Up (m)	=	76.3801
Hw Elev (m)	=	76.4474
Hw/D (m)	=	0.4548
Flow Regime	=	Inlet Control



Culvert Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. — Friday, May 5 2023

LOT 5 & 6 - 100 Year

Invert Elev Dn (m)	=	76.1100
Pipe Length (m)	=	12.0000
Slope (%)	=	0.9166
Invert Elev Up (m)	=	76.2200
Rise (mm)	=	500.0
Shape	=	Circular
Span (mm)	=	500.0
No. Barrels	=	1
n-Value	=	0.024
Culvert Type	=	Circular Corrugate Metal Pipe
Culvert Entrance	=	Projecting
Coeff. K,M,c,Y,k	=	0.034, 1.5, 0.0553, 0.54, 0.9

Embankment

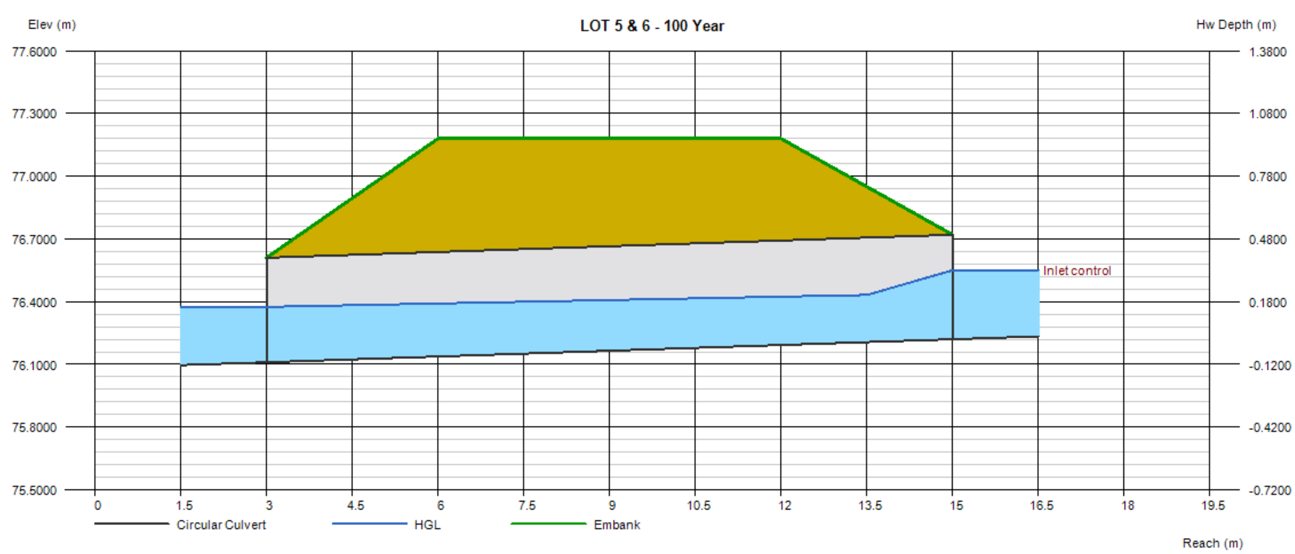
Top Elevation (m)	=	77.1800
Top Width (m)	=	6.0000
Crest Width (m)	=	3.0000

Calculations

Qmin (cms)	=	0.1070
Qmax (cms)	=	0.1070
Tailwater Elev (m)	=	Normal

Highlighted

Qtotal (cms)	=	0.1070
Qpipe (cms)	=	0.1070
Qovertop (cms)	=	0.0000
Veloc Dn (m/s)	=	1.0136
Veloc Up (m/s)	=	1.2850
HGL Dn (m)	=	76.3748
HGL Up (m)	=	76.4401
Hw Elev (m)	=	76.5501
Hw/D (m)	=	0.6602
Flow Regime	=	Inlet Control



Culvert Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. — Friday, May 5 2023

LOT 7 & 8 - 10 Year

Invert Elev Dn (m)	=	75.6200
Pipe Length (m)	=	12.0000
Slope (%)	=	0.6666
Invert Elev Up (m)	=	75.7000
Rise (mm)	=	500.0
Shape	=	Circular
Span (mm)	=	500.0
No. Barrels	=	1
n-Value	=	0.024
Culvert Type	=	Circular Corrugate Metal Pipe
Culvert Entrance	=	Projecting
Coeff. K,M,c,Y,k	=	0.034, 1.5, 0.0553, 0.54, 0.9

