



July 19th 2022

Reference: 21-815

Nivas Development Ltd.
22 Fairmont Close,
Brampton, ON
L6Y 2Y3

c/o
Delbrook Triumphant Builders Inc.
307-10376 Yonge Street, Suite 307.
Richmond Hill,
ON L4C 3B8

Attention: Mehdi Shafiei, Delbrook Triumphant Builders Inc.
Reference: 101 Main Street East, Markdale, Municipality of Grey Highlands
Flood Hazard Assessment

Dear Mr. Shafiei,

Nivas Development Ltd (Client) is proposing the development of an existing agricultural property located at 101 Main Street East (also known as Grey Road 12) within Markdale, Ontario. The Client proposes to develop the property into a residential subdivision. The property is bound by agricultural fields to the northeast and southeast, Main Street East to the northwest, and residential lands to the south. The subject property features a wetland located at the north corner of the property that the entire property drains towards. Opposite of the property, there are existing residential properties and a graveyard, where a minor drainage feature conveys flows from the property.

The Client has retained Greck and Associates Limited (Greck) to assess the Regulatory floodplain associated with the wetland feature.

Under Ontario Regulation 169/06, *Saugeen Valley Conservation Authority: Regulation of Development, Interference with Wetlands and Alterations to Shorelines and Watercourses*, the Saugeen Valley Conservation Authority (SVCA) regulates development taking place within the Regulatory floodplain, and states that “*The Authority may grant permission for development in or on the areas described in subsection 2 (1) if, in its opinion, the control of flooding, erosion, dynamic beaches pollution or the conservation of land will not be affected by the development*”.

Greck and Associates (Greck) have been retained to complete a flood hazard assessment of the property located at 101 Main Street East (Subject Property) in Markdale Ontario. Specifically, this report confirms the existing Regulatory floodplain limit on the subject property associated with the wetland. In addition, an assessment and analysis has been undertaken with consideration of proposed development conditions, regulatory impacts and SVCA policy. This includes an engineered design concept supported by hydraulic analysis and floodproofing recommendations founded on engineering/scientific principles in accordance with SVCA policy and ministry guidelines.

As such, the following assessments have been completed and are discussed in further detail below:

- Hydrologic Analysis to determine 2-year to 100-year return and Regional Storm event flows
- Hydraulic Analysis to determine the floodplain extents associated with the wetland
- Assess the proposed site plan and recommend appropriate setbacks with regards to flood hazards

Background Information Review and Site Visit

A site visit was undertaken on November 16, 2021, to document the subject property and assess existing drainage conditions. The entire property drains towards a wetland feature located at the north corner of the subject property. Once the wetland is at capacity, runoff is conveyed upgradient south along the ditches servicing Main Street East. Eventually, runoff discharges west across Main Street East via a 500mm diameter corrugated steel pipe (CSP) culvert, where stormwater is conveyed by a ditch that runs in between the Markdale Cemetery and the residential lots on Lawler Drive before ultimately discharging into Rocky Saugeen River to the west.

A topographic survey of the property was completed on February 15th, 2022, by Tham Surveying Limited. A copy of the topographic survey is provided in **Appendix A**.

Hydrologic and Hydraulic Analysis: Existing Conditions

PCSWMM software was used for the hydrologic modelling presented throughout this memo. PCSWMM was selected as it can be used as a combined hydraulic model as well, specifically, for a wetland (or storage) feature such as the one on site.

Watersheds were delineated using PCSWMM software using a 2.0m grid generated digital elevation model (DEM), referred to as the "SWOOP 2015 DEM Package B", made available from Land Information Ontario. The DEM contains information licensed under the Open Government License – Ontario. Four sub-catchments for a total area of 40.4 ha was delineated to define the watershed serviced by the wetland:

- S1: 7.5ha catchment consisting of the proposed development area
- S2: 1.2ha catchment consisting of the existing wetland
- S3: 18.7ha catchment consisting of external drainage area east of Main Street East
- S4: 13.1ha catchment consisting of external drainage area west of Main Street East

Area S4 is 13.1ha of external drainage from the north of the site, where an agricultural field drains towards a 500mm diameter culvert through Main Street East. Area S3 is 18.7ha and consists of of agricultural field which drains from the adjacent property to the northeast. The wetland feature has no clear outlet, and was likely formed due of the construction of Main Street East, where no outlet pipe was constructed at the low point in the road. As such, the wetland becomes inundated during rainfall events, where water must either pool and infiltrate naturally, or rise to the 500mm diameter outlet pipe located approximal 160m southeast of the wetland. This outlet pipe is elevated, with an invert of 416.39m, 0.52m above the invert of the wetland. Land-use information of the watershed was determined using the Southern Ontario Land Resource Information System (SOLARIS) in GIS format, dated June 2019. The land-use information was used to establish a

variety of catchment parameters in order to determine peak runoff from the watershed. Land-use information was either confirmed or updated via a review of available orthophotography from Google Earth.

Subsurface soil information was used to determine the infiltration parameters using the Soils Survey Complex Documentation, obtained from the MNRF dated November 2015. The Soil Survey Complex illustrates the hydrologic soil groups of the underlying soils within southern Ontario.

The Green-Ampt Infiltration Method was used to calculate infiltration, as it is the most applicable methodology for agricultural and rural land-uses, such as the subject watershed. Parameters including hydraulic conductivity, initial deficit ratio and suction head were determined based on soil texture class as reported in the “Green-ampt Infiltration Parameters from Soils Data” technical paper by Rawls et al. The Green-Ampt method is typically used within rural, agricultural watersheds due to its ability to account for the degree of soil saturation.

