Darlene Conway, P. Eng.
Ottawa, Ontario

March 2nd, 2010

By e-mail:
Steve Burns, District Manager, Ottawa District Office, MOE
Charles Goulet, P. Eng., District Engineer, Ottawa District Office, MOE
Jason Schaefer, P. Eng., District Engineer, Ottawa District Office, MOE
Mansoor Mahmood, P. Eng., Supervisor, Water and Wastewater, MOE
Doris Dumais, Director, Approvals Program, MOE
Agatha Garcia-Wright, Director, Environmental Assessment, MOE
Les Pataky, P. Eng., Regional Engineer, Southern Region, MNR
Dan Marinigh, Director, Lands and Waters Branch, MNR
David Lindensmith, P. Eng., Senior Project Engineer, Eastern Region, MTO
Hani Farghaly, P. Eng., Senior Engineer, Design Standards Section, MTO
Paul Lehman, P. Eng., Mississippi Valley Conservation

Dear Sirs/Mesdames:

Re: City of Ottawa's Response to January 2010 Submission re: Serious Concerns with Third Party Review Model of Record for the Carp River Restoration

On February 25th, the MOE District Office forwarded to me a copy of a letter dated February 17, 2010 from Greenland Engineering that provides a response on behalf of the City to my submission of January 18th, 2010. To date, the City has not forwarded a copy of this correspondence to me.

As a professional engineer, I am frankly disturbed by this response to the concerns I raised about questionable parameter selection and apparent manipulation of the hydraulic (floodplain) modeling through the Third Party Review process and revisions of earlier models. My detailed response is provided in the attached annotation of the February 17, 2010 Greenland Engineering correspondence.

The main focus of my concerns has to do with parameters used in the model of record that have been endorsed by the Third Party Review. In my professional opinion, there is no foundation to the rationale behind the selection of roughness (or Manning's 'n') values for a large proportion of the restoration reach. These assigned values have the effect of overestimating existing flood levels and underestimating future flood levels - the net result being that the expected impacts of the proposed floodplain development and relaxed stormwater management (SWM) criteria are masked. Specifically, my concerns are that:

- the use of an exceedingly low roughness value (0.001 – one tenth the roughness of *glass*) to represent the surfaces of the SWM ponds and habitat pools is not defensible;
- lowered 'n' values in the vicinity of the SWM ponds are not defensible simply because the pond berms have not been modeled accurately;
- there has been no consistent accounting for increased roughness resulting from naturalization of the river corridor; and
- since my January submissions, a further 10 % (or about 500 metres) of the corridor has been assigned very low 'n' values with no justification provided other than that these lowered values "can be debated."

To underscore the significance of these issues, it must be appreciated that Manning's 'n' is one of the most important parameters in terms of its influence on the computation of flood levels. Without a consistent, systematic and defensible approach to the assignment of this parameter, a valid impact assessment – essential to inform the determination of effective SWM criteria and the design of infrastructure - is not possible.

Much attention in the City's response has been given to the proposed safeguards to be applied to development proceeding before the modeling is calibrated and validated. In my opinion, these suggested safeguards are irrelevant to the essence of my concerns that relate to future flood levels that have been significantly underestimated by virtue of the inappropriate assignment of roughness values. In other words, the proposed safeguards will be of little utility if the future flood levels which will inform the design of multi-millions of dollars of infrastructure are underestimated. To put this in context, I estimate future flood levels are underestimated by as much as 0.3m in many locations – which would completely eliminate the required freeboard that basement elevations must be set above the 100 year hydraulic grade line.

The City's response has questioned the timing of my January submission, presumably implying I should have waited until after the Kanata West Class EAs were re-posted. The reasons for my submissions (January 18th and 24th, 2010) were made clear therein and are detailed again in the attached annotation. Further, if there had been full and proper documentation of the modeling parameters in the Third Party Review (as there notably was in the 2006 Class EA documents), I would certainly have raised these concerns almost a year ago during the public consultation period for the Third Party Review – but such an opportunity was not afforded at that time. Finally, I would have thought that in keeping with the letter and spirit of the Class EA process, members of the public raising concerns as early as possible to seek resolution and avoid delays following the posting of Class EA documents would be welcomed by the proponent.

The City's response has further suggested that I have formed my professional opinion on these matters without having all the facts at my disposal. This is to confirm that I have provided and stand by my professional opinion on the facts as represented by a version of the model that has been:

- recommended by the Third Party Review (March 2009, p.81) for use in support of *"any design related work to support development applications and other infrastructure design;"*
- endorsed by City Council and all agencies;
- used to conclude that no changes are required to the 22 Class EAs including the restoration plan;
- used in support of the approval by City Council of an additional 200 hectares of development (Fernbank); and
- as noted in the City's response, presumably used in support of an Implementation Plan to address the Minister's July 2008 order, that was endorsed by the Ministry in the fall of 2009.

I would suggest that if the version of the modeling provided to me in November 2009 did not sufficiently represent the facts in these matters, then it would seem obvious that its release - for endorsement by public agencies, use by development consultants, and for clearance of conditions of a Minister's order - should have been held off until it adequately did represent the facts.

I would add when I read that the purpose of the *Environmental Assessment Act* is: "… *the betterment of the people of the whole or any part of Ontario by providing for the protection, conservation and wise management in Ontario of the environment*" and consider the flooding impacts not accounted for in the modeling supporting the Carp River restoration plan – now almost four years after the original filing of Notices of Completion for the 22 Kanata West projects - I fail to see how this project, as currently proposed, comes anywhere near to meeting the purpose of the *EA Act*.

In the end, it is a matter of simple physics that extensive floodplain filling in combination with the uncontrolled runoff (beyond the 10 year event) from some 900 hectares of new development cannot *but* result in significant flood level and peak flow increases. The continuing revision and manipulation of Manning's 'n' values since 2008 at overbanks, bridges and the low flow channel are, in my opinion, an attempt to salvage a fundamentally flawed undertaking.

I have discussed my findings at length with a number of former colleagues from Conservation Authorities and consultants providing services to CAs. This body of opinion, informed by many years of professional practice, along with my own professional opinion, forces me to question whether the specific issues I have documented were presented in sufficient detail to members of the Project Advisory Committee (PAC) for them to have made informed decisions regarding:

- the appropriateness of the roughness values assigned in the future condition model;
- the approach used to model the SWM pond berms;
- the appropriateness of the proposed (ultimate) SWM criteria; and
- the resultant impact on future flood level and peak flow increases.

Given the significant impact that these factors have on the viability of the restoration plan and associated projects and, hence, the implications of increased risks to public health and safety, I believe it is incumbent upon the professional engineers who participated on the PAC to confirm, individually and in writing, their concurrence, or lack thereof, with:

- the roughness values assigned in the future condition model;
- the approach used to model the SWM pond berms; and
- the proposed (ultimate) SWM criteria; all resulting in
- the future flood levels documented in the Third Party Review (Table 3-6).

I believe that should the Ministry of the Environment choose to undertake such a survey of PAC members, its outcome could provide clear direction as to whether the Carp River restoration and associated projects should proceed as currently proposed or be required to fundamentally retrench.

In the absence of such feedback from the PAC participants, the matter of the adequacy of this modeling to support the Fernbank plan will be tested at the Ontario Municipal Board before a Board member who almost certainly has little or no knowledge of these matters and is not bound by the duties of a professional engineer. I would hope instead that professional engineers who participated on the PAC would weigh in on and resolve this matter before it comes to that. I foresee there will otherwise be much more public time and public money spent on this project.

Thank you in advance for your consideration of this response. I continue to look forward to your responses to the questions I posed in my January 24th, 2010 submission.