Embankment

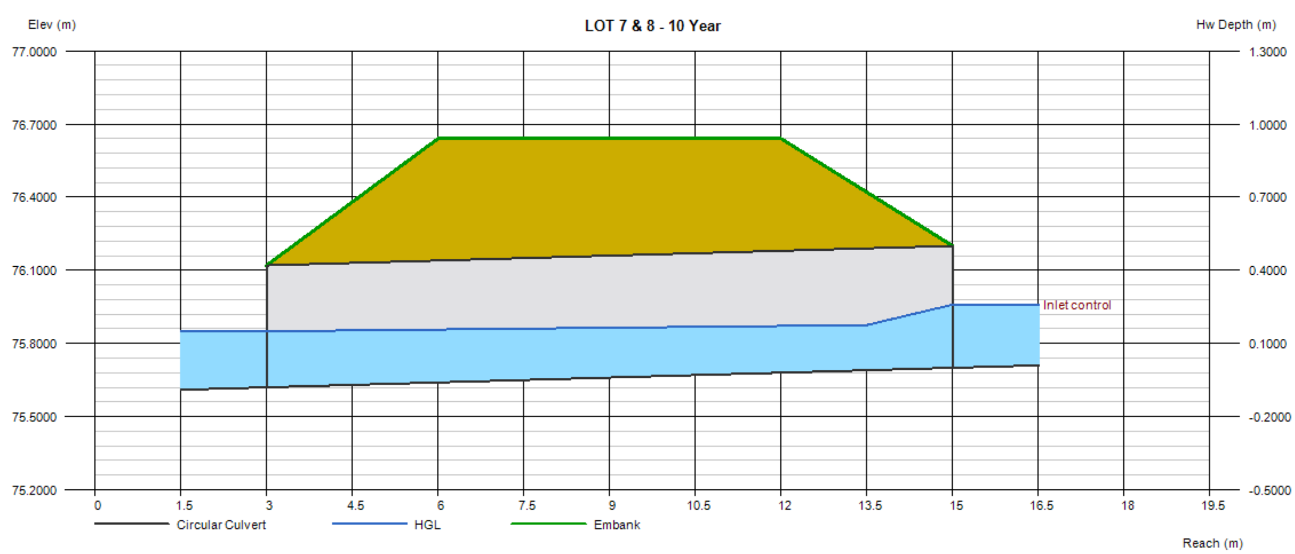
Top Elevation (m)	=	76.6400
Top Width (m)	=	6.0000
Crest Width (m)	=	3.0000

Calculations

Qmin (cms)	=	0.0720
Qmax (cms)	=	0.0720
Tailwater Elev (m)	=	Normal

Highlighted

Qtotal (cms)	=	0.0720
Qpipe (cms)	=	0.0720
Qovertop (cms)	=	0.0000
Veloc Dn (m/s)	=	0.8173
Veloc Up (m/s)	=	1.1386
HGL Dn (m)	=	75.8498
HGL Up (m)	=	75.8792
Hw Elev (m)	=	75.9591
Hw/D (m)	=	0.5182
Flow Regime	=	Inlet Control



Culvert Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. — Friday, May 5 2023

LOT 7 & 8 - 100 Year

Invert Elev Dn (m)	=	75.6200
Pipe Length (m)	=	12.0000
Slope (%)	=	0.6666
Invert Elev Up (m)	=	75.7000
Rise (mm)	=	500.0
Shape	=	Circular
Span (mm)	=	500.0
No. Barrels	=	1
n-Value	=	0.024
Culvert Type	=	Circular Corrugate Metal Pipe
Culvert Entrance	=	Projecting
Coeff. K,M,c,Y,k	=	0.034, 1.5, 0.0553, 0.54, 0.9

