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688, 694 & 698 BRANT STREET URBAN SPILL FLOOD PLAIN

BURLINGTON, ONTARIO

FLOOD ANALYSIS REPORT

Prepared For:

Elite 688 Brant Holdings Inc.

Prepared By:

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UPDATED:

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APPENDIX A

Flood Plain Maps for the 688 Brant Street Area

Flood Maps – to be determined once CH and City finish review of Wood Phase 2 and review of this report

STANDARD LIMITATIONS

This report was prepared by The Odan/Detech Group Inc. (Odan/Detech) for the client in accordance with the agreement between Odan/Detech and the client. This report is based on information provided to Odan/Detech which has not been independently verified. The disclosure of any information contained in this report is the sole responsibility of the client. The material in this report, accompanying spreadsheets and all information relating to this activity reflect Odan/Detech judgment in light of the information available to us at the time of preparation of this report and any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Odan/Detech accepts no responsibility for damages, if any, suffered by a third party as a result of decisions made or actions based on this report.

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This Standard Limitations statement is considered part of this report.

1. BACKGROUND

The property under study is approximately 0.76 ha (1.88 acre) in size. The Hager-Rambo Diversion Channel is located adjacent to the Site. The subject site is bounded by Brant Street to the north, existing commercial to the east, existing residential and Alfred Crescent to the south, and existing 2-storey building and Olga Street to the west. Refer to Figure 1 for the context map. The subject Site is in red.

The Site, which is subject to floodplain spill event during the Regulatory Storm (i.e. Hurricane Hazel). Preliminary analysis by the City and Conservation Halton (CH) is the site will be encrouched by water during the Regulatory Storm. A floodplain analysis is necessary to support the proposed development. The proposed development is regulated by Conservation Halton (CH) and is subject to permit by Conservation Halton.

The purpose of this report is to analyse and summarize the results of a floodplain analysis and demonstrate that the site can be economically flood proofed and that safe access to the proposed development can be provided.

2. SCOPE OF WORK

THE ODAN/DETECH GROUP INC.(OD) was retained by **ELITE 688 BRANT HOLDINGS INC.**, to review the site and given topology, review the existing area and models and incorporate it into the 1D/2D dynamic model. In General the following is the scope of work:

1) Virtual meetings (2) with Authorities and Client, if required.

2) Review the history of previous submissions and resubmissions. Review City comments and general correspondence, related to floodplain work completed to date.

3) Create models for both the existing and post development scenarios and iterate to ensure upstream and downstream flood conditions do not change appreciably.

4) Provide a Flood Analysis report including any observations and recommendations.

Figure 1 – Context map of existing area surrounding 688, 694 & 698 Brant Street



3. FLOOD PLAIN REVIEW CONSIDERATIONS

EXISTING CONDITIONS:

The best way to review the flood plain is via an Illustration. Refer to Figure 2 for existing system. Essentially the flood plain can be described as follow;

The Flood Hazard and Scoped Stormwater Management Assessment prepared by Wood (June 2020) (extract provided in Figure 2), identifies four spill locations of the West Rambo Creek and Hager-Rambo Diversion Channel at Fairview Street. These spill areas are shown in Figure 2 and outlined below:

1. South side of Hager-Rambo Diversion Channel east of Brant Street
2. Overtopping of the Hager-Rambo Diversion Culvert at Fairview Street (east of Brant Street)
3. Overtopping of the West Rambo Creek Culvert at Fairview Street
4. South side of Hager-Rambo Diversion Channel west of Brant Street

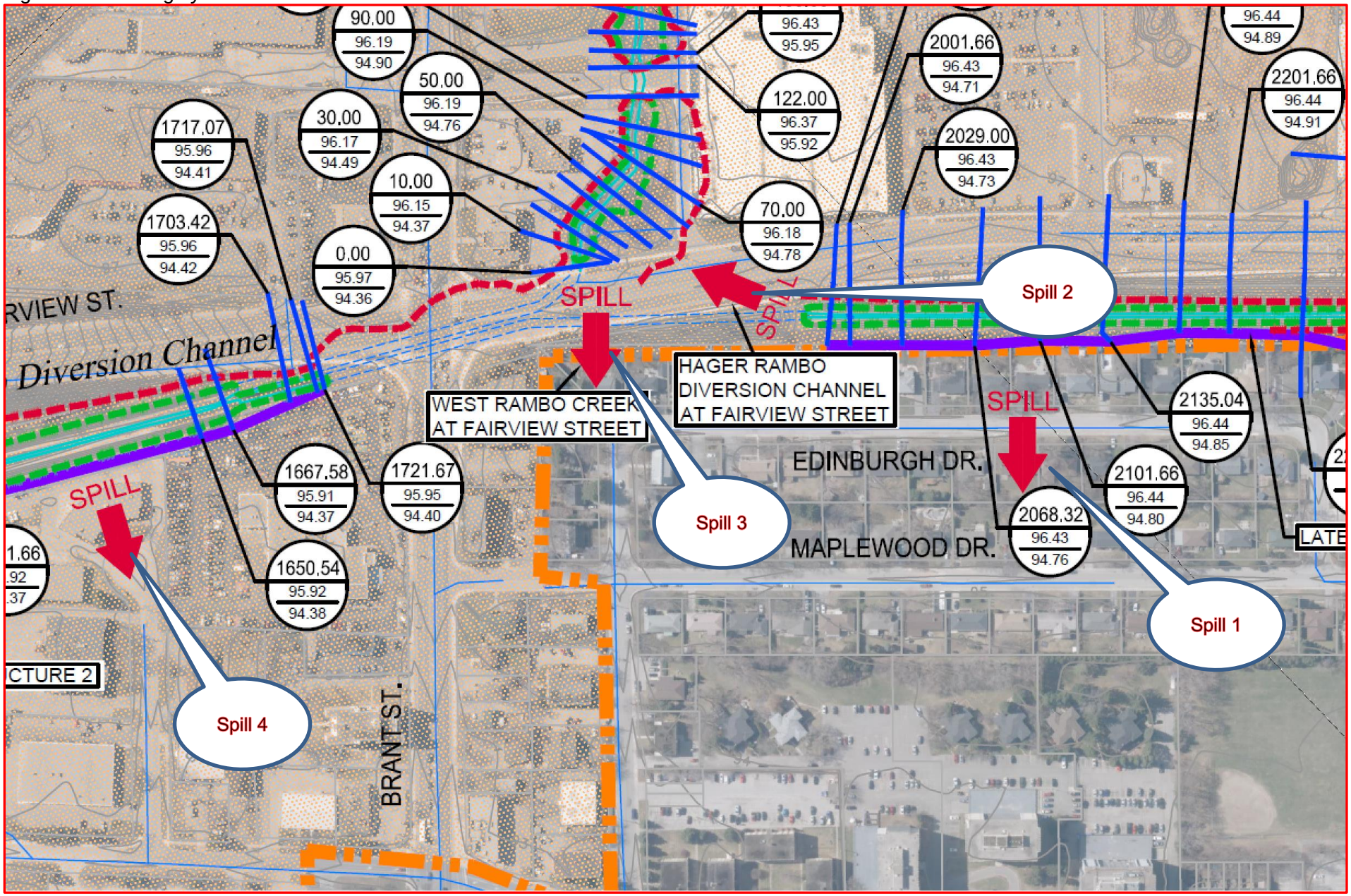
The spill area was studied by Wood Environment & Infrastructure Solutions (Wood) for the City. The findings are in the report titled **The Flood Hazard and Scoped Stormwater Management Assessment**. It should be noted that the Phase 1 of this report does not contain any Policy recommendations. Instead it refers to a Phase 2 study (presently under way by Wood). The Phase 2 report is to include refinements to the Phase 1 assessment. Prior to proceeding with this report OD called the City (Umar Malk) and the CH (David Irvin and Matt Howatt). They stated that the interim policy would more than likely be refined and that the MNR policy of treating urban spills like ravine areas would be rejected because it would neuter any redevelopment.

The Assessment tool used by Wood for the Phase 1 analysis, utilized a preliminary two-dimensional (2D) PCSWMM model to quantify the spill directions and extents. Odan/Detech (OD) obtained a copy of the PCSWMM from CH. The model extends from Fairview Street to Blairholm Avenue, has 5 m hexagonal mesh elements which utilize the Region of Halton's 2015 DEM. The PCSWMM model has no hydrology. The spill flows were modelled as a series of node inflows closely spaced to model spill 1 and 4 and 1 node to model the flow from spill 2 and 3. It appears that prior to the 2D model the analysis utilized a HEC-RAS model and the accompanying hydrology.

TOPOLOGY:

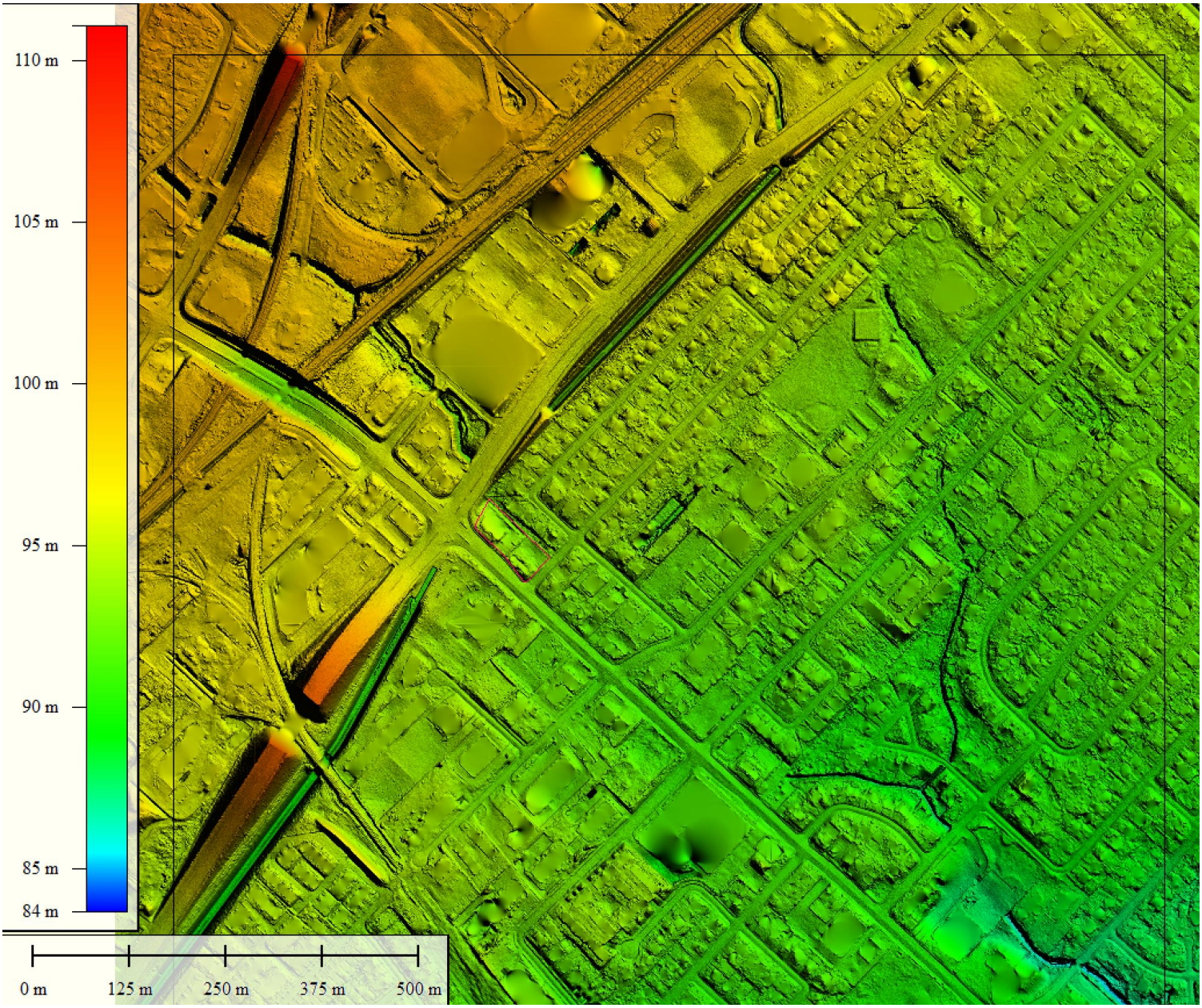
The PCSWMM model utilized the Region of Halton's 2015 DEM which is Lidar derived. The grid density is 0.5m x 0.5m. We obtained and reviewed topographic survey of the existing site (existing subject site terrain) prepared by A.T. McLaren Ltd, dated January 7, 2022. We compared the existing A.T. McLaren topographic survey to the lidar used in the hydraulic model and find the A.T. McLaren data to be 0.5m lower than the Lidar data. It should be noted that the Lidar and A.T. McLaren data are not based on the same vertical datum. OD adjusted the McLaren data to match the Lidar, since the Lidar was used in the Wood report. We will utilize the Region of Halton's 2015 DEM (based on Lidar) as the base line existing topology. Since the DEM are relative the flood analysis will utilize the Lidar as the base while the Site plan grading and services will utilize the McLaren topo data as the base.

