Appendix 1
Communication and Correspondence

Meeting Minutes

DATE:	08 May 2019
FILE NO.:	3861

DATE OF MEETING: 06 May 2019

ATTENDEES:		
	NICOLAS KEAST	Greenland Consulting Ltd.
	BRAD PARKER	Greenland Consulting Ltd.
	CASSIDY MORGAN	Greenland Consulting Ltd.
	NATASHA BIRCH	Town of Collingwood
	JOHN VELICK	Town of Collingwood

RECORDED BY: Brad Parker

RE: **TOWN OF COLLINGWOOD EXISTING CONDITIONS MODELLING PROJECT INITIATION MEETING**

Note: The following minutes are considered to be an accurate record of the action items discussed at the meeting with the above parties. Any discrepancies should be reported to the author immediately.

ITEM	COMMENTS	ACTION
1.	**Schedule**	
a	• Bi-weekly meetings are to be conducted for the initial stages of the projects and will be evaluated as the project moves forward. If the project team identifies less productive meetings, then the frequency of meetings may be scaled back as needed. • Communication and data gathering will be key for the success of the project. • J.Velick advised that GRN should update schedule per the new start date and ensure schedule is followed. A Project of this nature has the tendency to go over schedule and Town / Consultant would like to avoid delays.	**GRN** **GRN**
2	**Background Review**	
	• N.Keast advised that GRN will investigate previous studies for each watershed to establish a baseline script for the existing conditions modelling (McLaren, Black Ash Creek study, Subwatershed plans if any, Cranberry MSP etc.) Town to Send any studies not readily available. • Town advised they have an Active Development Map including existing as well as approved but not yet constructed subdivisions. J.Velick mentioned that this is an existing conditions study and some subdivisions have been approved for years without being constructed, therefore GRN will consult with Town on which approved subdivisions to model as open space.	**TOWN** **TOWN/ GRN**

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ITEM	COMMENTS	ACTION
	• Town has copies of ECAs for newly constructed SWM ponds, which will reference the reports for the stormwater calculations. GRN most interested in hydraulic grade line of ponds. If no reports exist, GRN will have to make assumptions.	**TOWN**
	• N.Birch asked if there is a size limit threshold for division of catchments in town? N.Keast advised it would likely be on a block by block basis depending on the area of town, some cases may require smaller contributing areas, i.e. manhole to manhole.	
	• N.Keast advised that some older SWM ponds and manholes may have orifices that aren't documented properly and GRN will have to make assumptions on outgoing flows. J.Velick advised information post 2012 is most reliable, pre 2012 may not have controls. It is understood that assumptions need to be made on old/non-existent reports.	
	• J.Velick asked how GRN plans to model in Town developments with storage. N.Keast advised that GRN will be relying on LiDAR for ground storage with some ground survey verification. N.Keast asked if there is underground storage for urban developments. J.Velick advised that some use manholes and pipes for storage. Again GRN will have to make assumptions if orifices exist in the manhole and aren't documented.	
	• Town to send release rates for town sites (25mm storm event)	
	• GIC to generate template for Town to fill in with known discharge information, data gaps will be evident.	**GRN**
	• Town to forward release rates / HGLs for ponds with up to date information.	**TOWN**
	• GRN plans to prepare a Model Basis Report which includes the understanding of conditions/methodology, list of events, and what is to be model. The intention is to get sign off from the Town and the Conservation Authority (NVCA) prior to actual modelling.	
	• A meeting with the NVCA is needed prior to completion of the report to go over the methodology and ensure acceptable to NVCA.	**GRN**
	• N.Keast advised that GRN subs had already started survey of Manholes (MH) in old parts of Town where as-builts likely don't exist.	
	• Town would like the Pretty River catchment prioritized as per previous discussions.	
3	**Stakeholder Meetings**	
	• N.Keast asked if project team should engage the surrounding municipalities ? J.Velick replied no. This should be an existing conditions report and doesn't really apply to other municipalities.	
	• Discussion surrounding Townline Creek as it is both NVCA and GSCA jurisdiction. GRN to make GSCA aware of study but is working with NVCA primarily.	**GRN**
	• Nic to send map to Town for jurisdictional limits of CAs.	
4	**Survey/ LiDAR**	
	• LiDAR is being flown in updated datum – some differences between 1928 and 2013 Datums, N.Keast advises as much as 40cm potential difference. J.Velick asked how will we know which datum other as-builts are in? GRN will have to work with Town and confirm datum and convert if necessary.	TOWN/GRN

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ITEM	COMMENTS	ACTION
5	**Monitoring**	
	• Discussion surrounding Oak St. Canal SMS 2D model. Town to send report to GRN. N.Keast asked if there was monitoring on-going? Ans. No. • GRN has sent out an RFP for instream monitoring to 3 companies. GRN will have three (3) monitors, two (2) in sewer and one (1) in channel. Town also has monitor in sewer on High St. (Tatham). • Arrange a meeting with Lindsey (Town) and George /Kirsten (GRN) to set up unique identifiers in PCSWMM / HEC-RAS model as town will import to GIS and then won't need to convert IDs. • Town uses MTO for Climate Change IDF.	**Town** **GRN**
6	**Other Business**	
	• Natasha will be principal point of Contact with Town, cc: J.Velick. • Invoices to be sent to J.Velick with monthly invoice total, summary of costs to date and remaining budget.	

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Meeting Minutes

DATE: 22 May 2019
FILE NO.: 3861

DATE OF MEETING: 22 May 2019

ATTENDEES:

NICOLAS KEAST	Greenland Consulting Ltd.
CASSIDY MORGAN	Greenland Consulting Ltd.
KIRSTEN MCFARLANE	Greenland Consulting Ltd.
NATASHA BIRCH	Town of Collingwood
JOHN VELICK	Town of Collingwood

RECORDED BY: Cassidy Morgan

RE: **TOWN OF COLLINGWOOD EXISTING CONDITIONS MODELLING PROJECT UPDATE MEETING**

ITEM	COMMENTS	ACTION
1.	**Review Action Items from Previous Meeting**	
	• A live/updating schedule will be used throughout the project to ensure accurate timelines for better communication. Brad to send most recent version to Town, including specific end date. (Approximately January 2020)	**GRN**
	• Town will review template sent by GRN and identify & include missing studies not identified by GRN	**Town**
	• Town to send dropbox of ECA's for newly constructed ponds and as-builts to build database/PC-SWMM.	**Town**
	• GRN to send excel template to Town.	**GRN**
	• GRN to prepare a model basis report with information from template, reports etc. Goal to have model basis report complete by arrival of LiDAR, but estimated 3 weeks.	**Town**
	• GRN and Town will be participating in a telephone call with NVCA in the morning of May 23 2019 to discuss scope of project and to schedule the next meeting/discussion.	**GRN/Town**

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ITEM	COMMENTS	ACTION
	• GRN confirmed with Town that GSCA was aware of study. CA jurisdiction limits were observed, recognizing GSCA only affects a small portion of project. Nic to confirm permission to use GSCA's data and modelling reports. • Arrange meeting between Lindsay and Kirsten to set up unique identifiers in PCSWMM/ HEC-RAS model.	**GRN** **GRN**
2	**Template**	
	• The template provided by GRN was reviewed and discussed. • Town to send reports and fill in template with site information (discharge, release rates, HGLs). Forward information as received. • GRN will find and extract information from SWM reports and background studies sent by Town • Town suggested using Regional Reports would be more effective instead of specific subdivision locations • Requested information from background studies • First priority: o **As-Builts** o SWM Reports o ECAs o Background zones o Site plans • Kirsten will be getting as-builts implemented while surveys come in. • Understood that data gaps will be evident	**Town** **GRN** **Town** **GRN**
3	**Risk Identification**	
	• High level risks identified by GRN were reviewed and discussed with Town. • Management methods for schedule o Coordinate early, update schedule if issues arise o Determine a decision for type of datum as soon as possible	
4	**Survey/ LiDAR**	
	• GRN mentioned the start of LiDAR on May 21 2019. • GRN and Town to determine what datum to use for LiDAR, as-builts, etc. Town would like to get in contact with GSCA, municipals, counties, other firms to decide best course of action.	**Town**

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ITEM	COMMENTS	ACTION
	• GSCA is converting all data to new datum • GRN will send more details regarding datum to Town. GRN to use Batch Conversion Tool to convert datum as necessary. Revealed that conversion of datum is a risk to schedule. • GRN to find out from GSCA what size data file is expected from LiDAR • GRN mentioned that current surveyors are using datum that matches LiDAR	**GRN** **GRN**
5	**Monitoring**	
	• Town is hoping to use GRN monitoring data from Oak St. Canal for Burnsides Flood Analysis to condense floodway for homeowners (2 zone mapping). GRN suggested a level logger to generate HEC-RAS Model to depict flows and pattern how channel reacts. Works to display two models, hydraulic and catchment. - Flow monitor at MH upstream of open channel or at open channel without rating curve development is more cost effective than current proposal from Calder. • GRN to send specific cost/budget to Town, Town to discuss if planning department to pay for monitoring. • GRN mentioned to Town that street manhole sanitary/sewer lids were not accurate in some locations in Georgian Meadows • Town to contact OPP office to confirm land use. • GRN to reevaluate monitoring location at OPP station (MH at Minnesota St) - 2 arch culverts at monitoring location, rather than single pipe • Kirsten to send map of locations to Town • Town to confirm that maintenance at Georgian Meadows monitoring location will not affect monitoring	**GRN/Town** **Town** **GRN** **GRN** **Town**
6	**Other Business**	

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Meeting Minutes

DATE: 23 May 2019
FILE NO.: 3861

DATE OF MEETING: 23 May 2019

ATTENDEES:	NICOLAS KEAST	Greenland Consulting Ltd.
	KIRSTEN MCFARLANE	Greenland Consulting Ltd.
	NATASHA BIRCH	Town of Collingwood
	JOHN VELICK	Town of Collingwood
	MARK HARTLEY	NVCA

RECORDED BY: Nicholas Keast

RE: **TOWN OF COLLINGWOOD EXISTING CONDITIONS MODELLING SCOPE REVIEW CONFERENCE CALL**

ITEM	COMMENTS	ACTION
1.	**Introduction to Call**	
	• Town of Collingwood is seeking commentary from the NVCA on the Scope of work for the Collingwood SWM modelling project. • Looking for feedback on items that will dramatically impact scope & effort.	
2	**Project Background**	
	John V. • Two components are driving the request for the study 1. Council Directed Staff to investigate Stormwater Fess to be implemented within the Town of Collingwood. 2. Update the Pretty River hydraulic model and spill mapping through Town. In addition, the model developed with assist with Requested Development Review.	
3	**NVCA Comments on Scope**	
	Mark H. • In agreeance developing a model will assist in Development Reviews. • NVCA has been highlighting the difference between riverine flooding and Urban flooding, and it is in agreeance that delineating the Urban flooding will be beneficial. • He is also in agreeance with the Scope to develop results for Standard flood flows and additional flow scenarios with an overarching view of the overall system (urban and riverine). • NVCA is in agreeance that development of the model for existing conditions is in the best interest at this time. 1. Overall System Discussion – Discharge Points	

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ITEM	COMMENTS	ACTION
	- Where the sewersheds discharge to and interact with the riverine systems is important to model development. - This is where the NVCA's interests lie within the correct development of the model. John V.: It is the Town's wish to look at capacity of systems (ie. Pretty River, Black Ash, etc.) - NVCA will review How the sewershed will work independently, but as a system. - The conditions at the discharge points will be of high importance to NVCA. Nic K.: It is the intent to develop as many boundary conditions as possible within the Modelling Basis Report. This will be an area discussed with the NVCA in the review of the report. 2. Stormwater Management Facilities (Ponds) - How are the ponds going to be modelled? Natasha B.: ECA's are being compiled and sent over to Greenland. Reports for ponds are to be provided to incorporate storage within the models. Site Plans are to be reviewed and have some standard values provided to Greenland for inclusion into the model. - NVCA is offering to share data as required. Nic K.: Can the NVCA look into digital models on file to share with Town and Greenland? - NVCA can investigate that opportunity. 3. What is the starting point for the Storm sewer modelling? Nic K.: Manhole (MH) to MH modelling is the target, however, lumping of very similar catchments may occur as the modelling progresses. Not modelling catchbasin (CB) to MH. Will lump CBs leading to each MH together and utilized a lumped inlet capacity. - PC-SWMM Dual Drainage assessment for spills that connect to the riverine systems are of most importance to NVCA. - However, PC-SWMM dual drainage model is highly anticipated and useful. 4. What are the 'spills' between Silver Creek & Townline Creek? - Anecdotal information provides good focal points for the study. John V.: 2 of the 3 spill points noted within the scope are historical and documented locations of spills. - The other noted spill noted in the scope is documented in the 'Preserve' (or newest name) development's Stormwater Management Plan.	

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Meeting Minutes

DATE: 5 June 2019
FILE NO.: 3861

DATE OF MEETING: 5 June 2019

ATTENDEES:

NICOLAS KEAST	Greenland Consulting Ltd. (GRN)
KIRSTEN MCFARLANE	Greenland Consulting Ltd.
CASSIDY MORGAN	Greenland Consulting Ltd.
NATASHA BIRCH	Town of Collingwood (Town)

RECORDED BY: Cassidy Morgan

RE: **TOWN OF COLLINGWOOD EXISTING CONDITIONS MODELLING PROJECT UPDATE MEETING No. 2**

ITEM	COMMENTS	ACTION
1	**Review Action Items from Previous Meeting**	
	• Outstanding question to GSCA regarding permission to use data and modelling reports.	**GRN**
	• GRN stated that NVCA was on board and aware, GRN is to arrange a meeting with NVCA urgently. Meeting to take place mid-July.	**GRN**
	• Lindsay to send Kirsten unique identifiers for PCSWMM/ HEC-RAS model.	**Town**
	• Town stated County of Simcoe was using old datum, and would like to continue using old until advised otherwise. o All monitoring from Scott must be converted to old datum	**GRN**
	• GRN to find out from GSCA what size data file is expected from LiDAR	**GRN**
	• Town to discuss if Planning Department to pay for monitoring.	**Town**
	• GRN to prepare a model basis report with information from template, reports, models, etc.	**GRN**
2	**LiDAR**	
	Natasha updated team that LiDAR has not flown yet. Mentioned crop and ditch grasses are more concerning than leaf/no leaf.	

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ITEM	COMMENTS	ACTION
	LiDAR is set to fly within the next two weeks. If no flight time available or if results are determined to be inaccurate, LiDAR will fly again in the fall. • Poses severe risk to schedule Conversation between Nic, Brad, and Cassidy at GRN • Discussed level of accuracy of LiDAR • Recognized that manhole lids will be highly accurate as located on open streets • Grassy swales and ditch elevation with tree canopy cover are more likely to be inaccurate. o R.J. Burnside recently surveyed Oak Street Canal, their report could be used instead of additional surveying of the area to have an accurate comparison to LiDAR results. GRN to look into this. The progress of the project will continue as: • Continue gathering data • Write Basis of Modelling Report and present to the NVCA • Begin addressing Pretty River o If Pretty River spills over into Town, must wait for LiDAR	**GRN**
3	**Risk Identification**	
	Kirsten discussed how parts of First St., Hurontario St., and Hume St. do not have As-Builts Town to look into old records to see if original storm sewer records exist. Additional time/resources will be required to survey these areas if no such records exist. • Poses a concern to safety and accessibility due to the busy streets where traffic control may be necessary • Nic suggested sending surveyors out during the night/early morning when traffic is least heavy. An opportunity to survey the streets during the Elvis Festival (July 23-28) was purposed as streets will be blocked.	
4	**Template**	
	GRN presented updated template to Town Town suggested specifying and prioritizing the data to be collected to more efficiently sift through volumes of data. Kirsten stated that GRN is mainly looking for Storm Sewer Inverts • Subdivision/site plans, and road system As-Builts are most important. • GRN is looking for more data on Mountain Croft Subdivision • GRN would like to have all roads/streets complete by the end of the month to alleviate Scott's monitoring work. GRN to ask George what threshold of site flow rates is sufficient enough. Mainly looking for heavy flow / large demographic areas. Natasha mentioned how there is a new storm pipe south of Day Drive which flows to Minnesota Drain, it should have no effect on monitoring but may not show up in Eden Oak (McNabb) Subdivision reports.	**GRN**

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ITEM	COMMENTS	ACTION
	Kirsten to upload Map of Watersheds to dropbox Natasha to send Tatham Report Natasha suggested that Town use an Optical Character Recognition to convert .pdfs to .txt files for model documents. Stated the Town did not carry many models until recent years. Mentioned the NVCA would have access to more models in digital copy. Town will continue to exchange data to GRN through template, subdivision and road reports, site plans, As-Builts, etc.	**GRN** **Town** **GRN** **Town**
5	**Monitoring**	

	John gave permission of the cost of additional monitor. GRN stated the additional monitor was already in budget.
	The five (5) locations for monitoring will be:
	• Monitor No. 1: Oak Street
	  ○ Option 1: Catchbasin located above culvert (requires site verification, preferred)
	  ○ Option 2: Downstream of culvert under Oak St.
	• Monitor No. 2: Huron Street
	  ○ Option 1: If Huron and Heritage sewer is trunk (requires site verification, preferred)
	  ○ Option 2: Else Huron St. and St. Marie St. sewer
	• Monitor No. 3: OPP Station, Minnesota St.
	  ○ One of the twin 750mm culverts
	• Monitor No. 4: OPP Station, Minnesota St.
	  ○ The other twin 750mm culverts
	• Monitor No. 5: Batteaux Subdivision
	  ○ Northeast corner of Silver Cres.
	
	Kirsten to maintain communication and updates with Calder for monitoring. GRN provided update for Scott’s monitoring work completion of Shipyards and Georgian Meadows areas.
	
	Conversations regarding OPP lands mays continue once surveyors are out. Potential risk of confusion concerning location of monitors in “massive underground structure”.
		GRN

6	**Other Business**	

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Meeting Minutes

DATE:	19 June 2019
FILE NO.:	3861

DATE OF MEETING: 19 June 2019

ATTENDEES:		
	BRAD PARKER	Greenland Consulting Ltd. (GRN)
	KIRSTEN MCFARLANE	Greenland Consulting Ltd.
	CASSIDY MORGAN	Greenland Consulting Ltd.
	NICHOLAS KEAST	Greenland Consulting Ltd. (phone)
	NATASHA BIRCH	Town of Collingwood (Town)

RECORDED BY: Cassidy Morgan

RE: TOWN OF COLLINGWOOD EXISTING CONDITIONS MODELLING PROJECT UPDATE MEETING No. 3

ITEM	COMMENTS	ACTION
1	**Review Action Items from Previous Meeting**	
	• Nic confirmed permission to use data and modelling reports from GSCA, GSCA is unaware of data file size of LiDAR. Notify Town as information arrives.	**GRN**
	• GRN confirmed efforts to get ahold of NVCA were made yet no established meeting time has been arranged to present the Basis of Modelling Report. GRN to continue reaching out.	**GRN**
	• Lindsay to send Kirsten unique identifiers for PCSWMM / HEC-RAS model.	**Town**
	• GRN to continue converting monitoring data from new to old datum	**GRN**
	• GRN updated Town that all six (6) monitors were within budget, no need for additional Planning Department funding.	
	• Town confirmed there was no additional As-Builts / records for storm sewer designs on First St., Hurontario St., and High St.	
	• GRN updated Town that progress on the Basis of Modelling Report has begun.	**GRN**
2	**LiDAR**	

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ITEM	COMMENTS	ACTION
	Town confirmed that LiDAR has flown GRN and Town expressed concerns for accuracy of LiDAR results. Town mentioned that Ground Truthing is a part of the contract for LiDAR • GRN to send elevations of manhole lids, as streets will be clear. • GRN suggested the use of Oak St Canal Study and existing information on the Pretty River to confirm accuracy on grassy or canopy covered areas	**GRN**
3	**Schedule**	
	GRN presented updated schedule to Town • Project schedule is highly dependent on progress of LiDAR • GRN to continue updating schedule as needed GRN will continue receiving data from Town and build template, GIS, and models GRN will develop Basis of Modeling Report to provide to Town July 3rd to allow for sufficient time for Town's comments/revisions. • Town suggested writing two reports, Basis of Modelling Report with hydraulic response and Pretty River Report with a more detailed review. • Nic believed these two reports will come in around the same time for Natasha and John to review. Town stated they were willing to prioritize. GRN will present Basis of Modeling Report to NVCA mid to late July, (BMR to be provided ahead of time, approx. 1 week)	**GRN** **Town /GRN** **Town /GRN** **GRN** **Town** **GRN**
4	**Template**	
	GRN presented updated template to Town and included list of missing information • Subdivision / Site Plans and Road System As-Builts containing Storm Sewer Inverts and heavy flow / large demographic areas are most important • Understanding that some areas have not be built yet, therefore no As-Builts. Kirsten mentioned she had placed temporary catchbasin and manholes in GIS as unique identifies were still missing. Lindsey to send. Kirsten mentioned that she was missing As-Builts in parts of Blue Shores area, (Phase 1, and around SWM Pond). Town to send available As-Builts GRN would like to have all roads/streets complete by the end of the month to alleviate Scott's monitoring work. GRN updated Town of work on the Pretty River Model. GRN has matched the Timmins Regional Storm Flow from the Hydrology model. • GRN was looking for rainfall data for the 100 year storm to continue constructing the model.	**Town** **Town** **GRN**

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<table>
<tr><th>ITEM</th><th>COMMENTS</th><th>ACTION</th></tr>
<tr><td></td><td>Town mentioned the Regional Storm at the time produced higher flows, therefore very little time was spent on the 100 year storm. Town suggested calling NVCA for additional storm water data.
GRN has updated the HEC-RAS Model of the Pretty River to reduce spills into Town.

Town will continue to exchange data to GRN through template, subdivision and road reports, site plans, As-Builts, prioritizing areas of missing information.</td><td>GRN

Town</td></tr>
<tr><td>5</td><td>Monitoring</td><td></td></tr>
<tr><td></td><td>Town and GRN confirmed six (6) monitoring locations:

Monitor No. 1: Oak Street Canal
Option 1: Catchbasin located above culvert (requires site verification, preferred)
Option 2: Downstream of culvert under Oak St.
Monitor No. 2: Huron Street
Option 1: If Huron and Heritage sewer is trunk (requires site verification, preferred)
Option 2: Else Huron St. and St. Marie St. sewer
Monitor No. 3 & 4: OPP Station, Minnesota St.
One monitor at each twin 750mm culverts
Monitor No. 5: Batteaux Subdivision
Northeast corner of Silver Cres.
Monitor No. 6:
First St

Kirsten to send map with updated monitoring locations

Kirsten updated the Town that the Subconsultant Agreement has been received and signed, and Scott to survey confirmed locations.

Conversations regarding OPP lands may occur once surveyors are out. Potential risk of confusion concerning location of monitors in “massive underground structure”.

Goal to have monitors installed by end of next week (Friday July 28th).
Monitors are to survey for six (6) months, checked every three (3) months (twice).
Town expressed concern for lack of (ideal) 10 various rainstorms during the next six (6) months, as the wet season is ending. (July – December)
Kirsten to maintain communication and updates with Calder for monitoring. GRN provided update for Scott’s monitoring work.

GRN to arrange surveying on First St., Hurontario St., and High St. as no additional As-Builts are available.
Determine areas where storm sewers records do not exist
Arrange monitoring dates to send surveyors
Night / Early Morning or during Elvis Festival (July 23-28)
Arrange traffic control as necessary</td><td>GRN

GRN

Town /GRN

GRN

GRN

GRN</td></tr>
<tr><td>6</td><td>Other Business</td><td></td></tr>
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Meeting Minutes

DATE: 18 July 2019
FILE NO.: 3861

DATE OF MEETING: 17 July 2019

ATTENDEES:

NICHOLAS KEAST	Greenland Consulting Ltd. (GRN)
KIRSTEN MCFARLANE	Greenland Consulting Ltd.
CASSIDY MORGAN	Greenland Consulting Ltd.
NATASHA BIRCH	Town of Collingwood (Town)

RECORDED BY: Cassidy Morgan

RE: TOWN OF COLLINGWOOD EXISTING CONDITIONS MODELLING PROJECT UPDATE MEETING No. 6

ITEM	COMMENTS	ACTION
1	**Review Action Items from Previous Meeting**	
	GRN provided Town with First Draft of Basis of Modelling Report. o Town to review and provide comments (1 week) o GRN to adjust per comments (2 weeks) • GRN confirmed efforts to get ahold of NVCA were made yet no established meeting time has been arranged to present the Basis of Modelling Report. GRN to continue reaching out, perhaps going through the Planning Department	**Town / GRN** **GRN**
2	**Surveying / Monitoring**	
	Kirsten presented map of existing / missing surveyed areas. • Red indicates areas that still need to be surveyed o Collection of Hurontario St. and First St. o Nic mentioned John is still looking for as-builts, o Natasha was unaware, high probability that nothing was found • Green indicates specific locations that need to be surveyed o Natasha to send Site Plans for Home Hardware and Home Depot • Orange indicates manholes which are unable to be opened. o Kirsten to send specific locations, Natasha to notify Public Works for lid removals Scott offered $5000 for all monitoring along First St. including Traffic Control	**Town** **Town** **GRN / Town**

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ITEM	COMMENTS	ACTION
	• Natasha to talk to Town regarding road closures Kirsten updated Natasha that one of the monitors had to be moved, because • From • To: Ste Marie St., just passed Ontario St. Town to send Oak St. Canal Report, if available • Looking for Diameters and Culverts • If unavailable, Send Scott to complete monitoring GRN to send Scott to Georgian Bay, on a calm day, to compare ACE • Ask OIS for Lake Elevations	**Town** **Town** **GRN**
3	**LiDAR**	
	GRN Updated Town the accuracy of the LiDAR results. • Nic stated that the majority of the grassy / swale areas are up to 5cm accurate, with no areas exceeding 8cm. • Nic and Kirsten expected the concrete surfaces to be surveyed at a high level of accuracy LiDAR is expected to arrive end of July	
4	**Pretty River Analysis Report**	
	Nic provided an update to Natasha on progress for Pretty River Analysis Report. • George has modelled the Pretty River, and surrounding areas for spills • Natasha: Does the Model change with Manning's End? Natasha's Questions: • What is required for maintenance? • Are areas of high sensitivity expected? • What channels need to stay open? At Eden Oak Subdivision, Town would like to avoid having 30 m^3/s going through crossing at Collins St. Instead use Tatham's Calculated 7 m^3/s. • Developer to upgrade if necessary Divert Tatham's Pretty River Estates spill back to main river, not Train Bridge • Natasha raise the concern for downstream residents in case of a spill if Pretty River Estates is diverted to main water channel, bypassing the bottleneck. • GRN to confirm with George using model Nic reviewed how the Maximum Snowmelt was calculated • Largest Snowfall, and then warmest March • This resulted in a HUGE snowmelt, larger than Timmins Storm, which was discussed by Nic and Natasha to be unrealistic.	 **GRN**

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ITEM	COMMENTS	ACTION
	• Nic / Natasha mention how this unrealistic event is an opportunity to discuss climate change. GRN to include in Report. Pretty River Analysis Draft Report to be complete in 2 weeks (31 July 2019) • Ideally have the report ready for when LiDAR arrives, expected end of July	**GRN** **GRN**
5	**Model**	

	Town's Objective for the Stormwater Model:
	• Identify Flood Prone Areas in various storms
	  o Build 2D Models for Spill Zones
	  o What properties / homeowners will be flooded in what storms?
	• Identify areas of high priority for maintenance
	  o Knowing type of SWM facility will indicate the type and schedule of maintenance required
	
	GRN is preparing PC-SWMM Model and is currently in the data waiting zone
	• Will to continue to build into catchments
	• And adjust per comments from Town
		
		GRN
		GRN

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Meeting Minutes

DATE:	14 August 2019
FILE NO.:	3861

DATE OF MEETING: 9 August 2019

ATTENDEES:	NICHOLAS KEAST	Greenland Consulting Ltd. (GRN)
	KIRSTEN MCFARLANE	Greenland Consulting Ltd.
	CASSIDY MORGAN	Greenland Consulting Ltd.
	NATASHA BIRCH	Town of Collingwood (Town)
	MARK HARTLEY	Nottawasaga Valley Conservation Authority (NVCA)

RECORDED BY: Cassidy Morgan

RE: **TOWN OF COLLINGWOOD EXISTING CONDITIONS MODELLING PROJECT UPDATE MEETING No. 7**

ITEM	COMMENTS	ACTION
1	**Project Understanding and Update**	
	Nic provided everyone with an overview of the project. Nic and Natasha confirmed LiDAR has flown, elevations were verified, and data is now being processed at GRN	
2	**Basis of Modelling Report**	
	<u>**Purpose**</u> Mark, "what is the purpose of this report? What succeeds this?" Nic expressed intent for report; to establish a basis of conditions that all models of the project will follow to determine: • River Bounding Conditions • Climate Change • Riverine Interactions • Spills • Locations of Damage Centers • High Priority Areas This basis will include seasonal (ice jams and snow melts), and regulatory rainfall events. Culverts, ditch, drainage paths, tributaries, and river runoff will be incorporated. Nic expressed how waterbodies like Silver Creek spills to Townline Creek	

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ITEM	COMMENTS	ACTION
	Black Ash and the resort areas are mainly open channel	
	Rainfall / Storms	
	Mark anticipated more discussion and detail on rain fall events. Nic discussed current method of modelling. Mark expressed clarity issues of how Intensity-Duration-Frequency for rainfall of historical events correlate with the design storms Natasha added, “We would like to ensure model reacts similar to what the town encounters”.	
	Various ideas regarding methods of standardization between storms were discussed.	
	The general consensuses of the discussion was: • Analysis historical rainfall events, with their associated observed runoff and flood / spill zones • Implement a model where historical rainfall events match realistic Town experiences. • Apply design storms Nic confirmed that snow melts and ice jams would be implemented the same way.	
	Mark raised a concern of project scope and feasibility, Mark, “This implies continuous models?” Nic, “yes” Mark, “where will the line be drawn? What is the scope of all the watersheds?” Nic, “the scope will be reduced to high priority areas. To include continuous models of all watersheds of both rainfall and snow events would be cumbersome and unnecessary”	**GRN**
	Mark would like to see the specific events used for rain and snowfall listed in the report	**GRN**
	Subdivisions	
	Mark expressed concern with “missing subdivisions”. Natasha confirmed those subdivision were intentionally excluded as they were not constructed / not approved yet. Other subdivisions contain models, and therefore do not need to be remodeled.	
	Mark would like this concept more clearly proclaimed in the report.	**GRN**
	A breakdown of Subdivision/Site Plan excel sheet should be utilized to aid in discussion	**GRN**
	Ponds	
	All ponds, regardless of whether assumed by Town or not, are being modelled. Mark expressed concern for scope, “to what degree of detail is each pond being addressed to?”	
	A determination of scale of detail will need to be looked into, depending on size, location, efficiency, of each pond.	**GRN / Town**
	A smaller table with details regarding all ponds should be included in the report.	**GRN**
	Ice Jams / Blockages	
	Use existing dates and locations for base of ice jams. To be included in report.	**GRN**
	Mark would like to see ice jam blockage percentages included	**GRN**

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ITEM	COMMENTS	ACTION
	Mark stated, "from a reader perspective, it appears as though GRN is starting from scratch". Past reports or studies regarding source of ice jam understanding should be included / referenced.	**GRN**
	<u>General Comments Regarding Basis of Modelling Report from Mark</u> • Please include additional details in areas with more complex ideas • Make connections / reference throughout report to ensure readability • Increase clarify with specific details • Declare decisions of detailed modeling • Ensure thought and process paths throughout report are easily followed	**GRN**
3	**Model**	
	<u>Goal</u> Deliver a working model for the Town of Collingwood to use to: • Identify hazard areas, spill zones, and high risk flooding areas. • Identify cause through storm system, and run off conveyance • Determine most effective solution based on model results The model will be a continuous model. Improve monitoring and management of existing infrastructure. Ability to have subsequent works and development added into the model to ensure up-to-date basis for decision making. Model will be spilt up into large and small sections. • Larger events will require less detail • Smaller events will require more detail	**GRN**
	More discussion regarding how the Town will be "split" into sections will be needed. • Consider watershed boundaries, spill zones, rainfall events, etc.	**GRN / Town**
4	**Project Progression**	
	GRN will be in full model "crunch" mode as LiDAR has arrived, and modeling can begin	**GRN**
	Mark to send suggested edits of report to GRN GRN to adjust report per NVCA and Town's edits	**NVCA** **GRN**

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Meeting Minutes

DATE:	12 Sept 2019
FILE NO.:	3861

DATE OF MEETING: 11 Sept 2019

ATTENDEES:		
	NICHOLAS KEAST	Greenland Consulting Ltd. (GRN)
	KIRSTEN MCFARLANE	Greenland Consulting Ltd.
	NATASHA BIRCH	Town of Collingwood (Town)
	JOHN VELICK	Town of Collingwood

RECORDED BY:
KIRSTEN MCFARLANE

RE: **TOWN OF COLLINGWOOD EXISTING CONDITIONS MODELLING**
PROJECT UPDATE MEETING No. 7

ITEM	COMMENTS	ACTION
1	**Review Action Items from Previous Meeting**	
	Model Basis Edits • Edits ongoing, delayed for Pretty River Draft completion	**GRN**
2	**Surveying / Monitoring**	
	Survey Update • Last 15-20 points being surveyed • Expected completion by beginning of next week • Asset Inventory expected to be complete in 2 weeks, dependent on survey data	**GRN**
3	**LiDAR**	
	LiDAR conversion • There have been some issues trying to convert Datums • Work is ongoing	**GRN**
4	**Pretty River Analysis Report**	
	Discuss Draft • Discussion of why water level is different in Tatham's vs GRN's model upstream of Train Trail Bridge • Tatham= Average of channel & banks; GRN= Different channel bottom v. banks	

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ITEM	COMMENTS	ACTION
	• GRN to clarify in report • How to proceed now that GRN's model shows that Liberty lots would flood • NVCA has approved Tatham's model, but Town can't accept if they accept GRN's model • John will have to bring up with Tatham • Possible to frame GRN's changes as sensitivity analysis? • Clarify in report what each Tatham scenario means in regards to what happens to flow at Train Trail Bridge • Add all spill volumes to Appendix B • Town: how much work to update models with LiDAR data; GRN to look into • GRN needs to know how Town will proceed, to know what scenario to run in own models • Thoughts for future: Floodway vs. Flood fringe: what will happen to spill zones with updated definition? • Town does not think that 1km of bank maintenance is plausible • GRN to clarify in report link between maintenance description and Black Ash Creek • Possible to raise dykes? • Town to talk to NVCA → what can be cut down in banks + what might be required to raise dykes	**GRN** **TOWN** **GRN** **GRN** **GRN** **TOWN** **TOWN** **GRN** **TOWN**
5	**Schedule**	
	Updated Schedule • Quick overview of projected schedule • Project finish expected mid to late February, as opposed to beginning of Feb • Change is due to LiDAR → collection and conversion • GRN to send updated schedule with next progress report	**GRN**

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Meeting Minutes

DATE: 6 Dec 2019
FILE NO.: 3861

DATE OF MEETING: 4 Dec 2019

ATTENDEES:	JIM HARTMAN	Greenland Consulting Ltd. (GRN)
	KIRSTEN MCFARLANE	Greenland Consulting Ltd.
	VINOD CHILKOTI	Greenland Consulting Ltd.
	NATASHA BIRCH	Town of Collingwood (Town)
	JOHN VELICK	Town of Collingwood

RECORDED BY: Kirsten McFarlane

RE: TOWN OF COLLINGWOOD EXISTING CONDITIONS MODELLING
PROJECT UPDATE MEETING No. 11

ITEM	COMMENTS	ACTION
1	**Vinod Introduction**	
	• GRN gave Town quick introduction to Vinod, who joined GRN in Nov. 2019 • Vinod to provide a QC role in the project	
2	**Call with GSCA**	
	• Greenland reviewed points discussed during call with GSCA on Nov. 28; o For vegetated slopes >10^{o} (18%), accuracy cannot be guaranteed; o This primarily applies to Black Ash Creek and Pretty River which have existing data in the form of hydraulic models / As-Builts (natural rivers not as steeply sloped); o Still expecting DEM with breaklines from LiDAR provider by end of year→ could provide accuracy improvement for channel bottom and side slopes; • GRN to email GSCA with request for update and to push for final data; • GRN explained to the Town that even with data errors in vegetated slopes, LiDAR is still highly accurate through Collingwood, and traditionally not used for riverine mapping because of the difficulty in obtaining high quality data for sloped areas and below water channel bottoms; • GSCA less concerned with accuracy, as LiDAR data is greatly improved from any existing information in their region; and,	**GRN**

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ITEM	COMMENTS	ACTION
	• GRN to use As-Built information to confirm LiDAR accuracy/ supplement LiDAR data to create hydraulic models for Black Ash & Batteaux Creeks.	**GRN**
3	**Pretty River**	
	• GRN met with contractor for tree clearing quote through the Pretty River dykes (request from meeting with NVCA Nov. 18); • Quote expected within a week; • GRN performed different scenarios to test how Siding Trail (Spurline) Bridge affects spills; and, • With bridge removed, or berm added surrounding the bridge, spills cannot be completely eliminated without maintenance.	
4	**NVCA**	
	• GRN and Town have attempted to contact NVCA about existing hydraulic models → no response; and, • GRN to examine other ways to move forward with riverine models without getting data from NVCA, to continue to progress project and advise Town.	**GRN**
5	**Additional Items**	
	• The Town informed that NVCA has contacted Town informing that they have started to go through Pretty River Report and the hydraulic model, and they will have comments with what is needed to approve a new floodline; and • GRN to provide updated project schedule to Town.	**GRN**

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Meeting Minutes

DATE: 30 Jan 2020
FILE NO.: 3861

DATE OF MEETING: 29 Jan 2020

ATTENDEES:	JIM HARTMAN	Greenland Consulting Ltd. (GRN)
	KIRSTEN MCFARLANE	Greenland Consulting Ltd.
	VINOD CHILKOTI	Greenland Consulting Ltd.
	NATASHA BIRCH	Town of Collingwood (Town)
	JOHN VELICK	Town of Collingwood

RECORDED BY:

RE: **TOWN OF COLLINGWOOD EXISTING CONDITIONS MODELLING**
PROJECT UPDATE MEETING No. 12

ITEM	COMMENTS	ACTION
1	**Outstanding Data**	

	• LiDAR data- not received yet
	  o Expected before end of week
	  o GRN to contact GSCA to confirm / ask for update
	• Flow monitoring data
	  o Last set of data received for Oak St Canal
	  o Remaining sites expected before end of week	

2	**Calibration**	
	• Once monitoring data is received, it will be used to validate Urban model • Town asked how data with low flow rates (<0.6 cms) can be used to calibrate larger storm events (ex. 2 or 5 year) • GRN explained that parameters used to calibrate smaller peak events can be applied to larger events • GRN to calculate statistics for various rain events recorded during the monitoring period to confirm model accuracy • GRN to provide calibration section of report to Town to help explain calibration process	**GRN**
3	**2D Model Results**	

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ITEM	COMMENTS	ACTION

	• GRN provided preliminary results from the 2D PCSWMM model for the Urban region of the project area:
	  o 5-year and 100-year 4 hour Chicago storm
	  o Separate flood maps for depth > 6cm and 15cm
	• Various areas of concern were discussed
	• Oak Street canal results:
	  o Town sought to compare the flooding area as indicated by the preliminary results with that from a 2018 report by Burnside for Oak street canal
	  o Less flooding was found when compared to Burnside report; the report did not indicate the flooding depth, hence a true comparison could not be established
	  o Town asked if GRN could calibrate Burnside's model using flow monitoring data
	  o Decision made that it would be inefficient for GRN to do, instead Town to provide flow data to Burnside to calibrate
	  o GRN to compare the flow results from the PCSWMM model to Burnside's model along Oak street canal
	  o Town to provide Burnside report to GRN
	• Minnesota Drain
	• Town requested:
	  o a memo be prepared for recommended sizing for the Minnesota Drain north of the Adult Learning Centre
	  o Preferably sized for the 5 year storm, however final recommendation up to GRN
	  o Consider minor modifications if overland flow route does not already exist
	  o 2 proposals: Round & Arch piping
	  o this would be an additional item
		Town
		GRN
		Town
		GRN

4	**NVCA Comments**	
	• NVCA emailed Town saying comments expected to be complete in approximately 2 weeks from Meeting date (Jan 29) • No clear response from NVCA to GRN on progress • GRN to continue to request updates from NCVA; pass on to Town if no response is given from NVCA	**GRN/ Town**
5	**Final Report Table of Contents**	

	• Table of Contents from the ongoing report writing was provided to Town for appraisal
	• Town: How is climate change being incorporated in to this project?
	  o Does MTO IDF curve account for climate change?
	  o Should a climate projection scenario be run?
	  o GRN to provide Town with recommendation for method used
	  o Section on Climate change to be included in Final Report
		GRN

6	**Project Schedule**	
	• GRN anticipates that draft report will be completed per December's schedule update (ie. submitted by Feb 21, 2020) dependent on external data (LiDAR, comments from NVCA)	
7	**Additional Items**	

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ITEM	COMMENTS	ACTION

	• GRN asked Town what storm events/ inundation depth constraints they wanted to see for 2D Urban Centre model
	    o GRN recommended ROW depth for one scenario to run (0.25m)
	    o Town asked what constitutes a risk area → what depth is considered a risk, what area makes it a risk
	    o GRN to provide update to the Town with recommendation
		GRN

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Meeting Minutes

DATE: 02 March 2020
FILE NO.: 3861

DATE OF MEETING: 27 Feb 2020

ATTENDEES:	KIRSTEN MCFARLANE	Greenland Consulting Ltd. (GRN)
	DON MOSS	Greenland Consulting Ltd.
	JOHN VELICK	Town of Collingwood (Town)

RECORDED BY: Kirsten McFarlane

RE: **TOWN OF COLLINGWOOD EXISTING CONDITIONS MODELLING PROJECT UPDATE MEETING No. 13**

ITEM	COMMENTS	ACTION
1	**Calibration Report**	
	• GRN delivered calibration report to Town o Details calibration process undertaken by GRN o GRN explained overview of calibration process o With no large events, calibration primarily used to determine timing of peak flows o Most sensitive parameters (XIMP, TIMP) had to be changed to unrealistic values to match observed & modelled flows o Final recommendation in report is for more monitoring	
2	**Flow Monitoring Extension**	
	• Town decided that 6 more months of flow monitoring is required to properly calibrate model • **Project to be delayed to finish monitoring** • GRN to determine what level to bring project to before putting on hold for monitoring completion o Once monitoring is complete, Town wants final report delivered ASAP • Town requested updated project schedule with cost estimate for further monitoring & calibration update	**GRN** **GRN**
3	**Minnesota Drain Sizing**	
	• Discussion regarding Minnesota Drain Sizing Analysis Memo previously delivered to Town	

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<table>
<tr><th>ITEM</th><th>COMMENTS</th><th>ACTION</th></tr>
<tr><td></td><td>Town expressed concern whether there was an overland flow route to Georgian Bay during large events, to allow sizing the culverts to the 5 year 24 hr SCS storm
GRN confirmed there is an existing overland flow route, therefore sizing was determined for 5 year 24 SCS Type II storm</td><td></td></tr>
<tr><td>4</td><td>Data Update</td><td></td></tr>
<tr><td></td><td>1D Minor System Flooding
GRN presented results from 1D model for 5 year & 100 year 24 hr SCS events
Mapping shows surcharging manholes & ROWs during storm events
Town expressed concern over modelled surcharging manholes vs historically observed surcharging manholes
Historically manholes have not surcharged during 5 year storm, though modelled storm sewers show surcharging
GRN explained this could be due to timing of peak in historical storms vs synthetic storms & how flows enter the system
GRN to review model results to confirm
Oak Street Canal Results
GRN presented results for flow within the Oak Street Canal during design storms compared to RJ Burnside’s (2018) flow values
Uncalibrated flows from Burnside’s hydraulic model & GRN’s model very similar
Calibrated flow rates significantly smaller (20-45%) than default values
Final calibrated flows could be slightly larger than current values from GRN’s model</td><td>GRN</td></tr>
<tr><td>5</td><td>Additional Items</td><td></td></tr>
<tr><td></td><td>Town has tried to contact NVCA for update regarding Pretty River Comments
No response yet</td><td></td></tr>
</table>

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MASTER STORMWATER COMMENTS
APRIL 6, 2021

DRAFT FINAL REPORT

Comment Number	Page Number	Comment	Greenland Response
1	General	Sensitivity analysis around high lake levels, ice jams, and snowmelt (as per work plan and Model Basis Report) are missing.	The high lake levels identified in 2019 were used as the downstream boundary condition in all events. A sensitivity analysis included a check on the potential impact of a snowmelt event on the Pretty River. Earlier tests completed for weather data for this area determined that there had to be at least nine hours of continuous warm temperatures on a "ripe" snowpack in order to exceed the equivalent summer event. Unless it is a significant warm front there is less than nine hours sunlight in winter months. Now that we have calibrated models we can complete an ice jam analysis for the Resort Areas and Batteaux Creek watersheds for any locations identified by the Town as problem areas. The Pretty River sensitivity analysis has been completed for the various range of parameters identified by the NVCA.
2	General	There should be a section on climate change. MTO IDF curves may account for this but there should be a dedicated section with some commentary.	A section was added that included a more extended discussion on the types of conditions that would realistically be expected to form part of a climate change impact. The new section focussed on impacts of a rain-on-snow event compared to summer events and how this impact is diminished with the higher return periods.