Embankment

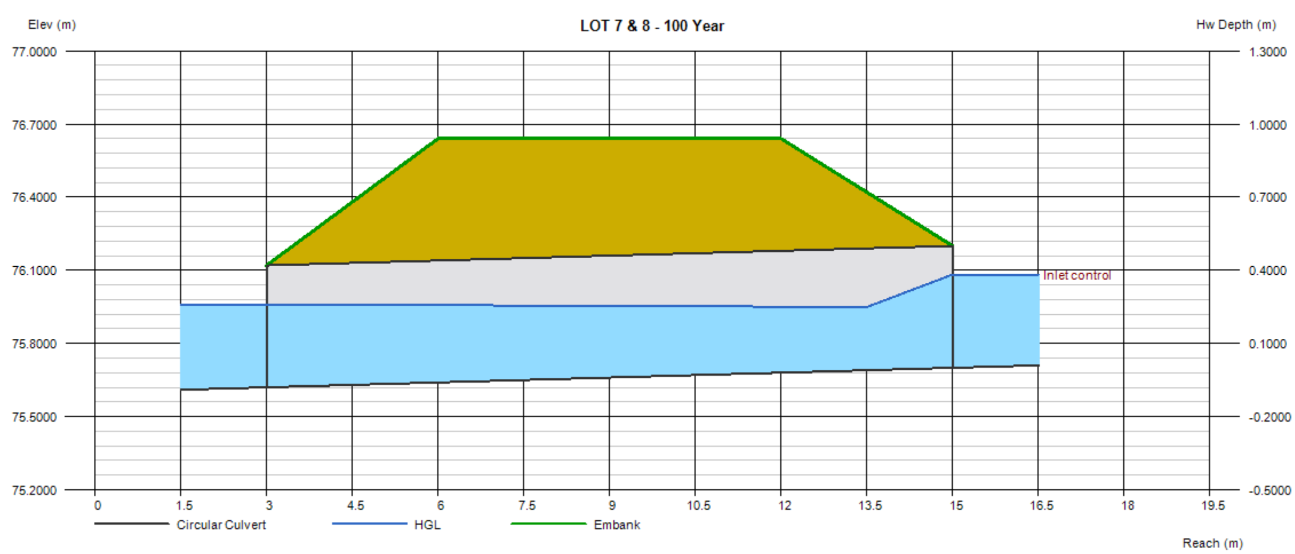
Top Elevation (m)	=	76.6400
Top Width (m)	=	6.0000
Crest Width (m)	=	3.0000

Calculations

Qmin (cms)	=	0.1340
Qmax (cms)	=	0.1340
Tailwater Elev (m)	=	Normal

Highlighted

Qtotal (cms)	=	0.1340
Qpipe (cms)	=	0.1340
Qovertop (cms)	=	0.0000
Veloc Dn (m/s)	=	0.9418
Veloc Up (m/s)	=	1.3813
HGL Dn (m)	=	75.9602
HGL Up (m)	=	75.9477
Hw Elev (m)	=	76.0826
Hw/D (m)	=	0.7652
Flow Regime	=	Inlet Control



APPENDIX J: RESPONSES TO REVIEW COMMENTS

Kollaard Associates
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Kollaard File # 200977
City of Ottawa File No. D02-02-22-0018
MVCA File No. PMRZA-43

May 5, 2023

The following review comments related to stormwater management were received May, 2022. Kollaard Associates Inc.'s response is provided in italics immediately after each comment for clarity:

1. **Submitted reports** – comments

   a. SWM Report, Proposed Residential Subdivision, 2050 Dunrobin Road, City of Ottawa (prepared by Kollaard Associates, dated Sep 24, 2021)

1. SWM modelling still needs to be reviewed but it has not been done presently, as the rail safety investigation may modify the design and make the review premature at this point in time.

Noted

2. Please note the quality of the former railway, downstream outlet culvert.

See photos below.

The existing box culvert under the former railway is 35 metres downstream of the outlet location for the stormwater outlet from the site. The stormwater outlets into the Harwood Creek.

The existing culvert is a double barrelled cast in place “box” culvert with wing walls. The side walls of the culvert are founded on bedrock. The bottom of the barrels consists of native material. Dimensions and elevations with respect to the culvert have been added to the drawing. The culvert belongs to the City of Ottawa. As such, inspection and maintenance of this infrastructure remains the responsibility of the City of Ottawa. A detailed inspection of the structural condition of the box culvert is beyond the responsibility of the civil consultant for the residential subdivision.

The culvert underneath the former railway for the site is depicted in Kollaard drawing 200977-GR-N and is noted as having an invert = 73.00 and obvert =74.45. Note that a detailed inspection has not been completed by Kollaard & Associates and that the depiction in drawings is for illustration only. Observations are noted in Kollaard Stormwater Management Report 200977.

3. PEO logo is not allowed to be used in a report and needs to be removed, as per their requirements.

Please note: Kollaard Associates has confirmed with PEO that the use of the Logo is acceptable.

4. MECP approval is required for SWM treatment facility and outlet to a watercourse

Noted. An ECA Application to the MECP can only be made after the City of Ottawa accepts the Relevant Drawings and Reports.