Figure 2 – Existing system



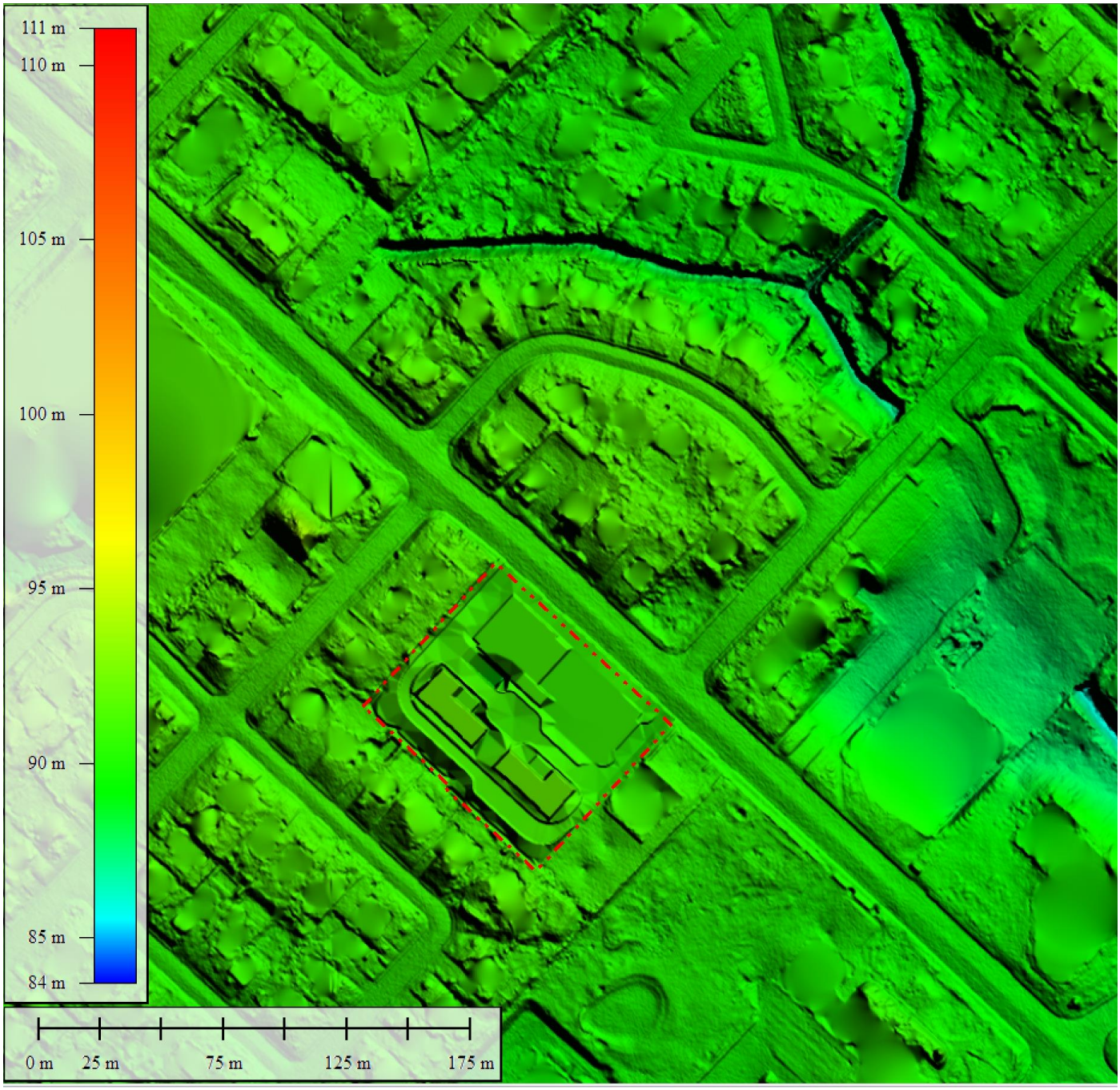
Source: Drawing 5B: Floodplain Mapping 'Scenario 2' - Flood Hazard and Scoped Stormwater Management Assessment, Wood, June 2020

Figure 3 – Existing Topography



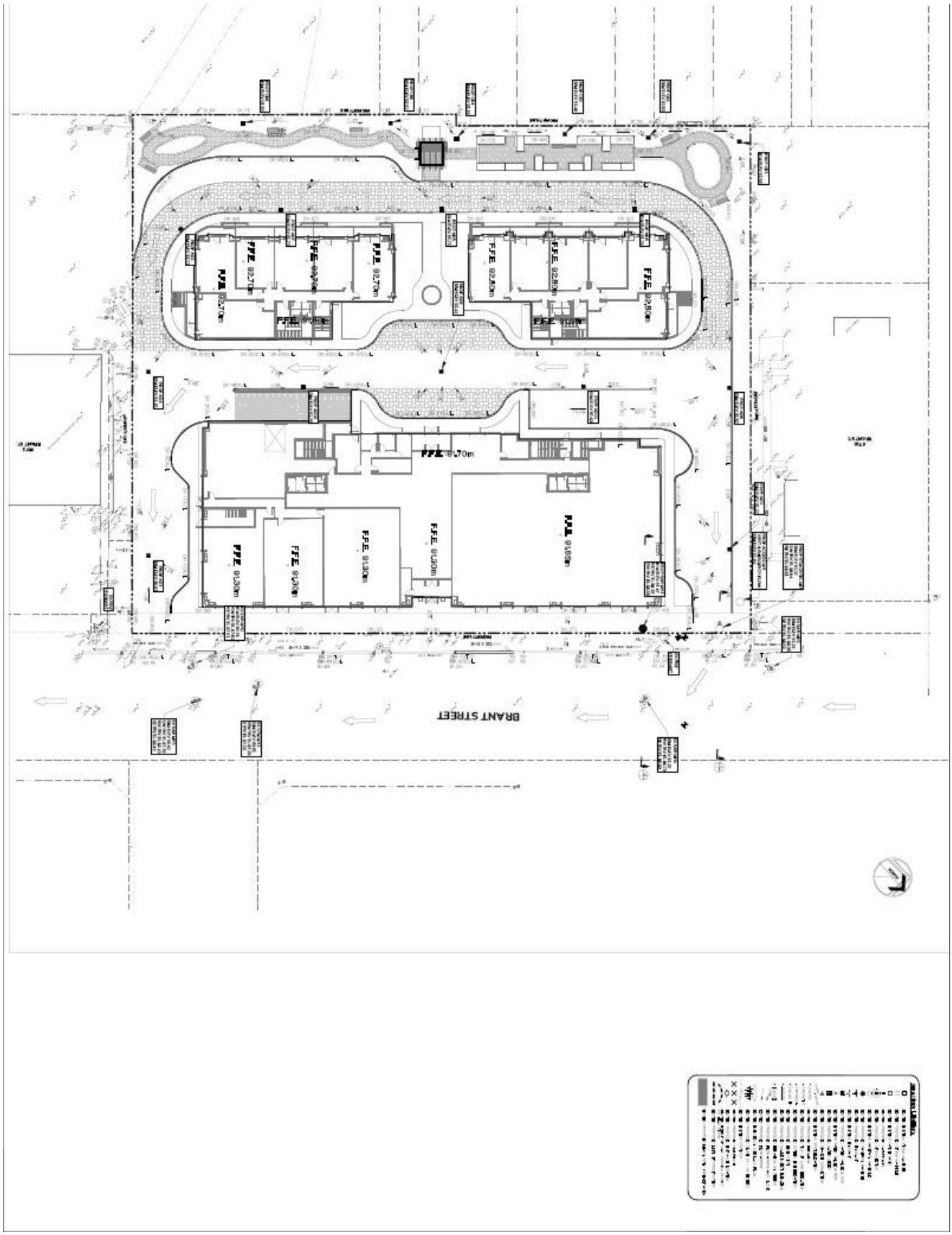
Global Mapper render of part Region of Halton 2015 DEM (Lidar derived)

Figure 4 – 688, 694 & 698 Brant Street Developed Topography



Global Mapper render of 688 Brant Street developed grading imposed on existing terrain. Subject Site is in red.

Figure 5 – 688, 694 & 698 Brant Street Developed Grading (close up)



METHODLOLOGY

The Floodplain Analysis work will in brief include the following tasks:

1. Review the City of Burlington Development Application Pre-Consultation Notes. Dated February 1, 2022.
2. Review the Flood Hazard and Scoped Stormwater Management Assessment –Burlington GO Mobility Hub and Downtown, (June 1, 2020, prepared for City of Burlington by Wood).
3. Compare Region of Halton DEM to KRCMAR Surveyors Ltd, dated November 16, 2021 survey. If comparison is ok, assume Region of Halton DEM is baseline.
4. Request and obtain from CH the PCSWMM hydraulic models used by Wood in preparing the Flood Hazard and Scoped Stormwater Management Assessment report.
5. Review the PCSWMM model. Ask CH if the PCSWMM is to be used in Phase 2. If not we will use XPSWMM 2D.

The following items will be evaluated via the XPSWMM 1D/2D model:

- Flood Elevations (Regulatory)
- **HGL at the subject areas.**
- Bed shear Calculations
- Velocity and depth Calculations (Hazard).
- Effects of regrading 688 Brant Street on adjacent properties.

HYDRAULIC ANALYSIS:

XPSWMM 1D/2D MODEL:

In item 5 above, Wood is not using PCSWMM. The timing of Phase 2 report is uncertain so we decided to create our own model but based on the PCSWMM model. The model we chose to use is XPSWMM. Many items were transferable. The boundary conditions and 1D nodes were easily copied and pasted from PCSWMM to XPSWMM. Spill inflows were the same. Copied and pasted from PCSWMM to XPSWMM. It should be noted that we ran PCSWMM and compared the results. We were told by CH that Wood in Phase 2 will use a 2D model but will refine the spill flows.

The PCSWMM Model had no hydrology or pipes. PCSWMM was run with the following scenarios:

1. Scenario 0 (Base) - The existing scenario was simulated under the assumption that there will be full spill flow from the West Rambo, and there will not be any flow optimization for the lateral structures, or culverts.
2. Scenario 1 - Consisted of optimizing Lateral Structure 1. The results indicate that optimizing Lateral Structure 1 will have the largest impact on the residential properties along Edinburgh Drive and Maplewood Drive.
3. Scenario 2 – Consisted of optimizing Lateral Structure 2A + 2B. The results indicate that the largest impact will be to the industrial properties located north of Grahams Lane.
4. Scenario 3 – Optimizing Lateral Structures 1, 2A, and 2B. The results are similar to Scenario 1 and 2 and indicates the impacts will be to the residential properties on Edinburgh Drive and Maplewood Drive, and the industrial properties north of Grahams Lane. In Scenario 3 there is less spill towards Maplewood Drive.
5. Scenario 4 – No flow optimization, there is only weir flow from the Hager-Rambo Diversion Channel Culvert. The results show that Scenario 4 generates the largest spill flows.