Comment Number	Page Number	Comment	Greenland Response
			Calibration efforts have also shown that there is flow leaving the various drainage systems during the summer events. A climate change scenario would be the response without these seasonal losses. Traditional parameters describing land use and soil for urban development are actually shown to be conservative and would simulate these climate change scenarios quite effectively.
3	General	Is consultation with surrounding municipalities required (from work plan)?	Consultation with other municipalities is not required unless there are spills from Town lands unto other municipalities.
4	General	What are next steps with NVCA? Workplan suggest their review after receiving Town comments.	The next step with the NVCA is to confirm their review of the updated report for the Pretty River and other documents with Town comments addressed.
5	General	How were catch basins with no pipe connections treated?	All the catch basins in any given catchment are included in the calculations for the rating curve in PCSWMM. It is assumed all catch basins will flow to the pipe system.
6	6	Deletion "the"	
7	7	Deletion "updated"	
8	11	Do these catchments represent all outlets within Collingwood? There are more outlets to the lake than identified in this drawing. For example, there is an outlet down Elliot Ave that drains the industrial properties along Hwy 26 East (AG Global/Starch plant all the way to Pilkington). Have areas east of the Batteaux Creek been analyzed? Please include an overall map that shows individual catchments per outlet?	The figure was updated to include additional minor outlets. The areas east of Batteaux Creek were not analysed, the storm sewers are not available for these areas. Figure 3-3 now also shows individual catchments per outlet.
9	11	Summit View drains to Black Ash Creek	It drains to Black Ash Creek in the model.
10	11	Where did these naming conventions come from?	From the report: Functional Servicing and Stormwater Management Report - Bridgewater on Georgian Bay (C.F. Crozier & Associates Inc. 2018)

Comment Number	Page Number	Comment	Greenland Response
			Regional SWM Update &Master SWM Strategy – Tanglewood at Cranberry Trail (C.F. Crozier & Associates Inc. 2007)
11	14	How much more conservative? I assume any overestimation will addressed through calibration?	The 24 hr event tends to generate higher flows for rural watersheds. Typically the NVCA requests the 4 hr Chicago and the 24 SCS events for comparison.
12	15	No issue with this, but would like to discuss further	
13	18	Are these really the only 2? What about Summit View and Balmoral? Why were new developments not added to Pretty River (or other watersheds) similar to BAC, such as Eden Oak and Pretty River Estates	The final model includes all developments that have been identified with Town staff through the study. The text has been revised.
14	19	Why not 24-hour SCS type II as per Section 4.1?	The 4-hour Chicago storm was used in order to match the original VO2 model flows specifically for comparison with the original model reports. The final PCSWMM model uses the 24-hour SCS storm as one of the scenarios tested.
15	23	Provide the original MacLaren flow for comparison similar to preceding sections.	The Timmins Storm (87%) peak flow is 178.84 m^3/s for the original MacLaren Study. This was added to the text.
16	25	Where? At the Cranberry Creek outlet? There are other outlets in this area such as the channel just east of 11510 Highway 26. There is also a STM outlet through Wyldewood Cove (across from the Greentree Garden Centre)	The text was adjusted to refer to a new subsection where the flows and locations were specifically identified at several outlet locations.
17	30	Is this new data or data from Town LIDAR? Needs clarification.	Yes
18	30	Deletion “to”	
19	35	I assume this mapping is based on older aerial surveying techniques. Why couldn’t the LIDAR data be exclusively used for this exercise?	The boundary of the drainage area used LiDAR. More detailed distribution of sewer catchments was based on similar catchments found in the SWM Reports.
20	43	What about Townline Creek? There is an observed spill just south of Silver Creek Drive. This was part of the original work plan.	Townline Creek has been added. There are spills at Silver Creek Drive and Georgian Trail. Detailed spills are documented and shown on the floodline mappings.
21	46	Would like to discuss further.	

Comment Number	Page Number	Comment	Greenland Response
22	53	Deletion “is”	
23	55	I would like to review what constitutes a flood area and what constitutes something that needs to be addressed with infrastructure dollars. A large vacant lot flooding may be OK as it is not causing damage to buildings or a danger to the public. This list needs to be reviewed more carefully, for example, why is Ferguson Rd included?	The list has been removed from the text
24	55	What about specific pipes? Were there obvious pipe sections that require upsizing?	The individual flooding area will be analysed further in Phase 2 study. Based on the preliminary analysis, some storm sewers need to be upsized.
25	56	Deletion “from”	

APPENDICES

Comment Number	Page Number*	Comment	Greenland Response
1	1	Bookmarks did not work	
2	6	Provide QA/QC report. LIDAR provider included text files showing the deviation between LIDAR and known surveyed points. This should be included in the appendix to confirm accuracy.	We have a QA/QC report from the LIDAR provider that follows the criteria from Natural Resources Canada. The three files provided show all points within the 0.15 m criteria. The difficulty is that the tests does not go to areas with vegetation and slopes greater than 20%. We tested locations along the watercourse and vegetated channel slopes and found greater discrepancies. The GSCA gave us the relevant raw files from the LIDAR provider which we converted to a DEM within a 50 m radius of the watercourse. The purpose of which was to create a higher accuracy DEM in areas with a steeper slope. This was merged with the remainder of the LIDAR file to produce the final DEM.
3	7	Please provide the latest revised LIDAR dataset to the	We can provide the adjusted file to the Town.

Comment Number	Page Number*	Comment	Greenland Response
4	12	Map should be updated	Map has been updated.
5	17	This is very concerning as summer events are very localized. Why wasn't a rain gauge installed? This is something Calder should have been able to do.	These were only small events. We have subsequently adjusted our calibration with several storm events in 2020.
6	35	Provide QA/QC report. LIDAR provider included text files showing the deviation between LIDAR and known surveyed points. This should be included in the appendix to confirm accuracy. NVCA will want this.	The documentation has been provided in the Pretty River report in an appendix that has been included with the package to the NVCA.
7	49	The explanation of these two scenarios should be moved from Section 7, to somewhere before this section.	The section was moved to another location.
8	50	References are not correct. All should be checked.	These were adjusted as required.
10	86	These appear to be missing	
11	152	Summit View outlets to Black Ash Creek	Summit View outlets to Black Ash Creek in the final model.
12	152	Is this map suggesting all these catchments share the same outlet?	The figure only shows the catchments created from the SWM study report.
13	171	Aerial imagery in general is from 2008, we should be using newer data. Can we add property lines?	Mapping was updated.
14	171	Why are NVCA and County logos included? These should be removed.	Logos were removed.
15	184	Is this surcharge above pipe invert, or flooding above MH rim?	It is flooding above MH rim.
16	184	Not clear what this is.	These are overland flow routes in the 1D model.
17	184	There are small discrepancies between this map and the GIS provided to the Town. They do not appear to be major, but what would account for this? Also, the pipe north of Second St is missing.	The pipes are added and the models updated. The pipe north of Second St is missing upstream manholes and catch basins. The drainage area is based on the pipe location. Due to lack of upstream catch basin and manhole connections, the catchment runoff is connected to the downstream end manhole. At upstream end, the catch basins are connected to other pipes. We require additional information for the inflow condition.

Comment Number	Page Number*	Comment	Greenland Response
18	184	How can the top ends of a newly installed (and sized) pipe be surcharged? There are other locations where this occurs as well.	The top end of pipe is surcharged by backup of the trunk sewer. It will be addressed in the flood alleviation analysis.
19	184	Outlet to river missing. This network of piping is not correct.	Outlet to the river is set at the nearest river node.
20	185	Should there be zoom ins of the remainder of downtown?	The remainder of downtown maps will be provided with zoom-ins.
21	192	Would you not expect to see more surcharging during the 100 year event?	The red color is the flooded manhole with depth over 5 cm. The blue color (depth less than 5 cm) will be changed to red.
22	195	Is it possible to have similar mapping for the west end (resort areas) and the east end?	We have not prepared 2D models for these areas. The overall model has already been separated into 3 models due to buffer sizes. We will review this with the Town during our next meeting.

***Page number reflects pdf comments pagination**

DRAFT REPORT

Comment 8: updated figure

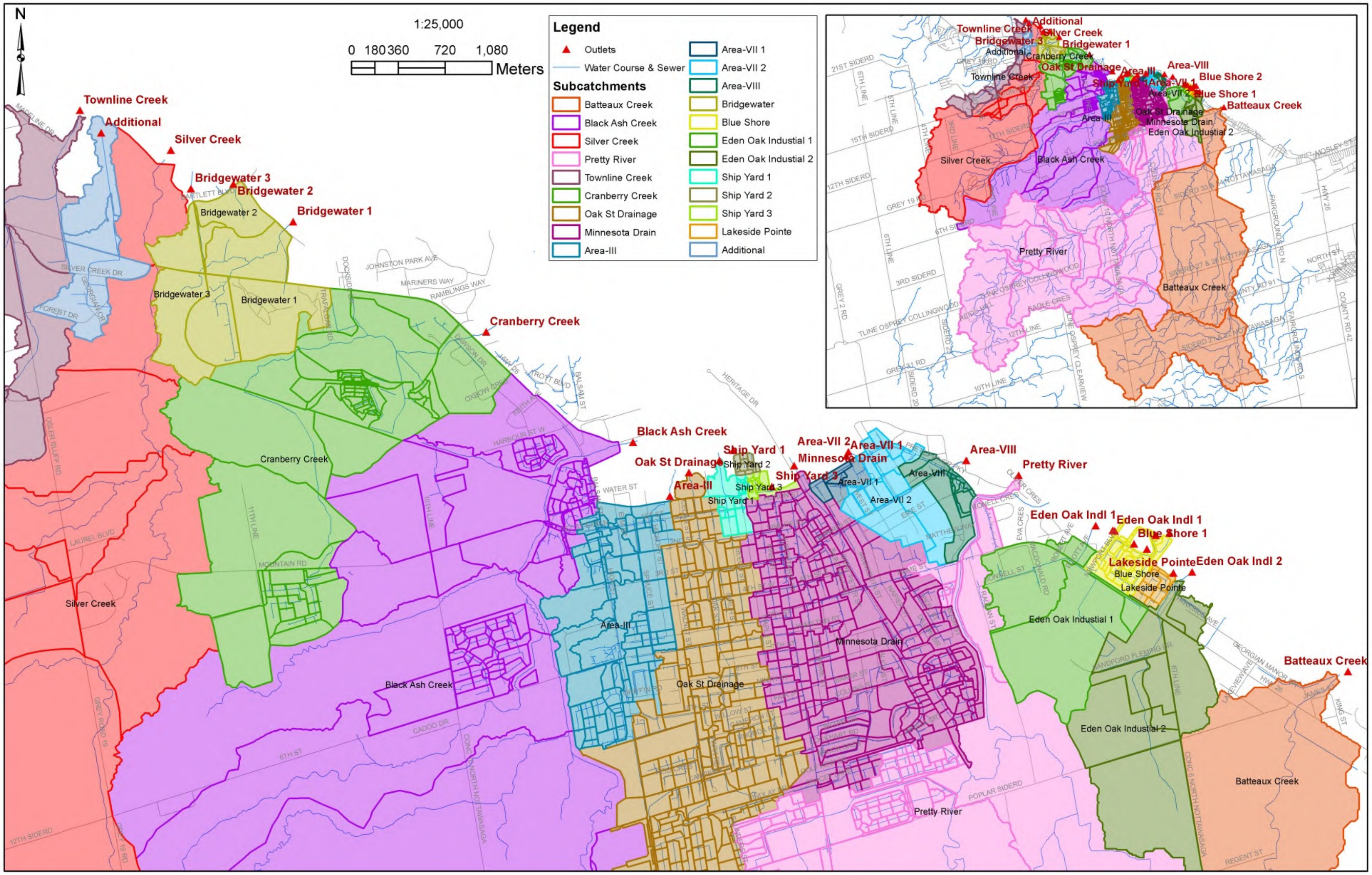


Figure 3-3 Study Watersheds

Comment 13: updated figures for BAC and Pretty River

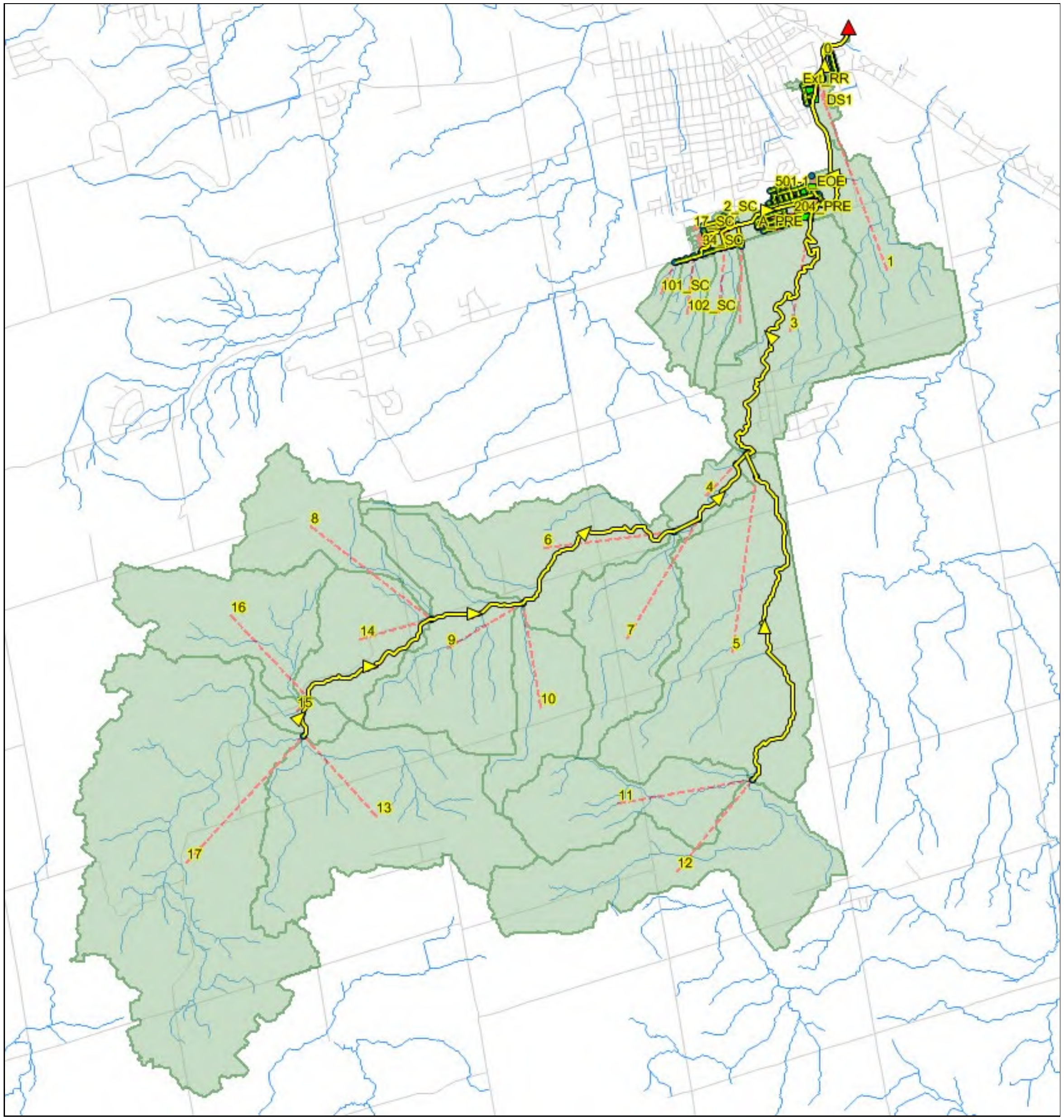


Figure 4-3 Pretty River Watershed in PCSWMM

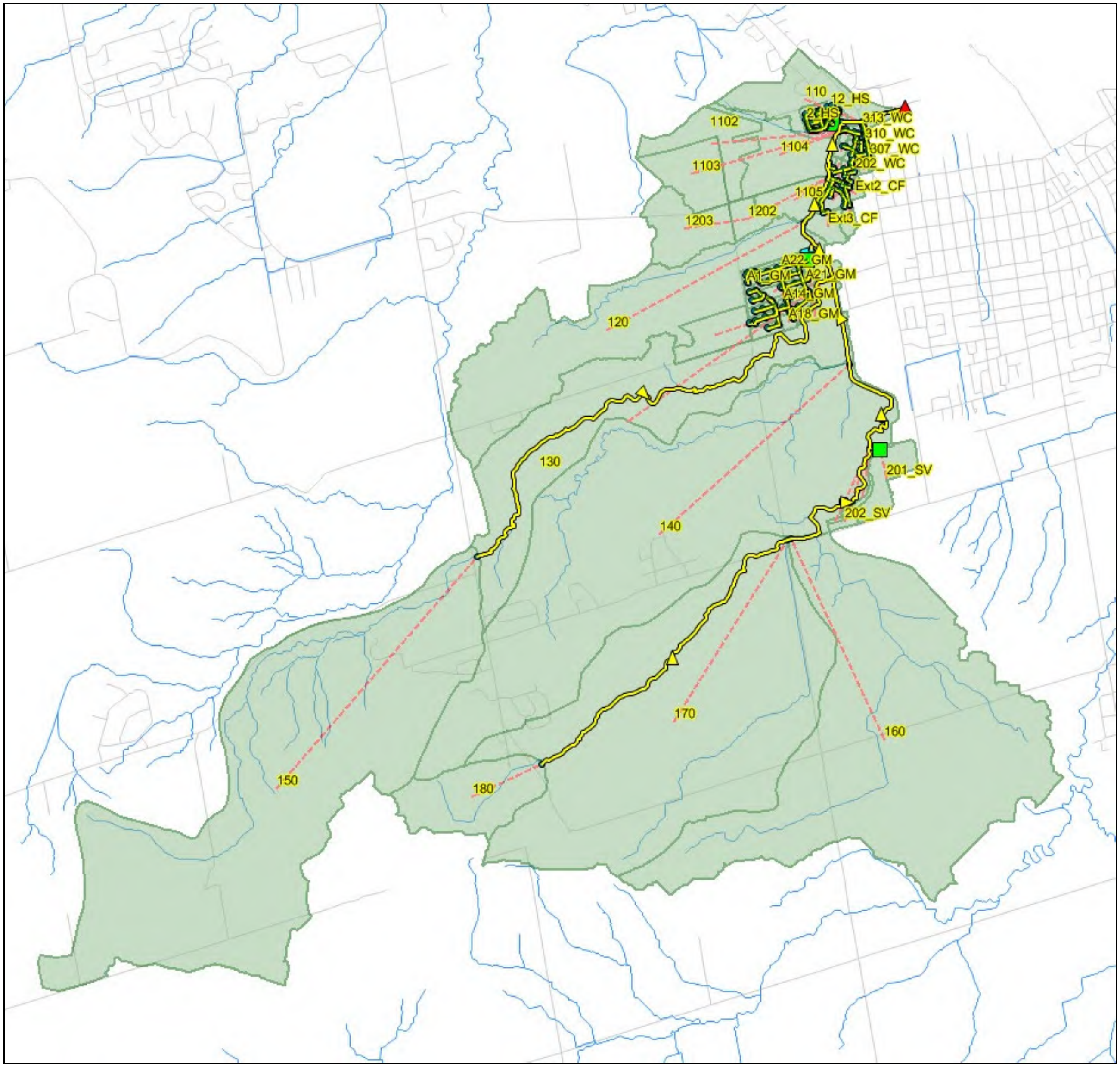


Figure 4-4 Black Ash Creek Watershed

APPENDICES

Comment 4:

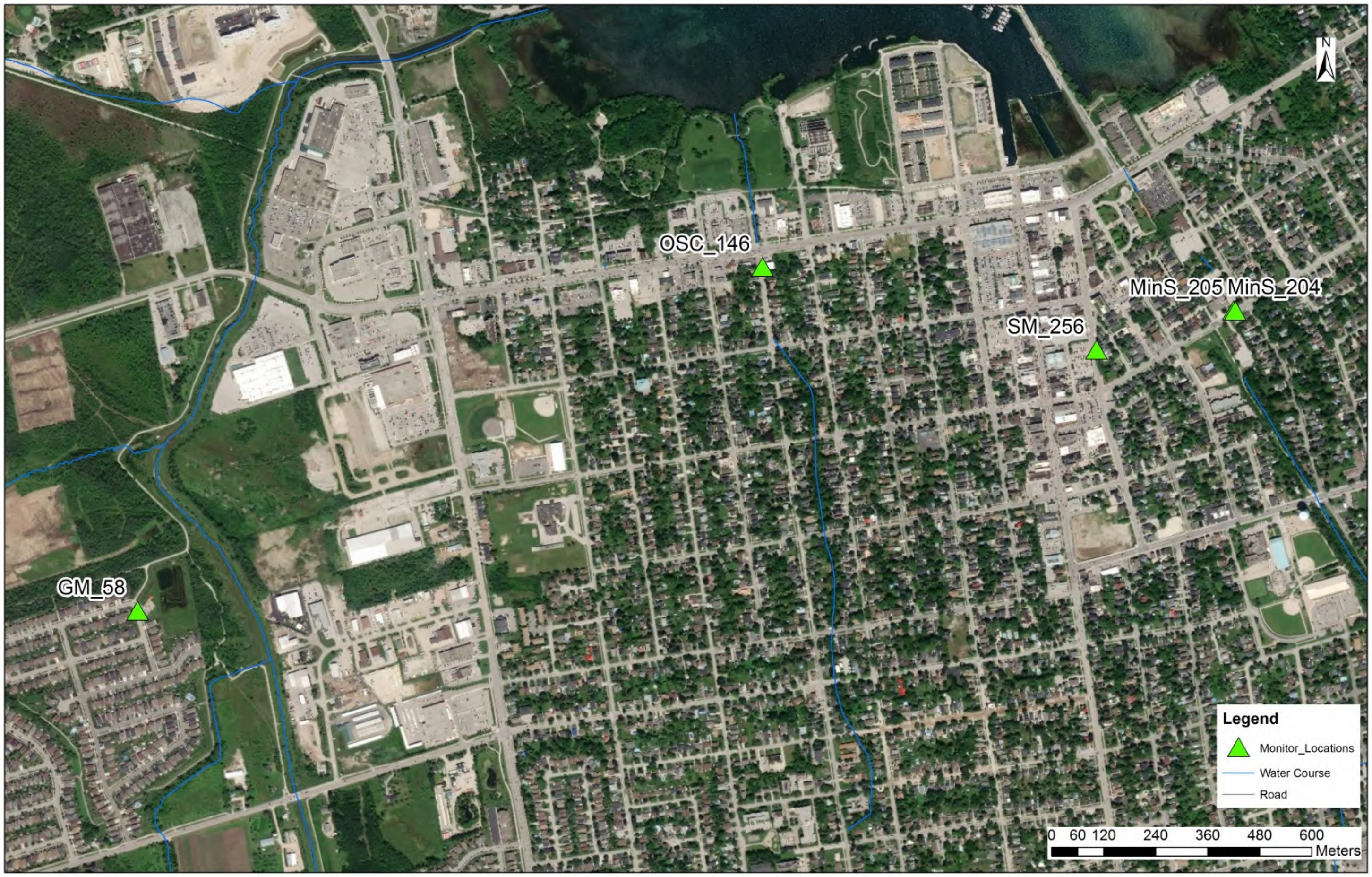
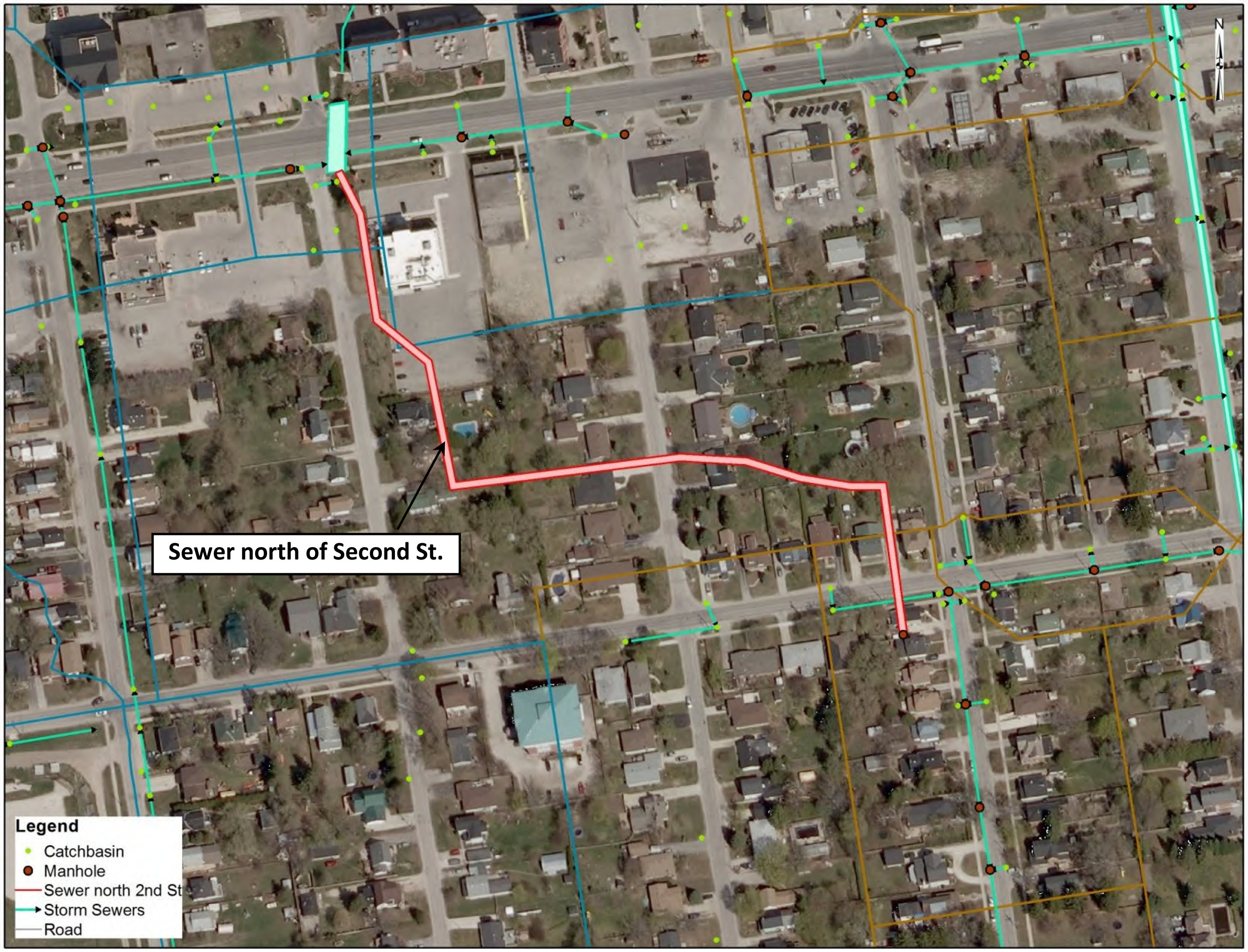


Figure A2- 4 Installed Flow Monitor Locations

Comment 17: The pipe north of Second St missing upstream manholes and catch basins. The drainage area is based on the pipe location. Due to lack of upstream catch basin and manhole connections, the catchment runoff is connected to the downstream end manhole. At upstream end, the catch basins connected to other pipes. Need more information for inflow condition.



Sewer north of Second St.

MASTER STORMWATER COMMENTS
October 29, 2021

DRAFT FINAL REPORT

Comment Number	Page Number*	Comment	Greenland Response
1	General	Climate change section was added (Section 3.3). More information should be provided about how the Town of Collingwood is responding to climate change data. The section provides information about what other municipalities have done, and the impact of snow melt, but does not particularly indicate how Collingwood is responding to this. The snowmelt events should possibly be moved to another section, unless it is being included to support a climate change narrative. The Town considers the use of the MTO IDF curves as a reasonable approach to the potential increase in rainfall events/intensity as the MTO has the experts to consider the impacts of climate change. The MTO IDF curves also provide greater "factor of safety". Some commentary should be proved around this.	Additional context provided in the report: "The Town considers the use of the MTO IDF curves as a reasonable approach to the potential increase in rainfall events/intensity as the MTO has the experts to consider the impacts of climate change. The MTO IDF curves also provide a greater "factor of safety". The Town may consider adjustments to the MTO IDF curves as a "stress test" with the Phase 2 work program. The MTO IDF curves can be compared with the rainfall volumes being estimated with other climate models as new information comes available." Snow melt events have not been moved as they were considered as one of two main climatic functions that could produce the greatest impact as a results of climate change. Additional wording has been provided in the report body to support this.
2	General	State what the downstream boundary conditions are in the modelling, ie. the Georgian Bay High Water elevation. Include this somewhere in the body of the report if not already done.	The downstream boundary condition was the 2019 high lake level. This has been included in the report body.
3	17	Figure 3-5 is not very clear, what is it trying to convey? Is it that a rain on snow melt event is greater than a 25 year storm, during a long duration? Should the 100 year event also be shown if that is what it is trying to convey?	Additional wording and a figure was included to help clarify Figure 3-5. "The snow melt event does not become the critical distribution for short response times that are typical within local subdivisions in urban boundaries. In the

Comment Number	Page Number*	Comment	Greenland Response
		What is the likelihood of a 100 year event occurring with lots of available snow pack?	Collingwood area, the 25-year flood event could be impacted by snow melt only on a river system that has greater than a 12-hour response and if there is an available snow pack with at least 90 mm of snow water equivalent. In other words, the snow melt event becomes the significant event only with warm temperatures that extend through the night and a full snow pack still available to produce runoff. However, the snow melt event is not the controlling event once the 25-year event is exceeded. Once the 100-year frontal rain storm event occurs, this climate adjusted rainfall event becomes the controlling event for both riverine and municipal drainage infrastructure. Figure 3-6 shows the comparison at the 100-year event where the summer frontal rainfall condition is the worst-case condition. With the more severe events (ie, 100 year event), the riverine systems and urban areas are still controlled by the frontal rain events. Therefore, climate change considerations will use the summer frontal rain events to analyze local drainage infrastructure and the Regional storm (Timmins storm event) still produces the controlling flood event in the river systems.”
4	39	Section 5.3, further clarification is still recommended. The description is difficult to interpret what is “Town LIDAR”, what is “new DEM”, and what is “existing DEM”.	Clarification has been added. A unique identifier has been provided for each iteration of the DEM.
5	General	Header on report body to reflect “final report”	Header has been updated.
6	71	Conclusions and Recommendations should be Section 8, not 7.	Section numbering updated.

Appendices

Comment Number	Page Number*	Comment	Greenland Response
1	1	Bookmarks do not work.	Bookmarks have been updated and fixed.
2	121	Appendix E and Appendix F in the pretty river report appear to be missing and should be included.	Appendix E and F have been included
3	311	Would you not expect to see more surcharging during the 100 year event? Why are none of the new subdivisions showing surcharging in a 100 year event?	The new subdivisions do not show a surcharge because the surcharge is less than 0.25 m in the gutters. The Town design standards help with this. If these subdivisions are small (ie less than 25 ha drainage area) there would not be enough flow generated to exceed the gutters. The MTO storm has regard for recent climate models that has been used in the modelling completed. As the climate impacts are further visited in Phase 2 we will be able to stress test these areas further, if desired.
4	239	Large spill shown over 6th Street. There is an active site plan application at this location. Hazard study is provided for this site under separate cover, which indicated that spill flows travelled east towards the Black Ash Creek, without spilling over Sixth Street. - See additional files provided to confirm if this is relevant information for the Black Ash Creek modelling.	The model has been updated. The spill upstream of Sixth street now flows east along the ditch toward Black Ash Creek. A smaller spill to the east is still observed downstream of the Sixth Street crossing.
5	248	There is a large bridge/culvert under Silver Creek Boulevard. This does not appear to be accounted for and is causing large backwater effects through the Silver Creek watershed/Townline Creek. Further review may be necessary. - Additional drawings and natural hazard study has been provided separately. - Once this culvert is incorporated, there may be spills across Cranberry Trail	The culvert under Silver Glen Boulevard has been included in the model as a lateral weir structure. The changes to the spills observed have been updated in the report body and mapping.

Comment Number	Page Number*	Comment	Greenland Response
		West, this has been witnessed by Town staff on several occasions. - There may be additional culverts under Hwy 26 and/or Georgian Trail that need to be captured in the spill model. - Results of this modelling may require updates to Section 7 within the main report body.	

***Page number reflects pdf comments pagination**

Appendix 2

Interim Technical Reports

Appendix 2-I

Pretty River Hydraulic Assessment Report

February 19, 2021

Collingwood Stormwater Management Master Model

Pretty River Hydraulics Assessment

Prepared for the Town of Collingwood

Authored by:

Greenland International Consulting Ltd.

Table of Contents

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Figures

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1 Introduction

Greenland Consulting Ltd. (Greenland) was retained by the Town of Collingwood (Town) to undertake the preparation of an existing conditions stormwater management, Town-wide model. As part of this model development, the existing Pretty River hydraulic model has been updated with the most recent hydrology accepted by the Town and Nottawasaga Conservation Authority (NVCA) and updated topography generated from new terrain models derived from recent LiDAR data.

The Town has acknowledged that the updated flood flows for the Pretty River could bring about potential changes to the Town's Official Plan, namely the Pretty River Two Zone Special Policy Area. The purpose of the Pretty River hydraulic model prepared by Greenland, in conjunction with the Stormwater Model Report, is to provide all technical details required to update the Pretty River hydraulics, based on the recently accepted hydrology. The updates to the Pretty River hydraulics may in turn require changes to the required flood protection and delineation of the Pretty River spill zones.

Finally, this assessment will also provide recommendations regarding maintenance of the Pretty River dyke system with a specific assessment of what maintenance is required to eliminate spills from the Pretty River (using the recently NVCA approved updates to the Pretty River hydrology).

1.1 Location

The Pretty River is one of a distinct group of watercourses that are considered the Blue Mountain Subwatershed (Silver Creek, Black Ash Creek, Pretty River, and Batteaux Creek). These watercourses are characterized by headwaters in the Niagara Escarpment in the Blue Mountains with mountain streams that transition into rolling hills with meadows to very flat plains with agricultural lands prior to outletting into Georgian Bay in the vicinity of the Town of Collingwood. **Figure 1** shows the location of the Pretty River watershed. Its headwaters are bounded by the village of Duntroon to the south, Rob Roy to the west and the main branch passes through Nottawa before entering the east side of the Town of Collingwood where it is confined by a system of dikes prior to outletting into Georgian Bay.

1.2 Background

The Pretty River floodplain is the only Two-Zone Floodplain Management Policy Area in the Town of Collingwood. A Two-Zone Floodplain Management Policy Area consists of two (2) identified flood zones: the floodway and the flood fringe. The floodway is defined by the flood flow depth, velocity and depth velocity product criteria set by the Ministry of Natural Resources. Flows in this floodway are deepest, fastest and present the greatest threat to human life and/or property damage. The flood fringe consists of the area between the floodway and the Regional flood elevation, in this case, the Timmins storm flood limit. Flow in this area is generally shallower and is flowing slower than in the floodway.

The Town has defined the floodway in the Official Plan as the land below the 100 year flood level. As required, a technical definition corresponding with the Provincial criteria is recommended as an update to the Town's Official plan to ensure that the Town's definition and flood limits are consistent with the Provincial guidelines.

The definition of these zones is important as, according to the Town's Official Plan, there can be no development within the floodway, and all development within the flood fringe must be flood proofed to the Timmins storm flood elevation. Additionally, any new development within the flood fringe must complete a cumulative impact analysis and Emergency Response Plan to be approved by the Town and

NVCA prior to construction. The limits of the flood fringe (spill areas) are depicted in the Town's Land Use Map from the 2019 Official Plan (**Appendix A, Figure 1**).

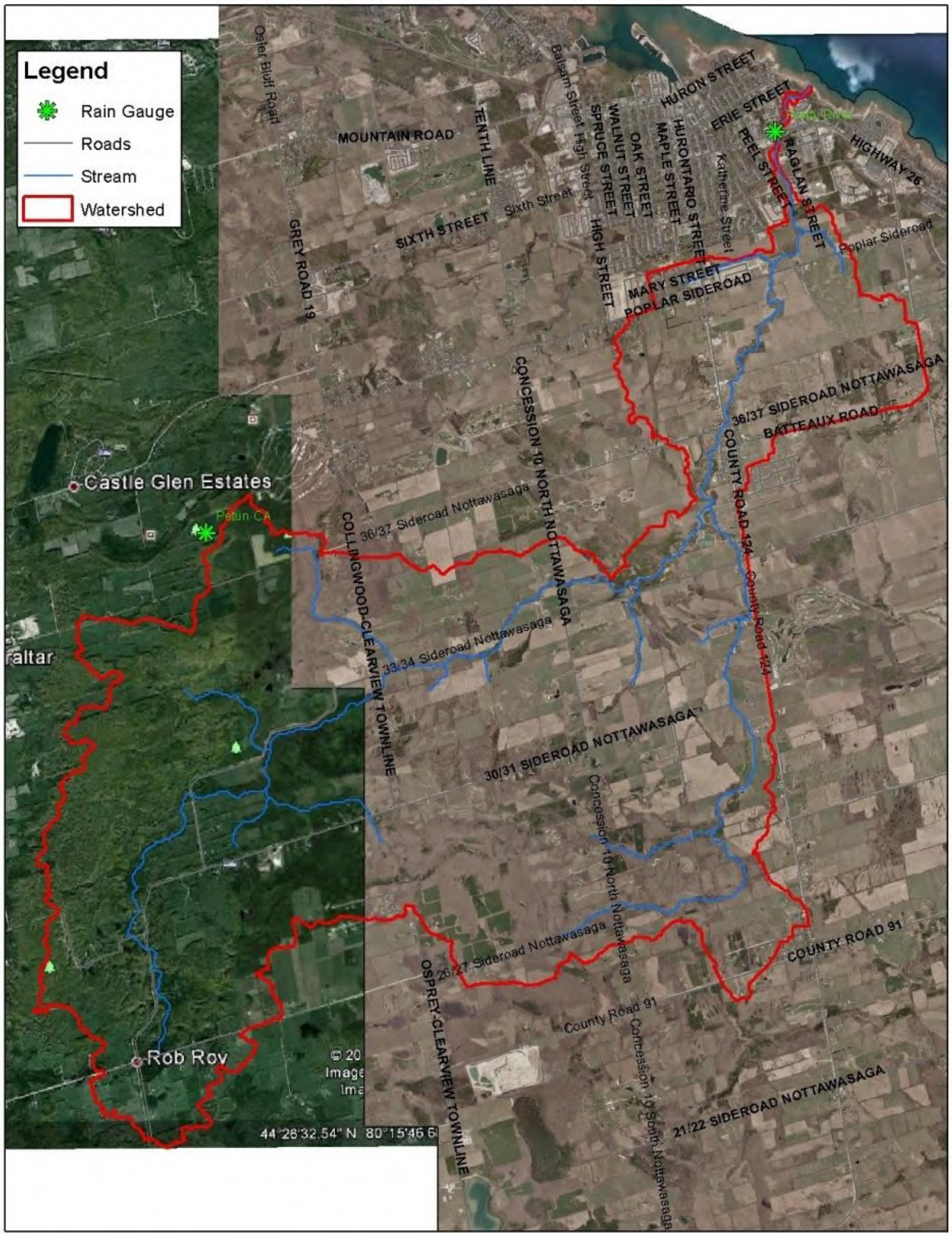

Figure 1 Pretty River Watershed

Currently, the limits of the flood fringe are identified by the 1999 Pretty River Flood Hazard Delineation Study completed by Stantec Consulting Ltd. (Stantec Report). Regional storm peak flows used in the Stantec Report were those derived in in the Watershed Hydrology Study by MacLaren Plansearch Inc. (MacLaren) for Nottawasaga, Pretty and Batteaux Rivers, Black Ash, Silver and Sturgeon Creeks. Namely, a Pretty River Regional storm flow of 227 m^3/s upstream of the former Barrie-Collingwood Railway Train Trail Bridge was identified in the MacLaren Study (see **Appendix A, Figure 2** for bridge names and locations). The Regulatory peak flows have been greatly contested in subsequent hydrologic updates since the MacLaren Study.

1.3 Project Scope

The following report has been prepared to update the hydraulic model and mapping for the Pretty River. The scope of the project includes:

- prepare an updated document that addresses comments received from the NVCA;
- adjustments made to the document to follow the protocols for the preparation of a flood hazard study;
- introduce how the analysis uses mapping based on recent LiDAR survey and field support program; and,
- summarize the technical information being provided including transition from earlier reports/models.

The NVCA comments and response matrix are provided in **Appendix B**.

2 Documentation of the Mapping Preparation

2.1 LiDAR Collection

In collaboration with the Grey Sauble Conservation Authority (GSCA), the Town of Collingwood engaged the LiDAR provider ATLIS to collect airborne LiDAR to create a highly accurate, up-to-date digital elevation model (DEM), used to update the overland stormwater pathways and major spill routes, fill in manhole rim elevations for minor system development, and cut channel cross sections for the development of riverine hydraulic models as part of the comprehensive existing conditions stormwater model.

The LiDAR was flown during leaf-on conditions in June 2019, creating the risk that the data would not be within the accuracy tolerance. If this were the case, then the project would have been put on hold until late fall or the following spring when LiDAR could be flown again during leaf-off conditions. Upon receipt of the accuracy report from the LiDAR provider, all points were well within tolerance (+/- 10 cm) on both hard surface and vegetated points and the project could proceed as planned. The QA/QC report from the LiDAR provider is located in **Appendix C**.

The LiDAR was flown in Canada's new standard vertical datum: the Canadian Geodetic Vertical Datum of 2013 (CGVD2013). To maintain a consistent datum through all their records, the Town made the decision to convert the LiDAR data, to the recently replaced reference system: the Canadian Geodetic Vertical Datum of 1928 (CGVD28). Due to the redefinition of the vertical reference system in Canada, differences in height between the two (2) datums are approximately 37 cm in Collingwood (CGVD2013 elevations are ~37 cm lower).

To accomplish the conversion of the LiDAR data, Greenland pursued multiple methods. This was a new request, therefore a method to convert between the datums had to be created. Initially, the decision was made to convert each point to the new datum using the GPS-H tool released by Natural Resources Canada, developed to convert between vertical datums. However, due to the extremely large data file of approximately 40 million points, processing was extremely slow, and errors were not noticed until significant effort had been put into each attempt.

Eventually, it was decided that using a uniform value to raise the entire DEM to an approximation of the CGVD28 elevation values would be sufficient for conversion. Through the Town, differences between the two datums ranged between 35 and 39 cm, therefore an average value of 37 cm was chosen to raise the DEM while maintaining an accuracy of +/- 2 cm to the original data. The Town provided Greenland the LiDAR data in raster format, with each raster a 1 km by 1 km grid tile. Using ESRI's ArcMap software, the tiles were mosaiced into a single DEM for the Town, then using the Raster Calculator tool, heights of each cell were increased by a uniform value of 37 cm.

Once the conversion was complete, the new DEM was then used to complete the minor-major system model and hydraulic models for the Town.

2.2 LiDAR within the Pretty River

During the update to the existing hydraulic model for the Pretty River, a comparison of the DEM elevations to the surveyed sections of the Pretty River from the existing model was completed. A large discrepancy between the two (2) elevation systems was noted by Greenland and brought to attention of the Town and GSCA, with concerns of the LiDAR accuracy in the vegetated channel slopes. Elevation differences were seen to be greater than 30cm on some sections of the channel slope. To confirm whether the previously surveyed sections of the Pretty River were accurate or the LiDAR data was correct, a field survey was conducted for a section of the Pretty River and compared to the other data sources. The detailed investigation is described further in **Section 4.2**.

Once the validity of the LiDAR data was in question, Greenland then compared the DEM to surveyed manhole rim elevations (completed as a part of the Collingwood existing conditions stormwater study). After this analysis, it was confirmed that the LiDAR data was accurate on flat surfaces, and that the areas of concerns were solely in steeply sloped areas. This issue was brought to the attention of the LiDAR provider, who explained that accuracy on steep slopes could not be guaranteed, per the Federal Airborne LiDAR Data Acquisition Guidelines (2018). Within the Town, these areas are primarily limited to the Pretty River and Black Ash Creek, which as dyked / constructed channels, consist of relatively steep slopes. In order to account for the discrepancy, it was determined that the existing (previously surveyed) data would be used for the slopes of the Pretty River within the Town, due to the high accuracy of the previous survey.

3 Hydrology Model

The hydrology model for the Pretty River was updated to be integrated into the overall master hydrology model being developed for the entire Town of Collingwood. The following section briefly describes the hydrology model development process including the past history for the watershed.

3.1 Hydrology Model History

The Pretty River watershed hydrology was first developed in 1988 Watershed Hydrology Study (MacLaren). The Pretty River was one of several watersheds discharging to South Georgian Bay that were ungauged. The hydrology was developed using the Qualhymo software with the individual catchment parameters derived from the transfer of (S* vs API) information from gauged stations. The Pretty River was described using four (4) catchments. **Figure 2** shows the original watershed discretization used in the MacLaren Study.

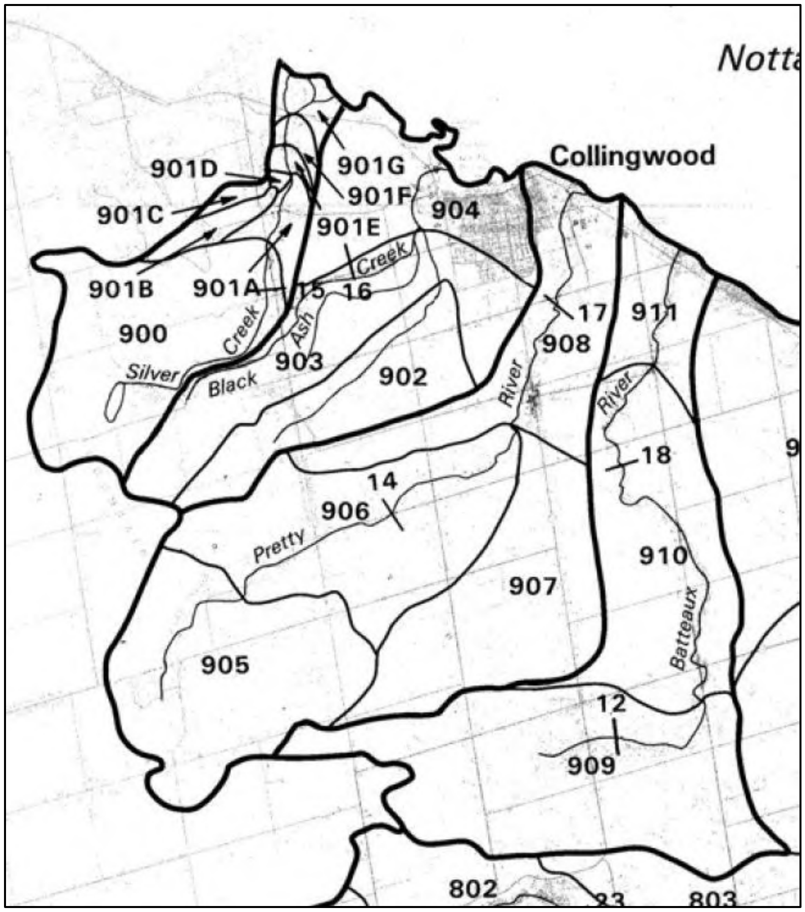

Figure 2 Earlier Watershed Discretization

Over time, the flow estimates were determined to be conservative and there was an effort made to reassess the flow conditions in the watershed. This work was completed once there were several years of gauged flow data available for the Pretty River. The Environment Canada hydrometric flow gauge 02ED031 has been active at the Hume Street bridge crossing since 2005.