5. References in the report need to be made to MECP not MOE.

A review of the report indicates that the reference to MOE is made with respect to the Ministry of the Environment, Stormwater Management Planning and Design Manual (SMPDM). Even though the Ministry of the Environment has been replaced (renamed) with the Ministry of Environment, Conservation and Parks, this does not change the title of the Manual published before the name change.

6. Please, provide calculations and detailed discussion how the sizes of the orifices were determined.

The size and elevation of the two orifices were determined by iteration. Discharge vs Storage curves were developed in excel. The Storage discharge curve was programmed into the RouteReservoir block within the OTTHYMO hydrologic model. This process was repeated until the model produced post-development peak flowrates less than or equal to pre-development peak flowrates for each design storm up to and including the 100 year event. See the Appendix of Kollaard stormwater Management Report 200977.

7. The report states in Section 6.2.1 that the Storage Swale outlet control structure will consist of two pipes, one 375 mm in diameter (with 210 mm orifice) placed, with the pipe's invert, at the bottom of the Storage Swale and 525 mm diameter pipe (with 410 mm orifice) above the bottom pipe, at the elevation of 0.45 m from the bottom. Please explain how the process of infiltration is to provide the quality control, as stated in Section 6.3 of the report, when direct outlet at the bottom of the Storage Swale is provided.

The quality control section has been revised the report. The outlet structure has been revised. The lowest ICD is raised above the bottom.

8. Section 6.3.1 of the report states that water quality treatment discharge will only be done through infiltration through the bottom of the ditch. Please provide additional discussion where quality will be addressed as a function of direct outlet at the bottom of the swale and how it relates to any applicable Subwatershed study guidelines (to be co-ordinated with the Mississippi Valley Conservation Authority [MVCA]). Please provide rationale, how the orifice sizes were determined.

The quality control section of the stormwater report has been revised. Based on the Subwatershed Studies Menu provided the City of Ottawa, there appear to be no subwatershed study guidelines available or in progress for either Harwood Creek or Constance Creek.

The Carp River Subwatershed study was reviewed for the goals and objectives for the subwatershed and the recommendations provided to achieve these goals. From this study the goals were divided into the following categories: 1) Surface/Groundwater Quantity; 2) Surface/Groundwater Quality; 3) Aquatic Resources; 4) Terrestrial Resources. Each category had its own objectives. Reviewing the objectives indicates that the majority of the objectives are centered on reducing flood risk and protecting groundwater supplies and groundwater base flow by reducing runoff, increasing infiltration and maintaining healthy aquatic and terrestrial communities. See response to Comment 6 above.

9. The quantity control will need to be deducted from that of the 100-year flood elevation. The 100-year flood elevation needs to be confirmed with MVCA.

The proposed stormwater management facility has been designed to have an outlet elevation above the MVCA 100 year flood plain. As such the100 year flood plain of the Harwood Creek does not affect the stormwater management facility.

10. Please provide the maximum depth of ponding and where it occurs while considering a 100-year flood, with the revised elevations.

The maximum ponding level in the storage swale is from a 100 yr storm event (SCS II 12hr 100yr storm) and is 76.22 m. The minimum elevation in the stormwater storage facility is 75.45 m. This results in a maximum depth of 0.77 m. The 100 year flood elevation is shown on the drawing.

11. Section 7 of the report states that 100 year storm will create headwater depth of 0.6 m and culverts and ditches will have enough capacity. Please explain how this relates to the two corner locations at Dunrobin Rd and Kanata Enclave Court where ditch depth is approximately 0.2 m and that location is going see significant length of flows from the north and south along Dunrobin Road. Please provide discussion and conclusion to assure that the intersection will not be flooded. Plans need to show the flood limit of 10 and 100 year storms, as per report.

The two locations at Dunrobin Rd and Kanata Enclave Court are at the upstream end of the ditches along Kanata Enclave Court. The headwater depth of 0.6 m was calculated for the peak 100 year flow which includes the flow from the entire catchment. It is generally understood that the peak flow occurs at the outlet or lower reaches of a ditch rather than at the start or upper reaches. The report has been revised to clarify this and to consider the depth at each lot as well as the depth for the entire catchment.

It is noted that the minimum ditch depth has been revised.

12. Minimum required open channel slope is 0.5%, with desirable being 1.0% (Ottawa Sewer Design Guidelines – Section 6.4), however some identified in the report are as low as 0.22% and as

high as 3.7%. for the higher slopes please review for erosive velocities and modify or provide ample justification explaining how sedimentation/erosion concerns were addressed and assurance that future maintenance is not going to be of concern. For the slopes below 0.5 % please modify them to be 0.5 %.