In the Assessment, Conservation Halton (CH) said that flows from optimization of the lateral structures would be acceptable to use for the spill analysis, therefore Scenario 3 is used for the analysis outlined herein. In addition CH Halton stated that the Phase 2 report will focus on optimization and refining the spill flows. Essentially we are assuming the Phase 1, scenario 3 model from the Wood report to be Conservative and that the Phase 2 study will give lesser spill flows.

We will run XP2D for:

1. The existing conditions and compare to the PCSWMM model.
2. We will run the same XPSWMM but with the topology changed to represent 688 Brant Street redeveloped grading changes.

MODEL:

The Hydrodynamic 2D model utilized is XP2D by Innovyze. XPSWMM 1D is similar to and has the modified EPA SWMM 5 engine. SWMM 5 models can be imported and exported into XPSWMM. XP2D is a computer program for simulating depth-averaged, two and one-dimensional free-surface flows such as occurs from floods and tides. XP2D is based on the computational engine TUFLOW which was originally developed for modelling two-dimensional (2D) flows, and stands for Two-dimensional Unsteady FLOW. XP2D has been dynamically linked (fully integrated) with the XPSWMM 1D solution engine.

2D: TUFLOW HPC's 2D explicit formulation assures unconditional stability. Thus a reasonable initial time step is 1 to 5 seconds. The program will use the initial time step and divide it by 10 to start the simulation. From that point on the program will adjust.

1D: Finite difference Runge-Kutta explicit scheme. Scheme solves all terms of the St. Venant equations.

1D and 2D schemes automatically switch between upstream and downstream controlled flow regimes to represent shocks.

Prior to embarking on a 2D model routine it is customary practice to create a well planned work flow so that major items are not missed. The pillar of this work flow is a well conceived Quality Control Check List. See the following check list. It is only checked after the modelling takes place to make sure the report and models are in sync.

Quality Control Check List

Item	*Description*	*Checked*
Modeling Log	A modeling log is highly recommended and should be a requirement on all projects. The log may be in Excel, Word or other suitable software. A review of the modeling log is to be made by an experienced modeller. It should contain sufficient information to record model versions during development and calibration, along with observations from simulations. A model version naming and numbering system needs to be designed prior to the modeling. The version numbering system should be reflected in input data filenames to allow traceability and the ability to reproduce an old simulation if needed.	√
File Naming, Structure and Management	A review of the data file management should check: • files are named using a logical and appropriate system that allows easy interpretation of file purpose and content; • a logical and appropriate system of folders is used that manages the files; • relative path names to be used for input files (eg. "..\model\geometry.tgc") so that models are easily moved from one folder to another. • documentation of the above in, for example, the projects Quality Control Document and/or Modeling Log.	√
2D Cell Size	Check whether the 2D cell size is appropriate to reproduce the topography needed to satisfactorily meet the objectives of the study.	√
Topography	The topography review should focus on: • correct interrogation of DTM; • correct datum; • modifications to the base data (eg. breaklines) have been checked. Regarding the latter, this is effectively carried out by producing a _zpt GIS check file using Write Check Files. The _zpt layer contains all modifications including any flow constriction adjustments. A DTM can be created from the Zpts using Global Mapper, or other 3D surface software, to aid in the review. Note: Reviewing the elevations in the .2dm file is not appropriate as only the ZH Zpt is represented in the .2dm file (the ZH elevation is not used in the hydrodynamic calculations).	√
Bed Resistance Values	Bed resistance values are to be reviewed by an experienced modeller. The review should focus on checking at least one of: • **Roughness Categories** in the Global Database; • the grid "Mat" or "Manning_n" values in the grd GIS check file; or • specifying weir output using the weir approach. The reviewer should be looking for: • relative consistency between different land-use (material) types; and • values are within accepted calibration values.	√
Calibration / Validation	Check that the model calibration or validation is satisfactory in regard to the study objectives. Identify any limitations or areas of potential uncertainty that should be noted when interpreting the study outcomes.	√

Mass Conservation	Standard practice is to place PO flow lines at a minimum of several locations through the model. They are typically aligned roughly perpendicular to the flow direction. The locations should include lines just inside each of the boundaries. Other suitable locations are upstream and downstream of key structures, through structures and areas of particular interest. The flows are graphed and conservation of mass checked (i.e. the amount of water entering the model equals the amount leaving allowing for any retention of water in the model). Check that any 1D flow paths crossed by a PO line are also included in the mass check. In dynamic simulations, an exact match between upstream and downstream will not occur due to retention of water, however, examination of the flow lines should reflect this phenomenon. For steady-state simulations, demonstration of reaching steady flow conditions is demonstrated when the flow entering the model equals the flow leaving the model.	√
Free-Over fall & Weir Flow	Especially if **Supercritical** is set to OFF, the percentage of free-over fall and weir flow velocity points should be checked. The review should seek to check that excessive number of points are not free-overfalling, and if so: that this is in accordance with the expected flow (e.g. weir flow over a levee) – check that the weir option is on if significant weir flow exists; and/or the effect on the overall flow patterns is minimal. The review is best carried out by: • Monitoring the numbers after “CS” or “FO” on the screen or in the .tlf file • Specifying flow regime output to generate the _R.dat file. This file shows the flow regime. The presence of significant areas of supercritical and/or weirs can be acceptable in large areas of sheet flow. However, care should be taken in interpreting the flow behavior in these areas, particularly if the flow is supercritical as complex hydraulic processes (e.g. hydraulic jumps, surcharging against buildings) can occur. Typically, most supercritical and weir flow occurs: • around the edge of a model where it is wetting and drying and has little influence over the general flow behavior; or • down steep slopes or over significant drops (eg. over a levee).	√
Hydraulic Structures	Head losses through a structure need to be validated through: • Calibration to recorded information (if available). • Crosschecked using desktop calculations based on theory and/or standard publications (eg. Hydraulics of Bridge Waterways). • Crosschecked with results using other hydraulic software (e.g. HEC-RAS). Simple checks can be made by calculating the number of dynamic head losses that occur and checking that this in accordance with that expected It is important to note that contraction and expansion losses associated with structures are modeled very differently in 1D and 2D schemes. 1D scheme rely on applying form loss coefficients, as they cannot simulate the horizontal or vertical changes in velocity direction and speed. 2D schemes model these horizontal changes and, therefore, do not require the introduction of form losses to the same extent as that required for 1D schemes. However, 2D schemes do not model losses in the vertical or fine-scale horizontal effects (such as around a bridge pier) and, therefore, may require the introduction of additional form losses. See Syme 2001b for further details.	√
Eddy Viscosity	Check that the eddy viscosity formulation and coefficient is appropriate	√

Find enclosed in Figure 7 the existing condition XPSWMM model. The XPSWMM model was built from the Regions 2015 DEM (lidar derived). The raw data was imported into Global Mapper (Geospatial software) where it was reviewed and edited if necessary. A digital terrain model was created in Global Mapper. Through Global Mapper a grid file (XYZ) file was created and sent to XPSWMM. XPSWMM then creates the DTM. The original Region DEM which was used in PCSWMM and the XPSWMM DEM are essentially the same since the density (grid) is the same 0.5 x 0.5 m. The DTM still satisfies the theory that a good 2D model should contain for each 2D cell at least 2 vertices on average.

TIME STEP:

As a rule, the time step is typically half the cell size. Typical 2D time steps is ½ the cell size (XPSWMM 2D manual). For steep models with high Froude numbers and supercritical flow, smaller time steps may be required. For this site it will not be an issue (this Site is relatively flat).

If the model is operating at high Courant numbers (>10), sensitivity testing with smaller time steps to demonstrate no measurable change in results should be carried out. The occurrence of high mass errors is also an indicator of using too high a time step. It is recommended that the time step of the 2D engine be equal to or an integer multiple of the time step of the 1D calculations.

We have adapted the following time steps to start:

1D model	1.0 sec
2D model	1.0 sec

XP2D is finite volume based, explicit formulation. As mentioned above the program will use the initial time step and divide it by 10 to start the simulation. From that point on the program will adjust. The above noted criteria are met and there are no stability issues with the model.

CELL SIZE:

The cell sizes of 2D domains need to be sufficiently small to reproduce the hydraulic behavior. Based on review of benchmark studies, experience and consultation with Innovyze the chosen **Grid size of 2.0 m** is adequate. It has enough resolution to capture local ditch's, and space between buildings.

CELL ROUGHNESS:

Refer to Figure 6 for the grid roughness. The areas in green were set to a **Manning n of 0.050** for the existing natural areas and residential lawns. The remainder in blank were the default urban area which were set to a **Manning n of 0.025**. these values were used in PCSWMM. The shape files of the polygons were imported from PCSWMM into XPSWMM.

Figure 6 to 11 show the process of creating a 1D/2D model, existing and proposed.

Figure 6 - Land use grid roughness



Region in green n = 0.05
Blank area n = 0.025
Mesh extents in red
Hatch areas in blue are buildings which are inactive 2D.