An area-weighted calculation was applied for the catchment to obtain overall catchment parameters. All catchment parameters associated with land-use and soils were based on industry standards and engineering judgement.

To incorporate the flood storage provided by the wetland, a depth-area storage curve was developed using a combination of the topographic survey and the DEM. The wetland was then modelled as a storage node in PCSWMM and assigned the depth-area storage curve. The depth-area storage curve is presented in **Table 1**.

TABLE 1: EXISTING WETLAND DEPTH-AREA STORAGE CURVE

Depth (m)	Area (m ²)
0	0
0.13	1357
0.33	3317
0.53	6096
0.73	14850
0.93	25266
1.13	35843
1.33	46548
1.53	54043
1.63	57474
1.73	61571
1.88	68388

The Main Street East 500mm diameter culvert crossing was modelled as a conduit which outlets to an outfall node that is assigned a free boundary condition. Culvert dimensions and invert elevations were determined via topographic survey and site inspection.

Several rainfall events were modelled as per the MNR Technical Guide – River and Stream Systems: Flood Hazard Limit, 2002. The Regional Storm event is noted as the 1954 Hurricane Hazel event is simulated in addition to the 24-hour SCS Type II Storm Distribution for the 2 through 100-year return period storm events. The 48-hour regional storm event was simulated rather than the standard 12 hour, to account for the saturated soil conditions, to mimic AMCIII soil conditions.

Peak flows reported at the wetland (Node Wetland) are presented in **Table 2**.

TABLE 2: PEAK FLOWS TOWARDS THE WETLAND (NODE WETLAND)

Storm Event	Peak Inflow (m ³ /s)	Runoff Volume (m ³)
2-year	0.52	1554
5-year	0.96	4128
10-year	1.25	5570
25-year	1.65	7653
50-year	1.99	9414
100-year	2.34	11360
Regional	3.29	41460

It can be established that flood hazards associated with the Regional Storm event (Hurricane Hazel) would result in the highest flow rate overall, and therefore will define the regulatory storm event through the subject property to be used for regulatory floodplain mapping delineation. This is typical for predominantly rural watersheds. Detailed hydrologic results for the Regional Storm event only, are provided in **Appendix B**.

PCSWMM software was used for the hydraulic modelling presented throughout this memo. To assess the impacts of development on the wetland, an existing conditions scenario was created.

The existing flood elevations associated with the wetland as well as peak runoff rates leaving the 500mm diameter culvert for the 2-year to 100-year storms, and the Regional Storm event are summarized in **Table 3**. Flood depths were determined therefore as a function of volume (or elevation), rather than conveyance capacity, seen typically in riverine modelling.

TABLE 3: EXISTING WETLAND FLOOD ELEVATIONS AND PEAK DISCHARGE AT CULVERT

Storm Event	Peak Runoff at Culvert (m ³ /s)	Flood Elevation (m)
2-year	0.00	416.41
5-year	0.08	416.63
10-year	0.12	416.71
25-year	0.18	416.80
50-year	0.22	416.87
100-year	0.25	416.93
Regional	0.46	417.57

The existing Regional floodplain occupies a significant amount of the subject property. Please see **Drawing FPM1** provided in **Appendix C** for the existing Regulatory floodline.

Hydrologic and Hydraulic Analysis: Proposed Conditions

The proposed development is a residential subdivision consisting of semidetached dwellings, townhouses and mixed-use residential-commercial development. The floodplain encroaches on the proposed development, therefore, to floodproof the proposed development, fill in the floodplain is proposed.

A preliminary grading exercise was completed based on a Regional floodline of 417.57m and a conservative 0.48m of vertical freeboard from the development area to the Regional floodline. It was determined that approximately 16,700m³ of fill is required within the floodplain to floodproof the proposed development.

A new depth-area storage curve was developed based on the preliminary grading. The proposed depth-area storage curve is presented in **Table 4**.

TABLE 4: PROPOSED WETLAND DEPTH-AREA STORAGE CURVE

Depth (m)	Area (m ²)
0	0
0.33	75
0.53	1371
0.73	4764
0.93	9363
1.13	15167
1.33	21231
1.53	23994
1.68	25828
1.73	26780
1.93	29279

The proposed fill will cause an increase to the flood elevation due to the loss of storage. The loss of flood storage therefore has implications in flood elevations. To mitigate this, the following is recommended:

- Replace the existing 500mm diameter CSP culvert with an 825mm diameter culvert (smooth walled) that runs under Main Street East to increase outlet conveyance. This will increase peak flows downstream, as such, Greck recommends that these downstream impacts be investigated during detailed design.
- Provide quantity controls via a stormwater management facility (SWMF) servicing the development area (7.5ha) for the 2-year to 100-year, and Regional Storm events.
- Propose Low Impact Developments (LIDs) to infiltrate surface runoff into the native soils. LIDs will decrease runoff volumes generated from the proposed development and mitigate the decrease in infiltration due to the proposed impervious surfaces.

A comparison of the Regional flood elevations as reported from the existing scenario and the proposed mitigation scenario is summarized below in **Table 5**.

TABLE 5: EXISTING VS PROPOSED REGIONAL WETLAND FLOOD ELEVATIONS

Storm Event	Existing Flood Elevation (m)	Proposed Flood Elevation with Mitigation (m)
Regional	417.57	417.54

Greck is confident that the proposed fill and culvert upgrade in the floodplain will have an insignificant impact on flood hazard associated with the wetland.

The proposed Regulatory floodline is plotted on **Drawing FPM2** provided in **Appendix D**.