3.1.1 Existing Model

The Pretty River watershed is the largest of the four (4) watersheds in the Town of Collingwood with a catchment area of 67.7 Km^2. Recently, the NVCA has approved the flood flows for the Pretty River detailed in the Pretty River Hydrology Update completed by CC. Tatham and Associates Ltd. (Tatham) in 2018. Flows in the Tatham study were determined to be 172.83 m^3/s upstream of the Train Trail Bridge and 180.04 m^3/s at Georgian Bay (outlet). The purpose of the study was to create a comprehensive hydrologic model that predicts the Regulatory Flow generated by the Timmins Storm. The hydrologic models in the C.C. Tatham report were developed in Visual OTTHYMO version 5.0 (VO5).

3.1.2 Updated Model

Since the original approved hydrology model for the Pretty River was developed in a different software, the new model constructed using PCSWMM had to match the flow results determined from the original hydrology model. A PCSWMM model was created by Greenland that imported the catchment areas and SCS-related parameters based on the VO5 model used by C.C. Tatham. Adjustments to the PCSWMM model were made to match the previous VO5 results. **Table 1** demonstrates that the PCSWMM model has a flow output of 180.08 cubic meters per second (m^3/s) at the outlet to Georgian Bay, matching closely that of the aforementioned VO5 model of 180.04 m^3/s.

Table 1 Pretty River Matched Flow and Adjusted Parameters – Original Catchment

Name	PCSWMM					VO5 Catchment	
	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Peak Runoff (m^3/s)	NHYD	Peak Flow
0	17.42	281.0	620	0.7	1.36	0	1.363
1	340.69	3406.9	1000	1.2	10.09	1	10.289
2	312.2	2312.6	1350	0.8	6.32	2	6.351
3	443.02	4430.2	1000	1.2	11.86	3	11.976
4	78.12	1420.4	550	2	2.01	4	2.021
5	773.27	5523.4	1400	7	33.5	5	33.59
6	344.9	2155.6	1600	2.5	14.02	6	14.012
7	285.27	1901.8	1500	5.3	12.01	7	12.025
8	244.13	1436.1	1700	8	7.61	8	7.615
9	418.49	4184.9	1000	8.5	18.49	9	18.453
10	208.43	1736.9	1200	9	9.17	10	9.231
11	269.42	2449.3	1100	10	9.57	11	9.599
12	486.99	3746.1	1300	8	18.03	12	18.081
13	653.33	2916.7	2240	6	18.93	13	18.971
14	229.96	2420.6	950	11	11.6	14	11.698
15	58.94	1071.6	550	10	2.99	15	2.986
16	331.77	2764.8	1200	8	12.9	16	12.86
17	1274.02	6370.1	2000	5.5	40.15	17	40.152
Outlet	6770.37				180.08		180.04

3.2 Updated Flood Hydrology

Using the PCSWMM model that matched to the VO5 model output, the model was then adjusted to integrate updated catchment boundaries delineated from the updated DEM, created as part of this study. The length to width ratios of the updated catchments however remain similar to those generated when matching the existing VO5 model. The updated catchment area is slightly smaller (67.2 Km^2) which compares with the 67.7 Km^2 in the earlier study. The delineated catchment boundaries in PCSWMM are shown in **Figure 3**. The computed peak flow in the new PCSWMM model corresponding to the Timmins storm was found to be 179.72 m^3/s at the outlet into Georgian Bay.

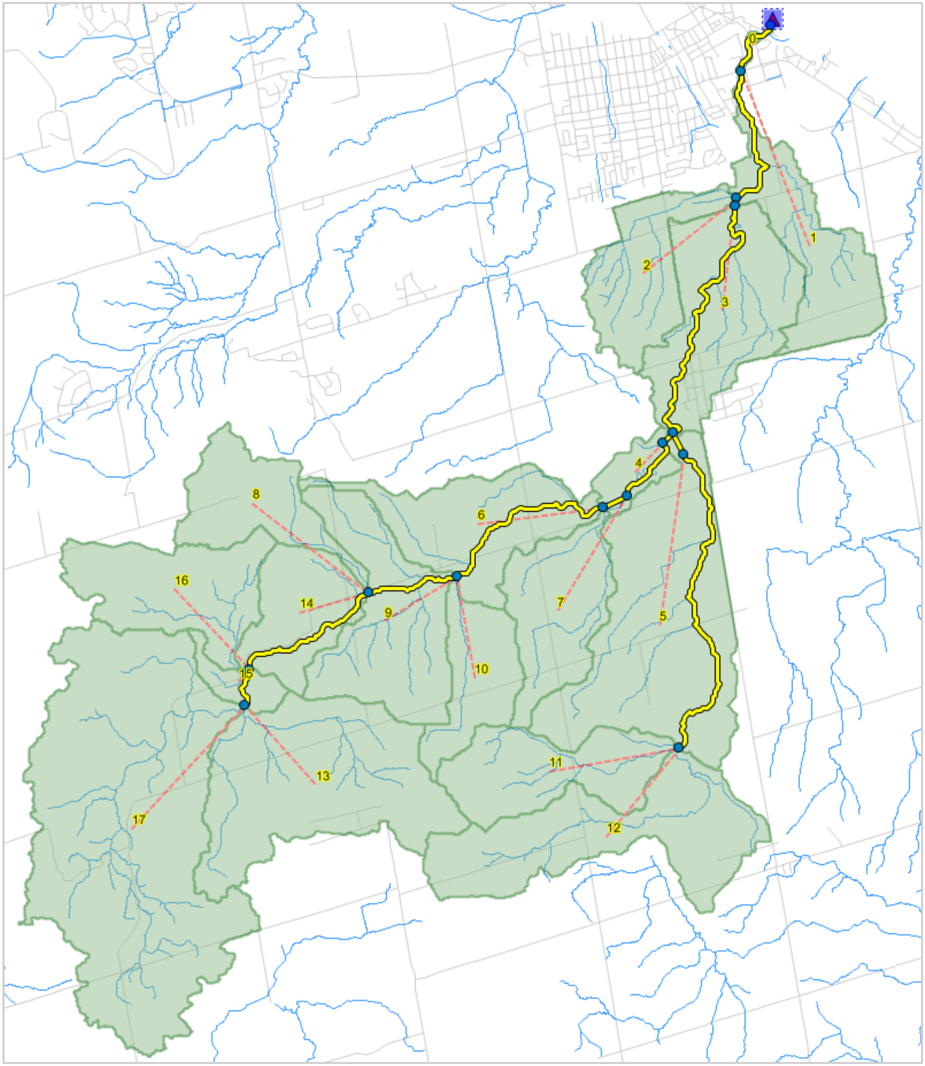

Figure 3 Pretty River Watershed in PCSWMM

For the hydraulic model, the flows from the Tatham hydrology were used since they were approved by the NVCA. **Table 2** provides the summary of flow conditions used for the various return periods modelled in the hydraulic model at key locations.

Table 2 Regional and 100 Year Flood Flows

Physical Location	Model Station	100 Year (cms)	Regional Flood (cms)
Hamilton Drain	320.1	4.22	6.351
400 m Upstream of Poplar SR	3759.028	80.797	167.09
Upstream of Hamilton Drain	369.117*	82.644	172.828
Siding Trail Bridge	1.01	85.8	180.068
Downstream of Pretty River Pkwy	-26.1	85.875	180.041

4 Field Information

Additional field information was collected to be used in the update of the hydraulic model for the Pretty River. The local structures throughout the study reach were investigated and documented for this assignment. The recent upgrades to the structures on Poplar Sideroad and Hume Street were accounted for in this study. The ice weir near the mouth of the river was reinstated from information found in earlier hydraulic models. A review of the LiDAR data was completed by Greenland, revealing discrepancies between the hydraulic model cross-section elevations and the digital elevation model (DEM) created from the LiDAR data. One of the key areas of focus was the flood dykes along the Pretty River. A detailed summary of the comparison is provided herein.

4.1 Dyke Information

To confirm whether the previously surveyed sections of the Pretty River were accurate or the LiDAR data was correct, a field survey was conducted for a section of the Pretty River and compared to the other data sources. The survey location was determined based on the results from the initial model run, and focused on the primary spill location determined under the Pretty River's existing conditions. **Figure 4** shows the key area that was investigated immediately upstream of the Siding Trail adjacent to the Collingwood Sand and Gravel Company on Raglan Street.

Figure 4 Survey Points Upstream of Siding Trail

The survey involved collecting topographic data for a cross section of the River at the Train Trail Bridge between the left and right overbanks, spot elevations approximately 400 m along the right and left overbanks upstream of the Train Trail Bridge, and a final cross section at the end of the 400 m. The field survey confirmed the accuracy of the model cross-sections and also found large elevation differences between the LiDAR and surveyed values on the channel slopes.

This location is represented by the hydraulic model cross sections 0.301 and 0.151. There are no sections in the model between these locations. The variation in elevation is shown both in the survey and the LiDAR data.

Table 3 and **Table 4** provide the comparison of the elevations in the hydraulic model, field surveyed and derived from the LiDAR data for the left and right bank of the dyke system upstream of Siding Trail. The hydraulic model contains a lateral weir for either side of the dyke system

Table 3 Left Bank Model Survey LiDAR Elevation Comparison

Distance	Survey Elevation	LiDAR Elevation	Difference (Survey-Lidar)	Model Elevation	Difference (Model-Lidar)	Difference (Model-Survey)
0		189.89		189.93	0.04	
48	189.46	189.56	.1	189.76	0.2	0.3
63	189.46	189.63	.17	189.71	0.08	0.25
75	189.54	189.22	.32	189.67	0.45	0.13
87	189.47	189.09	.38	189.62	0.53	0.15
97	189.52	188.66	.86	189.59	0.93	0.07
108	189.52	188.93	.59	189.55	0.62	0.03
110	189.57	188.83	.73	189.54	0.71	-0.03
122	189.57	189.46	.11	189.5	0.04	-0.07
131	189.55	189.1	.45	189.47	0.37	-0.08
142	189.42	188.66	.77	189.43	0.77	0.01
152	189.37	188.6	.78	189.39	0.79	0.02
165	189.28	188.02	1.27*	189.35	1.33	0.07
190	188.84**	189.09	-.25	189.26	0.17	0.42

*Concrete Retaining Wall

** Not at 190m- approximately at 193m

In the model, the change in elevation is assumed to be constant between cross-sections, while the actual elevation of the dyke system contains local elevation changes, small lows and highs, which create elevation differences up to 0.5m between the modelled terrain profile and the DEM. These elevation variations are summarized in the tables.

Table 4 Right Bank Model Survey LiDAR Elevation Comparison

Distance	Survey Elevation	LiDAR Elevation	Difference (Survey-LiDAR)	Model Elevation	Difference (Model-LiDAR)	Difference (Model-Survey)
0		190.24		189.8	-0.44	
70	189.5	189.49	0.01	189.67	0.18	0.17
84	189.62	189.52	0.1	189.64	0.12	0.02
99	189.52	189.44	0.08	189.61	0.17	0.09
112	189.47	189.13	0.34	189.59	0.46	0.12
129	189.4	189.55	-0.15	189.56	0.01	0.16
162	189.21	188.7	0.52	189.49	0.79	0.28
164	189.23	188.84	0.39	189.49	0.65	0.26
186	189.13	188.63	0.49	189.45	0.82	0.32
190	189.24	189.29	-0.04	189.44	0.15	0.2

Note: 0m Distance is at Station 0.301, 190m Distance is at Station 0.151

Although these tables show that the hydraulic model can have elevations that differ from the survey in this local reach, the model flood elevations that are shown in **Section 5** for the maintained condition scenario are below the survey elevations so the area does not spill. The Regional flood elevation is at 189.48 m at station 0 (section 0.301) and at 188.7 m at station 190 (section 0.151).

4.2 Inventory of Structures

The following section describes the field information for the structures that was imported into the hydraulic model. It includes the recently updated structures on Poplar Side Road and Hume Street **Figure 5** provides an example of the summary sheets that have been provided in **Appendix D**.

Culvert Datasheet

Location:	Poplar SR	Prepared by:	G. Yang
Date:	Aug 2020	Checked by:	
Project No:	4097	Page:	of

SPECIFICATIONS:

Type of Structure:	Bridge
Span (m):	14.68 m
Rise (m):	3.62 +/- m
Length of Structure (m):	10 m
Top of Road Elevation (m):	194.79 m
Low Chord Elevation Upstream (m):	193.96 m
Low Chord Elevation Downstream (m):	193.96 m
Upstream Invert Elevation (m):	190.34 m
Downstream Invert Elevation (m):	190.29 m
Effective Flow Area (m^2):	
Mannings 'n' Value:	0.013

NOTES:

SKETCH / PHOTOGRAPH(S):

GREENLAND® International Consulting Ltd.
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Offices: Greater Toronto and Collingwood

Figure 5 Sample Structure Data Sheet

5 Hydraulic Modelling

The following section describes the hydraulic model used to establish the flood lines to be adopted by the Town of Collingwood. A sensitivity analysis was completed to address NVCA comments and several scenarios investigated to address the maintenance of the dykes. The hydraulic model was updated to a newer version of the HEC-RAS software used to develop the flood scenarios tested for the reach through the Town of Collingwood.

5.1 Various Previous Models

The model analysis completed for this report is based entirely on the existing model that was originally created using survey data collected by the NVCA. This survey was completed for the 1999 Stantec Report. A similar numbering system was used for the cross section identification.

5.2 Sensitivity Analysis

The sensitivity analysis was completed to follow the NVCA Hazard Guidelines which suggest the following investigations:

Peak discharge	+20%
Channel and floodplain roughness	+20%
Expansion and contraction	+100%
Bridge/culvert blockage	-50%
Starting water levels	+0.5m

Table 5 provides a summary of the sensitivity analyses that were completed on the hydraulic model. The model sensitivity analysis was completed for **Scenario 3** described in the next section (**Section 5.3**) of the report. The sensitivity analyses indicate that there is a potential for significant stresses to the flood corridor through the dyke system. The flood elevations highlighted in yellow show areas where the dyke elevation will be exceeded if there is a variation from the maintained condition.

The likelihood of there being a significant increase in flood flows is questionable since the approved Regional flood flows from the Tatham report are lower than the original flows from the MacLaren study. There would not be a change in expansion or contraction coefficients since the flows are being passed through a corridor with no abrupt changes.

The key stress tests that should be considered are the change in Manning's coefficient and the impacts from a 50% blockage of the various bridge structures. The 20% increase in Manning's shows the first locations that would potentially overtop during a Regional flood event if the vegetation begins to fill in from the maintained state. The critical location that would begin to spill first is located at cross section -10.1 (adjacent MacLean Engineering building). The other location is immediately upstream of the ice weir (cross section -25.1).

This location would also be impacted by a 50% blockage of the opening at the Hume Street bridge. Other locations would also be impacted with 50% blockages of structures further downstream as well including upstream of the Pretty River Parkway structure and the ice weir. These structures would be part of a maintenance inspection program to ensure that they would be clear of any blockages.

Table 5 Sensitivity Analysis Comparison of Water Surface Elevations

			Pretty Spill_MaintC		Peak Flow +20%			Manning's n +20%		Exp/Con +100%		Bridge Blockage - 50%		Boundary +0.5m	
River	Reach	River Sta	Q Total	W.S. Elev	Q Total	W.S. Elev	Diff	W.S. Elev	Diff	W.S. Elev	Diff	W.S. Elev	Diff	W.S. Elev	Diff
			(m^3/s)	(m)	(m^3/s)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)
pretty	1	3759.028	167.09	194.37	200.51	195.16	0.79	194.79	0.42	195.01	0.64	194.9	0.53	194.37	0.00
pretty	1	3549.485	167.09	194.80	200.51	195.25	0.45	194.92	0.12	195.04	0.24	195.02	0.22	194.8	0.00
pretty	1	600	167.09	194.70	200.51	195.22	0.50	194.85	0.13	195	0.28	194.97	0.25	194.72	0.00
pretty	1	500	Bridge		Bridge	Bridge		Bridge		Bridge		Bridge		Bridge	
pretty	1	480	167.09	194.18	200.51	194.45	0.27	194.29	0.11	194.32	0.14	194.67	0.49	194.18	0.00
pretty	1	400	167.09	194.27	200.51	194.52	0.25	194.35	0.08	194.35	0.08	194.7	0.43	194.27	0.00
pretty	Downstream	300	172.83	194.26	207.39	194.51	0.25	194.34	0.08	194.34	0.08	194.69	0.43	194.26	0.00
pretty	Downstream	250	172.83	194.21	207.39	194.46	0.25	194.28	0.07	194.3	0.09	194.67	0.46	194.21	0.00
pretty	Downstream	249	Lat Struct		Lat Struct	Lat Struct		Lat Struct		Lat Struct		Lat Struct		Lat Struct	
pretty	Downstream	200	170.06	194.2	200.63	194.44	0.24	194.26	0.06	194.28	0.08	194.66	0.46	194.2	0.00
pretty	Downstream	6.5	Bridge		Bridge	Bridge		Bridge		Bridge		Bridge		Bridge	
pretty	Downstream	6	170.06	192.74	200.63	192.84	0.10	192.89	0.15	192.94	0.20	192.73	-0.01	192.74	0.00
pretty	Downstream	5	170.06	192.86	200.63	193.07	0.21	192.98	0.12	192.9	0.04	192.84	-0.02	192.86	0.00
pretty	Downstream	4	170.06	192.65	200.63	192.88	0.23	192.78	0.13	192.7	0.05	192.65	0.00	192.65	0.00
pretty	Downstream	3	170.06	192.58	200.63	192.79	0.21	192.68	0.10	192.63	0.05	192.58	0.00	192.58	0.00
pretty	Downstream	2	170.06	191.79	200.63	192.51	0.72	192.04	0.25	191.88	0.09	192.03	0.24	191.79	0.00
pretty	Downstream	1.56	170.06	191.57	200.63	191.93	0.36	191.86	0.29	191.65	0.08	192.07	0.50	191.57	0.00
pretty	Downstream	1.01	177.3	191.51	209.32	191.91	0.40	191.77	0.26	191.53	0.02	192.06	0.55	191.51	0.00
pretty	Downstream	1	177.3	191.36	209.32	191.8	0.44	191.64	0.28	191.39	0.03	192.01	0.65	191.36	0.00
pretty	Downstream	0.7	177.3	190.74	209.32	191.13	0.39	191.06	0.32	190.75	0.01	191.84	1.10	190.74	0.00
pretty	Downstream	0.65	Bridge		Bridge	Bridge		Bridge		Bridge		Bridge		Bridge	
pretty	Downstream	0.601	177.3	190.59	209.32	190.97	0.38	190.91	0.32	190.59	0.00	190.44	-0.15	190.59	0.00
pretty	Downstream	0.401	177.3	189.96	209.32	189.34	-0.62	190.24	0.28	189.92	-0.04	189.71	-0.25	189.96	0.00
pretty	Downstream	0.301	177.3	189.48	209.32	189.99	0.51	189.66	0.18	189.36	-0.12	189.03	-0.45	189.48	0.00
pretty	Downstream	0.29	Lat Struct		Lat Struct	Lat Struct		Lat Struct		Lat Struct		Lat Struct		Lat Struct	

pretty	Downstream	0.28	Lat Struct		Lat Struct	Lat Struct		Lat Struct		Lat Struct		Lat Struct		Lat Struct	
pretty	Downstream	0.151	177.3	188.7	209.32	189.99	1.29	188.66	-0.04	189.48	0.78	189.27	0.57	188.7	0.00
pretty	Downstream	0.126	Bridge		Bridge	Bridge		Bridge		Bridge		Bridge		Bridge	
pretty	Downstream	0.101	177.3	188.58	209.32	188.78	0.20	188.42	-0.16	188.7	0.12	188.56	-0.02	188.58	0.00
pretty	Downstream	0.098	Lat Struct		Lat Struct	Lat Struct		Lat Struct		Lat Struct		Lat Struct		Lat Struct	
pretty	Downstream	0.097	Lat Struct		Lat Struct	Lat Struct		Lat Struct		Lat Struct		Lat Struct		Lat Struct	
pretty	Downstream	0.051	177.3	188.49	209.32	188.67	0.18	188.75	0.26	188.52	0.03	188.48	-0.01	188.49	0.00
pretty	Downstream	-10.1	177.3	188.2	209.32	188.47	0.27	188.49	0.29	188.26	0.06	188.62	0.42	188.2	0.00
pretty	Downstream	-11.1	177.3	187.78	209.32	188.17	0.39	187.99	0.21	187.83	0.05	188.46	0.68	187.78	0.00
pretty	Downstream	-12.1	177.3	187.04	209.32	187.32	0.28	187.29	0.25	187.08	0.04	188.5	1.46	187.04	0.00
pretty	Downstream	-13.1	Bridge		Bridge	Bridge		Bridge		Bridge		Bridge		Bridge	
pretty	Downstream	-14.1	177.3	186.83	209.32	187.06	0.23	187.11	0.28	186.89	0.06	185.31	-1.52	186.83	0.00
pretty	Downstream	-15.1	177.3	186.75	209.32	187	0.25	187.01	0.26	186.74	-0.01	186.72	-0.03	186.75	0.00
pretty	Downstream	-16.1	177.3	185.93	209.32	186.14	0.21	186.18	0.25	185.91	-0.02	186.18	0.25	185.93	0.00
pretty	Downstream	-17.1	177.3	185.74	209.32	185.94	0.20	185.98	0.24	185.71	-0.03	186.1	0.36	185.74	0.00
pretty	Downstream	-18.1	177.3	184.65	209.32	185.01	0.36	184.86	0.21	184.71	0.06	186.29	1.64	184.65	0.00
pretty	Downstream	-19.1	177.3	184.17	209.32	184.62	0.45	184.28	0.11	184.37	0.20	186.22	2.05	184.17	0.00
pretty	Downstream	-20.1	177.3	184.26	209.32	184.67	0.41	184.33	0.07	184.38	0.12	186.13	1.87	184.26	0.00
pretty	Downstream	-21.1	Bridge		Bridge	Bridge		Bridge		Bridge		Bridge		Bridge	
pretty	Downstream	-22.1	177.3	183.78	209.32	184.1	0.32	183.87	0.09	183.88	0.10	182.18	-1.60	183.78	0.00
pretty	Downstream	-23.1	177.3	183.02	209.32	183.3	0.28	183.01	-0.01	183	-0.02	182.94	-0.08	183.02	0.00
pretty	Downstream	-25.1	177.3	180.53	209.32	182.33	1.80	180.69	0.16	180.57	0.04	180.47	-0.06	180.53	0.00
pretty	Downstream	-26.1	177.27	180.45	209.28	181.1	0.65	181.15	0.70	180.93	0.48	180.39	-0.06	180.45	0.00
pretty	Downstream	-26.13	Lat Struct		Lat Struct	Lat Struct		Lat Struct		Lat Struct		Lat Struct		Lat Struct	
pretty	Downstream	-26.14	115.74	180.25	113.95	180.43	0.18	180.19	-0.06	180.21	-0.04	180.19	-0.06	180.25	0.00
pretty	Spill	100	109.87	179.48	80.79	179.62	0.14	180.27	0.79	179.21	-0.27	179.3	-0.18	179.48	0.00
pretty	Spill	50	171.4	178.89	176.12	179.13	0.24	178.88	-0.01	178.72	-0.17	178.73	-0.16	178.89	0.00
pretty	culvert	-26.15	5.88	178.34	33.18	178.31	-0.03	178.34	0.00	180.64	2.30	180.71	2.37	178.34	0.00
pretty	culvert	-26.2	Culvert		Culvert	Culvert		Culvert		Culvert		Culvert		Culvert	
pretty	culvert	-29.1	5.88	178.08	33.18	177.97	-0.11	178.13	0.05	178.51	0.43	178.55	0.47	178.07	-0.01
pretty	culvert	-30.1	5.88	177.69	33.18	177.54	-0.15	177.76	0.07	178.33	0.64	178.24	0.55	177.85	0.16

pretty	culvert	-31.1	5.88	177.3	33.18	177.3	0.00	177.3	0.00	177.66	0.36	177.45	0.15		177.8	0.50
Hamilton Dr	Upstream	320.1	6.35	194.35	7.62	194.56	0.21	194.43	0.08	194.41	0.06	194.71	0.36		194.35	0.00
Hamilton Dr	Upstream	310.1	6.35	194.3	7.62	194.54	0.24	194.38	0.08	194.37	0.07	194.71	0.41		194.3	0.00
Hamilton Dr	Upstream	300.1	6.35	194.29	7.62	194.53	0.24	194.37	0.08	194.37	0.08	194.7	0.41		194.29	0.00
Hamilton Dr	Upstream	290.1	6.35	194.29	7.62	194.53	0.24	194.37	0.08	194.36	0.07	194.7	0.41		194.29	0.00
Hamilton Dr	Upstream	280.1	6.35	194.29	7.62	194.53	0.24	194.37	0.08	194.36	0.07	194.7	0.41		194.29	0.00
Hamilton Dr	Upstream	270.1	6.35	194.29	7.62	194.53	0.24	194.37	0.08	194.36	0.07	194.7	0.41		194.29	0.00
Hamilton Dr	Upstream	260.1	6.35	194.29	7.62	194.53	0.24	194.37	0.08	194.36	0.07	194.7	0.41		194.29	0.00
Hamilton Dr	Upstream	250.1	6.35	194.28	7.62	194.53	0.25	194.37	0.09	194.36	0.08	194.7	0.42		194.28	0.00

5.3 Spill Scenarios

The Pretty River hydraulics utilized for the Official Plan are based on a maintained state through the Pretty River dykes, defined in the 1999 Stantec Report. The report provides a clear definition for maintenance in hydraulic modelling terms, however, other than a definition for maintained vegetation as "harvested", the Stantec Report provides no details into the level of maintenance required by the Town to achieve this state in practice. Therefore, Greenland has referred to the condition of the Black Ash Creek flood conveyance channel, as a comparable state to which the Pretty River should be maintained.

As part of the Pretty River existing conditions stormwater management model development, the Town requested Greenland define the section of river along the Pretty River dyke system that must be maintained to prevent all spills for the Regional storm event. The same analysis was completed by Stantec for their flood hazard delineation. Stantec concluded that maintaining the stretch of the river dykes between the Siding Trail Bridge and station -10.1 (260 metres), and through the ice flow weir spillway would eliminate all spills downstream of the Train Trail Bridge.

However, with the large Regulatory flow rate from the Stantec study, the spill upstream of the Train Trail Bridge was projected to be 52.1 m^3/s, and would flood most of the downtown core of Collingwood (**Appendix A, Figure 11**). With the updated hydrology and new Regulatory flow regime, a new assessment had to be undertaken to determine the section of the Pretty River that must be maintained to eliminate spills.

To assess the updated hydraulics of the Pretty River through the Town and at spill locations, based on the new hydrology completed by Tatham, several scenarios were considered, taking into account the Town's preferred methodology to increase the river capacity and eliminate spills from the Pretty River. These scenarios include:

- **Scenario 1, Existing conditions, existing grading**- Reflects current conditions of the Pretty River;
- **Scenario 2, Existing conditions, updated grading**- Assesses the state of the Pretty River if the grading plan proposed by Tatham for Pretty River Estates Phase II is approved (an imminent existing condition), but the channel remains in its current state;
- **Scenario 3, Maintained dykes, existing grading**- Assesses the minimum section of the Pretty River that must be maintained to eliminate all spills downstream of the Train Trail Bridge, based on existing grading; and,
- **Scenario 4, Maintained dykes, updated grading**- Assesses the minimum section of the Pretty River that must be maintained to eliminate all spills downstream of the Train Trail Bridge, but with the proposed grading by Tatham.

A summary of results from the model for each scenario is detailed in **Appendix E.**

Based on the results of Tatham's July 2019 hydraulic model, which utilizes the new hydrology with the lower Regional flood flow, the existing topography between the Poplar Bridge and the Train Trail Bridge causes a portion of the Pretty River flood flow to spill upstream of the Train Trail Bridge and flow north towards the centre of Collingwood. The maximum water surface elevation is 194.18 metres during the Regional event, from Tatham's model. The existing topography of the area of concern is presented in **Figure 4** (**Appendix A**). A profile view of the ground surface elevation of the spill location (identified in

Figure 4, Appendix A) is displayed in **Figure 5** (**Appendix A**). The water surface exceeds the elevation of the existing ground surface at two points, resulting in the spill flowing north towards the Town core.

Tatham has proposed two (2) methods of diverting the spill. The first scenario ("Contained Spill") involves the re-grading of Parcel 2 (see **Figure 6, Appendix A**) to 194.5 metres, and the re-grading of a section of the Train Trail approximately 100 metres in length, allowing the water to spill over the trail and back into the river. Under this scenario, 164.3 m^3/s will be conveyed under the bridge, while 8.5 m^3/s will overtop the trail and spill back into the river downstream of the Train Trail Bridge. Water surface elevations between Poplar Side Road and the Train Trail will remain at current levels (194.18 metres), therefore not impacting the nearby properties. The profile of the proposed grading is available in **Figure 7** (**Appendix A**).

In the second scenario ("Maintained Spill"), Tatham has proposed the same re-grading of Parcel 2, in addition to the widening of the existing ditch along the western side of the Train Trail, increasing its capacity. Flow is split in three (3) directions at the trail: flowing along the trailside ditch (2.1 m^3/s), flowing in the river under the bridge (165.4 m^3/s), and overtopping the trail (5.3 m^3/s). The widened ditch will be capable of conveying the spill flow that does not overtop the trail. The maximum water elevation is modelled to be 194.19 metres: 1 cm above current levels, and below existing grades of adjacent properties, therefore not adversely impacting external lands. The proposed grading profile for this scenario is displayed in **Figure 8** (**Appendix A**).

As part of Greenland's assignment for the Town to create an existing conditions Stormwater management model, one of the Town watersheds to be assessed was the Pretty River. The Pretty River existing conditions model used the NVCA accepted Tatham hydrology and Greenland recreated the hydraulic models developed by Tatham to represent the imminent existing conditions that includes the Pretty River Estates II portion of the model, the results of which are summarized in **Appendix E**.

Differences between water surface elevations in the Greenland and Tatham hydraulic models, between Poplar Side Road and the Train Trail, are due to modifications of the channel roughness and how it is defined by Greenland.

Tatham's model uses an average roughness coefficient that encapsulates both the channel and overbanks, and then a higher roughness coefficient for the heavily vegetated floodplain. Greenland used a more specific approach, by defining the roughness coefficient for the channel bottom up to the average flow point, with a separate value for the overbanks of the channel, including the floodplain. This created a higher overall roughness for the channel during flood conditions in Greenland's model, resulting in an increase of 11 cm in the water surface elevation. The water surface elevation differences between the two (2) models under existing conditions are compared in **Figures 9** and **10** (**Appendix A**).

It should be noted, that it was not part of Greenland's scope of work to assess the impact of filling of the existing floodplain proposed in the above referenced Tatham scenarios on upstream or downstream flooding, nor was Greenland requested to provide an opinion on whether the proposed filling in the floodplain presented in the Tatham scenarios meets with current Town or NVCA regulatory policies.

5.3.1 Scenario 1- Existing Conditions, Existing Grading

A spill hydraulic assessment was completed for the current conditions of the Pretty River, based on the updated hydrology completed by Tatham. While the current floodplain mapping is based on maintained conditions within the Pretty River dykes, this does not reflect current conditions of the River. The Pretty River has not been maintained since the release of the Stantec Report and it is overgrown with large bushes and small trees (**Appendix A, Figure 14**). The hydraulic model completed in HEC-RAS by Greenland has been changed to reflect this. Based on current conditions, there were two (2) spills identified: upstream of the Train Trail Bridge and upstream of the Siding Trail Bridge (**Appendix A, Figure 12**).

Even taking into account the heavily vegetated conditions of the Pretty River channel and floodplain, which differ from the model scenario in the Stantec Report, the floodplain extents based on the updated hydrology of the Pretty River are considerably smaller than the boundaries of the current flood fringe being utilized in the Town's Official Plan. The spill upstream of the Train Trail Bridge is predicted to be 3.02 m^3/s with the updated Regulatory flow, compared to the 52.1 m^3/s of the MacLaren flow based Stantec Report. However, large spills to the west (20.86 m^3/s) and east (11.85m^3/s) are expected to occur upstream of the Siding Trail Bridge, which were originally estimated to be much smaller in the Stantec Report. The disparity is likely due to the condition of the Pretty River, the heavily vegetated state through the dykes, which greatly reduces efficiency of the system as a flood flow conveyance structure.

Maximum water surface elevation upstream of the Train Trail Bridge was modelled by Greenland to be 194.29m, or 11 cm higher than the 194.18m modelled by Tatham. Under the existing conditions of the River, a portion of the existing Liberty development (Pretty River Estates I) is a potential flood damage centre, as the grading of lots along Portland Street is 194.2m, which is significantly lower than the flood elevation

5.3.2 Scenario 2- Existing Conditions, Proposed Grading

One of the primary goals of the hydraulic assessment by Greenland is to provide the technical details to update the Pretty River hydraulics based on Tatham's updated hydrology. A part of this assessment is to confirm the elimination of the spill upstream of the Train Trail Bridge and determine the associated impacts in the river downstream, by employing both methods for the proposed grading at Pretty River Estates II, by Tatham.

Tatham has proposed two (2) grading scenarios upstream of the Train Trail Bridge to eliminate the spill occurring at the choke point of the channel by re-routing the water back into the river downstream of the bridge, allowing the opportunity for a Zoning change to permit development of the second phase of the Pretty River Estates. The dyke system is already close to capacity, and exceeding it in some areas, during the Regulatory event, resulting in overtopping of the dyke banks upstream of the Siding Trail Bridge.

The proposed grading of the subject area of the Pretty River Estates II, under existing conditions of the Pretty River would result in the elimination (contained) or redirection (maintained) of the spill at the Train Trail Bridge, depending on the scenario approved (see **Section 1.2** for details); however, the grading would introduce <u>increased spill rates downstream</u>, compared to the spills already occurring upstream and downstream of the Siding Trail Bridge under existing conditions, due to the increased flow downstream of the Train Trail Bridge (**Appendix A, Figure 12**).

In addition, with the increased roughness in the Greenland model, the spill via the ditch in Tatham's "maintained" scenario will increase to 2.57 m^3/s, compared to their calculated flow rate of 2.1 m^3/s. The Pretty River has the capacity to convey the increased flow upstream of the dyke system entrance, however cannot convey the entire flood flow through the dykes. This proposal under existing conditions does not provide the Town with the solution it is seeking in regards to the elimination of spills in the downstream reach of the Pretty River.

5.3.3 Scenario 3- Maintained Conditions, Existing Grading

In order to eliminate the spills through the downstream reach of the Pretty River, the Town's preferred solution is to maintain a section of the dykes as detailed in the Stantec Study and reflected in the Town's Official Plan. Maintaining the overbanks of the River would reduce roughness and allow it to convey flood flows through the Town without spilling, based on the approved Tatham hydrology.

To determine the minimum length of the Pretty River that must be maintained to eliminate all downstream spills, an iterative assessment was employed. Starting at the Train Trail Bridge, a lower roughness coefficient (0.04- 'maintained vegetation') was applied to the entire downstream section. The section of maintained channel was then reduced by increasing the roughness coefficient back to existing conditions values section by section, until the minimum maintained length before spills occur was achieved. The Town expressed the concern that the area to be maintained must be on land owned by the Town, as approval from Private landowners would be difficult to attain. Therefore, the area to be maintained was limited to areas within the Pretty River dyke system.

The channel length that must be maintained to eliminate all spills downstream of the Train Trail Bridge for the existing grading is 1,158m, between cross sections 0.601 (start of the dyke system) and -11.1 (downstream of the Siding Trail Bridge) (**Appendix A, Figure 13**). This level of maintenance would result in a single spill of the Pretty River within Town limits: upstream of the Train Trail Bridge. The spill will be reduced from 3.02 m^3/s under existing conditions to 2.78 m^3/s with the addition of maintenance; however, the spill upstream of the Train Trail Bridge cannot be eliminated with just the maintenance of the Pretty River dyke system.

It should be noted, it is not part of Greenland's scope of work to assess the natural heritage and fisheries implications of maintaining the Pretty River vegetation to the levels described herein.

5.3.4 Scenario 4- Maintained Conditions, Proposed Grading

The proposed grading by Tatham at the Pretty River Estates Phase II, under both proposed spill containment scenarios, will result in the re-direction of the spill upstream of the Train Trail Bridge, diverting a portion of the flow from the spill zone over the Train Trail and back into the River downstream of the Trail Bridge choke point. The increased flow downstream of the bridge does not create any additional spills in the Pretty River before the entrance to the dykes; however, based on existing conditions, additional spills are created through the dyke system, as the river does not have the capacity for the increased flow at certain sections along its length. However, with the addition of maintenance through the Pretty River dykes, the downstream spills can be eliminated, taking into account the increased flow downstream of the Train Trail Bridge.

With the proposed grading at the Pretty River Estates Phase II under existing conditions, the water surface elevation of the spill upstream of the Train Trail Bridge is equal to, or very close to, the existing elevation, therefore the minimum maintained length to remove all downstream spills for both scenarios for the proposed grading was determined to be 1,158m, between cross sections 0.601 and -11.1 (**Appendix A, Figure 13**), the same as is necessary for the existing grading. The methodology used to determine the length of dyke system that needs to be maintained is detailed in **Section 5.4**.

The maintenance of a section of the Pretty River dyke system, with the new hydrology and grading at the Pretty River Estates Phase II proposed by Tatham, will result in the elimination of all spills within the Town boundary.

5.4 Hydraulic Conditions of the River Vegetation

As part of the sensitivity analysis regarding the maintained section of the Pretty River, the level of maintenance must be defined. The location of the portion of the dyke system that must be maintained was identified in **Section 5.3**. This level of maintenance has been an issue in regards to the current Official Plan, where the definition of maintained is not defined in implementation terms, but is clear from a hydraulic modeling perspective (roughness coefficient) in the Stantec Report. The current Official Plan defines “Maintained Condition” as “harvested vegetation within the Pretty River dykes (channel).” Greenland seeks to clarify the language used and provide clear recommendations as to the level of maintenance required.

Currently the Pretty River dykes are in a naturalized condition. The banks of the River are fully vegetated with small trees and shrubs (**Appendix A, Figure 14**). The “existing conditions” roughness coefficient of the river in the identified section requiring maintenance is 0.08, a value between earth with brush and earth and heavy vegetation and/or earth with dense brush and trees, from the 1999 Stantec report.

The proposed coefficient for maintained vegetation by Greenland is 0.04, slightly higher than the value utilized in the Stantec Report (0.035) for the maintained section of the river. This value is also associated with short to tall grass and rip-rap. For the purposes of this study, grassed earth is preferable to rip-rap, to preserve the environmental integrity of the river through the dykes. To determine the level of maintenance required, Greenland has referred to the Black Ash Creek channelized floodway.

The section of Black Ash Creek flowing through the Town has been channelized to act as flood conveyance for the creek through Town. It is capable of conveying the Timmins storm without flood spill, which is the current goal for the Pretty River. Thus, as the intentions of both watercourses through the Town are the same, the channel/ bank conditions should be comparable to convey flow as intended.

The current conditions of the Black Ash Creek floodway vary through the Town. In the upstream area (South) of the Town, the banks consist of tall grasses with short trees and shrubs directly lining the creek as riparian protection (**Appendix A, Figure 15**). Further downstream, the creek banks consist of denser vegetation- more bushes, shrubs and small trees, in addition to some long grasses (**Appendix A, Figure 16**). The intention for the maintained section of the Pretty River dykes is to have a similar concept as the upstream Black Ash Creek floodway.

The Black Ash Creek has been accepted as a “maintained” flood conveyance channel by the NVCA, thus maintaining a section of the Pretty River dykes to the same level as the upstream section of the channelized Black Ash Creek should be acceptable to allow for the Pretty River to act as a flood conveyance channel. It is Greenland's conclusion that maintaining the Pretty River to a state of long grasses on the banks with small trees and bushes lining the channel will be adequate for the river to convey all flood flows through the dyke system.

6 Flood Line Generation

The floodline mapping for the Pretty River through Collingwood has been prepared based on the maintained scenario for the vegetation on the dykes as discussed in **Section 5**. **Figure 6** shows the extent of the flooding through the corridor. The flood maps are included in **Appendix F**.

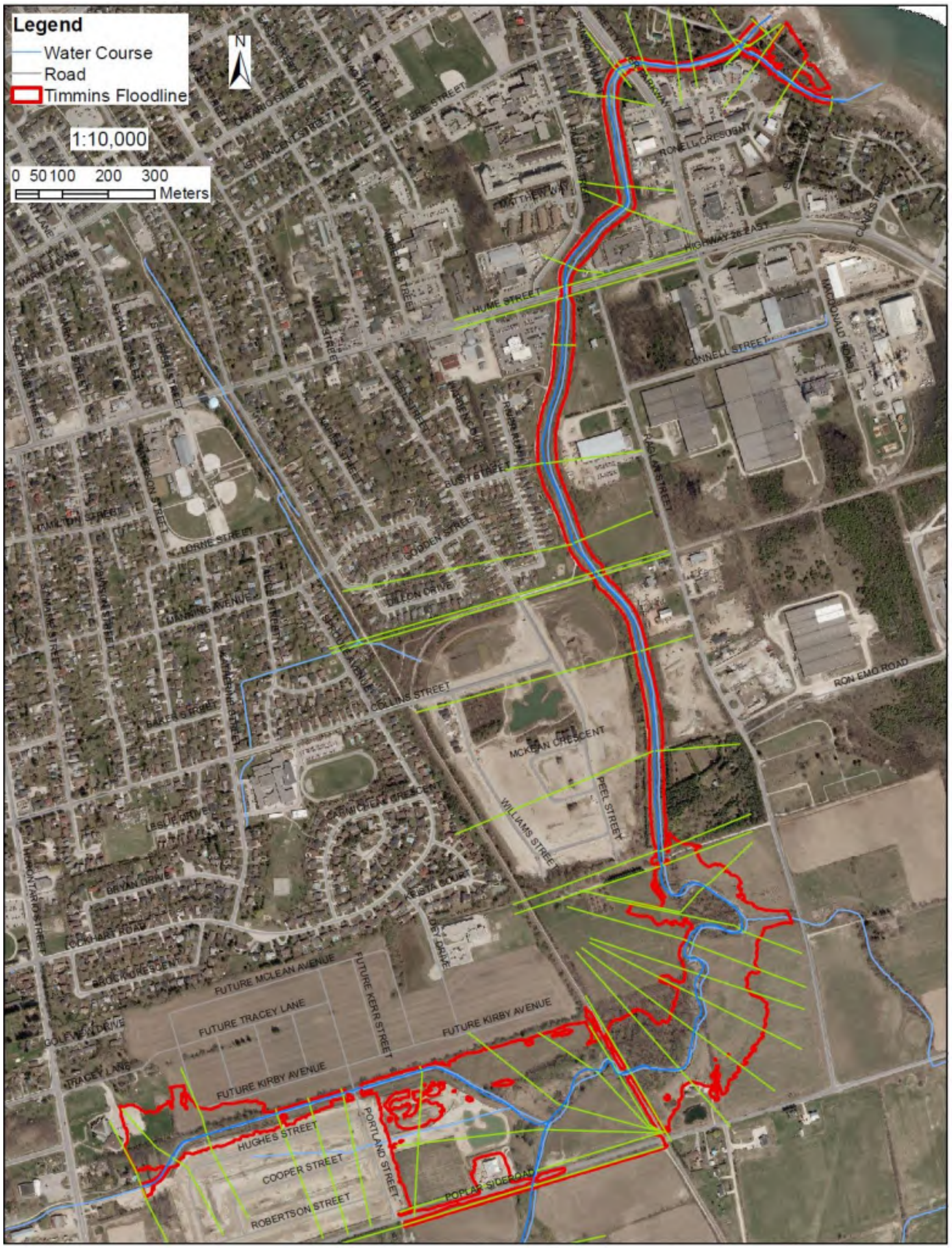


Figure 6 Pretty River Flood line

7 Conclusions and Recommendations

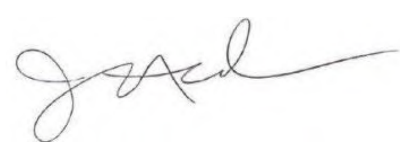
With the acceptance by the NVCA of the Tatham hydrology for the Pretty River, the Town is in the position to update its floodplain mapping in conjunction with updating its Official Plan for the Town, as it relates to the Pretty River spill floodplain. This change of floodplain and spill floodplain mapping, could bring about changes in development requirements and restrictions for areas of the Town that are currently in the flood fringe but will not be in the floodplain at all upon the completion of update to the Official Plan. In addition, changes may be required to any Emergency Response Plans for buildings within the current flood fringe.

Greenland has provided all necessary technical details required for the Town to assess the current Official Plan restrictions on development in the Pretty River floodplain. Four (4) scenarios were considered by Greenland, taking into account the Town's preferred method to increase river capacity and eliminate spills. With the acceptance of either method for the updated grading of the Pretty River Estates Phase II proposed by Tatham combined with the maintenance of the Pretty River dyke system, the Pretty River can convey all flood flows for the Regulatory event, without any spills through its downstream reach. With grading remaining in its current condition and maintenance to the Pretty River dykes, all spills downstream of the Train Trail Bridge will be eliminated. Without any maintenance of the river, multiple spills are expected through its downstream reach, in the event of a Regulatory Storm.

The above assessment of the updated Pretty River hydraulics, provides the Town of Collingwood with the technical details for four (4) viable scenarios, with which to undertake the necessary steps forward to update the Official Plan with the preferred solution.

Respectfully,

Greenland Consulting Ltd.



