GRANITE RIDGE SUBDIVISION-PHASE II PRELIMINARY STORMWATER MANAGEMENT

Municipality of Trent Lakes

P/N 09-2361

June 2011

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Prepared for: Mr. Jeff Chesher – Buckhorn Sand & Gravel

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TABLE OF CONTENTS

Page

LIST OF DRAWINGS

LIST OF APPENDIXES

REFERENCES

Nottawasaga Valley Conservation Authority – Stormwater Technical Guide, December 2013
Ministry of the Environment Stormwater Management Planning and Design Manual – March 2003
Ministry of Transportation – Drainage Management Manual, Parts 1&2

GRANITE RIDGE SUBDIVISION-PHASE II
PRELIMINARY STORMWATER MANAGEMENT REPORT
MUNICIPALITY OF TRENT LAKES

P/N 09–2361 March 2016

1.0 INTRODUCTION

Mr. Jeff Chesher is proposing to complete Phase II of the Granite Ridge Subdivision. This involves approvals under the planning act, including amendments to the Official Plan of the Township of Tent Lakes, and a new Plan of Subdivision. An update of the Phase I stormwater management plan is necessary to comply with Ministry of Environment (MOE) Guidelines and as-constructed conditions for the completed Phase I works.

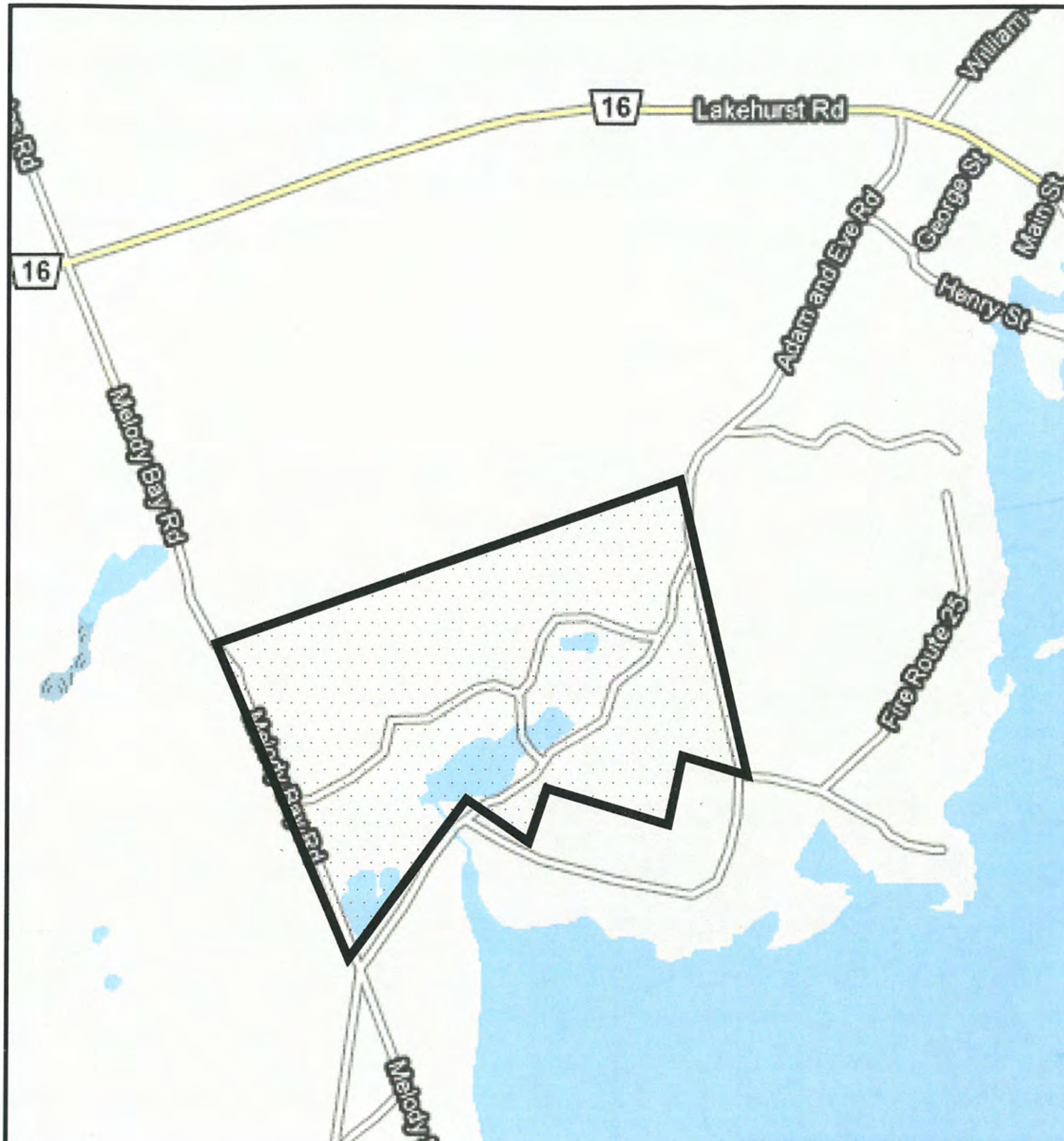
Skelton Brumwell and Associates (MOE) has been retained to provide consulting engineering and planning services for the Phase II development. This report has been completed as part of the requirements for the application of draft plan approval.

The property is legally described as Part of Lots 8 & 9, Concession 9, Geographic Township of Harvey, County of Peterborough and is 18.85 ha in size. The site is bounded to the north by Granite Ridge Phase I (Mitchell Street), to the west by Melody Bay Road and to the south and east by Adam & Eve Road. Buckhorn Lake lies generally south of Phase II lands.

The location of the subject site is show on Figure 1 – Site Location.

1.1 Stormwater Management Criteria

The stormwater management criteria for this development are relatively straight forward. Peak flows off of the site are to be maintained at existing magnitudes or lower. Stormwater runoff is to be treated to MOE Enhanced levels for quality, which is essentially 80% reduction in total suspended solids (TSS).



CHESHER SUBDIVISION PHASE II

FIGURE 1
SITE LOCATON

Scale: NTS

P/N 2361	JUNE 2011

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2.0 Proposed Pond Facility

It is proposed to utilize an existing pond in the Phase II lands to provide stormwater quality and quantity control for the majority portions of the Phase I and Phase II subdivision development. As discussed in this report, the pond provides a permanent pool volume in excess of the requirements for MOE Enhance treatment.

Proposed grading around the perimeter of the pond combined with the addition of a controlled flow outlet weir will provide for extended detention volumes in excess of MOE requirements and enable post-development peak flows from the pond to be reduced to magnitudes that are less that the existing conditions.

The proposed use of the existing pond as a stormwater management control feature has been discussed with municipal staff. Given that the pond is intended to accessible by neighboring residents the Township has insisted that they will not take ownership due to concerns about liability for recreational usage. However, the municipality will hold an easement over the entire pond for future maintenance to remove collected sediment and ensure that the outlet structure remains free draining as intended in the design. This easement will extend 15m from the edge of the permanent pool to provide for maintenance access and to ensure that the pond banks and associated vegetation are not able to be altered by the residents.

To address concerns about long term maintenance of the pond, the subdivision design will feature permanent rock check dams in the inlet channels that direct runoff from the roadways to the pond. These are intended to trap sediments near the municipal roadway where they are relatively easy to be collected and removed. These are discussed in Section 8.3. Maintenance requirements for the pond are discussed in detail ins Section 9.0

3.0 PHASE I DRAINAGE

The first phase of the development was designed and constructed in the early 2000's. Drainage is via open road side ditches and lot line swales which serve to convey site runoff generally south and east toward Adam & Eve Road and eventually to Buckhorn Lake. Soils in the area are a highly porous mix of sand, gravel and bedrock that allows for significant infiltration of runoff. This soil condition is consistent throughout Phase 1 and II. Please refer to Drawing 2361-SWM1 for the layout of Phase 1 lots and drainage catchments.

The Phase I development does not contain any constructed stormwater management control facilities such as ponds. The majority of the development and some external areas (23.06 Ha consisting of Catchment 101, 103, 105, 1051) drains southward to Phase II lands, which contain an existing pond that is the result of previous aggregate extraction. The pond drains via a culvert under Adam & Eve Road directly to Buckhorn Lake. This culvert appears to be is in good structural condition and is relatively free of debris or obstructions. Photos of the culvert are included in Appendix A, page A-13, 14, 15

The balance of Phase I and external areas (4.14 Ha consisting of Catchments 102 and 104) drains eastward through forested lands toward Adam & Eve Road and eventually to Buckhorn Lake. The eastern drainage area includes existing residential lots immediately south of a portion of the Phase II site and east of the existing pond outlet.

A stormwater study for Phase I was completed by D.W. Wills & Associates. These reports were made available to our office for review to ensure that the development of Phase II is consistent with drainage for Phase I.

Drainage patterns for the completed Phase I lands were initially determined based on review of design drawings by D.W. Wills. Subsequently, these drainage patterns were refined through review of areal mapping and field inspections by staff from our office during various site visits.

3.1 Drainage to Infiltration

Review of topography from areal mapping shows that a small portion of Phase I, 0.71 Ha drainage to a depressed area without a positive outlet (see drawing 2361-SWM1). This catchment, identified as 1051 was then confirmed by field review to contain an isolated depressed area that collects local runoff and appears to simply soak this collected water away. The volume of soakaway was estimated using contour areas to be 836 cu.m.. This volume was divided over the 0.71 Ha catchment area to calculate an average equivalent ponding depth that was then modelled as additional Initial Abstraction. Please refer to Appendix B, Page B-6

3.2 External Drainage to West

Through review of topographic mapping, an external area identified as Catchment 106 was identified as initially assumed to drain through Phase I lands to Phase II. Subsequent field reviews however, combined with review of topographic mapping to the west of Melody Bay Road have shown that his catchment instead ponds locally similar to Catchment 1051, to an elevation of 268.40m and then drains westward via an existing road crossing culvert under Melody Bay Road. Here runoff is collected in another isolated ponding area that drains primarily via soakaway which is part of Catchment 109.

Topographic mapping shows that the ponding area in Catchment 109 will then spill directly southward above elevation 268.40m with spill flows either soaking away in other isolated ponding areas or eventually making their way to Buckhorn Lake. Please refer to drawing 2631-SWM1

Catchment 106 and 109 do not drain to Phase II lands and as such are not considered further in the analysis and design of the subject development.

4.0 PHASE II – EXISTING CONDITIONS

Currently the lands proposed to be developed in Phase II are a mixture of bare ground and well treed forest. The site is a former wayside gravel pit that has not been licensed or in operation for several years. Given the fact that the area is a former gravel pit, it is assumed the site soils consist of sand, gravel and bedrock that will provide a high level of infiltration. This is supported by test pit logs provided by Geo-Logic in their report dated November 2010 which shows the shallow surface soils to consist generally of sand.

The site contains several existing gravel roadways that have been constructed generally where the property owner envisions the ultimate roadways to be constructed. The current roadways serve to provide access throughout the Phase II lands.

The majority of the subject property drains to the existing pond on the site. The drainage catchment for the pond totals 14.00 Ha. The remaining 5.21 Ha portion of the Phase II lands drain south and eastward to Adam & Eve Road and eventually Buckhorn Lake.

The existing drawing catchments are illustrated in drawing 2361-SWM1 included with this report.

4.1 Existing Pond

As reported by the owner, existing pond in the area of Phase II was created as a by-product of the previous aggregate extraction. A detailed survey of the existing pond was completed in the fall of 2015 in order to assess the existing areal extent and volume of the feature. This survey shows that the permanent water level in the pond is maintained at approximately 246.60m, the water surface area is 1.75 Ha, and the total permanent pool volume is 27,679 cu.m. Dividing the pond volume by the area gives an average depth of 1.58m. It should be noted however that maximum measured depth in the pond is 4.2m so the depth of water clearly varies throughout.

The pond drains via a shallow channel southward to Adam & Eve Road where flow is conveyed via a 100 mm diameter, corrugated steel pipe (CSP) culvert structure. This culvert drains to a short channel section which forms part of Buckhorn Lake. There is currently no enhanced quality or quantity control structures between the pond and the lake; however, the owner has taken steps to armour the upstream side of the culvert and channel with stone retaining walls utilizing materials from the former pit.

4.2 Groundwater Seeps

Field investigation by SBA staff have identified a couple of small, emergent groundwater drainage courses on the east side of the site in the area of the proposed Lots 20-21. The start of the drainage courses is at the base of the hill forming the boundary between Phase I and Phase II.

At this time location of these watercourses have been established in the field and surveyed. This will enable lot grading, septic and drainage plans to be developed at the detailed design of the subdivision. The aim of the design will be to collect and convey this emergent groundwater to existing the site pond and eventually to Buckhorn Lake. As a preliminary concept, it is proposed that the development of these lots be deferred until adjacent lots are developed and groundwater flow patterns are finalized. As a minimum the drainage from this area will be routed such that it is collected in road side ditches and conveyed to the site pond via an open channel inlet to the west end of the pond.

5.0 EXISTING CONDITION MODELING

The current drainage conditions for Phase I and II were modelled using Visual Otthymo Version 2.3 to estimate the peak runoff rates for various storm events. Drainage catchments were determined as described in Section 2.0 by review of contour information based on 2008 areal mapping, and visual field investigation. The subject lands were modelled as draining either southward to the 1000mm culvert across Adam & Eve Road, or eastward to Adam & Eve Road where drainage will flow to Buckhorn Lake by an indirect route.

Land coverage (forest, impervious, grassed) was determined based on review of aerial photography, typical rural road cross sections and assumptions of total coverage on each existing lot. Overland flow paths were determined based on topographic information in order to assess time to peak for each catchment. Runoff curve numbers for land use were selected based on MTO Design Chart 1.09 (see Appendix B, page B-2) for SCS Type A soils. All catchments were modelled using the Nashyd Subroutine which is utilized for catchments with low overall imperviousness. Calculated catchment inputs include: Time of Concentration (Uplands method), composite – area weighted - SCS Runoff Curve Number (CN) and Initial Abstraction Values (IA). Catchment input calculations for existing Phase I lands and modelling output files are included in Appendix B. All catchments are shown on drawing 2631-SWM1. Table 1 summarizes the drainage characteristics of each catchment analyzed.

Table 1 – Existing Condition Catchment Characteristics

Catchment ID	Area (Ha)	CN	IA	Time of Concertation (hrs)	Notes
101	4.25	63.6	7.7	0.60	External
102	8.38	56.6	8.4	0.74	External
103	11.14	60.8	7.9	0.19	Phase I
104	6.86	73.7	5.9	0.53	Phase I
105	6.96	62.1	7.6	0.65	Phase I
1051	0.71	56.8	126.6	0.08	Drains to internal soakaway
106	4.14	57.9	40.3	1.03	Internal soakaway, overflow to west of Melody Bay Road
107	14.00	67.1	8.9	0.31	Phase II
108	5.21	52.3	10.0	0.17	Phase II
109	43.23	51.4	42.9	1.23	Internal soakway, catchment located west of Melody Bay Road

The completed hydrologic model was analysed using rainfall data for Peterborough for the 2, 5, 25, 50 and 100 year return periods. Both the 24 Hour SCS and 4 Hour Chicago Storm distributions were analysed.

Refer to Section 6.0 for a summary of pre-development runoff rates to Buckhorn Lake.

5.1 Existing Pond Rating Curve

As stated previously, there is no existing flow control structure for the pond located in on the Phase II lands. The only outlet structure is the 1000 mm dia. CSP culvert under Adam & Eve Road. The inlet invert of the culvert is 264.10 m. We have determined that the water in the pond is maintained at a higher elevation of 246.60 m by existing grade, based on the detailed survey completed in 2015.

Consistent with the previous analysis by D.W. Wills, we have analysed the capacity of the culvert in both inlet and outlet control. The outlet control calculation is based on a high water level in Buckhorn Lake of 247.12 m (as calculated for the 1 in 100 year storm event), per current Township zoning by-laws. For all pond water levels analysed, it was found that the lowest flow rate through the culvert was calculated assuming outlet control. This is considered to be the most conservative assumption as it results in the lowest existing condition flow rates from the pond. Please refer to Appendix A, page A-10.

The detention volume in the pond (above the surveyed permanent water elevation of 246.60 m was calculated using average end areas for existing contours around the pond.

The resulting stage-storage-discharge curve was used in the existing condition model, via the route reservoir routine, which enabled the detention effect of the pond to be estimated. Table 2 below summarizes the modelled stage-storage rating curve for the existing pond.

Table 2 – Existing Pond Stage-Storage

Pond W/L (m)	Flow Rate (cms)	Detention Storage (Ha.m.)
247.12	0	0
247.20	1.17	0.58
247.50	1.83	1.27
247.80	2.53	1.70
248.00	3.01	1.93
248.30	3.78	2.24

5.2 Existing Condition Modelling Results

Summary output for the existing condition modelling is provided in Appendix E along with a comprehensive summary of existing and proposed condition peak flows.

6.0 PROPOSED CONDITION MODELLNG

Consistent with Phase I, it is proposed to drain Phase II with road side ditches and lot line swales. These will serve to convey runoff to either the existing pond in Phase II or to the existing ditch drainage system on Adam & Eve Road.

As per existing conditions, a proposed condition model was developed to estimate the expected runoff rates following the development of Phase II. The drainage catchments for Phase I and external areas to the north were unchanged from the existing condition model. Catchments for the Phase II lands were analysed based on the currently proposed lot and road layout, with input from the land owner. Please refer to Skelton Brumwell drawing 2361-SWM2 and Appendix B for details of the proposed condition inputs. The characteristics of the post development catchments are summarized in Table 3

Table 3 – Proposed Condition Catchment Characteristics

Catchment ID	Area (Ha)	CN	IA	Time of Concertation (hrs)	Notes
101	4.25	63.6	7.7	0.60	External
102	8.38	56.6	8.4	0.744	External
103	11.14	60.8	7.9	0.194	Phase I
104	6.86	73.7	5.9	0.535	Phase I
105	6.96	62.1	7.6	0.657	Phase I
1051	0.71	56.8	126.6 *	0.083	Drains to internal soakaway
106	4.14	57.9	40.3 *	1.031	Internal soakaway, overflow to west of Melody Bay Road
109	43.23	51.4	42.9 *	1.231	Internal soakway, catchment located west of Melody Bay Road
201	4.58	61.6	7.5	0.09	Phase II , Lots 17-23 & Roadway – Drains to pond
202	2.12	64.7	4.5	0.036	Phase II, Lots 24-27 & Roadway – Drains to Pond
203	3.80	55.1	9.2	0.029	Phase II, Lot 1-2, 29-34 Roadway – Drains away from pond
204	0.43	73.1	3.9	0.124	Phase II, portion of roadway-Drains to pond
205	8.25	69.6	4.1	0.067	Phase II, Lots 3-16, Pond

6.1 Proposed Pond Rating Curve

6.1.1 Pond Volume

At this preliminary stage, we have developed a perimeter grading concept for the pond and the lots surrounding it. This will include a 3 m wide shelf at 5% steepening to a 7:1 bank slope to elevation 247.75m. This top of bank forms the rear property grading limits of the lots bounding the pond. The grading will have the net effect of increasing the detention storage volume available in the pond. Based on this grading design, the proposed volume of the pond was calculated using the average end area method for successive design contour lines. The calculated volumes are presented in Appendix D.

6.1.2 Pond Outlet

It is intended to control peak pond flows to be less than pre-development conditions for all storm events analysed and to ensure peak flows for the maximum pond elevation are less than the capacity of the existing 1000mm road crossing culvert at Adam & Eve Road.

We have developed a concept for the control outlet structure. A 2-metre-wide concrete, sharp crested, weir will serve as the high flow outlet for 2 to 100 year storms. The weir invert is to be set at 247.15m, slightly above the downstream 100 year water level (247.12m) in Buckhorn Lake.

Flow through the outlet weir has been calculated in accordance with the MTO Drainage Management manual and details of this method are included in Appendix D. Using calculated flow rates and volumes for various water levels in the pond, proposed rating curve was developed. This was then input to the Route Reservoir routine in the post development Otthymo model. Through an iterative process, the size of the weir was determined that achieved the targets of maintaining peak flows as less then the pre-development condition and less than the flow capacity of the downstream culvert crossing Adam & Eve Road (assumed to be flowing in outlet control). Please refer to drawing 2361-POND for a view of the weir design. Calculations for the modelled pond rating curve are included at the end of Appendix D. The final rating curve is summarized in Table 4 below.

Table 4 – Proposed Pond Rating Curve

Pond W/L (m)	Flow Rate (cms)	Detention Storage (Ha.m.)
247.15	0	0
247.20	0.040	0.106
247.30	0.204	0.321
248.40	0.425	0.541
248.50	0.681	0.765

Below the weir invert of 247.15m, the pond will be drained via a 200mm PE pipe installed through the concrete weir. This will serve as the low flow / extended detention volume outlet and will maintain the pond at the normal water level of 246.60m.

6.1.3 100 year Water Level in Pond

The route reservoir routine in Otthymo allows estimation of the peak flow from, and the maximum retained volume in the pond for each storm event analyzed. Comparing the 24 Hour SCS and 4 Hour Chicago distributions, it can be seen that the peak flow and volumes from the pond are estimated to occur with the 24 Hour SCS distribution. For the 100 year event, this means a flow rate of 0.490 cms with a retained volume of 5980 cu.m.. Interpolating the corresponding water level based on calculated pond volumes provides a 100 year water level of 247.43m. Rounding up to 247.45 m and adding a 0.3 m free board allowance gives us at finished property boundary elevation of 247.75 m.

As discussed in section 4.1, Buckhorn Lake is subject to a 100 year water level of 247.12m. This is above the current 246.60m permanent water level in the pond. For most drainage conditions the pond will drain freely, however in a worst case, it will subject to a backwater elevation of 247.12m. To address this, the detention outlet design has been set with the high flow (2-100 year storm events) at an elevation of 247.15m. The detention pond volume available between this and the permeant pool elevation (246.60-247.15m) has then been ignored in the development of the proposed condition rating curve and modelling. This ignored volume is considered to be the extended detention volume for the pond and is estimated to be 10,877 cu.m. See Appendix D, page D-1. This is discussed in Section 7.0.

7.0 DEVELOPMENT IMPACTS ON RUNOFF RATES

7.1 Drainage to East

For all storm events, the proposed condition peak flow is expected to be less than existing conditions as shown in Table 5. This is because the overall drainage area to the east will be reduced from 4.14 Ha in the existing condition to 3.80 Ha. in the proposed condition. The balance of drainage area will be re-directed to the pond in phase II.

Table 5 – Peak Flow Summary to East

STORM EVENT	EXISTING HYDROGRAPH 007 (cms)	PROPOSED HYDROGRAPH 010 (cms)	CHANGE FROM EXISTING TO PROPOSED (cms)
2 YEAR SCS	0.177	0.169	-0.008
5 YEAR SCS	0.309	0.262	-0.047
25 YEAR SCS	0.553	0.513	-0.040
50 YEAR SCS	0.665	0.613	-0.052
100 YEAR SCS	0.788	0.720	-0.068
2 YEAR CHICAGO	0.100	0.095	-0.005
5 YEAR CHICAGO	0.206	0.194	-0.012
25 YEAR CHICAGO	0.422	0.391	-0.031
50 YEAR CHICAGO	0.523	0.483	-0.040
100 YEAR CHICAGO	0.629	0.580	-0.049

Please refer to Pre-Development Otthymo model schematic in Appendix B, page B-16 for reference to hydrograph numbering.

7.2 Drainage to South

For all storm events, the proposed condition peak flow to the south is expected to be less than existing conditions as shown in Table 6 below. This is due to the proposed expansion of the pond in Phase II and the installation of a flow control outlet structure.

Table 6 – Peak Flow Summary to South (Culvert to Buckhorn Lake)

STORM EVENT	EXISTING HYDROGRAPH 501 (cms)	PROPOSED HYDROGRAPH 008 (cms)	CHANGE FROM EXISTING TO PROPOSED (cms)
2 YEAR SCS	0.181	0.085	-0.096
5 YEAR SCS	0.327	0.162	-0.0165
25 YEAR SCS	0.596	0.326	-0.270
50 YEAR SCS	0.720	0.402	-0.318
100 YEAR SCS	0.853	0.490	-0.363
2 YEAR CHICAGO	0.103	0.046	-0.057
5 YEAR CHICAGO	0.218	0.115	-0.103
25 YEAR CHICAGO	0.452	0.254	-0.198
50 YEAR CHICAGO	0.562	0.325	-0.237
100 YEAR CHICAGO	0.680	0.402	-0.278

Please refer to Post-Development Otthymo model schematic in Appendix B, page B-17 for reference to hydrograph numbering.

8.0 STORMWATER QUALITY CONTROL

The Ministry of Environment identifies several methods of controlling and improving the quality of storm runoff. These include passive measures such as reduced lot grading, infiltration, vegetated filter strips, discharging sump pumps and roof leaders to rear yards. As well end-of-pipe controls such as oil grit separators, constructed wet lands and wet ponds can be utilized.