Channel Slope is calculated based on a simple mathematical formula where the elevation difference between the start and end of the channel segment is divided by the horizontal distance between the start and end of channel segment along the flow path of the channel segment. The shortest possible way to connect two points is by means of a straight line between the two points. If the outlet elevation of the channel segment is fixed based by the minimum elevation possible due to outlet conditions and the top elevation is fixed based on existing ground surface condition the elevation difference between the start and end is also fixed. If this fixed elevation difference divided by the shortest distance is less than 0.5% then there is no physical way of changing this regardless of what the Ottawa Sewer Design Guidelines state.

The swale along the north side of the proposed development is required to intersect and convey off site runoff occurring during the existing conditions. This means that the bottom of the swale plus a minimum swale depth must be below the existing ground surface. This results in a maximum elevation at the start of the channel section due to actual physical constraints which cannot be altered because the constraints are established by adjacent private property. The outlet elevation is fixed by the normal flow conditions within the receiving water course.

As such there is no possible way to make all of the channel slopes above 0.5%.

3.7% is only a steep slope with respect to the channels slopes proposed at less than 1 percent.

13. The 100-year storm water level needs to be confirmed with the Conservation Authority, assuring that the modified fill area near the railway corridor does not negatively impact the adjacent properties, including the proposed and the existing downstream dwellings.
It appears that the north end of the property swale drains directly to the adjacent property and the 100-year storm flood plain area was shifted entirely from the site to the adjacent property. Was there any discussion with the property owner and an agreement that can be presented to the City? Please provide clear justification of the proposed alignment of the 100-year storm water flood plain limits.

Drawings have been revised.

Plain is defined as an extensive level or even area. When used within respect to flooding, a flood plain is the extensive level area to which the water level will rise during a flood event. This extensive flooding is due to flow restriction and backup of flow.

A review of the flood plain mapping of the Harwood Creek provided by the MVCA indicates that the 100 year flood elevation varies along the Creek. This makes the label "Plain" incorrect when applied to the 100 year level along the Harwood Creek. The use of the label plain can be correctly applied in the case of the backwater flood plain as water is simply backed up into this area from a specific location in the flow channel. If the elevation changes from station to station, the 100 year flood level is a function of the elevation necessary for the channel to have sufficient cross sectional area to convey the flow rather than a function of a downstream flow restriction and backup of water. As discussed within the J.F. Sabourin Report, filling the backwater flood plain has no effect on the upstream or downstream 100 year flood levels.

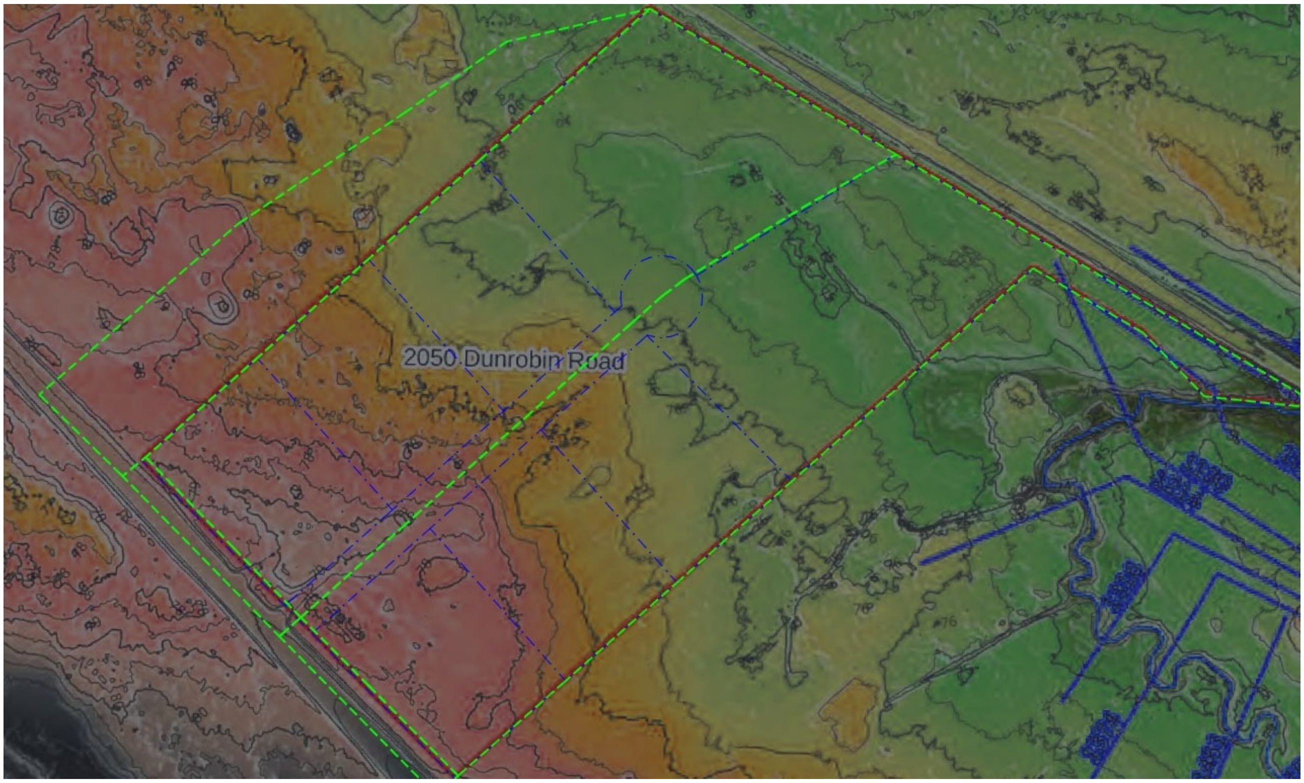
J.F. Sabourin was retained by Kollaard & Associates to perform a floodplain analysis on Harwood Creak and the associated backwater comprising the floodplain within the site. JFSA purchased City of Ottawa LIDAR data to update the MVCA floodplain map. The results indicate that the 100 year floodplain elevation in the vicinity of the site is 75.48. The floodplain analysis will be included in the appendix of Kollaard Stormwater Management Report 200977.

