



November 17, 2015

Via: Email (jinwood@innisfil.ca)

Mr. Jason Inwood
Manager of Operations
Town of Innisfil
2101 Innisfil Beach Road
Innisfil ON L9S 1A1

Dear Mr. Inwood:

**Re: Town of Innisfil
South Innisfil Creek Drain Peer Review - Phase 2
Project No.: 300037163.0000**

As described in our letter report dated August 7, 2015, addressed to Mr. Andrew Campbell of the Town of Innisfil, R.J. Burnside & Associates Limited (Burnside) was retained by the Town of Innisfil to carry out a peer review of the documentation for the South Innisfil Creek Drain. As noted in the earlier correspondence, it was agreed that the peer review would proceed in two phases with the first phase providing comments on the documentation, the process and the general concepts as set out in the report, as well as general compliance with the Drainage Referee's Orders including our interpretation of those orders. The second phase of our peer review was intended to be a more technical review including the hydrologic and hydraulic modeling, as well as the estimated cost of the work.

Our letter report of August 7, 2015 provided our findings, comments and recommendations resulting from the document review carried out in Phase 1 of this peer review process. The Phase 1 correspondence provided a summary of the documents reviewed including the Preliminary and Final Engineer's Reports for the South Innisfil Creek Drain and Branches, the Orders issued by the Ontario Drainage Referee with regard to this Drain, identified concerns of the public, as well as correspondence and communications from the consultants, the public, representatives of the public and agencies which was generated after the Final Engineer's report was submitted.

The Phase 1 review and report also identified a number of areas where possible reduction in costs may be considered although for the most part it became clear through the Phase 1 review that confirmation on any alterations to the proposed work to mitigate the costs would require the review of the hydrologic and hydraulic modelling completed for this project. Consequently, proceeding with Phase 2 of the peer review was recommended.

As noted in the summary of our Phase 1 Report, the desire to have improvements completed on the South Innisfil Creek Drain resulted from weather events that generated flood occurrences resulting in crop damage. Those weather (storm) events were, in fact, larger than a 1 in 2-year storm event, which is the design criteria applied to the proposed work on the South Innisfil Creek Drain and Branches and the typical design criteria used for Municipal Drains across Ontario. It must be anticipated that similar larger events may occur in the future and there will continue to be a risk of flooding resulting from higher frequency storm events. The improvements will assist to mitigate the effect of larger storm events but will not eliminate the potential for future flooding.

The following provides the results of our Phase 2 review in regard to the proposed upgrades of the South Innisfil Creek Drain and Branches. The emphasis of our review has been on the hydrologic and hydraulic modelling and the overall design criteria for the proposed work.

Overall Modelling Comments

Burnside has reviewed the HEC-RAS modelling for the Innisfil Creek Drain and offers the following general comments:

- The Drainage report refers to the topographic data referenced from field survey as well as DEM data provided by the NVCA. It should be confirmed that the base map created has been “ground truthed” in comparison to topographic survey data.
- Cross Section locations in the vicinity of roadway crossings have been observed to be spaced at large distances. These larger distances may play a role in the accuracy in the calculation of headwater elevations throughout the reach. It is recommended that additional cross sections be added to the model to reduce the large reach lengths in the vicinity of culvert crossings in accordance with standard HEC-RAS methodology.
- Calculated water surface elevations in excess of the 2-year peak flows have been observed to exceed the station and elevation data of a majority of cross sections within the model. Accordingly, the SICD_DILLON HEC RAS model is assumed to be valid for only return intervals up to and including the 2-year event.
- The Manning’s roughness values provided in the HEC-RAS modelling have been observed at 0.04 for the left and right overbanks as well as the channel section. The VO2 hydrology modelling shows Manning’s roughness values of 0.04 – 0.06. The manning’s coefficients should be consistent between models.

Downstream Limits of the Study Area

Burnside has noted that the Engineer’s report proposes that the South Innisfil Creek Drain will be extended downstream to the 15th Line. The proposed drain improvements on this section of drain located between Highway 89 and the 15th Line are outlined on Drawing 26. It appears as though the profile grade through this section of the drain is proposed to be lowered for future maintenance purposes although no physical work is proposed.

Burnside offers the following observations/comments:

- The HEC-RAS hydraulic modelling provided to Burnside for review does not include modelling at the downstream end of the Drain to the 15th Line crossing.