Phase I makes extensive use of the passive measures listed above. The land in this phase of the subdivision was, and remains, in a well vegetated forested state. The development roads are drained by open grassed ditches. The variable topography, combined with underlying sandy soils, makes implementation of these passive measures quite effective.

It is proposed that Phase II lands utilize these same measures as much as possible to minimize the need for and dependence upon end-of-pipe controls. It must be noted that the exiting pond in Phase II currently serves a stormwater quality control function that will continue through development.

Previous comments from Township consultants have indicated concerns with utilizing the pond for collection of stormwater from the perspective of groundwater impacts. It will be possible to enhance infiltration and filtration of storm runoff upstream of the pond through inclusion of permanent rock check dams at the points were road side ditches discharge to swales connected directly to the pond. These check dams will slow the velocity of run off causing sediment to drop out of suspension. The reduced flow velocity of runoff in the ditch will also increase the likely hood of this water simply infiltrating into the underlying sand and fractured rock underlying the development. Containing the silt and sediment in the ditches at points near the municipal road will facilitate removal by municipal staff using and tools and/or commonly available construction equipment such as backhoes, gradealls, excavators loading into trucks for disposal as suitable sites. Please refer to the check dam details provided in Appendix C, page C-11.

One of the significant contaminants in stormwater is salt used in de-icing during winter maintenance. Unfortunately removing salt from solution with water is not possible on a municipal scale. Salt is not removed through filtration nor settling in standing water. Salt laden runoff that is allowed to infiltrate can eventually contaminate groundwater resources once sufficient amounts are present.

The current best practice to limit salt contamination is to eliminate or at least minimize the amount of salt that is utilized in winter road maintenance. This is controlled by the municipality responsible for winter road maintenance. Many municipalities are seeking alternatives to salt for winter maintenance or at least ways to improve the efficiency of salt application to reduce the overall amount used. These measures are being undertaken both for economic reasons and to lessen the impact on the environment. Providing direction to the Municipality of Trent Lakes on winter road maintenance methods to minimize salt usage is beyond the scope of this report and outside of the area of expertise of the author.

8.1 Drainage to East

Review of drawing 2361-SWM2 shows that there are several lots in both Phase I and Phase II which drain eastward, away from the pond in Phase II (see catchments 104 and 203 on drawing 2361-SWM2. This portion of the development is heavily vegetated with variable topography. These catchments contain only a small portion of municipal roadways as well some house driveways. Quality control for this area is provided through filtration and infiltration on the lots in the proposed grassed roadside ditches. We will also investigate the creation of an infiltration feature at the termination of the roadway connecting to Adam & Eve Road. The concept would be to route roadside ditch runoff to a soakaway feature where it can be filtered by the native sandy soils. The section of Adam & Eve Road to the east of the development does not have road side ditches or culverts to convey runoff. We assume infiltration is very good in this area as this is effectively the only way runoff is being discharged now. Please refer to preliminary infiltration sizing calculations in Appendix C, page C-10.

We would also recommend permanent rock check dams be installed at the point were development road side ditches intersect with Adam & Eve Road. This will enable sand, silt and vegetative debris from the development roads to be collected near the source for relatively easy removal by municipal staff using hand tools and/or common equipment such as backhoes, gradealss, and trucks. Please refer to the check dam details provided in Appendix C, page C-11.

8.2 Drainage to South – Existing Pond

The balance of the development area (see catchments 101, 103, 105, 201, 202, 204, 205 on drawing 2351-SWM2) drains southward through the existing pond in Phase II. All of the same passive quality controls exist for these catchments and are augmented by the pond.

Review of information provided by the project surveyor and owner shows that the pond is currently 1.75 Ha in area with maximum surveyed depth of 4.2 metres. The survey shows that the bottom of pond has irregular in elevation and a terrain model was developed from survey data to enable to volume of the pond to be determined which we estimate to be 27,679 cu.m (refer to Appendix A, page A-2). Dividing volume by the1.75 Ha pond area, we estimate average depth of the pond to 1.58m which meets depth criteria as noted in the MOE Stormwater Management Planning & Design Manual (SWMPDM) Table 4.6 which is included in Appendix C, page C-6

The ultimate proposed catchment area of the pond after the development of Phase II is 38.55 Ha with an imperviousness of 27%. Using sizing guidelines provided by MOE in Table 3.2 of the (see Appendix C, page C-4) SWMPDM and extrapolating for 27% imperviousness we find that the permanent pool volume required for a wet pond serving this catchment area and providing Enhanced Protection (80% TSS removal) requires a total volume of 3,129 cu.m. Thus the existing pond is conservatively estimated to provide nearly nine times the required permanent pool volume to achieve Enhanced Protection. Further, as noted section 6.1.3, the extended volume retained in pond below the high flow weir is 10,877 cu.m. Per MOE Table 3.2, the required extended detention volume is only 1,542 cu.m. As such, we conclude that the pond as proposed, will provide sufficient permanent pool and extended detention volume to meet the requirements of the MOE for Enhanced Quality Control. Please refer to calculations provided in Appendix C.

8.3 Pond Inlet

Per MOE requirements, a quality control wet pond is to have a sediment control forebay to settle and collect heavy sediments from all inlets. In this instance, surface water will flow into the pond from several point sources as well as from surrounding rear lot areas. It will not be possible to collect and direct all runoff to the pond to a single inlet or even to one end of the pond. Furthermore, the pond is as deep as 4.2m and fed in part by groundwater. This will make construction of a berm separating the forebay from the rest of the pond prohibitive as the pond would have to be pumped dry and this condition maintained for an extended period of time to allow for construction of diversion berms.

For these reasons and the fact that the pond is significantly larger and deeper (at points) than required to perform quality control function, it is proposed to simply allow the pond to function un-altered from its current condition.

We have presented the 2013 version of the report to the MOE for brief review to get an opinion on the acceptability of using the existing pond for quality control in the manner proscribed. MOE has generally accepted the concept. Please refer to correspondence in Appendix C.

8.4 Inlet Channels

The current subdivision plan includes four (4) open channels draining to the pond. These channels will convey flows from the roadside ditches. Some form of armouring will be required in these channels to protect them from scour during high flow event. Details of the armouring will be developed in the detailed design stage but conceptually this could include permanent erosion control matting and river stone lining combined with the permanent check dams discussed previously. which will also reduce erosion potential by slowing flow velocities.

8.5 Pond Outlet

Previous design reports for the Phase 1 development discussed adding a filter hickenbottom outlet to the pond. However, this is not currently present. It is assumed that the hickenbottom was deemed unnecessary or prohibitive to construct due to the depth of pond.

We propose that the low flow outlet of the pond will consist of a 200mm high density polyethylene (HDPE) pipe installed through the concrete weir with an invert matching the permanent pool level of 246.60m. The pipe will serve to drain the pond below the weir invert and allow a controlled draw down over approximately a 24 hour time period to ensure sediment entering the pond is provided time to settle as recommended in MOE Table 4.6.

Pipe sizing and draw down calculations are included in Appendix D, page D-6. It was decided to size the low flow outlet to drain the proscribed the proscribed extended detention volume of 1,546 cu.m, over a time period between 24 and 48 hours. The rational is for this is that if the pond drains the entire 10,877 cu.m. extended detention volume in 24 hours, the peak flow rate will be relatively high and settling for minor storm events with low volumes will be relatively short. Also, since the weir outlet was sized neglecting any volume below it's invert, there will be no adverse flood control impacts from having an elevated water level in the pond when a major storm event happens. Essentially there is no downside to having the pond water level somewhat elevated for more than 24 hours after minor rainfall events.

Refer to drawing 2361-Pond and Appendix C an D for concept details of the pond outlet.

9.0 POND MAINTENANCE

Pond maintenance will be focused in three main areas. Maintaining the inlet channels in a free flowing condition, maintaining the outlet structure and channel in a free flowing condition and maintaining sufficient permeant pool volume to meet MOE criteria for quality control.

9.1 Inlet Channels

The pond design includes four inlet channels the convey flows from the development roadways to the pond. These will be vegetated and have stone armor (rip rap or river stone) on the invert. Periodic maintenance of vegetation will be required to ensure that the channel flow capacity is not impacted. It is expected that this would be required every 5-10 years.

The upstream end of each inlet channel will have a permanent rock check dam to filter runoff of force deposition of same in the roadside ditch. These permanent dams should be inspected regularly, every spring after winter road maintenance is complete. It is likely that removal of collected sand and sediment at these dams will be required every spring. Post likely the volumes to be remove would only require hand tools but backhoes/excavators could be required.

It is expected that finer sediments will be carried through the check dams and are likely to be deposited where the channels outlet to the permanent pool. Periodic removal of this collected sediment near the waters edge will be required. The estimated frequency of this clean up would be every 25-50 years.

9.2 Outlet Structure

It will be important to maintain a free flow condition in the outlet structure and downstream channel section. It is possible that floating debris could become caught in the 200mm low flow outlet pipe. Vegetation around the outlet could also spread and obstruct this pipe and parts of the high flow weir. Inspection and clean up of the outlet structure should be completed annually, in the spring or early summer.

9.3 Permanent Pool Volume

Maintaining the permeant pool volume is the most challenging and expensive component of over all pond maintenance. Typically, removal of sediment from a pond requires draining of the pond through valved outlet pipes or pumping. Because this pond is fed in part by groundwater, draining or pumping down will be quite difficult. Instead, dredging measures may be required.

Fortunately, the expected frequency of sediment being required is very low. Calculations for this frequency have been completed using guidelines provided in the MOE SWMPDM and take into account expected sediment loading from the upstream drainage area based on imperviousness. Please see Appendix C, page C-8.

The lowest imperviousness considered by MOE is 35% and the upstream drainage catchment has a total estimated imperviousness of 27%. Proceeding with calculations based on 35% imperviousness is inherently conservative. Also, the pond permanent pool volume significantly larger than required by MOE and equates to a volume of 718 cu.m./Ha.

MOE Figure 6.1: “Storage Volume vs Removal Frequency for 35% Impervious Catchments” provides expected removal frequencies for storage volumes up to approximately 100 cu.m/Ha with the resultant removal for wet ponds of 50 years. Since the current pond provides 718 cu.m. we extrapolate that the expected removal frequency for the pond is every 350 years.

As an alternate check, using MOE Table 6.3 “Annual Sediment Loadings” and again conservatively assuming an imperviousness of 35%, we find that the expected annual sediment loading is 0.6 cu.m./Ha. For the 38.55 Ha contributing catchment, this means roughly 23 cu.m. per year. The provided permanent pool is 27,679 cu.m which is 24,546 cu.m. larger than calculated to required per MOE guidelines. The estimated loading rate of 23 cu.m year means that would be estimated to take over 1000 years to fill the pond to the point that it just meets the necessary volume for Enhanced treatment.

None of the above calculations take into account the proposed sediment control measures upstream of the pond so these rather large sediment removal frequencies can be considered somewhat conservative. Based on these calculations and application of upstream sediment controls we conclude that the municipal requirements to remove sediment from the permeant pool will be negligible.

10.0 CULVERTS

The development will contain several road crossing culverts at low points in the right-of-way. The preliminary design completed to date has included sizing of the most significant of these structures. The selected design criteria is to pass the peak 1 in 25 year storm flows under free flow conditions and, the 1 in 100 year flow without overtopping the road way. The Municipality of Trent Lakes has confirmed their concurrence with this sizing criteria. See Appendix F, page F-1

The first culvert analyzed conveys flow from Catchment 201. (See drawing 2361-SWM2) We have determined that a twin, 500mm CSP culvert will meet the design criteria. The next culvert is located north of the pond and conveys flows from Catchment 202 as well as a large portion of Phase I lands. This will require (3) 680x500mm CSP Arch culverts to achieve the design goals.

We recognize that additional culverts will be required at the intersections with Adam & Eve Road as well as on Street 'B' as currently designed. These structures will convey a relatively minor flow rate and will be sized during detailed design.

The culvert sizing completed to date is considered preliminary and will be re-confirmed and up-dated during the detailed design phase. Culverts sizes are shown on drawing 2361-SWM2 and calculations are found in Appendix F Please also refer to Post-Development Otthymo model schematic in Appendix B, page B-17 for reference to hydrograph numbering.

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11.0 SEDIMENT AND EROSION CONTROL DURING CONSTRUCTION

The construction phase of a development is typically the time when there is the highest risk of erosion, leading to sedimentation off site. Construction works involve clearing of vegetation and exposing soils to the erosive forces. However, the lands of the Phase II development are currently largely exposed and devoid of vegetative cover. So the construction phase will not be significantly different from existing conditions.

In order to mitigate the effects of concentrated flows through the construction of swales and road side ditches, it is proposed that a series of rock check dams be employed during construction.

These will reduce flow velocities and collect sediment before it can be deposited in the existing pond or on surrounding roads. We will also be recommending the swale inverts be reinstated with a row of sod which will provide immediate protection from erosion at the point where the flows are the most concentrated.

Siltation fencing will be installed in areas of the site as required. At this stage of development planning it is assumed that siltation fencing will be required generally around the pond and along the sides of the existing outlet channel. Once graded, the pond banks should be immediately top soiled and seeded with an annual rye grass mixed with a native vegetation seed mix. This will allow for rapid vegetative cover as well as allowing long term vegetative growth to become established as soon as possible.

After pond perimeter grading is completed, additional siltation fence should be installed at the top of bank to limit flow concentrations and potential erosion of the placed topsoil.

The pond outlet structure installation should be deferred until at after the perimeter grading around the pond is completed to ensure that a minimum water level is maintained by draining via the current un-restricted swale.

12.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the preliminary analysis completed and summarized herein, we conclude that Phase II of the Granite Ridge subdivision development can be completed in accordance with accepted stormwater management practice and the requirements of Ministry of Environment.

We recommend the following:

1. Existing emergent groundwater noted on the west side of the site be routed via swales and culverts to the existing pond in Phase II.

2. Development of the affected Lots 20 and 21, be deferred until after adjacent lots (19 & 22) are developed and detailed review of the drainage patterns can be assessed.

3. The proposed roadways in Phase II be drained via open grassed swales which will provide flow conveyance to proper outlets as well as infiltration and filtration of development runoff.

4. The perimeter of the existing pond be graded with a 3m wide safety shelf sloped at 5% and from there up to a minimum elevation of 247.75m at a slope of 7:1.

5. A controlled outlet structure as described in Section 8.4 and shown on drawing 2361-POND be installed to ensure post-development peak flows from the pond are equal to or less than pre-development conditions.

6. The existing pond in Phase II be utilized as is for stormwater quality control of all development area proposed to drain to it.

7. The quality control function of the pond be enhanced through the addition of a 200mm low flow pipe which will cause the draw down of the proscribed extended detention volume to occur over 24 hours.

8. Quality control for the west portion of the site be achieved through passive measures including infiltration and filtration through existing vegetation. Roadway runoff treatment

can be enhanced through measures such as drainage to a soakway pit or similar infiltration system.

9. Permanent rock check dams be installed in the road side ditches at the east limit of the project and at the start of the four pond inlet swales such the as much sand and sediment can be collected near the subdivision roadways instead of simply being flushed downstream to adjacent roads and/or the pond.

10. Erosion and sediment controls generally specified in Section 8 be employed during the construction phase. Details of locations for check dams and siltation fencing be determined at the detailed design stage.

13.0 DISCLAIMER OF RESPONSIBILITIES TO THIRD PARTIES

This report was prepared by Skelton, Brumwell & Associates Inc. for the account of Mr. Jeff Chesher

The material in it reflects Skelton, Brumwell & Associates Inc.'s best judgement in light of the information available to it at the time of preparation. Any use which a party (other than the named above and the Municipality of Trent Lakes) makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties.

Skelton, Brumwell & Associates Inc. accepts no responsibility for damages, if any, suffered by a third party as a result of decisions made or actions based on this report.

All of which is respectfully submitted,
SKELTON, BRUMWELL & ASSOCIATES INC.

per:

Bryan W. Bolivar, P.Eng
Senior Project Engineer

LICENSED PROFESSIONAL ENGINEER
B.W. BOLIVAR
PROVINCE OF ONTARIO

APPENDIX A

Existing Pond Analysis & Rating Curve

Date: March 14, 2016

Project: 2361 Chesher Subdivision
Basin Description:

CURRENT POND PERMANENT VOLUME - AVERAGE END AREA CALCULATIONS

Contour Elevation	Individual Contour Area (sq. m)	Net Contour area (sq. m)	Average Area	Depth (m)	Incremental Volume (cu. m)	Cumulative Volume (cu. m)
242.40	0.10	0		0	0.0	0
242.50	2.41	2	1.3	0.1	0.1	0
242.60	7.74	8	5.1	0.1	0.5	1
242.70	16.12	16	11.9	0.1	1.2	2
242.80	27.52	28	21.8	0.1	2.2	4
242.90	41.95	42	34.7	0.1	3.5	7
243.00	59.42					
243.00	1.73					
243.00	21.81	83	62.5	0.1	6.2	14
243.10	79.92					
243.10	297.89	378	230.4	0.1	23.0	37
243.20	103.46					
243.20	533.97	637	507.6	0.1	50.8	88
243.30	859.78	860	748.6	0.1	74.9	162
243.40	1064.60	1065	962.2	0.1	96.2	259
243.50	1266.96	1267	1165.8	0.1	116.6	375
243.60	1475.88					
243.60	0.01	1476	1371.4	0.1	137.1	512
243.70	1719.37					
243.70	6.53	1726	1600.9	0.1	160.1	672
243.80	1957.84					
243.80	25.38	1983	1854.6	0.1	185.5	858
243.90	2191.28					
243.90	56.55	2248	2115.5	0.1	211.6	1,069
244.00	2434.22					
244.00	100.03	2534	2391.0	0.1	239.1	1,309
244.10	2724.70					
244.10	155.83	2881	2707.4	0.1	270.7	1,579
244.20	6.30					
244.20	3064.00					
244.20	223.95	3294	3087.4	0.1	308.7	1,888
244.30	3491.80					
244.30	320.41	3812	3553.2	0.1	355.3	2,243
244.40	3925.31					
244.40	464.64	4390	4101.1	0.1	410.1	2,653
244.50	4385.24					
244.50	656.68	5042	4715.9	0.1	471.6	3,125
244.60	5987.75					
244.60	-177.58					
244.60	1.77	5812	5426.9	0.1	542.7	3,668
244.70	6547.29					
244.70	-42.15					
244.70	14.39	6520	6165.7	0.1	616.6	4,284
244.80	7099.85					
244.80	-2.30					
244.80	39.14					
244.80	0.07	7137	6828.1	0.1	682.8	4,967
244.90	7597.09					
244.90	2.40					
244.90	76.02					
244.90	3.66	7679	7408.0	0.1	740.8	5,708
245.00	8017.99					
245.00	11.68					
245.00	125.04					
245.00	12.67	8167	7923.3	0.1	792.3	6,500
245.10	8462.09					
245.10	27.94					
245.10	186.19					
245.10	27.13	8703	8435.4	0.1	843.5	7,344
245.20	9161.87					
245.20	51.17					

Date: March 14, 2016

Project: 2361 Chesher Subdivision
Basin Description:

CURRENT POND PERMANENT VOLUME - AVERAGE END AREA CALCULATIONS

Contour Elevation	Individual Contour Area (sq. m)	Net Contour area (sq. m)	Average Area	Depth (m)	Incremental Volume (cu. m)	Cumulative Volume (cu. m)
245.20	47.01	9260	8981.7	0.1	898.2	8,242
245.30	9637.40					
245.30	81.38					
245.30	72.33	9791	9525.6	0.1	952.6	9,195
245.40	10078.44					
245.40	118.69					
245.40	103.08	10300	10045.7	0.1	1004.6	10,199
245.50	11377.82					
245.50	-270.06					
245.50	138.61	11246	10773.3	0.1	1077.3	11,276
245.60	12146.08					
245.60	-187.42					
245.60	178.06	12137	11691.5	0.1	1169.2	12,446
245.70	12826.72					
245.70	-119.83					
245.70	221.44	12928	12532.5	0.1	1253.3	13,699
245.80	14202.21					
245.80	-349.31					
245.80	-67.29	13786	13357.0	0.1	1335.7	15,035
245.90	14662.75					
245.90	-261.38					
245.90	-29.81	14372	14078.6	0.1	1407.9	16,442
246.00	15104.23					
246.00	-190.95					
246.00	-7.38	14906	14638.7	0.1	1463.9	17,906
246.10	15624.84					
246.10	-91.15					
246.10	-135.89	15398	15151.9	0.1	1515.2	19,421
246.20	16021.68					
246.20	-59.84					
246.20	-89.91	15872	15634.9	0.1	1563.5	20,985
246.30	16409.22					
246.30	-35.09					
246.30	-53.40	16321	16096.3	0.1	1609.6	22,595
246.40	16787.44					
246.40	-16.91					
246.40	-26.34	16744	16532.5	0.1	1653.2	24,248
246.50	17156.36					
246.50	-5.29					
246.50	-8.75	17142	16943.3	0.1	1694.3	25,942
246.60	17518.72					
246.60	29.94					
246.60	28.15					
246.60	29.27					
246.60	-0.61	17605	17373.9	0.1	1737.4	**27,679**

Permanent Pool Volume

Pond permanent volume based on survey of pond bottom - Fall 2015
Contours generated from Terrain model based on field survey

Permanent Pool W/L :	246.60	m
Minimum bottom elev:	242.40	m
Maximum Depth:	4.20	m

Date: March 15, 2016

Project: 2361 Chesher Subdivision
Basin Description

CURRENT POND DETENTION VOLUME - AVERAGE END AREA CALCULATIONS

Contour Elevation (m)	Individual Contour Area (sq. m)	Net Contour area (sq. m)	Average Area (sq.m.)	Depth (m)	Incremental Volume (cu. m)	Cumulative Volume (cu. m)	Cumulative Volume (Ha. m)
246.60	17650	17650				0.00	0.00
246.70	18281	18281	17965.6	0.1	1796.6	1797	0.18
246.80	18882	18882	18581.2	0.1	1858.1	3655	0.37
246.90	19518	19518	19199.7	0.1	1920.0	5575	0.56
247.00	20195	20195	19856.3	0.1	1985.6	7560	0.76
247.10	20819	20819	20506.7	0.1	2050.7	9611	0.96
247.20	21335	21335	21076.9	0.1	2107.7	11719	1.17
247.30	21812	21812	21573.7	0.1	2157.4	13876	1.39
247.40	22250	22250	22031.4	0.1	2203.1	16079	1.61
247.50	22651	22651	22450.8	0.1	2245.1	18324	1.83
247.60	23009	23009	22830.0	0.1	2283.0	20607	2.06
247.70	23438	23438	23223.2	0.1	2322.3	22930	2.29
247.80	23820	23820	23628.7	0.1	2362.9	25292	2.53
247.90	24201	24201	24010.4	0.1	2401.0	27693	2.77
248.00	24585	24585	24393.1	0.1	2439.3	30133	3.01
248.10	24973	24973	24779.2	0.1	2477.9	32611	3.26
248.20	25780	25780	25376.4	0.1	2537.6	35148	3.51
248.30	26567	26567	26173.3	0.1	2617.3	37766	3.78
248.40	27053	27053	26809.7	0.1	2681.0	40447	4.04
248.50	27683	27683	27368.0	0.1	2736.8	43183	4.32
248.60	28526	28526	28104.7	0.1	2810.5	45994	4.60

Pond Volumes above permanent pool (246.60m) based on contours generated by site survey, 2015

Culverts Flowing in Inlet Control

Sketches of inlet control flow for both unsubmerged and submerged projecting entrances are shown in Figure 8.30 a and b. Figure 8.30 c shows a mitered entrance flowing submerged with inlet control. An increase in barrel slope reduces headwater only to a small degree, and can normally be neglected for conventional culverts flowing in inlet control.

When the headwater (HW) exceeds 1.5D, true orifice flow exists and can be represented by:

$$Q = C_d A \sqrt{2g\,[HW - D/2]} \qquad (8.80)$$

where:

- C_d = coefficient of discharge (see Table 8.6)
- A = cross section area of discharge of the culvert, m^2
- g = the acceleration due to gravity, m/s^2
- HW = headwater depth, m (refer to Figure 8.30)
- D = diameter of the culvert, m

Table 8.6: Inlet Loss Coefficients (C_d)

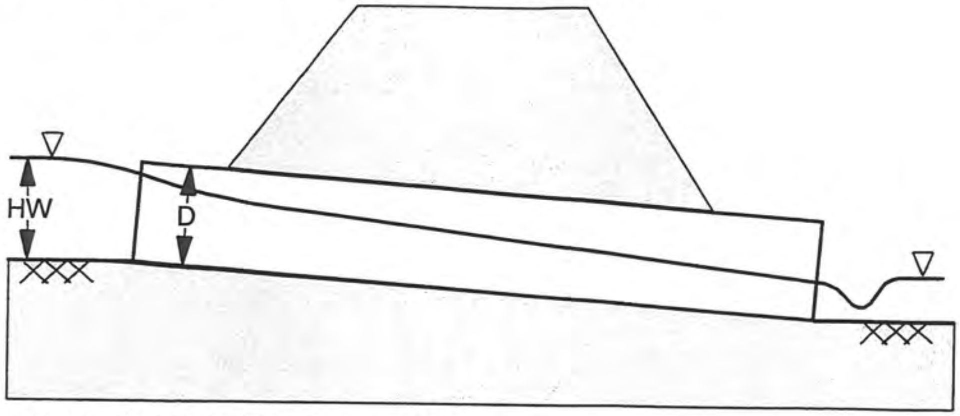
Inlet Type	Discharge Coefficient
Thin Walled Projecting (CSP)	0.50
Flush Headwall	0.60
Cylinder Inlet (1.25 D)	0.67
Socket Inlet (RCP)	0.70
Bellmouth Inlet	0.97

Design Charts 5.39 to 5.45 can be applied in place of Equation 8.80.