14. It appears that there is unrestricted overland flow from the development to the adjacent property at the south. Please provide a discussion on the impact of this scenario (lots 2,4,6,8) on the property to the south, especially with the proposed grade raise and added impervious area.

A swale has been added along the property line adjacent to lots 2,4,6,8. The rear yards are considered uncontrolled but are directed away from the adjacent property and will outlet into Harwood Creek.

15. Section 3.4 of the report does not provide enough information to explain the SWM tributary area that was considered in the surface run-off calculation – please expand.

A LIDAR image has been underlain on the pre-development drawing. The north limit of the off-site catchment essentially passes through the high points as indicated by the contour lines. Since the north limit is located on the high points it represents a flow divide with runoff originating north of the line being directed towards Constance Lake Road. Runoff originating on this offsite area south of the high point will be directed towards the site. As such the off-site area north of the site has been reasonably delineated and is supported. The LIDAR image also illustrates that the runoff originating south of the site is directed south and east towards the Harwood Creek. As such there is no off-site contributing area south of the site. The limit to the west is defined by the Centerline of Dunrobin Road. The limit to the east is defined by the ditching along the former railway.



16. It is not clear how the ditch capacity was determined for the proposed ditches along the new road and areas to the north and south of Dunrobin Road – please provide explanation.

The capacity of the ditches was determined using the simple open channel flow calculation formula. This formula is typically not something that should have to be explained.

17. There are ditches along north and south sides of Dunrobin Road that are proposed to drain through the subdivision. The report does not mention road tributary area. Could you please include that element in the discussion and how it affects the overall stormwater contribution?

Since this comment is not clear, it is assumed that, for the purposes of this comment, Dunrobin Road is oriented along a north south axis and that the north and south sides of Dunrobin Road refer to the east side of Dunrobin Road north and south of Kanata Enclave Court. The report discussed two offsite contributing areas from Dunrobin Road consisting of C-A and C-B which specifically and only included runoff from the section of ditch in question along Dunrobin Road. Further catchment C-OFF1 also included a portion of the east side of Dunrobin Road. If however this comment assumes that Dunrobin Road is oriented along an east west axis such that there is actually a north and south side, then there is no drainage across Dunrobin Road in proximity to the site.

These catchment areas are also discussed in the Revised SWM report.

18. The report does not show any direct communication with the MVCA to define adequately the new flood plain for a 100-year storm water levels and also the proposed SWM treatment facility. Could you please provide any reference to a pre-consultation or specific communication on the treatment facility and discussion regarding the proposed flood plain size?

The 100 year flood level in the backwater flood plain has been defined by the Harwood Flood Plain mapping. There is no discussion with MVCA required with respect to the 100 year storage level within the stormwater management facility as this 100 year storage level is a function of the stormwater management design and is not a flood plain.
The effect of the proposed development on the 100 year flood level in the Harwood Creek has been discussed in the report prepared by J.F Sabourin.