- Burnside has local knowledge of Innisfil Creek Drain and is aware that the 15th Line bridge crossing has a smaller geometry in comparison with other structures upstream and hence may be a flow restriction. If it is a restriction to flow, it should be included in the modelling as it may dictate back water elevations for the channel upstream.
- The MTO is currently in the process of replacing the Highway 89 crossing. This structure replacement is larger than the existing crossing which may impact the calculated water surface elevations for the downstream portion of the drain.
- Burnside has observed a difference in water surface elevations between existing and proposed conditions within the model. As the flow volume remains at the 2-year event, a better understanding of the reasons for the flow depth change would be beneficial. Given that the channel geometry and flows downstream of Highway 89 remain constant in existing and proposed conditions within the model, the calculated water surface elevations downstream of Highway 89 should also remain constant. Accordingly, additional cross sections should be added to the model downstream of Highway 89 to establish a static 2-year water surface elevation. This static water surface elevation would provide a benchmark whereby calculated water surface elevations between existing and proposed conditions could be directly compared.

Overflow Area No. 1

From the Final Drainage report, Burnside notes the following statements:

- "The overflow area and modifications to the drain will assist in regulating flows passing through the overflow area such that storms to the 1:2 year return period will be attenuated in the Innisfil Creek downstream watercourse compared to existing conditions"
- "Further the overflow area is to reduce flow capacities without sacrificing drain capacity and furthermore promote colloidal sediment transport."

The Dillon report suggests that there will be a marginal increase in conveyance capacity of the upstream drain as a result of the proposed channel improvements during smaller event storms up to and including the 2-year event.

Burnside has reviewed the methodology of Overflow Area No 1 and offers the following comments/observations:

- Overflow Area No 1 is to be constructed via a cut within approximately 6ha of land located between the 5th Sideroad and Highway 89 and will provide approximately 50,000 m³ of storage.
- The final drainage report calls for berming to be placed between the 5th Sideroad and Highway 400 to contain the 2-year peak flows. As noted in the Phase 1 report it appears that storage between Highway 89 and the 5th Sideroad is being created and yet the proposed berm construction upstream may be reducing existing storage between the 5th Sideroad and Highway 400.
- Burnside acknowledges that there may be potential for attenuation of flows as a result of the excavation associated with Overflow Area No 1. However, the Dillon report focuses on drain improvements north/upstream of Highway 89. Further, there is an absence of discussions concerning the drain downstream of Highway 89.

- Attenuation of flows via the proposed SWM facility may provide a hydraulic benefit in minor system flows to the receiving watercourse, however there has not been a rationale/justification provided on an analysis of the downstream drain suggesting that there is a conveyance issue in minor system events.
- There has been no provision in the design for any physical control of the discharge from Pond Area 1 but rather only an increase in storage volume through the excavation. With the combination of a new Highway 89 bridge, uncertain channel characteristics downstream of Highway 89 and the absence of any calculation to determine potential tail water elevations and the effect of the 15th Line Bridge on tail water, Burnside feels that the benefit of constructing Pond Area 1 to downstream flows is uncertain.

Highway No. 400 Crossings

The Highway 400 and Reive Road culvert crossings have been long considered by the upstream owners as a significant restriction to the outlet capacity of the Drain. We believe there is concern about the overall cross sectional area of the culvert crossings but it is also recognized that the culvert inverts are perched higher than the upstream channel invert which impedes the base flow through the structures. Dillon has indicated in correspondence to the Town that the hydraulic model for the drain indicates that, for a 2-year storm event, that the backwater levels only extend to the 2nd Line and further, if the culverts were completely removed, the water levels upstream of the 2nd Line would be unaffected. It is noted that Dillon suggested that consideration could be given to boring a small diameter culvert (800 mm diameter was suggested) at the grade of the proposed drain bottom.

We note that any work on the Highway 400 and Reive Road crossings will be very expensive and although such work, if required by the Final Engineer's Report, would be included in the overall total cost of the project, that Section 26 of the Drainage Act requires the cost of road crossings to be assessed to the respective road authority and therefore would not adversely affect the cost assessed to the property owners on the Drain.

As the cost of any work will be significant, there would need to be extremely strong technical evidence provided to the MTO to satisfy them that the work is required as any proposal to adjust the crossings will be heavily scrutinized by the Ministry.

We believe, from a practical/logistic perspective, that lowering of these culverts or at least providing a supplementary lower culvert, may benefit the upstream lands.