When the headwater HW is less than 1.5D, the culvert acts as a weir with a circular cross section; however, the weir equation cannot be solved analytically for such an application and it is not used in practice. Design Charts 2.31 to 2.33 and 5.39 to 5.45 can be used in such cases.

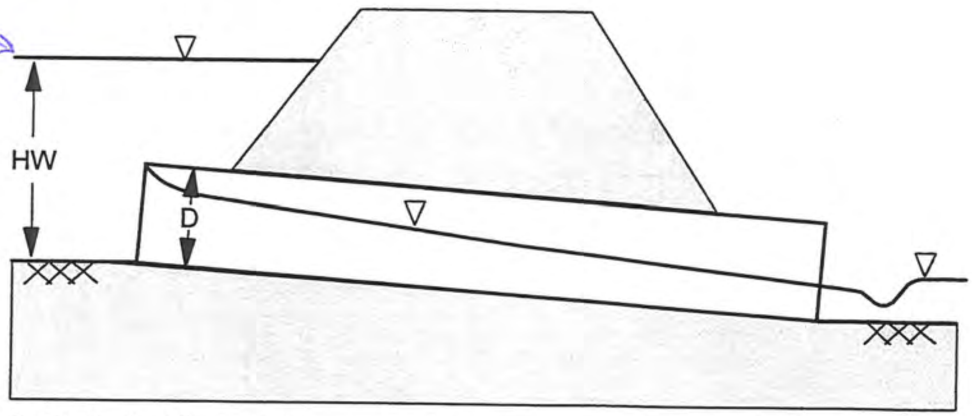
In all culvert design applications, it is important to recognize that headwater, or depth of ponding at the entrance to a culvert, is an important factor in culvert capacity. The headwater depth (HW) is the vertical distance from the culvert invert at the entrance to the energy gradeline of the headwater pool (depth + velocity head - refer to Figure 8.30). Because of the low velocities in most entrance pools, the water surface and the energy line at the entrance are usually assumed to be coincident, thus the headwater depths given by the inlet control charts (Design Charts 2.31 to 2.33 and 5.59 to 5.46) will be higher than will actually occur, by the amount of the velocity head $V^2/2g$ (refer to Figure 8.32). The difference may be ignored unless the approach velocity V_1 is exceptionally high.

Figure 8.30: Flow Profiles for Culvert in Inlet Control

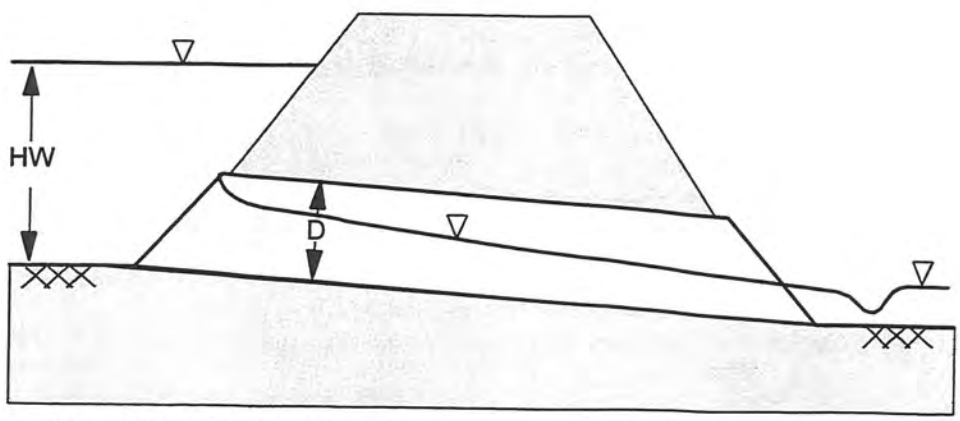


a. Projected End - Unsubmerged Inlet

W/L in Existing Pond

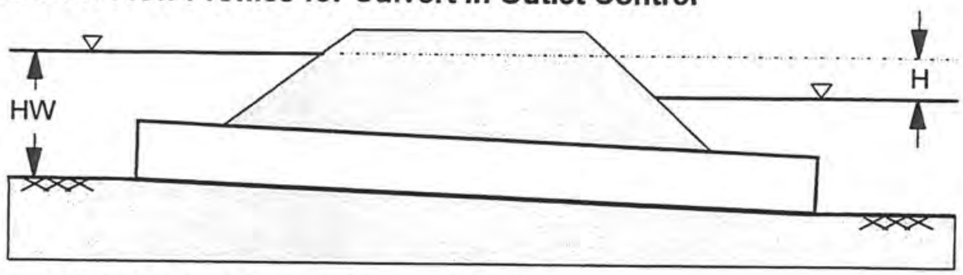


b. Projected End - Submerged Inlet

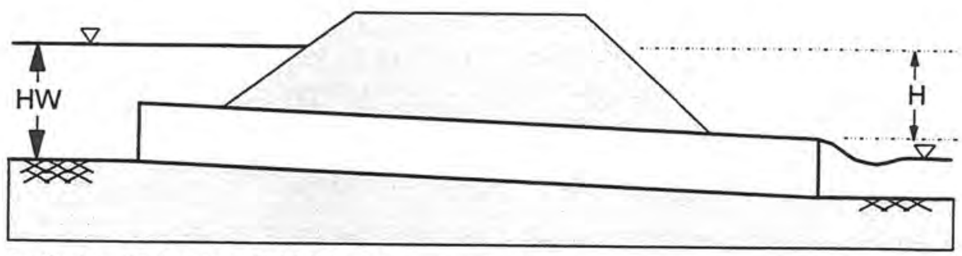


c. Mitered End - Submerged Inlet

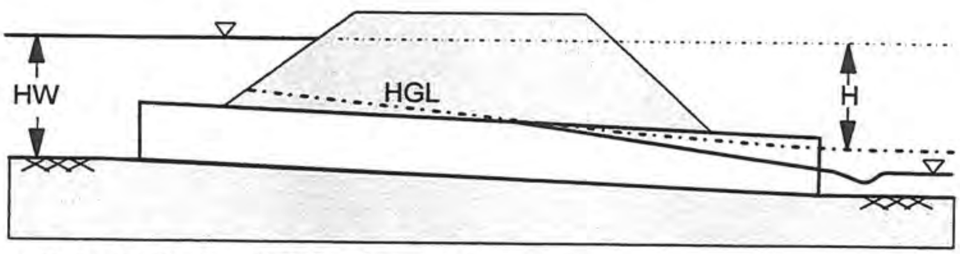
Figure 8.31: Flow Profiles for Culvert in Outlet Control



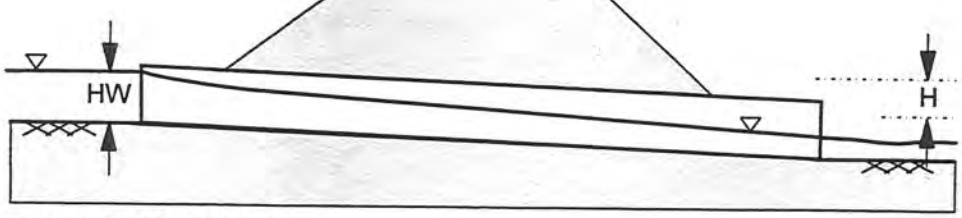
a. Culvert Flowing Full, Submerged Outlet



b. Culvert Flowing Full, Unsubmerged Outlet



c. Culvert Flowing Full For Part Of Its Length

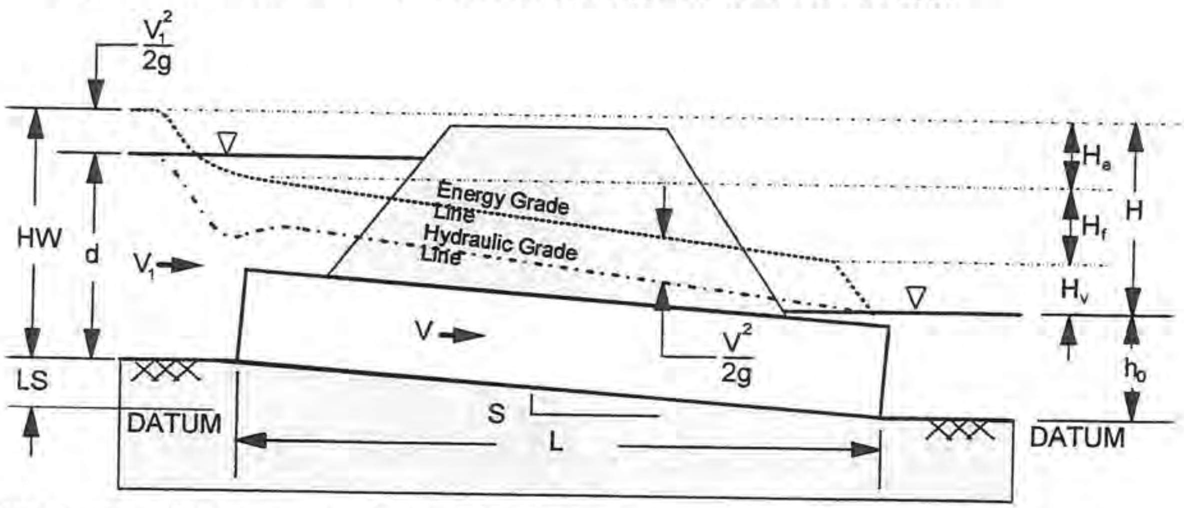


d. Culvert Not Flowing Full

Culverts Flowing in Outlet Control

Culverts in outlet control can flow with the culvert barrel full or partly full (see Figure 8.31). If the entire cross section of the barrel is filled with water for the total length of the barrel, the culvert is said to be flowing full, Figure 8.31 a and b. Two other common types of outlet control flow are shown in Figures 8.31c and d.

Figure 8.32: Hydraulics of Culvert Flowing Full in Outlet Control



The expression for determining the head H is derived by equating the total energy upstream the culvert entrance to the energy just inside the culvert outlet, considering all the major losses in energy. By referring to Figure 8.32 and using the culvert invert at the outlet as a datum, the result is:

$$d + \frac{V_1^2}{2g} + LS = h_0 + H_v + H_e + H_f \qquad (8.81)$$

where:

- d = depth of flow at inlet, m
- $V_1^2/2g$ = velocity head in entrance pool, m
- LS = length of culvert multiplied by the culvert barrel slope, m
- h_0 = depth of flow at outlet, m
- H_v = the velocity head within the barrel, m
- H_e = the entrance loss, m
- H_f = the friction loss, m

Rearranging Equation 8.81:

$$d + \frac{V_1^2}{2g} + LS - h_0 = H_v + H_e + H_f .$$

Head (H)

Head (H) is expressed as an equivalent depth of water (m), and comprises the velocity head within the barrel H_v, the entrance loss H_e, and the friction loss H_f (refer to Figure 8.32),

$$H = H_v + H_e + H_f . \tag{8.82}$$

The velocity head is the difference in elevations between the energy grade line and the hydraulic grade line, which are parallel over the length of the barrel except in the immediate vicinity of the inlet, where the flow contracts and then expands (refer to Figure 8.32). The velocity head H_v is:

$$H_v = \frac{V^2}{2g} \tag{8.83}$$

where:

V = the mean velocity in the culvert barrel, m/s
(the mean velocity is the discharge Q, divided by the barrel cross sectional area A)
g = acceleration due to gravity, m/s^2

H_e accounts for entrance losses and depends upon the geometry of the inlet edge. Lost energy is expressed as a coefficient k_e times the barrel velocity head, or:

$$H_e = k_e \frac{V^2}{2g} \tag{8.56}$$

where:

k_e = entrance loss coefficients (Design Chart 2.08).

The friction loss H_f is the energy required to overcome the roughness of the culvert barrel. The friction loss is given by Equation 8.57, which is derived from the Manning equation.

$$H_f = \frac{19.6\, n^2 L}{R^{4/3}} \frac{V^2}{2g} \tag{8.57}$$

where:

n = Manning's roughness coefficient (Design Chart 2.01);
R = hydraulic radius, m
L = length of culvert barrel, m

Substituting H_v, H_e and H_f in Equation 8.83 and simplifying, the head (H) for full flow is:

$$H = \left[1 + k_e + \frac{19.6\, n^2 L}{R^{4/3}} \right] \frac{V^2}{2g} . \tag{8.84}$$

Design Chart 2.08: Transition Loss Coefficients: Culverts

TYPE OF BARREL AND INLET	K_e
Pipe, Concrete	
Projecting from fill, socket end	0.2
Projecting from fill, square cut end	0.5
Headwall or headwall and wingwalls	
Socket end or pipe	0.2
Square-edge	0.5
Rounded (radius = 1/ 12D)	0.2
Mitered to conform to fill slope	0.7
End-Section conforming to fill slope (standard precast)	0.5
Bevelled edges, 33.7° or 45° bevels	0.2
Side-tapered or slope-tapered inlets	0.2
Pipe, or Pipe-Arch, Corrugated Steel	
Projecting from fill	0.9
Headwall or headwall and wingwalls, square edge	0.5
Mitered to conform to fill slope	0.7
End-Section conforming to fill slope (standard prefab)	0.5
Bevelled edges, 33.7° or 45° bevels	0.25
Side-tapered or slope-tapered inlets	0.2
Box, Reinforced Concrete	
Headwall	
Square-edged on 3 edges	0.5
Rounded on 3 edges to radius of 1/12 barrel dimension, or bevelled edges on 3 sides	0.2
Wingwalls at 30° to 75° to barrel	
Square-edged at crown	0.4
Crown edge rounded to radius of 1/12 barrel dimension, or bevelled top edge	0.2
Wingwalls at 10° to 25° to barrel	
Square-edged at crown	0.5
Wingwalls parallel (extension of sides)	
Square edged at crown	0.7
Side-tapered or slope-tapered inlet	0.2
Projecting	
Square-edge	0.7*
Bevelled edges, 33.7° or 45° bevels	0.2*

* Estimated

Source: Harrison et al (1972), Herr et al (1977)

4.30.7 Wetlands

New development within 30 metres (98.4 feet) of the boundary of a wetland either within the Environmental Protection (EP) Zone or in any other zone category shall only be permitted with the approval of Council, or the local Conservation Authority, where applicable. An approved Environmental Impact Study (EIS) may require a greater setback.

4.30.8 Special Provisions for Kawartha Lakes Shoreline

Section 4.30.1 also applies to lots adjacent to the shoreline along the Kawartha Lakes, including Pigeon Lake, Little Bald Lake, Big Bald Lake, Buckhorn Lake, Lower Buckhorn Lake and Lovesick Lake, which are controlled by the Trent Severn Waterway. Further, no new development, other than those permitted uses within the 30 metre setback as described in subsection 4.30.1 shall be permitted within the regulated flood level ad determined by the local Conservation Authority.

The regulated flood levels (mASL) as of the date of passing of this by-law are:

Buckhorn Lake – 247.12 mASL

Lower Buckhorn Lake – 244.31 mASL

Lovesick Lake – 242.16 mASL

Pigeon Lake – 247.12 mASL

Where it is not possible to achieve the 30-metre (98.4 ft.) setback on an existing lot, a geodetic survey to establish the flood elevation relative to the regulated flood level, as determined by the local Conservation Authority, for new development must be completed.

Proposed expansions to existing buildings or structures within the 30 metre high water mark setback must also provide a geodetic survey.

A geodetic survey is not required for expansions or new development that is outside of the 30 metre high water mark setback.

4.31 Setbacks On Provincial Highways, County Roads And Local Roads

No person shall erect any building or structure unless such building or structure complies with the setback requirements of the authority having jurisdiction for the road, as follows:

a) The minimum setback from the property limit of all Provincial highways shall be as required by the Ontario Ministry of Transportation.

Date: March 15, 2016

Project: 2361 Chesher Subdivision
Basin Description:

CURRENT POND DETENTION VOLUME - AVERAGE END AREA CALCULATIONS

Contour Elevation (m)	Individual Contour Area (sq. m)	Net Contour area (sq. m)	Average Area (sq.m.)	Depth (m)	Incremental Volume (cu. m)	Cumulative Volume (cu. m)	Cumulative Volume (Ha. m)
246.60	17650	17650				0.00	0.00
246.70	18281	18281	17965.6	0.1	1796.6	1797	0.18
246.80	18882	18882	18581.2	0.1	1858.1	3655	0.37
246.90	19518	19518	19199.7	0.1	1920.0	5575	0.56
247.00	20195	20195	19856.3	0.1	1985.6	7560	0.76
247.10	20819	20819	20506.7	0.1	2050.7	9611	0.96
247.20	21335	21335	21076.9	0.1	2107.7	11719	1.17
247.30	21812	21812	21573.7	0.1	2157.4	13876	1.39
247.40	22250	22250	22031.4	0.1	2203.1	16079	1.61
247.50	22651	22651	22450.8	0.1	2245.1	18324	1.83
247.60	23009	23009	22830.0	0.1	2283.0	20607	2.06
247.70	23438	23438	23223.2	0.1	2322.3	22930	2.29
247.80	23820	23820	23628.7	0.1	2362.9	25292	2.53
247.90	24201	24201	24010.4	0.1	2401.0	27693	2.77
248.00	24585	24585	24393.1	0.1	2439.3	30133	3.01
248.10	24973	24973	24779.2	0.1	2477.9	32611	3.26
248.20	25780	25780	25376.4	0.1	2537.6	35148	3.51
248.30	26567	26567	26173.3	0.1	2617.3	37766	3.78
248.40	27053	27053	26809.7	0.1	2681.0	40447	4.04
248.50	27683	27683	27368.0	0.1	2736.8	43183	4.32
248.60	28526	28526	28104.7	0.1	2810.5	45994	4.60

Pond Volumes above permanent pool (246.60m) based on contours generated by site survey, 2015

Flow capacy of culvert outlet, check inlet vs outlet control

Culvert Characteristics

Diameter	1000 mm	Material:	CSP	Downstream W/L	247.12 m
Length	18.8 m	Mannings N:	0.024	(Buckhorn Lake 100 year W/L)	
u/s inv	246.43 m	AREA (sq.m.) A=	0.7854		
d/s inv	246.08 m	R (m) =	0.2500		
Slope	1.86 %				

Calculation Flow under Outlet Control assuming Buckhorn Lake is at 100 year water Level, 247.12m

MTO equation 8.84 rearranged to solve for V (velocity). Q culvert = V x A (culvert area)
See MTO Drainage Mangaement Manual Ch 8, pg 139

Pond W/L (m)	Head above backwater (m)	Entrance Co - eff (ke)	Flow Q (cms)
247.20	0.08	0.5	**0.58**
247.50	0.38	0.5	**1.27**
247.80	0.68	0.5	**1.70**
248.00	0.88	0.5	**1.93**
248.30	1.18	0.5	**2.24**
248.60	1.48	0.5	**2.51**

Inlet co-efficient: See MTO Chart 2.08

Q = A*$((H*2*9.81)/(\frac{1+Ke+19.6*n^2*L}{R^{1.33}}))$^0.5

Calculation Flow under Inlet Control

TWL (m)	Height Above u/s Invert H (m)	Orifice Diameter (mm)	Orifice C	Q Pipe (cms)
247.80	1.37	1000	0.6	1.95
248.00	1.57	1000	0.6	2.16
248.30	1.87	1000	0.6	2.44
248.60	2.17	1000	0.6	2.70

Orifice co-efficient: See MTO Table 8.6 (Chapter 8, p135)

$$Q = \left(\sqrt{2*9.81*(H-\left(\frac{D}{2}\right))}\right)*C*\pi*(\frac{D}{2})\text{^}2$$

Flow rate under outlet control is lower than inlet control. We will consider this to be the worst case and use these flows for modelling the existing pond.

Resulting Stage Storage Rating Curve for Existing Pond (Catchment 501 in Otthymo Model)

Pond W/L (m)	Flow Rate (cms)	Detention Storage (Ha.m.)
247.20	**1.17**	**0.58**
247.50	**1.83**	**1.27**
247.80	**2.53**	**1.70**
248.00	**3.01**	**1.93**
248.30	**3.78**	**2.24**

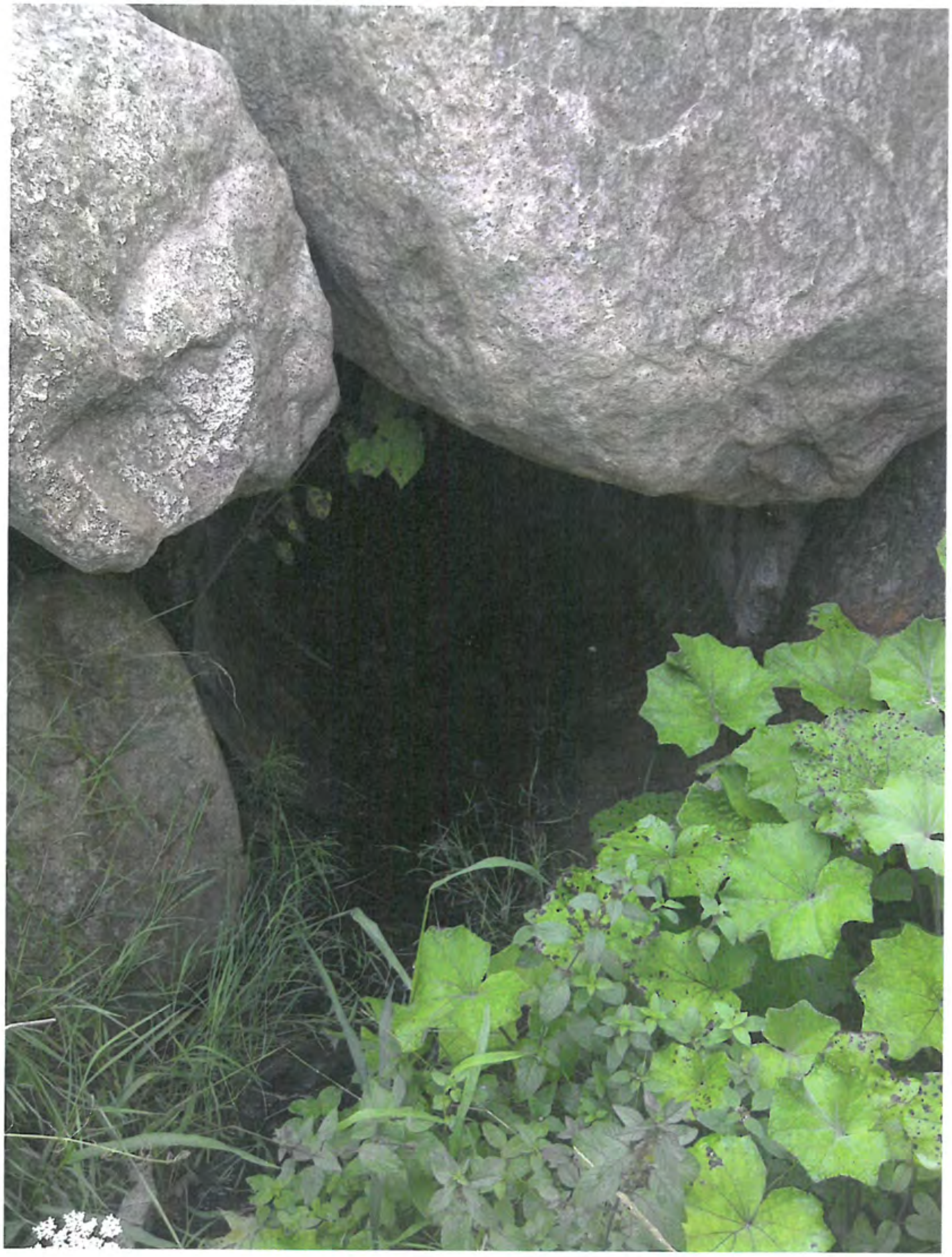
Reference: MTO Drainage Management Manual, Part 3&4, 1995-1997
Drainage and Hydrology Section, Transportation Engineering Branch, Quality and Standards Division

Otthymo Analysis Summary for Existing Pond (Hydrograph 501)

Storm	Outflow Rate	Detention Volume	
2 yr 24hr SCS	0.181	0.0899	
5 yr 24hr SCS	0.327	0.1621	
25 yr 25hr SCS	0.437	0.2167	
50 yr 24hr SCS	0.72	0.3567	
100 yr 24 hr SCS	0.853	0.4230	TWL 246.8 - 246.9
2 yr 4hr Chicago	0.103	0.0512	
5yr 4hr Chicago	0.218	0.1079	
25yr 4hr Chicago	0.452	0.2241	
50yr 4hr Chicago	0.562	0.2788	
100yr 4hr Chicago	0.68	0.3370	TWL 246.7 - 246.8

2361 Granite Ridge Subdivision – Phase II

Photo 1



Adam & Eve Road Culvert – North inlet

Photo 2

Adam & Eve Road Culvert –view from upstream to downstream

Photo 3

Adam & Eve Road Culvert – Outfall

APPENDIX B

Otthymo Model Input Assumptions & Calculations

Drainage Input Assumptions

Roadway ROW = 20m

Asphalt : 6.5m
Gravel : 2.4m } 8.9m Impervious $\frac{8.9m}{20m}$ = 45% C: 98

Lawn 55% C: 58

Lot Area Assumptions - per D.W. Wills report for Phase I

each building lot contains 500m² of Building Roof and Driveway (Impervious)

Balance of Lots in Phase I are wooded

Initial Abstraction Values Wooded : 10mm

Lawn : 5mm

Imp : 1.5mm

Pond : 0mm

Gravel : 10 mm (pit floor)

C factors for Analysis Imp : 98

Woods : 50

Lawn : 58

Gravel*: 70 (modelled as Bare Bedrock draining indirectly to outlet as groundwater.