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Appendix A

Figures

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Figure 1: Town of Collingwood Official Plan Schedule A- Land Use Plan

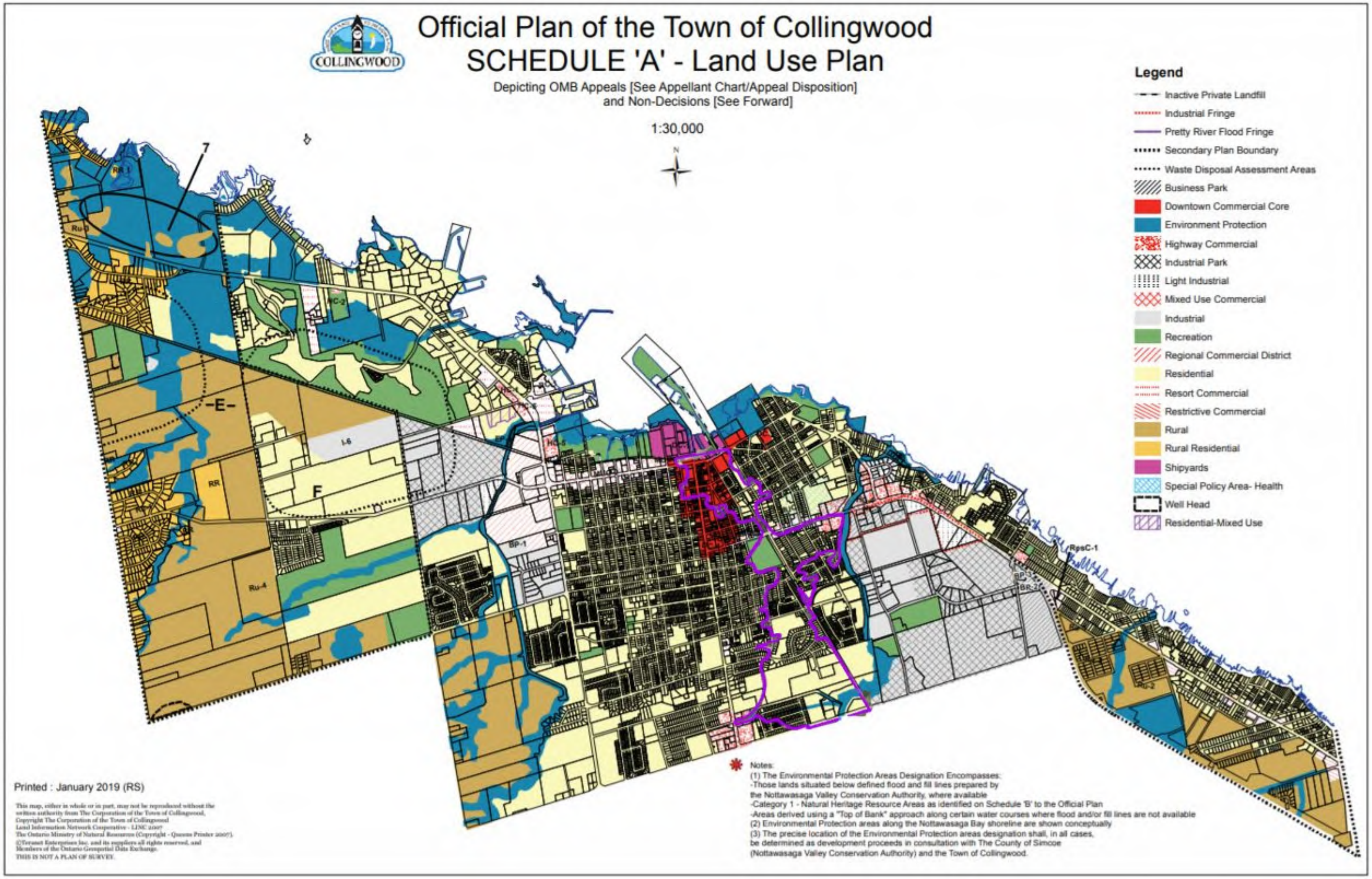

Figure 2: Pretty River Assigned Bridge Names and Locations

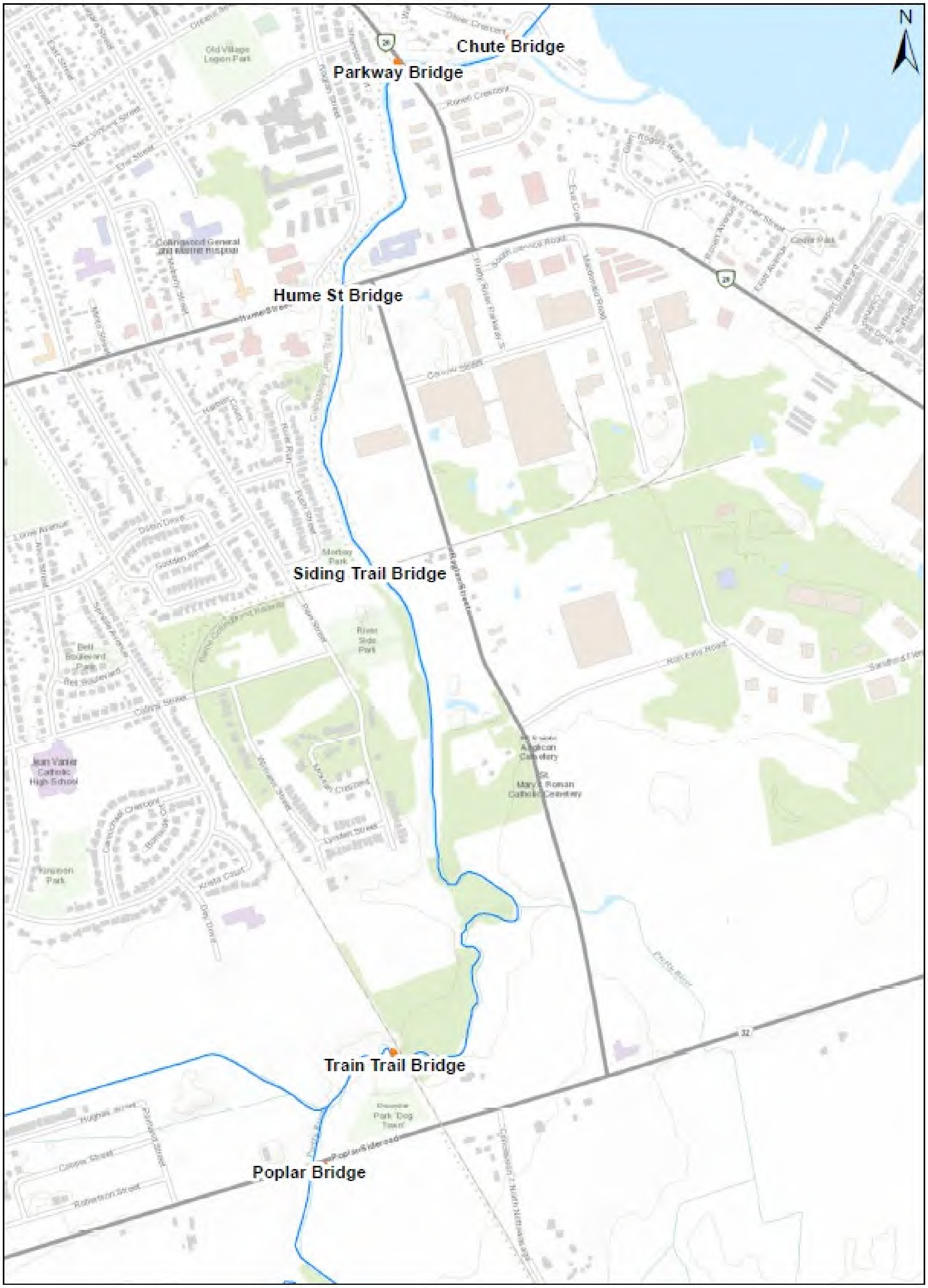

Figure 3: Town Of Collingwood Zoning By-Law, Map 24

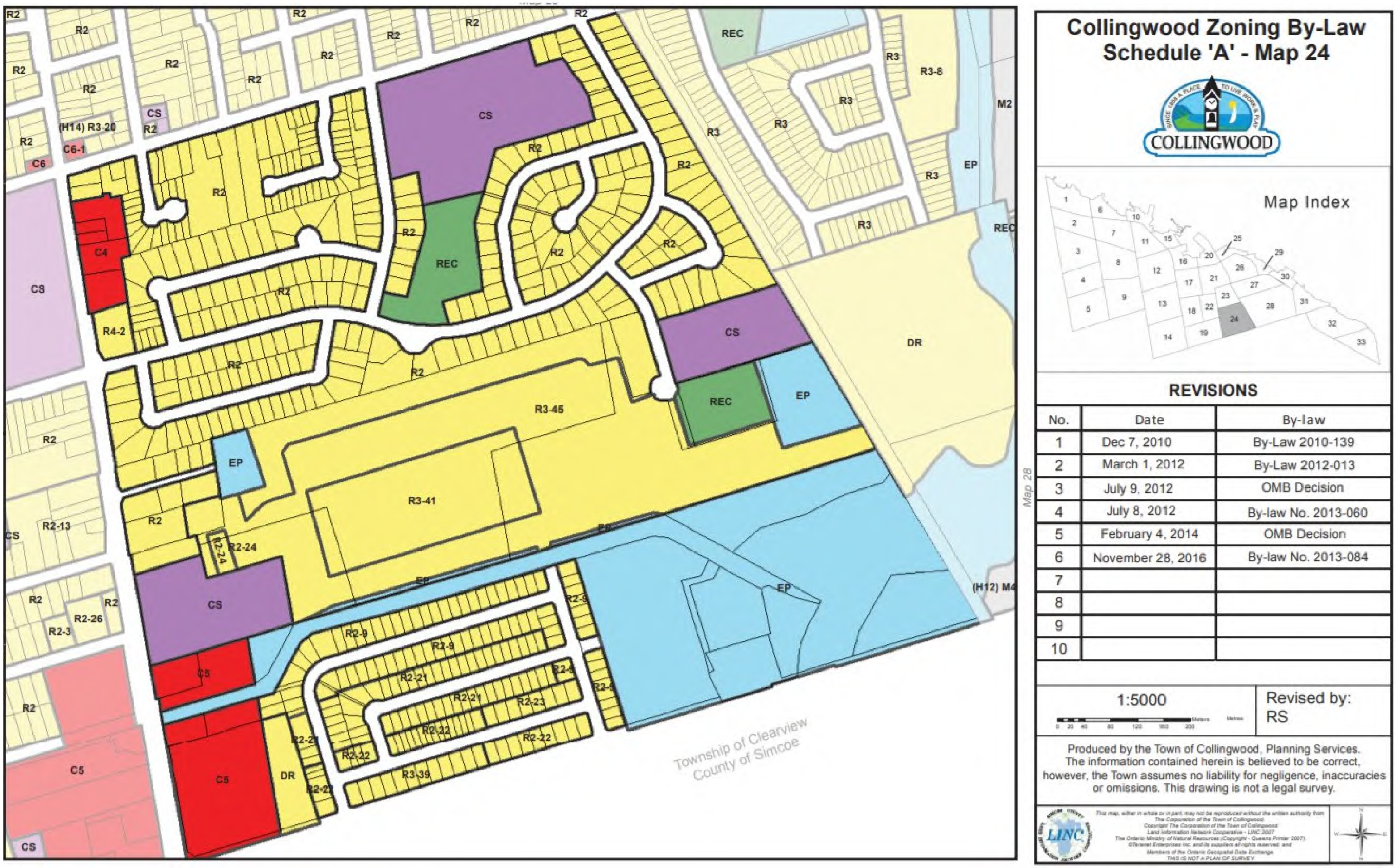

Figure 4: Pretty River Estates Phase II, Existing Grading contour map

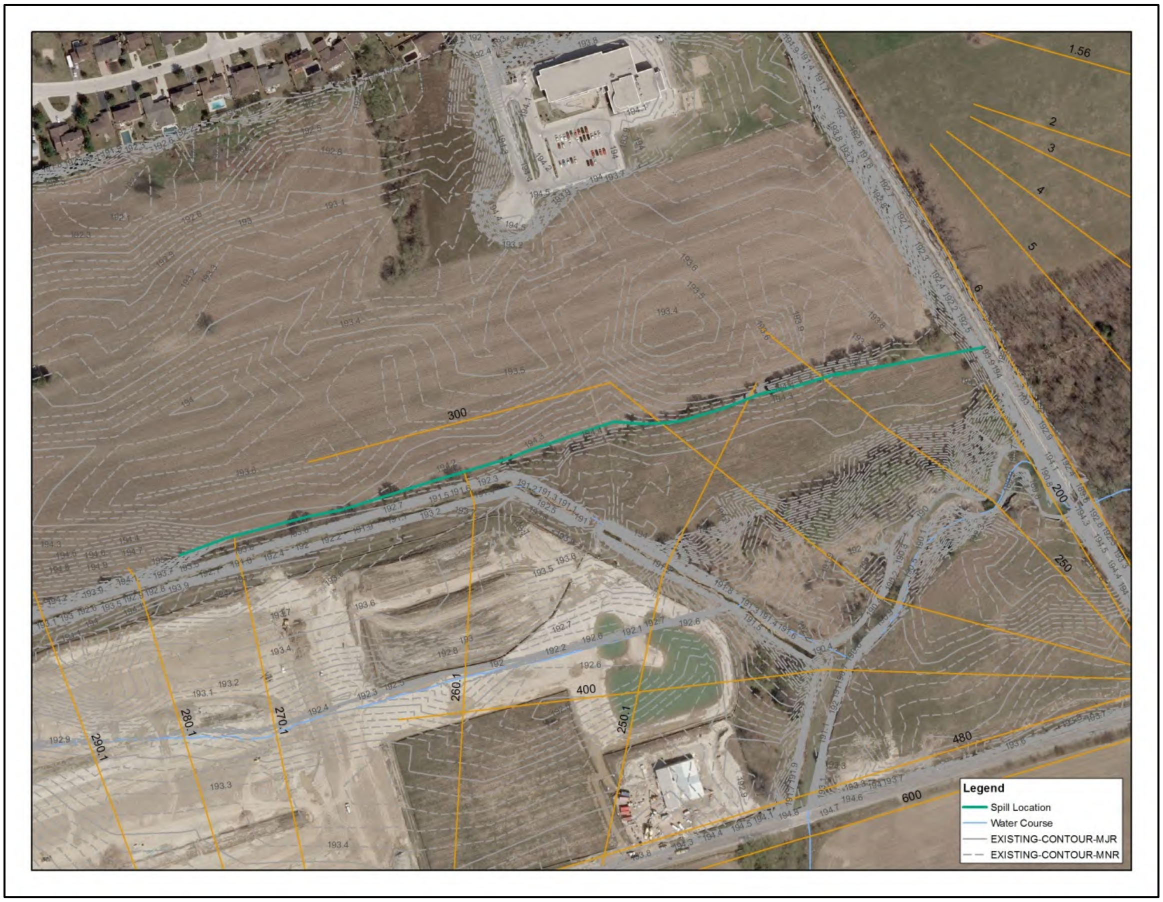

Figure 5: Pretty River Estates Phase II, Existing Grading Profile (Tatham Model)

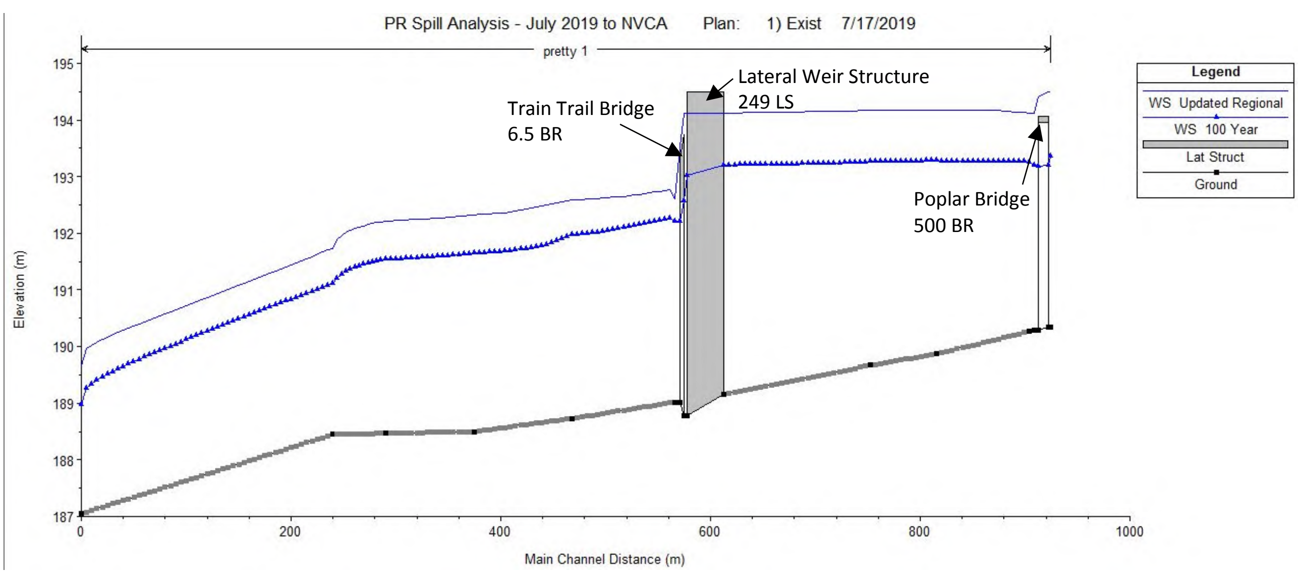

Figure 6: Pretty River Estates Phase II, Proposed Grading contour map

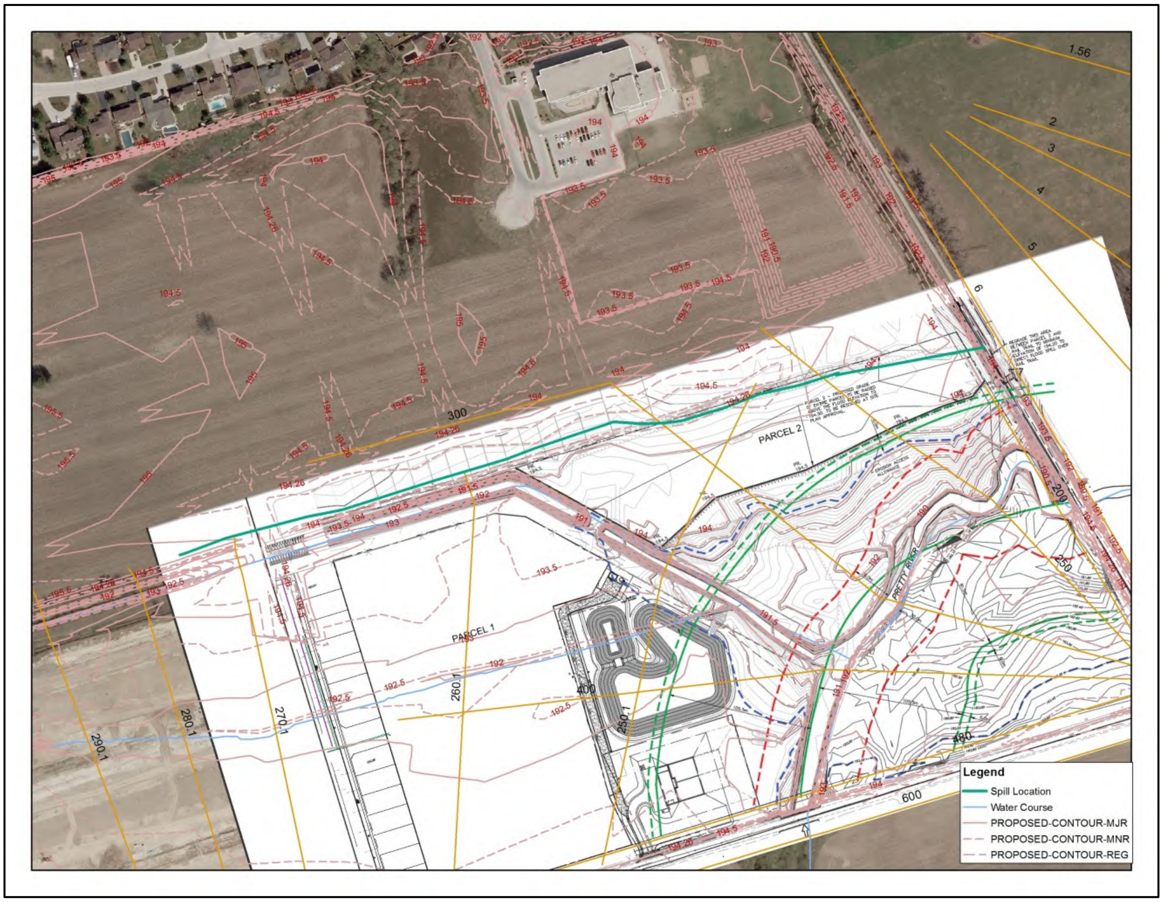

Figure 7: Pretty River Estates Phase II, Proposed Grading, Contained Spill Profile (Tatham Model)

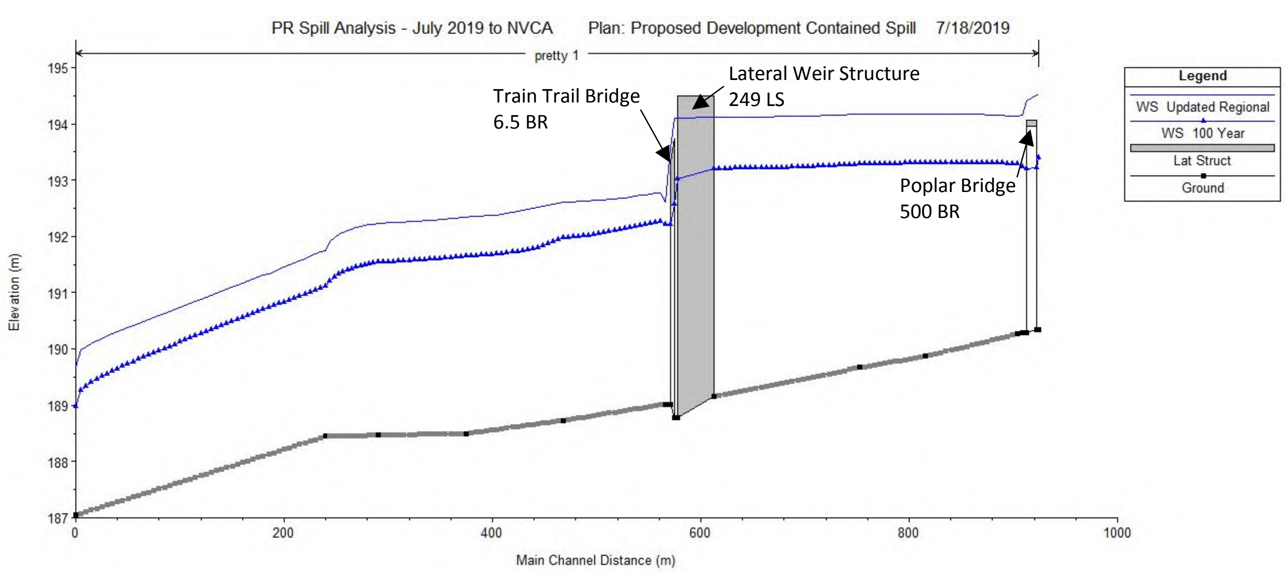

Figure 8: Pretty River Estates II, Proposed Grading Maintained Spill Profile (Tatham Model)

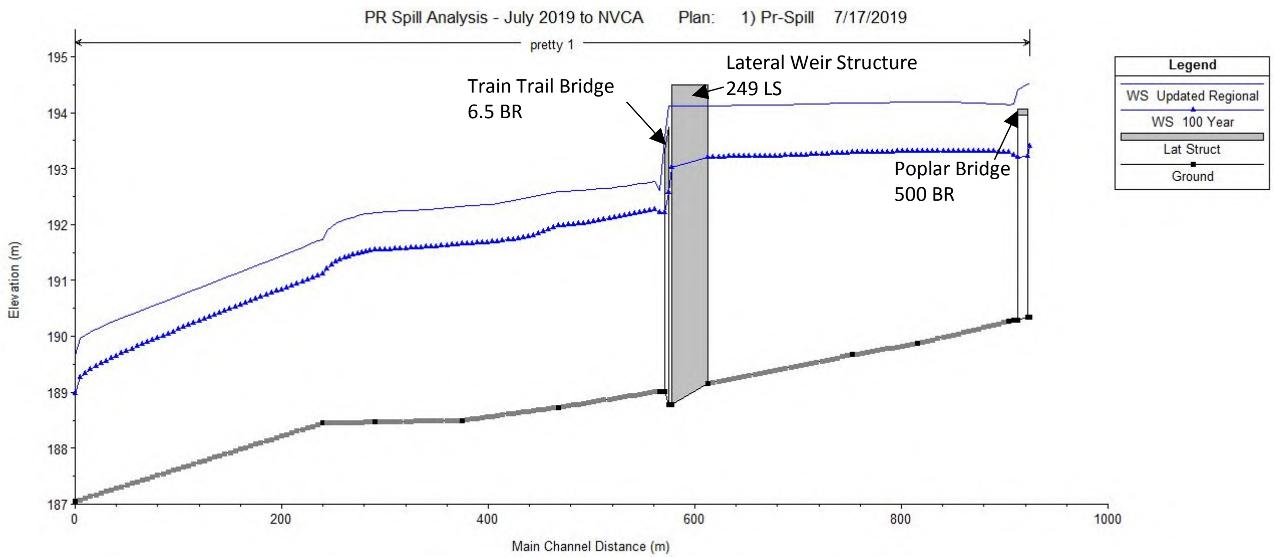

Figure 9: Section 300- Existing Conditions, Tatham Model

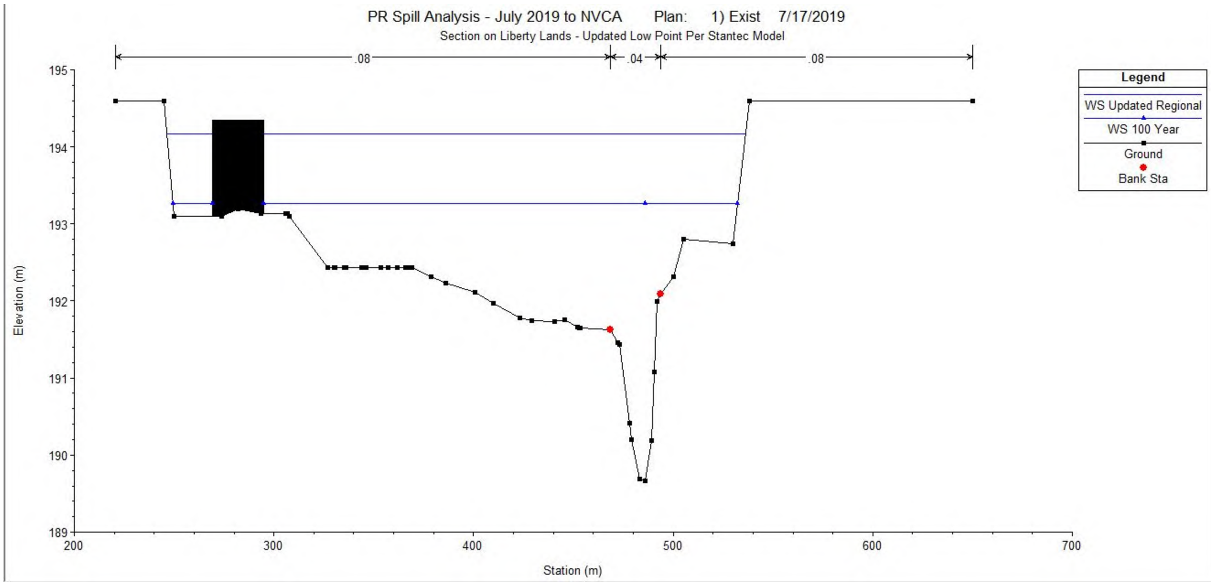

Figure 10: Section 300- Existing Conditions, Greenland Model

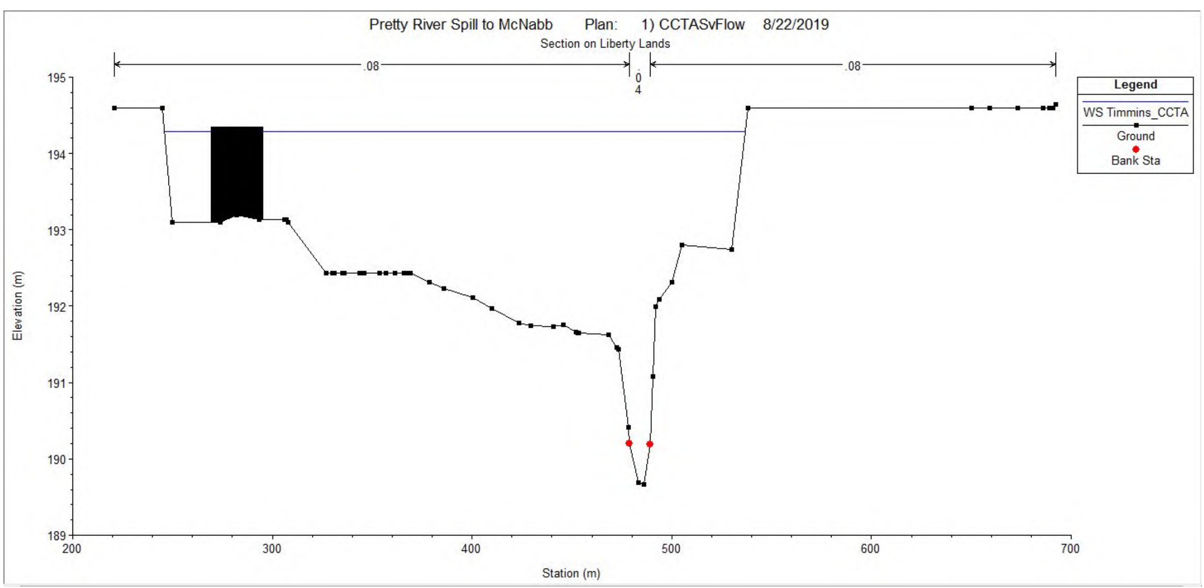

Figure 11: Pretty River Flood Fringe Boundary, from Official Plan Schedule A

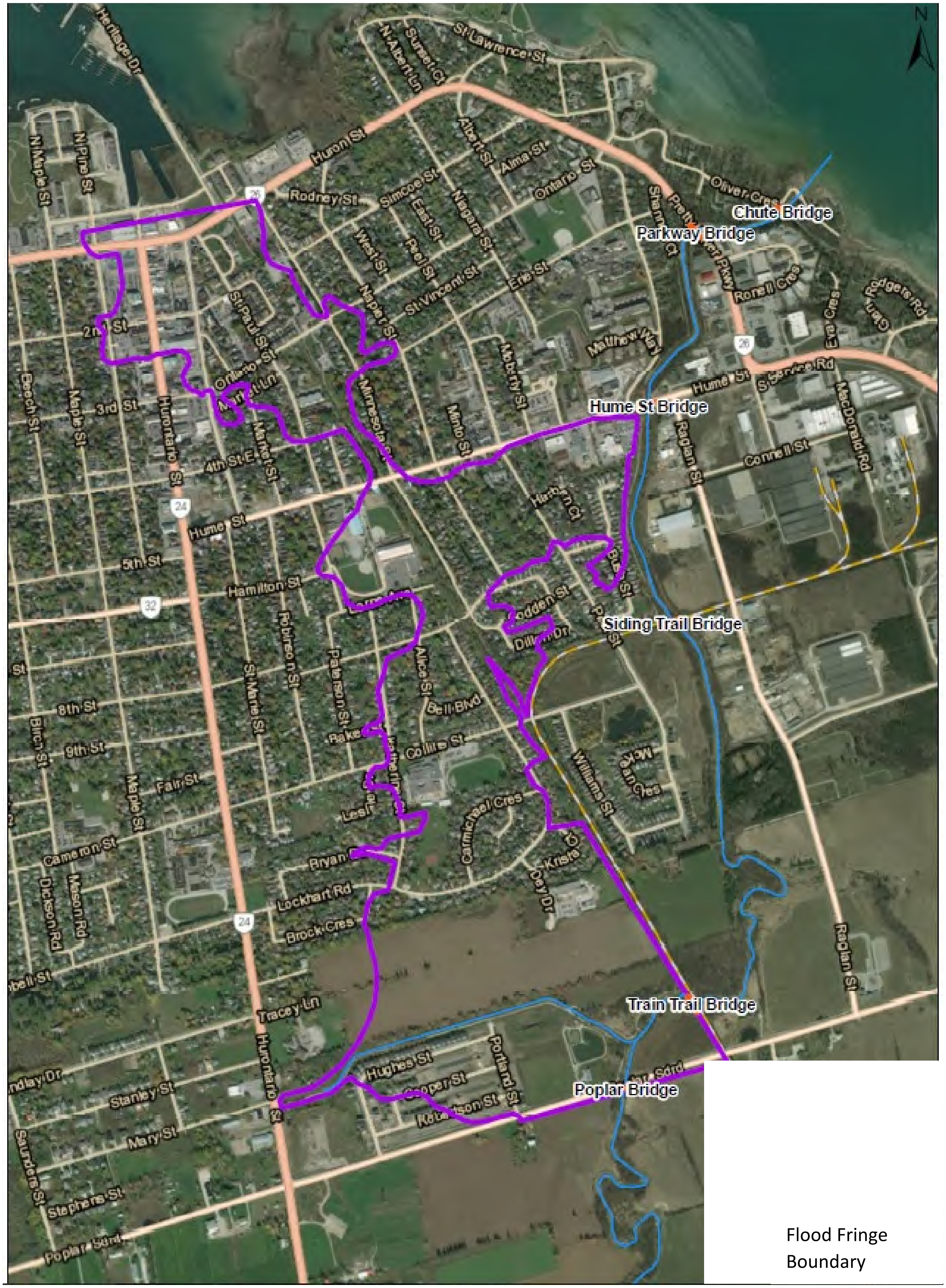

Figure 12: Spill Locations, Existing Conditions

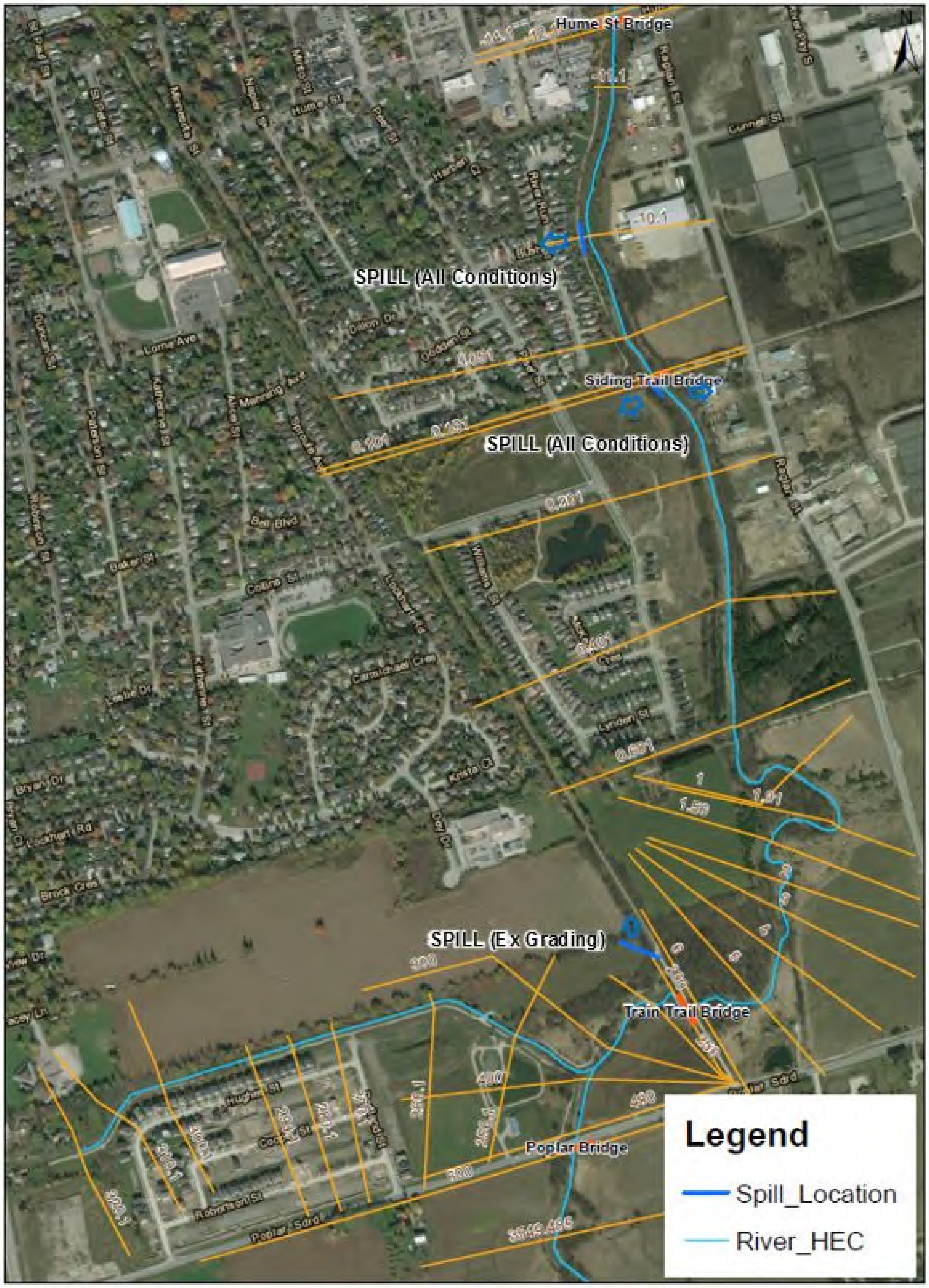

Figure 13: Maintained Section for Existing and Proposed Grading

Figure 14: Pretty River at Siding Trail Bridge looking Upstream (left) and Downstream (right)

Figure 15: Black Ash Creek South of Creekside Subdivision looking Upstream (left) and Downstream (Right)

Figure 15: Black Ash Creek at Georgian Trail Bridge, Looking Upstream

<u>Appendix B</u>

NVCA Comments and Response Matrix

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Nottawasaga Valley
Conservation Authority

6 July 2020

Mr. Jon Velick
Manager, Engineering Services
Town of Collingwood
55 Ste. Marie Street
Collingwood, ON L9Y 0W6

Dear Mr. Velick,

Re: Collingwood Stormwater Management Master Model
Pretty River Hydraulics Assessment [DRAFT]
Town of Collingwood
NVCA ID# 38118

Nottawasaga Valley Conservation Authority [NVCA] staff understands that Greenland Consulting Ltd., was retained by the Town of Collingwood to undertake an existing conditions stormwater management model. As part of the model, the existing Pretty River hydraulic model has been updated. As the Pretty River floodplain is within a two-zone floodplain concept policy area in the Town, updates to the Pretty River hydraulics may result in the need to amend the relevant policies and land use schedule within the Town of Collingwood Official Plan.

NVCA staff has reviewed the information presented in the following documents:

- Collingwood "Stormwater Management Master Model Pretty River Hydraulics Assessment – DRAFT", Greenland International Consulting Limited, October 4, 2019.
- "HEC-RAS model – Pretty River", Greenland International Consulting Limited, digital files provided November 21, 2019

Based upon our review of the above noted materials we offer the following comments:

ENGINEERING

1. A stand-alone report will be required to support the revision of the Pretty River floodline and possible revision of the two-zone concept policies and land use schedule in the Official Plan.
2. The report will need to comply with NVCA Natural Hazard Guidelines.
3. The compilation of topographic data will need to be described including the specifications/accuracy of the LiDAR data as well as any associated survey data. It was noted in the draft report that there may be some discrepancies between historic survey data and recently obtained LiDAR data in some areas (Section 4).
4. Similarly, all hydraulic structures will need to be documented included the crossing associated with 452 Raglan Street.
5. It is preferable that the top of the Pretty River dyke (left & right) as well as the channel invert be surveyed and merged with the other topographic data.

HEC-RAS Model

6. The spatial extent of the model should extend from Georgian Bay to immediately upstream of Poplar Side Road.
7. Please explain the reasoning behind the names used for the River Stations (ie - 10.1).
8. Cross-section -10.1 has unusual geometry near the right levee. Please review if this is accurate, as we do not recall seeing this geometry in the field.
9. It is noted that the existing ice bypass structure near the mouth of the Pretty River does not appear to be accounted for in the model (however this is acknowledged to be conservative). Please include the ice control structure the model.
10. There is an existing farm bridge crossing the river at 452 Raglan Street that does not appear to be included in the HEC-RAS model. The bridge itself is elevated and may not have impact flows, however, there appears to be a constriction in the channel at the bridge abutments that may impact hydraulic capacity of the watercourse. Please review if this restriction point should be included in the HEC-RAS model.
11. It is noted that the lateral structures within the dyke are modelled with a weir coefficient of 1.1 which appears to be lower than standard broad-crested weir coefficient. Please include a justification for the weir coefficients assumed in the report.
12. Please include reaches downstream of all lateral structures and change tailwater connection from "out of system" to "cross section of a reach".
13. Please review the cross-section locations immediately upstream and downstream of all bridge crossings and ensure compliance with HEC-RAS reference manual guidance.
14. Please review if expansion and contraction coefficients should be increased surrounding bridge crossings as recommended by the HEC-RAS hydraulic reference manual or justify why this may not be needed in the report.
15. Please review if ineffective flow stations should be used up and downstream of bridge crossings or justify why they may not be needed in the report.
16. It is noted that the Hume Street bridge was reconstructed in the past few years. Has this bridge reconstruction altered the geometry and if so can the model be updated to reflect this change?
17. Please review and justify the roughness values used for unmaintained overbank sections of the channel. Downstream of the assumed "maintained" section, overbank roughness values of 0.043 and 0.053 are used, which may not reflect a densely vegetated, unmaintained channel. On other projects, roughness values in the range of 0.080 have been used to reflect unmaintained, vegetated channel conditions. Please review and justify the roughness values used for unmaintained channel sections.

18. It is noted that some HEC-RAS cross-sections reference topographic survey sections from the 1999 flood study. We note that some of the cross-sections in the HEC-RAS model do not appear to match the topographic survey cross-sections in our records (for example J-J vs. HEC-RAS Section -15.1). Please review and confirm why this is the case and that the most relevant topographic data is being used.
19. In some scenarios, the flood elevation in HEC-RAS seems to increase going downstream between sections 0.301 and 0.151. Please review if this is a model stability issue that can be resolved through adding additional cross-sections, etc

We note that these comments are related to this submission and the information provided within this submission. NVCA requires additional information in order to complete our review and additional comments may be provided in the future.

Please feel free to contact the undersigned at mhartley@nvca.on.ca should you require any further information or clarification on any matters contained herein.

Sincerely,

Lee Bull, MCIP, RPP
Manager, Planning Services

Mark Hartley, P. Eng
Senior Engineer

Pretty River Hydraulics Assessment [DRAFT]
Comments on Proposed Revisions

NVCA Comments	Greenland Response
Engineering	
1. A stand-alone report will be required to support the revision of the Pretty River floodline and possible revision of the two-zone concept policies and land use schedule in the Official Plan.	Greenland is responsible for the technical support for the updating of the Pretty River hydraulics and updating of the current Official Plan. A stand-alone report supporting the update of hydraulic modelling to establish revised floodlines will be completed. The revision of current concept policies is the responsibility of the Town of Collingwood.
2. The report will need to comply with NVCA Natural Hazard Guidelines.	The guidelines are being reviewed. The report will be updated to ensure that it complies with the NVCA Natural Hazard Guidelines specifically for model construction. Some of the sensitivity analyses for 50% blockage and hazard lines due to meander will not be added.
3. The compilation of topographic data will need to be described including the specifications/accuracy of the LiDAR data as well as any associated survey data. It was noted in the draft report that there may be some discrepancies between historic survey data and recently obtained LiDAR data in some areas (Section 4).	This has been included in the Town-wide Stormwater Management Report. For the Pretty River Hydraulics Report be considered a stand-alone report, it will be updated with the same information.
4. Similarly, all hydraulic structures will need to be documented included the crossing associated with 452 Raglan Street.	A section documenting the hydraulic structures has been added to the report.
5. It is preferable that the top of the Pretty River dyke (left & right) as well as the channel invert be surveyed and merged with the other topographic data.	The cross-sections in the model were originally based on surveyed data. The accuracy of the old survey data was confirmed with a limited survey, as detailed in the report. If desirable, the surveyed cross-sections can be merged with the LiDAR data along the overbanks.
HEC-RAS Model	
6. The spatial extent of the model should extend from Georgian Bay to immediately upstream of Poplar Side Road.	The spatial extent of the model has been reduced to the recommended extent.
7. Please explain the reasoning behind the names used for the River Stations (ie -10.1).	The sections have been updated to use present standard methodology and are cross-referenced with the original surveyed model nomenclature from the NVCA and the Stantec report.
8. Cross-section -10.1 has unusual geometry near the right levee. Please review if this is accurate, as we do not recall seeing this geometry in the field.	It is a surveyed section. Geometry will be confirmed.