Sensitivity Analysis

A sensitivity analysis was carried out to assess key input parameters and their effects on flood levels. A sensitivity analysis is important to determine factors of safety and freeboard allowance. The analysis was carried out based on varying the following parameters by a certain percentage determined through engineering judgement and relative confidence in data and methodology, as outlined below:

- Catchment Area: +/- 10%
- Catchment Slope: +/- 20%
- Catchment Length: +/- 20%
- Percent Impervious: +/- 20%
- Impervious Manning roughness: +/- 20%
- Pervious Manning roughness: +/- 20%
- Impervious Depression Storage: +/- 20%
- Pervious Depression Storage: +/- 20%

Soil infiltration parameters were varied as outlined below:

- Suction Head: +/- 20%
- Conductivity: +/- 20%

The sensitivity analysis was completed for the Regional Storm event only (Hurricane Hazel), as the Regional Storm event produces the highest flood elevation. The results of the sensitivity analysis are presented below in **Table 6**.

TABLE 6: HYDROLOGY MODEL SENSITIVITY ANALYSIS RESULTS

	Sensitivity	Reg. Flood Elev. (m)		Change in Flood Elev. (m)	
		+	-	+	-
Base Condition	-	417.54		0	0
Sub-catchment Area	+/- 10%	417.60	417.48	+0.06	-0.06
Sub-catchment Slope	+/- 20%	417.56	417.52	+0.01	-0.02
Sub-catchment Length	+/- 20%	417.51	417.57	-0.03	+0.03
Imperviousness	+/- 20%	417.55	417.54	+0.01	0
N Impervious	+/- 20%	417.54	417.54	0	0
N Pervious	+/- 20%	417.51	417.57	-0.04	+0.03
Impervious Depression Storage	+/- 20%	417.54	417.54	0	0
Pervious Depression Storage	+/- 20%	417.54	417.54	0	0
Suction Head	+/- 20%	417.54	417.54	0	0
Conductivity	+/- 20%	417.50	417.57	-0.04	+0.03

The lack of significant changes in the flood elevation due to varying hydrologic parameters gives confidence in the flood elevation recommended in this report. Increasing the sub-catchment area resulted in the greatest Regional flood elevation increase of 0.06m. In addition to this, the Regional peak flows will not overtop the Main Street East which has a centerline of road elevation of approximately 417.75m at the low point.

The sensitivity analysis concluded that a freeboard of 0.48m applied in the preliminary grading exercise is adequate and the Main Street East will provide safe ingress and egress for all return events.

Typically, a 300mm freeboard is applied to account for sensitivity within hydraulic models, DTMs, topographic survey, etc. The resulting above sensitivity analysis concluded that a 300mm freeboard is adequate to define the freeboard associated with the development. As such, Greck recommends to the client that all development area maintain a 300mm freeboard from the Regulatory flood elevation.

Conclusions and Recommendations

Greck and Associates is confident that this memo and the analyses completed are consistent with the latest municipal and provincial standards and guidelines with respect to scientific analysis and engineering principles. In summary:

- A hydrology and hydraulic assessment was completed with PCSWMM using topographic survey and DTM. The Regulatory floodline associated with the wetland encroaches onto the proposed development therefore, to floodproof the proposed development, fill is proposed.
- To mitigate the loss of flood storage within the floodplain, a SWMF is recommended to service the development area (7.5ha) and provide quantity controls for the 2-year to 100-year, and Regional Storm events. The SWMF will have a separate outlet to the external drainage area and will not discharge towards the wetland. To convey the external drainage area (32.9ha), the existing 500mm diameter culvert that runs under Main Street East is recommended to be upsized to an 825mm diameter culvert (smooth walled) to increase

outlet conveyance capacity. This will increase peak flows downstream, as such, Greck recommends that these downstream impacts be investigated during detailed design.

- Founded on engineering/scientific principles, in accordance with SVCA policy and ministry guidelines, Greck proposes that the 0.3m freeboard setback will provide sufficient flood protection, including safe access from Main Street East and dry floodproofing for the proposed structures.

If you require additional information or have any questions, please feel free to contact me at (289) 657-9797 ext.230.