Regards,

Darlene Conway, P. Eng.

cc:
Roman Diduch, P. Eng., City of Ottawa
Alain Gonthier, P. Eng., City of Ottawa
Don Herweyer, City of Ottawa
Peggy Feltmate, Councillor, City of Ottawa
Shad Qadri, Councillor, City of Ottawa
Marianne Wilkinson, Councillor, City of Ottawa
Christina Rudzki, Ministry of the Environment
Michael Harrison, Ministry of the Environment
Millicent Dixon, Ministry of the Environment
Al Perks, P. Eng., RV Anderson
Barry Adams, P. Eng., University of Toronto

APPENDIX

1. **Detailed response to Greenland Engineering correspondence of February 17, 2010**

2. **Table 1: Comparison of future conditions 100 year event for various revisions to Third Party Review/Fernbank modeling**

3. **Attachment 1: Standard Manning's Roughness Coefficients for TRCA Watershed Hydraulic Modelling**

17 February 2010 File No. 09-G-2286

Via email
Attention: **The Honourable John Gerretsen, Minister of the Environment**
Mansoor Mahmood, P.Eng., Supervisor, Water and Wastewater, MOE
Agatha Garcia-Wright, Director, Environmental Assessment, MOE
Les Pataky, P.Eng., Regional Engineer, Southern Region, MNR
Dan Marinigh, Director, Lands and Water Branch, MNR
Dave Lindensmith, P.Eng., Sen. Project Engineer, Eastern Region MTO
Hani Farghaly, P.Eng., Senior Engineer, Design Standards Section MTO
Paul Lehman, P.Eng., MVC

RE: Ms. Darlene Conway P.Eng. Correspondence – Jan 18, 2010
MOE Minister's Order (July 21, 2008), Kanata West Class EAs and Concerns
With Third Party Review of the Carp River Restoration Plan

Dear Sirs and Madam:

We are writing this letter to address or clarify the concerns that have been raised in the above noted correspondence by Ms. Conway. Greenland International Consulting Ltd. (Greenland) was retained by the City of Ottawa to complete the Third Party Review (TPR) of the Carp River Restoration Plan and associated Class EA documents. Greenland prepared the TPR with the assistance of a Steering Committee that contained members of three ministries addressed in the above list that Ms Conway's correspondence is directed. We have reviewed this response with our client, the City of Ottawa.

The modelling review and safeguards placed in the TPR document that was approved by City Council in May 2009 were presented to the Steering Committee (incl. Mr. Lindensmith, Mr. Price, and Mr.Farghaly) and discussed at length prior to the report being tabled. Subsequent to the Council approval, Greenland along with City staff presented the findings to MOE staff (incl. Ms. Garcia-Wright and Mr. Mahmood). In conversation with Mr. Price, we understand that the TPR findings have also been reviewed with MNR representatives as well during the process.

It is not our intent to defend the findings of the TPR but to place everything into a proper context since the ultimate goal of all the parties to this correspondence is to ensure that the appropriate safeguards are in place. Greenland's role during the TPR included reviewing models prepared by other professional engineers that were being used as a tool in decision making for the Carp River watershed. We requested adjustments or corrections to be made through the process. When we requested an investigation of parameters that were within known acceptable ranges in the software, these consultants were not prepared to do any further modelling without additional monitored data that would support the rationale for the investigation.
This is a curious justification given that it fails to acknowledge a number of key items:

- **The modeling supporting the 2006 Class EAs made use of equivalent 'n' values for both the existing and future conditions in all locations (bridges, overbanks and low flow channel). It was only at some point after the egregious error of the missing hydrographs from some 700 hectares of development was uncovered in early 2008 that roughness ('n') values were**

significantly lowered and/or revised in many locations. The modeling was as uncalibrated when those changes were made (some time in 2008) as it remains now but there was apparently no hesitation at that time to make significant changes to the roughness values after the hydrograph errors came to light.

- **Exceedingly high roughness values (0.187, 0.100, 0.075) through bridge structures are clearly not within acceptable ranges for characterizing low flow channels through bridge structures, particularly given the lowered roughness value (0.035) assigned to the remainder of the reach's low flow channel (although it is not evident whether these high bridge values, other than at Richardson Side Road, were actually considered by the Third Party Review).**
- **Likewise, the extremely low roughness value (0.001) assigned to SWM pond and habitat pool surfaces is not "within the known acceptable range" for Manning's 'n.' For the effect it had on the weighted calculations provided for the overbanks, an 'n' value of zero could just as well have been used. In my experience, I have never come across an example of an artificial channel or conduit being assigned a roughness value even approaching this exceedingly low value, let alone a restored river corridor.**

We recorded the results of these models in various tables in the report. Ms. Conway refers to Table 3-6 on page 41 of the TPR document that identifies higher water levels for the future corridor model than with the existing conditions model. Greenland outlined that should the designer of the corridor pursue the higher water elevations, MVC approval required a demonstration of no increased flood risk. Greenland also identified that there should be an allowance for a 10 cm discrepancy for model tolerance. This has been misconstrued as an endorsement of increased flood risk.

To clarify, I have not misconstrued the allowance for a "10 cm discrepancy for model tolerance" as an endorsement of increased flood risk as I did not directly address this issue in my submission. But since this issue has been raised, it is my opinion that this criterion is essentially without foundation on both technical and watershed management/policy grounds:

- **Firstly, it misconstrues the concept of model tolerance or accuracy. By accuracy, I refer to the extent of difference between "reality" (true, observed natural phenomena) and what can be represented by a model. Without question, there are limitations to how well any hydrologic/hydraulic modeling exercise can reflect what is "true": these limitations include various (often simplifying) model assumptions, the accuracy of geometric and flow data, and the actual numerical solution approach used. Notwithstanding a certain level of inherent model inaccuracy, if the model has been set up properly, it provides a reasonable surrogate for "reality" which then allows consideration of various scenarios to assess the impacts of change (increased urbanization, floodplain filling, etc.) on the existing condition. Regardless of the inaccuracy inherent to the model itself, a 10cm increase in future flood levels represents an impact resulting from changes to the watershed and floodplain that have been modeled. From a technical perspective, to suggest that such a change (10cm) can be allowed on the basis of "model tolerance" misses the point of the modeling exercise and impact assessment to begin with.**
- **Secondly, from a watershed management perspective, this proposed 10 cm allowance fails to acknowledge the need to avoid cumulative impacts over the long term and as such, is inconsistent with many past decisions of the Ontario Mining and Lands Commissioner**

(OMLC). In one particularly instructive example (http://www.web2.mnr.gov.on.ca/mnr/omlc/Bill%20Chalmers%20Apr.htm), the OMLC found in favour of the Grand River Conservation Authority's refusal to issue a fill permit that would have resulted in a calculated flood level increase of 1.9 inches (less than 5cm). The Commissioner denied the appeal stating: *"The tribunal finds that it will adopt the words of Mr. Lorant, whose expert evidence in matters of watershed management bears considerable weight, in finding that the proposed filling and construction poses a dangerous precedent, both in terms of the Chalmers land itself and on the ability of this and other conservation authorities to manage watersheds within their jurisdictions."*

It is worth noting that the floodplain criterion in this case – the flooding resulting from an event equivalent to Hurricane Hazel – is a much more stringent criterion than the 100 year event applied in eastern Ontario.

I would encourage anyone interested in better understanding the underpinnings of provincial floodplain policy to peruse these OMLC decisions (available here: http://www.mnr.gov.on.ca/en/Business/OMLC/2ColumnSubPage/STEL02_163868.html). The contrast between the decades-old precautionary approach to managing cumulative impacts on a watershed basis represented by the body of these decisions and the approach put forth for Kanata West and the Carp River restoration plan is stark.