19. It is not clear how the volume of the flood plain was determined, and the new flood plain storage volume created. Please provide assurance that it will not negatively impact properties upstream along the creek (south of the site) and the City property (formerly railway) and what effect it might have on water wells and septic beds.

J.F. Sabourin was retained by Kollaard & Associates to perform a floodplain analysis on Harwood Creak and the associated backwater comprising the floodplain within the site. JFSA purchased City of Ottawa LIDAR data to update the MVCA floodplain map. The results indicate that the 100 year floodplain elevation in the vicinity of the site is 75.48. The floodplain analysis will be included in the appendix of Kollaard Stormwater Management Report 200977.

Based on the flood plain analysis the proposed development will not affect the 100 year flow level within the Harwood Creek. As such there is no mechanism whereby upstream or downstream water wells and septic beds will be affected.

There does not appear to be any clear rational as to why or how filling the backwater flood plain during the proposed development could affect the upstream or downstream water wells and septic systems.

20. Runoff coefficients for individual tributary areas are not mentioned anywhere in the report. They also need to be included in the stormwater management plan. The plan should show all individual catchment areas with runoff coefficients and they should be referenced in the report in order to understand how the surface run-off quantity was generated from all tributary areas. This needs to be done for both, the pre and post construction condition, in order to better understand the effect of the subdivision on the surface run-off quantity.
Section 3.5.1 of the report generically mentions Dunrobin Road as one off-site catchments but no details are provided. Please update the conclusion and add more clarity, in order to be able to clearly see the run-off quantity for the pre-construction condition, the effect of development and

mitigation measures that are implemented to offset the effects of development. This also pertains to sections 5 and 6 of the report. It lacks a summary that allows to compare pre- and post-construction conditions that can be easily identified. The tables do not show summaries but individual calculations that would be best suited for appendices. The summary table should concentrate on showing existing and proposed condition and solution.

The hydrologic analysis does not make use of the runoff coefficient "C". Instead the Nash Instantaneous unit Hydrograph method was used by way of the "NASHYD" watershed command within OTTHYMO V6.0. The NASHYD Command uses the Runoff Curve Number or CN instead of the Runoff Coefficient C. It is noted that the City of Ottawa Sewer Design Guideline does reference the CN number.

See excerpt below from the OTTHYMO reference manual.: *"NASHYD is used to simulate runoff flows with the Nash instantaneous unit hydrograph.*
This hydrograph is made of cascade of 'N' linear reservoirs. The command is mainly used for rural areas but can also be used for very large urban watersheds and to simulate the effects of infiltration /inflow in sanitary sewers. Rainfall losses can be computed by a SCS modified CN procedure or Proportional Loss Coefficient"

Tables have been added to the report to summarize the difference between pre and post development conditions.

21. Section 3.3.3 of the report sets a range of Manning's coefficients between 0.25 and 0.6 as relevant for the analysis of the proposed development and states that they are dependent on the surface type. The City's Manning coefficients listed in Appendix 6-C, of the Ottawa Sewer Design Guidelines (SDG), are 10 times smaller than the stated above values. In addition, the same section of the report, mentions Manning's number of 0.027 for open channels considerations, which follows the order of magnitude, as stated in the SDG. This section also makes a reference to Appendix B for details of calculation, where all Manning's n values that were used are 0.3.
Could you please explain the order of magnitude difference and why all values that were used do not follow the discussion on page 7 and 8 of the report (n = 0.25 to 0.6 for sheet flow and 0.1 for concentrated flow)?
Also, the formula and data that was provided on page 8 to calculate T_{SC} = 0.05 hr (3 minutes) for Catchment 8 does not match the example from Appendix B, where Total Time of Concentration was determined to be 0.14 hr (8.4 minutes) – could you please provide rationale for the difference and how it relates to the accuracy of the calculation?

The stormwater management report has been revised

It is noted that the manning's roughness coefficient is not the same for a channel as for flood plain, shallow concentrated / overland or for sheet flow. During open channel flow, the flow depth is typically assumed to be many time deeper than the obstructions which would impede the flow or *roughness. During overland flow or shallow concentrated flow, the flow depth is typically between 3 and 15 cm which depending on the ground cover is still less than the height of the flow obstructions. During sheet flow the flow depth will be limited to less than 3 cm which, when across a lawn, is less than the height of the grass obstructing the flow. As such, it is reasonable for the different flow scenarios to have different roughness coefficients.*

22. City SWM Guidelines specify Time of concentration 10 minutes for all land uses and grading configurations (Section 5.4.5.2), while the report used velocity method. Please provide a justification why this method was used.