<table>
<tr><td>9. It is noted that the existing ice bypass structure near the mouth of the Pretty River does not appear to be accounted for in the model (however this is acknowledged to be conservative). Please include the ice control structure the model.</td><td>The ice structure was not included in the Tatham hydraulic model provided, which was updated for this study. It has been retrieved from the earlier 1999 Stantec study and imported into the updated model.</td></tr>
<tr><td>10. There is an existing farm bridge crossing the river at 452 Raglan Street that does not appear to be included in the HEC-RAS model. The bridge itself is elevated and may not have impact flows, however, there appears to be a constriction in the channel at the bridge abutments that may impact hydraulic capacity of the watercourse. Please review if this restriction point should be included in the HECRAS model.</td><td>This structure has been added to the field summary and the model.</td></tr>
<tr><td>11. It is noted that the lateral structures within the dyke are modelled with a weir coefficient of 1.1 which appears to be lower than standard broad-crested weir coefficient. Please include a justification for the weir coefficients assumed in the report.</td><td>The coefficient is based on the lateral weir coefficient from the HEC-RAS manual. Should the lateral structures be required in the updated model, the justification will be added to the report. If not required, then the lateral structures will be removed from the model, resolving this comment.
Table 3-1. Lateral Weir Coefficients
<table>
<tr><th>What is being modeled with the Lateral Structure</th><th>Description</th><th>Range of Weir Coefficients</th></tr>
<tr><td>Levee/Roadway – 3ft or higher above natural ground</td><td>Broad crested weir shape, flow over levee/road acts like weir flow</td><td>1.5 to 2.6 (2.0 default)
SI Units: 0.83 to 1.43</td></tr>
<tr><td>Levee/Roadway – 1 to 3 ft elevated above ground</td><td>Broad crested weir shape, flow over levee/road acts like weir flow, but becomes submerged easily.</td><td>1.0 to 2.0
SI Units: 0.55 to 1.1</td></tr>
<tr><td>Natural high ground barrier – 1 to 3 ft high</td><td>Does not really act like a weir, but water must flow over high ground to get into 2D flow area.</td><td>0.5 to 1.0
SI Units: 0.28 to 0.55</td></tr>
<tr><td>Non elevated overbank terrain. Lat Structure not elevated above ground</td><td>Overland flow escaping the main river.</td><td>0.2 to 0.5
SI Units: 0.11 to 0.28</td></tr>
</table></td></tr>
<tr><td>12. Please include reaches downstream of all lateral structures and change tailwater connection from “out of system” to “cross section of a reach”.</td><td>The spills flow to the town drainage system. It will not flow back to the river.</td></tr>
<tr><td>13. Please review the cross-section locations immediately upstream and downstream of all bridge crossings and ensure compliance with HEC-RAS reference manual guidance.</td><td>The model has been reviewed and the cross sections are updated.</td></tr>
<tr><td>14. Please review if expansion and contraction coefficients should be increased surrounding bridge crossings as recommended by the HEC-RAS hydraulic</td><td>Some bridges are wide enough not to contact the stream. The justification will be added to the report.</td></tr>
</table>

reference manual or justify why this may not be needed in the report.	
15. Please review if ineffective flow stations should be used up and downstream of bridge crossings or justify why they may not be needed in the report.	The model is updated.
16. It is noted that the Hume Street bridge was reconstructed in the past few years. Has this bridge reconstruction altered the geometry and if so can the model be updated to reflect this change?	The model has been updated with the new structure at Hume Street. It is also documented in the structure inventory.
17. Please review and justify the roughness values used for unmaintained overbank sections of the channel. Downstream of the assumed “maintained” section, overbank roughness values of 0.043 and 0.053 are used, which may not reflect a densely vegetated, unmaintained channel. On other projects, roughness values in the range of 0.080 have been used to reflect unmaintained, vegetated channel conditions. Please review and justify the roughness values used for unmaintained channel sections.	Justification for the channel roughness values will be included in the report.
18. It is noted that some HEC-RAS cross-sections reference topographic survey sections from the 1999 flood study. We note that some of the cross-sections in the HEC-RAS model do not appear to match the topographic survey cross-sections in our records (for example J-J vs. HEC-RAS Section -15.1). Please review and confirm why this is the case and that the most relevant topographic data is being used.	The report is being updated based on the discussion in the August 19 meeting with the NVCA and Town. The discussion will be more focused on how the cross sections in the model reflect the LiDAR mapping and present surveys. Any information from older models and reports will be cross-referenced with an updated cross-section numbering system that follows newer protocols.
19. In some scenarios, the flood elevation in HEC-RAS seems to increase going downstream between sections 0.301 and 0.151. Please review if this is a model stability issue that can be resolved through adding additional cross-sections, etc	This phenomenon is caused by backwater from a bridge and the early stage of a hydraulic jump.

Appendix C

QA/QC Report LiDAR Provider

Z:\1757_OwenSound\8_Working\Mike_K\Owen_Sound.csv

Number	Easting	Northing	Known Z	Laser Z	Dz
PLC0100	513110.420	4936845.082	310.737	310.690	-0.047
PLC0100	511332.177	4934387.817	306.674	306.670	-0.004
PLC0100	513110.420	4936845.082	310.737	310.690	-0.047
PLC01001	511332.168	4934387.819	306.669	306.670	+0.001
PLC01001	511332.168	4934387.819	306.669	306.670	+0.001
PLC01002	511333.673	4934378.842	306.745	306.730	-0.015
PLC01002	511333.673	4934378.842	306.745	306.730	-0.015
PLC01003	511335.068	4934370.405	306.807	306.770	-0.037
PLC01003	511335.068	4934370.405	306.807	306.770	-0.037
PLC02001	506666.096	4934882.790	242.979	242.970	-0.009
PLC02001	506666.096	4934882.790	242.979	242.970	-0.009
PLC02002	506671.818	4934883.762	242.692	242.700	+0.008
PLC02002	506671.818	4934883.762	242.692	242.700	+0.008
PLC02003	506677.598	4934884.708	242.395	242.400	+0.005
PLC02003	506677.598	4934884.708	242.395	242.400	+0.005
PLC02004	506673.395	4934890.811	242.590	242.570	-0.020
PLC02004	506673.395	4934890.811	242.590	242.570	-0.020
PLC02005	506672.415	4934896.541	242.655	242.670	+0.015
PLC02005	506672.415	4934896.541	242.655	242.670	+0.015
PLC02006	506671.487	4934902.217	242.745	242.760	+0.015
PLC02006	506671.487	4934902.217	242.745	242.760	+0.015
PLC03001	504642.634	4929783.213	272.534	272.540	+0.006
PLC03001	504642.634	4929783.213	272.534	272.540	+0.006
PLC03002	504653.378	4929784.575	272.395	272.350	-0.045
PLC03002	504653.378	4929784.575	272.395	272.350	-0.045
PLC03003	504664.214	4929786.065	272.437	272.410	-0.027

PLC03003	504664.214	4929786.065	272.437	272.410	-0.027
PLC04001	501566.571	4929284.202	260.296	260.300	+0.004
PLC04001	501566.571	4929284.202	260.296	260.300	+0.004
PLC04002	501575.410	4929284.420	260.319	260.330	+0.011
PLC04002	501575.410	4929284.420	260.319	260.330	+0.011
PLC04003	501588.147	4929286.423	260.247	260.230	-0.017
PLC04003	501588.147	4929286.423	260.247	260.230	-0.017
PLC05001	500859.626	4933102.368	239.373	239.360	-0.012
PLC05001	500859.626	4933102.368	239.373	239.360	-0.012
PLC05002	500858.215	4933111.175	239.334	239.340	+0.006
PLC05002	500858.215	4933111.175	239.334	239.340	+0.006
PLC05003	500856.821	4933120.094	239.295	239.300	+0.005
PLC05003	500856.821	4933120.094	239.295	239.300	+0.005
PLC06001	500702.760	4934428.309	235.614	235.620	+0.006
PLC06001	500702.760	4934428.309	235.614	235.620	+0.006
PLC06002	500709.429	4934429.348	235.621	235.590	-0.031
PLC06002	500709.429	4934429.348	235.621	235.590	-0.031
PLC06003	500715.399	4934430.276	235.618	235.610	-0.008
PLC06003	500715.399	4934430.276	235.618	235.610	-0.008
PLC07004	503255.893	4939406.077	209.530	209.490	-0.040
PLC07004	503255.893	4939406.077	209.530	209.490	-0.040
PLC07005	503264.332	4939404.143	209.484	209.470	-0.014
PLC07005	503264.332	4939404.143	209.484	209.470	-0.014
PLC07006	503273.251	4939402.174	209.430	209.390	-0.040
PLC07006	503273.251	4939402.174	209.430	209.390	-0.040
PLC07007	503282.548	4939400.044	209.385	209.360	-0.025
PLC07007	503282.548	4939400.044	209.385	209.360	-0.025
PLC08001	504376.715	4942459.839	213.754	213.730	-0.024
PLC08001	504376.715	4942459.839	213.754	213.730	-0.024

PLC08002	504380.580	4942477.251	213.706	213.630	-0.076
PLC08002	504380.580	4942477.251	213.706	213.630	-0.076
PLC08003	504384.462	4942495.009	213.653	213.630	-0.023
PLC08003	504384.462	4942495.009	213.653	213.630	-0.023
PLC09001	505518.846	4947626.026	236.194	236.160	-0.034
PLC09001	505518.846	4947626.026	236.194	236.160	-0.034
PLC09002	505520.681	4947634.266	236.162	236.110	-0.052
PLC09002	505520.681	4947634.266	236.162	236.110	-0.052
PLC09003	505522.608	4947642.754	236.141	236.100	-0.041
PLC09003	505522.608	4947642.754	236.141	236.100	-0.041
PLC1001	526991.417	4941053.912	241.448	241.400	-0.048
PLC1001	526991.417	4941053.912	241.448	241.400	-0.048
PLC1002	526990.118	4941062.398	241.781	241.790	+0.009
PLC1002	526990.118	4941062.398	241.781	241.790	+0.009
PLC1003	526988.886	4941070.755	242.121	242.100	-0.021
PLC1003	526988.886	4941070.755	242.121	242.100	-0.021
PLC11001	494613.546	4958950.577	180.961	180.960	-0.001
PLC11001	494613.546	4958950.577	180.961	180.960	-0.001
PLC11002	494621.789	4958953.951	180.906	181.000	+0.094
PLC11002	494621.789	4958953.951	180.906	181.000	+0.094
PLC11003	494630.051	4958957.408	180.912	180.970	+0.058
PLC11003	494630.051	4958957.408	180.912	180.970	+0.058
PLC11004	494638.706	4958961.024	180.910	181.000	+0.090
PLC11004	494638.706	4958961.024	180.910	181.000	+0.090
PLC3001	531652.171	4939259.428	204.183	204.200	+0.017
PLC3001	531652.171	4939259.428	204.183	204.200	+0.017
PLC3002	531658.045	4939260.855	204.138	204.130	-0.008
PLC3002	531658.045	4939260.855	204.138	204.130	-0.008
PLC3003	531663.946	4939262.495	204.107	204.150	+0.043

PLC3003	531663.946	4939262.495	204.107	204.150	+0.043
PLC4001	529775.337	4938358.750	220.919	221.010	+0.091
PLC4001	529775.337	4938358.750	220.919	221.010	+0.091
PLC4002	529766.381	4938356.008	220.993	221.050	+0.057
PLC4002	529766.381	4938356.008	220.993	221.050	+0.057
PLC4003	529757.982	4938353.373	221.016	221.110	+0.094
PLC4003	529757.982	4938353.373	221.016	221.110	+0.094
PLC5001	543008.968	4934724.718	189.417	189.470	+0.053
PLC5001	543008.968	4934724.718	189.417	189.470	+0.053
PLC5002	543013.358	4934721.421	189.430	189.450	+0.020
PLC5002	543013.358	4934721.421	189.430	189.450	+0.020
PLC5003	543017.765	4934718.156	189.448	189.440	-0.008
PLC5003	543017.765	4934718.156	189.448	189.440	-0.008
PLC6001	544855.043	4932953.027	186.974	186.990	+0.016
PLC6001	544855.043	4932953.027	186.974	186.990	+0.016
PLC6002	544856.568	4932944.106	187.045	187.050	+0.005
PLC6002	544856.568	4932944.106	187.045	187.050	+0.005
PLC6003	544858.726	4932931.377	187.189	187.220	+0.031
PLC6003	544858.726	4932931.377	187.189	187.220	+0.031
PLC6004	544860.226	4932922.241	187.295	187.310	+0.015
PLC6004	544860.226	4932922.241	187.295	187.310	+0.015
PLC6005	544861.927	4932912.568	187.403	187.400	-0.003
PLC6005	544861.927	4932912.568	187.403	187.400	-0.003
PLC7001	547416.831	4920669.759	436.240	436.310	+0.070
PLC7001	547416.831	4920669.759	436.240	436.310	+0.070
PLC7002	547399.513	4920664.354	435.712	435.770	+0.058
PLC7002	547399.513	4920664.354	435.712	435.770	+0.058
PLC7003	547382.269	4920658.945	435.311	435.370	+0.059
PLC7003	547382.269	4920658.945	435.311	435.370	+0.059

PLC8001	553723.595	4930401.978	181.321	181.380	+0.059
PLC8001	553723.595	4930401.978	181.321	181.380	+0.059
PLC8002	553681.880	4930428.511	181.997	182.060	+0.063
PLC8002	553681.880	4930428.511	181.997	182.060	+0.063
PLC8003	553640.198	4930455.037	182.674	182.710	+0.036
PLC8003	553640.198	4930455.037	182.674	182.710	+0.036
PLC9001	513718.335	4936795.792	311.481	311.400	-0.081
PLC9001	513718.335	4936795.792	311.481	311.400	-0.081
PLC9002	513719.398	4936789.099	311.695	311.690	-0.005
PLC9002	513719.398	4936789.099	311.695	311.690	-0.005
PLC9003	513727.280	4936782.964	311.446	311.390	-0.056
PLC9003	513727.280	4936782.964	311.446	311.390	-0.056
PP001	517524.594	4947843.123	223.961	223.910	-0.051
PP001	517524.594	4947843.123	223.961	223.910	-0.051
VEG01001	511329.401	4934369.019	306.404	306.400	-0.004
VEG01001	511329.401	4934369.019	306.404	306.400	-0.004
VEG01002	511330.983	4934358.630	306.389	306.310	-0.079
VEG01002	511330.983	4934358.630	306.389	306.310	-0.079
VEG01003	511332.101	4934349.554	306.387	306.290	-0.096
VEG01003	511332.101	4934349.554	306.387	306.290	-0.096
VEG03001	504666.212	4929773.115	271.960	271.920	-0.040
VEG03001	504666.212	4929773.115	271.960	271.920	-0.040
VEG03002	504656.647	4929771.672	271.985	271.960	-0.025
VEG03002	504656.647	4929771.672	271.985	271.960	-0.025
VEG03003	504644.102	4929769.934	272.041	272.010	-0.031
VEG03003	504644.102	4929769.934	272.041	272.010	-0.031
VEG04001	501590.230	4929270.326	259.735	259.680	-0.055
VEG04001	501590.230	4929270.326	259.735	259.680	-0.055
VEG04002	501580.026	4929268.497	259.778	259.770	-0.008

VEG04002	501580.026	4929268.497	259.778	259.770	-0.008
VEG04003	501569.486	4929266.801	259.693	259.650	-0.043
VEG04003	501569.486	4929266.801	259.693	259.650	-0.043
VEG05001	500864.936	4933122.256	238.392	238.380	-0.012
VEG05001	500864.936	4933122.256	238.392	238.380	-0.012
VEG05002	500866.766	4933114.482	238.537	238.550	+0.013
VEG05002	500866.766	4933114.482	238.537	238.550	+0.013
VEG05003	500869.075	4933104.812	238.978	239.000	+0.022
VEG05003	500869.075	4933104.812	238.978	239.000	+0.022
VEG08001	504378.737	4942496.767	213.394	213.460	+0.066
VEG08001	504378.737	4942496.767	213.394	213.460	+0.066
VEG08002	504376.488	4942487.632	213.406	213.330	-0.076
VEG08002	504376.488	4942487.632	213.406	213.330	-0.076
VEG08003	504374.460	4942477.113	213.433	213.370	-0.063
VEG08003	504374.460	4942477.113	213.433	213.370	-0.063
VEG09001	505515.808	4947645.421	235.653	235.590	-0.063
VEG09001	505515.808	4947645.421	235.653	235.590	-0.063
VEG09002	505517.445	4947653.440	235.785	235.760	-0.025
VEG09002	505517.445	4947653.440	235.785	235.760	-0.025
VEG09003	505519.666	4947663.171	235.769	235.700	-0.069
VEG09003	505519.666	4947663.171	235.769	235.700	-0.069
VEG10001	504976.929	4952343.190	244.815	244.860	+0.045
VEG10001	504976.929	4952343.190	244.815	244.860	+0.045
VEG10002	504984.678	4952343.403	244.845	244.850	+0.005
VEG10002	504984.678	4952343.403	244.845	244.850	+0.005
VEG10003	504995.616	4952343.787	244.893	244.850	-0.043
VEG10003	504995.616	4952343.787	244.893	244.850	-0.043
VEG1001	526983.824	4941069.870	241.588	241.750	+0.162
VEG1001	526983.824	4941069.870	241.588	241.750	+0.162

VEG1002	526984.845	4941062.189	241.149	241.300	+0.151
VEG1002	526984.845	4941062.189	241.149	241.300	+0.151
VEG1003	526986.226	4941053.469	240.790	240.920	+0.130
VEG1003	526986.226	4941053.469	240.790	240.920	+0.130
VEG12001	494640.363	4958956.150	180.664	180.750	+0.086
VEG12001	494640.363	4958956.150	180.664	180.750	+0.086
VEG12002	494633.858	4958953.350	180.610	180.760	+0.150
VEG12002	494633.858	4958953.350	180.610	180.760	+0.150
VEG12003	494624.322	4958949.289	180.630	180.700	+0.070
VEG12003	494624.322	4958949.289	180.630	180.700	+0.070
VEG12004	491144.739	4954914.429	216.485	216.490	+0.005
VEG12004	491144.739	4954914.429	216.485	216.490	+0.005
VEG12005	491131.094	4954928.505	216.264	216.250	-0.014
VEG12005	491131.094	4954928.505	216.264	216.250	-0.014
VEG12006	491125.825	4954923.474	216.249	216.250	+0.001
VEG12006	491125.825	4954923.474	216.249	216.250	+0.001
VEG13001	491123.861	4954946.582	215.546	215.520	-0.026
VEG13001	491123.861	4954946.582	215.546	215.520	-0.026
VEG13002	491118.917	4954941.969	215.504	215.520	+0.016
VEG13002	491118.917	4954941.969	215.504	215.520	+0.016
VEG13003	491112.460	4954935.751	215.454	215.500	+0.046
VEG13003	491112.460	4954935.751	215.454	215.500	+0.046
VEG3001	531661.162	4939274.973	203.999	204.030	+0.031
VEG3001	531661.162	4939274.973	203.999	204.030	+0.031
VEG3002	531654.296	4939273.404	204.017	204.040	+0.023
VEG3002	531654.296	4939273.404	204.017	204.040	+0.023
VEG3003	531646.115	4939271.379	203.988	204.020	+0.032
VEG3003	531646.115	4939271.379	203.988	204.020	+0.032
VEG4001	529759.783	4938346.994	220.782	220.870	+0.088

VEG4001	529759.783	4938346.994	220.782	220.870	+0.088
VEG4002	529750.281	4938344.063	220.813	220.900	+0.087
VEG4002	529750.281	4938344.063	220.813	220.900	+0.087
VEG4003	529733.711	4938339.290	220.874	220.950	+0.076
VEG4003	529733.711	4938339.290	220.874	220.950	+0.076
VEG7001	547400.575	4920670.661	435.321	435.330	+0.009
VEG7001	547400.575	4920670.661	435.321	435.330	+0.009
VEG7002	547412.462	4920674.690	435.431	435.460	+0.029
VEG7002	547412.462	4920674.690	435.431	435.460	+0.029
VEG7003	547424.400	4920678.332	435.951	435.960	+0.009
VEG7003	547424.400	4920678.332	435.951	435.960	+0.009
VEG8001	553648.735	4930437.192	182.214	182.280	+0.066
VEG8001	553648.735	4930437.192	182.214	182.280	+0.066
VEG8002	553665.863	4930426.708	181.847	181.920	+0.073
VEG8002	553665.863	4930426.708	181.847	181.920	+0.073
VEG8003	553685.389	4930414.445	181.602	181.740	+0.138
VEG8003	553685.389	4930414.445	181.602	181.740	+0.138
VEG9001	513737.972	4936748.376	310.663	310.660	-0.003
VEG9001	513737.972	4936748.376	310.663	310.660	-0.003
VEG9002	513736.862	4936755.635	310.633	310.600	-0.033
VEG9002	513736.862	4936755.635	310.633	310.600	-0.033
VEG9003	513735.245	4936766.294	310.633	310.640	+0.007
VEG9003	513735.245	4936766.294	310.633	310.640	+0.007
VERT0100	513113.698	4936841.034	310.784	310.760	-0.024
VERT0100	513113.698	4936841.034	310.784	310.760	-0.024
VERT0101	513121.148	4936851.384	310.794	310.750	-0.044
VERT0101	513121.148	4936851.384	310.794	310.750	-0.044
VERT0102	513130.830	4936865.144	310.711	310.690	-0.021
VERT0102	513130.830	4936865.144	310.711	310.690	-0.021

VERT02001	500670.339	4934453.230	235.509	235.510	+0.001
VERT02001	500670.339	4934453.230	235.509	235.510	+0.001
VERT02002	500682.908	4934456.264	235.517	235.520	+0.003
VERT02002	500682.908	4934456.264	235.517	235.520	+0.003
VERT02003	500697.935	4934459.671	235.589	235.590	+0.001
VERT02003	500697.935	4934459.671	235.589	235.590	+0.001
VERT10001	504999.969	4952338.730	245.248	245.250	+0.002
VERT10001	504999.969	4952338.730	245.248	245.250	+0.002
VERT10002	504987.979	4952338.335	245.217	245.210	-0.007
VERT10002	504987.979	4952338.335	245.217	245.210	-0.007
VERT10003	504975.960	4952338.023	245.176	245.180	+0.004
VERT10003	504975.960	4952338.023	245.176	245.180	+0.004
VERT1001	517524.846	4947852.835	223.954	223.950	-0.004
VERT1002	517516.781	4947848.178	223.823	223.780	-0.043
VERT1003	517499.663	4947837.800	223.377	223.390	+0.013
VERT1003	517499.663	4947837.800	223.377	223.390	+0.013
VERT11001	498151.304	4956555.628	255.244	255.270	+0.026
VERT11001	498151.304	4956555.628	255.244	255.270	+0.026
VERT11002	498142.682	4956550.367	255.465	255.490	+0.025
VERT11002	498142.682	4956550.367	255.465	255.490	+0.025
VERT11003	498132.129	4956543.992	255.731	255.780	+0.049
VERT11003	498132.129	4956543.992	255.731	255.780	+0.049
VERT13001	491121.322	4954926.708	216.180	216.220	+0.040
VERT13001	491121.322	4954926.708	216.180	216.220	+0.040
VERT13002	491127.526	4954932.916	216.164	216.190	+0.026
VERT13002	491127.526	4954932.916	216.164	216.190	+0.026
VERT13003	491138.127	4954942.560	216.107	216.140	+0.033
VERT13003	491138.127	4954942.560	216.107	216.140	+0.033
VERT2001	518988.726	4938758.033	353.998	353.970	-0.028

VERT2001	518988.726	4938758.033	353.998	353.970	-0.028
VERT2002	518989.970	4938746.561	354.131	354.080	-0.051
VERT2002	518989.970	4938746.561	354.131	354.080	-0.051
VERT2003	518991.842	4938734.799	354.290	354.240	-0.050
VERT2003	518991.842	4938734.799	354.290	354.240	-0.050
VERT9001	513728.526	4936775.486	311.142	311.110	-0.032
VERT9001	513728.526	4936775.486	311.142	311.110	-0.032
VERT9002	513731.021	4936762.257	310.884	310.870	-0.014
VERT9002	513731.021	4936762.257	310.884	310.870	-0.014
VERT9003	513733.572	4936747.041	310.843	310.820	-0.023
VERT9003	513733.572	4936747.041	310.843	310.820	-0.023

Average dz +0.007

Minimum dz -0.096

Maximum dz +0.162

Average magnitude 0.037

Root mean square 0.050

Std deviation 0.050

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Number	Easting	Northing	Known Z	Laser Z	Dz
PLC0100	513110.420	4936845.082	310.737	310.690	-0.047
PLC0100	511332.177	4934387.817	306.674	306.670	-0.004
PLC0100	513110.420	4936845.082	310.737	310.690	-0.047
PLC01001	511332.168	4934387.819	306.669	306.670	+0.001
PLC01001	511332.168	4934387.819	306.669	306.670	+0.001
PLC01002	511333.673	4934378.842	306.745	306.730	-0.015
PLC01002	511333.673	4934378.842	306.745	306.730	-0.015
PLC01003	511335.068	4934370.405	306.807	306.770	-0.037
PLC01003	511335.068	4934370.405	306.807	306.770	-0.037
PLC02001	506666.096	4934882.790	242.979	242.970	-0.009
PLC02001	506666.096	4934882.790	242.979	242.970	-0.009
PLC02002	506671.818	4934883.762	242.692	242.700	+0.008
PLC02002	506671.818	4934883.762	242.692	242.700	+0.008
PLC02003	506677.598	4934884.708	242.395	242.400	+0.005
PLC02003	506677.598	4934884.708	242.395	242.400	+0.005
PLC02004	506673.395	4934890.811	242.590	242.570	-0.020
PLC02004	506673.395	4934890.811	242.590	242.570	-0.020
PLC02005	506672.415	4934896.541	242.655	242.670	+0.015
PLC02005	506672.415	4934896.541	242.655	242.670	+0.015
PLC02006	506671.487	4934902.217	242.745	242.760	+0.015
PLC02006	506671.487	4934902.217	242.745	242.760	+0.015
PLC03001	504642.634	4929783.213	272.534	272.540	+0.006
PLC03001	504642.634	4929783.213	272.534	272.540	+0.006
PLC03002	504653.378	4929784.575	272.395	272.350	-0.045
PLC03002	504653.378	4929784.575	272.395	272.350	-0.045
PLC03003	504664.214	4929786.065	272.437	272.410	-0.027

PLC03003	504664.214	4929786.065	272.437	272.410	-0.027
PLC04001	501566.571	4929284.202	260.296	260.300	+0.004
PLC04001	501566.571	4929284.202	260.296	260.300	+0.004
PLC04002	501575.410	4929284.420	260.319	260.330	+0.011
PLC04002	501575.410	4929284.420	260.319	260.330	+0.011
PLC04003	501588.147	4929286.423	260.247	260.230	-0.017
PLC04003	501588.147	4929286.423	260.247	260.230	-0.017
PLC05001	500859.626	4933102.368	239.373	239.360	-0.012
PLC05001	500859.626	4933102.368	239.373	239.360	-0.012
PLC05002	500858.215	4933111.175	239.334	239.340	+0.006
PLC05002	500858.215	4933111.175	239.334	239.340	+0.006
PLC05003	500856.821	4933120.094	239.295	239.300	+0.005
PLC05003	500856.821	4933120.094	239.295	239.300	+0.005
PLC06001	500702.760	4934428.309	235.614	235.620	+0.006
PLC06001	500702.760	4934428.309	235.614	235.620	+0.006
PLC06002	500709.429	4934429.348	235.621	235.590	-0.031
PLC06002	500709.429	4934429.348	235.621	235.590	-0.031
PLC06003	500715.399	4934430.276	235.618	235.610	-0.008
PLC06003	500715.399	4934430.276	235.618	235.610	-0.008
PLC07004	503255.893	4939406.077	209.530	209.490	-0.040
PLC07004	503255.893	4939406.077	209.530	209.490	-0.040
PLC07005	503264.332	4939404.143	209.484	209.470	-0.014
PLC07005	503264.332	4939404.143	209.484	209.470	-0.014
PLC07006	503273.251	4939402.174	209.430	209.390	-0.040
PLC07006	503273.251	4939402.174	209.430	209.390	-0.040
PLC07007	503282.548	4939400.044	209.385	209.360	-0.025
PLC07007	503282.548	4939400.044	209.385	209.360	-0.025
PLC08001	504376.715	4942459.839	213.754	213.730	-0.024
PLC08001	504376.715	4942459.839	213.754	213.730	-0.024

PLC08002	504380.580	4942477.251	213.706	213.630	-0.076
PLC08002	504380.580	4942477.251	213.706	213.630	-0.076
PLC08003	504384.462	4942495.009	213.653	213.630	-0.023
PLC08003	504384.462	4942495.009	213.653	213.630	-0.023
PLC09001	505518.846	4947626.026	236.194	236.160	-0.034
PLC09001	505518.846	4947626.026	236.194	236.160	-0.034
PLC09002	505520.681	4947634.266	236.162	236.110	-0.052
PLC09002	505520.681	4947634.266	236.162	236.110	-0.052
PLC09003	505522.608	4947642.754	236.141	236.100	-0.041
PLC09003	505522.608	4947642.754	236.141	236.100	-0.041
PLC1001	526991.417	4941053.912	241.448	241.400	-0.048
PLC1001	526991.417	4941053.912	241.448	241.400	-0.048
PLC1002	526990.118	4941062.398	241.781	241.790	+0.009
PLC1002	526990.118	4941062.398	241.781	241.790	+0.009
PLC1003	526988.886	4941070.755	242.121	242.100	-0.021
PLC1003	526988.886	4941070.755	242.121	242.100	-0.021
PLC11001	494613.546	4958950.577	180.961	180.960	-0.001
PLC11001	494613.546	4958950.577	180.961	180.960	-0.001
PLC11002	494621.789	4958953.951	180.906	181.000	+0.094
PLC11002	494621.789	4958953.951	180.906	181.000	+0.094
PLC11003	494630.051	4958957.408	180.912	180.970	+0.058
PLC11003	494630.051	4958957.408	180.912	180.970	+0.058
PLC11004	494638.706	4958961.024	180.910	181.000	+0.090
PLC11004	494638.706	4958961.024	180.910	181.000	+0.090
PLC2001	529136.278	4945345.241	212.196	outside	*
PLC2001	529136.278	4945345.241	212.196	outside	*
PLC2002	529134.883	4945354.149	212.268	outside	*
PLC2002	529134.883	4945354.149	212.268	outside	*
PLC2003	529133.440	4945363.158	212.344	outside	*

PLC2003	529133.440	4945363.158	212.344	outside	*
PLC3001	531652.171	4939259.428	204.183	204.200	+0.017
PLC3001	531652.171	4939259.428	204.183	204.200	+0.017
PLC3002	531658.045	4939260.855	204.138	204.130	-0.008
PLC3002	531658.045	4939260.855	204.138	204.130	-0.008
PLC3003	531663.946	4939262.495	204.107	204.150	+0.043
PLC3003	531663.946	4939262.495	204.107	204.150	+0.043
PLC4001	529775.337	4938358.750	220.919	221.010	+0.091
PLC4001	529775.337	4938358.750	220.919	221.010	+0.091
PLC4002	529766.381	4938356.008	220.993	221.050	+0.057
PLC4002	529766.381	4938356.008	220.993	221.050	+0.057
PLC4003	529757.982	4938353.373	221.016	221.110	+0.094
PLC4003	529757.982	4938353.373	221.016	221.110	+0.094
PLC5001	543008.968	4934724.718	189.417	189.470	+0.053
PLC5001	543008.968	4934724.718	189.417	189.470	+0.053
PLC5002	543013.358	4934721.421	189.430	189.450	+0.020
PLC5002	543013.358	4934721.421	189.430	189.450	+0.020
PLC5003	543017.765	4934718.156	189.448	189.440	-0.008
PLC5003	543017.765	4934718.156	189.448	189.440	-0.008
PLC6001	544855.043	4932953.027	186.974	186.990	+0.016
PLC6001	544855.043	4932953.027	186.974	186.990	+0.016
PLC6002	544856.568	4932944.106	187.045	187.050	+0.005
PLC6002	544856.568	4932944.106	187.045	187.050	+0.005
PLC6003	544858.726	4932931.377	187.189	187.220	+0.031
PLC6003	544858.726	4932931.377	187.189	187.220	+0.031
PLC6004	544860.226	4932922.241	187.295	187.310	+0.015
PLC6004	544860.226	4932922.241	187.295	187.310	+0.015
PLC6005	544861.927	4932912.568	187.403	187.400	-0.003
PLC6005	544861.927	4932912.568	187.403	187.400	-0.003

PLC7001	547416.831	4920669.759	436.240	436.310	+0.070
PLC7001	547416.831	4920669.759	436.240	436.310	+0.070
PLC7002	547399.513	4920664.354	435.712	435.770	+0.058
PLC7002	547399.513	4920664.354	435.712	435.770	+0.058
PLC7003	547382.269	4920658.945	435.311	435.370	+0.059
PLC7003	547382.269	4920658.945	435.311	435.370	+0.059
PLC8001	553723.595	4930401.978	181.321	181.380	+0.059
PLC8001	553723.595	4930401.978	181.321	181.380	+0.059
PLC8002	553681.880	4930428.511	181.997	182.060	+0.063
PLC8002	553681.880	4930428.511	181.997	182.060	+0.063
PLC8003	553640.198	4930455.037	182.674	182.710	+0.036
PLC8003	553640.198	4930455.037	182.674	182.710	+0.036
PLC9001	513718.335	4936795.792	311.481	311.400	-0.081
PLC9001	513718.335	4936795.792	311.481	311.400	-0.081
PLC9002	513719.398	4936789.099	311.695	311.690	-0.005
PLC9002	513719.398	4936789.099	311.695	311.690	-0.005
PLC9003	513727.280	4936782.964	311.446	311.390	-0.056
PLC9003	513727.280	4936782.964	311.446	311.390	-0.056
PP001	517524.594	4947843.123	223.961	223.910	-0.051
PP001	517524.594	4947843.123	223.961	223.910	-0.051
VERT0100	513113.698	4936841.034	310.784	310.760	-0.024
VERT0100	513113.698	4936841.034	310.784	310.760	-0.024
VERT0101	513121.148	4936851.384	310.794	310.750	-0.044
VERT0101	513121.148	4936851.384	310.794	310.750	-0.044
VERT0102	513130.830	4936865.144	310.711	310.690	-0.021
VERT0102	513130.830	4936865.144	310.711	310.690	-0.021
VERT02001	500670.339	4934453.230	235.509	235.510	+0.001
VERT02001	500670.339	4934453.230	235.509	235.510	+0.001
VERT02002	500682.908	4934456.264	235.517	235.520	+0.003

VERT02002	500682.908	4934456.264	235.517	235.520	+0.003
VERT02003	500697.935	4934459.671	235.589	235.590	+0.001
VERT02003	500697.935	4934459.671	235.589	235.590	+0.001
VERT10001	504999.969	4952338.730	245.248	245.250	+0.002
VERT10001	504999.969	4952338.730	245.248	245.250	+0.002
VERT10002	504987.979	4952338.335	245.217	245.210	-0.007
VERT10002	504987.979	4952338.335	245.217	245.210	-0.007
VERT10003	504975.960	4952338.023	245.176	245.180	+0.004
VERT10003	504975.960	4952338.023	245.176	245.180	+0.004
VERT1001	517524.846	4947852.835	223.954	223.950	-0.004
VERT1002	517516.781	4947848.178	223.823	223.780	-0.043
VERT1003	517499.663	4947837.800	223.377	223.390	+0.013
VERT1003	517499.663	4947837.800	223.377	223.390	+0.013
VERT11001	498151.304	4956555.628	255.244	255.270	+0.026
VERT11001	498151.304	4956555.628	255.244	255.270	+0.026
VERT11002	498142.682	4956550.367	255.465	255.490	+0.025
VERT11002	498142.682	4956550.367	255.465	255.490	+0.025
VERT11003	498132.129	4956543.992	255.731	255.780	+0.049
VERT11003	498132.129	4956543.992	255.731	255.780	+0.049
VERT13001	491121.322	4954926.708	216.180	216.220	+0.040
VERT13001	491121.322	4954926.708	216.180	216.220	+0.040
VERT13002	491127.526	4954932.916	216.164	216.190	+0.026
VERT13002	491127.526	4954932.916	216.164	216.190	+0.026
VERT13003	491138.127	4954942.560	216.107	216.140	+0.033
VERT13003	491138.127	4954942.560	216.107	216.140	+0.033
VERT2001	518988.726	4938758.033	353.998	353.970	-0.028
VERT2001	518988.726	4938758.033	353.998	353.970	-0.028
VERT2002	518989.970	4938746.561	354.131	354.080	-0.051
VERT2002	518989.970	4938746.561	354.131	354.080	-0.051

VERT2003	518991.842	4938734.799	354.290	354.240	-0.050
VERT2003	518991.842	4938734.799	354.290	354.240	-0.050
VERT9001	513728.526	4936775.486	311.142	311.110	-0.032
VERT9001	513728.526	4936775.486	311.142	311.110	-0.032
VERT9002	513731.021	4936762.257	310.884	310.870	-0.014
VERT9002	513731.021	4936762.257	310.884	310.870	-0.014
VERT9003	513733.572	4936747.041	310.843	310.820	-0.023
VERT9003	513733.572	4936747.041	310.843	310.820	-0.023

Average dz +0.001

Minimum dz -0.081

Maximum dz +0.094

Average magnitude 0.030

Root mean square 0.038

Std deviation 0.039

Used loaded points

Average magnitude: 0.03990

Flightline	Points	Magnitude	Dz
1	6821170	0.0367	-0.0010
3	7574506	0.0347	-0.0025
4	9780995	0.0320	-0.0051
5	2624822	0.0298	-0.0047
6	8750881	0.0303	-0.0005
7	3384203	0.0533	-0.0183
9	9014710	0.0313	-0.0031
10	5950827	0.0413	-0.0116
11	8717336	0.0343	-0.0024
12	3883718	0.0502	-0.0011
13	10268506	0.0362	-0.0070
14	9641396	0.0379	-0.0018
15	6593555	0.0341	-0.0015
16	6453792	0.0394	-0.0027
17	9995786	0.0395	-0.0040
18	8745272	0.0400	-0.0001
20	7060552	0.0452	-0.0069
22	6794176	0.0407	-0.0039
23	8165720	0.0342	-0.0063
24	6835136	0.0422	-0.0086
25	3229272	0.0490	-0.0049
27	3225197	0.0525	-0.0048
28	8945373	0.0314	-0.0024
29	2071451	0.0774	-0.0193

30	1756942	0.0800	-0.0130
31	6115036	0.0312	-0.0019
33	1936616	0.0893	-0.0261
34	8715470	0.0321	-0.0065
35	2165809	0.0788	-0.0123
36	2924466	0.0754	-0.0217
37	5852009	0.0309	-0.0036
39	4476801	0.0562	-0.0063
40	7200037	0.0376	-0.0085
41	5656616	0.0519	-0.0136
42	3926762	0.0546	-0.0078
43	2046821	0.0583	-0.0080
44	1852098	0.0478	-0.0062
45	2096664	0.0851	-0.0229
46	892108	0.0969	-0.0227
49	2346220	0.0594	-0.0025
52	3243820	0.0535	-0.0027
53	58685139	0.0407	+0.0134
55	3818862	0.0459	+0.0016
57	6144175	0.0344	-0.0027
58	6182153	0.0389	+0.0016
59	8241567	0.0332	+0.0034
60	9312189	0.0353	-0.0002
61	2925056	0.0525	-0.0039
62	3139962	0.0502	-0.0100
64	7650627	0.0380	+0.0005
65	3463549	0.0435	-0.0045
66	5582177	0.0348	-0.0030
67	6136417	0.0350	+0.0057

68	4919055	0.0377	+0.0010
69	3754839	0.0338	+0.0006
70	3066632	0.0374	+0.0071
71	6517717	0.0340	-0.0028
72	8482616	0.0320	+0.0014
73	2795825	0.0368	-0.0005
74	2165974	0.0367	+0.0019
75	9035441	0.0343	+0.0040
76	8519687	0.0380	+0.0048
77	2282156	0.0370	-0.0056
78	9166129	0.0386	-0.0004
79	1209012	0.0465	-0.0013
80	444486	0.0511	+0.0002
81	8097732	0.0411	+0.0018
82	6761548	0.0438	-0.0008
84	5227600	0.0452	+0.0017
86	5478886	0.0404	-0.0030
88	8097711	0.0360	+0.0039
91	7099139	0.0378	+0.0012
93	7092613	0.0346	+0.0003
95	7538946	0.0341	-0.0010
96	6729993	0.0356	+0.0050
98	7205931	0.0349	+0.0000
103	105390	0.0568	+0.0048
104	2060105	0.0513	-0.0065
106	3583481	0.0501	-0.0051
107	4349923	0.0554	-0.0094
108	3606114	0.0710	-0.0138
109	2491199	0.0915	-0.0337

110	107371803	0.0371	+0.0051

Appendix D

Structure Inventory

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Culvert Datasheet

Location:	Poplar SR	Prepared by:	G. Yang
Date:	Aug 2020	Checked by:	
Project No:	4097	Page:	of

SPECIFICATIONS:

Type of Structure:	Bridge
Span (m):	14.68 m
Rise (m):	3.62 +/- m
Length of Structure (m):	10 m
Top of Road Elevation (m):	194.79 m
Low Chord Elevation Upstream (m):	193.96 m
Low Chord Elevation Downstream (m):	193.96 m
Upstream Invert Elevation (m):	190.34 m
Downstream Invert Elevation (m):	190.29 m
Effective Flow Area (m^2):	
Mannings 'n' Value:	0.013

NOTES:

SKETCH / PHOTOGRAPH(S):

GREENLAND® International Consulting Ltd.
120 Hume Street, Collingwood, Ontario, Canada, L9Y 1V5
TEL: **705 444-8805** FAX: **705 444-5482** E-MAIL: **greenland@grnland.com** WEBSITE: **www.grnland.com**

Offices: Greater Toronto and Collingwood

Location: Railway Upstream
Date: Aug 2020
Project No: 4097

Prepared by: G. Yang
Checked by:
Page: ______ of ______

SPECIFICATIONS:

Type of Structure:	Bridge
Span (m):	11.59 m
Rise (m):	3.78 +/- m
Length of Structure (m):	4.0 m
Top of Road Elevation (m):	194.50 m
Low Chord Elevation Upstream (m):	192.56 m
Low Chord Elevation Downstream (m):	192.51 m
Upstream Invert Elevation (m):	188.78 m
Downstream Invert Elevation (m):	189.02 m
Effective Flow Area (m^2):	
Mannings 'n' Value:	0.013

NOTES:

SKETCH / PHOTOGRAPH(S):

Location:	Farm Bridge	Prepared by:	G. Yang
Date:	Aug 2020	Checked by:	
Project No:	4097	Page:	of

SPECIFICATIONS:

Type of Structure:	Conc Box
Span (m):	11.5 m
Rise (m):	5.0 +/- m
Length of Structure (m):	4.0 m
Top of Road Elevation (m):	191.78 m
Low Chord Elevation Upstream (m):	190.78 m
Low Chord Elevation Downstream (m):	190.78 m
Upstream Invert Elevation (m):	185.78 m
Downstream Invert Elevation (m):	185.78 m
Effective Flow Area (m^2):	
Mannings 'n' Value:	0.013

NOTES:

SKETCH / PHOTOGRAPH(S):

Location:	Railway Downstream	Prepared by:	G. Yang
Date:	Aug 2020	Checked by:	
Project No:	4097	Page:	of

SPECIFICATIONS:

Type of Structure:	Bridge
Span (m):	25.0 m
Rise (m):	4.11 +/- m
Length of Structure (m):	6.0 m
Top of Road Elevation (m):	190.60 m
Low Chord Elevation Upstream (m):	189.50 m
Low Chord Elevation Downstream (m):	189.80 m
Upstream Invert Elevation (m):	185.39 m
Downstream Invert Elevation (m):	185.39 m
Effective Flow Area (m^2):	
Mannings 'n' Value:	0.013

NOTES:

SKETCH / PHOTOGRAPH(S):

Location:	Hume Street	Prepared by:	G. Yang
Date:	Aug 2020	Checked by:	
Project No:	4097	Page:	of

SPECIFICATIONS:

Type of Structure:	Bridge
Span (m):	15.0 m
Rise (m):	4.4 +/- m
Length of Structure (m):	18.0 m
Top of Road Elevation (m):	188.62 m
Low Chord Elevation Upstream (m):	187.82 m
Low Chord Elevation Downstream (m):	187.82 m
Upstream Invert Elevation (m):	183.39 m
Downstream Invert Elevation (m):	183.39 m
Effective Flow Area (m^2):	
Mannings ‘n’ Value:	0.013

NOTES:

SKETCH / PHOTOGRAPH(S):

Location:	Pretty River Parkway	Prepared by:	G. Yang
Date:	Aug 2020	Checked by:	
Project No:	4097	Page:	of

SPECIFICATIONS:

Type of Structure:	Bridge
Span (m):	18.0 m
Rise (m):	3.6 +/- m
Length of Structure (m):	20.0 m
Top of Road Elevation (m):	185.12 m
Low Chord Elevation Upstream (m):	184.14 m
Low Chord Elevation Downstream (m):	184.14 m
Upstream Invert Elevation (m):	180.54 m
Downstream Invert Elevation (m):	180.54 m
Effective Flow Area (m^2):	
Mannings ‘n’ Value:	0.013

NOTES:

SKETCH / PHOTOGRAPH(S):

Location:	Culvert	Prepared by:	G. Yang
Date:	Aug 2020	Checked by:	
Project No:	4097	Page:	of

SPECIFICATIONS:

Type of Structure:	CSP
Span (m):	1.95 m
Rise (m):	1.95 +/- m
Length of Structure (m):	15.0 m
Top of Road Elevation (m):	181.10 m
Low Chord Elevation Upstream (m):	179.70 m
Low Chord Elevation Downstream (m):	179.55 m
Upstream Invert Elevation (m):	177.75 m
Downstream Invert Elevation (m):	177.60 m
Effective Flow Area (m^2):	
Mannings ‘n’ Value:	0.015

NOTES:

SKETCH / PHOTOGRAPH(S):

Location:	Spill Weir	Prepared by:	G. Yang
Date:	Aug 2020	Checked by:	
Project No:	4097	Page:	of

SPECIFICATIONS:

Type of Structure:	Spill Weir
Span (m):	18.0 m
Rise (m):	+/- m
Length of Structure (m):	1.0 m
Top of Road Elevation (m):	178.45 m
Low Chord Elevation Upstream (m):	
Low Chord Elevation Downstream (m):	
Upstream Invert Elevation (m):	178.24 m
Downstream Invert Elevation (m):	178.00 m
Effective Flow Area (m^2):	
Mannings 'n' Value:	

NOTES:

SKETCH / PHOTOGRAPH(S):

Appendix E

Pretty River Hydraulics Summary

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All flow with CCTA updated flow 172.83 cms

* All spill flow rates downstream of the Train Trail Bridge are conservative values; flow in the river does not decrease with each spill