Figure 7 - XPSWMM Existing system Model Global

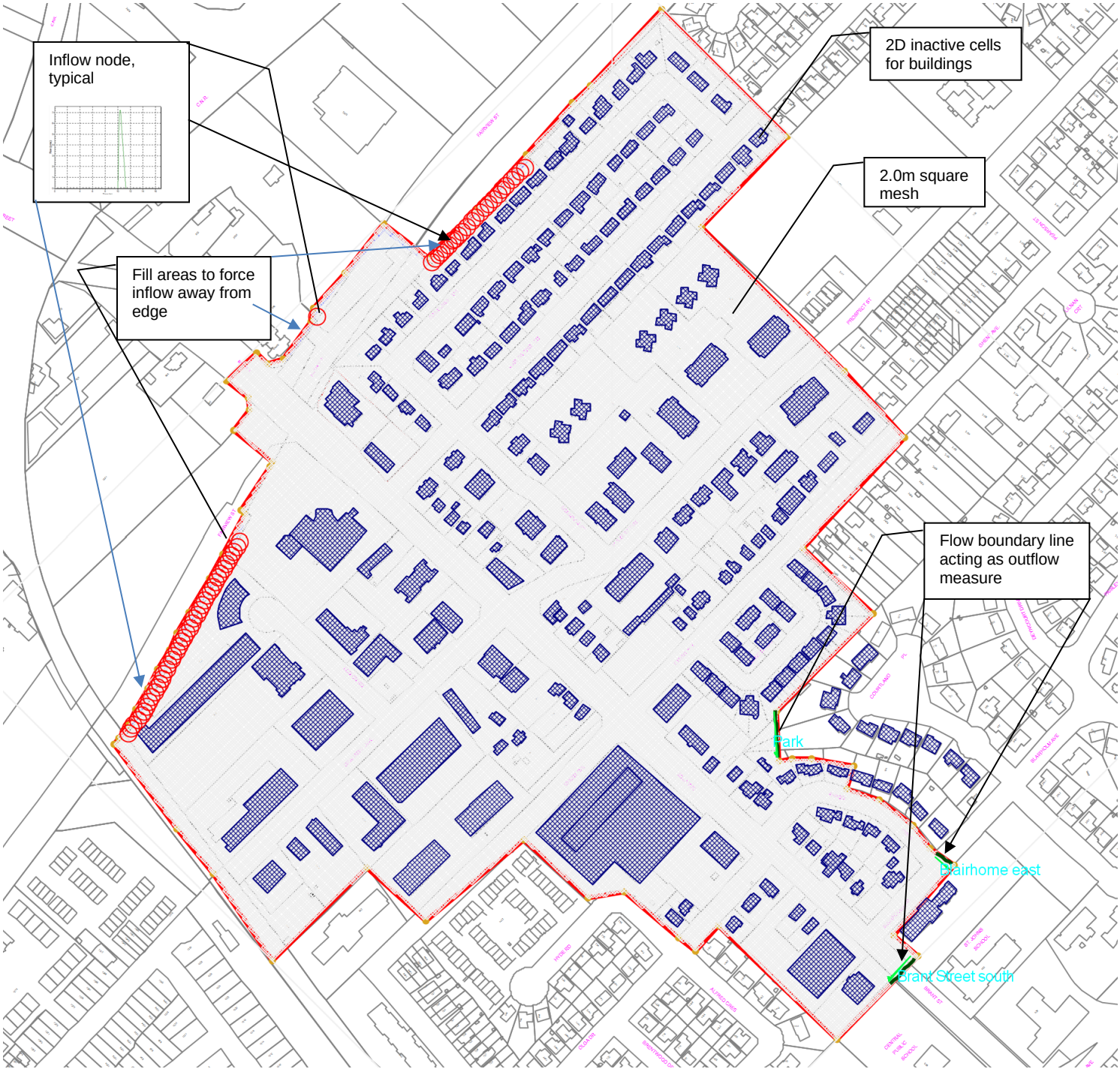


Figure 8 - Showing DTM Existing

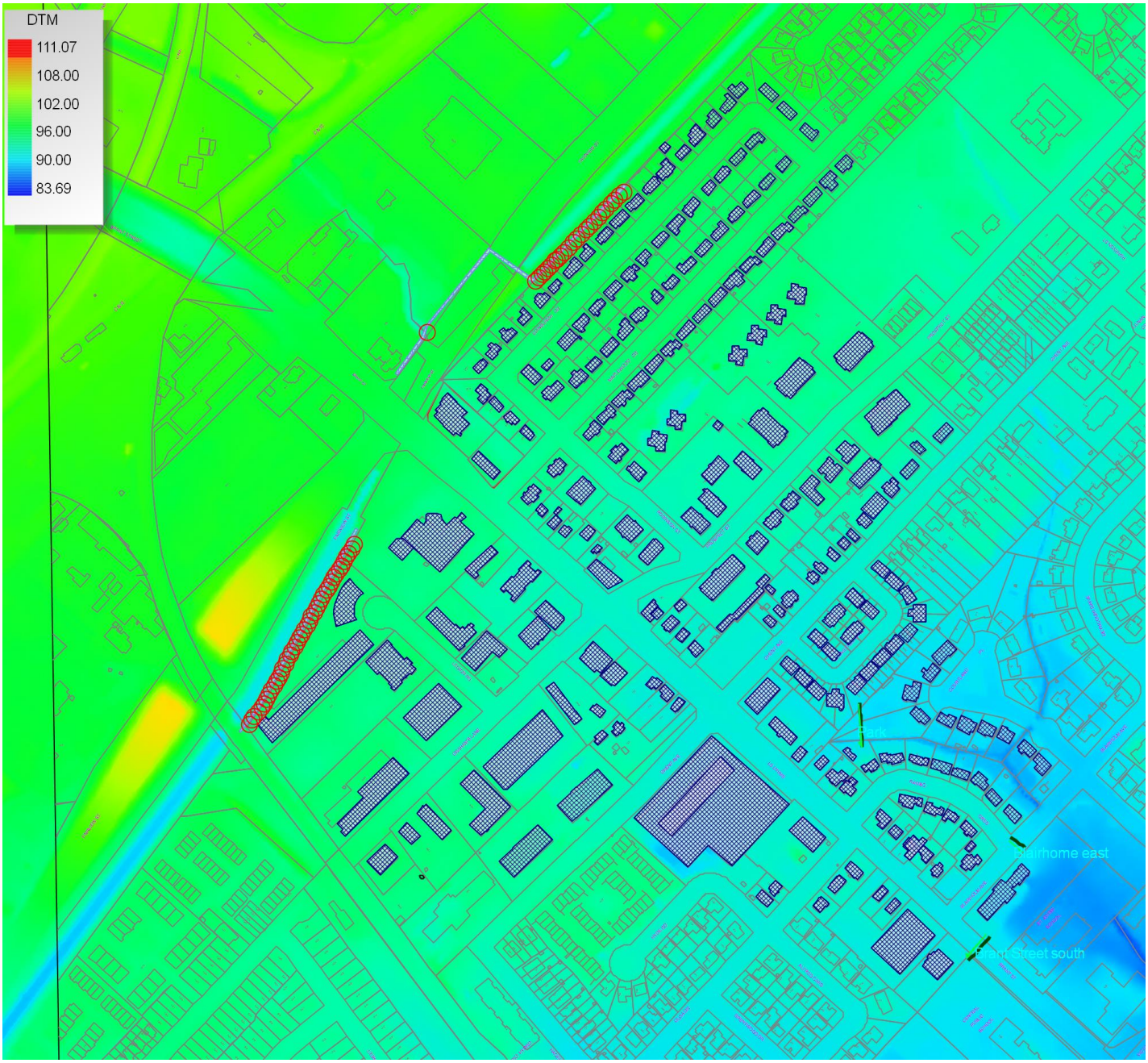


Figure 9 - Showing DTM 688 Brant Regraded (Developed)

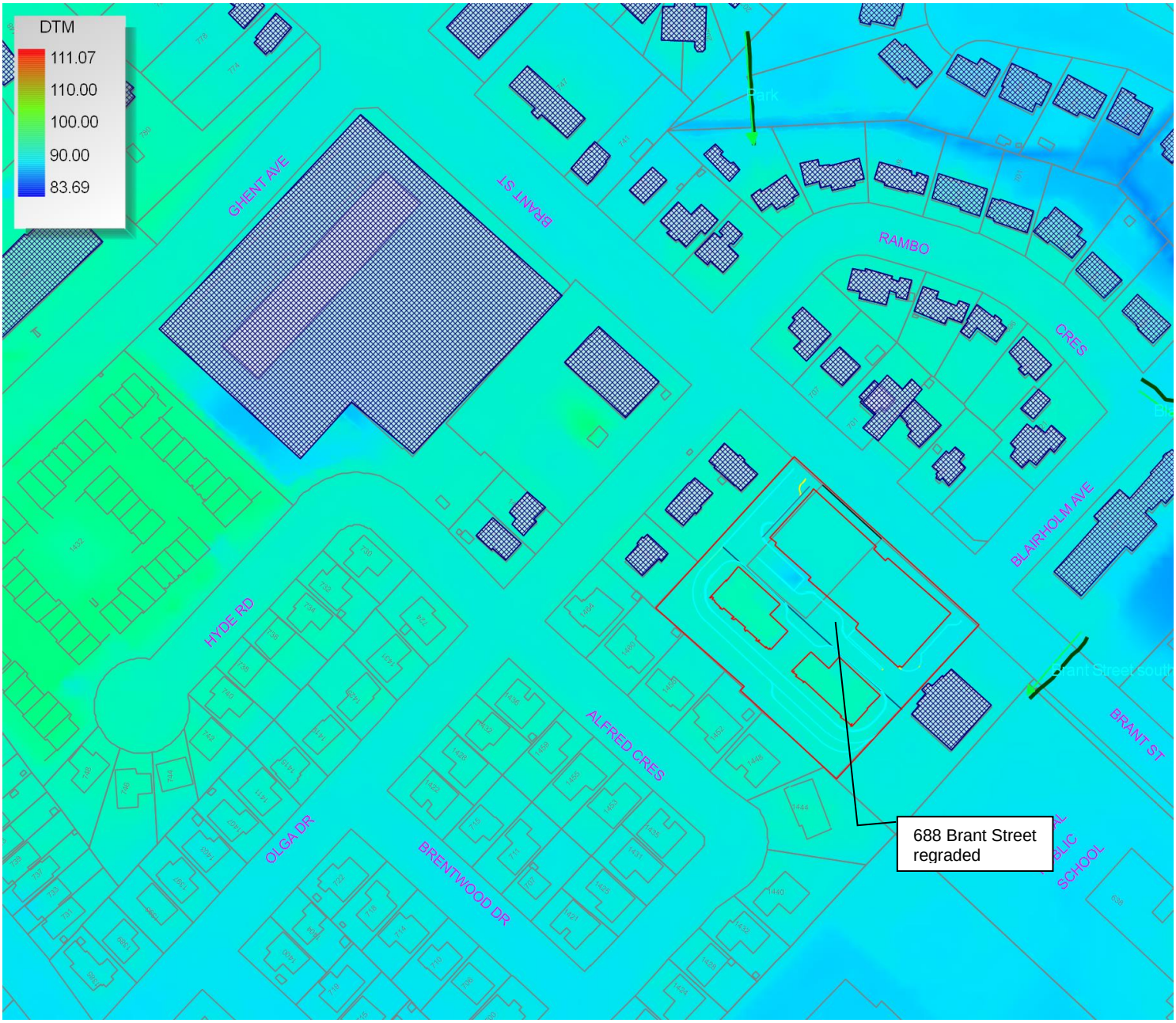
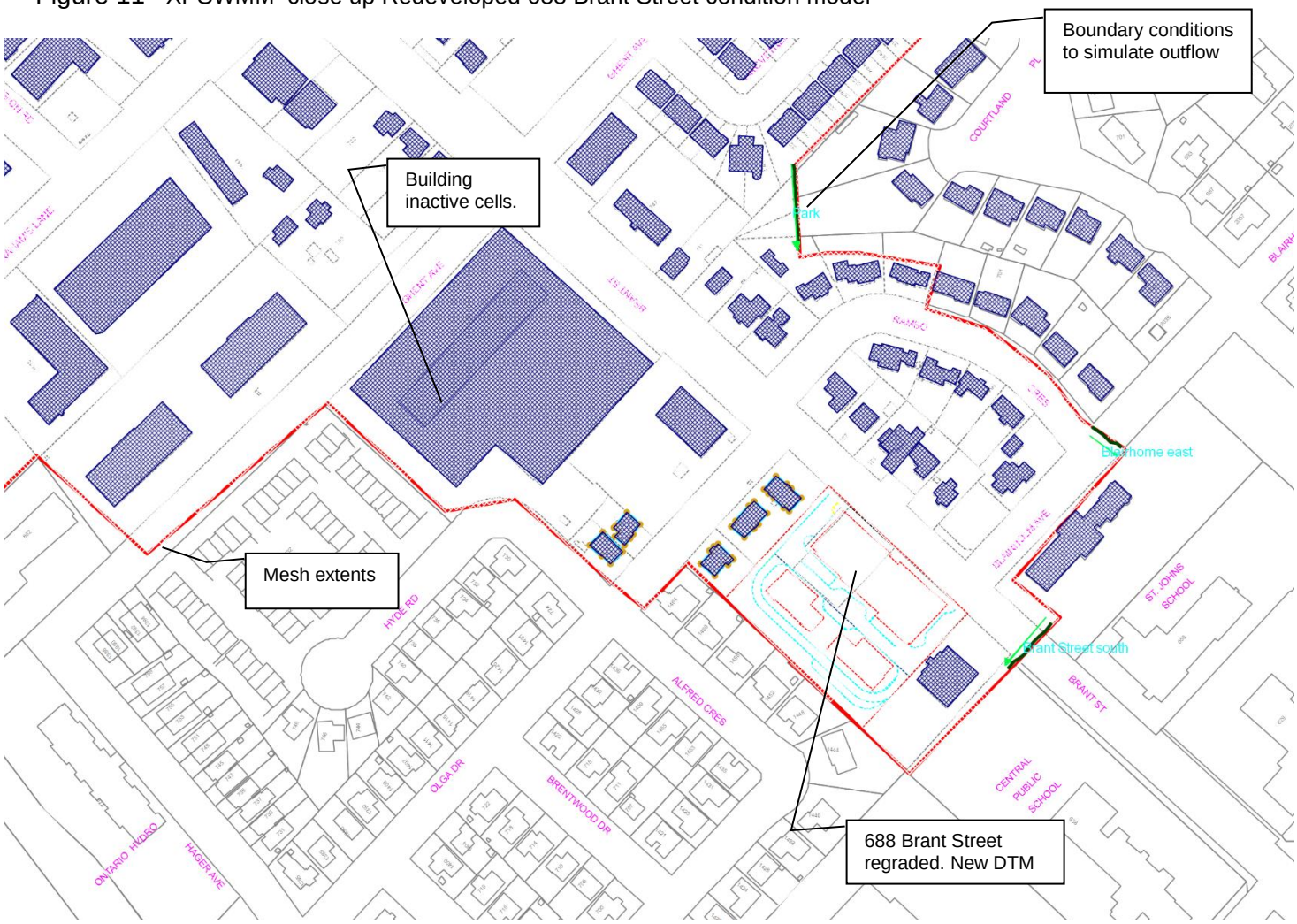