*Pit floor

Design Chart 1.09: Soil Conservation Service Curve Numbers (Continued)

Land Use or Surface	Hydrologic Soil Group						
	A	AB	B	BC	C	CD	D
Fallow (special cases only)	77	82	86	89	91	93	94
Crop and other improved land	66** (62)	70** (68)	74	78	82	84	86 AMC I
Pasture & other unimproved land	58* (38)	62* (51)	65	71	76	79	81
Woodlots and forest	50* (30)	54* (44)	58	65	71	74	77
Impervious areas (paved)							98
Bare bedrock draining directly to stream by surface flow							98
Bare bedrock draining indirectly to stream as groundwater (usual case)							70
Lakes and wetlands							50

Notes

(i) All values are based on AMC II except those marked by * (AMC III) or ** (mean of AMC II and AMC III).

(ii) Values in brackets are AMC II and are to be used only for special cases.

(iii) Table is not applicable to frozen soils or to periods in which snowmelt contributes to runoff.

Table 2.5: Initial Abstraction / Depression Storage

Cover	Depth (mm)
Woods	10
Meadows	8
Cultivated	7
Lawns	5
Impervious areas	2

Ref: UNESCO, Manual on Drainage in Urbanized Areas, 1987.

Table 2.6: Manning Roughness Coefficients - Overland Flow

Cover	n
Impervious areas	0.013
Woods	
with light underbrush	0.400
with dense underbrush	0.800
Lawns	
Short grass	0.150
Dense grass	0.240
Agriculture Land	0.050-0.170

Ref: Adapted from Soil Conservation Service, Urban Hydrology for Small Watersheds, U.S. Dept. of Agriculture, Soil Conservation Service, Engineering Division, Technical Release 55, June 1986

Uplands Method

Table 2.10: $V/(S^{0.5})$ Relationship for Various Land Covers

Land Cover	$V/(S^{0.5})$ m/s
Forest with heavy ground litter, hay meadow	0.6
Trash fallow or minimum tillage cultivation	1.5
Short Grass Pasture	2.3
Cultivated, straight row	2.7
Nearly bare soil, untilled	3.0
Grassed Waterway (ditch)	4.6
Paved Areas; small upland gullies	6.1

t_c = sum of travel times for each land use

$$\text{Travel Time} = \text{Travel Length} * \left(\text{Slope}^{0.5} * V/(S^{0.5})\right)$$

Where: S = slope, m/m

Notes: * Travel times must be calculated individually for each land use
* Travel times must be calculated along the longest continuous travel path

Ref: Figure 3.11: Velocities for Upland Method for Estimating Travel Time for Overland Flow, American Iron and Steel Institute, "Modern Sewer Design: Canadian Edition," Corrugated Steel Pipe Institute. (1996)

Calculation: Overland Flow Lengths for STANDHYD

Pervious Areas

A typical value for urban pervious areas is 40 m, the depth of a residential lot.

Impervious Areas

The overland flow length for un-calibrated watersheds can be calculated using the following equation:

$$LGI = (A / 1.5)^{0.5}$$

A = subcatchment area, m^2
LGI = overland flow length, m

PN 2361

CHESHER SUBDIVISION - PHASE 2

DATE March 14, 2016
CALCS BWB
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CALCULATION OF OTTHYMO INPUTS EXISTING CONDITIONS

Catchment 101 External, Drains throught Subdivison (Buckhorn Community Center Site)

SCS SOIL TYPE A

AREA **4.25 HA**

GROUND COVER TYPE	**AREA**	**PROPORTION**	**CN (AMC II)**		**INITIAL ABSTRACTION**	
IMPERVIOUS	1.19	28%	98	27.49	2	0.6
GRASSED	0.09	2%	58	1.23	5	0.1
WOODED	2.97	70%	50	34.92	10	7.0
TOTAL	4.25 Ha					
		WEIGHTED AVERAGE		**63.6**		**7.7 mm**

UPSTREAM ELEVATION	273 m		
DOWNSTREAM ELEVATION	272.57 m		
LENGTH OF LONGEST FLOW PATH	145 m ASPHAT SHEET FLOW	SLP =	0.30%
UPSTREAM ELEVATION	272.57 m		
DOWNSTREAM ELEVATION	270.26 m		
LENGTH OF LONGEST FLOW PATH	164 m WOODED	SLP =	1.41%

	LAND USE CONSTANT		VELOCITY	DISTANCE		TIME
FLOW VELOCITY ON ASPHALT	V/S^0.5=	6.1	0.33 m/s	145 m		0.121 HR
FLOW VELOCITY IN WOODED	V/S^0.5=	0.6	0.07 m/s	164 m		0.640 HR
					TOTAL tc	0.761 HR
					Tp=0.67 Tc	**0.510 HR**

Travel Time per NVCA Development Review Guidelines, Table 2.10 pg 2-15

CATCHMENT 102 External, drains through Phase 1 and then east to Adam & Eve Road

SCS SOIL TYPE: A

AREA **8.38 HA**

GROUND COVER TYPE	**AREA**	**PROPORTION**	**CN (AMC II)**		**INITIAL ABSTRACTION**	
IMPERVIOUS	0.99	12%	98	11.55	2	0.2
GRASSED	1.03	12%	58	7.13	5	0.6
WOODED	6.36	76%	50	37.96	10	7.6
TOTAL	8.38 Ha					
		WEIGHTED AVERAGE		**56.6**		**8.4 mm**

UPSTREAM ELEVATION	277.75 m		
DOWNSTREAM ELEVATION	271.63 m		
LENGTH OF LONGEST FLOW PATH	208 m DITCH	SLP =	2.94%
UPSTREAM ELEVATION	271.63 m		
DOWNSTREAM ELEVATION	267.84 m		
LENGTH OF LONGEST FLOW PATH	267 m WOODED	SLP =	1.42%

	LAND USE CONSTANT		VELOCITY	DISTANCE		TIME
FLOW VELOCITY ON ASPHALT	V/S^0.5=	4.6	0.79 m/s	208 m		0.073 Hr
FLOW VELOCITY IN WOODED	V/S^0.5=	0.6	0.07 m/s	267 m		1.038 Hr
					TOTAL tc	1.111 Hr
					Tp=0.67 Tc	**0.744 Hr**

Travel Time per NVCA Development Review Guidelines, Table 2.10 pg 2-15

CATCHMENT 103 Central Portion of Phase I that drains to Phase II and Pond

SCS SOIL TYPE: A

AREA **11.14 HA**

GROUND COVER TYPE	**AREA**		**PROPORTION**	**CN (AMC II)**		**INITIAL ABSTRACTION**	
ROAD ASP & SHOULDER	0.75	45%	7%	98	6.60	2	0.1
ROAD GRASSED DITCH	0.92	55%	8%	58	4.79	5	0.4
HOUSE & DRIVEWAYS	1.60 32 lots		14%	98	14.08	2	0.3
LOT LAWN AREAS			0%	58	0.00	5	0.0
WOODED	7.87		71%	50	35.32	10	7.1
TOTAL	11.14 Ha						
			WEIGHTED AVERAGE		**60.8**		**7.9 mm**

UPSTREAM ELEVATION	273.16 m		
DOWNSTREAM ELEVATION	260 m		
LENGTH OF LONGEST FLOW PATH	671 m GRASSED DITCH	SLP =	1.96%
UPSTREAM ELEVATION	m		
DOWNSTREAM ELEVATION	m		
LENGTH OF LONGEST FLOW PATH	m CULTIVATED	SLP =	#DIV/0!

	LAND USE CONSTANT		VELOCITY	DISTANCE		TIME
FLOW VELOCITY IN GRASSED DITCH	V/S^0.5=	4.6	0.64 m/s	671 m		0.289 Hr
FLOW VELOCITY IN CULTIVATED	V/S^0.5=	2.7	0.00 m/s	0 m		0.000 Hr
					TOTAL tc	0.289 Hr
					Tp=0.67 Tc	**0.194 Hr**

Travel Time per NVCA Development Review Guidelines, Table 2.10 pg 2-15

PN 2361

CHESHER SUBDIVISION - PHASE 2

DATE March 14, 2016
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CALCULATION OF OTTHYMO INPUTS EXISTING CONDITIONS

CATCHMENT 104 Portion of Phase I that drains east to Adam & Eve Road (Lots 2-27, 37-39)

SCS SOIL TYPE: A

AREA **6.86 HA**

GROUND COVER TYPE	AREA		PROPORTION	CN (AMC II)		INITIAL ABSTRACTION	
ROAD ASP & SHOULDER	2.79	45%	41%	98	39.79	2	0.8
ROAD GRASSED DITCH	0.34	55%	5%	58	2.88	5	0.2
HOUSE & DRIVEWAYS	0.55 11 lots		8%	98	7.86	2	0.2
LOT LAWN AREAS			0%	58	0.00	5	0.0
WOODED	3.18		46%	50	23.21	10	4.6
TOTAL	6.86 Ha						
			WEIGHTED AVERAGE		**73.7**		**5.9 mm**

UPSTREAM ELEVATION	270.88 m			
DOWNSTREAM ELEVATION	265.9 m			
LENGTH OF LONGEST FLOW PATH	257 m	GRASSED DITCH	SLP =	1.94%
UPSTREAM ELEVATION	265.9 m			
DOWNSTREAM ELEVATION	261.88 m			
LENGTH OF LONGEST FLOW PATH	207 m	WOODED	SLP =	1.94%

		LAND USE CONSTANT	VELOCITY	DISTANCE		TIME
FLOW VELOCITY IN GRASSED DITCH	V/S^0.5=	4.6	0.64 m/s	257 m		0.111 Hr
FLOW VELOCITY IN WOODED	V/S^0.5=	0.6	0.08 m/s	207 m		0.688 Hr
					TOTAL tc	0.799 Hr
					Tp=0.67 Tc	**0.535 Hr**

Travel Time per NVCA Development Review Guidelines, Table 2.10 pg 2-15

CATCHMENT 105 West Portion of Phase I that drains to Phase II and Pond

SCS SOIL TYPE: A

AREA **6.96 HA**

GROUND COVER TYPE	AREA		PROPORTION	CN (AMC II)		INITIAL ABSTRACTION	
ROAD ASP & SHOULDER	0.54	45%	8%	98	7.60	2	0.2
ROAD GRASSED DITCH	0.65	55%	9%	58	5.42	5	0.5
HOUSE & DRIVEWAYS	1.10		16%	98	15.49	2	0.3
LOT LAWN AREAS			0%	58	0.00	5	0.0
WOODED	4.67		67%	50	33.55	10	6.7
TOTAL	6.96 Ha						
			WEIGHTED AVERAGE		**62.1**		**7.6 mm**

UPSTREAM ELEVATION	275.22 m			
DOWNSTREAM ELEVATION	270.95 m			
LENGTH OF LONGEST FLOW PATH	232 m	WOODED	SLP =	1.84%
UPSTREAM ELEVATION	270.95 m			
DOWNSTREAM ELEVATION	260 m			
LENGTH OF LONGEST FLOW PATH	474 m	GRASSED DITCH	SLP =	2.31%

		LAND USE CONSTANT	VELOCITY	DISTANCE		TIME
FLOW VELOCITY WOODED	V/S^0.5=	0.6	0.08 m/s	232 m		0.792 Hr
FLOW VELOCITY IN GRASSED DITCH	V/S^0.5=	4.6	0.70 m/s	474 m		0.188 Hr
					TOTAL tc	0.980 Hr
					Tp=0.67 Tc	**0.657 Hr**

Travel Time per NVCA Development Review Guidelines, Table 2.10 pg 2-15

CATCHMENT 1051 West Portion of Phase I that drains to internal, natural soak away

SCS SOIL TYPE: A

AREA **0.71 HA**

GROUND COVER TYPE	AREA		PROPORTION	CN (AMC II)		INITIAL ABSTRACTION	
ROAD ASP & SHOULDER	0.00	45%	0%	98	0.00	2	0.0
ROAD GRASSED DITCH	0.00	55%	0%	58	0.00	5	0.0
HOUSE & DRIVEWAYS	0.10 2 lots		14%	98	13.80	2	0.3
LOT LAWN AREAS			0%	58	0.00	5	0.0
WOODED	0.61		86%	50	42.96	10	8.6
TOTAL	0.71 Ha						
			WEIGHTED AVERAGE		**56.8**		8.9 mm

Internal site ponding capture 836 cu.m. Equivalent depth of additional abstraction 118 mm **126.6 mm**

UPSTREAM ELEVATION	270 m			
DOWNSTREAM ELEVATION	265.8 m			
LENGTH OF LONGEST FLOW PATH	67 m	WOODED	SLP =	6.27%

		LAND USE CONSTANT	VELOCITY	DISTANCE		TIME
FLOW VELOCITY WOODED	V/S^0.5=	0.6	0.15 m/s	67 m		0.124 Hr
FLOW VELOCITY IN GRASSED DITCH	V/S^0.5=	4.6	0.70 m/s	0 m		0.000 Hr
					TOTAL tc	0.124 Hr
					Tp=0.67 Tc	**0.083 Hr**

Travel Time per NVCA Development Review Guidelines, Table 2.10 pg 2-15

PN 2361

CHESHER SUBDIVISION - PHASE 2

DATE March 14, 2016
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CALCULATION OF OTTHYMO INPUTS EXISTING CONDITIONS

CATCHMENT 106 West Limit of Phase I and pre-existing lots on Melody Bay Road, drains to soakaway then west across Melody Bay Road

SCS SOIL TYPE: A

AREA **4.14 HA**

GROUND COVER TYPE	AREA		PROPORTION	CN (AMC II)		INITIAL ABSTRACTION	
ROAD ASP & SHOULDER	0.23	45%	6%	98	5.44	2	0.1
ROAD GRASSED DITCH	0.29	55%	7%	58	4.06	5	0.4
HOUSE & DRIVEWAYS	0.40		10%	98	9.47	2	0.2
LOT LAWN AREAS	0.00		0%	58	0.00	5	0.0
WOODED	3.22		78%	50	38.89	10	7.8
TOTAL	4.14 Ha						
			WEIGHTED AVERAGE		**57.9**		8.4 mm

Internal site ponding capture 1321 cu.m. Equivalent depth of additional abstraction: 32 mm **40.3 mm**

UPSTREAM ELEVATION	275.11 m		
DOWNSTREAM ELEVATION	266.40 m		
LENGTH OF LONGEST FLOW PATH	420 m WOODED	SLP =	1.60%

	LAND USE CONSTANT		VELOCITY	DISTANCE		TIME
FLOW VELOCITY IN GRASSED DITCH	V/S^0.5=	4.6	0.70 m/s	0 m		0.000 Hr
FLOW VELOCITY IN WOODED	V/S^0.5=	0.6	0.08 m/s	420 m		1.538 Hr
					TOTAL tc	1.538 Hr
					Tp=0.67 Tc	**1.031 Hr**

Travel Time per NVCA Development Review Guidelines, Table 2.10 pg 2-15

CATCHMENT 107 Main Portion of Phase II, drains to Pond

SCS SOIL TYPE: A

AREA **14.00 HA**

GROUND COVER TYPE	AREA	PROPORTION	CN (AMC II)		INITIAL ABSTRACTION	
ROAD ASP & SHOULDER	0.23	2%	98	1.61	2	0.0
ROAD GRASSED DITCH	0.00	0%	58	0.00	5	0.0
POND*	1.75	13%	100	12.50	2	0.3
GRAVEL**	7.07	50%	70	35.33	10	5.0
WOODED	4.95	35%	50	17.69	10	3.5
TOTAL	14.00 Ha					
		WEIGHTED AVERAGE		**67.1**		**8.9 mm**

* Pond water surface modelled with CN = 100. All rainfall will be converted to runoff
**Gravel (pit floor) modelled as Bare bedrock draining indirectly to stream as groundwater, IA assumed to be similar to wooded areas

UPSTREAM ELEVATION	265.38 m		
DOWNSTREAM ELEVATION	249.71 m		
LENGTH OF LONGEST FLOW PATH	160 m WOODED	SLP =	9.79%
UPSTREAM ELEVATION	249.71 m		
DOWNSTREAM ELEVATION	248.86 m		
LENGTH OF LONGEST FLOW PATH	42 m GRAVEL	SLP =	2.02%
UPSTREAM ELEVATION	248.86 m		
DOWNSTREAM ELEVATION	248.2 m		
LENGTH OF LONGEST FLOW PATH	44 m WOODED	SLP =	1.50%
UPSTREAM ELEVATION	248.2 m		
DOWNSTREAM ELEVATION	247.2 m		
LENGTH OF LONGEST FLOW PATH	77 m DITCH	SLP =	1.30%

	LAND USE CONSTANT		VELOCITY	DISTANCE		TIME
FLOW VELOCITY WOODED	V/S^0.5=	0.6	0.19 m/s	160 m		0.237 Hr
FLOW VELOCITY GRAVEL	V/S^0.5=	3.0	0.43 m/s	42 m		0.027 Hr
FLOW VELOCITY WOODED	V/S^0.5=	0.6	0.07 m/s	44 m		0.166 Hr
FLOW VELOCITY DITCH	V/S^0.5=	4.6	0.56 m/s	77 m		0.038 Hr
area					TOTAL tc	0.468 Hr
					Tp=0.67 Tc	**0.314 Hr**

Travel Time per NVCA Development Review Guidelines, Table 2.10 pg 2-15

CATCHMENT 108 East Portion of Phase II, Drains to Adam & Eve Road, drains to soak away then to south

SCS SOIL TYPE: A

AREA **5.21 HA**

GROUND COVER TYPE	AREA	PROPORTION	CN (AMC II)		INITIAL ABSTRACTION	
POND	0.00	0%	50	0.00	2	0.0
GRAVEL*	0.61	12%	70	8.16	10	1.2
WOODED	4.60	88%	50	44.17	10	8.8
TOTAL	5.21 Ha					
		WEIGHTED AVERAGE		**52.3**		**10.0 mm**

* Gravel (pit floor) modelled as Bare bedrock draining indirectly to stream as groundwater, IA assumed to be similar to wooded areas

UPSTREAM ELEVATION	264.00 m		
DOWNSTREAM ELEVATION	247.72 m		
LENGTH OF LONGEST FLOW PATH	171 m WOODED	SLP =	9.52%

	LAND USE CONSTANT		VELOCITY	DISTANCE		TIME
FLOW VELOCITY WOODED	V/S^0.5=	0.6	0.19 m/s	171 m		0.257 Hr
					TOTAL tc	0.257 Hr
					Tp=0.67 Tc	**0.172 Hr**

Travel Time per NVCA Development Review Guidelines, Table 2.10 pg 2-15

PN 2361

CHESHER SUBDIVISION - PHASE 2

DATE March 14, 2016
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CALCULATION OF OTTHYMO INPUTS EXISTING CONDITIONS

CATCHMENT 109 External Drainage area, West of Melody Bay Road

SCS SOIL TYPE A

AREA **43.23 HA**

GROUND COVER TYPE	AREA		PROPORTION	CN (AMC II)		INITIAL ABSTRACTION	
ROAD ASP & SHOULDER	0.23	45%	1%	98	0.52	2	0.0
ROAD GRASSED DITCH	0.28	55%	1%	58	0.38	5	0.0
IMPERVIOUS (WORKS YARD)	1.18		3%	50	1.36	2	0.1
AGRICUTURAL PASTURE	10.50		24%	58	14.09	5	1.2
WOODED	31.04		72%	50	35.90	10	7.2
TOTAL	43.23 Ha						
			WEIGHTED AVERAGE		**51.4**		8.4 mm

Internal site ponding capture	14903 cu.m.	Equivalent depth of additional abstraction	34 mm	**42.9 mm**

UPSTREAM ELEVATION	290.00 m		
DOWNSTREAM ELEVATION	282.5 m		
LENGTH OF LONGEST FLOW PATH	280 m PASTURE	SLP =	2.68%
UPSTREAM ELEVATION	285.20 m		
DOWNSTREAM ELEVATION	268.4 m		
LENGTH OF LONGEST FLOW PATH	593 m WOODED	SLP =	2.83%

	LAND USE CONSTANT		VELOCITY	DISTANCE		TIME
FLOW VELOCITY PASTURE	V/S^0.5=	2.3	0.38 m/s	280 m		0.207 Hr
FLOW VELOCITY WOODED	V/S^0.5=	0.6	0.10	593 m		1.631 Hr
					TOTAL tc	1.838 Hr
					Tp=0.67 Tc	**1.231 Hr**

Travel Time per NVCA Development Review Guidelines, Table 2.10 pg 2-15

PN 2361

CHESHER SUBDIVISION - PHASE 2

DATE March 14, 2016
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CALCULATION OF OTTHYMO INPUTS PROPOSED CONDITIONS

Catchment 101 External, Drains throught Subdivison (Buckhorn Community Center Site)

SCS SOIL TYPE: A

AREA **4.25 HA**

GROUND COVER TYPE	AREA	PROPORTION	CN (AMC II)		INITIAL ABSTRACTION	
IMPERVIOUS	1.19	28%	98	27.49	2	0.6
GRASSED	0.09	2%	58	1.23	5	0.1
WOODED	2.97	70%	50	34.92	10	7.0
TOTAL	4.25 Ha					
		WEIGHTED AVERAGE		**63.6**		**7.7 mm**

UPSTREAM ELEVATION 273 m
DOWNSTREAM ELEVATION 272.57 m
LENGTH OF LONGEST FLOW PATH 145 m ASPHAT SHEET FLOW SLP = 0.30%

UPSTREAM ELEVATION 272.57 m
DOWNSTREAM ELEVATION 270.26 m
LENGTH OF LONGEST FLOW PATH 164 m WOODED SLP = 1.41%

		LAND USE CONSTANT	VELOCITY	DISTANCE		TIME
FLOW VELOCITY ON ASPHALT	V/S^0.5=	6.1	0.33 m/s	145 m		0.121 HR
FLOW VELOCITY IN WOODED	V/S^0.5=	0.6	0.07 m/s	164 m		0.640 HR
					TOTAL tc	0.761 HR
					Tp=0.67 Tc	**0.600 HR**

Travel Time per NVCA Development Review Guidelines, Table 2.10 pg 2-15

CATCHMENT 102 External, drains through Phase 1 and then east to Adam & Eve Road

SCS SOIL TYPE: A

AREA **8.38 HA**

GROUND COVER TYPE	AREA	PROPORTION	CN (AMC II)		INITIAL ABSTRACTION	
IMPERVIOUS	0.99	12%	98	11.55	2	0.2
GRASSED	1.03	12%	58	7.13	5	0.6
WOODED	6.36	76%	50	37.96	10	7.6
TOTAL	8.38 Ha					
		WEIGHTED AVERAGE		**56.6**		**8.4 mm**

UPSTREAM ELEVATION 277.75 m
DOWNSTREAM ELEVATION 271.63 m
LENGTH OF LONGEST FLOW PATH 208 m DITCH SLP = 2.94%

UPSTREAM ELEVATION 271.63 m
DOWNSTREAM ELEVATION 267.84 m
LENGTH OF LONGEST FLOW PATH 267 m WOODED SLP = 1.42%

		LAND USE CONSTANT	VELOCITY	DISTANCE		TIME
FLOW VELOCITY ON ASPHALT	V/S^0.5=	4.6	0.79 m/s	208 m		0.073 Hr
FLOW VELOCITY IN WOODED	V/S^0.5=	0.6	0.07 m/s	267 m		1.038 Hr
					TOTAL tc	1.111 Hr
					Tp=0.67 Tc	**0.744 Hr**

Travel Time per NVCA Development Review Guidelines, Table 2.10 pg 2-15

PN 2361

CHESHER SUBDIVISION - PHASE 2

DATE March 14, 2016
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CALCULATION OF OTTHYMO INPUTS PROPOSED CONDITIONS

CATCHMENT 103 Central Portion of Phase I that drains to Phase II and Pond

SCS SOIL TYPE: A

AREA **11.14 HA**

GROUND COVER TYPE	AREA		PROPORTION	CN (AMC II)		INITIAL ABSTRACTION	
ROAD ASP & SHOULDER	0.75	45%	7%	98	6.60	2	0.1
ROAD GRASSED DITCH	0.92	55%	8%	58	4.79	5	0.4
HOUSE & DRIVEWAYS	1.60 32 lots		14%	98	14.08	2	0.3
LOT LAWN AREAS			0%	58	0.00	5	0.0
WOODED	7.87		71%	50	35.32	10	7.1
TOTAL	11.14 Ha						
				WEIGHTED AVERAGE	**60.8**		**7.9 mm**

UPSTREAM ELEVATION	273.16 m			
DOWNSTREAM ELEVATION	260 m			
LENGTH OF LONGEST FLOW PATH	671 m GRASSED DITCH	SLP =	1.96%	
UPSTREAM ELEVATION	m			
DOWNSTREAM ELEVATION	m			
LENGTH OF LONGEST FLOW PATH	m CULTIVATED	SLP =	#DIV/0!	