Burnside has reviewed the drain hydraulic model in the vicinity of the Highway 400 crossings and offers the following observations/comments:

- The water surface elevation profiles for both existing and proposed conditions is relatively flat upstream of Highway 400 crossings with profile grades of 0.03-0.04%. The water surface profile grades are slightly less (0.01%) than the profile grade of the drain. This would suggest that there is a slight restriction in flows at the Highway 400 crossing.
- Burnside has observed a 0.40 m (226.55 m – 226.55 m) difference in water surface elevations from the downstream to upstream limits of Highway 400. This elevation difference may provide an opportunity for future conveyance improvements. Burnside has explored the option of an increased culvert sizing at Highway 400 and noted that calculated water surface elevation reductions may be possible as far upstream as the 3rd Line.

To determine the impacts of the Highway 400 crossing on water surface elevations located between Highway 400 and the 2nd Line, a HEC-RAS geometry file was created whereby the lower Highway 400 2400 mm diameter CSP culvert was replaced with a 5 m span x 3 m rise concrete box culvert. The size of the concrete box culvert was not calculated but rather the size was selected to be notably larger in size than the existing culvert to determine the influence of additional conveyance under the highway.

The proposed 5 m span x 3 m rise concrete culvert has been observed to reduce water surface elevations by up to 0.4 m depending on location. Reductions in water surface elevations have been observed as far upstream as the 3rd line.

In summary, we believe upgrades to the Highway 400 culvert crossings would provide a hydraulic benefit to the 2-year water surface elevations upstream. Comments regarding potential benefits from adjusting the grade line through the Highway 400 culverts will be addressed in the following section.

Proposed Grade Line

It was noted through our review and was also identified by representatives of the property owners that the proposed grade line downstream of Highway 89 is actually below the existing bottom of the watercourse. However, there was no immediate work proposed in the engineers report on this section of the Drain. This could place the Town in the position that maintenance would be required immediately after the rest of the work is completed. It is Burnside's position that if the proposed profile grade is below the existing grade of the channel that the work required to meet the proposed grade should be undertaken as part of the physical Drain improvements.

It is noted that if the grade downstream of Highway 89 was consistent with the grade upstream of Highway 89 (0.05%) that there would be very little excavation required on this section. A further reduction to 0.04% from the 5th Sideroad downstream would remove almost any required excavation downstream of Highway 89.

It is noted that approximately 300 metres of drain in the vicinity of the Highway 400 crossings is proposed at 0.22% grade. This would seem to reflect the need to adjust the invert elevation from a deeper invert downstream of the Highway 400 crossing to a shallower invert upstream of Highway 400. Outside of this section, the drain downstream and upstream is at 0.04%. Flattening this section of Drain from 0.22% grade to 0.04% grade would lower the drain invert upstream of Highway 400 by approximately 0.5 meters. Adding this increased depth to the channel cross sections would definitely increase the upstream drain capacity. Although, subject to foundation depths of the new Highway 89 bridge and the relatively new bridge on the 5th Sideroad, we note a 0.04% grade on the drain from the 5th Line to Highway 400 would generate an additional 0.5 meters of potential depth. As the existing Highway 400 culvert crossings are already perched above the existing Drain, either adjustment to the grade would generate the need for the Highway 400 crossing replacement.

The effect of such a change in profile grade on the capacity of the Drain would be significant but would need to be quantified and confirmed through revisions to the hydraulic model.

Overflow Area No 3

Key design characteristics of the proposed SWM facility located south of the 5th Line and west of the Innisfil Creek Drain have been outlined below for reference:

- Pond block of 6 ha.
- Provide approximately 50,000 m³ of storage. This storage has been created by placing berming around the perimeter of the pond as shown on Drawing 52 and 53 in the Engineers Report.
- Provides attenuation of 2-year flows.
- Inflows into the pond provided via a lateral weir structure.
- Capture approximately 75% of the 2-year peak flows at depths above 1.5 m.

Burnside has reviewed the VO2 hydrologic model and agrees that the proposed SWM facility provides a reduction in flows (approximately 5 m³/s) to the downstream reach. The proposed channel cross section as designed has been observed to contain the attenuated 2-year peak flows.

Design Criteria

Burnside is of the belief that the original focal point of the proposed drainage improvements was to protect the valuable market garden lands from frequent flooding events.