Neither MVC, Greenland nor any agency have the right to place additional increases on a known flood risk.
Agreed - and neither does any such right or authority exist to permit flood level increases, regardless of whether a "known flood risk" exists or not - at least not according to the body of Ontario Mining and Lands Commissioner's decisions, and not without the permission of affected landowners. These OMLC decisions, I submit, represent the real test to be met, not a criterion based upon misperceptions of model accuracy and/or an on-going, potentially "moving target" assessment of what does or does not represent an increase in flood risk as the watershed builds out.

Ms. Conway is stating that the development is going to proceed with only 10 year control in the SWM facilities along the Carp River corridor.
Again, to clarify, I did not state this. In my submission of January 18th, 2010, I referred to the ultimate SWM criterion (meaning only 10 year control) as this criterion was used to generate the future condition flood elevations documented in the Third Party Review. My concerns with respect to interim approvals proceeding - regardless of whatever SWM criterion may be applied in the interim - relate to underestimated future flood levels resulting from the use of lowered Manning's 'n' values over a significant portion of the study reach. I trust all can appreciate that the design of multi-millions of dollars of infrastructure is dependent on a reasonably accurate, if not conservative, estimate of ultimate flood levels – regardless of whether that infrastructure is built in the interim or after the model is calibrated and validated. This includes the setting of basement elevations a minimum of 0.3m above the (ultimate) 100 year hydraulic grade line and the setting of overflow elevations for both existing (to be upgraded) and future sanitary pumping stations. Once built, this infrastructure cannot be "adaptively managed" if the ultimate flood level used in its design was too low. In such an instance, future residents would be subject to a greater risk of basement flooding and/or the City would be saddled with extremely costly remedial works. Lest it

be suggested that the installation of protective devices such as backflow preventers could "adaptively" mitigate this risk, the failure of these devices during the July 24th/09 flooding event provides a cautionary reminder that such measures are no substitute for properly setting basement elevations in the first place. Given the undisputed uncertainties with the uncalibrated model of record, the use of extremely low 'n' values to reflect a naturalized river corridor is not defensible in my opinion. It effectively masks the actual impacts of inadequate ultimate SWM criteria and extensive floodplain filling, posing risks that could be avoided by precluding development in the floodplain in the first place and providing sufficient off-line storage to avoid increased peak flows and flood levels – in other words, implementing standard requirements of development.

The TPR is very clear that in order for development to proceed, specific conditions must be adhered to. In concert with City staff recommendations, several safeguards were recommended as part of the TPR should development proceed in advance of the final validation of the model. The pertinent safeguards to this issue are as follows:

- To have a qualified individual or group within the City or a qualified/external consultant act as the "Model Keeper" to ensure the models are updated and used appropriately throughout the development process.
- All interim facilities are to control post development flows to pre-development conditions.
- A deficit volume was identified that accounted for the uncertainty in runoff volume and timing of flows in the models that were reviewed.(NOTE: The Fernbank lands were accounted for in this analysis.)

  To be clear, the "deficit volume" cannot account for the uncertainty in the timing of flows. This remains to be confirmed once additional monitoring data is available, particularly for Poole Creek flows.
- All development must provide a prorated portion of this deficit volume until the models are fully verified.
- A limit was placed on development that can proceed before the Carp River corridor is restored.
- The City also recommended a further permanent corridor widening to provide 25% of the deficit volume regardless of whether it will be required with the validated model.

  As stated in my previous submission this would better be characterized as reduced filling/encroachment into the floodplain - unless property owners will be offering up developable table land for this purpose. Furthermore, regardless of any "deficit volume" to be provided, there were additional reasons noted in the May 2009 staff report, including the elimination of flood level increases between Maple Grove Road and Palladium Drive and an attempt to reduce the significantly increased cost of the restoration:
  http://www.ottawa.ca/calendar/ottawa/citycouncil/pec/2009/05-11/1-ACS2009-ICS-CSS-0005%20-%20Carp%20River.htm
- ***"Although there is no increase in flood risk, staff recommends that the restoration plan be revised to decrease the water levels such that there is no back up of floodwater on to the parking lot. This may include widening the corridor between Maple Grove Road and Palladium."*** **(This would appear to indicate there is some recognition that flood levels cannot be raised at will on private property.)**
- ***"The cost estimate for the Carp River restoration has increased due to two factors- inflationary price increases since the estimates were prepared in early 2007 and design changes to account for the water volume from the missing hydrographs. The design***

changes include three additional fish habitat ponds, expansions of habitat ponds already in the restoration plan and refinements to floodplain grading. The cost of the Carp River restoration is estimated to have increased from $6M to $8.5M. To potentially avoid some of this cost increase, staff wishes to investigate whether corridor width increases would be a less expensive way to accommodate the increased water volumes than additional fish habitat ponds."

Please note that the ultimate SWM facilities (water quality treatment only) adjacent to the Carp River corridor that have been identified in the Master Servicing EA will not be constructed until the model is validated or the corridor restoration has been completed and the deficit volume is completely incorporated.

This statement appears to assume that the eventual calibration and validation of the modeling will confirm that reduced quantity controls are justified. And yet, if an "apples to apples" impact assessment is undertaken, future flood levels increase significantly throughout the corridor. While the Third Party Review and previous Class EAs (2006) make note of the apparently grave concern regarding the potential for increased flood levels to result from coincident peaks if post to pre-development controls are implemented, to my knowledge, there has never been any documentation of actual modeled results demonstrating this phenomenon. Such documentation is a standard requirement to defend recommended SWM criteria and determine preferred SWM solutions. If this possibility does, in fact, represent a valid concern, then it may be that over-control of post-development flows is required to avoid flood level increases – but such a scenario has never even been considered.

Secondly, the City has worked closely with MOE staff to prepare an Implementation Plan also incorporating TPR recommendations that will address the Minister's July 2008 directive. This plan was agreed to in the fall of 2009. Specific additional safeguards that have been implemented include:

- Prior to issuance of a Certificate of Approval for any storm water management works, the City must demonstrate that the proposed interim facility and development have been designed in conformance to the recommendations made in the Third Party Review report for the Carp River Restoration Plan (May 2009). Also, there are no adverse impacts to the proposed works and the works are not going to adversely impact the findings of the TPR based on potential modelling changes with the adaptive management measures being implemented and proposed updates to the Kanata West EA documents.
- Specific requirements have been formalized for ongoing monitoring programs.

Thirdly, the City has also implemented additional safeguards that are presently being done with each application that is received. Along with the normal City review process, all applications are being reviewed by the current Model Keeper (Greenland) to ensure that any changes in development that impact the models of record are identified and tested prior to approval of the application. This has included an independent check of hydraulic gradelines to ensure basements are protected. Any changes required for model parameters are introduced into the model of record. Correspondence is kept on file for future changes in the models and design adjustments that may be required when ultimate SWM facility locations are being designed.

Such safeguards are, in my opinion, irrelevant to the essence of my concerns that relate to future flood levels that have been significantly underestimated by virtue of the inappropriate assignment

of post-development roughness values. In other words, the proposed safeguards will be of little benefit if the future flood levels which will inform the design of infrastructure are underestimated.