Elliot Pai, EIT.
Water Resources EIT



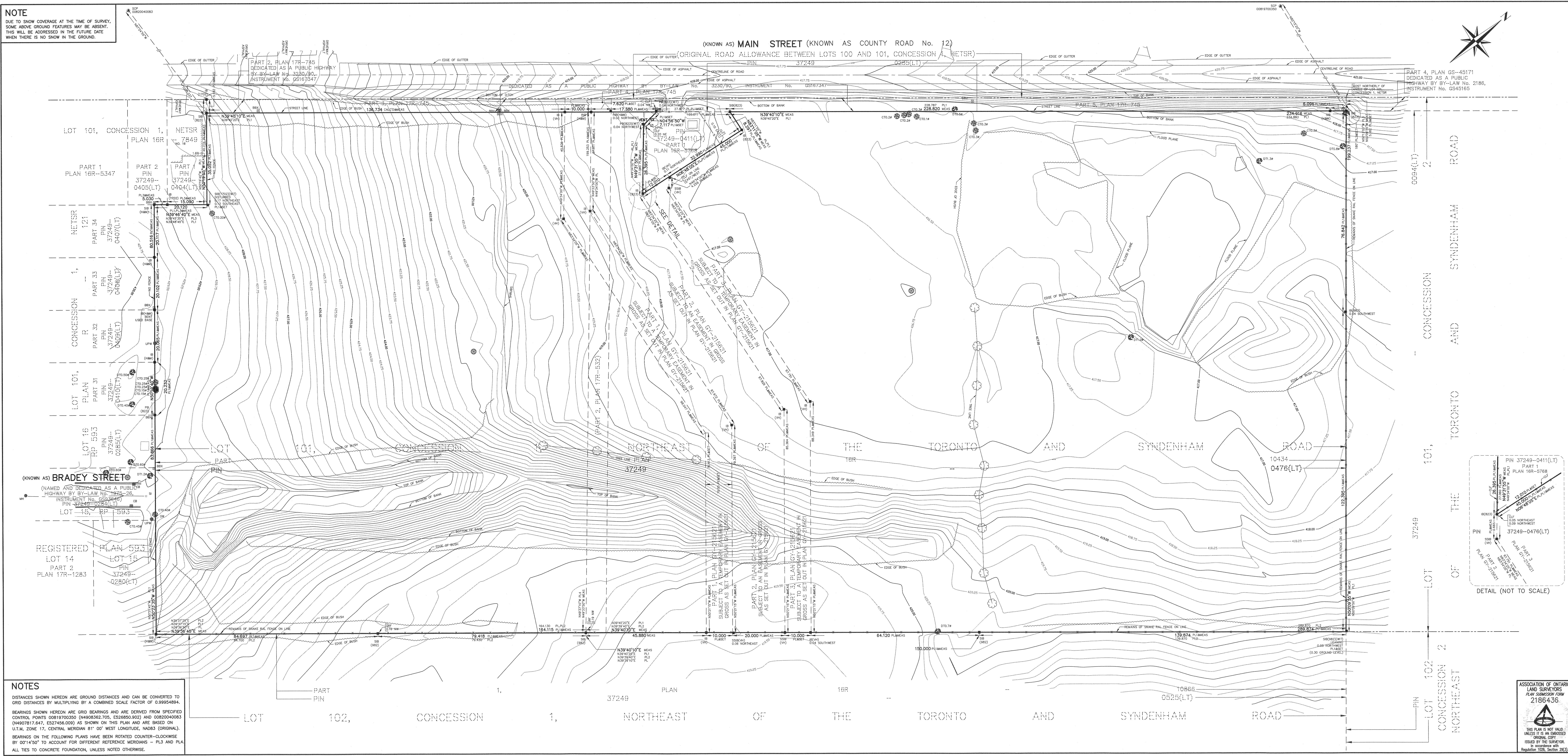
Reviewed by Scott Sexton, P.Eng.
Water Resources Engineer

APPENDIX A

Topographic Survey and Site Plan

NOTE
DUE TO SNOW COVERAGE AT THE TIME OF SURVEY,
SOME ABOVE GROUND FEATURES MAY BE ABSENT.
THIS WILL BE ADDRESSED IN THE FUTURE DATE
WHEN THERE IS NO SNOW IN THE GROUND.

NOTES
DISTANCES SHOWN HEREON ARE GROUND DISTANCES AND CAN BE CONVERTED TO
GRID DISTANCES BY MULTIPLYING BY A COMBINED SCALE FACTOR OF 0.99954894.
BEARINGS SHOWN HEREON ARE GRID BEARINGS AND ARE DERIVED FROM SPECIFIED
CONTROL POINTS 00819700350 (N4908362.705, E526850.902) AND 00820040083
(N4907817.647, E527456.009) AS SHOWN ON THIS PLAN AND ARE BASED ON
U.T.M. ZONE 17, CENTRAL MERIDIAN 81° 00' WEST LONGITUDE, NAD83 (ORIGINAL).
BEARINGS ON THE FOLLOWING PLANS HAVE BEEN ROTATED COUNTER-CLOCKWISE
BY 0°14'50" TO ACCOUNT FOR DIFFERENT REFERENCE MERIDIANS - PL3 AND PL4.
ALL TIES TO CONCRETE FOUNDATION, UNLESS NOTED OTHERWISE.



PLAN OF SURVEY AND
PLAN OF TOPOGRAPHY OF
PART OF LOT 101
CONCESSION 1, NORTHEAST
OF THE TORONTO AND
SYDENHAM ROAD
(GEOGRAPHIC TOWNSHIP OF ARTEMESIA)
MUNICIPALITY OF GREY HIGHLANDS
COUNTY OF GREY
SCALE 1:500
10m 5 0 10 20 30 40 50 METRES
THAM SURVEYING LIMITED, O.L.S. ©
METRIC
DISTANCES AND COORDINATES SHOWN ON THIS PLAN ARE IN METRES
AND CAN BE CONVERTED TO FEET BY DIVIDING BY 0.3048