		LAND USE CONSTANT	VELOCITY	DISTANCE		TIME
FLOW VELOCITY IN GRASSED DITCH	V/S^0.5=	4.6	0.64 m/s	671 m		0.289 Hr
FLOW VELOCITY IN CULTIVATED	V/S^0.5=	2.7	0.00 m/s	0 m		0.000 Hr
					TOTAL tc	0.289 Hr
					Tp=0.67 Tc	**0.194 Hr**

Travel Time per NVCA Development Review Guidelines, Table 2.10 pg 2-15

CATCHMENT 104 Portion of Phase I that drains east to Adam & Eve Road (Lots 2-27, 37-39)

SCS SOIL TYPE: A

AREA **6.86 HA**

GROUND COVER TYPE	AREA		PROPORTION	CN (AMC II)		INITIAL ABSTRACTION	
ROAD ASP & SHOULDER	2.79	45%	41%	98	39.79	2	0.8
ROAD GRASSED DITCH	0.34	55%	5%	58	2.88	5	0.2
HOUSE & DRIVEWAYS	0.55 11 lots		8%	98	7.86	2	0.2
LOT LAWN AREAS			0%	58	0.00	5	0.0
WOODED	3.18		46%	50	23.21	10	4.6
TOTAL	6.86 Ha						
				WEIGHTED AVERAGE	**73.7**		**5.9 mm**

UPSTREAM ELEVATION	270.88 m		
DOWNSTREAM ELEVATION	265.9 m		
LENGTH OF LONGEST FLOW PATH	257 m GRASSED DITCH	SLP =	1.94%
UPSTREAM ELEVATION	265.9 m		
DOWNSTREAM ELEVATION	261.88 m		
LENGTH OF LONGEST FLOW PATH	207 m WOODED	SLP =	1.94%

		LAND USE CONSTANT	VELOCITY	DISTANCE		TIME
FLOW VELOCITY IN GRASSED DITCH	V/S^0.5=	4.6	0.64 m/s	257 m		0.111 Hr
FLOW VELOCITY IN WOODED	V/S^0.5=	0.6	0.08 m/s	207 m		0.688 Hr
					TOTAL tc	0.799 Hr
					Tp=0.67 Tc	**0.535 Hr**

Travel Time per NVCA Development Review Guidelines, Table 2.10 pg 2-15

PN 2361 | CHESHER SUBDIVISION - PHASE 2 | DATE March 14, 2016 | CALCS BWB | CHECKED

CALCULATION OF OTTHYMO INPUTS PROPOSED CONDITIONS

CATCHMENT 105 West Portion of Phase I that drains to Phase II and Pond

SCS SOIL TYPE: A

AREA **6.96 HA**

GROUND COVER TYPE	AREA		PROPORTION	CN (AMC II)		INITIAL ABSTRACTION	
ROAD ASP & SHOULDER	0.54	45%	8%	98	7.60	2	0.2
ROAD GRASSED DITCH	0.65	55%	9%	58	5.42	5	0.5
HOUSE & DRIVEWAYS	1.10		16%	98	15.49	2	0.3
LOT LAWN AREAS			0%	58	0.00	5	0.0
WOODED	4.67		67%	50	33.55	10	6.7
TOTAL	6.96 Ha						
				WEIGHTED AVERAGE	**62.1**		**7.6 mm**

UPSTREAM ELEVATION	275.22 m		
DOWNSTREAM ELEVATION	270.95 m		
LENGTH OF LONGEST FLOW PATH	232 m WOODED	SLP =	1.84%
UPSTREAM ELEVATION	270.95 m		
DOWNSTREAM ELEVATION	260 m		
LENGTH OF LONGEST FLOW PATH	474 m GRASSED DITCH	SLP =	2.31%

		LAND USE CONSTANT	VELOCITY	DISTANCE		TIME
FLOW VELOCITY WOODED	V/S^0.5=	0.6	0.08 m/s	232 m		0.792 Hr
FLOW VELOCITY IN GRASSED DITCH	V/S^0.5=	4.6	0.70 m/s	474 m		0.188 Hr
					TOTAL tc	0.980 Hr
					Tp=0.67 Tc	**0.657 Hr**

Travel Time per NVCA Development Review Guidelines, Table 2.10 pg 2-15

CATCHMENT 1051 West Portion of Phase I that drains to internal, natural soak away

SCS SOIL TYPE: A

AREA **0.71 HA**

GROUND COVER TYPE	AREA		PROPORTION	CN (AMC II)		INITIAL ABSTRACTION	
ROAD ASP & SHOULDER	0.00	45%	0%	98	0.00	2	0.0
ROAD GRASSED DITCH	0.00	55%	0%	58	0.00	5	0.0
HOUSE & DRIVEWAYS	0.10 2 lots		14%	98	13.80	2	0.3
LOT LAWN AREAS			0%	58	0.00	5	0.0
WOODED	0.61		86%	50	42.96	10	8.6
TOTAL	0.71 Ha						
				WEIGHTED AVERAGE	**56.8**		8.9 mm

Internal site ponding capture 836 cu.m. Equivalent depth of additional abstraction: 118 mm **126.6 mm**

UPSTREAM ELEVATION	270 m		
DOWNSTREAM ELEVATION	265.8 m		
LENGTH OF LONGEST FLOW PATH	67 m WOODED	SLP =	6.27%

		LAND USE CONSTANT	VELOCITY	DISTANCE		TIME
FLOW VELOCITY WOODED	V/S^0.5=	0.6	0.15 m/s	67 m		0.124 Hr
FLOW VELOCITY IN GRASSED DITCH	V/S^0.5=	4.6	0.70 m/s	0 m		0.000 Hr
					TOTAL tc	0.124 Hr
					Tp=0.67 Tc	**0.083 Hr**

Travel Time per NVCA Development Review Guidelines, Table 2.10 pg 2-15

PN 2361

CHESHER SUBDIVISION - PHASE 2

DATE March 14, 2016
CALCS BWB
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CALCULATION OF OTTHYMO INPUTS PROPOSED CONDITIONS

CATCHMENT 106 West Limit of Phase I and pre-existing lots on Melody Bay Road, drains to soakaway then west across Melody Bay Road

SCS SOIL TYPE: A

AREA **4.14 HA**

GROUND COVER TYPE	AREA		PROPORTION	CN (AMC II)		INITIAL ABSTRACTION	
ROAD ASP & SHOULDER	0.23	45%	6%	98	5.44	2	0.1
ROAD GRASSED DITCH	0.29	55%	7%	58	4.06	5	0.4
HOUSE & DRIVEWAYS	0.40		10%	98	9.47	2	0.2
LOT LAWN AREAS	0.00		0%	58	0.00	5	0.0
WOODED	3.22		78%	50	38.89	10	7.8
TOTAL	4.14 Ha						
				WEIGHTED AVERAGE	**57.9**		8.4 mm

Internal site ponding capture 1321 cu.m. Equivalent depth of additional abstraction: 32 mm **40.3 mm**

UPSTREAM ELEVATION		275.11 m			
DOWNSTREAM ELEVATION		268.40 m			
LENGTH OF LONGEST FLOW PATH		420 m WOODED		SLP = 1.60%	
	LAND USE CONSTANT		VELOCITY	DISTANCE	TIME
FLOW VELOCITY IN GRASSED DITCH	V/S^0.5=	4.6	0.70 m/s	0 m	0.000 Hr
FLOW VELOCITY IN WOODED	V/S^0.5=	0.6	0.08 m/s	420 m	1.538 Hr
				TOTAL tc	1.538 Hr
				Tp=0.67 Tc	**1.031 Hr**

Travel Time per NVCA Development Review Guidelines, Table 2.10 pg 2-15

CATCHMENT 109 External Drainage area, West of Melody Bay Road

SCS SOIL TYPE: A

AREA **43.23 HA**

GROUND COVER TYPE	AREA		PROPORTION	CN (AMC II)		INITIAL ABSTRACTION	
ROAD ASP & SHOULDER	0.23	45%	1%	98	0.52	2	0.0
ROAD GRASSED DITCH	0.28	55%	1%	58	0.38	5	0.0
IMPERVIOUS (WORKS YARD)	1.18		3%	50	1.36	2	0.1
AGRICUTURAL PASTURE	10.50		24%	58	14.09	5	1.2
WOODED	31.04		72%	50	35.90	10	7.2
TOTAL	43.23 Ha						
				WEIGHTED AVERAGE	**51.4**		8.4 mm

Internal site ponding capture 14903 cu.m. Equivalent depth of additional abstraction: 34 mm **42.9 mm**

UPSTREAM ELEVATION		290.00 m			
DOWNSTREAM ELEVATION		282.50 m			
LENGTH OF LONGEST FLOW PATH		280 m PASTURE		SLP = 2.68%	
UPSTREAM ELEVATION		285.20 m			
DOWNSTREAM ELEVATION		268.4 m			
LENGTH OF LONGEST FLOW PATH		593 m WOODED		SLP = 2.83%	
	LAND USE CONSTANT		VELOCITY	DISTANCE	TIME
FLOW VELOCITY PASTURE	V/S^0.5=	2.3	0.38 m/s	280 m	0.207 Hr
FLOW VELOCITY WOODED	V/S^0.5=	0.6	0.10	593 m	1.631 Hr
				TOTAL tc	1.838 Hr
				Tp=0.67 Tc	**1.231 Hr**

Travel Time per NVCA Development Review Guidelines, Table 2.10 pg 2-15

PN 2361

CHESHER SUBDIVISION - PHASE 2

DATE March 14, 2016
CALCS BWB
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CALCULATION OF OTTHYMO INPUTS PROPOSED CONDITIONS

CATCHMENT 201 West Portion of Phase II, Drains to Pond

SCS SOIL TYPE: A

AREA **4.58 HA**

GROUND COVER TYPE	AREA		PROPORTION	CN (AMC II)		INITIAL ABSTRACTION	
ROAD ASP & SHOULDER	0.63	45%	14%	98	13.44	2	0.3
ROAD GRASSED DITCH	0.77	55%	17%	58	9.72	5	0.8
HOUSE & DRIVEWAYS	0.35 7 lots		8%	98	7.49	2	0.2
LOT LAWN AREAS			0%	58	0.00	5	0.0
WOODED	2.83		62%	50	30.94	10	6.2
TOTAL	4.58 Ha						
				WEIGHTED AVERAGE	**61.6**		**7.5 mm**

UPSTREAM ELEVATION		260.00 m			
DOWNSTREAM ELEVATION		247.00 m			
LENGTH OF LONGEST FLOW PATH		400 m GRASSED DITCH		SLP =	3.25%
UPSTREAM ELEVATION		m			
DOWNSTREAM ELEVATION		m			
LENGTH OF LONGEST FLOW PATH		m GRASSED DITCH		SLP =	#DIV/0!

	LAND USE CONSTANT		VELOCITY	DISTANCE		TIME
FLOW VELOCITY WOODED	V/S^0.5=	4.6	0.83 m/s	400 m		0.134 Hr
FLOW VELOCITY IN WOODED	V/S^0.5=	0.6	0.00 m/s	0 m		0.000 Hr
					TOTAL tc	0.134 Hr
					Tp=0.67 Tc	**0.090 Hr**

Travel Time per NVCA Development Review Guidelines, Table 2.10 pg 2-15

CATCHMENT 202

SCS SOIL TYPE: A

AREA **2.12 HA**

GROUND COVER TYPE	AREA		PROPORTION	CN (AMC II)		INITIAL ABSTRACTION	
ROAD ASP & SHOULDER	0.15	45%	7%	98	7.15	2	0.1
ROAD GRASSED DITCH	0.19	55%	9%	58	5.17	5	0.4
HOUSE & DRIVEWAYS	0.20 4 lots		9%	98	9.25	2	0.2
LOT LAWN AREAS	1.58		74%	58	43.13	5	3.7
WOODED	0.00		0%	50	0.00	10	0.0
POND	0.00		0%	50	0.00	0	0.0
TOTAL	2.12 Ha						
				WEIGHTED AVERAGE	**64.7**		**4.5 mm**

UPSTREAM ELEVATION		260.00 m			
DOWNSTREAM ELEVATION		249.01 m			
LENGTH OF LONGEST FLOW PATH		205 m GRASSED DITCH		SLP =	5.36%
UPSTREAM ELEVATION		m			
DOWNSTREAM ELEVATION		m			
LENGTH OF LONGEST FLOW PATH		m WOODED		SLP =	#DIV/0!

	LAND USE CONSTANT		VELOCITY	DISTANCE		TIME
FLOW VELOCITY IN GRASSED DITCH	V/S^0.5=	4.6	1.07 m/s	205 m		0.053 Hr
FLOW VELOCITY IN WOODED	V/S^0.5=	0.6	#DIV/0! m/s	0 m		0.000 Hr
					TOTAL tc	0.053 Hr
					Tp=0.67 Tc	**0.036 Hr**

Travel Time per NVCA Development Review Guidelines, Table 2.10 pg 2-15

PN 2361

CHESHER SUBDIVISION - PHASE 2

DATE March 14, 2016
CALCS BWB
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CALCULATION OF OTTHYMO INPUTS PROPOSED CONDITIONS

CATCHMENT 203 East side of Phase II, drains to Adam & Eve Road

SCS SOIL TYPE: A

AREA **3.80 HA**

GROUND COVER TYPE	AREA		PROPORTION	CN (AMC II)		INITIAL ABSTRACTION	
ROAD ASP & SHOULDER	0.00		0%	98	0.00	2	0.0
ROAD GRASSED DITCH	0.00		0%	58	0.00	5	0.0
HOUSE & DRIVEWAYS	0.40		11%	98	10.32	2	0.2
LOT LAWN AREAS	0.00		0%	58	0.00	5	0.0
WOODED	3.40		89%	50	44.74	10	8.9
TOTAL	0.40 Ha						
			WEIGHTED AVERAGE		**55.1**		**9.2 mm**

UPSTREAM ELEVATION	259.00 m		
DOWNSTREAM ELEVATION	249.00 m		
LENGTH OF LONGEST FLOW PATH	121 m WOODED	SLP =	8.26%
UPSTREAM ELEVATION	m		
DOWNSTREAM ELEVATION	m		
LENGTH OF LONGEST FLOW PATH	m CULTIVATED	SLP =	#DIV/0!

	LAND USE CONSTANT		VELOCITY	DISTANCE		TIME
FLOW VELOCITY IN GRASSED DITCH	V/S^0.5=	4.6	0.00 m/s	0 m		Hr
FLOW VELOCITY IN WOODED	V/S^0.5=	2.7	0.78 m/s	121 m		0.043 Hr
					TOTAL tc	0.043 Hr
					Tp=0.67 Tc	**0.029 Hr**

Travel Time per NVCA Development Review Guidelines, Table 2.10 pg 2-15

CATCHMENT 204 South Half Street C, Drains to channel then to Pond

SCS SOIL TYPE: A

AREA **0.43 HA**

GROUND COVER TYPE	AREA		PROPORTION	CN (AMC II)		INITIAL ABSTRACTION	
ROAD ASP & SHOULDER	0.16	45%	38%	98	36.92	2	0.8
ROAD GRASSED DITCH	0.20	55%	46%	58	26.71	5	2.3
HOUSE & DRIVEWAYS	0.00		0%	98	0.00	2	0.0
LOT LAWN AREAS	0.07		16%	58	9.44	5	0.8
WOODED	0.00		0%	50	0.00	10	0.0
TOTAL	0.43 Ha						
			WEIGHTED AVERAGE		**73.1**		**3.9 mm**

UPSTREAM ELEVATION	249.86 m		
DOWNSTREAM ELEVATION	247.00 m		
LENGTH OF LONGEST FLOW PATH	299 m DITCH	SLP =	0.96%
UPSTREAM ELEVATION	m		
DOWNSTREAM ELEVATION	m		
LENGTH OF LONGEST FLOW PATH	m CULTIVATED	SLP =	#DIV/0!

	LAND USE CONSTANT		VELOCITY	DISTANCE		TIME
FLOW VELOCITY IN GRASSED DITCH	V/S^0.5=	4.6	0.45 m/s	299 m		0.185 Hr
FLOW VELOCITY IN WOODED	V/S^0.5=	2.7	0.26 m/s	m		0.000 Hr
					TOTAL tc	0.185 Hr
					Tp=0.67 Tc	**0.124 Hr**

Travel Time per NVCA Development Review Guidelines, Table 2.10 pg 2-15

PN 2361

CHESHER SUBDIVISION - PHASE 2

DATE March 14, 2016
CALCS BWB
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CALCULATION OF OTTHYMO INPUTS PROPOSED CONDITIONS

CATCHMENT 205	Residendial Lots surrounding pond							
								SCS SOIL TYPE: A
AREA	8.25 HA							
GROUND COVER TYPE	AREA		PROPORTION	CN (AMC II)		INITIAL ABSTRACTION		
ROAD ASP & SHOULDER	0.24	45%	3%	98	2.83	2	0.1	
ROAD GRASSED DITCH	0.29	55%	4%	58	2.05	5	0.2	
HOUSE & DRIVEWAYS	0.65 13 ots		8%	98	7.72	2	0.2	
LOT LAWN AREAS	4.80 Lot 10-19		58%	58	33.77	5	2.9	
WOODED	0.52 Lot 7,8,9		6%	50	3.13	10	0.6	
POND *	1.75		21%	100	21.21	0	0.0	
TOTAL	8.25 Ha							
				WEIGHTED AVERAGE	70.7		3.9 mm	

* Pond water surface modelled with CN = 100. All rainfall will be converted to runoff

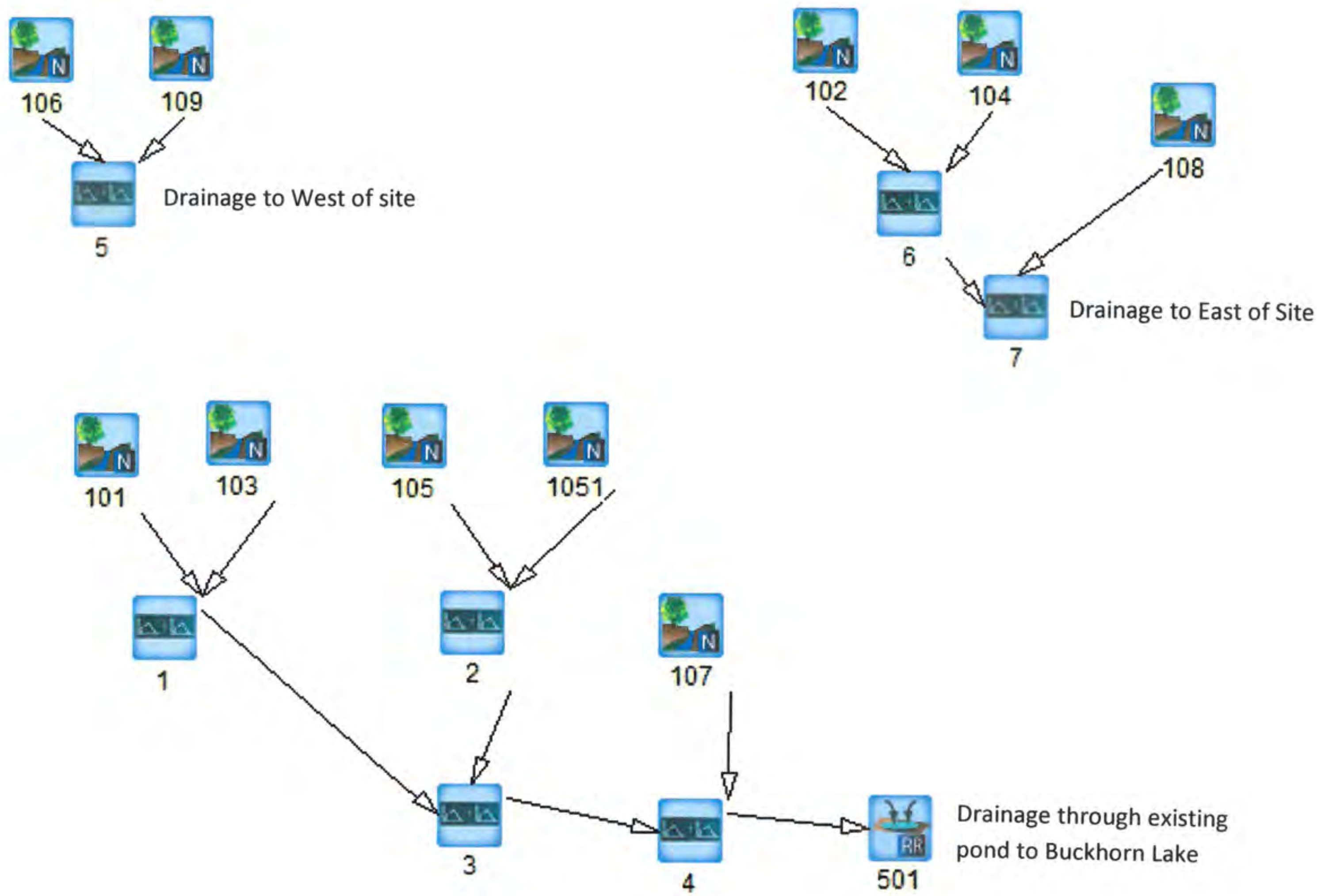
UPSTREAM ELEVATION		249.86 m			
DOWNSTREAM ELEVATION		247.00 m			
LENGTH OF LONGEST FLOW PATH		198 m WOODED		SLP =	1.44%
UPSTREAM ELEVATION		m			
DOWNSTREAM ELEVATION		m			
LENGTH OF LONGEST FLOW PATH		m CULTIVATED		SLP =	#DIV/0!