Manning's 'n' value review

A significant portion of Ms. Conway's response is centered on the selection of Manning's n to be used in the HEC-RAS (hydraulic) model. During the TPR, Greenland interviewed the consultant (formerly TSH and now AECOM) that prepared the future corridor model. The selection of 0.035 for the low flow channel was done since the new channel was to be a shallow (0.6 m deep) channel with a gravel substrate and light vegetation along the immediate banks. The US Army Corps of Engineers recommends in the HEC-RAS model software for dredged channels with stony bottom and weedy banks n values ranging from 0.025 to 0.040. TSH used 0.035 as opposed to the 0.060 suggested by Ms. Conway. The vegetative buffer of shrubs that are proposed to be planted are set back from the low flow channel and stretching into the overbank areas. TSH determined that the vegetation in the low flow channel would be so inundated during a major flood event that it would have a negligible impact on the main flood flow therefore warranting the low end of the acceptable range of values (telephone conversation with Mr. Paul Frigon, P. Eng., TSH/AECOM).
To clarify, I did not suggest a value of 0.06 for the low flow channel – this was the value assigned for both the existing and future condition low flow channels in the 2005/2006 Class EAs by the engineer(s) of record. Further, the original (2005) value assigned for the existing condition low flow channel ranged from 0.035 to 0.04, essentially equivalent to the revised lowered 'n' value noted above (see Appendix C in Flow Characterization and Flood Level Analysis: Carp River, Feedmill Creek and Poole Creek, CH2MHill Ltd., 2005). However, these initial values were then subsequently increased by a factor of 1.5 (i.e., to 0.0525 and 0.06) in an attempt to calibrate the existing condition model to observed water levels. These increased 'n' values were maintained in the post-development condition for the 2006 Class EA (Post-Development Flow Characterization and Flood Level Analysis for Carp River, Feedmill Creek, and Poole Creek, CH2MHill Ltd., 2006). If a valid impact assessment is to be provided, a comparable factor must be applied to both existing and future condition 'n' values – otherwise, the roughness effects in the existing condition are significantly overestimated compared to those in the post-development condition and the full impacts of development/uncontrolled runoff and floodplain filling are masked. The Third Party Review does not acknowledge this obvious discrepancy in the assignment of the post-development 'n' value for the low flow channel.

I would further note that MVC (at least in 2005) specifically requested the use of equivalent 'n' values in all subsequent modeling scenarios (see comments at front of: Flow Characterization and Flood Level Analysis: Carp River, Feedmill Creek and Poole Creek, CH2MHill Ltd., 2005):

> ***"Since the calibration of water levels to the September 9, 2004 flood shows that using Manning's n values 1.5 times typical values (sic), these increased values should be used for all subsequent scenarios…"***

Table 1, attached, shows how sensitive flood levels can be to the Manning's 'n' values selected. This table compares the existing condition flood levels (Fernbank version) with the existing condition flood levels that result when the initial 'n' values are applied (i.e., 'n' values as specified by the engineer of record in 2005 before being increased by 50%). As indicated, existing flood levels drop considerably, up to 20 cm in one location (column A-B). Comparing these reduced

existing flood levels (column B) to the future unrevised flood levels (Fernbank version making use of TPR model) results in flood level increases up to 0.46m (column C-B).

Lest it be presumed that I am now suggesting that the existing condition 'n' values be reduced by 50%, I am not. I have undertaken the above exercise in the interest of demonstrating the high sensitivity of Manning's 'n' values and to underscore the importance of a consistent, systematic and defensible approach to the assignment of this parameter. Without such an approach, a valid impact assessment – essential to inform the determination of effective SWM criteria and the design of infrastructure - is not possible.

During the TPR, Greenland reviewed several locations throughout the corridor to confirm whether an overbank n value of 0.040 could be applied by TSH in the vicinity of ponds and habitat pools. For conservatism, in the vicinity of pools, we assumed that all non pond/pool locations in the overbank were planted with brush (n=0.08) including pond slopes and floodplain slopes.
The use of an 'n' value of 0.08 to represent a naturalized river corridor (a key objective of the restoration plan) is reasonable in this instance. A couple of examples bear this out and are provided to demonstrate 0.08 is a roughness value commonly applied to stream corridors and floodplains. The first is a table of 'n' values (Attachment 1) used by the Toronto and Region Conservation Authority in their floodplain mapping exercises: a value of 0.08 is used to represent "Natural Areas" (pasture, agricultural, brush, forest, riparian vegetation) not subject to regular maintenance. (Notably, the category of "Urban Uses (Pervious)," referring to playing fields, golf courses, municipal parks, etc., applies a roughness of 0.05 but specifies that regular maintenance of such areas is required.)

A further example is provided by a recent floodplain mapping exercise completed for the Rideau Valley Conservation Authority for the Van Gaal Drain in the village of Richmond (final report and mapping available here (see Appendix E): http://www.rvca.ca/watershed/Richmond_New_Mapping/support/P709%20-%20Richmond%20Floodplain%20Mapping%20Report%20-%20FINAL.pdf). In this instance, an 'n' value of 0.08 (summer conditions) was also assigned to the overbanks of an agricultural drain.

I would therefore agree that 0.08 represents a reasonable value to be applied to overbank areas in a naturalized stream corridor, although this begs the question as to why 0.09, the existing 'n' value in many locations, was not specified. Again, not accounting for the 50% increase in 'n' values applied to the existing condition when assigning future 'n' values contributes to the problem of underestimated future flood levels. I also note it appears that the suggested future value of 0.08 is applied only in the vicinity of SWM pond and habitat pool overbanks but not applied to other areas in the reach where existing 'n' values are lower than 0.08. This would seem to indicate that there has been no accounting (except at the pond/pool overbanks) for the roughness effects of increased riparian cover that is called for in the restoration plan.

The actual pool comprising water an n value of 0.001 was taken and an average n value computed for the entire overbank. In each case the average n value was less than the 0.040 value used by TSH with the exception of section 43582 where we computed a value of 0.046. This value is considerably lower than the predevelopment value of 0.09 suggested by Ms. Conway.

Firstly, the use of an extremely low 'n' value (0.001) to characterize the surfaces of the five SWM ponds proposed to be located within the floodplain is not defensible because the SWM ponds have not been modeled accurately, i.e., in a manner that appropriately reflects the physical encroachment into the floodplain that will result from the construction of berms to create the proposed SWM storage. In other words, the SWM pond berms as currently proposed will inevitably result in a local constriction to the passage of flood flows (compared to existing conditions). This is confirmed by the conceptual plans for the SWM ponds provided in the Master Servicing Study (Stantec, 2006), all of which have pond berms set above the 100 year flood elevation (along with a spillway located at or near the 10 year water level).

While flood flows (from the river) may backflow into the SWM facilities once flood levels rise above the elevation of the ponds' overflow spillways, this does not mean that the pond berms will not exist at all – which is how the model of record has represented them, i.e., all of the SWM ponds have been modeled as if the full length of pond berms were no higher than the 10 year water level.

Given standard design principles that require the provision of freeboard above the maximum pond operating level, I have assumed that the intent is not to literally build the facilities with berms that end at the 10 year water level. Such a design would be unacceptable for numerous reasons: it would allow for no future berm settlement or construction tolerances, would subject the pond to much more frequent overtopping/erosion/re-suspension of pond sediments, and could result in a reduction of design storage capacity for the minimal (10 year) quantity controls that are proposed. In fact, the MOE Stormwater Management Planning and Design Manual (2003) is explicit regarding general freeboard requirements as well as requirements for the construction of water quality facilities in floodplains:

> ***p. 4-60: "A 0.3 m freeboard should be provided above the design high water level."***
>
> ***p. 4-5: "End-of-pipe SWMPs should normally be located outside of the floodplain (above the 100 year elevation). If the facility is multi-purpose in nature (e.g., providing quantity control in addition to quality and erosion control) it must be located above the highest design flood level. In some site specific instances, SWMPs may be allowed in the floodplain if there is sufficient technical or economic justification and if they meet certain requirements:***
>
> - ***The cumulative effects resulting from changes in floodplain storage and balancing cut and fill do not adversely impact existing or future development;***
> - ***Effects on corridor requirements and functional valleyland values must be assessed. SWMPs would not be allowed in the floodplain if detrimental impacts could occur to the valleyland values or corridor processes;***
> - ***The SWMPs must not affect the fluvial processes in the floodplain; and***
> - ***The outlet invert elevation of the SWMP should be higher than the 2 year floodline and the overflow elevation must be above the 25 year floodline*.**" **(emphasis added)**

While it is recognized that all SWM ponds will have overflow spillways at lower elevations than the remainder of the pond berm, this spillway length represents a very small proportion of the total berm length and it is not accurate to model as if the berm is not there for the whole length. Rather,

if the storage within the SWM facilities above the maximum operating level is considered significant then there is a means within HEC-RAS of modeling this as off-line storage that does not ignore the constricting effect of the pond berms on flood flows for almost their full length.