- LEGEND
- DENOTES MONUMENT FOUND
 - SB DENOTES IRON BAR
 - SBIB DENOTES STANDARD IRON BAR
 - SBIB DENOTES SHORT STANDARD IRON BAR
 - SBIB DENOTES ROUND IRON BAR
 - PB DENOTES PLASTIC BAR
 - SCP DENOTES SPECIFIED CONTROL POINTS
 - PL1 DENOTES PLAN 07-21821
 - PL2 DENOTES PLAN 16R-10434
 - PL3 DENOTES PLAN 16R-10866
 - PL4 DENOTES PLAN 16R-7849
 - CALC'D DENOTES CALCULATED FROM PL AND PL1
 - (823) DENOTES DINGMARE & ENGLAND LTD., O.L.S.
 - (982) DENOTES HARRY R. WHALE INC., O.L.S.
 - (1702) DENOTES COYNE & WHALE SURVEYING LIMITED, O.L.S.
 - (H&M) DENOTES HEWITT & MILNE LTD., O.L.S.
 - (VH) DENOTES VAN HARTEN SURVEYING INC., O.L.S.
 - (OU) DENOTES ORIGIN UNKNOWN
 - (WT) DENOTES WITNESS
 - PIN DENOTES PROPERTY IDENTIFIER NUMBER
 - UTM DENOTES UNIVERSAL TRANSVERSE MERCATOR
 - NAD DENOTES NORTH AMERICAN DATUM
 - NETSR DENOTES NORTHWEST OF THE TORONTO AND SYDENHAM ROAD
 - MEAS DENOTES MEASURED
 - CLF DENOTES CHAIN LINK FENCE
 - SRF DENOTES SNAKE RAIL FENCE
 - AE DENOTES ASPHALT EDGE
 - AN DENOTES ANCHOR
 - BBX DENOTES BELL PEDESTAL
 - BD DENOTES BOTTOM OF DITCH
 - BLO DENOTES BUILDING OUTLINE
 - BOB DENOTES BOTTOM OF BANK
 - CB DENOTES CATCHBASIN
 - CHAMBER DENOTES VALVE CHAMBER
 - CL DENOTES CENTRELINE OF ROAD
 - CO DENOTES CONCRETE OUTLINE
 - CON DENOTES CONCRETE
 - CT DENOTES CONIFEROUS TREE
 - CU DENOTES CULVERT INVERT
 - CUD DENOTES CULVERT OVERT
 - DRWY DENOTES DRIVEWAY
 - DT DENOTES DECIDUOUS TREE
 - EG DENOTES EDGE OF GUTTER
 - EB DENOTES EDGE OF BUSH
 - FTE DENOTES FINISH FLOOR ELEVATION
 - FLPL DENOTES FLOOD PLANE
 - GU DENOTES EDGE OF GUTTER
 - HYDP DENOTES HYDRO PANEL BOARD
 - MH DENOTES MAINTENANCE HOLE UNKNOWN
 - MW DENOTES MONITORING WELL
 - OC DENOTES ORIGINAL GROUND
 - PO DENOTES UTILITY POLE
 - SHED DENOTES SHED
 - SHRUB DENOTES SHRUB LINE
 - SI DENOTES SIGN
 - SWC DENOTES SIDEWALK
 - TOB DENOTES TOP OF BANK
 - TOC DENOTES TOP BACK OF CURB
 - TRL DENOTES TREE LINE
 - UPW DENOTES UTILITY POLE
 - VENT DENOTES VENT
 - WB DENOTES BELL PEDESTAL
 - WB DENOTES BELL PEDESTAL
 - CB DENOTES CATCHBASIN
 - CTO104 DENOTES CONIFEROUS TREE AND DIAMETER
 - CTO105 DENOTES DECIDUOUS TREE AND DIAMETER
 - CTO106 DENOTES HYDRO PANEL BOARD
 - MH DENOTES MAINTENANCE HOLE UNKNOWN
 - SI DENOTES SIGN
 - UP DENOTES UTILITY POST
 - UP DENOTES UTILITY POST
 - WB DENOTES MONITORING WELL
 - VENT DENOTES PIPE VENT

BENCHMARK NOTE
ELEVATIONS SHOWN HEREON ARE GEODETIC AND DERIVED FROM ONTARIO MINISTRY
OF NATURAL RESOURCES AND FORESTRY BENCHMARK NO. 00820048011, HAVING AN
ELEVATION OF 416.888 METRES (GVD28.78). CAP IN CONCRETE, 40 CENTIMETRE
BELOW GRADE. BENCHMARK IS LOCATED ON TOP OF A CONCRETE CULVERT, ON EAST
SIDE OF HIGHWAY 10 APPROXIMATE 1.20 KM NORTH OF ROAD (ARTEMESIA) AND
0.80 KM SOUTH OF GREY COUNTY ROAD 12 IN MARKDALE.

SURVEYOR'S CERTIFICATE
I CERTIFY THAT:
1. THIS SURVEY AND PLAN ARE CORRECT AND IN ACCORDANCE
WITH THE SURVEYS ACT, THE SURVEYORS ACT AND THE
REGULATIONS MADE UNDER THEM.
2. THE SURVEY WAS COMPLETED ON THE 9th DAY OF FEBRUARY, 2022
DATE 9 Feb 2022 T. Shanmuganathan
T. SHANMUGANATHAN
ONTARIO LAND SURVEYOR
ASSOCIATION OF ONTARIO
LAND SURVEYORS
PLAN SUBCOMMITTEE FORM
2186436
THIS PLAN IS NOT VALID
UNLESS IT IS AN UNBROKEN
ORIGINAL COPY
ISSUED BY THE SURVEYOR
IN ACCORDANCE WITH
REGULATION 1036, SECTION 2(3)
THAM SURVEYING LIMITED
ONTARIO LAND SURVEYORS
www.thamsurveying.ca
8888 KEELE STREET, UNIT 7 PHONE: 905-761-6521 FAX: 905-761-6523
VAUGHAN, ONTARIO, L4K 2N2 1-855-761-6521
DRAWN BY: CHECKED BY: CAD NUMBER: JOB NUMBER:
M.M. T.H.S. 21-206P05 21-206

APPENDIX B

Hydrology Modelling Outputs

PCSWMM OUTPUT - EXISTING CONDITIONS – REGIONAL STORM (HURRICANE HAZEL)