	LAND USE CONSTANT		VELOCITY	DISTANCE		TIME
FLOW VELOCITY IN GRASSED DITCH	V/S^0.5=	4.6	0.55 m/s	198 m		0.099 Hr
FLOW VELOCITY IN WOODED	V/S^0.5=	2.7	0.32 m/s	0 m		0.000 Hr
					TOTAL tc	0.099 Hr
					Tp=0.67 Tc	0.067 Hr

Travel Time per NVCA Development Review Guidelines, Table 2.10 pg 2-15

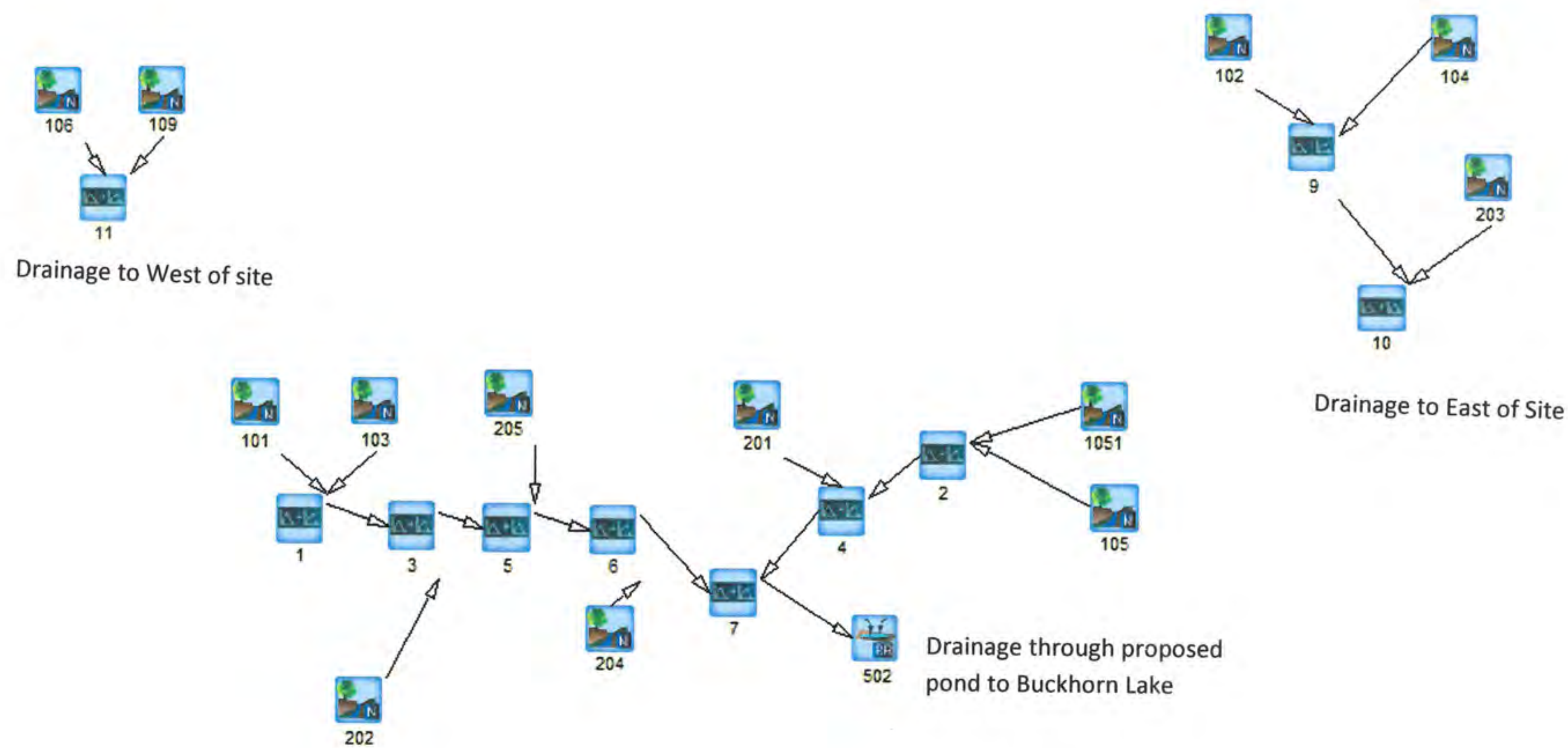
GRANITE RIDGE SUBDIVISON – PHASE II

Pre-Development Otthymo Model



GRANITE RIDGE SUBDIVISON – PHASE II

Post-Development Otthymo Model



APPENDIX C

Stormwater Quality Control Analysis

Bryan Bolivar

From: Johnston, Chris (ENE) [Chris.Johnston@ontario.ca]
Sent: April-29-13 1:17 PM
To: Bryan Bolivar
Cc: Trudy Paterson; Castro, Victor (ENE)
Subject: RE: 2361 Granite Ridge Subdivision - Phase II

Hi Bryan,

Mr. Victor Castro from the Ministry's Technical Support Section – Surface Water Group has undertaken a review of your proposal and provides the following comments:

I reviewed the Granite Ridge Subdivision – Phase 2 Preliminary Stormwater Management Report Township of Galway-Cavendish & Harvey dated June 2011 prepared by Skelton, Brumwell and Associated Inc.

The property is located in Part of Lots 8 & 9, Concession 9 in the geographic Township of Harvey. The site is 18.85 ha and proposed for a second phase of a residential subdivision adjacent to Buckhorn Lake.

The stormwater plan for Phase 2 is to use an existing pond that was created historically as part of a previous aggregate extraction operation. Drainage from most of Phase II would be directed into this pond which drains via a culvert under Adam & Eve Road directly to Buckhorn Lake. Buckhorn Lake is part of the Kawartha Lakes system. Water quality in the lake is generally considered good, however, over the last few years there have been reported algae blooms on this system.

The consultant proposes an enhanced level of treatment for Phase 2. This level of treatment is considered appropriate given the proximity of Buckhorn Lake. Enhanced protection corresponds to the end of pipe storage volumes required for the long-term average removal of 80% of suspended solids. This will be accomplished through the use of the existing pond on site. According to the consultants, the existing pond is capable of conservatively meeting these storage volumes. I will defer to the Approvals Branch Review Engineer to assess these calculations and the design aspects of the application to determine if they meet MOE guidelines.

A small portion of the lands that drain to the east will not flow to the stormwater pond. Instead, lot level and conveyance type controls will be used to manage this stormwater. I have no concerns with this approach.

Please forward these comments to Approvals Branch.

If you have any questions regarding these comments please contact me at (613) 540-6862.

If you still wish to have a meeting please let me know and we can try to arrange it.

Regards,

Chris Johnston, B.A. C.E.T.
Provincial Officer, Badge No. 782
Peterborough District Office
Eastern Region

Ontario Ministry of the Environment
300 Water Street, 2nd Floor, South Tower
Peterborough, ON K9J 8M5

Tel: 705-755-4308, Fax: 705-755-4321
Toll Free: 1-800-558-0595

After Hours Spills: 1-800-268-6060
Email: chris.johnston@ontario.ca
Website: http://www.ene.gov.on.ca

From: Bryan Bolivar [mailto:bbolivar@skeltonbrumwell.ca]
Sent: April 10, 2013 2:57 PM
To: Johnston, Chris (ENE)
Cc: Trudy Paterson
Subject: RE: 2361 Granite Ridge Subdivision - Phase II

Mr. Johnston

I writing to follow up on this request for a pre-consultation meeting. Our client is anxious for us to proceed and the next step is pre-consultation with MOE.

Can you follow up with tech support and give us an idea as to when they may be finished their review?

Thank-you

Bryan W. Bolivar, P.Eng | Senior Project Engineer
Skelton, Brumwell & Associates Inc.
Engineering Planning Environmental Consultants
93 Bell Farm Rd, Suite 107, Barrie, ON L4M 5G1
Tel: 705-726-1141*114 | Toll Free: 877-726-1141
Cell: 705-715-6997
www.skeltonbrumwell.ca
"Adding Value to Your Enterprise"

From: Jamieson, Keith (ENE) [mailto:Keith.Jamieson@ontario.ca]
Sent: March-28-13 4:00 PM
To: Johnston, Chris (ENE)
Cc: Bryan Bolivar
Subject: FW: 2361 Granite Ridge Subdivision - Phase II

Hi Chris,

I have sent this to tech support for review (SW). When the review is complete the client would like to set up a pre-consultation meeting.

Keith Jamieson
Senior Environmental Officer
Ministry of the Environment
Peterborough District Office
Office: 705-755-4309
Fax: 705-755-4321

From: Bryan Bolivar [mailto:bbolivar@skeltonbrumwell.ca]
Sent: March 18, 2013 3:10 PM
To: Jamieson, Keith (ENE)
Subject: FW: 2361 Granite Ridge Subdivision - Phase II

Mr. Jamieson

Following up on the email below. Our client is instructing us to proceed with this development project and your feedback is needed. Please get back to us as soon as you are able.

Bryan W. Bolivar, P.Eng | Senior Project Engineer
Skelton, Brumwell & Associates Inc.
Engineering Planning Environmental Consultants
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From: Bryan Bolivar
Sent: March-08-13 10:20 AM
To: 'keith.jamieson@ontario.ca'
Cc: Trudy Paterson
Subject: 2361 Granite Ridge Subdivision - Phase II

Mr. Jamieson

Our office has completed a preliminary SWM design a proposed residential subdivision development in Buckhorn. The site is located generally at the intersection of Melody Bay Road and Adam and Eve Road. The proponent is Mr. Jeff Chesher.

The site itself is former wayside pit with an existing pond that was constructed as a by-product of aggregate extraction. We are proposing to modify the pond out structure to allow it to act as a stormwater management quality / quantity control pond as well as an amenity feature for the proposed lots that will surround it.

We would like to pre-consult with your office regarding the proposed SWM plan in advance of detailed design and application for an ECA. We are attaching a PDF copy of the SWM report that has already been circulated to the municipality. We can also forward you bound hard copies with full size drawings for your review and / or electronic files for flow modelling, volume calculations, etc.

Please confirm that your office is able to pre-consult on this project and what your requirements are.

I will be away from the office March 11 to 15 however the project is being headed by Ms. Trudy Paterson at our office and she can answer back ground questions and expedite document delivery in my absence.

Bryan W. Bolivar, P.Eng | Senior Project Engineer
Skelton, Brumwell & Associates Inc.
Engineering Planning Environmental Consultants
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3.3.2 Water Quality Sizing Criteria

The volumetric water quality criteria are presented in Table 3.2. The values are based on a 24 hour drawdown time and a design which conforms to the guidance provided in this manual. Requirements differ with SWMP type to reflect differences in removal efficiencies. Of the specified storage volume for wet facilities, 40 m^3/ha is extended detention, while the remainder represents the permanent pool.

Table 3.2 Water Quality Storage Requirements based on Receiving Waters[1, 2]

Protection Level	SWMP Type	Storage Volume (m^3/ha) for Impervious Level			
		35%	**55%**	**70%**	**85%**
Enhanced 80% long-term S.S. removal	Infiltration	25	30	35	40
	Wetlands	80	105	120	140
	Hybrid Wet Pond/Wetland	110	150	175	195
	Wet Pond	140	190	225	250
Normal 70% long-term S.S. removal	Infiltration	20	20	25	30
	Wetlands	60	70	80	90
	Hybrid Wet Pond/Wetland	75	90	105	120
	Wet Pond	90	110	130	150
Basic 60% long-term S.S. removal	Infiltration	20	20	20	20
	Wetlands	60	60	60	60
	Hybrid Wet Pond/Wetland	60	70	75	80
	Wet Pond	60	75	85	95
	Dry Pond (Continuous Flow)	90	150	200	240

[1] Table 3.2 does not include every available SWMP type. Any SWMP type that can be demonstrated to the approval agencies to meet the required long-term suspended solids removal for the selected protection levels under the conditions of the site is acceptable for water quality objectives. The sizing for these SWMP types is to be determined based on performance results that have been peer-reviewed. The designer and those who review the design should be fully aware of the assumptions and sampling methodologies used in formulating performance predictions and their implications for the design.

[2] Hybrid Wet Pond/Wetland systems have 50-60% of their permanent pool volume in deeper portions of the facility (e.g., forebay, wet pond).

For levels of imperviousness below 35%, required storage volumes may be obtained by extrapolating the values provided in Table 3.2. For levels of imperviousness between those included in Table 3.2, required storage volumes may be obtained by interpolation.

It should be noted that the total drainage area contributing to the facility should be included in sizing (lumped imperviousness or separate calculations for internal and external drainage areas is permissible) in most cases. The exception occurs when an external drainage area is itself controlled by a separate water quality facility (and erosion and quantity control are either not required or provided separately). Modelling studies (Marshall Macklin Monaghan Limited, 1997) indicate comparable combined long-term removal rates for ponds in series and separate parallel ponds. More frequent overflows will occur from the most downstream pond, but this can be compensated for by doubling the water quality active storage volume from 40 to 80 m^3/ha.

The volumetric criteria specified in Table 3.2 address only water quality, not erosion, baseflow or flooding concerns. Furthermore, the criteria were developed based on the removal of suspended solids via settling, and therefore, may not adequately address contaminants which must be removed by other mechanisms.

3.3.3 Results of Monitoring SWMP Performance

In the late 1990s a partnership of government agencies pooled their resources to undertake a series of monitoring studies aimed at assessing the water quality performance of selected SWMPs through the Stormwater Assessment and Monitoring Performance (SWAMP) Program (Meek and Liang, 1998). Most of the facilities monitored did not meet the design guidance provided in this or the previous version of the Manual as they were constructed before this guidance was available. Nevertheless, the results of the monitoring program are of use in assessing the performance of stormwater management facilities.

In addition to the efforts conducted under SWAMP, numerous studies of performance have been conducted both inside and outside of Ontario. Most performance studies in Ontario have been of wet pond or pond/wetland systems. Key results of performance studies, and their implications to SWMP design in Ontario, are summarized below.

- The results of performance studies indicate a fair consistency for most end-of-pipe SWMP types (typically 60-80% suspended solids (SS) removal and 40-50% total phosphorus (TP) removal);

Table 4.6: Wet Ponds – Summary of Design Guidance

Design Element	Design Objective	Minimum Criteria	Preferred Criteria
Drainage Area	Volumetric turnover	5 hectares	≥ 10 hectares
Treatment Volume	Provision of appropriate Level of protection (see Section 3.3.1.1)	As per Table 3.2	1. Permanent Pool volume increased by expected maximum ice volume 2. Active Storage increased from 40 m^3/ha to 25% of total volume
Active Storage Detention	Suspended Solids Settling	24 hrs (12 hrs if in conflict with minimum orifice size)	24 hrs
Forebay	Pre-treatment	Minimum Depth: 1 m Sized to ensure non-erosive velocities leaving forebay Maximum Area: 33% of total Permanent Pool	Minimum Depth: 1.5 m Maximum Volume: 20% of total Permanent Pool
Length-to-Width Ratio	Maximize flow path and minimize short-circuiting potential	Overall: minimum 3:1 (may be accomplished by berms, etc.) Forebay: minimum 2:1	From 4:1 to 5:1
Permanent Pool Depth	Minimize re-suspension, avoid anoxic conditions	Maximum Depth: 3 m Mean Depth: 1 m - 2 m	Maximum Depth: 2.5 m Mean Depth: 1 m - 2 m
Active Storage Depth	Storage/Flow Control	Water Quality and Erosion Control: maximum 1.5 m Total (including quantity control): 2 m	Water Quality and Erosion Control: maximum 1.0 m Total (including quantity control): 2 m
Side slopes	Safety Maximize the functionality of the pond	5:1 for 3 m on either side of the permanent pool Maximum 3:1 elsewhere	7:1 near normal water level plus use of 0.3 m steps 4:1 elsewhere

Table 4.6: Wet Ponds – Summary of Design Guidance (cont'd)

Design Element	Design Objective	Minimum Criteria	Preferred Criteria
Inlet	Avoid clogging/ freezing	Minimum: 450 mm Preferred pipe slope: > 1% If submerged, obvert 150 mm below expected maximum ice depth	
Outlet	Avoid clogging/ freezing	Minimum: 450 mm outlet pipe Reverse sloped pipe should have a minimum diameter of 150 mm Preferred pipe slope: > 1% If orifice control used, 75 mm diameter minimum	Minimum 100 mm orifice
Maintenance Access	Access for backhoes or dredging equipment	Provided to approval of Municipality	Provision of maintenance drawdown pipe
Sediment Drying Area	Sediment removal	While preferable, should only be incorporated into the design when it imposes no additional land requirement	To be provided above maximum water quality water level Drainage returned to Pond
Buffer	Safety	Minimum 7.5 m above maximum water quality/erosion control water level Minimum 3 m above high water level for quantity control	

PN 09-2361	CHESHER SUBDIVISION PHASE 2 - GALWAY-CAVENDISH & HARVEY	DATE	March 15, 2016
	QUALITY CONTROL WET CELL SIZING	CALCS	BWB
		Revised	

Existing Pond to be treated as a combined Quantity / Quality Control Wet facility, sized for MOE Enhanced (80% sediment removal)

TOTAL POND CATCHMENT AREA

Existing 101	4.25 Ha	1.19 Ha Asphalt, Concrete, Gravel, Roofs
Existing 103	11.14 Ha	3.28 Ha Asphalt, Concrete, Gravel, Roofs
Existing 105	6.96 Ha	2.29 Ha Asphalt, Concrete, Gravel, Roofs
Existing 1051	0.71 Ha	0 Ha Asphalt, Concrete, Gravel, Roofs
Proposed 201	4.58 Ha	1.75 Ha Asphalt, Concrete, Gravel, Roofs
Proposed 202	2.12 Ha	0.54 Ha Asphalt, Concrete, Gravel, Roofs
Proposed 204	0.43 Ha	0.36 Ha Asphalt, Concrete, Gravel, Roofs
Proposed 205	8.36 Ha	1.18 Ha Asphalt, Concrete, Gravel, Roofs
	38.55 Ha	10.59 Ha Asphalt, Concrete, Gravel

Overall Imperviousness contributing to sediment loading **27%**

Per MOE SWMPDM, Table 3.2

35% Imperviousness requires total volume =	140 cu.m./Ha	wet pond		
55% Imperviousness requires total volume =	190 cu.m./Ha	wet pond		
27% Imperviousness requires total volume =	121.18 cu.m/ Ha			
Extended Detention portion =	40.00 cu.m / Ha		=	1542 cu.m
so that Permanent Pool portion =	81.18 cu.m / Ha		=	3129 cu.m

Extended Detention Volume Provided: Total extended detention volume provided is approximately 10,877 cu.m. as calculated between the permanent pool surface and the high flow weir outlet. Refer to "Stormwater Mangement Pond" in Appendix D.

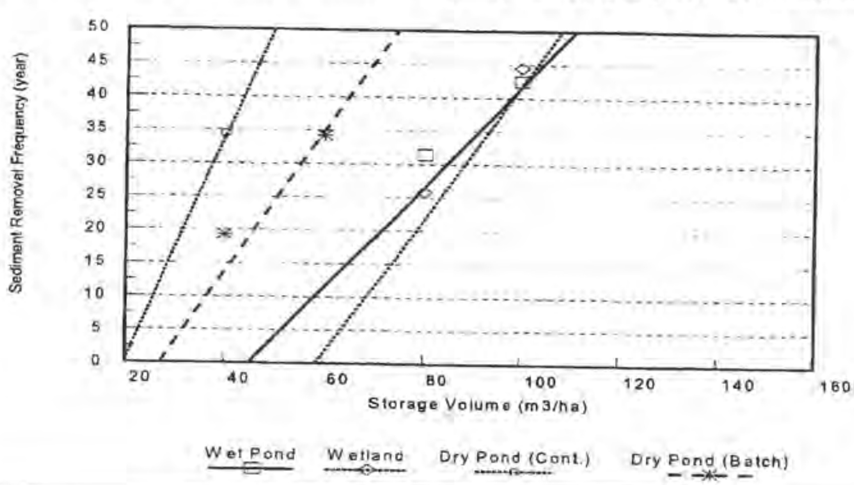
Exisitng pond formed from previous aggregate extraction with a max depth of approximately 4.2m, and an averge 1.58m

The total permanent pool volume in the pond is 27,679 cu.m. This is roughly 8.8 times the required permanent pool volume required to meeting MOE Enhanced Quality Control.

The effective storage volume is 718 cu.m./Ha

Using MOE Figure 6.1 - the estimate required interval to maintain at least 75% removal efficiency would be roughly 7 x 50 years =350 yrs if we conservatively treat the catchment to be 35% impervious rather than it's actual 27% imperviousness

Figure 6.1: Storage Volume vs. Removal Frequency - for 35% Impervious Catchments



To better quantify the cleaning interval, calculate the time interval to fill the pond the the minimum required volume of 3,129 cu.m.

Current Pond Volume	27,675
Minimum Volume	3,129
Volume of Sediment allowed to fill pond	24,546 cu.m.

MOE Table 6.3 - estimates that the annual sediment loading from a catchment that his 35% impvious is 0.6 cu.m./Ha
Conservatively, assuming that the 38.55 Ha catchment is 35%, the annual sediment loading would be 23.13 cu.m.

The time frame to fill the pond with 24,546 cu.m. of sediment would be: 1,061 years.

Table 6.3: Annual Sediment Loadings

Catchment Imperviousness	Annual Loading (kg/ha)	Wet Density (kg/m³)	Annual Loading (m³/ha)
35%	770	1,230	0.6
55%	2,300	1,230	1.9
70%	3,495	1,230	2.8
85%	4,680	1,230	3.8

SWM Planning & Design Manual - 6-13 - *Operation, Maintenance and Monitoring*

Asssuming that the first cleaning of the pond would be 1000 years in the future is of course not practical. It is likely that sediment would accumulate in the pond at the intlet points, creating mouding that would need to be cleaned out for aesthetic concerns and to ensure the inlet channel flow capacities are maintained. Depending on the efficiency and maintenance of upstream sediment capture practices, it would be roughly estimated that cleaning of the pond at the point where inlet channels discharge may be required after say 50-100 years.

PN 09-2361 **CHESHER SUBDIVISION PHASE 2 - GALWAY-CAVENDISH & HARVEY**

DATE March 15, 2016
CALCS BWB
Revised

QUALITY CONTROL INFILTRATION VOLUME SIZING

Existing Pond to be treated as a combined Quantity / Quality Control Wet facility, sized for MOE Enhanced (80% sediment removal)

TOTAL POND CATCHMENT AREA

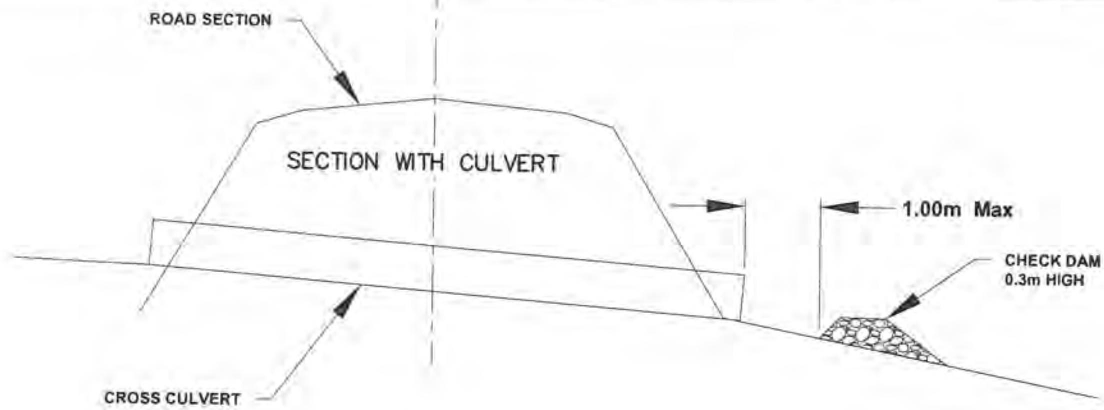
Proposed 203	3.80 Ha	0.4 Ha Asphalt, Concrete, Gravel, Roofs
	3.80 Ha	0.4 Ha Asphalt, Concrete, Gravel

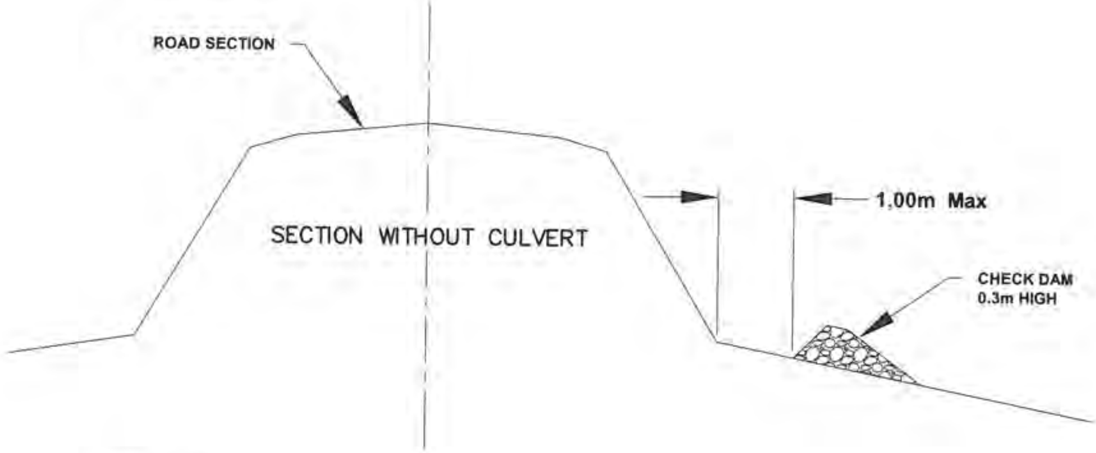
Overall Imperviousness contributing to sediment loading **11%**

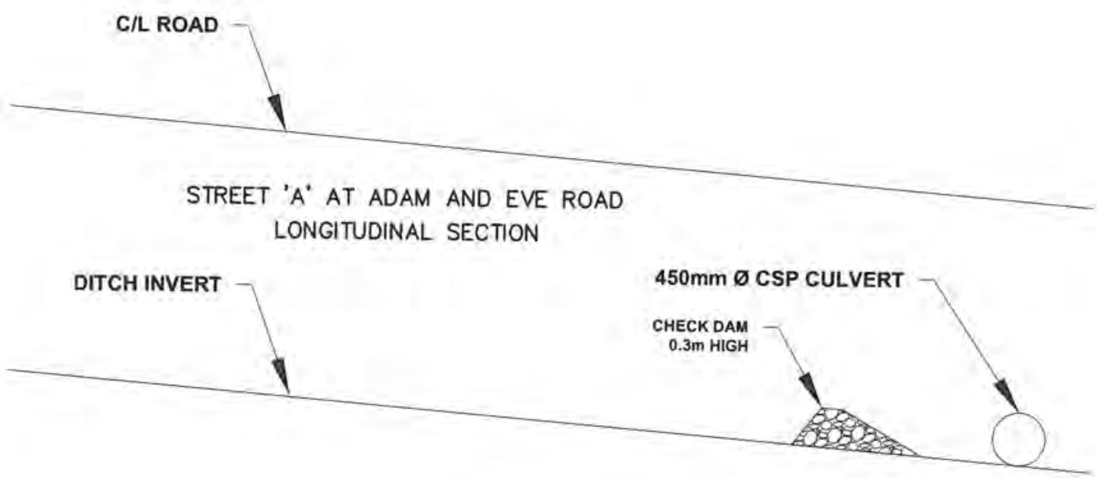
Per MOE SWMPDM, Table 3.2

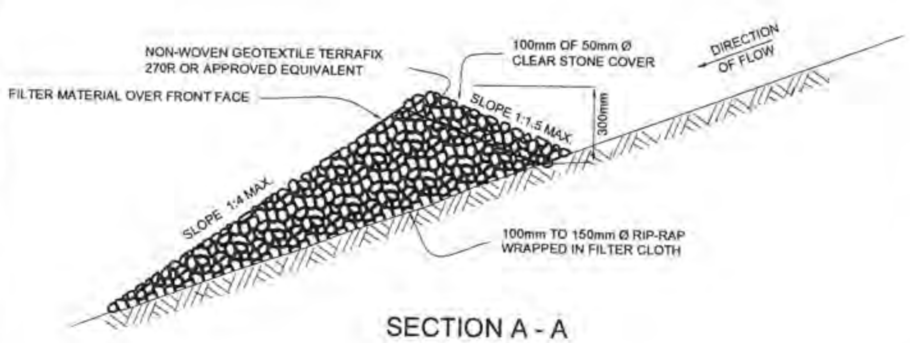
35% Imperviousness requires total volume =	25 cu.m./Ha	infiltration
55% Imperviousness requires total volume =	30 cu.m./Ha	infiltration
11% Imperviousness requires total volume =	18.88 cu.m/ Ha	

Total Infiltration volume = 18.88 cu.m / Ha = 72 cu.m









SECTION A - A

Chesher Subdivision Phase 2 Trent Lakes	
Figure C-1 Pond Inlet Sections with Check Dams	
Scale	
P/N 09-2361	March 31, 2016

93 BELL FARM ROAD, SUITE 107
BARRIE, ONTARIO L4M 5G1
TELEPHONE (705) 726-1141
FAX (705) 726-0331

APPENDIX D

Proposed Stormwater Pond & Outlet Design

PN 2361 **CHESHER SUBDIVISION - PHASE 2**

DATE March 23, 2016
CALCS BWB

Pond Volume Calculation

Permanent Pool: 246.60m
Safety Shelf: 3m @ 5% to 246.75m
Pond Bank slope to 100 yr W/L: 7:1 from 246.75m to 247.50m

Contour Elevation		Contour Area (sq. m)		Average Area (sq.m.)	Depth (m)		Incremental Volume (cu. m)	Cumulative Volume (cu. m)
246.60		17,595			N/A		N/A	0
246.68		18,513		18054	0.08		1444	1,444
246.75		19,330		18922	0.07		1325	2,769
246.80		19,660		19495	0.05		975	3,744
246.90		20,074		19867	0.10		1987	5,730
247.00		20,492		20283	0.10		2028	7,759
247.10		20,913		20703	0.10		2070	9,829
247.15		20,998		20956	0.05		1048	10,877
247.20		21,338		21168	0.05		1058	11,935
247.30		21,765		21552	0.10		2155	14,090
247.40		22,195		21980	0.10		2198	16,288
247.50		22,498		22347	0.10		2235	18,523

Low flow / extended detention outlet will be 200mm pipe set at invert 246.60.