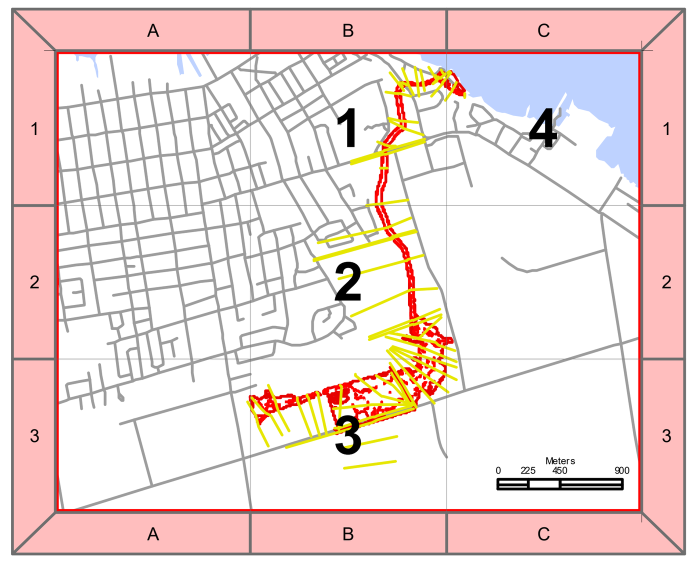
			Existing Channel											Partial Maintained Channel												
			Existing Grading			Proposed Grading Contained Spill				Proposed Grading Maintained Spill				Existing Grading				Proposed Grading Contained Spill				Proposed Grading Maintained Spill				
River	Reach	River Sta	Q Total	W.S. Elev	Spill	Q Total	W.S. Elev	Spill	Difference	Q Total	W.S. Elev	Spill	Difference	Q Total	W.S. Elev	Spill	Maintained	Q Total	W.S. Elev	Maintained	Difference	Q Total	W.S. Elev	Spill	Maintained	Difference
			(m3/s)	(m)	Location	(m3/s)	(m)	Location	(m)	(m3/s)	(m)	Location	(m)	(m3/s)	(m)	Location	XSs	(m3/s)	(m)	XSs	(m)	(m3/s)	(m)	Location	XSs	(m)
Hamilton Drain	Upstream	320.1	6.35	194.36		6.35	194.37		0.01	6.35	194.39		0.03	6.35	194.35			6.35	194.37		0.02	6.35	194.39			0.04
Hamilton Drain	Upstream	310.1	6.35	194.32		6.35	194.33		0.01	6.35	194.35		0.03	6.35	194.3			6.35	194.33		0.03	6.35	194.35			0.05
Hamilton Drain	Upstream	300.1	6.35	194.31		6.35	194.32		0.01	6.35	194.34		0.03	6.35	194.29			6.35	194.32		0.03	6.35	194.34			0.05
Hamilton Drain	Upstream	290.1	6.35	194.31		6.35	194.32		0.01	6.35	194.34		0.03	6.35	194.29			6.35	194.32		0.03	6.35	194.34			0.05
Hamilton Drain	Upstream	280.1	6.35	194.31		6.35	194.32		0.01	6.35	194.34		0.03	6.35	194.29			6.35	194.32		0.03	6.35	194.34			0.05
Hamilton Drain	Upstream	270.1	6.35	194.31		6.35	194.32		0.01	6.35	194.34		0.03	6.35	194.29			6.35	194.32		0.03	6.35	194.34			0.05
Hamilton Drain	Upstream	260.1	6.35	194.3		6.35	194.32		0.02	6.35	194.34		0.04	6.35	194.29			6.35	194.32		0.03	6.35	194.34			0.05
Hamilton Drain	Upstream	250.1	6.35	194.3		6.35	194.32		0.02	6.35	194.34		0.04	6.35	194.29			6.35	194.32		0.03	6.35	194.34			0.05
pretty	1	600	167.09	194.5		167.09	194.54		0.04	167.09	194.58		0.08	167.09	194.43			167.09	194.54		0.11	167.09	194.58			0.15
pretty	1	500	Poplar Bridge			Bridge				Bridge				Bridge				Bridge				Bridge				
pretty	1	480	167.09	194.2		167.09	194.25		0.05	167.09	194.28		0.08	167.09	194.18			167.09	194.25		0.07	167.09	194.28			0.1
pretty	1	400	167.09	194.29		167.09	194.28		-0.01	167.09	194.3		0.01	167.09	194.27			167.09	194.28		0.01	167.09	194.3			0.03
pretty	Downstream	300	172.83	194.28		172.83	194.27		-0.01	172.83	194.29		0.01	172.83	194.26			172.83	194.27		0.01	172.83	194.29			0.03
pretty	Downstream	250	172.83	194.24		172.83	194.19		-0.05	172.83	194.22		-0.02	172.83	194.21			172.83	194.19		-0.02	172.83	194.22			0.01
pretty	Downstream	249	Lat Struct		Spill (3.02)	Lat Struct				Lat Struct		Spill (2.57)		Lat Struct		Spill (2.78)		Lat Struct				Lat Struct		Spill (2.58)		
pretty	Downstream	200	169.86	194.22		172.83	194.18		-0.04	170.3	194.2		-0.02	170.08	194.2			172.83	194.18		-0.02	170.28	194.2			0
pretty	Downstream	6.5	Train Trail Bridge			Bridge				Bridge				Bridge				Bridge				Bridge				
pretty	Downstream	6	169.86	192.79		172.83	192.76		-0.03	170.3	192.74		-0.05	170.08	192.74			172.83	192.76		0.02	170.28	192.74			0
pretty	Downstream	5	169.86	192.91		172.83	192.88		-0.03	170.3	192.84		-0.07	170.08	192.85			172.83	192.88		0.03	170.28	192.85			0
pretty	Downstream	4	169.86	192.73		172.83	192.67		-0.06	170.3	192.62		-0.11	170.08	192.63			172.83	192.68		0.05	170.28	192.64			0.01
pretty	Downstream	3	169.86	192.65		172.83	192.61		-0.04	170.3	192.59		-0.06	170.08	192.56			172.83	192.6		0.04	170.28	192.58			0.02
pretty	Downstream	2	169.86	192.21		172.83	191.89		-0.32	170.3	191.89		-0.32	170.08	191.73			172.83	191.82		0.09	170.28	191.79			0.06
pretty	Downstream	1.56	169.86	192.24		172.83	191.94		-0.3	170.3	191.91		-0.33	170.08	191.55			172.83	191.57		0.02	170.28	191.55			0
pretty	Downstream	1.01	177.1	192.23		180.07	191.93		-0.3	177.54	191.89		-0.34	177.32	191.48			180.07	191.52		0.04	177.52	191.49			0.01
pretty	Downstream	1	177.1	192.19		180.07	191.85		-0.34	177.54	191.82		-0.37	177.32	191.33			180.07	191.37		0.04	177.52	191.33			0
pretty	Downstream	0.601	177.1	191.42		180.07	191.18		-0.24	177.54	191.15		-0.27	177.32	190.59			180.07	190.61		0.02	177.52	190.59			0
pretty	Downstream	0.401	177.1	190.03		180.07	190.11		0.08	177.54	190.09		0.06	177.32	189.96			180.07	189.99		0.03	177.52	189.96			0
pretty	Downstream	0.301	177.1	189.57		180.07	189.58		0.01	177.54	189.58		0.01	177.32	189.48			180.07	189.51		0.03	177.52	189.48			0
pretty	Downstream	0.29	Lat Struct (Left)		Spill (20.86)	Lat Struct (Left)		Spill (22.41)		Lat Struct (Left)		Spill (21.43)		Lat Struct (Left)				Lat Struct (Left)								
pretty	Downstream	0.28	Lat Struct (Right)		Spill (11.85)	Lat Struct (Right)		Spill (13.15)		Lat Struct (Right)		Spill (12.33)		Lat Struct (Right)				Lat Struct (Right)								
pretty	Downstream	0.151	177.1	189.82		180.07	189.83		0.01	177.54	189.82		0	177.32	188.7		Maintained	180.07	188.71	Maintained	0.01	177.52	188.7		Maintained	0
pretty	Downstream	0.126	Siding Trail Bridge			Bridge				Bridge				Bridge				Bridge				Bridge				
pretty	Downstream	0.101	177.1	189.05		180.07	188.23		-0.82	177.54	188.99		-0.06	177.32	188.57			180.07	188.58		0.01	177.52	188.57			0
pretty	Downstream	0.98	Lat Struct (Left)		Spill (0.17)	Lat Struct (Left)		Spill (1.63)		Lat Struct (Left)		Spill (0.49)		Lat Struct (Left)				Lat Struct (Left)								
pretty	Downstream	0.97	Lat Struct (Right)			Lat Struct (Right)				Lat Struct (Right)				Lat Struct (Right)				Lat Struct (Right)								
pretty	Downstream	0.051	177.1	188.7		180.07	188.75		0.05	177.54	188.74		0.04	177.32	188.48			180.07	188.49		0.01	177.52	188.48			0
pretty	Downstream	-10.1	177.1	188.24		180.07	188.28		0.04	177.54	188.25		0.01	177.32	188.18			180.07	188.24		0.06	177.52	188.19			0.01
pretty	Downstream	-11.1	177.1	187.74		180.07	187.78		0.04	177.54	187.75		0.01	177.32	187.75			180.07	187.78		0.03	177.52	187.75			0
pretty	Downstream	-12.1	177.1	186.94		180.07	186.97		0.03	177.54	186.95		0.01	177.32	186.94			180.07	186.97		0.03	177.52	186.95			0.01
pretty	Downstream	-13.1	Hume St Bridge			Bridge				Bridge				Bridge				Bridge				Bridge				
pretty	Downstream	-14.1	177.1	186.78		180.07	186.8		0.02	177.54	186.78		0	177.32	186.78			180.07	186.8		0.02	177.52	186.79			0.01
pretty	Downstream	-15.1	177.1	186.75		180.07	186.77		0.02	177.54	186.75		0	177.32	186.75			180.07	186.77		0.02	177.52	186.75			0
pretty	Downstream	-16.1	177.1	185.92		180.07	185.95		0.03	177.54	185.93		0.01	177.32	185.91			180.07	185.93		0.02	177.52	185.91			0
pretty	Downstream	-17.1	177.1	185.74		180.07	185.76		0.02	177.54	185.75		0.01	177.32	185.72			180.07	185.74		0.02	177.52	185.72			0
pretty	Downstream	-18.1	177.1	184.64		180.07	184.67		0.03	177.54	184.65		0.01	177.32	184.71			180.07	184.74		0.03	177.52	184.72			0.01
pretty	Downstream	-19.1	177.1	183.95		180.07	183.99		0.04	177.54	183.96		0.01	177.32	183.74			180.07	183.76		0.02	177.52	183.73			-0.01
pretty	Downstream	-20.1	177.1	184.11		180.07	184.15		0.04	177.54	184.12		0.01	177.32	183.96			180.07	183.99		0.03	177.52	183.96			0
pretty	Downstream	-21.1	HWY 26 Bridge			Bridge				Bridge				Bridge				Bridge				Bridge				
pretty	Downstream	-22.1	177.1	183.76		180.07	183.79		0.03	177.54	183.77		0.01	177.32	183.76			180.07	183.79		0.03	177.52	183.77			0.01
pretty	Downstream	-23.1	177.1	183.05		180.07	183.08		0.03	177.54	183.05		0	177.32	183.05			180.07	183.08		0.03	177.52	183.05			0
pretty	Downstream	-25.1	177.1	180.62		180.07	180.64		0.02	177.54	180.62		0	177.32	180.62			180.07	180.64		0.02	177.52	180.62			0
pretty	Downstream	-26.1	177.08	181.59		180.04	181.62		0.03	177.51	181.59		0	177.29	181.59			180.04	181.62		0.03	177.49	181.59			0
pretty	Downstream	-26.15	177.08	180.83		180.04	180.85		0.02	177.51	180.83		0	177.29	180.83			180.04	180.85		0.02	177.49	180.83			0
pretty	Downstream	-26.2	Culvert (Chute Bridge)			Culvert				Culvert				Culvert				Culvert				Culvert				
pretty	Downstream	-29.1	177.08	180.21		180.04	180.24		0.03	177.51	180.21		0	177.29	180.21			180.04	180.24		0.03	177.49	180.21			0
pretty	Downstream	-30.1	177.08	180.2		180.04	180.22		0.02	177.51	180.2		0	177.29	180.2			180.04	180.22		0.02	177.49	180.2			0
pretty	Downstream	-31.1	177.08	179.58		180.04	179.6		0.02	177.51	179.58		0	177.29	179.58			180.04	179.6		0.02	177.49	179.58			0

Appendix F

Flood Mapsheets

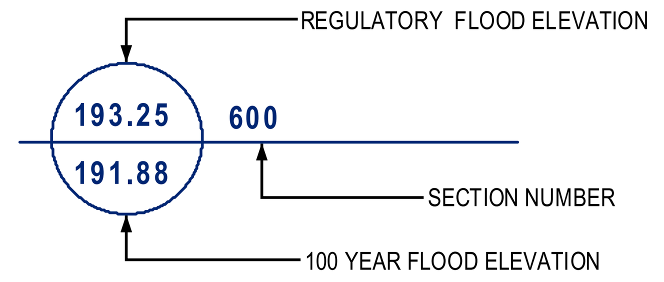
Collingwood

Floodlines - Pretty River
(Existing Condition)



Legend

- Rivers
- Road
- Contour
- Cross Sections
- Building Footprint
- 100 Year Floodline
- Timmins Floodline
- Property Parcels



N
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Sheet: Index

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Meters 0 60 120 240 360 480 600

COLLINGWOOD

GREENLAND®

Scale: 1 : 2,000
1 cm on the map represents 20 m on the ground

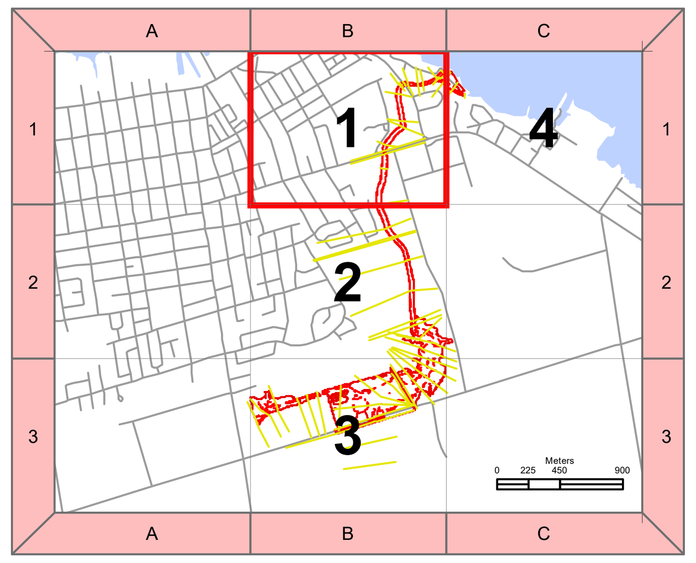
All measurements are in Metric.

Vertical Datum: Mean Sea Level (G.S.C.)
Horizontal Datum: North American Datum 1983 (NAD 83)
Projection: Universal Transverse Mercator
Zone: 17
Central Meridian: 81° West
Grid Spacing: 100 Meters

NOTES:
1. Floodlines were generated using a DEM derived from a LiDAR survey.
2. Where a discrepancy between the contours and the Floodlineis evident, the Floodline shall take precedence.
3. An additional topographic survey and professional expertise may be used to more precisely locate the Floodline on specific properties.

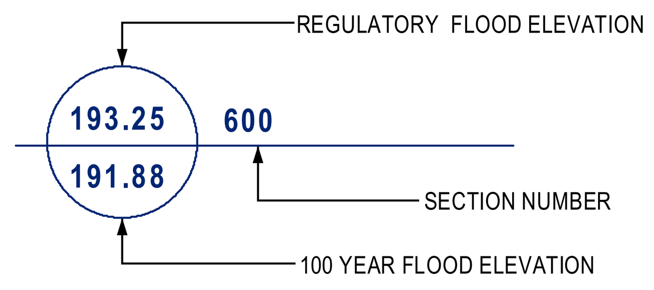
Collingwood

Floodlines - Pretty River
(Existing Condition)



Legend

- Rivers
- Road
- Contour
- Cross Sections
- Building Footprint
- 100 Year Floodline
- Timmins Floodline
- Property Parcels



N
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Sheet: 1

1:2,000

Meters 0 20 40 80 120 160 200

Scale: 1 : 2,000
1 cm on the map represents 20 m on the ground

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Vertical Datum: Mean Sea Level (G.S.C.)
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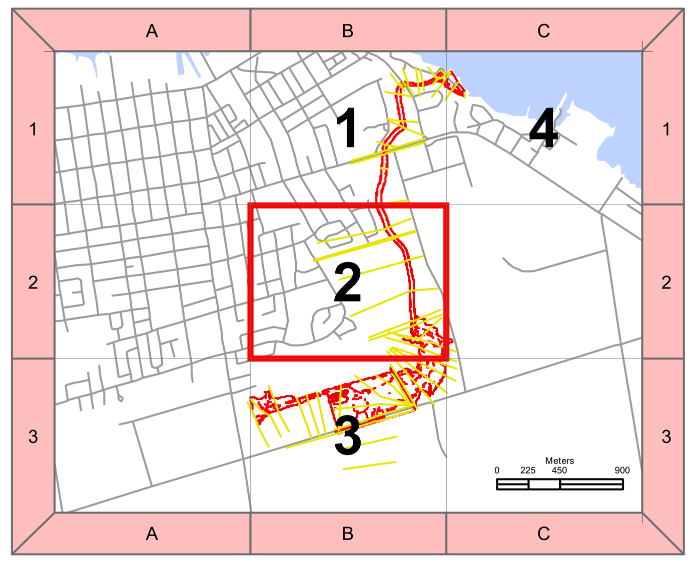
Collingwood

Floodlines - Pretty River
(Existing Condition)



Legend

Rivers		Building Footprint	
Road		100 Year Floodline	
Contour		Timmins Floodline	
Cross Sections		Property Parcels	

REGULATORY FLOOD ELEVATION
193.25
600
191.88
SECTION NUMBER
100 YEAR FLOOD ELEVATION

N
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S

Sheet: 2

1:2,000

Meters 0 20 40 80 120 160 200

COLLINGWOOD

GREENLAND®

Scale: 1 : 2,000
1 cm on the map represents 20 m on the ground

All measurements are in Metric.

Vertical Datum: Mean Sea Level (G.S.C.)
Horizontal Datum: North American Datum 1983 (NAD 83)
Projection: Universal Transverse Mercator
Zone: 17
Central Meridian: 81° West
Grid Spacing: 100 Meters

NOTES:
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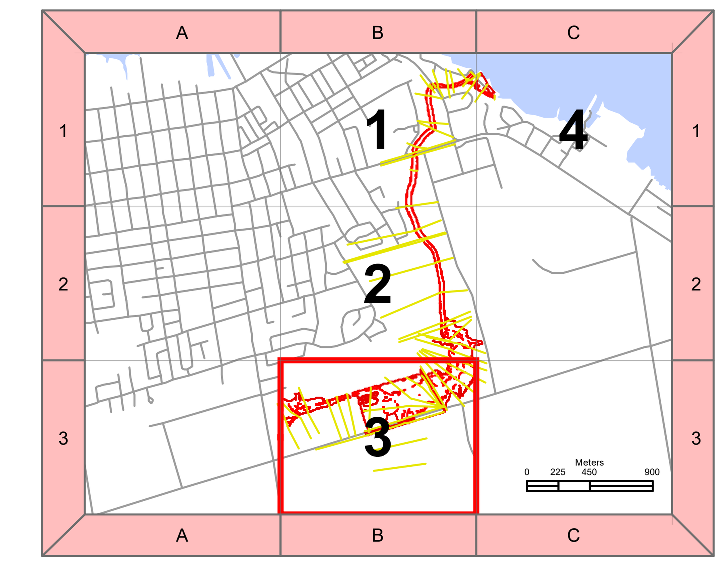
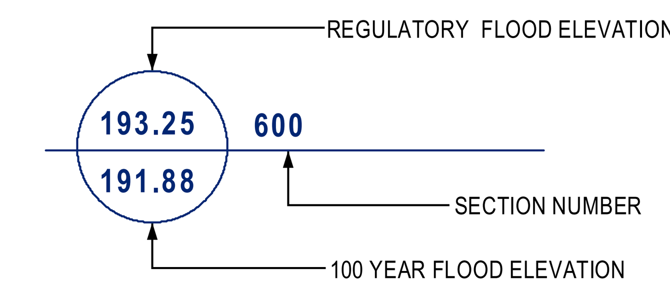
Collingwood

Floodlines - Pretty River
(Existing Condition)



Legend

Rivers	Building Footprint
Road	100 Year Floodline
Contour	Timmins Floodline
Cross Sections	Property Parcels



N
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Sheet: 3

1:2,000

Meters 0 20 40 80 120 160 200

COLLINGWOOD

GREENLAND®

Scale: 1 : 2,000
1 cm on the map represents 20 m on the ground

All measurements are in Metric.

Vertical Datum: Mean Sea Level (G.S.C.)
Horizontal Datum: North American Datum 1983 (NAD 83)
Projection: Universal Transverse Mercator
Zone: 17
Central Meridian: 81° West
Grid Spacing: 100 Meters

NOTES:
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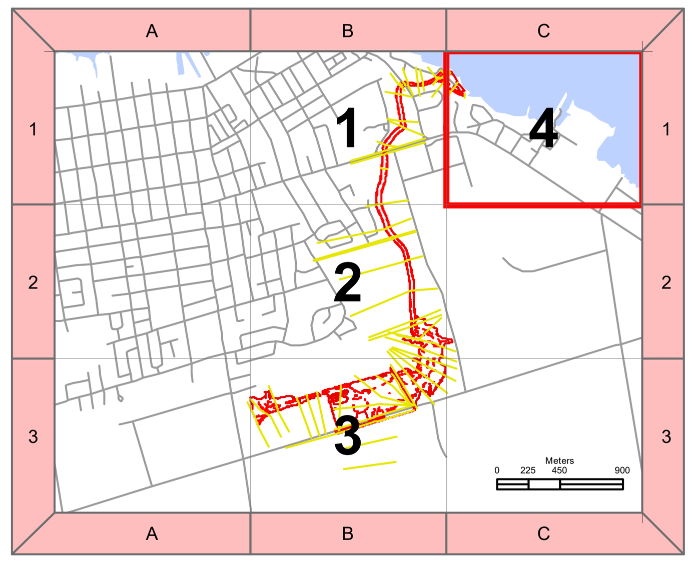
Collingwood

Floodlines - Pretty River
(Existing Condition)



Legend

- Rivers
- Road
- Contour
- Cross Sections
- Building Footprint
- 100 Year Floodline
- Timmins Floodline
- Property Parcels

REGULATORY FLOOD ELEVATION
193.25
600
191.88
SECTION NUMBER
100 YEAR FLOOD ELEVATION

N
W E
S

Sheet: 4

1:2,000

Meters 0 20 40 80 120 160 200

COLLINGWOOD

GREENLAND®

Scale: 1 : 2,000
1 cm on the map represents 20 m on the ground

All measurements are in Metric.

Vertical Datum: Mean Sea Level (G.S.C.)
Horizontal Datum: North American Datum 1983 (NAD 83)
Projection: Universal Transverse Mercator
Zone: 17
Central Meridian: 81° West
Grid Spacing: 100 Meters

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Appendix 2-II

Model Basis Report

GREENLAND®

Table of Contents

APPENDICES

1. Introduction & Background

Greenland Consulting Ltd. (Greenland) was retained by the Town of Collingwood (Town) to complete an existing conditions Master Stormwater Management (SWM) Model consisting of multiple watercourses within the Town limits. Presently, the Town does not have a comprehensive model. Most models use old hydrology models, are missing recently constructed subdivisions, only include a portion of the total water courses within the Town, and are in need of an update. The existing conditions SWM model will ultimately assist the Town with forecast modelling, development proposals, asset management, and form a basis for future by-law decision making.

Per consultation with the Town of Collingwood, the SWM model will incorporate hydraulic models for six (6) identified receiving watercourses within the Blue Mountains Watersheds, all with outlets located within the Collingwood municipal boundary, listed below (in no particular order):

- Pretty River;
- Black Ash Creek;
- Silver Creek;
- Batteaux Creek;
- Urban Town Centre; and,
- Resort Drainage Areas.

This report provides the basis for the fundamental hydrologic / hydraulic modelling inputs to create the existing conditions of stormwater infrastructure, and open channel flows within the Town. The model will update expanded / reduced flood damage zones within the Town, thereby assisting the Town with approvals for future development. The hydraulic model will also inform any discussion on Stormwater Service Fees and Capital Asset Management over the next 10 years.

The following Model Basis Report (report) is provided to the Town for review and approval, with input from the Nottawasaga Valley Conservation Authority (NVCA). The intent of the report is to create efficiencies in the approval processes and create a model following an accepted methodology outlining the fundamental inputs from parameters inside and outside Town boundaries. At the time when an encompassing existing conditions model can be produced, acceptance of the model should generally be streamlined as the model basis will have been previously circulated and approved.

Existing conditions hydrologic models were created in PCSWMM using the most recent accepted hydrology for each watershed, where catchments limits and flow results defined in the previous studies have been imported and tweaked. Updates to the catchment boundaries may be required using up-to-date LiDAR data, gathered as part of this project.

In order to update the hydrologic models, Greenland, in consultation with the Town, undertook an extensive background review to update the areas within the Town where development has occurred since the publishing date of the most recent comprehensive hydrologic study of the watersheds identified. In addition to completed construction, attention was given to areas approved and currently under construction. Background data included any information the Town has access to, including, but not limited to: SWM reports, Site plans, Master Servicing Studies, Record Drawings, Existing Models, and SWM pond Environmental Compliance Approvals (ECAs). The background information was reviewed and all available information has been summarized in a spreadsheet provided in **Appendix B**. This information was then inputted into existing hydrologic models to determine updated flow values.

The methodology and results for each major watershed's hydrologic model is detailed further in **Section 3** below.

1.1. Study Area

As outlined in **Section 1.0**, the existing model study will focus on the major catchments and receiving watercourses traversing through, and outletting within, the Town boundaries. Located between the base of Blue Mountain and Georgian Bay, Collingwood is a major component of the Blue Mountains Watersheds, which have multiple outlets within the Town limits. The Blue Mountains Watersheds consist of multiple rivers and creeks which outlet directly to Georgian Bay. **Figure 1** (below) depicts the subwatershed boundary defined by the NVCA. Although all of the catchments identified as part of this study outlet within the Town limits, five (5) of the six (6) catchments have headwaters outside the municipal boundary. **Figure 2a** (below) outlines the catchment areas of the identified watercourses.

For the watercourses originating outside Town limits, previous studies are utilized to establish a base flow at the location where the watercourse enters the Town of Collingwood jurisdiction. The 1988 MacLaren Plansearch Inc. (MacLaren) study is the most up to date and accepted hydrology which captures the Blue Mountains Watersheds as a whole.

The MacLaren study is the basis for most of current floodplain mapping in the NVCA jurisdictional limits. The updated watershed boundaries are compared in **Figure 2a** with those delineated in the 1988 MacLaren study (**Figure 2b**). Depending on the subwatershed being considered, updated studies have been completed since the MacLaren study, and the most up to date approved model will be used to form the basis for the modelling. A summary of the most recent hydrology study for each watershed, and the flow values from each report are available in **Table 1.1, Appendix A.**

Figure 1- Blue Mountains Watersheds - NVCA

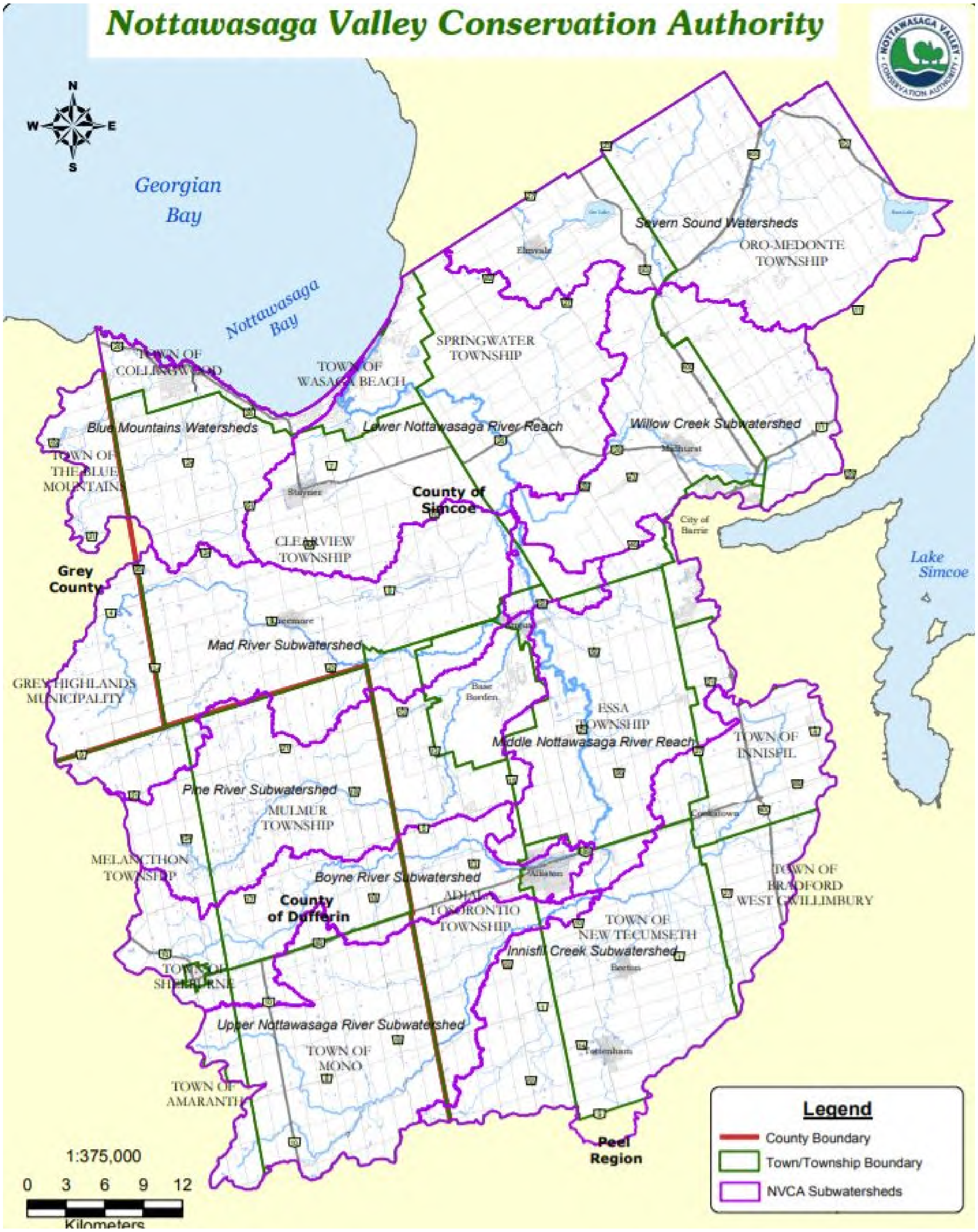


Figure 2a- Catchment Boundaries- Updated Models

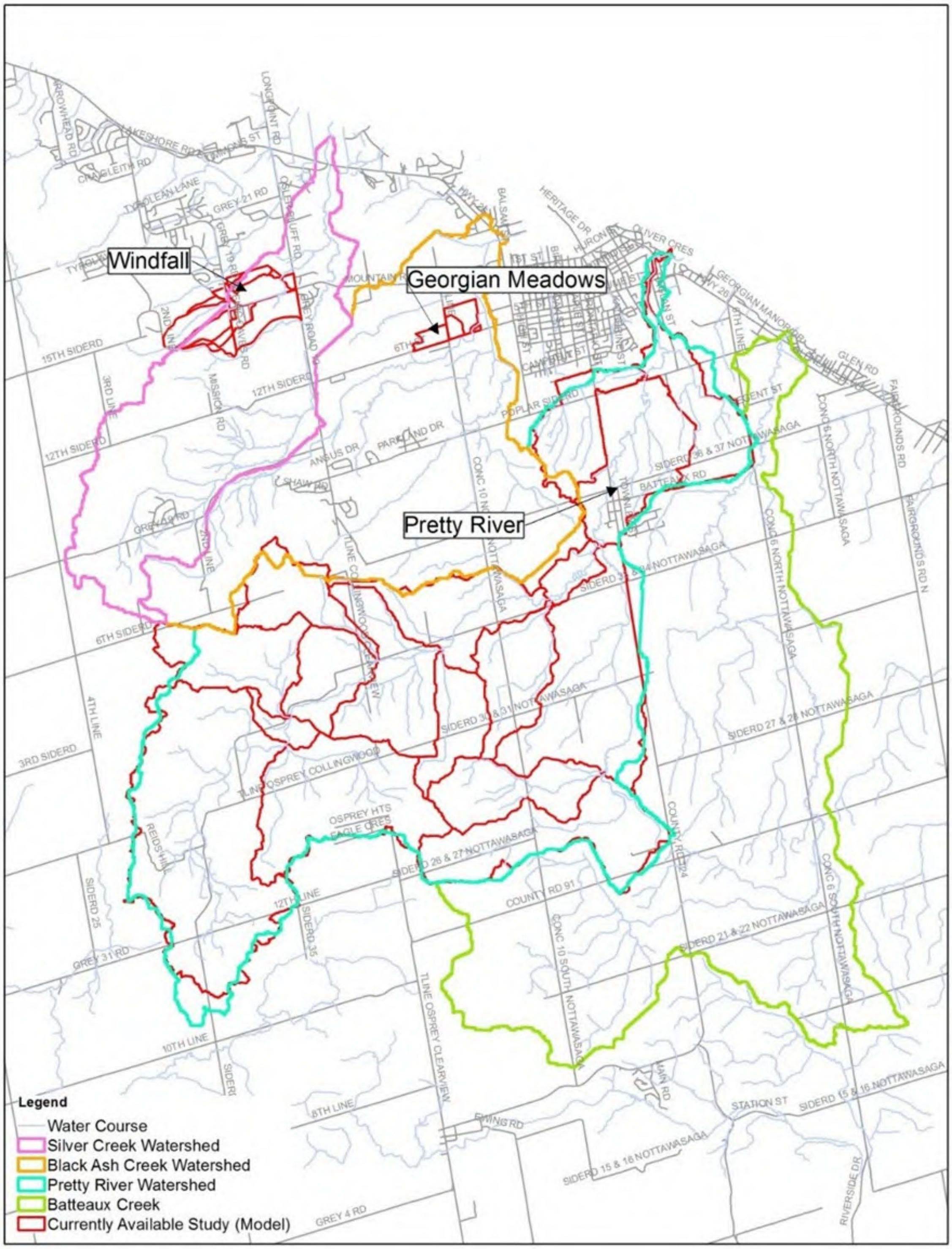
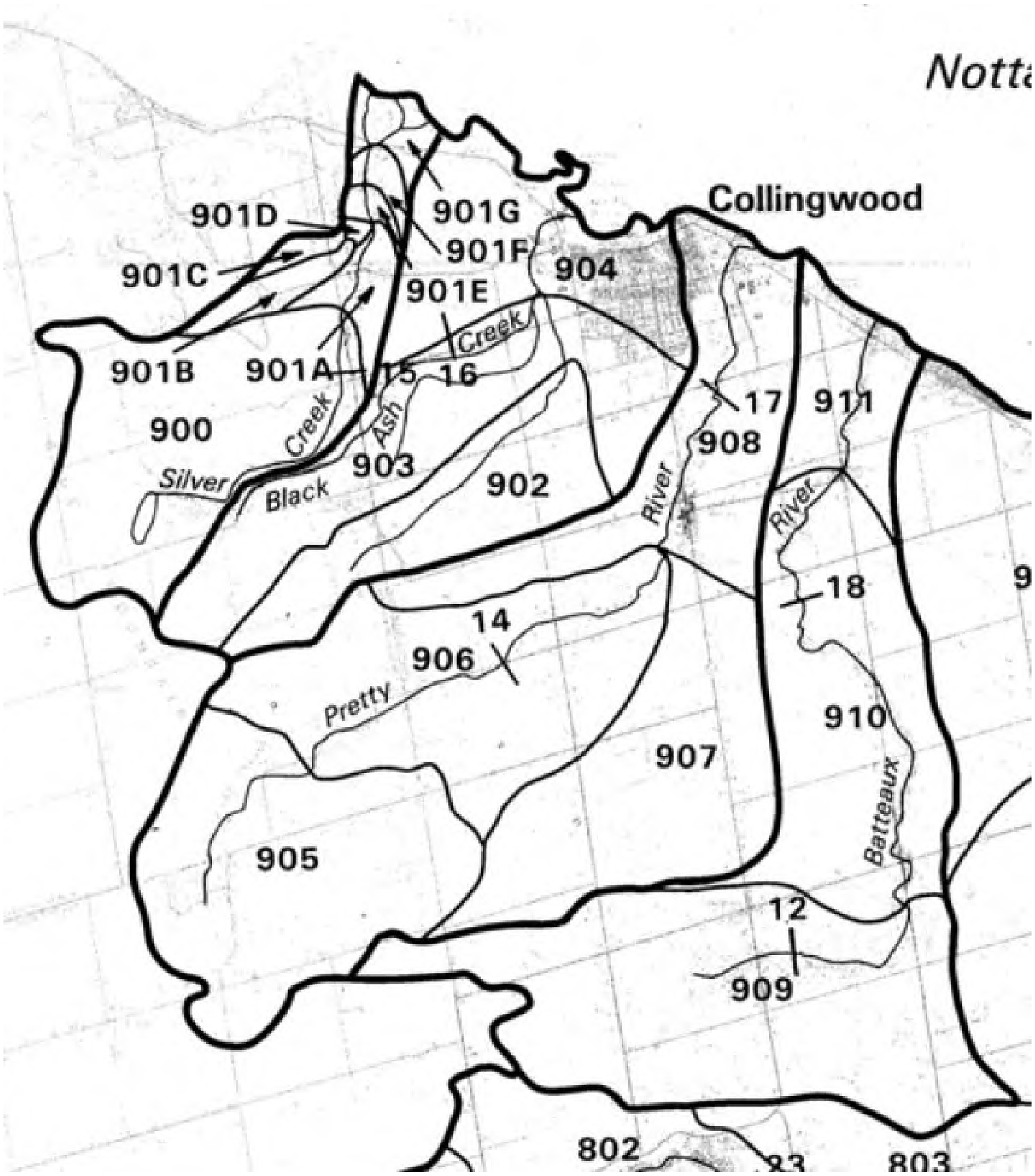


Figure 2b- Catchment Boundaries- MacLaren Report



2. Existing Conditions Field Update

2.1. Storm Sewer Database

In order to complete the minor system drainage models, the Town provided Greenland with its GIS database of municipal storm drainage infrastructure. Greenland completed a data gap analysis to determine the extent of additional data that needed to be collected from existing As-Built information and/or topographic survey to be able to successfully model the minor system. To aid in the update of the storm sewer inventory, the Town provided Greenland with all available As-Built drawings, including: recent construction projects, major roadways and local roads.

To fill in gaps from the As-Built information, a field survey investigation is underway. Upon receipt of the field survey and LiDAR data, Greenland will provide the Town with the updated GIS database as an early deliverable.

2.2. LiDAR

The Town has engaged a LiDAR provider to collect airborne LiDAR data and provide topographic information of the development of the Asset Inventory and models. The focus of the LiDAR is to fill in manhole elevations (minor system development), and develop the details of the overland stormwater pathways and major stormwater spill routes. The LiDAR data will also be used to update catchment boundaries for any elevations / contours downstream of the Town border to produce the most accurate model possible.

The LiDAR is being flown in Canada's most recent reference standard for heights across Canada: the Canadian Geodetic Vertical Datum of 2013 (CGVD2013); however, the Town has made the decision to convert the data to the previous reference system, CGVD28, to maintain a consistent reference system through its records. To convert the data between datums, Greenland will utilize the GPS-H tool released by Natural Resources Canada.

2.3. Field Monitoring

As part of this study, monitoring has been undertaken at four (4) locations, in addition to two (2) locations being monitored by the Town prior to the inception of this study. These locations have been chosen to encapsulate as much of the Town's drainage areas as possible, to best calibrate the hydrologic model.

As shown in **Figure 3** (below), flow monitors are installed in the following locations:

- Monitor 1 – Downstream of Oak St. Canal
- Monitor 2 – Ste. Marie St.
- Monitor 3A- Minnesota Drain Culvert A at Police Station
- Monitor 3B – Minnesota Drain Culvert B at Police Station
- Monitor 4- Downstream of Georgian Meadows Subdivision
- Monitor 5 (Existing) – High St.
- Monitor 6 (Existing) – Hickory St.

Figure 3 - Flow Monitoring Locations in the Town of Collingwood

3. Subwatershed Models

3.1. Pretty River Subwatershed

3.1.1. Existing Model

Existing conditions of the Pretty River catchment were developed using the Pretty River Hydrology Update completed by C.C. Tatham and Associates Ltd. (Tatham) in 2018. The purpose of this study was to create a comprehensive hydrologic model that predicts Regulatory Flow, defined by Tatham as the Timmins storm. Hydrologic models were developed by Tatham in VO5.

The PCSWMM model is created based on the VO5 model parameters used by Tatham and calibrated to match the VO5 results. As shown in **Table 1.2** (**Appendix A**) the updated PCSWMM model has a flow output of 180.08 cubic meters per second (m^3/s) at the outlet to Georgian Bay, matching that of the aforementioned Tatham VO5 model of 180.04 m^3/s.

3.1.1. Proposed Model

Using the existing PCSWMM model matched to the previous 2018 Tatham model output, the proposed model will integrate updated catchment boundaries delineated from a previous report completed by Greenland utilizing a DEM provided by the NVCA as well as LiDAR data gathered as part of this project. The length to width ratio of the updated catchments remains same as those in the existing 2018 Tatham model. The new delineated catchment boundaries in PCSWMM are shown in **Figure 1.1** (**Appendix A**). The results from the updated model are summarized in **Table 1.3** (**Appendix A**). As shown in **Table 1.3**, the areas for the proposed PCSWMM Model compared to the Tatham model are the same, and therefore can be used as the base hydraulic model. This will be updated with current developments.

3.2. Black Ash Creek Subwatershed

3.2.1. Existing Model

The reference study for the existing conditions for the Black Ash Creek Watershed is entitled Black Ash Creek Subwatershed Plan (2000), prepared by Greenland Consulting Engineers and the Nottawasaga Valley Conservation Authority (NVCA). It includes the following aspects:

- Stormwater management;
- Hydrologic study; and,
- Hydraulic study.

The Integrated Stormwater Management System (ISWMS) was utilized to develop hydrologic models for the study and Visual OTTHYMO models were developed to verify the results of the ISWMS models.

To create the existing conditions model to be used in this master plan, the Visual OTTHYMO model was imported to VO2 to run the results. Due to the age of the original model, it could not be imported in VO5; therefore VO2 was used. The PCSWMM model is created based on the VO2 model parameters and matched to the VO2 results. Catchments were delineated using catchments from the 2000 study and CAD files and are shown in **Figure 1.2** (**Appendix A**). The flows have been matched to the Visual OTTHYMO model, and catchment flow and length are adjusted to match flow values. The matched flow values and catchment information is shown in **Table 1.4** (**Appendix A**). As with the Pretty River catchment, pending the information of the LiDAR investigation, boundaries may be adjusted slightly per the updated elevations.

3.2.2. Proposed Model

To update the model, the watershed boundary was first adjusted to match the Pretty River watershed boundary. The length to width ratio of the updated catchments remains same. The updated model boundary is shown in **Figure 1.3** (**Appendix A**)

Since the 2000 Subwatershed Study, there have been two major developments constructed within the watershed which alter flows to the stream- Georgian Meadows and Mair Mills subdivisions, **Figures 1.4 and 1.5**, respectively (**Appendix A**). The updated PCSWMM model for Black Ash Creek is shown in **Figure 1.6** (**Appendix A**). As part of the proposed model, these developments (and any other additional developments not already accounted for) have been added to the model to update flow characteristics in the subwatershed. Flows and catchment areas are summarized in **Appendix B**, from each development's respective SWM report. The updated values from the background data collected was inputted into the PCSWMM and results for the 100 year 4 Hour Chicago storm are available in **Table 1.5** (**Appendix A**).

3.3. Silver Creek Subwatershed

3.3.1. Existing Model

The existing model for the Silver Creek Watershed was prepared by MacLaren Plansearch Inc. in 1988. This study established Regulatory Flow values for watercourses within the NVCA and is the basis for floodplain mapping within the watershed. The Silver Creek catchment boundaries per the MacLaren study are detailed in **Figure 1.7** (**Appendix A**), with the PCSWMM model developed per the MacLaren Study in **Figure 1.8** (**Appendix A**).

QUALHYMO was utilized to develop hydrologic models in the MacLaren study. In order to create a PCSWMM model using parameters from QUALHYMO, the following equation (below) was used to determine CN values. SMAX, SMIN, SK, API are converted to CN.

$$S^{*} = Smin + (Smax - Smin)e^{-(SK*API)}$$
$$S^{*} = \frac{25400}{CN(Condition1)} - 254)$$

The existing conditions model catchment boundaries are created based on the catchments identified from the MacLaren report and updated to reflect current conditions. The flows are matched to the QUALHYMO model, and the catchment flow length and slope have been adjusted to match the flow. QUALHYMO parameters are shown in **Table 1.6** (**Appendix A**). The above noted QUALHYMO model and parameters were matched to PCSWMM using the Timmins (94%) storm and results are shown in **Table 1.7** (**Appendix A**).

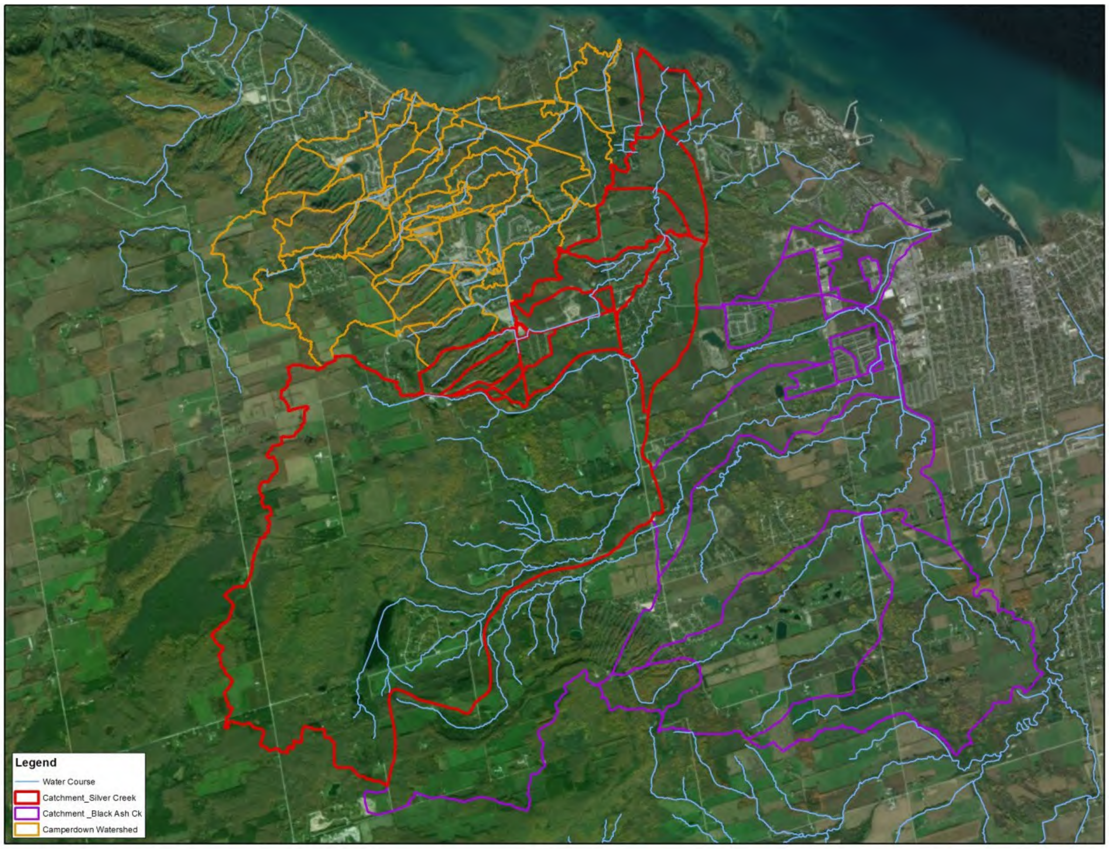
3.3.2. Updated Model

3.3.2.1. Windfall Master SWMM

To update the hydrology in the Silver Creek watershed, the flows and catchments derived in Windfall Master Stormwater Management Report were utilized. The study was prepared by Tatham in 2012. **Figure 1.9** (**Appendix A**) identifies the Windfall original catchment boundaries. The VO2 model developed for this study was re-evaluated for Price's Subdivision by Greenland in 2018. The hydrologic model encapsulates the largest land uses changes in the Silver Creek watershed since the MacLaren report- the Windfall Subdivision and the Orchard at Blue Mountain Resorts Ltd. Using the 100 year 24 Hour SCS, the VO2 from the 2012 Tatham study was matched to the PCSWMM model and results are shown in **Table 1.8** (**Appendix A**).