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

* * * * *

Element Count

Number of rain gages 8

Number of subcatchments ... 4

Number of nodes 2

Number of links 1

Number of pollutants 0

Number of land uses 0

* * * * *

Raingage Summary

* * * * *

Name	Data Source	Data Type	Recording Interval
Hurricane_Hazel_(0-25)	Hurricane_Hazel_(0-25)	INTENSITY	60 min.
HurricaneHazel_48hr	HurricaneHazel_48hr	VOLUME	60 min.
SCS_Type_II_24hr_100yr	SCS_Type_II_24hr_100yr	INTENSITY	15 min.
SCS_Type_II_24hr_10yr	SCS_Type_II_24hr_10yr	INTENSITY	15 min.
SCS_Type_II_24hr_25yr	SCS_Type_II_24hr_25yr	INTENSITY	15 min.
SCS_Type_II_24hr_2yr	SCS_Type_II_24hr_2yr	INTENSITY	15 min.
SCS_Type_II_24hr_50yr	SCS_Type_II_24hr_50yr	INTENSITY	15 min.
SCS_Type_II_24hr_5yr	SCS_Type_II_24hr_5yr	INTENSITY	15 min.

* * * * *

Subcatchment Summary

Name	Area	Width	%Imperv	%Slope	Rain Gage	Outlet
S1	7.51	195.46	6.23	1.1000	HurricaneHazel_48hr	Wetland
S2	1.19	39.73	6.23	0.1000	HurricaneHazel_48hr	Wetland
S3	18.66	190.19	6.23	0.7000	HurricaneHazel_48hr	Wetland
S4	13.09	129.44	6.23	0.8000	HurricaneHazel_48hr	Wetland

* * * * *

Node Summary

* * * * *

Name	Type	Invert Elev.	Max. Depth	Ponded Area	External Inflow
J1	OUTFALL	416.30	0.50	0.0	
Wetland	STORAGE	415.87	1.88	0.0	

* * * * *

Link Summary

* * * * *

Name	From Node	To Node	Type	Length	%Slope	Roughness
C175 1	Wetland	J1	CONDUIT	18.3	0.4918	0.0230

* * * * *

Cross Section Summary

Conduit	Shape	Full Depth	Full Area	Hyd. Rad.	Max. Width	No. of Barrels	Full Flow
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C175_1 CIRCULAR 0.50 0.20 0.12 0.50 1 0.15

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

Analysis Options

Flow Units CMS

Process Models:

Rainfall/Runoff YES
RDII NO
Snowmelt NO
Groundwater NO
Flow Routing YES
Ponding Allowed NO
Water Quality NO
Infiltration Method HORTON
Flow Routing Method DYNWAVE
Surcharge Method EXTRAN
Starting Date 10/07/2021 00:00:00
Ending Date 10/12/2021 00:00:00
Antecedent Dry Days 0.0
Report Time Step 00:01:00
Wet Time Step 00:05:00
Dry Time Step 00:05:00
Routing Time Step 5.00 sec
Variable Time Step YES
Maximum Trials 8
Number of Threads 1
Head Tolerance 0.001500 m

*****	Volume	Depth
Runoff Quantity Continuity	hectare-m	mm
*****	-----	-----
Total Precipitation	11.526	285.000
Evaporation Loss	0.000	0.000
Infiltration Loss	6.134	151.670
Surface Runoff	5.388	133.227
Final Storage	0.005	0.125
Continuity Error (%)	-0.008	

*****	Volume	Volume
Flow Routing Continuity	hectare-m	10^6 ltr
*****	-----	-----
Dry Weather Inflow	0.000	0.000
Wet Weather Inflow	5.388	53.877
Groundwater Inflow	0.000	0.000
RDII Inflow	0.000	0.000
External Inflow	0.000	0.000
External Outflow	5.201	52.010
Flooding Loss	0.000	0.000
Evaporation Loss	0.000	0.000
Exfiltration Loss	0.000	0.000
Initial Stored Volume	0.000	0.000
Final Stored Volume	0.187	1.867
Continuity Error (%)	0.000	

Time-Step Critical Elements

Link C175_1 (43.41%)

Highest Flow Instability Indexes

All links are stable.

Routing Time Step Summary

Minimum Time Step : 2.56 sec
Average Time Step : 4.21 sec
Maximum Time Step : 5.00 sec
Percent in Steady State : -0.00
Average Iterations per Step : 2.00
Percent Not Converging : 0.00
Time Step Frequencies :
5.000 - 3.155 sec : 74.21 %
3.155 - 1.991 sec : 25.79 %
1.991 - 1.256 sec : 0.00 %
1.256 - 0.792 sec : 0.00 %
0.792 - 0.500 sec : 0.00 %

Subcatchment Runoff Summary

Total	Peak	Runoff	Total	Total	Total	Total	Imperv	Perv	Total
Runoff	Runoff	Coeff	Precip	Runon	Evap	Infil	Runoff	Runoff	Runoff
Subcatchment	Subcatchment		mm	mm	mm	mm	mm	mm	mm
10^6 ltr	CMS								
S1			285.00	0.00	0.00	139.34	17.63	127.93	145.57
10.93	0.76	0.511							
S2			285.00	0.00	0.00	151.32	17.63	115.95	133.58
1.59	0.10	0.469							
S3			285.00	0.00	0.00	154.86	17.63	112.40	130.03
24.26	1.45	0.456							
S4			285.00	0.00	0.00	154.22	17.63	113.04	130.67
17.10	1.03	0.458							

Node Depth Summary

Node	Type	Average Depth Meters	Maximum Depth Meters	Maximum HGL Meters	Time of Max Occurrence days hr:min	Reported Max Depth Meters
J1	OUTFALL	0.20	0.45	416.75	2 03:18	0.45
Wetland	STORAGE	0.89	1.70	417.57	2 03:18	1.70

Node Inflow Summary

Maximum Lateral	Maximum Total	Time of Max	Lateral Inflow	Total Inflow	Flow Balance
--------------------	------------------	-------------	-------------------	-----------------	-----------------

Node	Type	Inflow CMS	Inflow CMS	Occurrence days hr:min	Volume 10^6 ltr	Volume 10^6 ltr	Error Percent
J1	OUTFALL	0.000	0.458	2 03:18	0	52	0.000
Wetland	STORAGE	3.290	3.290	2 00:00	53.9	53.9	0.001

Node Surcharge Summary

No nodes were surcharged.