Figure 10 - XPSWMM close up existing condition model



Figure 11 - XPSWMM close up Redeveloped 688 Brant Street condition model



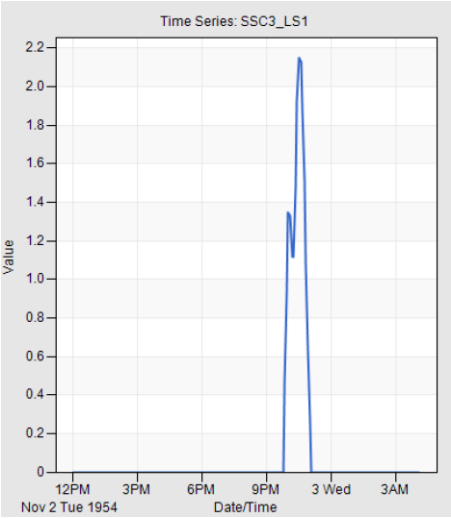
Note, the following is the difference between existing and 688 Brant Street redeveloped

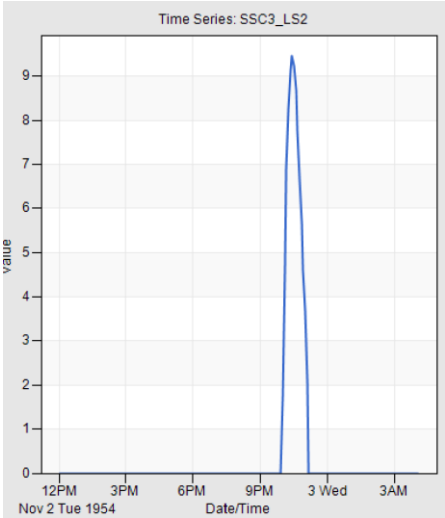
1. Revised DTM to reflect new grading for 688 Brant street.

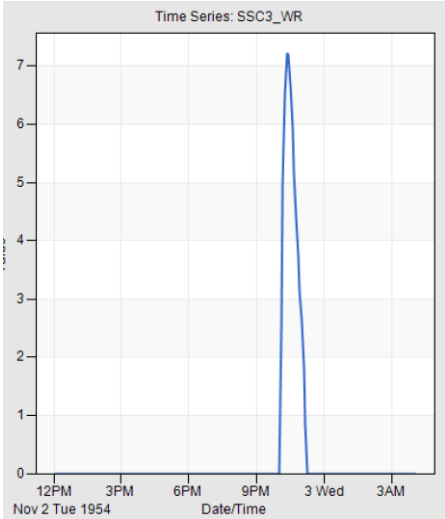
INFLOW HYDROGRAPHS:

The PCSWMM model under scenario 3 had inflow inserted by a series of nodes. The global times series are as follows: (refer to Figure 2)

1. LS1 spill flow from Spill 1
2. LS2 spill flow from Spill 4
3. WR spill flow from Spill 2 and 3







LS1 was divided among 24 nodes
LS2 was divided among 43 nodes
WR was input as shown at one -node

The divisions were copied from PCSWMM and pasted into XPSWMM.

BOUNDARY CONDITIONS:

1. Upstream we used fill polygons behind the inflow nodes to force flow away from the cells at the edge. This will prevent stacking of water at the edge of the grid.

2. The downstream boundary are at the same location as PCSWMM model. See figure 7. In essence these boundaries are like outflow nodes in 1D model. The PCSWMM model uses a series of nodes as free flow outflow along this line. XP2D has a similar outcome but using a polyline and setting the elevation verses time below the DTM for that line.

3. Fill polygons (artificial) were used to create walls to deflect flow to desired areas. The cells within the polygon are raised to the desired elevation. We will use this in the first scenario to deflect flow away from the edge.

MODEL RUNS:

The XPSWMM model will be run under the following scenarios:

1. Existing (subject site not developed) existing flow conditions, existing DTM
2. Developed (subject site developed) existing flows, revised DTM.

The 1D-2D model was run under the Regulatory storm event (Hurricane Hazel). Based on the Wood report there are no spills from the 100 year event.

SENSITIVITY ANALYSIS

Since we are using flows and grid roughness and the same DTM we do not see a reason for a sensitivity analysis. We assume Wood looked into variation of input variables when they prepared their report.

DISCUSSION OF SENSITIVITY ANALYSIS:

N/A

DISCUSSION OF MODELLING OPTIONS:

Option 1 – regrade the subject site and run the model.

Option 1 is the only option, since we cannot deflect water from the subject site. See results below.

RESULTS

The purpose of the 1D-2D model was to ascertain the flood extends. In particular we want to evaluate the effects of flood hazards. We will show the 2D colour maps showing the following:

- Water Depth m
- Hazard (v x depth)
- Bed shear Calculations

In addition the sectional plots showing section plots with the HGL will be shown.

Refer to figures below for the maps and sections.

Maps will be for depth, hazard and Bed shear.