High flow weir invert will be set at 247.15m, which is just above 100 year Buckhorn lake level of 247.12m

Extended detention volume provided in the design is then: **10,877 cu.m.**
Per calculaions for Quality Control Wet Cell Sizing, the requried extended detention volume is :
1542 cu.m.

The provided extended detention volume is >>> than the required.

For modelling purposes, the avaialble pond volume below the weir will be ignored, conservatively assuming that the downstream water level is at 247.12m

Ignoring the volume between 246.60m and 247.15m for detention, the resulting pond volumes are:

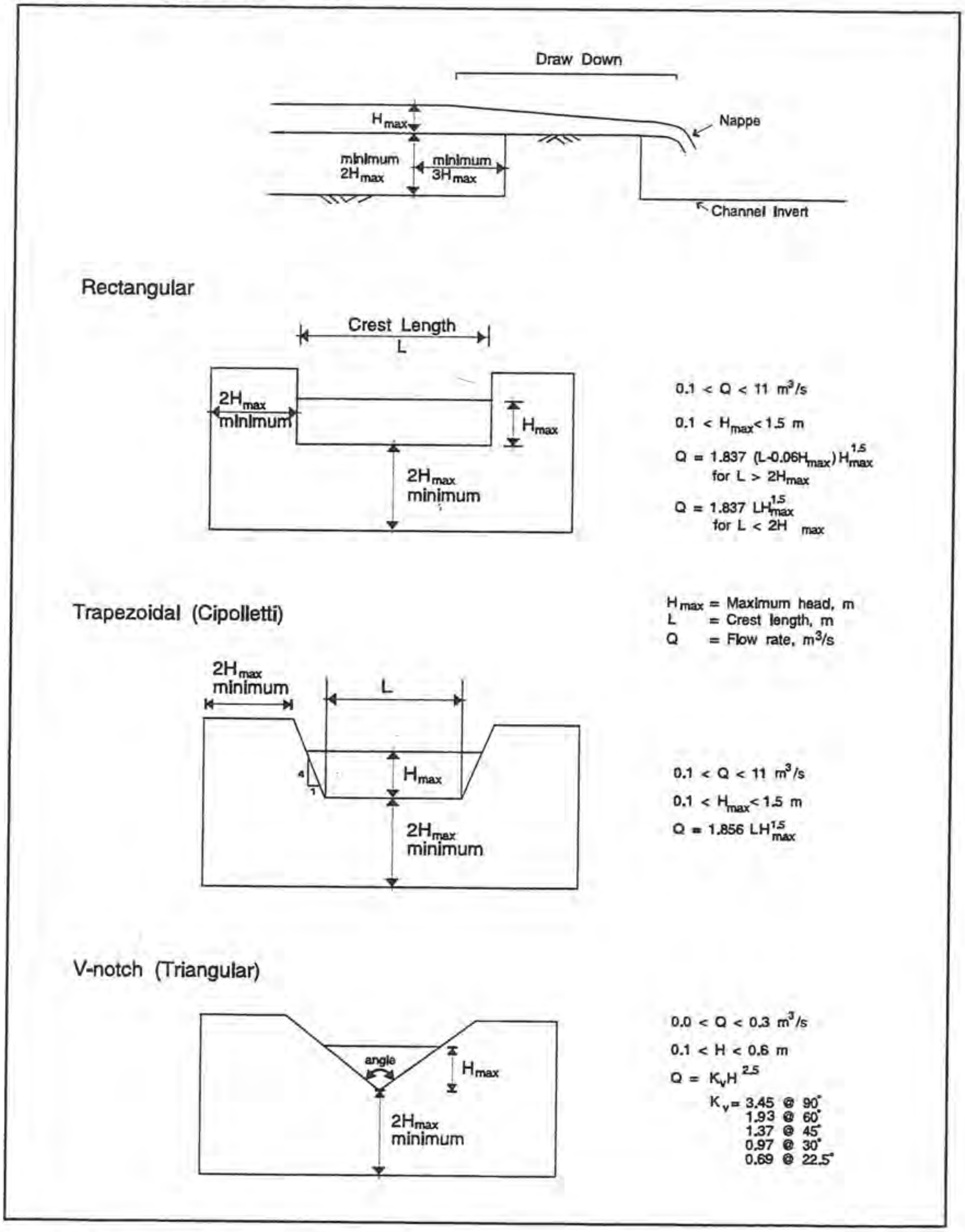
Contour Elevation		Contour Area (sq. m)		Average Area (sq.m.)	Depth (m)		Incremental Volume (cu. m)	Cumulative Volume (cu. m)
247.15		20,998						0
247.20		21,338		21168	0.05		1058.4	1,058
247.30		21,765		21552	0.10		2155.15	3,214
247.40		22,195		21980	0.10		2198	5,412
247.50		22,498		22347	0.10		2234.65	7,646

Table 2.9: Routing Coefficients

Application	C
Orifice	0.63
Orifice Tube	0.80 ← Applied for low flow outlet pipe through weir
~~Sharp Crested Weir~~	~~1.7~~
Broad Crested Weir	1.5

A sharp crested weir coefficient should be used when there is air underneath the nappe. Such conditions would exist for a stormwater management pond weir outlet. A broad crested weir assumes the nappe is supported. An example of a broad crested weir would be a road crossing. Generally, when the ratio of flow depth divided by the weir thickness is greater than 0.5 a sharp crested weir coefficient should be used. When the ratio is less than 0.5 the broad crested weir coefficient should be used.

Figure 8.28: Types of Weirs



(MTO, 1992)

MTO Drainage Management Manual 1997

Flow Over Weirs and Notches

A weir is a flow control device used in drainage systems to control discharges, typically in detention ponds. It can also be used as a flow measuring device by measuring the head over the weir and converting it into a dishcarge by knowing the head-discharge relationship. A weir may consists of a flat vertical plate, in this case it would be known as sharp-crested weir, or a solid broad section, this would be referred to as a broad-crested weir. Weirs may be classified according to their shape, rectangular, triangular, trapezoidal (Cipoletti) or parabolic. The most common geometric shapes of weir structures and their corresponding head-discharge relationships are shown in Figure 8.28 (MTO, 1992).

For the flow over a weir to follow the head-dishcarge relationships, shown in Figure 8.28 and described in the following sections, the downstream water level must be lower than the crest. If the downstream water level is high such that it effects the flow over the weir, a situation referred to as a flood out situations, the submergence effect should taken into account and evaluated.

Rectangular Sharp-Crested Weir

Water flowing over a sharp-crested weir under free discharge conditions is shown in Figure 8.28. Air is usually trapped between the nappe and the weir. The pressure of the trapped air is below atmospheric pressure and has the effect of increasing the discharge of the weir. This may cause damage to the downstream channel. Proper design of sharp-crested weirs should include ventilation pipes to release this pressure differential.

The discharge over a sharp-crested weirs can be estimated from Smith (1978) formula:

$$Q = 1.837\, b * h^{3/2} \tag{8.72}$$

where:

- b = crest length of weir, m
- h = upstream head, m, measured vertically from weir crest to the water surface (at least 3 h distance upstream of the weir).

Two major factors that influence the discharge are the approaching flow velocity and side contractions for the flow.

If $b/h > 2$, the weir crest length should be reduced to account for the effects of side contractions. For such weirs, discharge can be calculated using:

$$Q = 1.837 * (b - 0.06h) * h^{3/2} \tag{8.73}$$

The discharge from these equations should be further adjusted for the effects of submergence using Design Chart 2.47.

For cases where the weir width, b, is less than the channel width, B, Design Chart 2.42 gives the weir coefficient, adjusted for rectangular contractions for different b/B ratios.

Example 8.22: Sharp-Crested Rectangular Weir

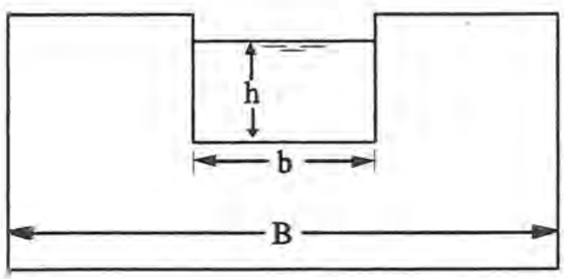
Required

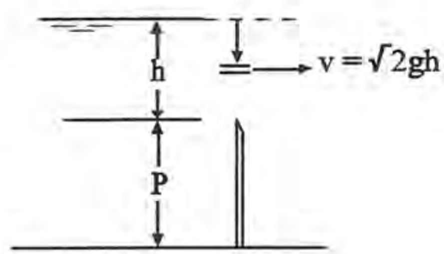
The cross section and longitudinal elevation of a sharp crested weir is shown in the figure below. It is a standard, uncontracted, horizontal weir where width, L, is equal to the channel width, B.

Given

Weir crest length, b = 5.0 m
Weir height, P = 0.5 m
Upstream headwater above crest, h = 0.5 m
Downstream headwater above crest, h_s = 0.25 m

Solution





Crest length b/h > 2
Discharge $Q = 1.837 * (b - 0.06h) * h^{3/2}$ (8.73)
Apply submergence factor (Design Chart 2.47)

$h_s/h = 0.5$
$C_s/C = 0.85$

Therefore,

$$Q = (0.85)(1.837)(b - 0.06h)h^{3/2} = 2.75\ m^3/s \quad (8.73)$$

P/N 09-2361

CHESHER SUBDIVISION - PHASE 2

Date: March 30, 2016
Calcs: BWB

Stormwater Management Pond

Outflow Weir
2 m Width (b)
0.35 m Height (h)
247.15 m invert
5.71 (b)/(h) > 2
Q = 1.837 * (b-0.06h) * h^1.5

Culvert under Adam & Eve Road
Diameter (mm)= 1000 | Entrance Coefficient = 0.5 | AREA (sq.m.) = 0.7854
Length (m)= 18.8 | Number of Culverts = 1 | R (m) = 0.2500
Mannings n = 0.024

	TWL (m)	Stage 1 WEIR: Depth Over Weir (h) (m)	Stage 1 WEIR: Q Weir (cms)	RATING CURVE: Total Weir Flow (cms)	RATING CURVE: Storage Volume (Ha.m.)	Total (cu.m.)	TWL m
1	247.15	0.00	0	0.000	0.000	0	247.15
2	247.20	0.05	0.04	0.040	0.106	1,058	247.20
3	247.30	0.15	0.20	0.204	0.321	3,214	247.30
5	247.40	0.25	0.42	0.425	0.541	5,412	247.40
7	247.50	0.35	0.68	0.681	0.765	7,646	247.50

Road Crossing Culvert based on Outlet Control

Buckhorn Lake Level m	Head Difference m	Culvet Flow cms	Is road flow greater than pond flow?
247.120	0.03	0.36	yes
247.120	0.08	0.58	yes
247.120	0.18	0.87	yes
247.120	0.28	1.09	yes
247.120	0.38	1.27	yes

Notes:
1. Weir flow calculation: Q=1.837*(b-0.06h)* h^1.5, per MTO Drainage Manual, Chapter 8, pg 119 (sharp crested weir), Equation 8.73
2. Anaysis completed assuming downstream water level in Buckhorn lake is at 100 year level = 247.12m. Low flow, extended detention outlet pipe assumed to have zero flow

TOP WATER LEVEL INTERPOLATION (BASED ON DETAINED VOLUME) 4 HOUR CHICAGO DISTRIBUTION

			VOLUME (cu.m.)	TWL (cms)
2 YEAR CHICAGO	DETAINED VOLUME	1140 cu.m.	1,058	247.20
INTERPOLATED TOP WATER LEVEL		**247.20 m**	3,214	247.25
5 YEAR CHICAGO	DETAINED VOLUME	2045 cu.m.	1058	247.20
INTERPOLATED TOP WATER LEVEL		**247.25 m**	3214	247.30
25 YEAR CHICAGO	DETAINED VOLUME	3704 cu.m.	3214	247.30
INTERPOLATED TOP WATER LEVEL		**247.32 m**	5412	247.40
50 YEAR CHICAGO	DETAINED VOLUME	4416 cu.m.	3214	247.30
INTERPOLATED TOP WATER LEVEL		**247.35 m**	5412	247.40
100 YEAR CHICAGO	DETAINED VOLUME	5179 cu.m.	5412	247.40
INTERPOLATED TOP WATER LEVEL		**247.39 m**	7646	247.50

TOP WATER LEVEL INTERPOLATION (BASED ON DETAINED VOLUME) 24 HOUR SCS DISTRIBUTION

			VOLUME (cu.m.)	TWL (cms)
2 YEAR SCS	DETAINED VOLUME	1644 cu.m.	1058	247.20
INTERPOLATED TOP WATER LEVEL		**247.21 m**	3214	247.25
5 YEAR SCS	DETAINED VOLUME	2664 cu.m.	1058	247.20
INTERPOLATED TOP WATER LEVEL		**247.24 m**	3214	247.25
25 YEAR SCS	DETAINED VOLUME	4423 cu.m.	3214	247.30
INTERPOLATED TOP WATER LEVEL		**247.36 m**	5412	247.40
50 YEAR SCS	DETAINED VOLUME	5183 cu.m.	5412	247.40
INTERPOLATED TOP WATER LEVEL		**247.39 m**	7646	247.50
100 YEAR SCS	DETAINED VOLUME	5980 cu.m.	5412	247.40
INTERPOLATED TOP WATER LEVEL		**247.43 m**	7646	247.50

Size low flow - extended detention outlet

Per MOE SWMPDM Table 3.2, the calculated required extended detention volume (active storage volume) for the pond is: 1542 cu.m. (Refer to calculation sheet : Quantity Control Wet Cell Sizing)
The design permanent water level is the same as existing, 246.60m. The weir invert has been set at 247.15m. This means the pond volume between 246.60m and 247.15m is considered extended deteiton
Reviewing pond design volumes, this shows the pond design provides a total extended detention volume of : 10,877 cu.m.

Refereing the MOE SWMPDM Table 4.6, it is desireable to have the active storage volume drain down over a time period of between 24-48 hours. However, the in this pond design, the active storage volume is being ignored in terms of pond detention performance. As such, the upper limit of draw down time is not significant in terms of overall pond performance. Furhter, the provided extneded detention volume is approximately 7 times the requirement. This means that the pond has the ability to collect a series of small, frequent storm events withought impacting the ability to settle out suspended solids as intended.

The design intent then, will be to drain out the required active storage volume of 1542 cu.m. in a time period of 24 hours or greater. The low flow outlet will not be sized to drain the entire 10,877 cu.m. active storage volume in 48 hours or less.

Using MOE SWMPDM Equation 4.10 (Page 4-58), calculate the pond draw down time and adjust orifice to achieve 24 hours.

Contour Elevation	Contour Area (sq. m)	Average Area (sq.m.)	Depth (m)	Incremental Volume (cu. m)	Cumulative Volume (cu. m)
246.60	17,595		N/A	N/A	0
246.68	18,513	18054	0.08	1444	1,444
246.75	19,330	18922	0.07	1325	2,769

Interpolate Pond Water level for volume: 1542 cu.m. **246.69 m**

VOLUME (cu.m.)	Water Level (cms)
1444	246.68
2769	246.75

Iterpolate Pond Surface Area for volume: 1542 cu.m. **18573 m**

VOLUME (cu.m.)	Area (sq.m.)
1444	18513
2769	19330

Orifice Invert 246.6
Top Water Level 246.69 m — Above Orifice 0.09 m — Water Surface Area 18,573 Top Water Level
Permanent Pool 246.6 m — Above Orifice 0 m — Water Surface Area 17,595 sq.m. Permanent Pool
Average Surface Area 18084 sq.m.

Orifice Diameter 200 mm — **Area 0.031415927 sq.m.** — **Orifice C 0.8**

Draw down time = $\frac{(2 * \text{Pond Area} * \text{Change in Head})}{C * \text{Orifice Area} * (2*g)^{0.5}}$ — Equation 4.10 MOE SWMPD Manual, March 2003

94821 seconds

Draw down time = 26.3 hours which is less than 48 maximum, but greater than the 24 minimum recommended by MOE

Conclusion: A 200mm diameter low flow outlet pipe at an invert of 246.60m will provide a draw down time of the required 1,542 cu.m active storage volume in 26.3 hours.

APPENDIX E

Otthymo Modelling Summary

PN 2361

CHESHER SUBDIVISION - PHASE 2

DATE March 30, 2016
CALCS BWB

SUMMARY OF OTTHYMO MODELING RESULTS

	SOUTH OUTLET VIA POND			EAST OUTLET VIA ADAM & EVE		
STORM EVENT	Existing Hyrdrograph 501 (cms)	Post-Development Hydrograph 502 (cms)	Change Ext - Post (cms)	Existing Hydrograph 007 (cms)	Post-Development Hydrograph 010 (cms)	Change Ext-Post (cms)
24 Hour SCS						
2 Yr SCS	0.181	0.085	-0.096	0.177	0.169	-0.008
5 Yr SCS	0.327	0.162	-0.165	0.309	0.262	-0.047
25 Yr SCS	0.596	0.326	-0.270	0.553	0.513	-0.040
50 Yr SCS	0.720	0.402	-0.318	0.665	0.613	-0.052
100 Yr SCS	0.853	0.490	-0.363	0.788	0.720	-0.068
4 Hour Chicago						
2 Yr Chicago	0.103	0.046	-0.057	0.100	0.095	-0.005
5 Yr Chicago	0.218	0.115	-0.103	0.206	0.194	-0.012
25 Yr Chicago	0.452	0.254	-0.198	0.422	0.391	-0.031
50 Yr Chicago	0.562	0.325	-0.237	0.523	0.483	-0.040
100 Yr Chicago	0.680	0.402	-0.278	0.629	0.580	-0.049

==
=========

```
 V   V  I   SSSSS  U   U    A    L
 V   V  I   SS     U   U   A A   L
  V V   I    SS    U   U  AAAAA  L
  V V   I     SS   U   U  A   A  L
   VV   I   SSSSS  UUUUU  A   A  LLLLL

  OOO  TTTTT TTTTT H   H Y   Y  M   M  OOO
 O   O   T     T   H   H  Y Y   MM MM O   O
 O   O   T     T   H   H   Y    M   M O   O
  OOO    T     T   H   H   Y    M   M  OOO
```

Developed and Distributed by Clarifica Inc.