Node Flooding Summary

No nodes were flooded.

Storage Volume Summary

	Average	Avg	Evap	Exfil	Maximum	Max	Time of Max
	Volume	Pcnt	Pcnt	Pcnt	Volume	Pcnt	Occurrence
Outflow Storage Unit CMS	1000 m3	Full	Loss	Loss	1000 m3	Full	days hr:min
Wetland 0.458	11.652	22	0	0	41.456	78	2 03:18

Outfall Loading Summary

Outfall Node	Flow Freq Pcnt	Avg Flow CMS	Max Flow CMS	Total Volume 10^6 ltr
J1	77.98	0.206	0.458	52.009
System	77.98	0.206	0.458	52.009

Link Flow Summary

Link	Type	Maximum Flow CMS	Time of Max Occurrence days hr:min	Maximum Veloc m/sec	Max/ Full Flow	Max/ Full Depth
C175_1	CONDUIT	0.458	2 03:18	2.38	3.06	0.95

Flow Classification Summary

Conduit	Adjusted /Actual Length	----- Fraction of Time in Flow Class -----								
		Up Dry Dry		Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Norm Ltd	Inlet Ctrl
C175_1	1.00	0.21	0.00	0.00	0.79	0.00	0.00	0.00	0.00	0.00

Conduit Surcharge Summary

Conduit	----- Hours Full -----		----- Hours -----		Hours
	Both Ends	Upstream	Dnstream	Above Full Normal Flow	Capacity Limited
C175_1	0.01	32.16	0.01	38.84	0.01

Analysis begun on: Wed Jul 13 16:07:09 2022
Analysis ended on: Wed Jul 13 16:07:09 2022
Total elapsed time: < 1 sec

PCSWMM OUTPUT - PROPOSED CONDITIONS – REGIONAL STORM (HURRICANE HAZEL)

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

* * * * *

Element	Count
1	1
2	1
3	1
4	1
5	1
6	1
7	1
8	1
9	1
10	1
11	1
12	1
13	1
14	1
15	1
16	1
17	1
18	1
19	1
20	1
21	1
22	1
23	1
24	1
25	1
26	1
27	1
28	1
29	1
30	1
31	1
32	1
33	1
34	1
35	1
36	1
37	1
38	1
39	1
40	1
41	1
42	1
43	1
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80	1
81	1
82	1
83	1
84	1
85	1
86	1
87	1
88	1
89	1
90	1
91	1
92	1
93	1
94	1
95	1
96	1
97	1
98	1
99	1
100	1

* * * * *

Number of rain gages 8

Number of subcatchments ... 4

Number of nodes 2

Number of links 1

Number of pollutants 0

Number of land uses 0

* * * * *

Rainage Summary

* * * * *

Name	Data Source	Data Type	Recording Interval
Hurricane_Hazel_(0-25)	Hurricane_Hazel_(0-25)	INTENSITY	60 min.
HurricaneHazel_48hr	HurricaneHazel_48hr	VOLUME	60 min.
SCS_Type_II_24hr_100yr	SCS_Type_II_24hr_100yr	INTENSITY	15 min.
SCS_Type_II_24hr_10yr	SCS_Type_II_24hr_10yr	INTENSITY	15 min.
SCS_Type_II_24hr_25yr	SCS_Type_II_24hr_25yr	INTENSITY	15 min.
SCS_Type_II_24hr_2yr	SCS_Type_II_24hr_2yr	INTENSITY	15 min.
SCS_Type_II_24hr_50yr	SCS_Type_II_24hr_50yr	INTENSITY	15 min.
SCS_Type_II_24hr_5yr	SCS_Type_II_24hr_5yr	INTENSITY	15 min.

* * * * *

Subcatchment Summary

Name	Area	Width	%Imperv	%Slope	Rain Gage	Outlet
S1	7.51	195.46	6.23	1.1000	HurricaneHazel_48hr	Wetland
S2	1.19	93.85	6.23	0.1000	HurricaneHazel_48hr	Wetland
S3	18.66	231.49	6.23	0.9000	HurricaneHazel_48hr	Wetland
S4	13.09	156.73	6.23	1.0000	HurricaneHazel_48hr	Wetland

* * * * *

Node Summary

* * * * *

Name	Type	Invert Elev.	Max. Depth	Ponded Area	External Inflow
J1	OUTFALL	416.30	0.82	0.0	
Wetland	STORAGE	415.87	1.88	0.0	

* * * * *

Link Summary

* * * * *

Name	From Node	To Node	Type	Length	%Slope	Roughness
C175 1	Wetland	J1	CONDUIT	18.3	0.4918	0.0130

Cross Section Summary

Conduit	Shape	Full Depth	Full Area	Hyd. Rad.	Max. Width	No. of Barrels	Full Flow

C175_1 CIRCULAR 0.82 0.53 0.21 0.82 1 1.01

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

Analysis Options

Flow Units CMS

Process Models:

Rainfall/Runoff YES
RDII NO
Snowmelt NO
Groundwater NO
Flow Routing YES
Ponding Allowed NO
Water Quality NO
Infiltration Method HORTON
Flow Routing Method DYNWAVE
Surcharge Method EXTRAN
Starting Date 10/07/2021 00:00:00
Ending Date 10/12/2021 00:00:00
Antecedent Dry Days 0.0
Report Time Step 00:01:00
Wet Time Step 00:05:00
Dry Time Step 00:05:00
Routing Time Step 5.00 sec
Variable Time Step YES
Maximum Trials 8
Number of Threads 1
Head Tolerance 0.001500 m

*****	Volume	Depth
Runoff Quantity Continuity	hectare-m	mm
*****	-----	-----
Total Precipitation	11.526	285.000
Evaporation Loss	0.000	0.000
Infiltration Loss	5.959	147.341
Surface Runoff	5.563	137.559
Final Storage	0.005	0.125
Continuity Error (%)	-0.009	

*****	Volume	Volume
Flow Routing Continuity	hectare-m	10^6 ltr
*****	-----	-----
Dry Weather Inflow	0.000	0.000
Wet Weather Inflow	5.563	55.634
Groundwater Inflow	0.000	0.000
RDII Inflow	0.000	0.000
External Inflow	0.000	0.000
External Outflow	5.549	55.493
Flooding Loss	0.000	0.000
Evaporation Loss	0.000	0.000
Exfiltration Loss	0.000	0.000
Initial Stored Volume	0.000	0.000
Final Stored Volume	0.015	0.148
Continuity Error (%)	-0.012	

Time-Step Critical Elements

Link C175_1 (16.09%)

Highest Flow Instability Indexes

All links are stable.

Routing Time Step Summary

Minimum Time Step : 1.55 sec
Average Time Step : 4.63 sec
Maximum Time Step : 5.00 sec
Percent in Steady State : 0.00
Average Iterations per Step : 2.00
Percent Not Converging : 0.00
Time Step Frequencies :
5.000 - 3.155 sec : 88.56 %
3.155 - 1.991 sec : 6.50 %
1.991 - 1.256 sec : 4.94 %
1.256 - 0.792 sec : 0.00 %
0.792 - 0.500 sec : 0.00 %

Subcatchment Runoff Summary

Total	Peak	Runoff	Total	Total	Total	Total	Imperv	Perv	Total
Runoff	Runoff	Coeff	Precip	Runon	Evap	Infil	Runoff	Runoff	Runoff
Subcatchment	Subcatchment		mm	mm	mm	mm	mm	mm	mm
10^6 ltr	CMS								
S1			285.00	0.00	0.00	139.34	17.63	127.93	145.57
10.93	0.76	0.511							
S2			285.00	0.00	0.00	140.25	17.63	127.02	144.66
1.72	0.12	0.508							
S3			285.00	0.00	0.00	149.61	17.63	117.66	135.29
25.24	1.58	0.475							
S4			285.00	0.00	0.00	149.35	17.63	117.92	135.55
17.74	1.11	0.476							

Node Depth Summary

Node	Type	Average Depth Meters	Maximum Depth Meters	Maximum HGL Meters	Time of Max Occurrence days hr:min	Reported Max Depth Meters
J1	OUTFALL	0.13	0.82	417.13	2 00:03	0.82
Wetland	STORAGE	0.67	1.67	417.54	2 00:54	1.67

Node Inflow Summary

Maximum Lateral Inflow	Maximum Total Inflow	Time of Max Occurrence	Lateral Inflow Volume	Total Inflow Volume	Flow Balance Error
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Node	Type	CMS	CMS	days hr:min	10^6 ltr	10^6 ltr	Percent
J1	OUTFALL	0.000	2.163	2 00:54	0	55.5	0.000
Wetland	STORAGE	3.513	3.513	2 00:00	55.6	55.6	-0.012

Node Surcharge Summary

No nodes were surcharged.

Node Flooding Summary

No nodes were flooded.

Storage Volume Summary

	Average	Avg	Evap	Exfil	Maximum	Max	Time of Max
Maximum	Volume	Pcnt	Pcnt	Pcnt	Volume	Pcnt	Occurrence
Outflow							
Storage Unit	1000 m3	Full	Loss	Loss	1000 m3	Full	days hr:min
CMS							
Wetland	1.484	7	0	0	16.283	74	2 00:54
2.163							

Outfall Loading Summary

Outfall Node	Flow Freq Pcnt	Avg Flow CMS	Max Flow CMS	Total Volume 10^6 ltr
J1	82.90	0.270	2.163	55.493
System	82.90	0.270	2.163	55.493

Link Flow Summary

Link	Type	Maximum Flow CMS	Time of Max Occurrence days hr:min	Maximum Veloc m/sec	Max/ Full Flow	Max/ Full Depth
C175_1	CONDUIT	2.163	2 00:54	4.05	2.15	1.00

Flow Classification Summary

Adjusted ----- Fraction of Time in Flow Class -----

Conduit	/Actual Length	Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Norm Ltd	Inlet Ctrl
C175_1	1.00	0.03	0.00	0.00	0.66	0.31	0.00	0.00	0.02	0.00

Conduit Surcharge Summary

Conduit	----- Both Ends	Hours Full Upstream	----- Dnstream	Hours Above Full Normal Flow	Hours Capacity Limited
C175_1	0.01	4.27	0.01	6.08	0.01

Analysis begun on: Wed Jul 13 16:03:56 2022
Analysis ended on: Wed Jul 13 16:03:56 2022
Total elapsed time: < 1 sec

APPENDIX C

Floodplain Mapping – Existing Conditions

APPENDIX D

Floodplain Mapping – Proposed Conditions