SCENARIO 1 Site existing conditions existing flows

Figure 12 - XPSWMM depth MAP- site undeveloped existing flows

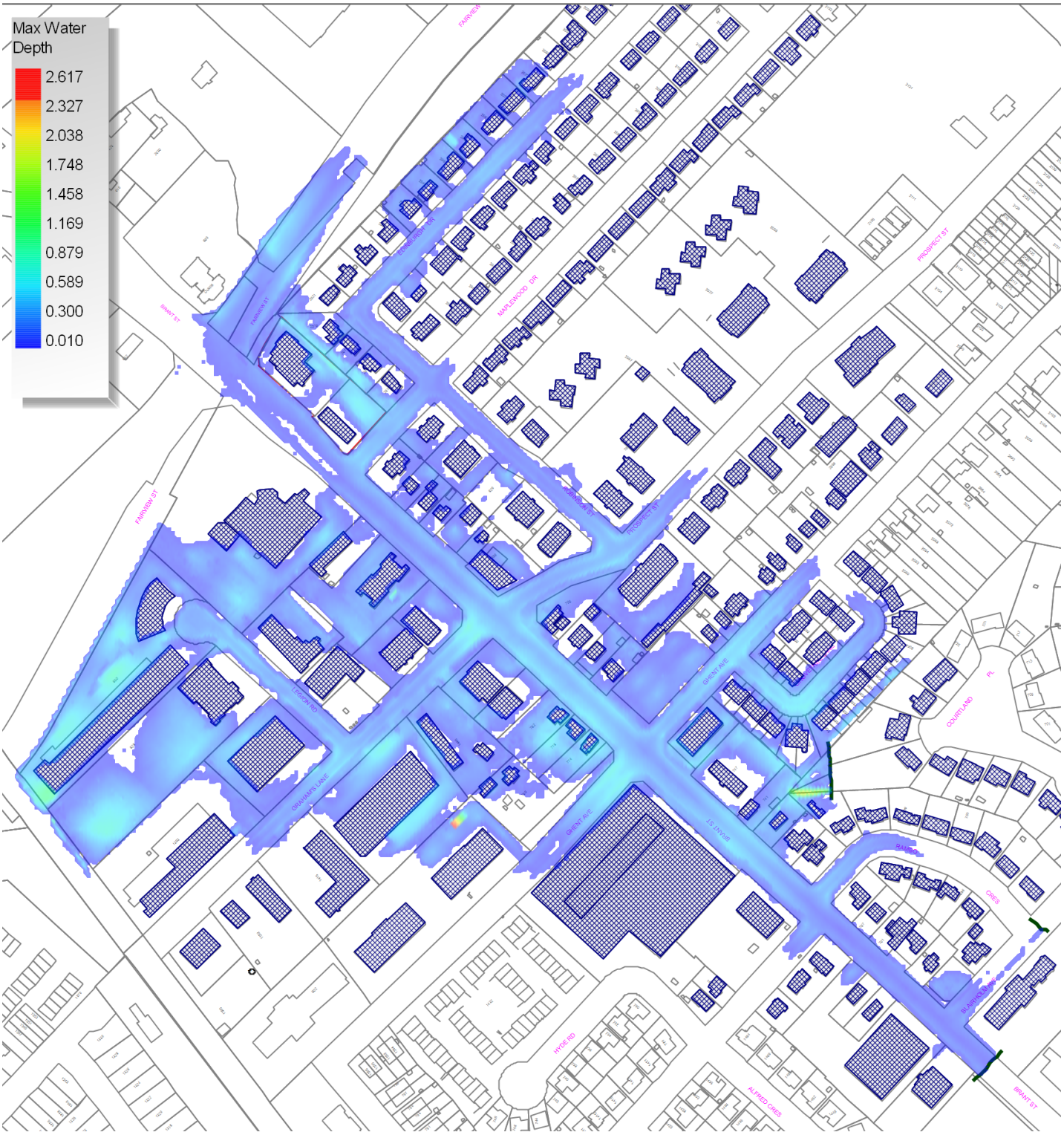


Figure 13 - XPSWMM hazard MAP- site undeveloped existing flows

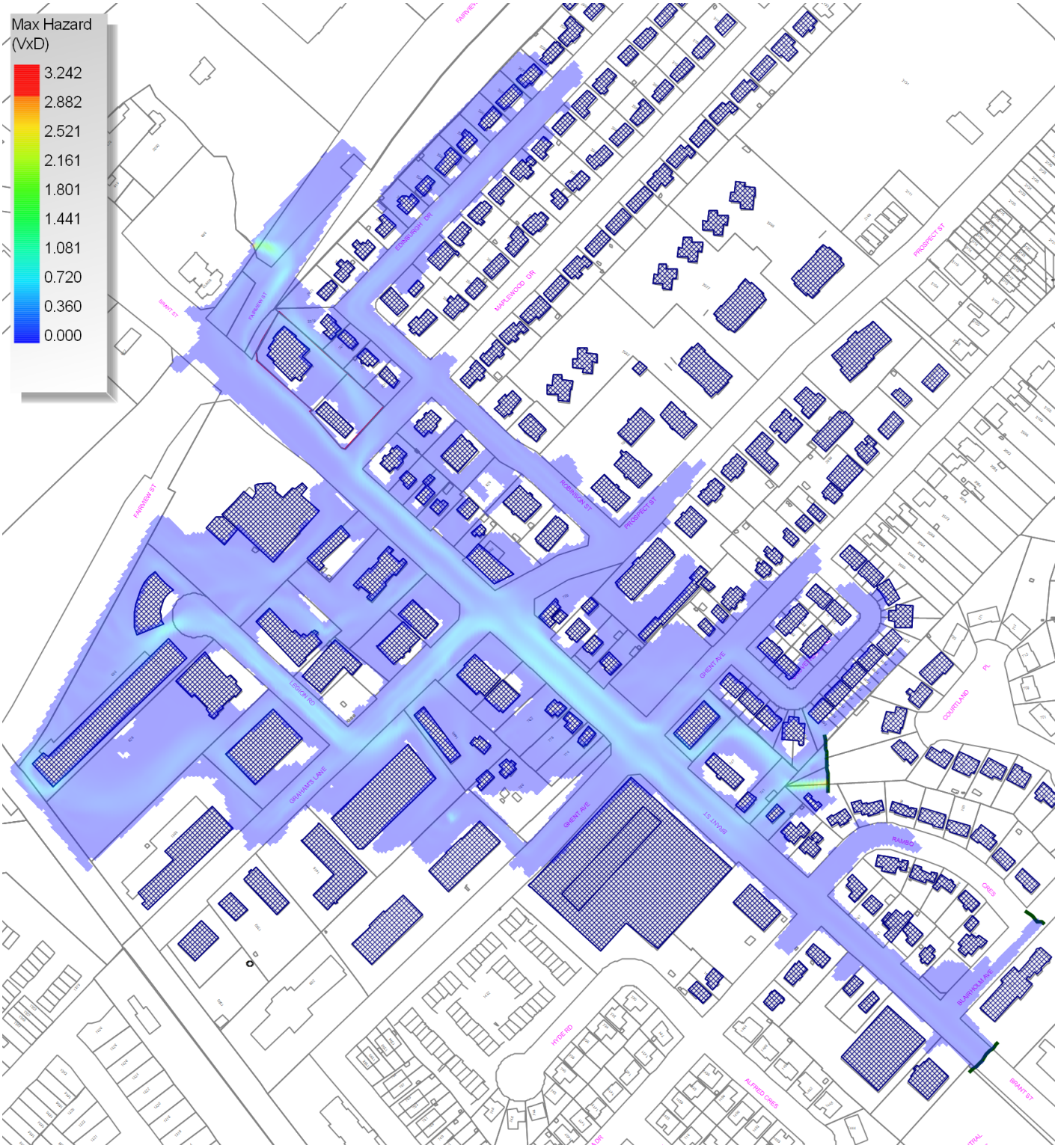
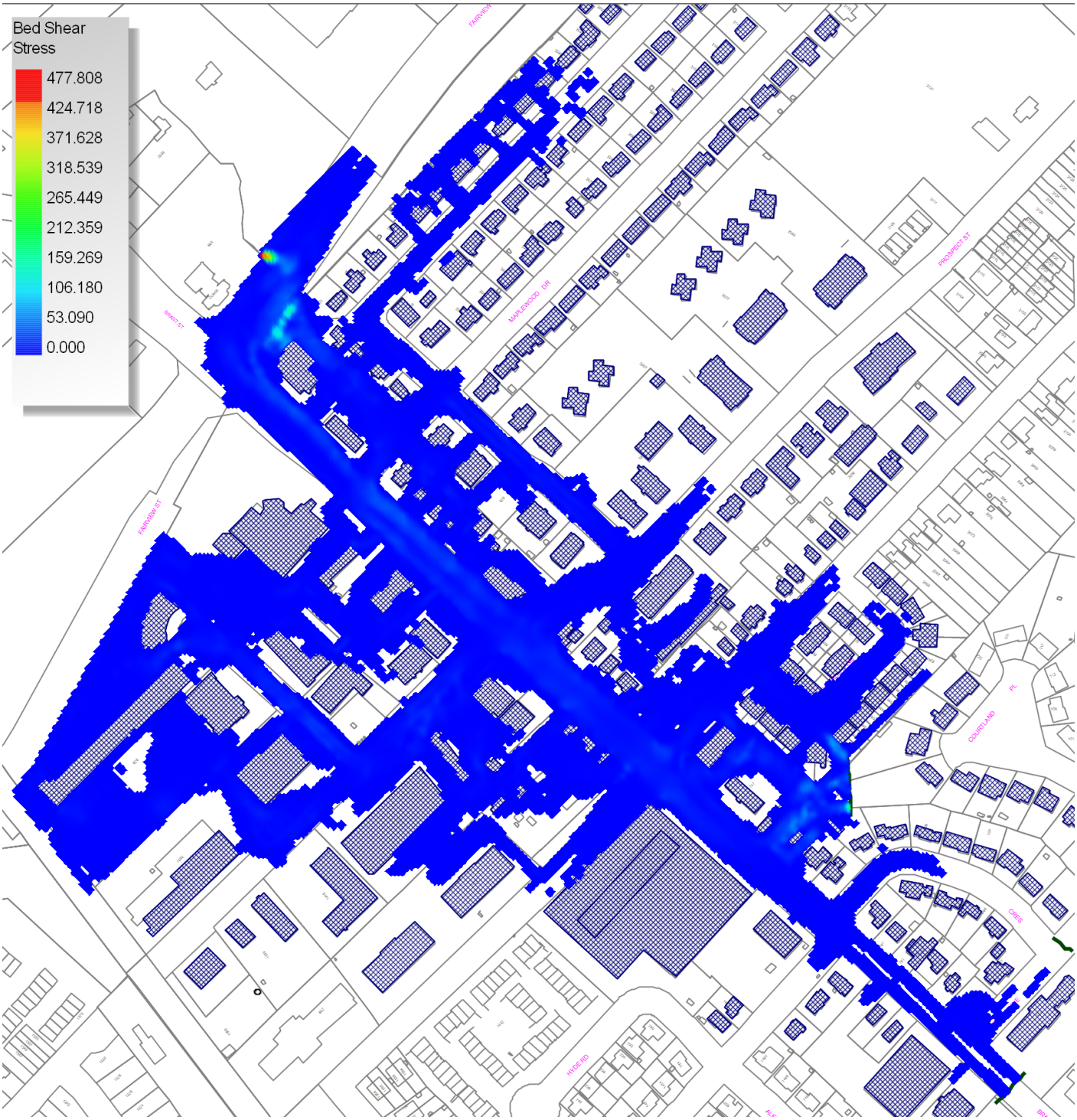