The watershed boundary is adjusted to match the Black Ash Creek Watershed and Camperdown Catchment- delineated as part of floodplain mapping completed by Greenland in 2019 for the GSCA. **Figure 4** (below) details the above noted catchment alteration. The length to width ratio of the updated catchments remains same. With the adjusted parameters, the PCSWMM model (**Figure 1.10, Appendix A**) was run with the same Timmins Storm (94%) previously matched to the VO2 model and results are shown in **Table 1.9** (**Appendix A**).

Figure 4 - Updated Silver Creek Catchment Boundary



3.4. Batteaux Creek Subwatershed

3.4.1. Existing Model –Matched Original Catchment

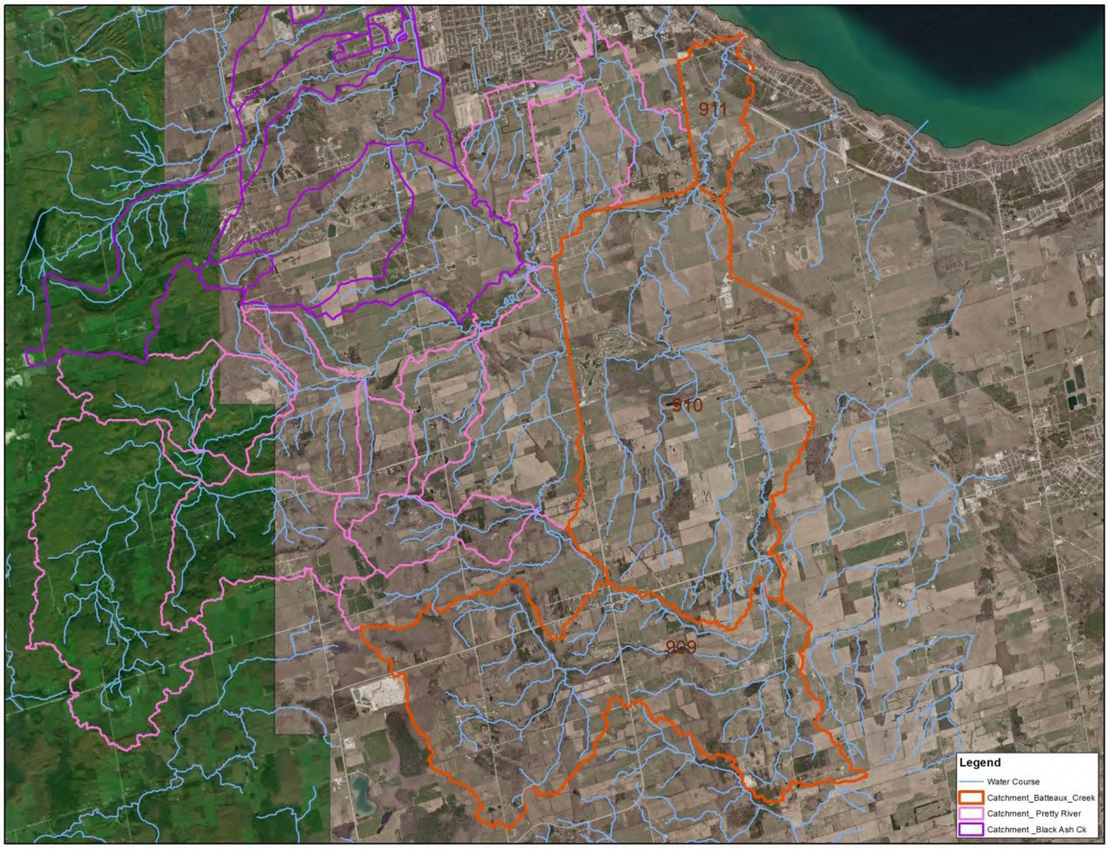
The existing hydrology of the Batteaux River Watershed is based on the 1988 MacLaren Plansearch Inc. study. The existing condition model from the MacLaren Study (**Figure 1.11, Appendix A**) was imported into PCSWMM (**Figure 1.12**, **Appendix A**) and used as the basis to create the catchment boundaries.

Refer to **Section 3.2.1** for detailed methodology utilized to convert the MacLaren QUALHYMO model to PCSWMM. QUALHYMO parameters are shown in **Table 1.10** (**Appendix A**). The QUALHYMO model and parameters were matched to PCSWMM using the Timmins (87%) storm and results are shown in **Table 1.11** (**Appendix A**).

3.4.2. Updated Model

The watershed boundary was adjusted in PCSWMM (**Figure 1.13, Appendix A**) to match the Pretty River watershed and DEM catchment from the previous **Section 3.1.1**, as the delineation changed with updated modelling. The length to width ratio of the updated catchments remains same. In the base model for the watershed there are no developments that must be added to the model to update the hydrology. **Figure 5** (below) shows the updated Batteaux Creek boundary. The updated model with the boundary was run using the matched Timmins (87%) storm and results are shown in **Table 1.12** (**Appendix A**).

Figure 5- Batteaux Creek Updated Catchment Boundary



3.5. Urban Town Centre

3.5.1. Existing Model

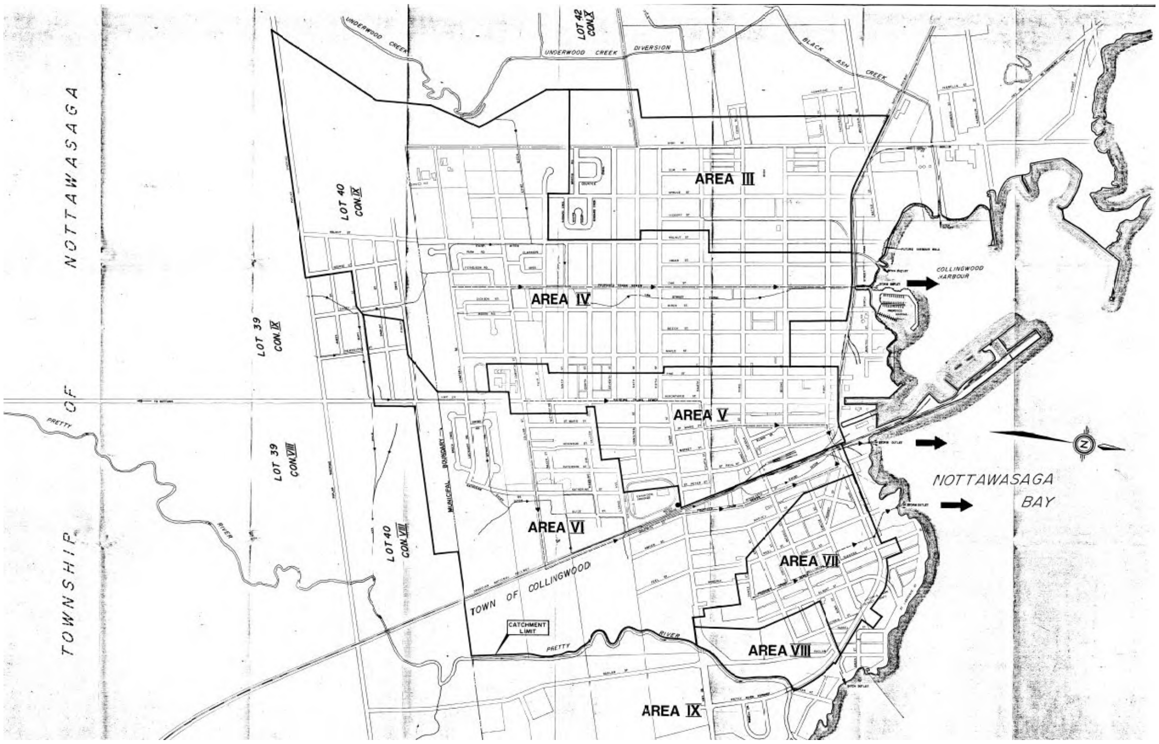
The Urban Town Centre hydrology was included in the MacLaren Study completed in 1988. Most of the Town was included in the delineation of the Black Ash Creek Watershed, with the eastern portion of Collingwood included in the Pretty River Watershed.

Since the MacLaren study, watershed boundaries and hydrology have been updated for both the Pretty River Watershed and Black Ash Creek Watershed and the Town Centre is no longer included within either watershed. Therefore, the Urban Town Centre does not have any up to date hydrology to base the hydrologic model on, as the flows from the MacLaren report are not relevant for the urban area.

3.5.2. Updated Model

To create the hydrologic model for the Urban Town Centre, Greenland will utilize the drainage areas of current flow monitors in the Town Centre and will be based off the drainage areas defined by Ainley and Associates in 1972 and shown in **Figure 6** (below).

Figure 6 -Drainage Study Catchment Areas- Ainley



Design flows will be defined through the major and minor system models. Completion of updates to the Asset Inventory and LiDAR data will be required to complete the hydrologic model and identify flow values. Calibration of the model will utilize Town storm sewer monitoring data.

3.6. Resort Drainage Areas

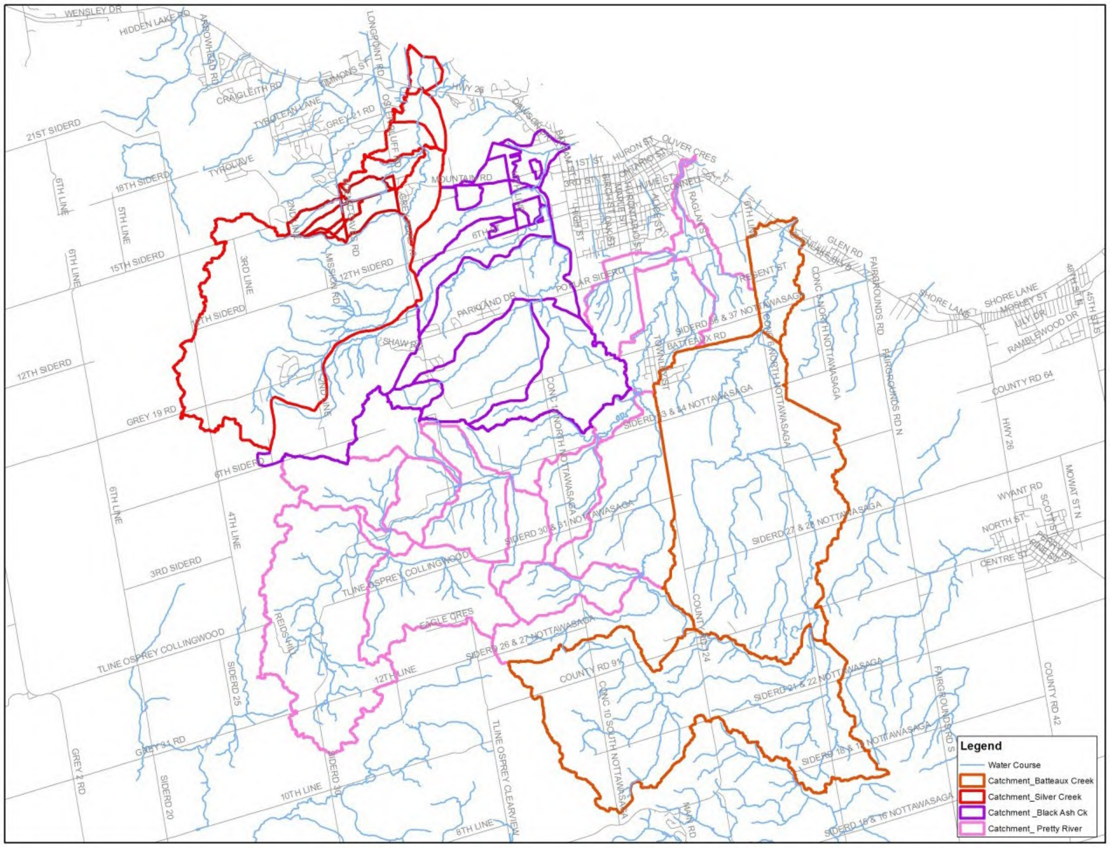
The hydrologic model for the Resort Drainage Areas will be created based on catchment drainage areas defined in post development drainage plans of several constructed and planned developments (see **Appendix B**). The SWM report prepared by C.F. Crozier and Associates for Tanglewood at Cranberry Trail (2007) provides the most comprehensive hydrology for the Resort Drainage Areas, and will therefore be the basis for the hydrologic model created by Greenland for this watershed. Upon completion of the storm sewer database update, the minor system will be inputted to PCSWMM and the minor and major models will be created.

The focus of the analysis of this watershed will be the spills from the Silver Creek Watershed as they pass through the Resort Drainage Areas and their impacts.

3.7. Combined PCSWMM Model

The PCSWMM models completed for the four major watersheds in the Collingwood area (Pretty River, Batteaux Creek, Black Ash Creek and Silver Creek) have been combined in the PCSWWM base model and are shown in **Figure 1.14** (**Appendix A**). The model was run using the 100 year 24Hr SCS storm and the Timmins storm event (adjusted for each sub-watershed), and results are shown in **Table 1.13** (**Appendix A**). **Figure 7** (below) shows the updated catchment boundaries for each of the 4 major watersheds. While each watershed has been defined in PCSWMM, it anticipated that during flood events there will be overlap between the watersheds, therefore watershed interaction will be an important part of the combined model. The finalized combined model will be imported to HEC-RAS to create a hydraulic model that encapsulates the entire study area, including the Urban Town Centre and Resort Drainage Areas, in addition to the individual watershed assessments.

Figure 7- Final Catchment Boundaries



4. Modelled Events

4.1. Design Storm

Greenland is proposing to model the 2 through 100 year design storm events.

The 24 hour SCS type II distribution is used for the design storm. The distribution is derived from MTO Drainage Manual (1997).

The IDF curve values from the MTO's IDF Curve Lookup were used for the studied design storms. IDF values are shown below.

Figure 8 – Collingwood IDF Curve-MTO

Coefficient summary

IDF Curve: 44° 29' 45'' N, 80° 13' 14'' W (44.495833,-80.220833)

Retrieved: Mon, 29 Jul 2019 13:37:48 GMT

Data year: 2010
IDF curve year: 2010

Return period	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
A	20.9	27.7	32.1	37.8	42.0	46.2
B	-0.699	-0.699	-0.699	-0.699	-0.699	-0.699

Statistics

Rainfall intensity (mm hr^{-1})

Duration	5-min	10-min	15-min	30-min	1-hr	2-hr	6-hr	12-hr	24-hr
2-yr	118.7	73.1	55.1	33.9	20.9	12.9	6.0	3.7	2.3
5-yr	157.3	96.9	73.0	45.0	27.7	17.1	7.9	4.9	3.0
10-yr	182.3	112.3	84.6	52.1	32.1	19.8	9.2	5.7	3.5
25-yr	214.7	132.3	99.6	61.4	37.8	23.3	10.8	6.7	4.1
50-yr	238.6	147.0	110.7	68.2	42.0	25.9	12.0	7.4	4.6
100-yr	262.4	161.6	121.8	75.0	46.2	28.5	13.2	8.1	5.0

Rainfall depth (mm)

Duration	5-min	10-min	15-min	30-min	1-hr	2-hr	6-hr	12-hr	24-hr
2-yr	9.9	12.2	13.8	17.0	20.9	25.7	35.8	44.2	54.4
5-yr	13.1	16.2	18.2	22.5	27.7	34.1	47.5	58.5	72.1
10-yr	15.2	18.7	21.1	26.1	32.1	39.5	55.0	67.8	83.6
25-yr	17.9	22.0	24.9	30.7	37.8	46.6	64.8	79.9	98.4
50-yr	19.9	24.5	27.7	34.1	42.0	51.7	72.0	88.7	109.3
100-yr	21.9	26.9	30.4	37.5	46.2	56.9	79.2	97.6	120.3

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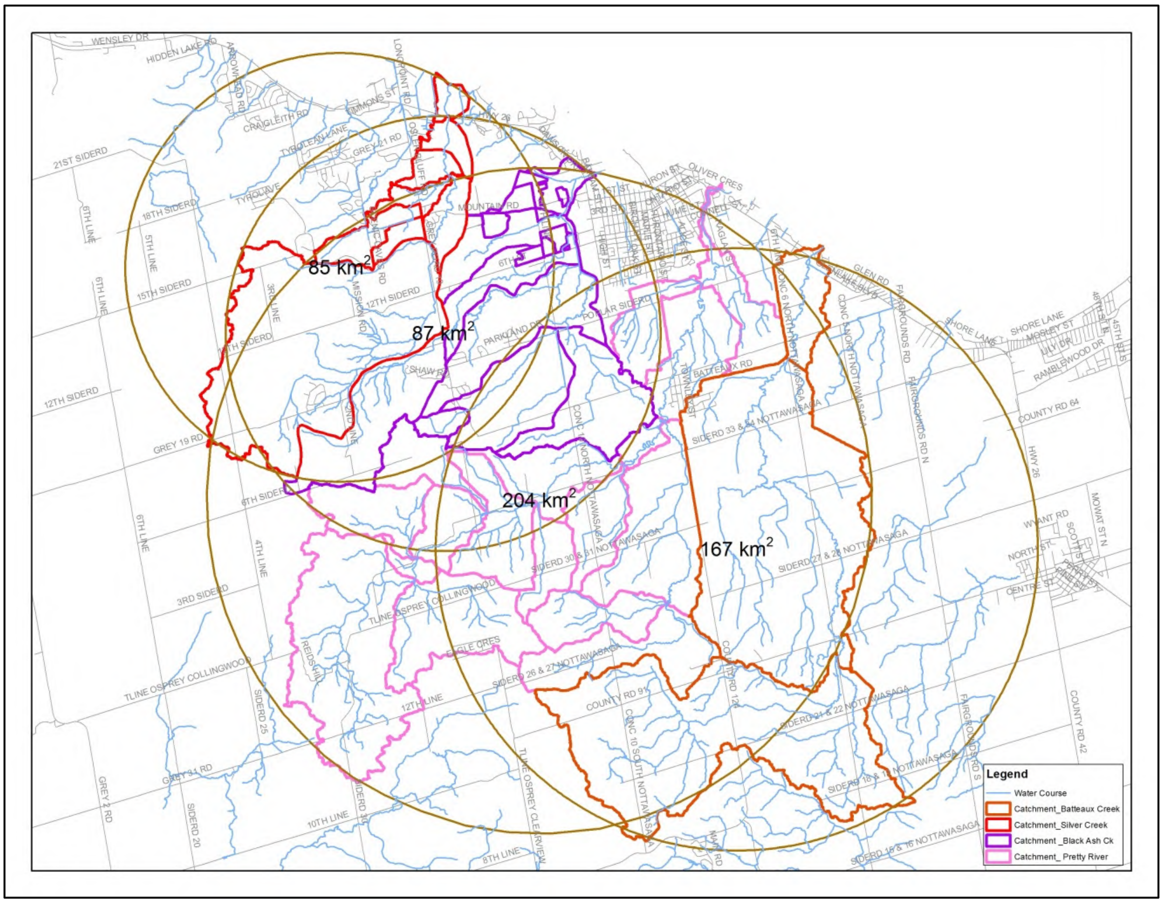
4.1.1. Regional Storm

The Timmins storm will be used to calculate regional flood elevation, as flow values are calculated to be larger than those of the 100 year storm event. An area reduction factor must be applied to account for areas greater than 25 km^2. MTO Design Chart 1.04 (**Figure 1.15, Appendix A**) gives the design rainfall distribution and the areal reduction factors, based on the equivalent area of watersheds as determined in **Figure 9** below.

The updated reduction factors for Batteaux Creek, Pretty River, Black Ash Creek and Silver Creek are 84%, 84%, 90% and 90%, respectively.

Figure 9 - Watershed Equivalent Area



4.2. Calibration Events

Historical events will be used to predict the impacts of nuisance storms through the Town. The Pretty River is the only gaged watercourse in the study area, making it difficult to directly calibrate the hydrologic models through the rest of the Town. Instead, similar parameters modelled for the Pretty River Watershed during each of the selected historical events, such as antecedent conditions, will be applied to the remaining watersheds to determine the response in the sewer system and watercourses through the rest of the Town. The Pretty River hydrologic model was calibrated using several of the historical events **tabulated below**. The first twelve (12) events in the table are the preferred events used to validate the hydrologic models, with the remaining events to be used if further validation is required. A range of events for varying antecedent conditions was selected, to determine watershed response in a range of conditions.

By using the historical events and associated response, the model can be used to predict how the watercourses and sewer system would respond in the future as these types of events become more common.

Table 1: Validation Event Summary

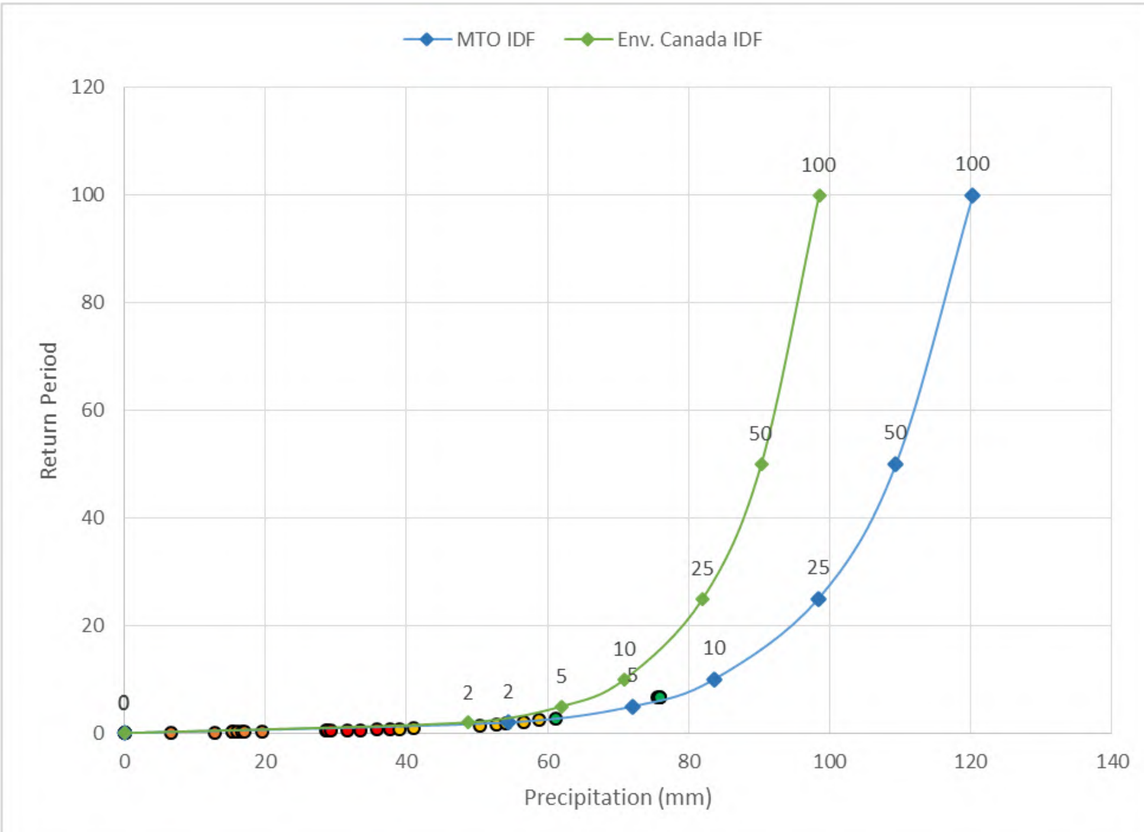
Storm Date	Rainfall Depth (mm)	Peak Flow (m^3/s)	Model Calibration*
5/13/2010	29.2	26.4	Tatham
4/17/2013	31.6	19	Tatham
6/17/2017	76	44.6	Tatham
3/28/2016	54.1 (Rain+Melt)	79.8	Tatham
3/15/2019	6.6 (Rain+Melt)	18.4	New
1/11/2018	13 (Rain+Melt)	34.5	New
9/8/2012	75.6	4.48	Greenland
8/5/2008	56.6	3.86	Greenland
10/27/2012	76	31.1	Tatham
10/10/2009	28.6	1.18	Greenland
9/21/2013	63.2	7.75	New
9/15/2008	61.2	9.1	Tatham
5/14/2011	37.6	27.8	Tatham
6/4/2011	17	9.8	Tatham
5/1/2017	35.6	22.8	New
3/10/2013	0 (Melt)	25.9	Tatham
3/28/2014	16.6 (Rain+Melt)	23.2	New
1/6/2008	0 (Melt)	25.9	Tatham
10/21/2010	33.4	1	Greenland
11/16/2008	41	21.5	Tatham
9/28/2010	35.8	10.6	Tatham
9/22/2010	52.8	2.2	Greenland
8/25/2007	28.8	1.32	Greenland
7/29/2011	50.4	1.72	Greenland

* Model Calibration refers to the study the historical events were used in to calibrate the hydrologic model; Tatham: Pretty River Hydrology Update (2018), Greenland: Model Calibration Study Pretty River Watershed (2012), New: neither study

The Town requested that the IDF curves from the MTO's IDF curve look up be used for creation of the hydrologic models. The IDF values previously used were obtained from the Collingwood station from Environment Canada. The new precipitation values have increased by 10% or more for each return period compared to those from the Environment Canada data. This means that events that were once considered a 10 year event are now a 5 year event, increasing the likelihood of these large storm events occurring more often.

Typically storm sewers are designed to convey the 5 year storm, however as the climate has changed and will continue to change, these events are now classified as closer to a 2 year event. Using historical events to validate the Urban Town Centre model, will be critical to confirm the existing conditions of the storm sewer system and its capacity to convey the increased design flows. **Figure 10** below demonstrates the difference in the two IDF curves and how the likelihood of larger storms has increased with the advent of the MTO's definition of the Town's IDF values. For example, multiple events that were once classified as 15 year return period storms, are now 6 year storms. Historical storm events were plotted on the new IDF curve, then compared against the Town's previous standard (Environment Canada, Collingwood Station).

Figure 10 – Comparison of Standard IDF Values for the Town of Collingwood



4.3. Climate Scenarios

4.3.1. Snowmelt

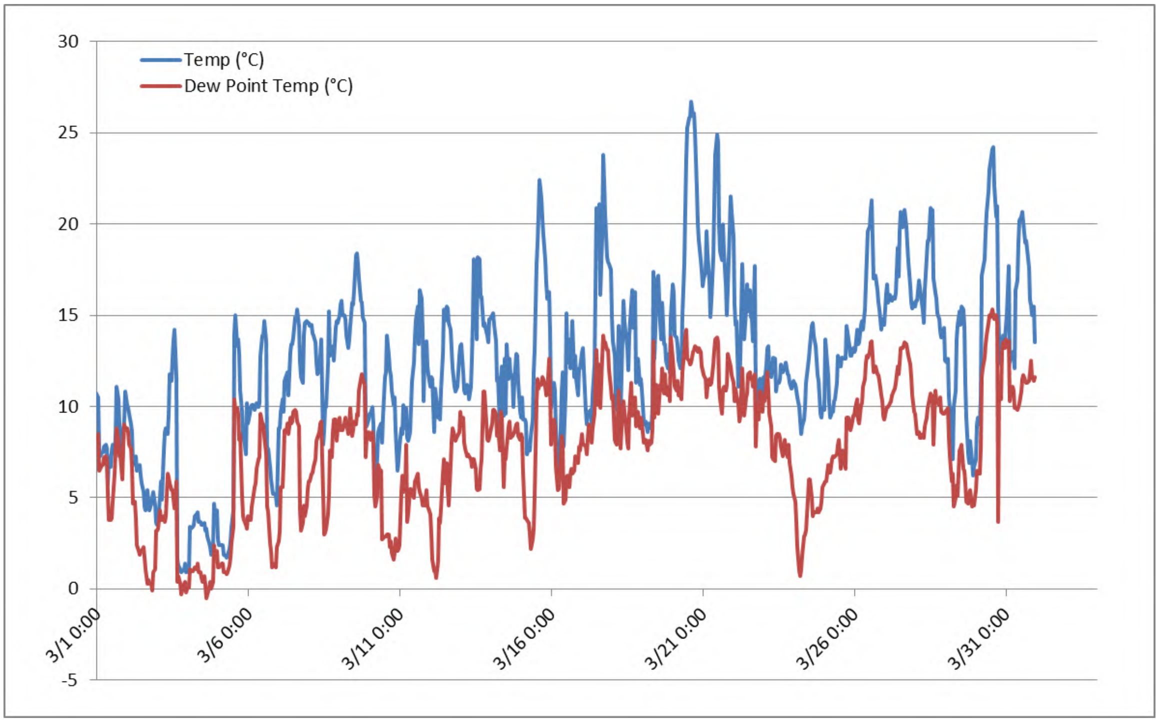
Due to the location of Collingwood, situated between Blue Mountain and Georgian Bay, there is increased risk of flooding due to large snowmelt events. To model expected/ typical watershed response to snowmelt, 2019 melt events are to be modelled using a snowmelt model created in HEC-HMS. Mid-winter melt events are becoming more common, and utilizing recent data can help the Town identify where efforts are required to best reduce impacts under likely scenarios.

To determine watershed sensitivity to potential high snowmelt scenarios, a snowmelt model created in HEC-HMS will be applied to hydraulic models. The historical snowmelt model will be created utilizing derived maximum March snow water equivalent in the upstream area of the watershed, and inputting maximum historical temperature and dew point temperature values. This process has been completed for the Pretty River Watershed, and will be repeated for each individual watershed to determine individual sensitivities and responses to historical snowmelt.

To create the Pretty River hydraulic response, the historical maximum March snow water equivalent from available data (370.8 mm from 1988 to 2019) for Petun and maximum temperature and dew point temperature for Collingwood (available data: 1994 to 2019) were derived and inputted to the HEC-HMS model. The results from the HEC-HMS model were then inputted into HEC-RAS to determine response to snowmelt, identify the most vulnerable areas, and where the Town can best invest its efforts to reduce impacts.

An alternative to the maximum snowmelt scenario mentioned above was proposed by the Town. It was suggested using a historical snowmelt scenario and modelling it with 5 to 10 year storm event. This approach will be tested for the Pretty River Watershed to determine watershed response compared to the first method of using historical maximum temperature and snowmelt, and the preferred scenario will selected by the Town to apply to the remaining watersheds.

Figure 11 - Collingwood Maximum March Temperature (1994 to 2019)



4.3.2. Ice Jams

Ice jam conditions will be modelled in HEC-RAS for each of the four major watercourses identified for this study to assess individual watershed sensitivities to ice jams. To model ice jams, ice thickness and roughness are inputted to the HEC-RAS model for the main channel, and right and left over banks at each cross section where ice is present. The user can identify whether the ice jam will occur solely within the channel or in the overbanks and the channel. For this model, Greenland will be modelling potential ice jams at identified historically problematic road crossings/ bridges along the watercourses. Additional parameters (internal friction angle of jam, ice jam porosity, coefficient K1, maximum mean velocity under ice cover) are estimated by the program.

Historical ice cover data is not available for watercourses, therefore an approximate value of ice thickness will be used based on available climate data.

4.3.3. Lake Levels

To model various design storms under typical conditions, the average July Michigan-Huron lake level (176.58 m, IGLD85) will be inputted into the initial conditions for the hydraulic models in HEC-RAS. This data is available from the US Army Corps of Engineers.

As part of the individual watershed assessment, high lake levels will be modelled as a potential climate scenario. Greenland is proposing using 2018/2019 lake levels as a recent historical maximum lake level scenario. 2019 lake levels are approaching, and are projected to exceed, previous historical maximums for June and July. High lake level modelling provides detail into backwater effects and the creation of potential flood damage centres from the storm sewer system during high storm events when combined with high outlet water levels.

5. Major/Minor System Model

5.1 PCSWMM Inputs

To develop the minor and major system models, Greenland is updating the GIS database of municipal storm drainage infrastructure to input into PCSWMM. Information from available As – Built drawings supplied by the Town form the basis of the data and to supplement areas where As-Built drawings do not exist, field investigations are being undertaken to fill in data gaps.

5.1.1. Minor Sewer System

To create the minor system model, the minor system is imported from the Manhole and Sewer shapefiles provided by the Town, which contain mapping of every manhole, catch basin and storm sewer in the Town limits.

To create the PCSWMM model, attributes in the imported shapefiles must contain:

- Manhole

  Name (ID)
  Invert Elevation
  Depth

- Sewer

  Name (ID)
  Inlet Node (Upstream Manhole)
  Outlet Node (Downstream Manhole)
  Inlet Elevation (Upstream invert)
  Outlet Elevation (Downstream invert)
  Shape (CIRCULAR, RECT_CLOSED, ARCH, HORIZ_ELLIPSE, VERT_ELLIPSE, etc.)
  Geom1 (depth, or diameter)
  Geom2 (width)

- Catch basin

  Catch basin Type: single catch basin (CB), double catch basin (DCB), triple catch basin (TCB) ditch inlet catch basin (DICB), catch basin manhole (CBMH), rear lot catch basin (RLCB)

The catchments will be delineated from the proposed Drainage Plan from available SWM reports, or the DEM created from the LiDAR data.

5.1.2. Major System

The major system will be created by the “Dual Drainage Creator” in Tools Menu in PCSWMM. Before this can be done, the road Transact must be created (20 m or 26 m ROW).

For the dynamic wave routing method (as opposed to the kinematic wave method), Outlet (Major to Minor) has to be selected. This method will model the major system outletting to the minor system during modelled events, and can take into account: channel storage, pressurized flow, backwater, surcharging, reverse flow and surface ponding conditions required to simulate conditions. This will allow the evaluation of the performance of the Town’s major and minor systems under various design storms and what if scenarios (lake levels, ice jams, snow melt). The rating curve will be created later.

5.1.3. Catchments

To import catchments into PCSWMM, they are first delineated in ArcGIS using the proposed drainage plan from SWM Reports, or if not available, then using the DEM to be created from collected LiDAR data. The outlet of the catchments is set using “SET Outlet” in Tools Menu. The outlet should be set at the Major Node, the modification is necessary from automatic settings.

- Catch basin clipping

The rating curve of the outlet (major to minor) will be calculated based on the catch basins in the contributing catchment. The catch basin shapefile is clipped by catchments. Then the catch basins are counted in each catchment in the spreadsheet.

5.1.4. Stormwater Management Ponds

Since the creation of the Town model and previous models, multiple subdivisions and associated stormwater management ponds have been constructed within the Town to provide stormwater protection to each subdivision. As each pond has its own drainage area and functions, they must be added to the model to account for each individual scenario. A summary of the ponds to be added to the hydrologic models is included in **Table 1.14, Appendix A**. To add Stormwater Management (SWM) ponds to the model, the storage rating curve and outlet structure are required. The rating curve is set as depth-area relationship. Therefore the pond area (or volume)-elevation file is needed either from the SWM report or CAD file. The Town has provided all available SWM reports, and a summary of extracted information is available in **Appendix B.**

5.2 Pretty River Estates

The culmination of the methodology laid out in **Section 5** has been utilized for the Pretty River Estates Subdivision. Delineated catchments and storm sewer data were inputted to create the PCSWMM schematic and the calculation to be used to develop the outlet rating curve.

6. Riverine Models

6.1. HEC-RAS

Results from the PCSWMM major and minor conveyance models will be inputted into HEC-RAS to develop the riverine models and develop detailed hydraulics of spill routes. Riverine interaction will be included in the PCSWMM models; however, the HEC-RAS model is more widely utilized for riverine and flood plain mapping, which should allow the models to be easier utilized by future users.

These HEC-RAS models will be utilized to identify and understand Flood Damage Centres and areas that are nearing capacity to handle stormwater loads.

7. Closure

The above report outlines the methodology used to create the existing models in order to match previous models for each of the six (6) sub-watersheds reviewed as part of this Existing Conditions Master SWM Model. Using the above noted models as a base, certain parameters can be updated, i.e. flow inputs, elevations, climate consideration, and construction to create an up to date existing conditions model that incorporates the whole Town. The existing conditions Master SWM Model will form the basis for future modelling for the Town as required to facilitate future development, support any potential by-law decision making, and inform capital asset management.

As previously noted herein, the intent of this report is to create efficiencies within the approval process. By detailing the methods used to create the baseline model, review of the final model should be expedited as the only changes will be within the Town of Collingwood limits from any activities undertaken since the most recent approved model.

Sincerely,

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Appendix A

Figures and Tables

Table 1.1 Pretty River Matched Flow and Adjusted Parameters – Original Catchment

	PCSWMM					VO5 Catchment	
Name	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Peak Runoff (m^3/s)	NHYD	Peak Flow
0	17.42	281.0	620	0.7	1.36	0	1.363
1	340.69	3406.9	1000	1.2	10.09	1	10.289
2	312.2	2312.6	1350	0.8	6.32	2	6.351
3	443.02	4430.2	1000	1.2	11.86	3	11.976
4	78.12	1420.4	550	2	2.01	4	2.021
5	773.27	5523.4	1400	7	33.5	5	33.59
6	344.9	2155.6	1600	2.5	14.02	6	14.012
7	285.27	1901.8	1500	5.3	12.01	7	12.025
8	244.13	1436.1	1700	8	7.61	8	7.615
9	418.49	4184.9	1000	8.5	18.49	9	18.453
10	208.43	1736.9	1200	9	9.17	10	9.231
11	269.42	2449.3	1100	10	9.57	11	9.599
12	486.99	3746.1	1300	8	18.03	12	18.081
13	653.33	2916.7	2240	6	18.93	13	18.971
14	229.96	2420.6	950	11	11.6	14	11.698
15	58.94	1071.6	550	10	2.99	15	2.986
16	331.77	2764.8	1200	8	12.9	16	12.86
17	1274.02	6370.1	2000	5.5	40.15	17	40.152
Outlet	**6770.37**				**180.08**		**180.04**

Figure 1.1 Pretty River PCSWMM Model

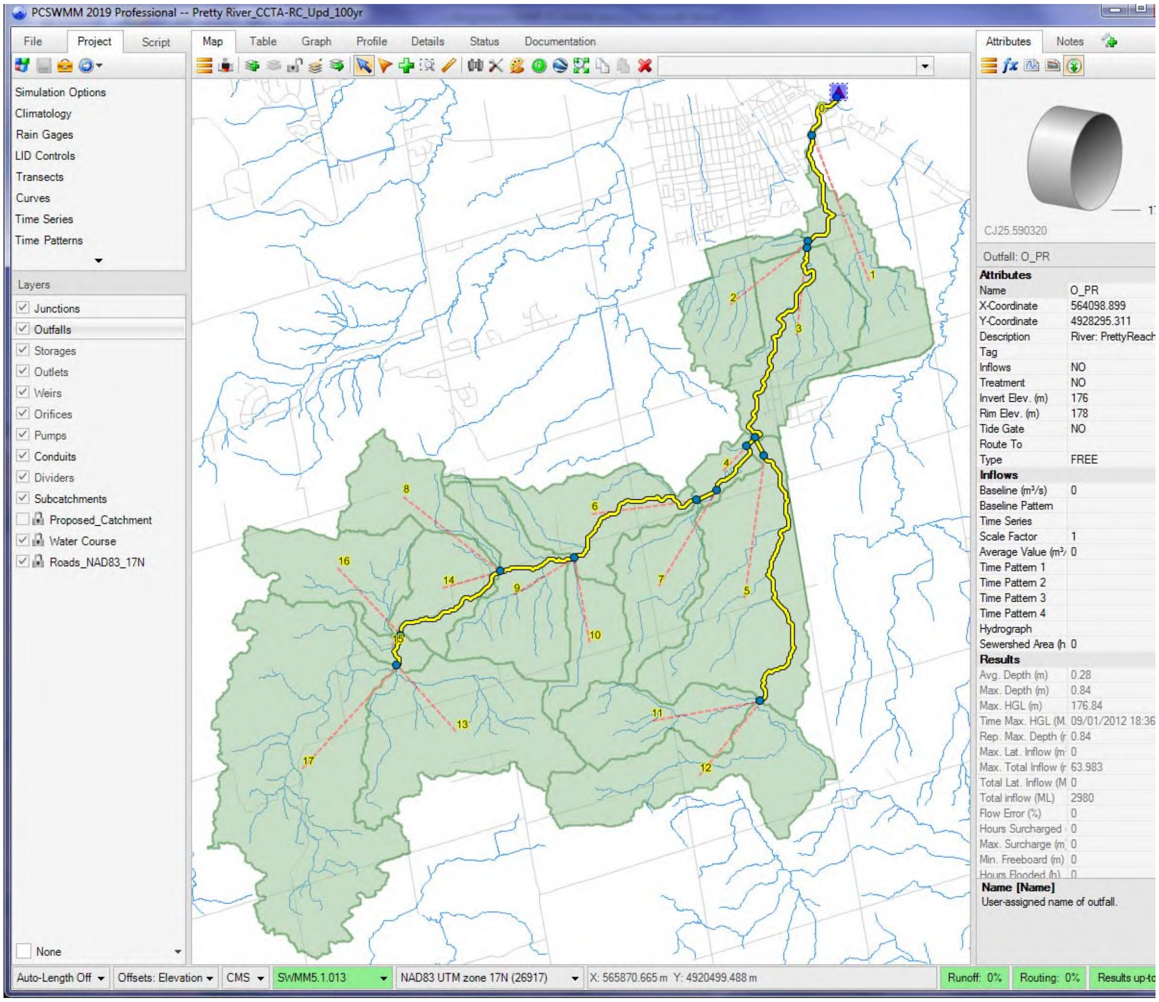

Table 1.2 Pretty River Updated Model Flow - Updated Catchment (Timmins 84%)

	PCSWMM				
Name	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Peak Runoff (m³/s)
0	6.013	164.7	365	0.7	0.52
1	303.402	3193.7	950	1.2	9.16
2	263.48	2107.8	1250	0.8	5.47
3	442.39	4423.9	1000	1.2	11.84
4	77.06	1401.1	550	2	1.98
5	735.367	5252.6	1400	7	31.86
6	350.151	2188.4	1600	2.5	14.23
7	286.887	1912.6	1500	5.3	12.08
8	242.907	1428.9	1700	8	7.57
9	412.56	4125.6	1000	8.5	18.23

10	205.091	1709.1	1200	9	9.02
11	306.56	2786.9	1100	10	10.89
12	502.899	3725.2	1350	8	18.47
13	643.49	2872.7	2240	6	18.65
14	233.033	2453.0	950	11	11.75
15	61.887	1125.2	550	10	3.14
16	337.339	2811.2	1200	8	13.12
17	1309.655	6388.6	2050	5.5	40.87
Outlet	**6720.17**				**179.13**

Figure 1.2 Black Ash Creek PCSWMM Matched Model – Original Catchment

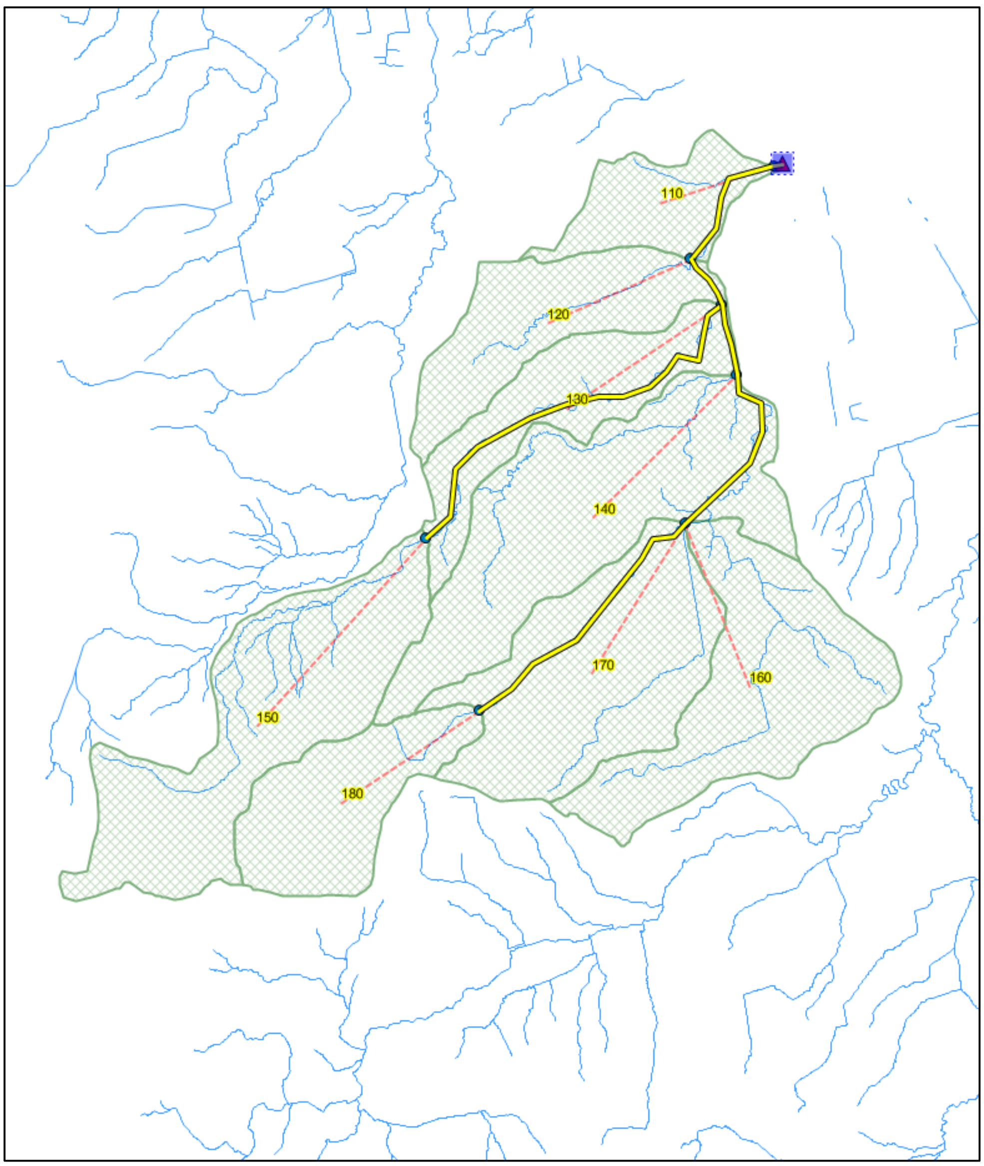

Table 1.2 Black Ash Creek Matched Flow and Adjusted Parameters – Original Catchment