Modeling the pond berms accurately, i.e., as encroachments into the floodplain with the top of berms at or above the 100 year flood level, results in additional flood level increases of 3 to 5cm over the increases documented in my previous submissions. As shown in the attached Table 1, the maximum flood level increase over the (unrevised) existing condition (column A) is now 0.41m (column E-A). Note: this analysis ignores the effect of the minor proportion of flood flow that could backflow into the ponds via the spillways. Since this is a "planning level" model, this is a reasonable simplification and detailed modeling of the spillways, in my opinion, is not warranted.

To summarize, the application of an extremely low 'n' value (0.001) to represent the surface of the SWM ponds is not defensible because the vast majority of the flood flow will be confined in these areas to the river side of the SWM pond berms, in other words, to overbank areas that will be fully vegetated (i.e., in the order of 80 to 90 times rougher than the proposed 'n' value of 0.001).

Secondly, the use of an extremely low 'n' value (one tenth the roughness of *glass*) to represent the habitat pool surfaces has been recommended with no reference to published values or any other justification provided. This is concerning given that Manning's 'n' is one of the most important parameters in terms of its influence on hydraulic computations – as evidenced by the significant flood level increases documented in my previous submissions and the analysis provided in Table 1. Ideally, Manning's 'n' values are calibrated to observed water levels but this is not always possible so values must be assigned on the basis of comparison to other similar situations where empirical values have been determined. I am aware of no standard references that list the extremely low value of 0.001. Further, it is well-recognized that roughness effects are related to depth of flow – but if that is the rationale for using an exceedingly low roughness value over the habitat pool surface areas, then the same argument could be made to lower every single 'n' value throughout the corridor with the depths of flow experienced during a 100 year event. But this is clearly not defensible without calibration of such values. Further, the assumption seems to be that the flood flows will somehow simply "skim" over the surface of the habitat pools - which stretches credulity, given there will be no distinct surface between the flood flow and the pool water as the flood wave moves through.

Regardless of whether such a published value of 0.001 exists or not, using such a low 'n' value necessarily presumes that these habitat features will never change over time, i.e., never be subject to natural succession, or lowered water levels resulting in increased colonization by emergent vegetation, or disconnection from the river and filling via siltation or vegetation growth over the connecting channels, etc. Such an assumption could result in the need for regular maintenance efforts in a "naturalized" corridor in perpetuity to ensure flood levels do not rise as the result of increased roughness not accounted for. This possibility, as outlined in my follow-up submission of January 24th, 2010, has apparently been given no consideration.

Our review of the 4.43 kilometre corridor has determined that 43.7 % of the future corridor model has the same overbank n values used in the existing model. 34.8 % of the new corridor contains ponds or habitat pools where the use of an n value of 0.04 is easily defendable. There is only 9.3% where there can be any debate on the selection of the n value. This area is in the vicinity of the new crossings for the Arterial and Campeau Drive. The remainder of the corridor is the actual bridge crossings and transition areas.

That there "can be no debate" on the selection of 'n' values is a puzzling statement given the lack of a consistent, systematic and defensible approach to assigning these values evidenced by:

- **Endorsing the use of an extremely low 'n' value (0.001) that results in significantly reduced future flood levels without reference to a published or documented value;**
- **Applying that same low 'n' value to SWM pond surface areas when the vast majority of the flood flow will pass on the (much rougher) river side of the pond berms;**
- **Inconsistency in the application of 'n' values to existing and future conditions, i.e., existing condition values were increased by 50%; and**
- **Not fully accounting for increased roughness in the future condition that will result from the riparian plantings recommended for at least 70% of the corridor.**

Furthermore, as per the revised listing of future 'n' values provided by the City's consultant (February 17, 2010), there are now even more locations (in the order of 10% of the corridor, or about 500 meters of the reach) where 'n' values have been reduced to 0.04. There has been no justification provided for this additional lowering, merely a statement that this can be subject to "debate." Assigning an 'n' value of 0.04 in this area is arbitrary: there are no overbank areas in the existing condition model with such a low 'n' value (the lowest being 0.06), and most of this area was assigned an 'n' value of 0.09 in the existing condition model. There is no indication in the restoration plan that this area has been singled out to remain a manicured area, let alone that a future 'n' value of 0.04 suggests that any existing vegetation beyond high grass will have to be removed during construction and a manicured area maintained in perpetuity. If this is the actual intent - to require perpetual maintenance of the overbanks in a specific area of the river corridor - then such intent, with all the attendant implications of additional maintenance burden and risk management, will have to be clearly identified in the supporting EA and design documents.

Finally, the transition areas ('n' values at interpolated sections calculated by the model) should be revised to reflect the actual 'n' value intended at the location given the planting areas will be continuous, not transitioned. Even if the actual planting areas were so transitioned, natural succession would eventually fill in such transition areas.

The locations where there can be some debate compare n values of 0.04 to 0.06 and some areas to 0.0675 or 0.09. The 0.04 value is defendable if the area is to have light brush or pasture grasses. Over 90% of the future corridor model overbank n values are either similar to predevelopment values or describing pool locations. Universally applying the high end Manning's n from the predevelopment model to the future corridor overbanks (as Ms. Conway proposes) would be extremely conservative and defeat the purpose of introducing the various types of pools to the corridor for efficient control/conveyance as well as water quality and habitat features.

To clarify, I did not propose the 'n' values but merely applied the values that were assigned by the engineer(s) of record to both the existing and future condition models for the 2006 Class EAs. The response above again fails to acknowledge that the 'n' values for the 2006 Class EAs were multiplied by a factor of 1.5 in an attempt to better calibrate the model to observed water levels. For

example, when original 'n' values of 0.04 were raised by 50% (to 0.06) for the existing condition model, it cannot now be defensible to lower those same values for the post-development model, the more so when the restoration plan calls for a significant increase in riparian cover.

For the record, and as I indicated in my January 24th, 2010 submission, it is my opinion that the 2006 'n' values may, in fact, be on the high side in some cases (but the resolution of these values rests upon further calibration efforts). However, the existing condition 'n' values were approved by all agencies in 2006 and again endorsed by the Third Party Review for the existing condition model. That being the case, I do not follow how using those values for the purpose of an impact assessment can now be considered "extremely conservative."

Ms. Conway oversimplified her assessment of the Manning's n values that could be applied to the future corridor model by universally applying certain assumptions. She has subsequently used this concern as a platform to raise questions on the overall approach, planning efforts and in her opinion, lack of safeguards for development in the Carp River corridor. This has not been the case. There are more stringent criteria to be applied in this watershed than if individual developments simply followed the Provincial Policy Statement.

My responses above should dispense with any perception that I have "oversimplified" my assessment of the assignment of Manning's 'n' values. As I have also previously stated, given my opinion that the future flood levels have been significantly underestimated, the proposed safeguards are a secondary matter not worth considering until such time as a defensible, conservative assessment of future flood levels is undertaken.