Figure 14 - XPSWMM Bed Shear MAP- site undeveloped existing flows



SCENARIO 2 – 688 Brant Street Site developed existing flows

Figure 15 - XPSWMM depth MAP - 688, 694 & 698 Brant Street Site developed

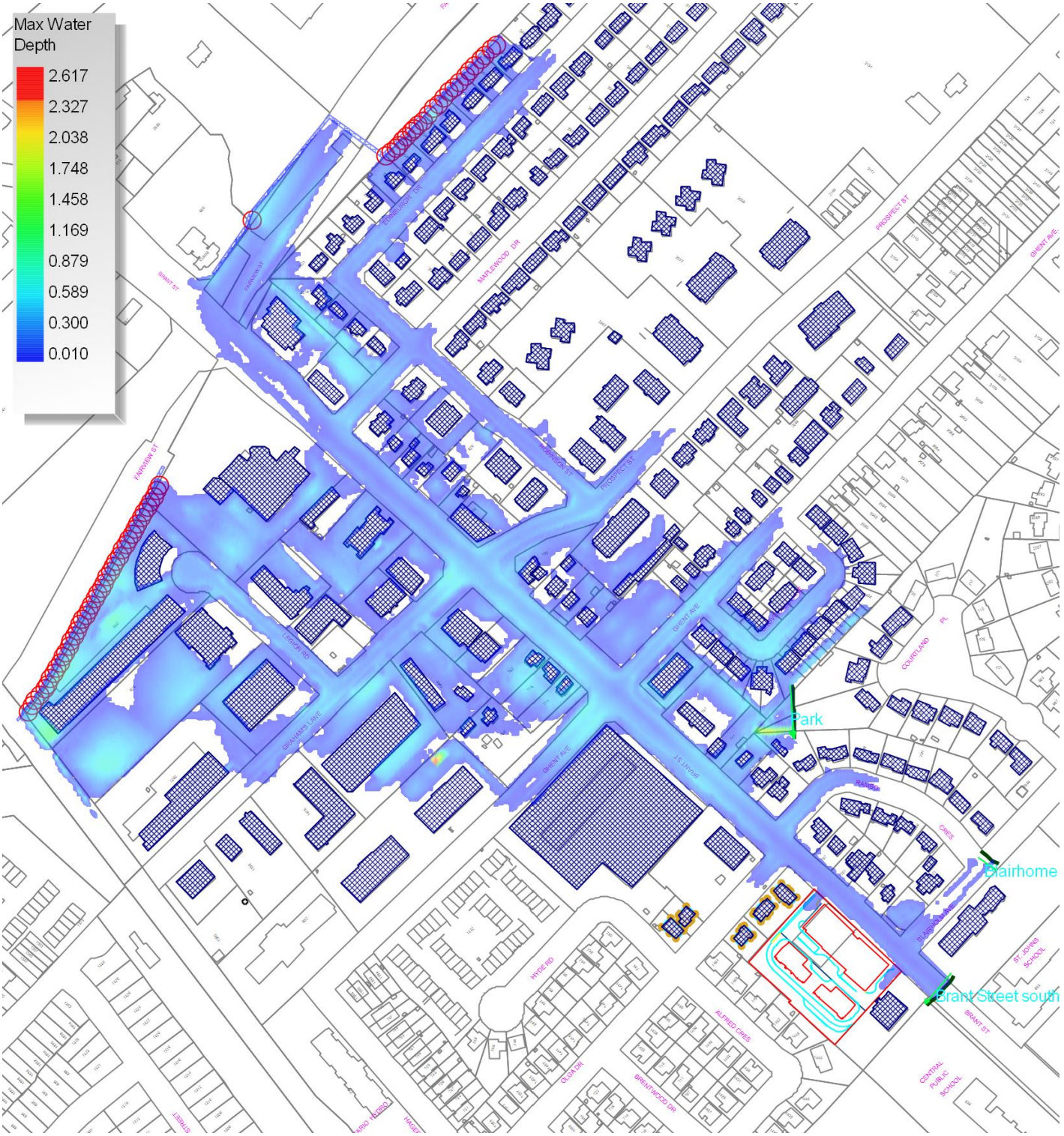


Figure 16 - XPSWMM hazard MAP- 688, 694 & 698 Brant Street Site developed

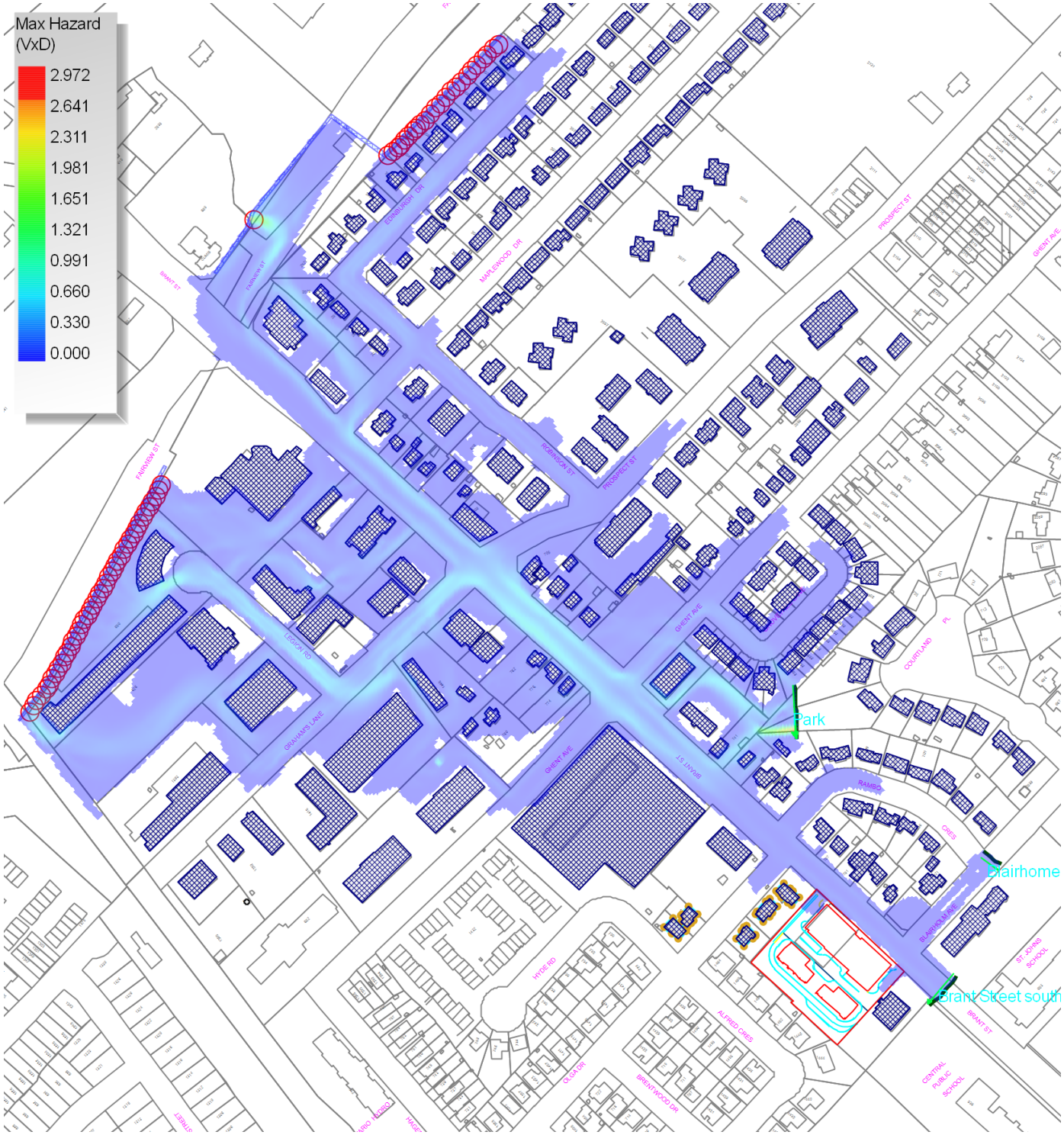
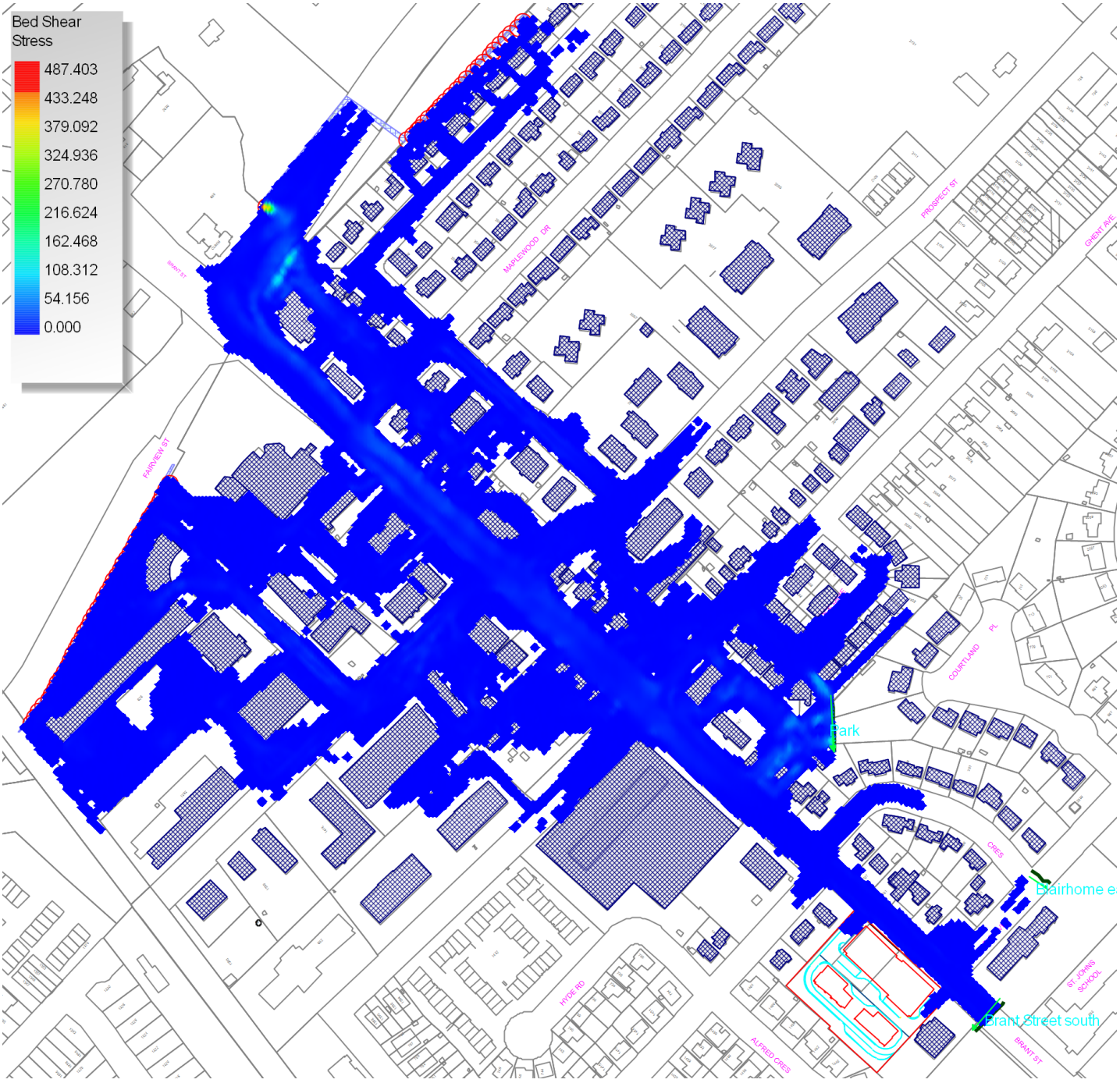


Figure 17 - XPSWMM Bed Shear MAP- 688, 694 & 698 Brant Street Site developed



SECTION PLOTS AND POINT HEAD PLOT



The purple point are locations where HGL are retrieved. The green lines are the cross section where HGL plots are retrieved. See table 1 for points summary. See below for the section plots. It should be noted that the geospatial locations of these points and sections are identical for existing conditions scenario and 688 Brant street developed scenario.

Table 1 Summary of hydraulic effects existing and 688, 694 & 698 Brant Street Developed

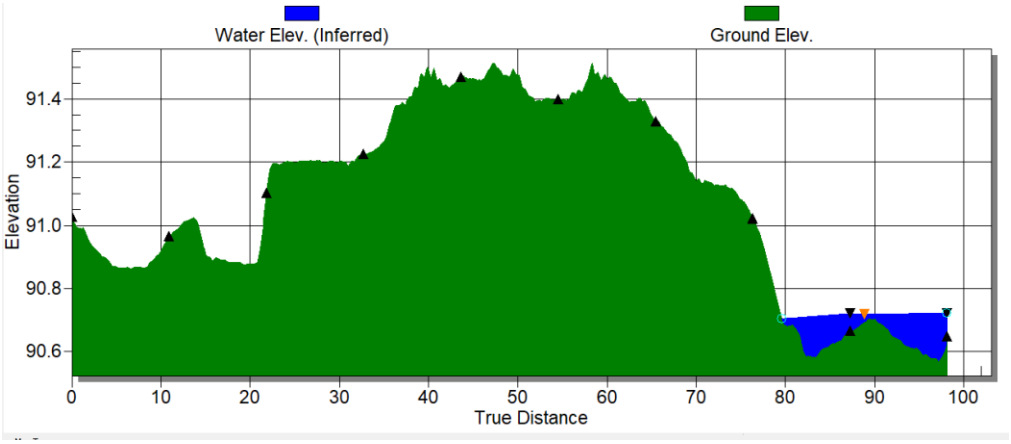
	Depth (m)		HGL (m)	
Location	existing	Developed	existing	Developed
Point 1	0.00	0.00	91.10 (Gnd)	90.81 (Gnd)
Point 2	0.05	0.05	90.75	90.75
Point 3	0.15	0.15	90.60	90.60

Note, all developed HGL are at or below the existing conditions.

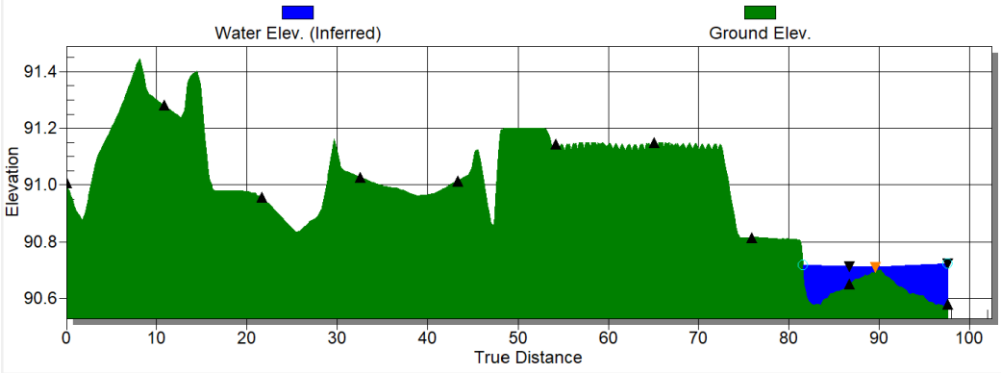
SECTION PLOTS

Profile 1

Existing



688 Brant Developed



EROSION REVIEW:

The bed shear stress is calculated as follows in XP2D:

$$\tau_{bed\,(metric)} = \frac{\rho g v^2 n^2}{y^{1/3}}$$

where:

ρ = Density

g = Gravity

v = Velocity

n = Manning's n

y = Depth

Units are in N/m^2

Reproduced from HEC-15, FHWA-NHI-01-021 August 2001, Urban Drainage Design Manual, the following are the recommended shear stress as per vegetative cover.

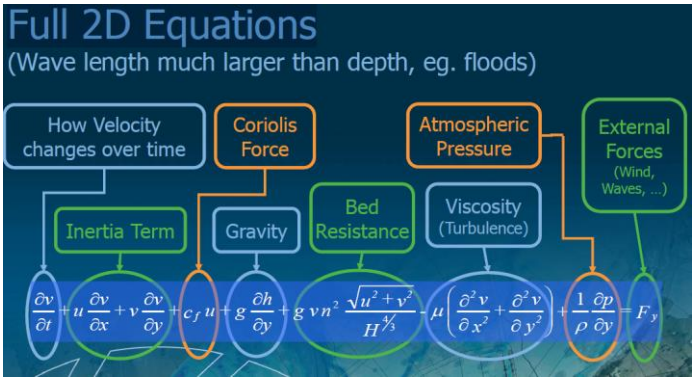
Lining Category	Type	Permissible Unit Shear Stress (Pa)
Vegetative	Class A	177.2
	Class B	100.6
	Class C	47.9
	Class D	28.7
	Class E	16.8

Refer to the bed shear maps above for the calculated unit shear stress. Majority of the cells in the residential landscaped area and the ditch area have bed shear stress less than 100 N/m2. Note this is for the Regional Storm. The typical 2 year would not generate anywhere near the 100 N/m2 shear stress.

COMPARISON OF PCSWMM MODEL AND XPSWMM MODEL:

Since we virtually used the same input data and topology the only difference is the 2D formulations. At this point I would like to reveal that PCSWMM is not a true 2D model. The Vendor for PCSWMM (CHI) admits that they do not solve the Coriolis force and turbulence (eddy viscosity), thus cannot be used where friction dominates (eg. shallow flow). In addition the UK Environmental Agency 2D Benchmarking findings, show Pseudo-2D unsuitable for detailed flood hazard and impact assessments.

XP2D is a full 2D model. It solves the SWE as shown below



The comparison of results between XPSWMM and PCSWMM will be as follows:

The only possible comparison is the existing conditions (Wood report) scenario 3.