Burnside notes the design criteria for the proposed drainage improvements to contain the 2-year peak flows. To accommodate this design criteria, berming, drain cross section and profile revisions are proposed within the Engineer's Report. While Burnside agrees that these measures may contain the 2-year flows, Burnside has concerns about the drainage capabilities of individual lands when peak flows from larger than 2-year storm events overtop the proposed berming. The Drainage report speaks to the requirement of pipe outlets with flap gates. Given that the proposed berming will be a barrier to localized sheet flow to the drain, sizing of individual outlet drains and long term maintenance of these drains would be required to mitigate additional flooding on private lands.

Based on the information provided by Dillon, we note that the proposed reduction in the channel cross section as described in their memorandum of February 3, 2015, reduces the cost of the Main Drain improvement by \$500,000. The proposed reduction in cross section removes the 0.4 m of freeboard which was included in the original design which provided some margin of safety. We understand the reduced cross section will still accommodate the 1 in 2-year storm event which has been the established design criteria for this drainage system.

We would note that the 0.4 m of freeboard provided a margin of safety against flooding in the 1 in 2-year event storm and provided additional capacity within the channel for larger storm events. Removal of the freeboard removes the margin of safety and would theoretically result in any storm larger than the 1 in 2-year event overtopping the banks of the drain.

It is also noted that the reduced cross section impacts less land on either side off the existing drain. Considering the nature and value of the crops being grown in the market garden farm area, all efforts to minimize the land required should be considered.

On the basis of the information provided by Dillon, we recommend that efforts be made to reduce the channel cross section as proposed by Dillon and the modeling be reviewed to provide confirmation.

Hnydczak Outlet Relief Drain

As noted in our Phase 1 report a significant deepening of the Hnydczak Outlet Relief Drain channel downstream of the Highway 400 crossing culverts is proposed in the Engineer's report which we anticipate will improve the capacity of the Hnydczak Outlet Relief Drain. It is anticipated that this will hydraulically allow more of the runoff flows from the upstream Hnydczak Drain to be directed through the Relief Drain and hence provide more capacity for the South Innisfil Creek Drain to accommodate upstream flows.

The effect of providing a low flow culvert at the lower elevation of the upstream Hnydczak Drain under the Highway 400 and Reive Road was not addressed within the Engineer's Report. We expect that such a culvert may further reduce the pressure on the South Innisfil Creek Drain.

It appears, however, that modelling of the proposed improvements to the Hnydczak Outlet Relief Drain was not undertaken and consequently any of the proposed improvements to this outlet are not supported by the modelling. We believe from a practical perspective that the proposed work will provide some benefits to the overall watershed and that some work is required on the Hnydczak Outlet Relief Drain unless the Highway 400 culverts on the South Innisfil Creek Drain are replaced.

Review of Cost Estimates

We have undertaken a very cursory review of the cost estimates within the Engineer's Report which were based on the proposed work. At this time we believe that the most positive effect on the total cost of the proposed work will not be found in the minor adjustment of unit prices for various components of the work but rather in adjustment of the design criteria for the components of the work or the removal of certain works. The unit costs within the report generally seem reasonable considering the report submission date of 2013. As the report is dated 2013, it should be expected that the unit costs for various works may have increased as well as the required allowances.

Summary of Recommendations

The following will provide Burnside's recommendations to the Town of Innisfil which result from our documentation review completed in Phase 1 as well as the review of the hydrologic and hydraulic modelling carried out as Phase 2 of the peer review process. We have attached our Phase 1 report to facilitate reference to the details of particular items.

- Additional channel cross sections, details and characteristics for the reach of the proposed Drain situated between Highway 89 and the 15th Line, including the existing structure at the 15th Line and the new structure currently being constructed on Highway 89, should be obtained through additional field work followed by detailed modelling analysis of the 2-year flows under existing and proposed conditions. The objective of this exercise would be to more accurately establish the merits of constructing Pond Area 1 and/or provide some technical rationale for the removal of Pond Area 1 from the proposed work.