Since the completion of the TPR, there has been considerable work done on the future corridor model to introduce the permanent widening and the features proposed in the restoration plan. Actual road widening plans have been used to introduce the revised bridge crossings as well. In concert with this work, there has also been further adjustment of Manning's n values in certain reaches and definitely at the bridge locations.

This work will form part of an addendum report that will be tabled with the Carp River Corridor Restoration EA document in the near future. To-date, Ms. Conway has not been provided this information that is being prepared by Greenland on behalf of the City. However, she will have the opportunity soon to review all of these documents once they are made available by the City to the general public. We understand that Ms. Conway was aware of this situation. Therefore, we do not understand the timing of her letter without Ms. Conway having knowledge of the latest up-to-date information that is highlighted above.

If the timing of my submissions (January 18th and 24th, 2010) is not understood, then I would recommend a more careful reading of them. I certainly noted I was aware of changes being made, however, the version of the modeling I received – which I have reviewed in detail and with which I have serious concerns - had already been used in support of the Fernbank development which is under appeal to the Ontario Municipal Board. As I also indicated, I have elected to appear as an expert witness on my own time for the appellant, specifically with respect to the inadequacy of the model of record to support the Fernbank plan. Further, I pointed out that, regardless of any on-going changes, the version of the model of record documented in the Third Party Review (March 2009) was endorsed by City Council and all agencies giving the impression that after many years of delay, an ultimate solution was in sight, and interim approvals could proceed in advance of

re-posting and approval of the Kanata West Class EAs. However, based on my recent review and this latest response from the City, it remains my opinion this is not the case: flood levels have been significantly underestimated in many locations, changing the boundary conditions for a number of the Class EA undertakings and demonstrating that the proposed ultimate SWM criteria are inadequate to avoid impacting riparian landowners.

If there had been full and proper documentation of the modeling parameters in the Third Party Review (as there notably was in the 2006 Class EA documents), I would certainly have raised these concerns almost a year ago during the public consultation period for the Third Party Review – but such an opportunity was not afforded at that time. It would appear that the "Lessons Learned" noted in the staff report for the Third Party Review were not applied to the Third Party Review: http://www.ottawa.ca/calendar/ottawa/citycouncil/pec/2009/05-11/1-ACS2009-ICS-CSS-0005%20-%20Carp%20River.htm

"Lessons Learned

1. ***Requiring that documentation for all model runs include a concise hydrologic summary report that relies upon simple catchment maps, plotted hydrographs of key points and tributaries, plotted water surface profiles showing watercourse features, bridges and crossings, and summaries of flows and volumes and all parameters in tabular format."*** **(emphasis added)**

Finally, I would have thought that in keeping with the letter and spirit of the Class EA process, members of the public raising concerns as early as possible to seek resolution and avoid delays following the posting of Class EA documents would be welcomed by the proponent.

Ms. Conway has expressed her professional opinion on the development review process for projects in the Carp River watershed without having all the facts at her disposal.
I have provided and stand by my professional opinion on the facts as represented by a version of the model that has been:

- **recommended by the Third Party Review (March 2009, p.81) for use in support of *"any design related work to support development applications and other infrastructure design;"***
- **endorsed by City Council and all agencies;**
- **used to conclude that no changes are required to the 22 Class EAs including the restoration plan;**
- **used in support of the approval by City Council of an additional 200 hectares of development (Fernbank);**
- **as noted in the response from the City's consultant, presumably used in support of an Implementation Plan to address the Minister's July 2008 order that was endorsed by the Ministry in the fall of 2009.**

If the version of the modeling provided to me in November 2009 did not sufficiently represent the facts in these matters, then it would seem obvious that the release of this modeling - for endorsement by public agencies, use by development consultants, and for clearance of conditions of a Minister's order - should have been held off until it adequately did represent the facts.

The MOE, MVC and other City staff have been working very closely to ensure that this planning process can go forward with no interim development scenarios without full controls. To address the Manning's n issue we have included a summary document for your reference. On February 11, 2010 in concert with our client (City of Ottawa), we met with MOE, MVC and MTO staff to clarify the information that has been provided as well as review the full scope of the safeguards that have been implemented in this planning/development process. The City of Ottawa has endorsed this response and we trust that this clarifies the overall concerns that have been raised and that this matter can be now placed in its proper context.

Yours truly,

GREENLAND INTERNATIONAL CONSULTING LTD.
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Table 1: Comparison of future conditions 100 year event for various revisions to Third Party Review/Fernbank modeling

EXISTING CONDITION						FUTURE CONDITION								
A			B			C			D			E		
i) HEC-RAS Plan: 100-FCDP-EX **Fernbank existing conditions** **no change to 'n' values**			ii) HEC-RAS Plan: Carp 100 YR Ex Mar 2009 **TPR existing conditions** **n' values lowered by 50%**			iii) HEC-RAS Plan: 100FCDP-FUT2 **Fernbank future conditions** **no change to 'n' values**			iv) HEC-RAS Plan: Plan 11 **Fernbank future conditions** **'n' values revised to match existing** **(at channel, overbanks and bridges)**			v) HEC-RAS Plan: Plan 11 **Fernbank future conditions** **'n' values revised to match existing** **(at channel, overbanks and bridges)** **SWM pond berms modeled**		
Reach	Q Total (m3/s)	**W.S. Elev (m)**	River Sta	Q Total (m3/s)	**W.S. Elev (m)**	River Sta	Q Total (m3/s)	**W.S. Elev (m)**	Reach	Q Total (m3/s)	**W.S. Elev (m)**	River Sta	Q Total (m3/s)	**W.S. Elev (m)**
44953	9.46	94.97	44953	10.33	94.79	44953	11.19	94.94	44953	11.25	94.81	44953	11.44	94.85
44890	9.45	94.96	44890	10.32	94.79	44890	11.16	94.94	44890	11.23	94.81	44890	11.42	94.85
44751	9.43	94.96	44751	10.27	94.78	44751	11.13	94.94	44751	11.19	94.80	44751	11.4	94.84
44548	16.09	94.95	44548	17.05	94.77	44548	17.87	94.92	44548	17.96	94.78	44548	18.22	94.83
44325	17.06	94.92	44325	16.99	94.75	44325	18.95	94.91	44325	19.04	94.76	44325	19.32	94.81
44324 Hazeld	Culvert		44324 Hazelde	Culvert		44324 Hazelde	Bridge		44324 Hazelde	Bridge		44324 Hazelde	Bridge	
44302	16.33	94.54	44302	16.94	94.34	44302	18.92	94.70	44302	18.98	94.71	44302	19.14	94.76
						44218	18.92	94.71	44218	18.98	94.71	44218	19.15	94.76
						44193	18.91	94.71	44193	18.98	94.71	44193	19.12	94.76
44153	16.45	94.54	44153	16.93	94.37	44153	18.92	94.71	44153	18.96	94.71	44153	19.14	94.76
						44093	18.9	94.71	44093	18.97	94.71	44093	19.1	94.76
						44068	18.91	94.71	44068	18.97	94.71	44068	19.1	94.76
						44044.2	18.9	94.71	44044.2	18.94	94.71	44044.2	19.08	94.76
						44013.6	18.9	94.71	44013.6	18.94	94.71	44013.6	19.08	94.76
43966	16.41	94.54	43966	16.91	94.36	43966	18.89	94.71	43966	18.94	94.71	43966	19.05	94.76
						43954	20.93	94.71	43954	20.97	94.71	43954	21.23	94.76
						43946	20.93	94.71	43946	20.96	94.71	43946	21.23	94.76
						43938	20.92	94.71	43938	20.97	94.71	43938	21.21	94.76
						43852	20.92	94.70	43852	20.94	94.70	43852	21.18	94.76
						43822	20.9	94.70	43822	20.95	94.70	43822	21.2	94.76
						43813	20.9	94.70	43813	20.93	94.70	43813	21.18	94.76
43764	17.53	94.53	43764	18.97	94.35	43764	20.9	94.70	43764	20.91	94.70	43764	21.13	94.75
43582	17.74	94.52	43582	19.38	94.35	43582	21.43	94.70	43582	21.46	94.70	43582	21.7	94.75
						43572.4	21.48	94.70	43572.4	21.43	94.70	43572.4	21.67	94.75
43375	18.06	94.44	43375	19.83	94.23	43375	21.87	94.68	43375	21.52	94.67	43375	21.5	94.72
43370 Maple	Culvert		43370 Maple G	Culvert		43370 Maple G	Bridge		43370 Maple G	Bridge		43370 Maple G	Bridge	
43364	18.06	94.43	43364	19.89	94.23	43364	19.93	94.63	43364	19.7	94.64	43364	19.95	94.69
43223	18.03	94.44	43223	19.87	94.26	43223	20.52	94.65	43223	20.12	94.64	43223	20.47	94.70
						43180.6	20.52	94.65	43180.6	20.17	94.64	43180.6	20.36	94.70
43173	18.02	94.44	43173	19.86	94.26	43173	20.57	94.65	43173	20.17	94.64	43173	20.36	94.70
						43163.8	40.68	94.64	43163.8	41.07	94.64	43163.8	42.88	94.70
						43100	40.67	94.64	43100	41.06	94.64	43100	42.88	94.69
43072	34.55	94.43	43072	37.99	94.24	43072	40.67	94.64	43072	41.05	94.64	43072	42.87	94.69
						42975	40.83	94.64	42975	41.23	94.63	42975	43.1	94.68