The City SWM Guidelines were written in general for urban development where the entire property including the house has a length of 50 metres or less. A rural estate lot on a 0.8 hectare property has significantly larger dimensions than this. Since time of concentration is a function of the time it takes for water to travel from the furthest reach of a catchment to its outlet point, why would a rural lot between 5 and 10 times the size of the urban lot have the same time of concentration as the urban lot.

The velocity method is a common and accepted method to determine time of concentration and as such was used because the specify time of concretion of 10 minutes is simply not correct for this rural subdivision. Further the velocity method combines sheet flow followed by shallow concentrated flow in the calculation which incidentally is how runoff actual travels across the ground surface.

23. Report states that flow rates of Harwood Creek were estimated by comparison to calculations performed by others for other creeks in the West Carlton area of Ottawa.
Please specify if other studies, besides listed "Carp River Watershed/Subwatershed study" by Robinson Consultants, were used. Please discuss the validity of the approach and similitude.
Please provide a thorough discussion on how the other creek flow volumes relate to Harwood Creek, as the shown data of other creeks shows spread of 0.8 m^3/s – to 27 m^3/s, for a 100 year storm. Please state the relevance of the flows from other creeks for Harwood Creek. It is not currently clear how flows from other creeks helped in determining 100-year flows of Harwood Creek.

Acknowledged. This is no longer relevant and has been removed the report. MVCA has supplied *stream flow data for Harwood Creek. See revised Kollaard Stomwater Management Report 200977.*

24. The report speaks of negligible impact of the development on the surrounding properties but it does not adequately address the impacts of the flood plain modification on the adjacent properties. Please provide discussion, potential mitigation strategies and conclusions.

There are no significant impacts to the adjacent properties as evidenced by the J.F. Sabourin Report

25. Section 6.1 of the report speaks of infiltration. Please address presence of thin soils on site and also possible concurrence with any applicable Watershed/Subwatershed studies (Please provide reference to MVCA and their requirements; relevant Hydrogeological report findings should also be referenced). Please add discussion, conclusions and recommendations for all elements of the report, which address infiltration.

Please provide the name(s) and source of the applicable Watershed/Subwatershed study(s) being referenced by this comment.

Other than test pit TP1 put down at the northwest corner of the development, the thin soil has a thickness of greater than 0.5 metres. There will be more than 1 metre of soil cover between the bottom of the proposed stormwater storage swale and the underlying bedrock.

26. Section 6.1 states potential occurrence of local ponding about 0.1 m but does not state what return period was considered and it is important to provide maximum ponding depths for all areas where it happens during a 100-year storm; please add, this also needs to be included on the plans.

Section 6.1 states "It is considered that the low slope in the drainage easement swale will be insufficient to ensure that there are no localized high or low spots within the easement channel. The localized high and low spots will result in ponded water within the swales following a storm event. It is expected however that the ponding will be of limited depth."

This means that the potential occurrence of local ponding of about 0.1 m is a result of undulations within the bottom of the channel. That means that there might be a point downstream in the channel with a slightly higher elevation due to imperfect grading. This slightly higher elevation will result in ponding within the swale. This ponding has the potential to occur at every storm event and is completely independent of the 100 year storm event maximum ponding depth.

Since the precise area where imperfect grading will occur is not predetermined, it is not possible to show on the plans the locations where the imperfect grading will occur.

27. Report makes references to swales between properties, along property lies, as "easement" swales. These swales are not going to be a subject to easements. Please remove this reference.

Acknowledged, report revised

28. Section 9 of the report needs to address more accurately the phasing conditions of the site, which will included bringing fill to the site (individual lots and MVCA flood plain), road construction and typical individual lot development measures. This section only addresses it generically and is not site specific. This portion of the report requires to be updated with the site-specific detailed information, including prevention of mud tracking onto public roads (mud mat). Different stages of

the development present different opportunities for contamination of the watercourse on site and they need to be specifically addressed.

Acknowledged, report revised

We trust that this response provides sufficient information for your present purposes. If you have any questions concerning this response please do not hesitate to contact our office.

Sincerely,

LICENSED PROFESSIONAL ENGINEER
05.MAY.2023
S.E. deWit
100079612
PROVINCE OF ONTARIO

Steven deWit, P.Eng.
Kollaard Associates Inc