- Reconsider the design criteria for the portion of the drain situated downstream of Highway 400 and, in particular, remove the provision of the 0.4 metre freeboard through this portion of the drain, with the objective to remove the construction of berms downstream of Highway 400. In support of this objective, over bank flooding in this area, which currently would be experienced, appears to be onto less sensitive land uses and has not been raised as a concern to our knowledge through the public's involvement as an issue.
- Liaison with the Ministry of Transportation in regard to the Highway 400 crossing should be undertaken to determine the timing for improvements to the South Innisfil Creek and Hnydczak Drain crossings. It is acknowledged that any improvements to these crossings have in the past been considered unlikely. However, considering the impedance to the flows and the fact that they are perched above the proposed drain invert and that any increase in Drain cost is attributable to the Province under Section 26 of the Drainage Act, we believe this matter must be addressed again with the Town participating in those discussions. Over and above the potential capacity deficiencies at these crossings, we note that adjustments to the invert elevations of the drain bottom by revisiting the grade of the downstream channel and the replacement of the Highway 400 crossings provides for significant potential to increase the upstream drain capacity. We note that part of the discussions with the MTO may include a better understanding by the Town of the effect of the recently constructed solid concrete median barrier during larger storm events and in particular the design storm events for the crossings themselves to determine if the median has adversely affected the potential for flooding in the Town of Innisfil.
- The Drain grade line from Highway 400 downstream be reinvestigated to reduce the need for excavation work in the downstream reaches or alternatively to determine the potential to provide a lower outlet elevation at Highway 400 and therefore a deeper channel with more hydraulic capacity upstream of Highway 400.
- The inclusion of the Hnydczak Relief Outlet Drain in the hydrologic and hydraulic modelling should be considered although the need may be affected by the recommended discussions with the MTO. If crossing improvements were being considered by the Ministry the design criteria for the crossing would be significantly greater than the 1 in 2-year event. The larger consideration may be the invert elevation of the crossing. We believe the modelling should be included but this should occur after the liaison with the MTO.
- We believe the proposed improvements to South Innisfil Drain and branches were originally driven by storm events that produced significant flooding of the lands within the Innisfil Market Garden area and recognized that those storm events were greater (more intense) than the proposed 1 in 2-year storm design criteria. Although we concur with the design criteria for this drain and note that it is a more or less accepted criteria for Municipal Drains in the province, there seems to be some merit and support from the public for a reduced criteria on the 3rd Line Branch and the 10th Sideroad Branch of the South Innisfil Creek Drain. Hence we recommend consideration of including the branches in the Engineer's report for the purpose of creating plans, specifications and an assessment schedule but the proposed work be reduced to more closely resemble a maintenance and repair of the branches.
- We note that the construction of berms along the drain are beneficial to increase the capacity of the drain to meet the 1 in 2-year storm criteria, but in more intense storm events, overtopping of the berms should be expected which would be similar to the occurrences which initiated the drain improvements. Although culverts and flap gates are referenced in the report as a method to remove flood waters from behind the berm it is unclear from our perspective in the report who will be responsible for those discharge facilities. The more traditional method on Municipal Drains is for flood waters to discharge from the adjoining

lands after the storm events through swales provided through the excavated material spoil banks. This would be a contradiction to the provision of berms to increase the capacity. It is possible that increasing the depth of the drain, which may be possible if the grade of the drain is adjusted downstream of Highway 400, may reduce the need for the berms. If berms are to be placed, the report needs to clearly identify that removal of floodwater from the land behind the berm will be the property owner's responsibility and that the time to remove those flood waters will be contingent on the storm event, the care and maintenance of floodwater discharge facilities through the berm or the number and capacity of pump discharge systems used by the property owners.

- As set out in our Phase 1 report, we believe there is some potential to share the Farm Crossings required on the South Innisfil Creek Drain and note that Dillon also presented revisions in this regard to help mitigate the overall cost of the Drain Improvements. Please reference Section 4.4 of our Phase 1 report.
- Also as set out in our Phase 1 report, we propose that the foundations of the proposed farm crossings should be revisited to reduce the complexity and cost of these crossings. The need for deep pile foundations was driven by the potential for some settlement of the proposed crossings. We suggest that, providing the settlement does not adversely affect the structural integrity of the structures, minor settlement of the structures is not a serviceability issue. Details of this can be found in Section 4.5 of our Phase 1 report. We recommend that the amount of settlement be addressed by the geotechnical sub consultant and consideration be given to reduce the foundation requirements for these structures.
- Considering our findings generated from our peer review of this South Innisfil Creek Drain and Branches as well as the above noted recommendations, our closing recommendation would be to send the report back to the consultants for consideration of the above noted comments and recommendations.

If you have any questions or require clarification in regard to matters discussed above, please contact our office.

Yours truly,

R.J. Burnside & Associates Limited



Don McNalty, P.Eng.
Vice President, Public Sector
DMcN:sj

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