	PCSWMM					VO2 Catchment	
Name	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Peak Runoff (m^3/s)	NHYD	Peak Flow
110	177	3540	500	2	1.26	110	1.221
120	305	4357	700	5	2.3	120	2.276
130	294	2450	1200	3	2.05	130	2.071
140	620	8857	700	8	5.49	140	5.465
150	574	4783	1200	5	5.29	150	5.43
160	490	4455	1100	7	2.92	160	2.989
170	515	8583	600	18	14.23	170	14.479
180	283	11891	238	18	5.12	180	5.534
Outlet					**31.103**	1	**29.69**

Figure 1.3 Black Ash Creek Updated Watershed

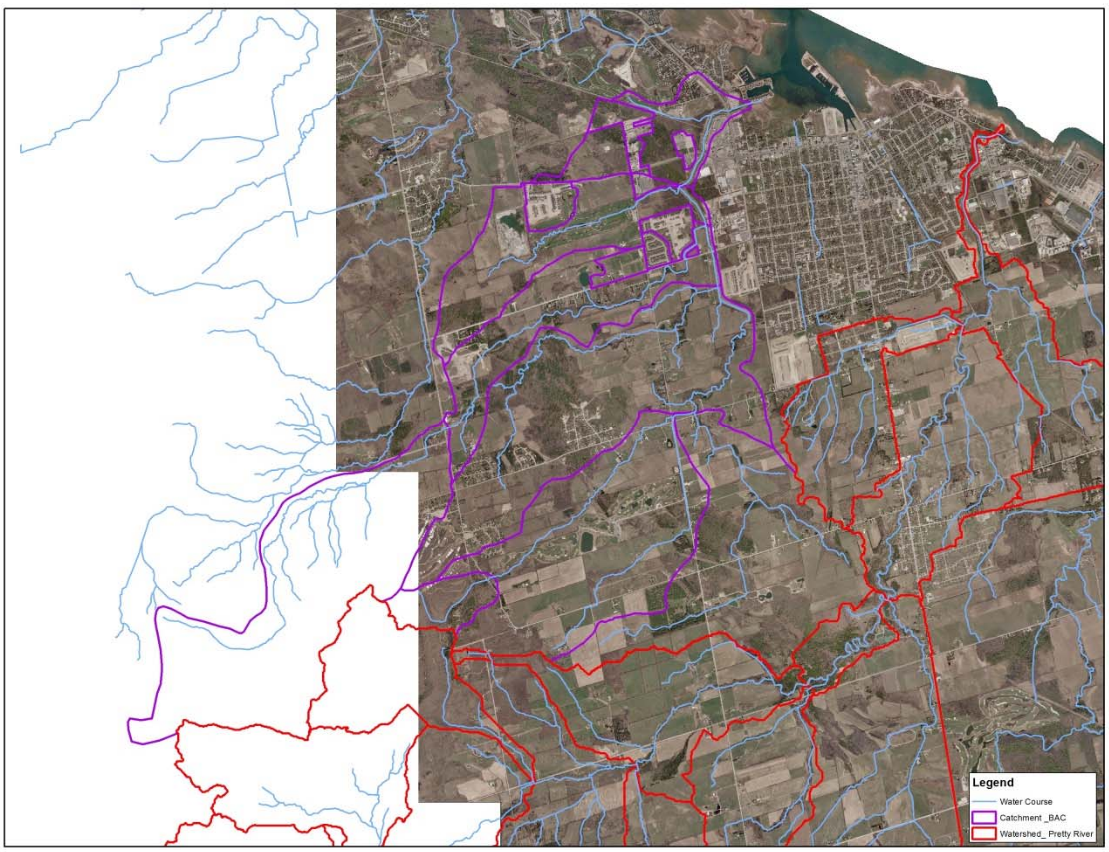

Figure 1.4 Georgian Meadows Catchment

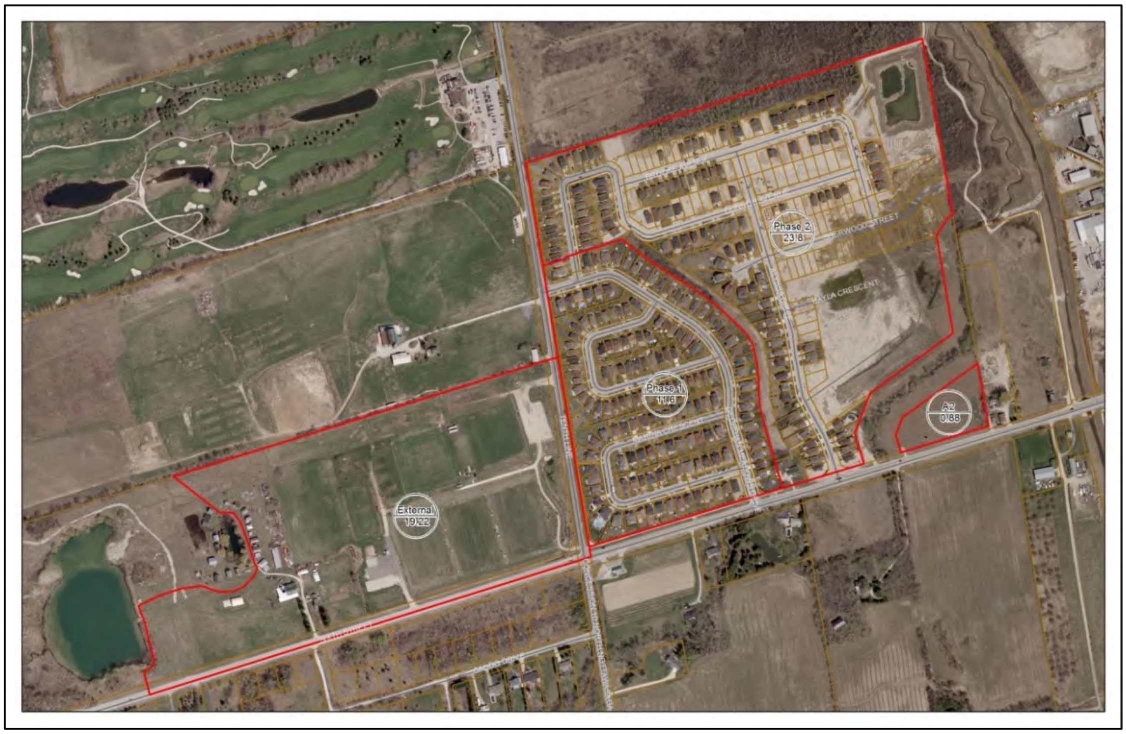

Figure 1.5 Mair Mills Catchment

Figure 1.6 Black Ash Creek Updated PCSWMM Model

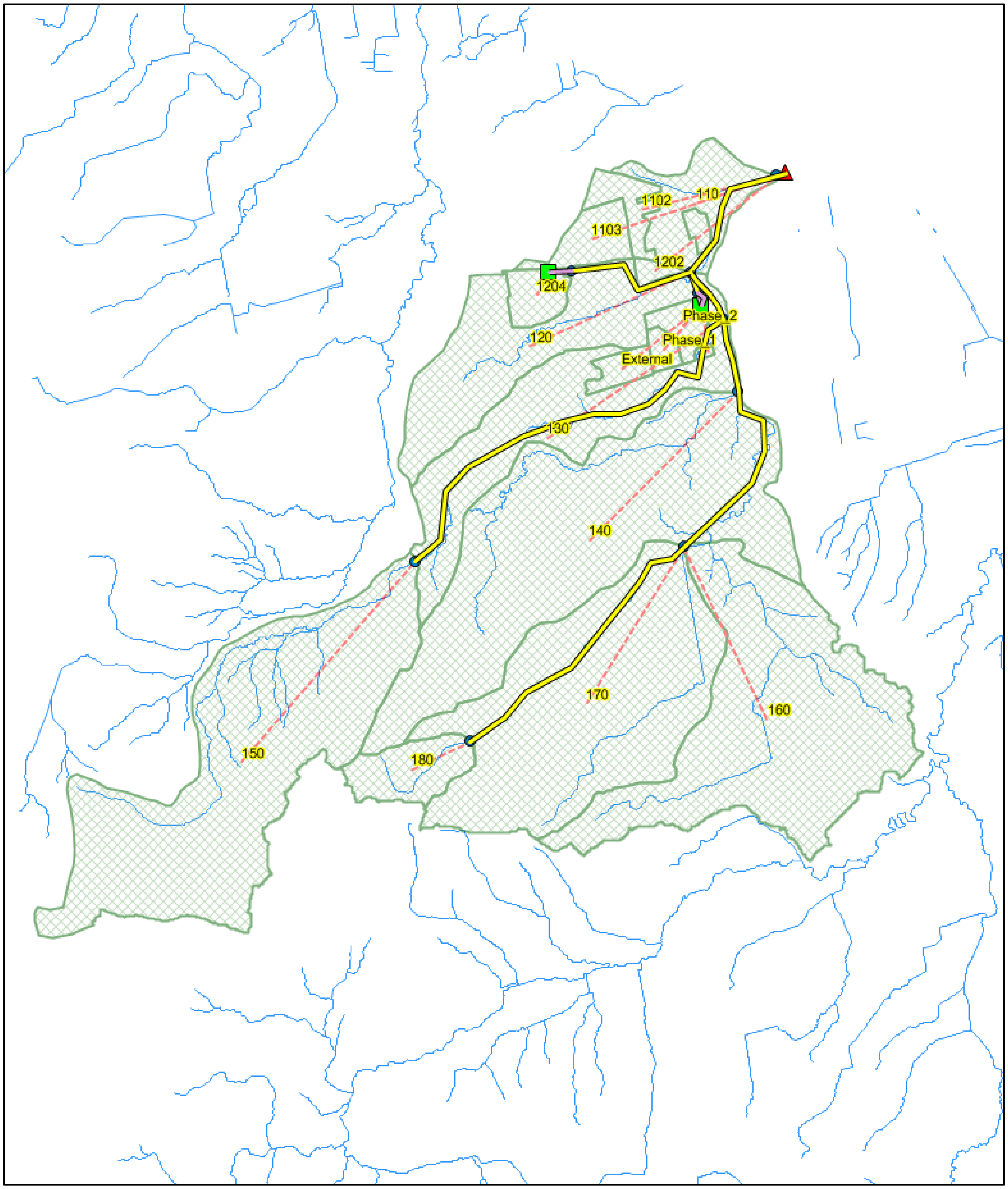

Table 1.3 Black Ash Creek Updated Model Flow - Updated Catchment (100yr 4hr Chi)

	PCSWMM				
Name	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Peak Runoff (m^3/s)
110	95.4	2577.8	370	2	0.78
120	247.4	3927.3	630	5	1.96
130	255.3	2219.9	1150	3	1.83
140	618.9	8840.8	700	8	5.48
150	610.1	4960.2	1230	5	5.55
160	520.8	4568.6	1140	7	3.04
170	521.3	8687.7	600	18	14.4
180	65.8	4388.0	150	18	1.48
1102	39.0	1220.2	320	1.5	17.29
1103	41.8	1673.7	250	2	0.41
1202	8.5	532.5	160	2	5.01
1204	31.9	127.7	2500	1	2.23
A2	1.0	507.6	20	2.5	0.05
External	19.2	4576.3	42	2.5	0.71
Phase_1	11.6	105.8	1100	2.52	2.31
Phase_2	23.9	159.6	1500	0.97	2.79
Outlet	**3111.9**				**28.66**

Figure 1.7 Silver Creek Catchment – MacLaren Study

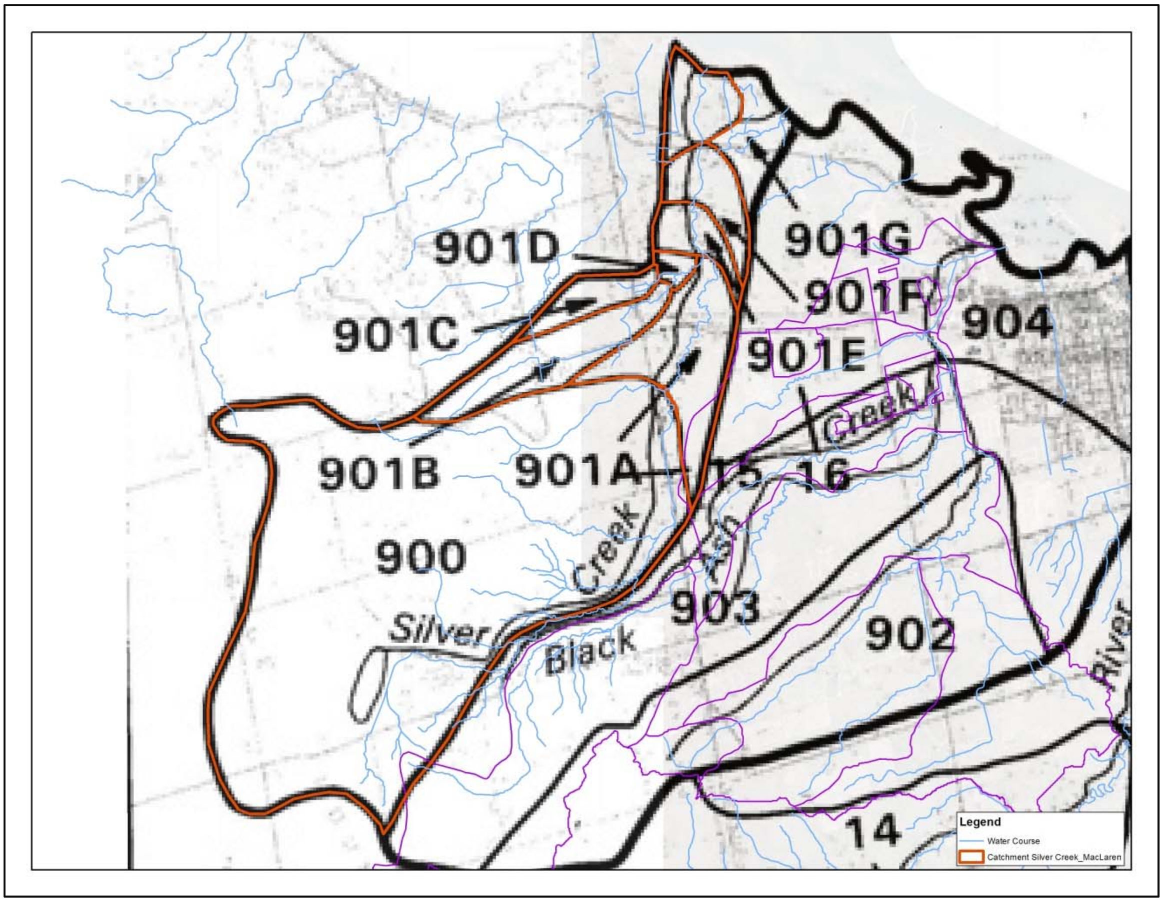

Figure 1.8 Silver Creek PCSWMM Model –MacLaren Catchment

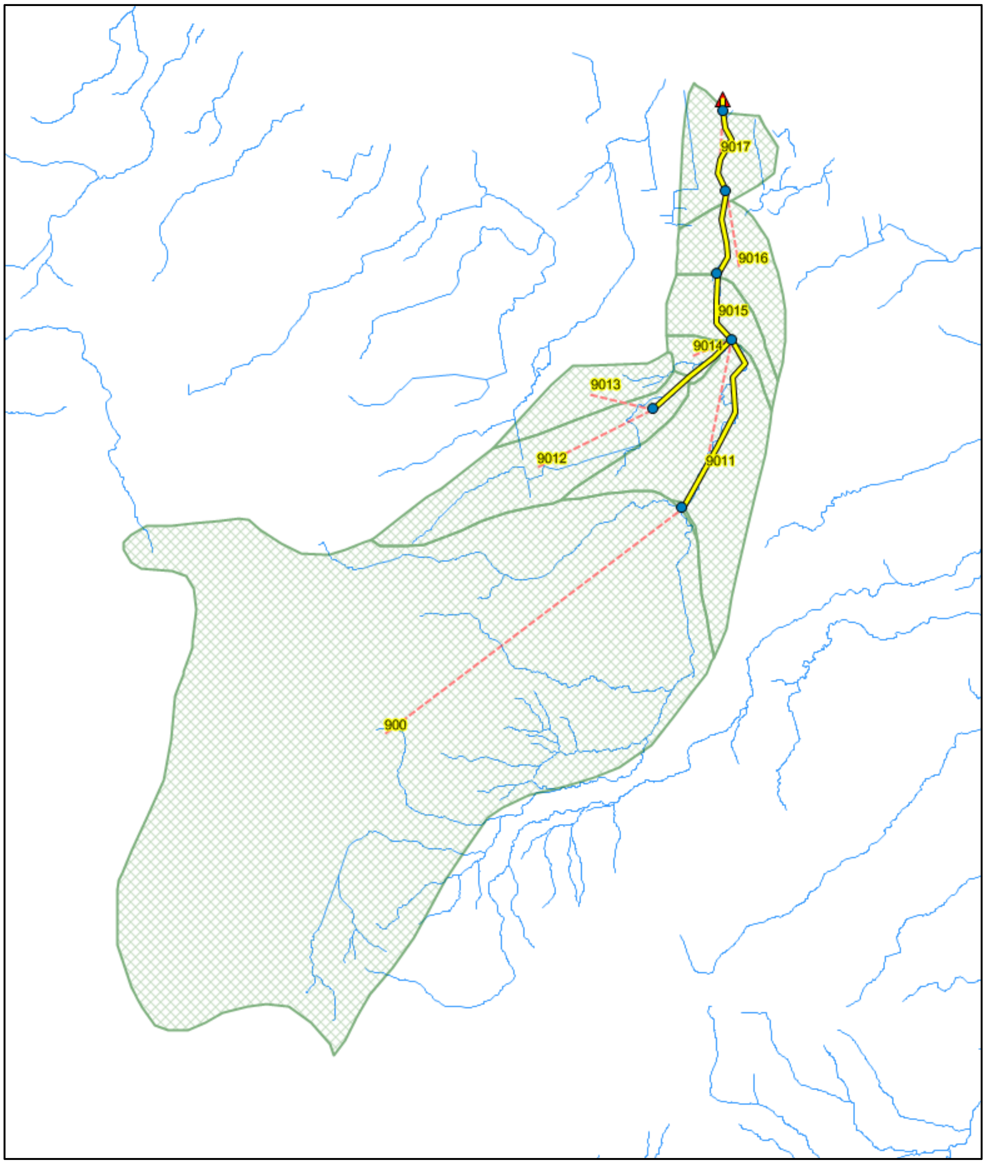

Table 1.4 Silver Creek QUALHYMO Parameters

SubWatershed ID	SMAX	SMIN	API	SK	S*	CN condition I	CN condition II	Area
900	2100	61	27	0.11	165.6	60.5	78	2032
9011	881	22	27	0.11	66.1	79.4	90	227
9012	1202	30	27	0.11	90.1	73.8	87	165
9013	766	20	27	0.11	58.3	81.3	92	85
9014	1910	43	27	0.11	138.8	64.7	81	30
9015	2174	70	27	0.11	177.9	58.8	77	88
9016	3339	121	27	0.11	286.1	47.0	67	35.2

9017	2032	54	27	0.11	155.5	62.0	79	16
9018	3339	121	27	0.11	286.1	47.0	67	38
9019	2032	54	27	0.11	155.5	62.0	79	67

Table 1.5 Silver Creek Matched Flow and Adjusted Parameters (Timmins94%)

	PCSWMM					**QUALHYMO**	
Name	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Peak Runoff (m^3/s)	ISER	Peak Flow
900	2032	6773	3000	5	77.24	900	77.206
9011	227	1335	1700	1.5	10.58	9011	10.732
9012	165	1833	900	15	13.69	9012	13.284
9013	85	1063	800	15	7.79	9013	7.616
9014	30	545	550	2	1.84	9014	1.779
9015	88	880	1000	1	3.69	9015	3.595
9016	35.2	352	1000	0.5	1.01	9016	0.921
9017	16	457	350	1	0.98	9017	0.921
Outlet	**2678.2**				**105.75**	**97**	**110.26**

Figure 1.9 Windfall Catchment - Original Catchment

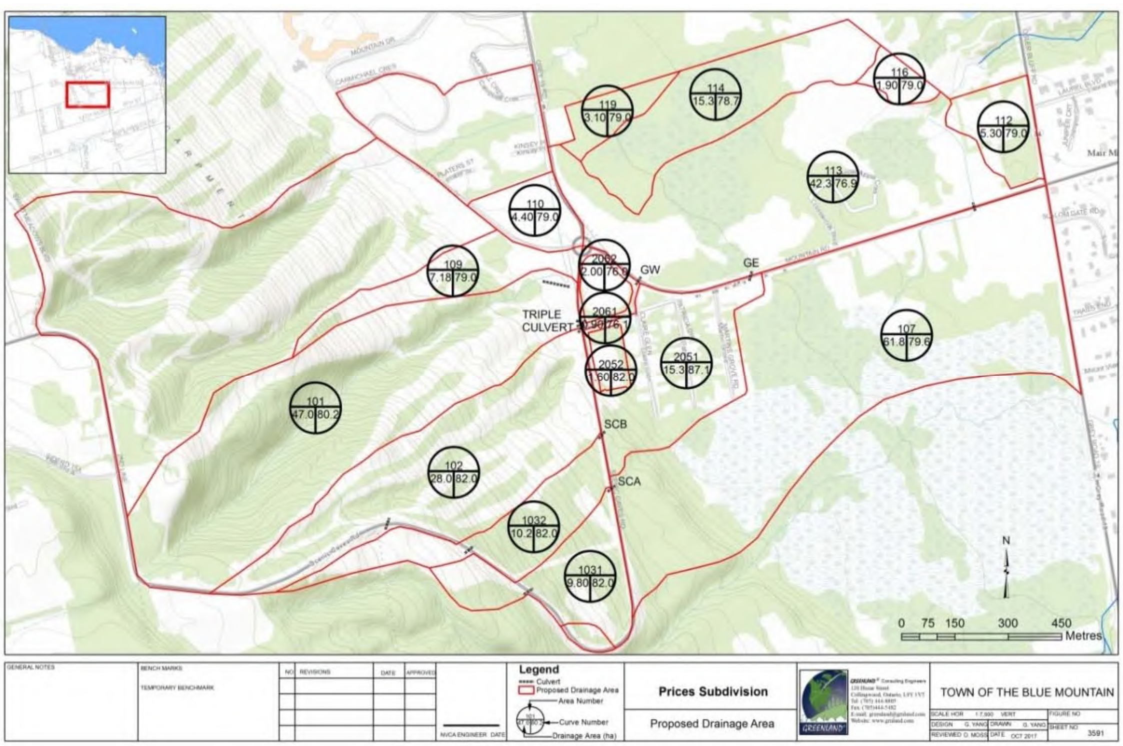

Table 1.6 Windfall Matched Flow and Adjusted Parameters - Original Catchment (100yr 24 SCS)

	PCSWMM					VO2 Catchment	
Name	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Peak Runoff (m^3/s)	NHYD	Peak Flow
101_Prc	47	1469	320	18	3.91	101	3.847
102_Prc	28	933	300	18	2.86	102	2.866
1031_Prc	9.8	576	170	18	1.36	1031	1.358
1032_Prc	10.2	408	250	18	1.16	1032	1.093
105_Prc	16.9	845	200	5	1.95	105	1.919
107_Prc	61.8	1236	500	10	2.68	107	2.666
112_Prc	5.3	353	150	5	0.41	112	0.396
113_Prc	42.3	1410	300	7	1.87	113	1.823
2061_Prc	0.9	150	60	2	0.09	2061	0.087
2062_Prc	2	200	100	3	0.47	2062	0.45
Outlet	**224.2**				**11.75**		**11.53**

Figure 1.10 Silver Creek Updated PCSWMM Model

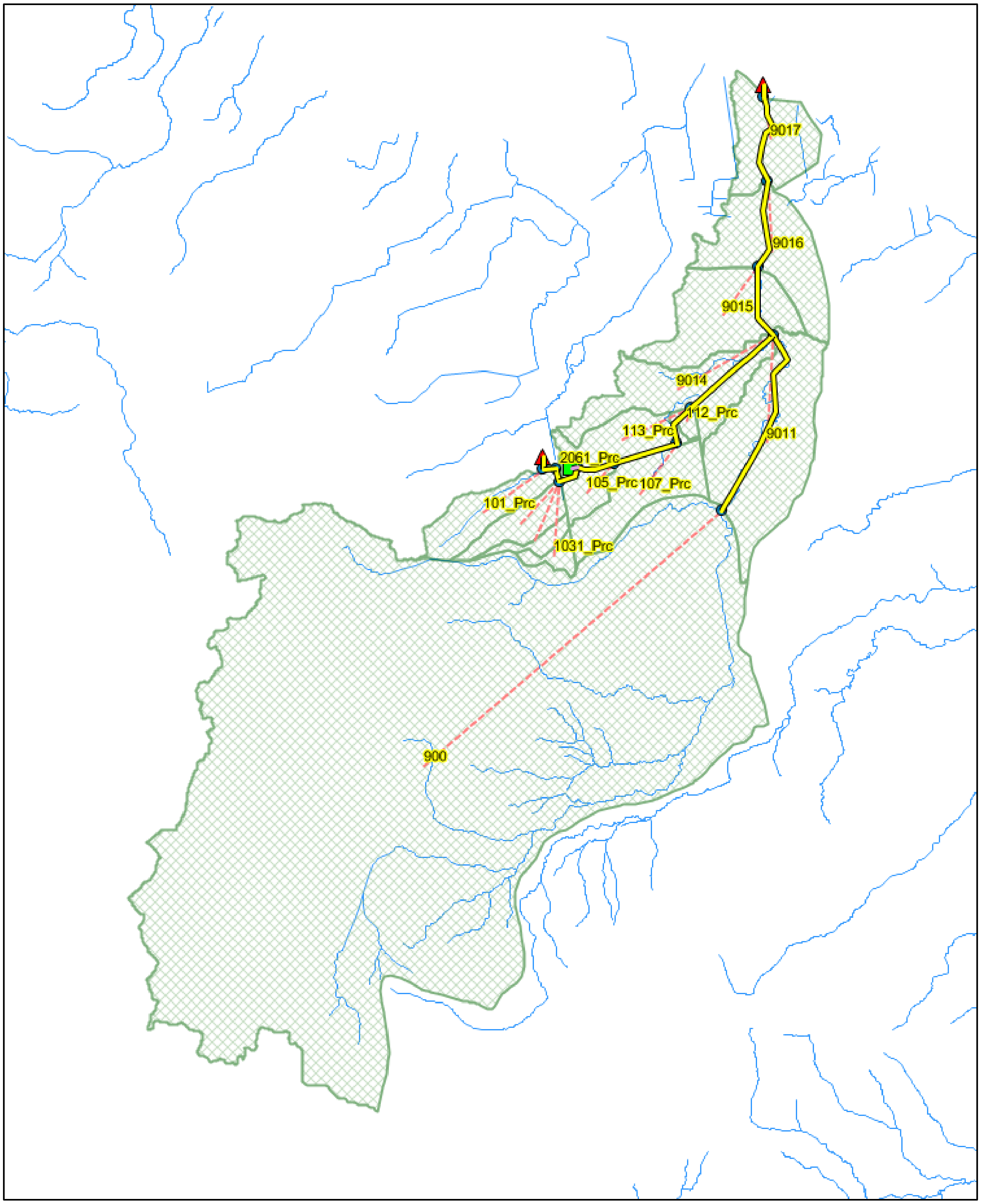

Table 1.7 Silver Creek Updated Model Flow - Updated Catchment (Timmins 94%)

	PCSWMM				
Name	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Peak Runoff (m^3/s)
101_Prc	43.90	1372.0	320	18	4.08
102_Prc	28.03	934.5	300	18	2.7
1031_Prc	9.85	579.1	170	18	0.98
1032_Prc	10.16	406.6	250	18	0.99
105_Prc	16.87	843.7	200	5	1.69
107_Prc	61.86	1237.1	500	10	4.99
112_Prc	5.26	350.6	150	5	0.49
113_Prc	42.30	1410.0	300	7	3.5
2061_Prc	0.98	163.6	60	2	0.09
2062_Prc	2.00	199.7	100	3	0.22
900	2024.43	6748.1	3000	5	76.95
9011	148.37	1099.0	1350	1.5	7.46
9014	81.48	905.3	900	2	4.12
9015	88.66	886.6	1000	1	3.72
9016	87.59	583.9	1500	0.5	2.1
9017	64.57	922.4	700	1	3.11
Outlet	**2716.31**				**103.32**

Figure 1.11 Batteaux Creek Catchment – MacLaren Study

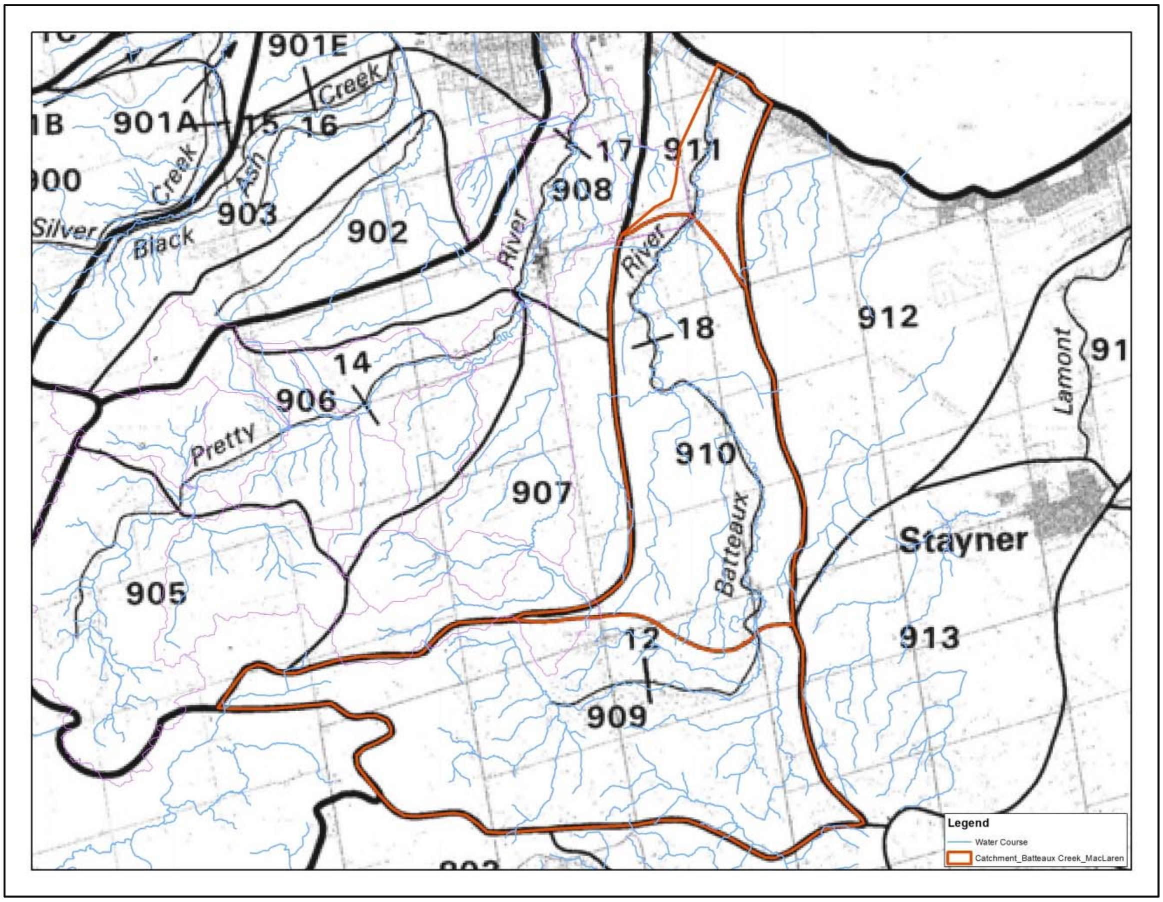

Figure 1.12 Batteaux Creek PCSWMM Model –MacLaren Catchment

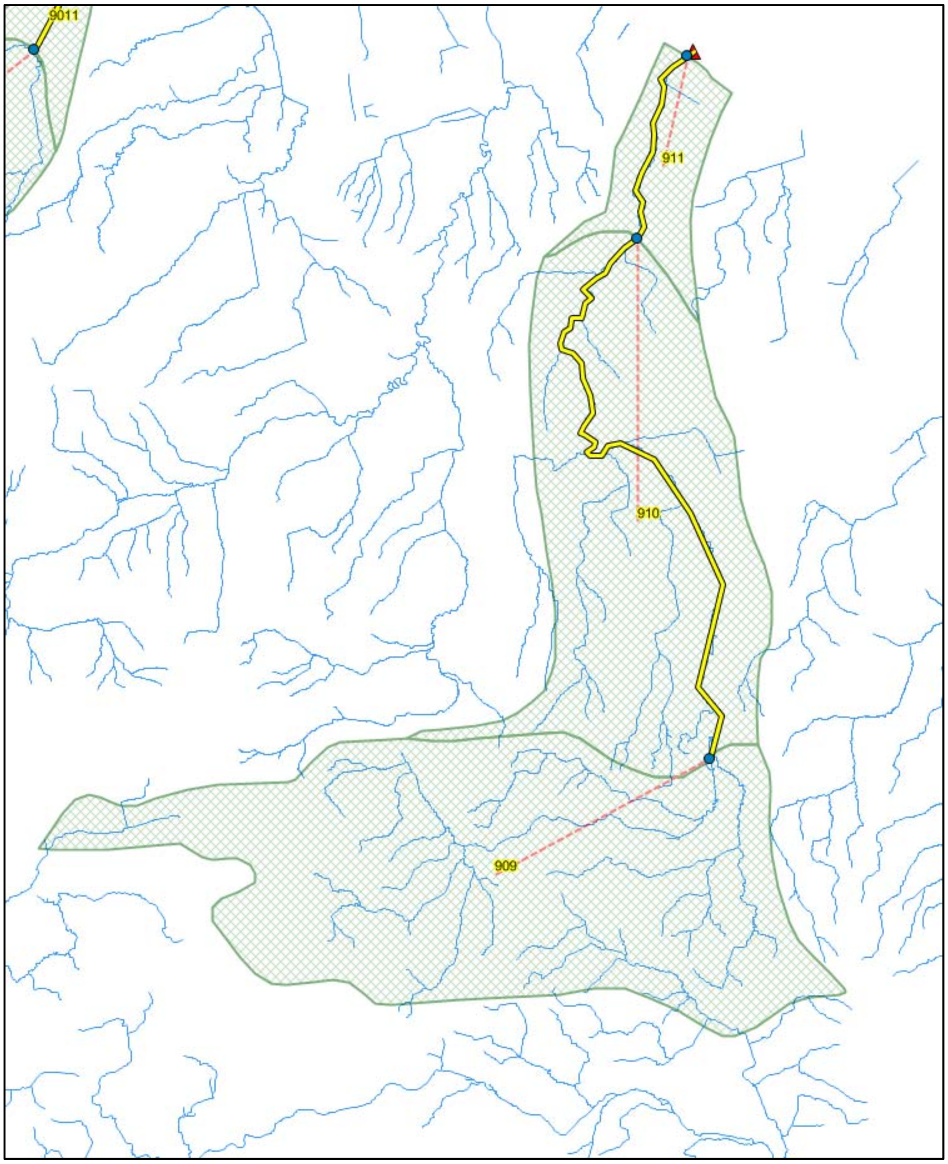

Table 1.8 Batteaux Creek QUALHYMO Parameters

SubWatershed ID	SMAX	SMIN	API	SK	S*	CN condition I	CN condition II	Area
909	1735	43.4	27	0.11	130.2	66.1	82	3021
910	1735	43.4	27	0.11	130.2	66.1	82	2118
911	1344	33.7	27	0.11	100.9	71.6	86	372

Table 1.9 Batteaux Creek Matched Flow and Adjusted Parameters – Original Catchment (Timmins 87%)

	PCSWMM					QUALHYMO	
Name	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Peak Runoff (m^3/s)	ISER	Peak Flow
909	3021	7746	3900	7	105.14	909	105.481
910	2118	5724	3700	4	65.62	910	65.155
911	372	2067	1800	1.5	14.63	911	14.451
Outlet	5511				176.46		178.837

Figure 1.13 Batteaux Creek Updated PCSWMM Model

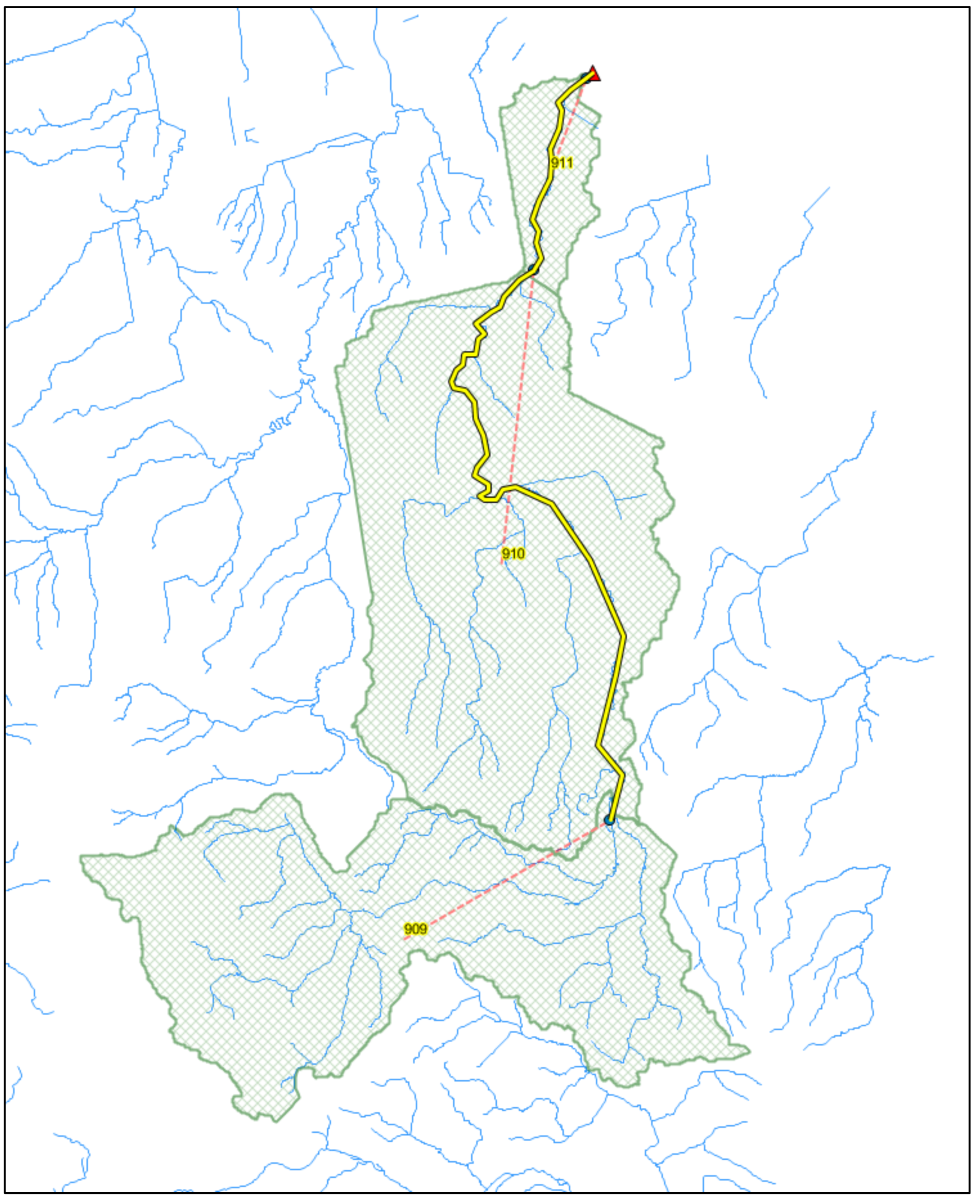

Table 1.10 Batteaux Creek Updated Model Flow - Updated Catchment (Timmins 87%)

	PCSWMM				
Name	Area (ha)	Width (m)	Flow Length (m)	Slope (%)	Peak Runoff (m^3/s)
909	2249.3	6615.5	3400	7	83.3
910	2696.1	7286.8	3700	4	83.53
911	274.5	1770.7	1550	1.5	11.43
Outlet	**5219.8**				**169.86**

Figure 1.14 Combined PCSWMM Model

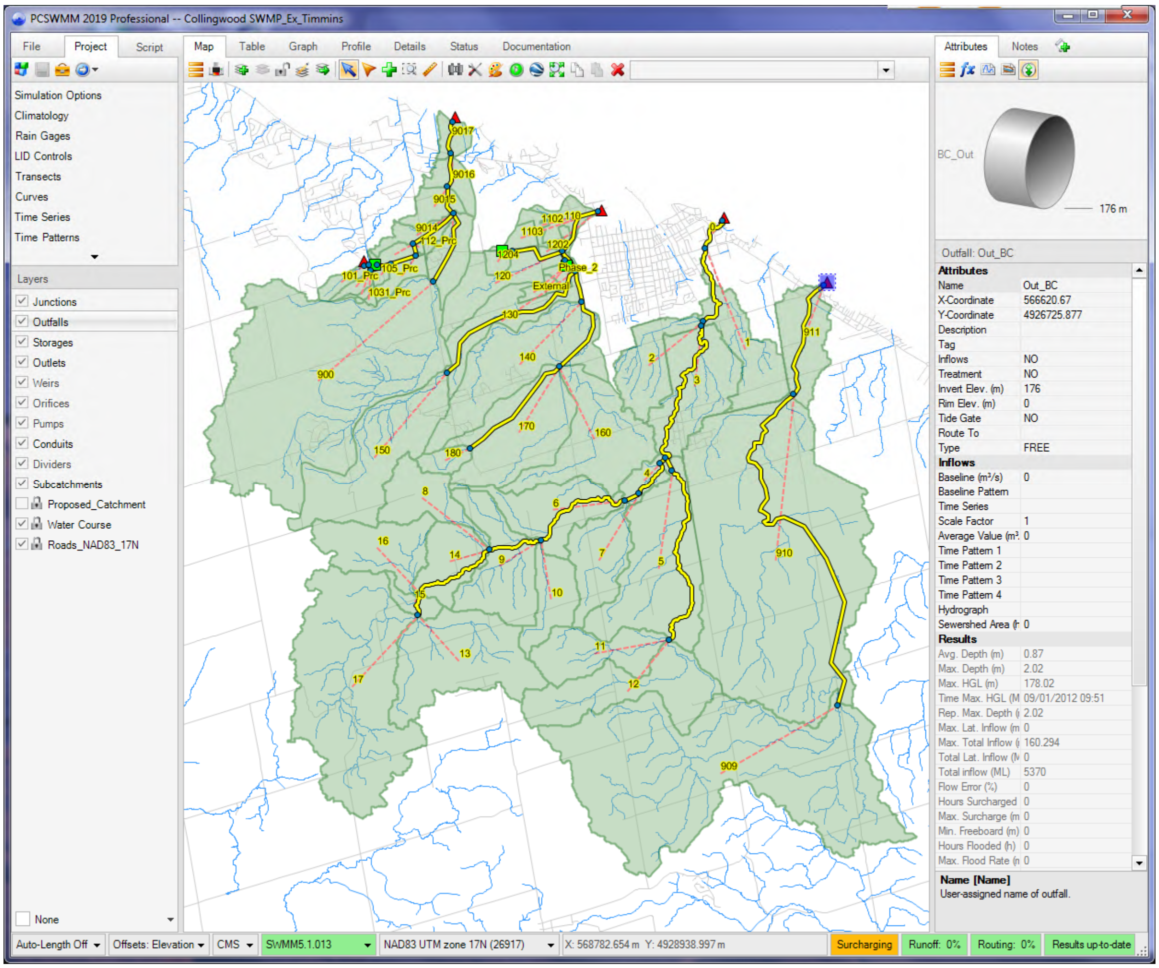

Table 1.11 PCSWMM Watershed Flows

Watershed	Flow (cms)	
	100yr 24hr SCS	Timmins (%)
Batteaux Creek	92.31	160.29 (84%)
Pretty River	85.18	179.04 (84%)
Black Ash Creek	76.37	112.81 (90%)
Silver Creek	57.03	96.37 (90%)

Figure 1.15 MTO Design Chart 1.04: Timmins Storm

	Depth		Percent of 12 hour
	(mm)	(inches)	
1st hour	15	0.6	8
2nd hour	20	0.8	10
3rd hour	10	0.4	6
4th hour	3	0.1	1
5th hour	5	0.2	3
6th hour	20	0.8	10
7th hour	43	1.7	23
8th hour	20	0.8	10
9th hour	23	0.9	12
10th hour	13	0.5	6
11th hour	13	0.5	7
12th hour	8	0.3	4
	193	7.6	100

Drainage Area (km^2)	Percentage
0 to 25	100.0
26 to 50	97
51 to 75	94
76 to 100	90
101 to 150	87
151 to 200	84
201 to 250	82
251 to 375	79
376 to 500	76
501 to 750	74
751 to 1000	70
1001 to 1250	68
1251 to 1500	66
1501 to 1800	65
1801 to 2100	64
2101 to 2300	63
2301 to 2600	62
2601 to 3900	58
3901 to 5200	56
5201 to 6500	53
6501 to 8000	50

Source: Ministry of Transportation, MTO (1989)

Appendix B

Background Information Summary