1. Compare Depth at local area around 688 Brant street with labels.
2. Compare velocity at local area around 688 Brant street with labels.
3. Outflow comparison downstream.

See below for depth and velocity comparison. See table 2 for outflow comparison.

Table 2 Comparison of Outflow

	PCSWMM	XPSWMM
Location	Simulated Peak Outflows (m3/s)	Simulated Peak Outflows (m3/s)
West Branch of Lower Rambo Creek	15.88	15.80
Brant Street South of Blairholm	1.33	1.07
Blairholm Ave	0.0	0.02

Discussion on Comparison:

1. The outflows match well.

2. The 5m cell density in PCSWMM is too crude to pick up water depth in urban areas. XP2D 2.0m density is much more conducive to Urban 2D simulations. The depth results are similar.

3. The velocity formulation in PCSWMM is not as accurate due to the diffusive wave formulation which cannot incorporate cross-momentum/inertia and eddy viscosity which are important for velocity calculations. Velocities are greatly different due to the formulation of PCSWMM.

4. The hazard calculation (depth x velocity) thus will be lower in PCSWMM.

Figure 18 - Max Depth (M): PCSWMM Followed by XPSWMM

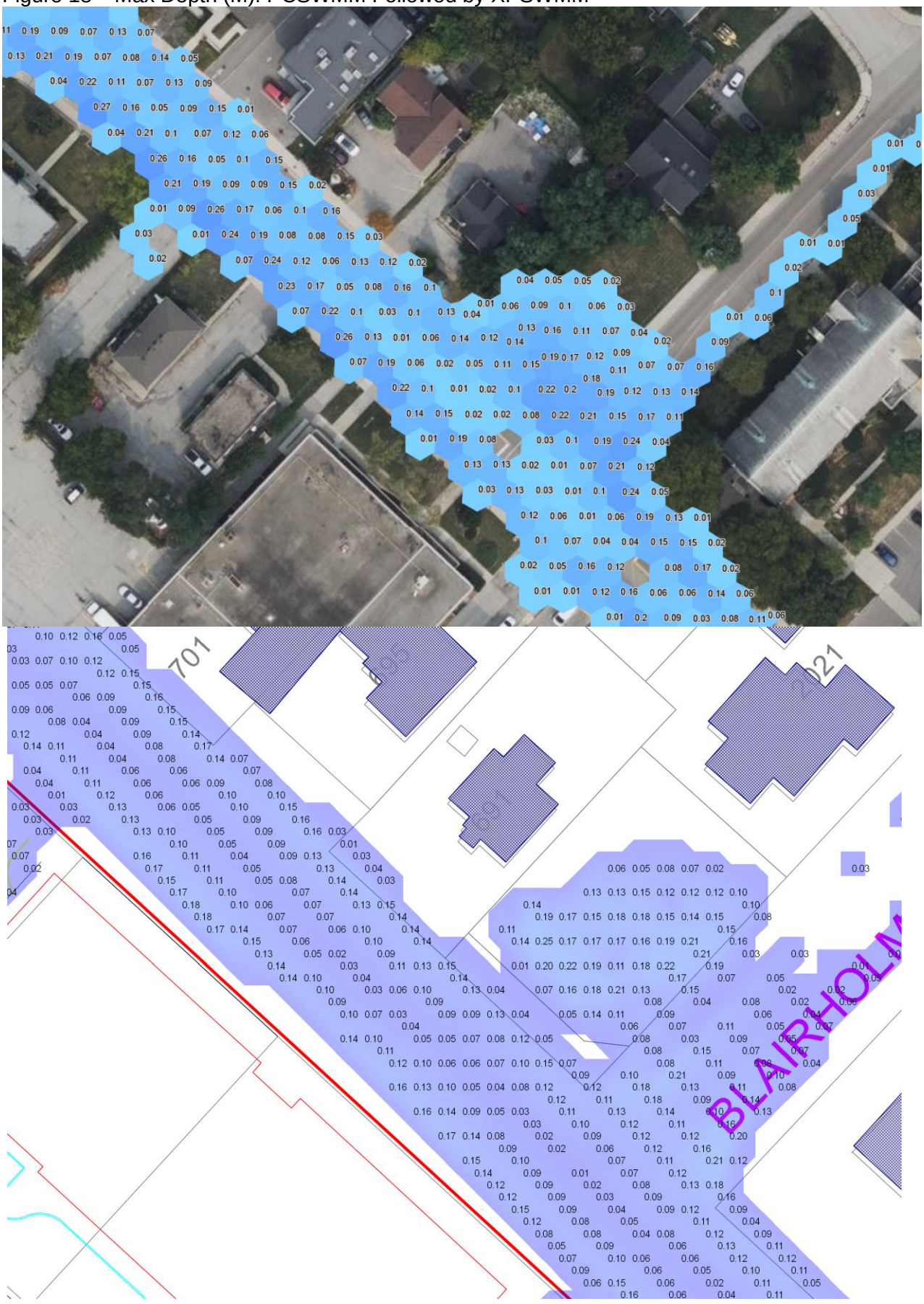


Table 3 - XPSWMM comparison of Outflow – existing and redeveloped

	Existing	688 Brant Street redeveloped
Location	Simulated Peak Outflows (m3/s)	Simulated Peak Outflows (m3/s)
West Branch of Lower Rambo Creek	15.80	15.60
Brant Street South of Blairholm	1.07	1.02
Blairholm Ave	0.01	0.01

DISCUSSION OF XP2D MODEL:

The following items are in no particular order.

1) There are no celerity issues with the model.

2) The continuity error is excellent.

3) There were no error messages from the analysis.

4) The HGL maximum at any given point in the system is the most useful result. The animation of the flow with time, best shows how the upper flows are attenuated through the system and the effect of downstream tail water if it exists.

5) Hydro-dynamic models provide the most accurate, reliable and defensible representation of flows in the collection system. They account for varying inflows, non-coincident peak flows, in system storage, hydrograph attenuation, and tail and backwater effects. In addition the integration with a 2D model allows accurate spill over calculations of the Flood plain along with the attenuation effects of the spill.

6) **The following are the key items affecting HGL in dynamic models:**
   - pipe and or channel volume,
   - length of flow, spill and volume in the spill area,
   - runoff hydrograph (length in time and volume),
   - timing of peaks which are controlled by the above.

7) The analysis is based on clean channels. No percentage blocked.

4. REVIEW OF INGRESS/EGRESS AND RISK ASSESSMENT

INGRESS/EGRESS

Source: (Ontario MNR Technical Guide – River and Streams Systems: Flooding Hazard Limits, 2002).

MNR Technical Guide Appendix 5 page 28 states the question of safety for the passage of vehicles can be subdivided into:

- Flood depth and velocity considerations affecting egress of private vehicles from flood proofed areas;
- Flood depth and velocity affecting access of private and emergency vehicles to flood proofed areas.

The highest priorities for access to emergency vehicles should be given to police, ambulance and fire services, especially where evacuation is a distinct possibility in areas surrounded by flooding.

Access to the proposed development will be provided via Brant Street at entrances.

Private Vehicle: at entrances allowable depth 0.3 m and velocity of 3.0 m/sec, hazard 1.0 m2/sec

Table 4 - Depth and velocity at the ingress/egress points (private vehicles)

	POST DEVELOPMENT – XPSWMM results		
Location	Max Depth of water (m)	Max Velocity (m/sec)	Max Hazard d x v (m2/sec)
INGRESS/EGRESS Brant Street	0.13	0.006	0.0

Therefore, Private vehicle ingress/egress is not an issue.

Emergency Vehicle: at entrances allowable depth 0.9 m and velocity of 4.5 m/sec for firefighting and depth 0.3 m and velocity of 3.0 m/sec for police and ambulance and hazard of 1.0 m2/sec (MNR Technical Guide).

Table 5 Depth and velocity at the ingress/egress points (emergency vehicles)

	POST DEVELOPMENT – XPSWMM results		
Location	Max Depth of water (m)	Max Velocity (m/sec)	Hazard d x v (m2/sec)
INGRESS/EGRESS Brant Street	0.13	0.006	0.0

Therefore, emergency vehicle ingress/egress is not an issue.

Pedestrian: at entrances allowable depth 0.8 m and velocity of 1.7 m/sec and max hazard of 0.40 m2/sec (MNR Technical Guide).

Table 6 Depth and velocity at the ingress/egress points (Pedestrian)

	POST DEVELOPMENT – XPSWMM results		
Location	Max Depth of water (m)	Max Velocity (m/sec)	Max Hazard d x v (m2/sec)
Entrance to site from Brant Street	0.13	0.006	0.0

Therefore, Pedestrian ingress/egress is not an issue.

Emergency Vehicle on Brant Street: allowable depth 0.9 m and velocity of 4.5 m/sec for firefighting and depth 0.3 m and velocity of 3.0 m/sec for police and ambulance and hazard of 1.0 m2/sec (MNR Technical Guide).

Table 7 Depth and velocity at the ingress/egress points (emergency vehicles)

	POST DEVELOPMENT – XPSWMM results		
Location	Max Depth of water (m)	Max Velocity (m/sec)	Max Hazard d x v (m2/sec)
INGRESS/EGRESS Brant Street	0.14	0.77	0.11

RISK ASSESSMENT:

Application of the 2 x 2 rule (see Ontario MNR Technical Guide – River and Streams Systems: Flooding Hazard Limits, 2002) used in the assessment of potential loss of life. The 2 x 2 rule defines that people would be at risk if the product of the velocity and the depth (HAZARD) exceeded 0.40 square metres per second or if velocity exceeds 1.7 metres per second or if depth of water exceeds 0.8 metres. (Source MNR flood plain management).

Based on the above the risk is low.

5. DISCUSSION/COMMENTARY AND OBSERVATIONS

The following are in no particular order:

1) The proposed infill development will not have a negative effect on the properties adjacent to the Site when developed.

2) Erosion is not a concern for the subject site. Refer to section on erosion review.

3) Emergency vehicles can easily negotiate Brant street.

4) The outflows to the three outfall locations from the 2D grid are approximately the same.

5) The existing conditions and conditions when 688 Brant is developed are essentially the same. Refer to figures 12 to 17.

6. RECOMMENDATIONS

Based on the XPSWMM model (1D/2D) and the review of documentation and design criteria received, we recommend and conclude the following:

1. The proposed redevelopment of 688 Brant Street be allowed.

7. REFERENCES

1. Global Mapper User's Manual for Global Mapper v24.0.

2. Flood Hazard and Scoped Stormwater Management Assessment, Burlington GO Mobility Hub and Downtown, prepared by Wood Environmental, January 8, 2020.

3. City of Burlington, Stormwater Management Design Guidelines, May 21, 2020.

4. Ontario MNR Technical Guide – River and Streams Systems: Flooding Hazard Limits, 2002.

5. FEMA Chapter 4 - Flood Risk Assessment.

6. **PCSWMM users Guide** by CHI 2022

7. **XPSWMM users Guide** by Innovyze 2023.

8. **EPA SWMM 5**, Build 5.0.022, Manual.

9. American Society of Civil Engineers “Flood Resistant Design and Construction” **ASCE STANDARD ASCE/SEI 24-05** Published by the American Society of Civil Engineers, 2005.

10. USACE **“Flood Proofing Regulations”** US Army Corp of Engineers, June 1972.

11. FEMA “**Flood Damage-Resistant Materials Requirements**”, for Buildings Located in Special Flood Hazard Areas in accordance with the National Flood Insurance Program Technical Bulletin 2 / August 2008.

Respectfully Submitted;

The Odan Detech Group Inc.

Date: January 13, 2023
John Krpan, M.S.C.E. P.Eng



APPENDIX A

Flood Plain Maps for the 688 Brant Street Area

Flood Maps – to be determined once CH and City finish review of Wood Phase 2 and review of this report