									42970.1	40.83	**94.64**		42970.1	41.23	**94.63**		42970.1	43.1	**94.68**
	42890	34.51	**94.36**		42890	38.17	**94.17**		42890	45.63	**94.63**		42890	46.19	**94.62**		42890	48.52	**94.67**
									42889	45.62	**94.61**		42889	46.12	**94.59**		42889	48.46	**94.64**
42885	Palladi Bridge			42885	Palladiu Bridge			42885	Palladiu Bridge			42885	Palladiu Bridge			42885	Palladiu Bridge		
	42855	34.51	**94.34**		42855	38.17	**94.15**		42855	45.33	**94.32**		42855	45.97	**94.50**		42855	48.24	**94.55**
	42686	34.5	**94.32**		42686	38.18	**94.15**		42686	45.37	**94.32**		42686	45.99	**94.50**		42686	48.26	**94.54**
	42558	34.5	**94.29**		42558	38.16	**94.12**		42558	45.37	**94.30**		42558	45.98	**94.48**		42558	48.26	**94.52**
	42410	34.85	**94.25**		42410	38.85	**94.09**		42410	46.3	**94.26**		42410	46.97	**94.44**		42410	49.36	**94.48**
	42212	34.86	**94.23**		42212	38.85	**94.07**		42212	46.3	**94.18**		42212	46.96	**94.37**		42212	49.33	**94.41**
	42182	34.84	**94.18**		42182	38.77	**94**		42182	46.3	**94.11**		42182	46.93	**94.29**		42182	49.3	**94.33**
42172	Highwa Bridge			42172	Highway Bridge			42172	Highway Bridge			42172	Highway Bridge			42172	Highway Bridge		
	42154	34.84	**94.13**		42154	38.67	**93.97**		42154	46.24	**93.94**		42154	46.78	**94.20**		42154	49	**94.23**
	42134	34.84	**94.11**		42134	38.54	**93.95**		42134	46.28	**94.01**		42134	46.88	**94.25**		42134	49.24	**94.28**
	42124	34.8	**94.08**		42124	38.39	**93.93**		42124	46.23	**93.90**		42124	46.37	**94.14**		42124	47.51	**94.17**
42119	Highwa Bridge			42119	Highway Bridge			42119	Highway Bridge			42119	Highway Bridge			42119	Highway Bridge		
	42097	34.56	**94.00**		42097	37.79	**93.85**		42097	41.23	**93.73**		42097	42.61	**94.02**		42097	39.15	**94.06**
	42075	34.74	**94.03**		42075	38.4	**93.93**		42075	44.35	**93.83**		42075	41.37	**94.08**		42075	42.99	**94.13**
									42036	44.35	**93.83**		42036	41.19	**94.08**		42036	41.7	**94.11**
	42002	34.74	**94.02**		42002	38.2	**93.92**		42002	44.25	**93.83**		42002	41.07	**94.07**		42002	42.05	**94.11**
									41997.6	44.38	**93.83**		41997.6	41.16	**94.07**		41997.6	42.17	**94.11**
									41970.1	44.36	**93.83**		41970.1	41.07	**94.07**		41970.1	41.82	**94.11**
									41948.9	44.93	**93.82**		41948.9	41.42	**94.07**		41948.9	42.1	**94.10**
	41896	34.92	**94.00**		41896	38.69	**93.9**		41896	44.85	**93.82**		41896	41.28	**94.07**		41896	41.77	**94.10**
									41845.2	44.92	**93.82**		41845.2	41.06	**94.06**		41845.2	41.53	**94.09**
									41836	44.86	**93.81**		41836	40.87	**94.06**		41836	41.48	**94.09**
									41776	44.76	**93.81**		41776	40.6	**94.05**		41776	41.33	**94.09**
									41769	44.68	**93.81**		41769	40.15	**94.05**		41769	41.16	**94.09**
									41744	44.92	**93.81**		41744	40.11	**94.05**		41744	41.35	**94.08**
	41743	34.95	**93.97**		41743	39	**93.89**		41743	43.7	**93.76**		41743	38.64	**94.02**		41743	39.82	**94.06**
								41738	Fut Tran Bridge			41738	Fut Tran Bridge			41738	Fut Tran Bridge		
									41725.5	43.09	**93.74**		41725.5	38.51	**94.02**		41725.5	39.79	**94.05**
	41671	34.44	**93.95**		41671	38.76	**93.87**		41671	43.41	**93.75**		41671	38.67	**94.02**		41671	39.85	**94.06**
									41608	47.46	**93.72**		41608	41.82	**93.99**		41608	43.54	**94.02**
								41602	Future C Bridge			41602	Future C Bridge			41602	Future C Bridge		
									41572	45.40	**93.67**		41572	40.75	**93.97**		41572	42.8	**94.00**
									41374.8	44.08	**93.63**		41374.8	38.51	**93.92**		41374.8	41.11	**93.95**
	41357	37.17	**93.61**		41357	44.18	**93.5**		41357	43.43	**93.62**		41357	37.93	**93.91**		41357	40.52	**93.94**
									41349.4	44.34	**93.63**		41349.4	38.43	**93.91**		41349.4	40.99	**93.95**
									41338	44.36	**93.63**		41338	38.38	**93.91**		41338	40.99	**93.94**
									41320	44.37	**93.63**		41320	38.43	**93.91**		41320	40.96	**93.94**
									41198	44.21	**93.63**		41198	38.25	**93.91**		41198	40.86	**93.94**
									41180	44.16	**93.63**		41180	38.25	**93.91**		41180	40.78	**93.94**
									41125.4	44.19	**93.63**		41125.4	38.25	**93.91**		41125.4	40.79	**93.94**
	41117	35.84	**93.57**		41117	43.37	**93.46**		41117	44.17	**93.63**		41117	38.27	**93.90**		41117	40.74	**93.94**
									41071	44.83	**93.63**		41071	38.85	**93.90**		41071	41.3	**93.93**
									40965.2	45.10	**93.63**		40965.2	39.13	**93.90**		40965.2	41.48	**93.93**
									40956	45.10	**93.62**		40956	39.12	**93.90**		40956	41.46	**93.93**

	40910	35.09	**93.55**
	40703	33.69	**93.53**
	40505	30.22	**93.51**
	40298	28.01	**93.50**
	40092	26.82	**93.49**
40070	Richarc Culvert		
	40050	25.74	**93.45**
	39892	26.05	**93.45**
	39695	23.75	**93.43**
	39202	22.48	**93.40**
	38697	22.34	**93.39**
	38236	22.33	**93.38**
	37894	44.85	**93.37**
	37890 Bridge		
	37101	41.79	**92.93**
	36580	41.55	**92.92**
	35288	41.4	**92.87**
	35073	41.37	**92.84**
	34555	41.36	**92.76**
	33472	41.39	**92.66**
	33201	42.65	**92.63**
	33197 Bridge		
	32609	42.64	**92.58**
	32096	42.62	**92.57**
	31662	42.38	**92.53**
	31658 Bridge		
	31414	-94.66	**92.50**

	40910	43.31	**93.44**
	40703	42.98	**93.42**
	40505	43.22	**93.39**
	40298	42.1	**93.38**
	40092	38.86	**93.36**
40070	Richards Culvert		
	40050	31.25	**93.29**
	39892	33.14	**93.31**
	39695	31.22	**93.28**
	39202	29.03	**93.25**
	38697	28.73	**93.24**
	38236	28.73	**93.23**
	37894	55.37	**93.17**
	37890 Bridge		
	37101	53.56	**92.86**
	36580	53.47	**92.85**
	35288	53.46	**92.8**
	35073	53.45	**92.78**
	34555	53.4	**92.71**
	33472	53.5	**92.63**
	33201	57.06	**92.6**
	33197 Bridge		
	32609	57.05	**92.57**
	32096	57.01	**92.56**
	31662	57.23	**92.52**
	31658 Bridge		
	31414	-122.43	**92.5**

	40919.2	44.98	**93.62**
	40910	45.00	**93.62**
	40703	44.96	**93.62**
	40688.5	46.26	**93.62**
	40505	45.85	**93.60**
	40423.5	45.72	**93.60**
	40415	45.68	**93.60**
	40348.1	45.67	**93.60**
	40339.7	45.60	**93.60**
	40298	45.67	**93.60**
	40092	45.97	**93.59**
	40071.5	18.92	**93.53**
40070	Richards Culvert		
	40050	18.92	**93.53**
	39892	19.12	**93.53**
	39695	18.75	**93.52**
	39400	18.44	**93.51**
	39202	18.43	**93.51**
	38697	18.38	**93.51**
	38692.5	18.38	**93.51**
	38236	18.32	**93.50**
	37894	42.54	**93.47**
37890	Huntmai Bridge		
	37869.5	40.24	**92.97**
	37101	40.01	**92.95**
	36580	39.97	**92.93**
	35288	39.92	**92.88**
	35073	39.92	**92.86**
	34555	39.91	**92.79**
	33472	39.89	**92.70**
	33201	41.25	**92.66**
33197	March R Bridge		
	33181	41.25	**92.64**
	32609	41.22	**92.59**
	32096	41.15	**92.57**
	31662	40.91	**92.53**
31658	Carp Roa Bridge		
	31642	40.65	**92.53**
	31414	-92.7	**92.50**

	40919.2	39.14	**93.90**
	40910	39.13	**93.90**
	40703	39.13	**93.89**
	40688.5	40.15	**93.89**
	40505	40.06	**93.88**
	40423.5	40.01	**93.88**
	40415	40.01	**93.88**
	40348.1	39.95	**93.88**
	40339.7	39.91	**93.88**
	40298	39.88	**93.88**
	40092	40.05	**93.87**
	40071.5	41.18	**93.76**
40070	Richards Culvert		
	40050	20.33	**93.51**
	39892	20.33	**93.51**
	39695	20.12	**93.50**
	39400	19.79	**93.49**
	39202	19.77	**93.49**
	38697	19.69	**93.48**
	38692.5	19.69	**93.48**
	38236	19.61	**93.48**
	37894	42.26	**93.44**
37890	Huntmai Bridge		
	37869.5	39.87	**92.96**
	37101	39.59	**92.94**
	36580	39.53	**92.92**
	35288	39.45	**92.88**
	35073	39.45	**92.85**
	34555	39.44	**92.78**
	33472	39.46	**92.70**
	33201	40.58	**92.66**
33197	March R Bridge		
	33181	40.58	**92.63**
	32609	40.56	**92.58**
	32096	40.53	**92.57**
	31662	40.09	**92.53**
31658	Carp Roa Bridge		
	31642	39.78	**92.53**
	31414	-92.7	**92.50**

	40919.2	41.4	**93.93**
	40910	41.42	**93.93**
	40703	41.37	**93.92**
	40688.5	42.53	**93.92**
	40505	42.39	**93.91**
	40423.5	42.39	**93.91**
	40415	42.38	**93.91**
	40348.1	42.35	**93.91**
	40339.7	42.35	**93.91**
	40298	42.35	**93.91**
	40092	42.75	**93.90**
	40071.5	43.4	**93.79**
40070	Richards Culvert		
	40050	20.18	**93.52**
	39892	20.17	**93.52**
	39695	19.75	**93.51**
	39400	19.41	**93.50**
	39202	19.4	**93.49**
	38697	19.34	**93.49**
	38692.5	19.34	**93.49**
	38236	19.29	**93.49**
	37894	42.39	**93.45**
37890	Huntmai Bridge		
	37869.5	40	**92.97**
	37101	39.72	**92.94**
	36580	39.67	**92.93**
	35288	39.59	**92.88**
	35073	39.59	**92.86**
	34555	39.58	**92.78**
	33472	39.61	**92.70**
	33201	40.77	**92.66**
33197	March R Bridge		
	33181	40.77	**92.63**
	32609	40.74	**92.59**
	32096	40.7	**92.57**
	31662	40.33	**92.53**
31658	Carp Roa Bridge		
	31642	40.08	**92.53**
	31414	-92.7	**92.50**

Standard Manning's Roughness Coefficients for TRCA Watershed Hydraulic Modelling		
Land Use	Description and Conditions	"n" Value [1]
Channel Component		
Watercourse/ Channel	• low flow channel • extends typically from bank to bank	0.035
Hydraulic Structures	• culvert crossings (e.g., corregated metal, concrete open/closed footing etc.) • bridge crossings	Variable [2]
Floodplain Component		
Urban Uses (Impervious)	• Road crossings, existing parking lots or any large impervious surfaces etc. • typically located within valley and stream corridors • Does not include structures or buildings (to be modelled using available ineffective flow area options)[2]	0.025
Urban Uses (Pervious)	• Existing uses including municipal parks, playing fields, golf courses etc. • typically located within valley and stream corridors • Regular maintenance of area is required	0.050
Natural Areas	• Pasture, meadow, agricultural, riparian vegetation, brush and forest • located within urban and/or rural land use setting • typically located within valley and stream corridors • Not subject to regular maintenance • Assumes regeneration of open space type uses including pasture, meadow and agricultural uses within floodplain areas (Consistent with TRCA's VSCMP and Natural Heritage Strategies)	0.080
Flood Control Channels	• Flood control channels and associated works designed specifically for flood flow conveyance (eg., trapezoidal lined and un-lined channels etc.) • "n" value based on original design or maximum allowable value determined through a sensitivity analysis • Regular maintenance of area is required	Variable [2]

Notes:
1. Manning's "n" values represent average values based on literature data assuming flooding conditions.
2. Refer to HEC-2 and/or HEC-Ras User's Manual for further details.