***** S U M M A R Y   O U T P U T *****

Input   filename: C:\Program Files (x86)\Visual OTTHYMO 2.3.2\voin.dat
Output filename: D:\OTTHYM~1\2361OT~1\existing conditions.out
Summary filename: D:\OTTHYM~1\2361OT~1\existing conditions.sum

DATE: 3/30/2016 TIME: 2:25:01 PM

USER:

COMMENTS:

Existing Conditions Model
2, 5, 25, 50 and 100 year return periods
City of Peterborough 4 hour Chicago & 24 Hour SCS Distributions

```
****************************
** SIMULATION NUMBER:   1 **
****************************

W/E COMMAND          HYD ID  DT   AREA  Qpeak Tpeak  R.V. R.C.  Qbase
                           min   ha    cms   hrs    mm         cms

  START @   .00 hrs
  --------------------
  READ STORM              6.0
  [ Ptot= 48.22 mm ]
  fname : D:\Otthymo - backup to G when finished editing\2361 Otthymo\Peterborough\2YR 24 SCS Peterborough.stm
  remark: Peterborough 2Yr 24 Hour SCS Distribution
*
** CALIB NASHYD       0107  1  2.0  14.00    .21 12.20  9.39  .19   .000
   [CN=67.1      ]
   [ N = 3.0:Tp  .31]
*
** CALIB NASHYD       0101  1  2.0   4.25    .04 12.43  8.83  .18   .000
   [CN=63.6      ]
   [ N = 3.0:Tp  .51]
*
** CALIB NASHYD       0103  1  2.0  11.14    .19 12.07  7.97  .17   .000
   [CN=60.8      ]
   [ N = 3.0:Tp  .19]
*
** CALIB NASHYD       1051  1  2.0    .71    .00   .00   .00  .00   .000
   [CN=56.8      ]
   [ N = 3.0:Tp  .08]
*
** CALIB NASHYD       0105  1  2.0   6.96    .06 12.63  8.43  .17   .000
   [CN=62.1      ]
   [ N = 3.0:Tp  .66]
*
** CALIB NASHYD       0108  1  2.0   5.21    .06 12.07  5.41  .11   .000
   [CN=52.3      ]
   [ N = 3.0:Tp  .17]
*
** CALIB NASHYD       0102  1  2.0   8.38    .05 12.73  6.76  .14   .000
   [CN=56.6      ]
   [ N = 3.0:Tp  .74]
*
** CALIB NASHYD       0104  1  2.0   6.86    .11 12.47 13.47  .28   .000
   [CN=73.7      ]
   [ N = 3.0:Tp  .54]
*
** CALIB NASHYD       0109  1  2.0  42.23    .00 24.27   .12  .00   .000
   [CN=51.4      ]
   [ N = 3.0:Tp 1.23]
*
** CALIB NASHYD       0106  1  2.0   4.14    .00 24.13   .33  .01   .000
   [CN=57.9      ]
   [ N = 3.0:Tp 1.03]
*
   ADD [0101 + 0103] 0001  3  2.0  15.39    .22 12.10  8.20  n/a   .000
*
   ADD [1051 + 0105] 0002  3  2.0   7.67    .06 12.63  7.65  n/a   .000
*
   ADD [0102 + 0104] 0006  3  2.0  15.24    .16 12.53  9.78  n/a   .000
*
   ADD [0109 + 0106] 0005  3  2.0  46.37    .00 24.23   .13  n/a   .000
*
   ADD [0001 + 0002] 0003  3  2.0  23.06    .25 12.10  8.02  n/a   .000
*
   ADD [0108 + 0006] 0007  3  2.0  20.45    .18 12.43  8.67  n/a   .000
*
   ADD [0107 + 0003] 0004  3  2.0  37.06    .46 12.17  8.54  n/a   .000
*
   RESRVR [ 2 : 0004] 0501  1  2.0  37.06    .18 13.00  8.54  n/a   .000
   {ST=   .09 ha.m }
```

```
****************************
** SIMULATION NUMBER:   2 **
****************************

W/E COMMAND            HYD ID  DT   AREA  Qpeak Tpeak  R.V. R.C.  Qbase
                  min     ha    cms  hrs    mm        cms

  START @   .00 hrs
  --------------------
  READ STORM            6.0
  [ Ptot= 62.87 mm ]
  fname : D:\Otthymo - backup to G when finished editing\2361 Otthymo\Peterborough\5YR 24 SCS Peterborough.stm
  remark: Peterborough 5Yr 24 Hour SCS Distribution
*
** CALIB NASHYD     0107  1  2.0  14.00    .39 12.20  16.27  .26   .000
  [CN=67.1       ]
  [ N = 3.0:Tp  .31]
*
** CALIB NASHYD     0101  1  2.0   4.25    .08 12.43  15.18  .24   .000
  [CN=63.6       ]
  [ N = 3.0:Tp  .51]
*
** CALIB NASHYD     0103  1  2.0  11.14    .35 12.07  13.81  .22   .000
  [CN=60.8       ]
  [ N = 3.0:Tp  .19]
*
** CALIB NASHYD     1051  1  2.0    .71   .00  .00    .00  .00   .000
  [CN=56.8       ]
  [ N = 3.0:Tp  .08]
*
** CALIB NASHYD     0105  1  2.0   6.96   .10 12.60  14.53  .23   .000
  [CN=62.1       ]
  [ N = 3.0:Tp  .66]
*
** CALIB NASHYD     0108  1  2.0   5.21   .12 12.07   9.82  .16   .000
  [CN=52.3       ]
  [ N = 3.0:Tp  .17]
*
** CALIB NASHYD     0102  1  2.0   8.38   .09 12.73  11.90  .19   .000
  [CN=56.6       ]
  [ N = 3.0:Tp  .74]
*
** CALIB NASHYD     0104  1  2.0   6.86   .18 12.43  21.99  .35   .000
  [CN=73.7       ]
  [ N = 3.0:Tp  .54]
*
** CALIB NASHYD     0109  1  2.0  42.23    .02 16.37   1.53  .02   .000
  [CN=51.4       ]
  [ N = 3.0:Tp 1.23]
*
** CALIB NASHYD     0106  1  2.0   4.14   .00 15.00   2.46  .04   .000
  [CN=57.9       ]
  [ N = 3.0:Tp 1.03]
*
  ADD [0101 + 0103] 0001  3  2.0  15.39   .40 12.10  14.19  n/a   .000
*
  ADD [1051 + 0105] 0002  3  2.0   7.67   .10 12.60  13.18  n/a   .000
*
  ADD [0102 + 0104] 0006  3  2.0  15.24   .27 12.53  16.44  n/a   .000
*
  ADD [0109 + 0106] 0005  3  2.0  46.37   .02 16.33   1.62  n/a   .000
*
  ADD [0001 + 0002] 0003  3  2.0  23.06   .46 12.10  13.85  n/a   .000
*
  ADD [0108 + 0006] 0007  3  2.0  20.45   .31 12.33  14.76  n/a   .000
*
  ADD [0107 + 0003] 0004  3  2.0  37.06   .83 12.13  14.77  n/a   .000
*
  RESRVR [ 2 : 0004] 0501  1  2.0  37.06   .33 12.97  14.76  n/a   .000
  {ST=   .16 ha.m }
```

```
*****************************
** SIMULATION NUMBER:   3 **
*****************************

W/E COMMAND          HYD ID  DT   AREA  Qpeak Tpeak  R.V. R.C.  Qbase
                         min   ha    cms  hrs    mm          cms

   START @   .00 hrs
   --------------------
   READ STORM              6.0
   [ Ptot= 84.47 mm ]
   fname : D:\Otthymo - backup to G when finished editing\2361 Otthymo\Peterborough\25YR 24 SCS Peterborough.st
   remark: Peterborough 25Yr 24 Hour SCS Distribution
*
** CALIB NASHYD      0107  1  2.0   14.00    .70 12.20  28.48  .34    .000
   [CN=67.1       ]
   [ N = 3.0:Tp  .31]
*
** CALIB NASHYD      0101  1  2.0    4.25    .14 12.40  26.53  .31    .000
   [CN=63.6       ]
   [ N = 3.0:Tp  .51]
*
** CALIB NASHYD      0103  1  2.0   11.14    .63 12.07  24.39  .29    .000
   [CN=60.8       ]
   [ N = 3.0:Tp  .19]
*
** CALIB NASHYD      1051  1  2.0     .71    .00   .00    .00  .00   .000
   [CN=56.8       ]
   [ N = 3.0:Tp  .08]
*
** CALIB NASHYD      0105  1  2.0    6.96    .19 12.60  25.48  .30    .000
   [CN=62.1       ]
   [ N = 3.0:Tp  .66]
*
** CALIB NASHYD      0108  1  2.0    5.21    .23 12.07  18.11  .21    .000
   [CN=52.3       ]
   [ N = 3.0:Tp  .17]
*
** CALIB NASHYD      0102  1  2.0    8.38    .17 12.70  21.37  .25    .000
   [CN=56.6       ]
   [ N = 3.0:Tp  .74]
*
** CALIB NASHYD      0104  1  2.0    6.86    .31 12.43  36.48  .43    .000
   [CN=73.7       ]
   [ N = 3.0:Tp  .54]
*
** CALIB NASHYD      0109  1  2.0   42.23    .10 14.40   6.13  .07    .000
   [CN=51.4       ]
   [ N = 3.0:Tp 1.23]
*
** CALIB NASHYD      0106  1  2.0    4.14    .02 13.37   8.52  .10    .000
   [CN=57.9       ]
   [ N = 3.0:Tp 1.03]
*
   ADD [0101 + 0103] 0001  3  2.0   15.39    .72 12.10  24.98  n/a    .000
*
   ADD [1051 + 0105] 0002  3  2.0    7.67    .19 12.60  23.12  n/a    .000
*
   ADD [0102 + 0104] 0006  3  2.0   15.24    .47 12.50  28.17  n/a    .000
*
   ADD [0109 + 0106] 0005  3  2.0   46.37    .11 14.33   6.35  n/a    .000
*
   ADD [0001 + 0002] 0003  3  2.0   23.06    .83 12.10  24.36  n/a    .000
*
   ADD [0108 + 0006] 0007  3  2.0   20.45    .55 12.23  25.61  n/a    .000
*
   ADD [0107 + 0003] 0004  3  2.0   37.06   1.51 12.13  25.92  n/a    .000
*
   RESRVR [ 2 : 0004] 0501  1  2.0   37.06    .60 12.93  25.91  n/a    .000
   {ST=   .30 ha.m }
```

```
****************************
** SIMULATION NUMBER:   4 **
****************************

W/E COMMAND         HYD ID  DT   AREA  Qpeak Tpeak  R.V. R.C.  Qbase
                    min   ha   cms  hrs   mm        cms

  START @   .00 hrs
  -------------------
  READ STORM           6.0
  [ Ptot= 93.54 mm ]
  fname : D:\Otthymo - backup to G when finished editing\2361 Otthymo\Peterborough\50YR 24 SCS Peterborough.st
  remark: Peterborough 50Yr 24 Hour SCS Distribution
*
** CALIB NASHYD     0107  1  2.0  14.00    .85 12.17  34.18  .37   .000
  [CN=67.1       ]
  [ N = 3.0:Tp  .31]
*
** CALIB NASHYD     0101  1  2.0   4.25    .17 12.40  31.87  .34   .000
  [CN=63.6       ]
  [ N = 3.0:Tp  .51]
*
** CALIB NASHYD     0103  1  2.0  11.14    .76 12.07  29.40  .31   .000
  [CN=60.8       ]
  [ N = 3.0:Tp  .19]
*
** CALIB NASHYD     1051  1  2.0    .71    .00   .00    .00  .00   .000
  [CN=56.8       ]
  [ N = 3.0:Tp  .08]
*
** CALIB NASHYD     0105  1  2.0   6.96    .22 12.60  30.65  .33   .000
  [CN=62.1       ]
  [ N = 3.0:Tp  .66]
*
** CALIB NASHYD     0108  1  2.0   5.21    .28 12.07  22.14  .24   .000
  [CN=52.3       ]
  [ N = 3.0:Tp  .17]
*
** CALIB NASHYD     0102  1  2.0   8.38    .21 12.70  25.90  .28   .000
  [CN=56.6       ]
  [ N = 3.0:Tp  .74]
*
** CALIB NASHYD     0104  1  2.0   6.86    .37 12.43  43.08  .46   .000
  [CN=73.7       ]
  [ N = 3.0:Tp  .54]
*
** CALIB NASHYD     0109  1  2.0  42.23    .15 13.60   8.82  .09   .000
  [CN=51.4       ]
  [ N = 3.0:Tp 1.23]
*
** CALIB NASHYD     0106  1  2.0   4.14    .03 13.33  11.91  .13   .000
  [CN=57.9       ]
  [ N = 3.0:Tp 1.03]
*
  ADD [0101 + 0103]  0001  3  2.0  15.39    .87 12.10  30.09  n/a   .000
*
  ADD [1051 + 0105]  0002  3  2.0   7.67    .22 12.60  27.81  n/a   .000
*
  ADD [0102 + 0104]  0006  3  2.0  15.24    .56 12.50  33.63  n/a   .000
*
  ADD [0109 + 0106]  0005  3  2.0  46.37    .18 13.53   9.09  n/a   .000
*
  ADD [0001 + 0002]  0003  3  2.0  23.06   1.00 12.10  29.33  n/a   .000
*
  ADD [0108 + 0006]  0007  3  2.0  20.45    .67 12.23  30.70  n/a   .000
*
  ADD [0107 + 0003]  0004  3  2.0  37.06   1.83 12.13  31.16  n/a   .000
*
  RESRVR [ 2 : 0004] 0501  1  2.0  37.06    .72 12.90  31.16  n/a   .000
  {ST=   .36 ha.m }
```

```
*****************************
** SIMULATION NUMBER:   5 **
*****************************

W/E COMMAND          HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.   Qbase
                             min     ha     cms   hrs     mm          cms

    START @   .00 hrs
    --------------------
    READ STORM              6.0
    [ Ptot=102.77 mm ]
    fname : D:\Otthymo - backup to G when finished editing\2361 Otthymo\Peterborough\100YR 24 SCS Peterborough.s
    remark: Peterborough 100Yr 24 Hour SCS Distribution
*
 ** CALIB NASHYD     0107  1  2.0   14.00   1.00 12.17  40.28  .39    .000
    [CN=67.1       ]
    [ N = 3.0:Tp  .31]
*
 ** CALIB NASHYD     0101  1  2.0    4.25    .20 12.40  37.59  .37    .000
    [CN=63.6       ]
    [ N = 3.0:Tp  .51]
*
 ** CALIB NASHYD     0103  1  2.0   11.14    .90 12.07  34.80  .34    .000
    [CN=60.8       ]
    [ N = 3.0:Tp  .19]
*
 ** CALIB NASHYD     1051  1  2.0     .71    .00   .00    .00  .00    .000
    [CN=56.8       ]
    [ N = 3.0:Tp  .08]
*
 ** CALIB NASHYD     0105  1  2.0    6.96    .27 12.60  36.20  .35    .000
    [CN=62.1       ]
    [ N = 3.0:Tp  .66]
*
 ** CALIB NASHYD     0108  1  2.0    5.21    .33 12.07  26.52  .26    .000
    [CN=52.3       ]
    [ N = 3.0:Tp  .17]
*
 ** CALIB NASHYD     0102  1  2.0    8.38    .25 12.70  30.80  .30    .000
    [CN=56.6       ]
    [ N = 3.0:Tp  .74]
*
 ** CALIB NASHYD     0104  1  2.0    6.86    .43 12.43  50.04  .49    .000
    [CN=73.7       ]
    [ N = 3.0:Tp  .54]
*
 ** CALIB NASHYD     0109  1  2.0   42.23    .23 13.53  11.95  .12    .000
    [CN=51.4       ]
    [ N = 3.0:Tp 1.23]
*
 ** CALIB NASHYD     0106  1  2.0    4.14    .04 13.27  15.79  .15    .000
    [CN=57.9       ]
    [ N = 3.0:Tp 1.03]
*
    ADD [0101 + 0103] 0001  3  2.0   15.39   1.03 12.10  35.57  n/a   .000
*
    ADD [1051 + 0105] 0002  3  2.0    7.67    .27 12.60  32.85  n/a   .000
*
    ADD [0102 + 0104] 0006  3  2.0   15.24    .66 12.50  39.46  n/a   .000
*
    ADD [0109 + 0106] 0005  3  2.0   46.37    .26 13.47  12.29  n/a   .000
*
    ADD [0001 + 0002] 0003  3  2.0   23.06   1.19 12.10  34.66  n/a   .000
*
    ADD [0108 + 0006] 0007  3  2.0   20.45    .79 12.20  36.17  n/a   .000
*
    ADD [0107 + 0003] 0004  3  2.0   37.06   2.17 12.13  36.78  n/a   .000
*
    RESRVR [ 2 : 0004] 0501  1  2.0   37.06    .85 12.90  36.78  n/a   .000
    {ST=   .42 ha.m }
```

```
****************************
** SIMULATION NUMBER:   6 **
****************************

W/E COMMAND          HYD ID  DT   AREA  Qpeak Tpeak  R.V. R.C.  Qbase
                         min   ha    cms  hrs    mm          cms

   START @   .00 hrs
   -------------------
   READ STORM              5.0
   [ Ptot= 33.04 mm ]
   fname : D:\Otthymo - backup to G when finished editing\2361 Otthymo\Peterborough\2YR 4HR CHI Peterborough.st
   remark: Peterborough 2 Yr 4 Hour Chicago Distribution
 *
** CALIB NASHYD      0107  1  2.0   14.00    .10  1.87   3.89  .12    .000
   [CN=67.1        ]
   [ N = 3.0:Tp  .31]
 *
** CALIB NASHYD      0101  1  2.0    4.25    .02  2.13   3.76  .11    .000
   [CN=63.6        ]
   [ N = 3.0:Tp  .51]
 *
** CALIB NASHYD      0103  1  2.0   11.14    .09  1.63   3.34  .10    .000
   [CN=60.8        ]
   [ N = 3.0:Tp  .19]
 *
** CALIB NASHYD      1051  1  2.0     .71    .00   .00    .00  .00    .000
   [CN=56.8        ]
   [ N = 3.0:Tp  .08]
 *
** CALIB NASHYD      0105  1  2.0    6.96    .03  2.37   3.59  .11    .000
   [CN=62.1        ]
   [ N = 3.0:Tp  .66]
 *
** CALIB NASHYD      0108  1  2.0    5.21    .02  1.63   2.08  .06    .000
   [CN=52.3        ]
   [ N = 3.0:Tp  .17]
 *
** CALIB NASHYD      0102  1  2.0    8.38    .03  2.53   2.77  .08    .000
   [CN=56.6        ]
   [ N = 3.0:Tp  .74]
 *
** CALIB NASHYD      0104  1  2.0    6.86    .06  2.13   6.25  .19    .000
   [CN=73.7        ]
   [ N = 3.0:Tp  .54]
 *
** CALIB NASHYD      0109  1  2.0   42.23    .00   .00    .00  .00    .000
   [CN=51.4        ]
   [ N = 3.0:Tp 1.23]
 *
** CALIB NASHYD      0106  1  2.0    4.14    .00   .00    .00  .00    .000
   [CN=57.9        ]
   [ N = 3.0:Tp 1.03]
 *
   ADD [0101 + 0103] 0001  3  2.0   15.39    .10  1.70   3.46  n/a    .000
 *
   ADD [1051 + 0105] 0002  3  2.0    7.67    .03  2.37   3.25  n/a    .000
 *
   ADD [0102 + 0104] 0006  3  2.0   15.24    .09  2.23   4.34  n/a    .000
 *
   ADD [0109 + 0106] 0005  3  2.0   46.37    .00   .00    .00  n/a    .000
 *
   ADD [0001 + 0002] 0003  3  2.0   23.06    .11  1.73   3.39  n/a    .000
 *
   ADD [0108 + 0006] 0007  3  2.0   20.45    .10  2.13   3.76  n/a    .000
 *
   ADD [0107 + 0003] 0004  3  2.0   37.06    .21  1.80   3.58  n/a    .000
 *
   RESRVR [ 2 : 0004] 0501  1  2.0   37.06    .10  3.00   3.58  n/a    .000
   {ST=   .05 ha.m }
```

```
******************************
** SIMULATION NUMBER:   7 **
******************************

W/E COMMAND          HYD ID  DT   AREA  Qpeak Tpeak  R.V. R.C.  Qbase
                        min   ha   cms  hrs   mm        cms

   START @   .00 hrs
   --------------------
   READ STORM              5.0
   [ Ptot= 44.81 mm ]
   fname : D:\Otthymo - backup to G when finished editing\2361 Otthymo\Peterborough\5YR 4HR CHI Peterborough.st
   remark: Peterborough 5 Yr 4 Hour Chicago Distribution
*
** CALIB NASHYD      0107  1  2.0   14.00    .23  1.83   8.00  .18   .000
   [CN=67.1        ]
   [ N = 3.0:Tp  .31]
*
** CALIB NASHYD      0101  1  2.0    4.25    .05  2.10   7.55  .17   .000
   [CN=63.6        ]
   [ N = 3.0:Tp  .51]
*
** CALIB NASHYD      0103  1  2.0   11.14    .20  1.63   6.79  .15   .000
   [CN=60.8        ]
   [ N = 3.0:Tp  .19]
*
** CALIB NASHYD      1051  1  2.0     .71    .00   .00    .00  .00   .000
   [CN=56.8        ]
   [ N = 3.0:Tp  .08]
*
** CALIB NASHYD      0105  1  2.0    6.96    .07  2.30   7.20  .16   .000
   [CN=62.1        ]
   [ N = 3.0:Tp  .66]
*
** CALIB NASHYD      0108  1  2.0    5.21    .06  1.60   4.55  .10   .000
   [CN=52.3        ]
   [ N = 3.0:Tp  .17]
*
** CALIB NASHYD      0102  1  2.0    8.38    .06  2.47   5.74  .13   .000
   [CN=56.6        ]
   [ N = 3.0:Tp  .74]
*
** CALIB NASHYD      0104  1  2.0    6.86    .13  2.10  11.69  .26   .000
   [CN=73.7        ]
   [ N = 3.0:Tp  .54]
*
** CALIB NASHYD      0109  1  2.0   42.23    .00  5.00    .02  .00   .000
   [CN=51.4        ]
   [ N = 3.0:Tp 1.23]
*
** CALIB NASHYD      0106  1  2.0    4.14    .00  4.60    .11  .00   .000
   [CN=57.9        ]
   [ N = 3.0:Tp 1.03]
*
   ADD [0101 + 0103] 0001  3  2.0   15.39    .22  1.67   7.00  n/a   .000
*
   ADD [1051 + 0105] 0002  3  2.0    7.67    .07  2.30   6.54  n/a   .000
*
   ADD [0102 + 0104] 0006  3  2.0   15.24    .18  2.20   8.41  n/a   .000
*
   ADD [0109 + 0106] 0005  3  2.0   46.37    .00  4.83    .02  n/a   .000
*
   ADD [0001 + 0002] 0003  3  2.0   23.06    .26  1.70   6.85  n/a   .000
*
   ADD [0108 + 0006] 0007  3  2.0   20.45    .21  2.10   7.43  n/a   .000
*
   ADD [0107 + 0003] 0004  3  2.0   37.06    .48  1.77   7.28  n/a   .000
*
   RESRVR [ 2 : 0004] 0501  1  2.0   37.06    .22  2.83   7.28  n/a   .000
   {ST=   .11 ha.m }
```

```
****************************
** SIMULATION NUMBER:  8 **
****************************

W/E COMMAND          HYD ID  DT   AREA  Qpeak Tpeak  R.V. R.C.  Qbase
                        min   ha    cms   hrs    mm          cms

  START @  .00 hrs
  --------------------
  READ STORM              5.0
  [ Ptot= 62.46 mm ]
  fname : D:\Otthymo - backup to G when finished editing\2361 Otthymo\Peterborough\25YR 4HR CHI Peterborough.s
  remark: Peterborough 25 Yr 4 Hour Chicago Distribution
*
** CALIB NASHYD     0107  1  2.0  14.00    .49 1.80 16.06 .26   .000
  [CN=67.1       ]
  [ N = 3.0:Tp  .31]
*
** CALIB NASHYD     0101  1  2.0   4.25    .10 2.07 14.98 .24   .000
  [CN=63.6       ]
  [ N = 3.0:Tp  .51]
*
** CALIB NASHYD     0103  1  2.0  11.14    .42 1.60 13.63 .22   .000
  [CN=60.8       ]
  [ N = 3.0:Tp  .19]
*
** CALIB NASHYD     1051  1  2.0    .71   .00  .00   .00 .00   .000
  [CN=56.8       ]
  [ N = 3.0:Tp  .08]
*
** CALIB NASHYD     0105  1  2.0   6.96    .14 2.27 14.34 .23   .000
  [CN=62.1       ]
  [ N = 3.0:Tp  .66]
*
** CALIB NASHYD     0108  1  2.0   5.21    .14 1.60  9.69 .16   .000
  [CN=52.3       ]
  [ N = 3.0:Tp  .17]
*
** CALIB NASHYD     0102  1  2.0   8.38    .12 2.40 11.75 .19   .000
  [CN=56.6       ]
  [ N = 3.0:Tp  .74]
*
** CALIB NASHYD     0104  1  2.0   6.86    .25 2.07 21.73 .35   .000
  [CN=73.7       ]
  [ N = 3.0:Tp  .54]
*
** CALIB NASHYD     0109  1  2.0  42.23    .06 4.27  1.47 .02   .000
  [CN=51.4       ]
  [ N = 3.0:Tp 1.23]
*
** CALIB NASHYD     0106  1  2.0   4.14    .01 3.93  2.37 .04   .000
  [CN=57.9       ]
  [ N = 3.0:Tp 1.03]
*
  ADD [0101 + 0103]  0001  3  2.0  15.39   .48 1.63 14.01  n/a   .000
*
  ADD [1051 + 0105]  0002  3  2.0   7.67   .14 2.27 13.01  n/a   .000
*
  ADD [0102 + 0104]  0006  3  2.0  15.24   .36 2.17 16.24  n/a   .000
*
  ADD [0109 + 0106]  0005  3  2.0  46.37   .07 4.23  1.55  n/a   .000
*
  ADD [0001 + 0002]  0003  3  2.0  23.06   .55 1.70 13.68  n/a   .000
*
  ADD [0108 + 0006]  0007  3  2.0  20.45   .42 2.03 14.57  n/a   .000
*
  ADD [0107 + 0003]  0004  3  2.0  37.06  1.03 1.77 14.58  n/a   .000
*
  RESRVR [ 2 : 0004] 0501  1  2.0  37.06   .45 2.73 14.57  n/a   .000
  {ST=  .22 ha.m }
```

```
******************************
** SIMULATION NUMBER:   9 **
******************************

W/E COMMAND          HYD ID  DT   AREA  Qpeak Tpeak  R.V. R.C.  Qbase
                        min   ha   cms  hrs   mm         cms

   START @   .00 hrs
   --------------------
   READ STORM              5.0
   [ Ptot= 69.58 mm ]
   fname : D:\Otthymo - backup to G when finished editing\2361 Otthymo\Peterborough\50YR 4HR CHI Peterborough.s
   remark: Peterborough 50 Yr 4 Hour Chicago Distribution
*
** CALIB NASHYD      0107  1  2.0   14.00    .62  1.80  19.83  .28   .000
   [CN=67.1        ]
   [ N = 3.0:Tp  .31]
*
** CALIB NASHYD      0101  1  2.0    4.25    .13  2.07  18.48  .27   .000
   [CN=63.6        ]
   [ N = 3.0:Tp  .51]
*
** CALIB NASHYD      0103  1  2.0   11.14    .53  1.60  16.88  .24   .000
   [CN=60.8        ]
   [ N = 3.0:Tp  .19]
*
** CALIB NASHYD      1051  1  2.0     .71    .00   .00    .00  .00   .000
   [CN=56.8        ]
   [ N = 3.0:Tp  .08]
*
** CALIB NASHYD      0105  1  2.0    6.96    .17  2.27  17.70  .25   .000
   [CN=62.1        ]
   [ N = 3.0:Tp  .66]
*
** CALIB NASHYD      0108  1  2.0    5.21    .18  1.60  12.19  .18   .000
   [CN=52.3        ]
   [ N = 3.0:Tp  .17]
*
** CALIB NASHYD      0102  1  2.0    8.38    .16  2.40  14.62  .21   .000
   [CN=56.6        ]
   [ N = 3.0:Tp  .74]
*
** CALIB NASHYD      0104  1  2.0    6.86    .30  2.07  26.28  .38   .000
   [CN=73.7        ]
   [ N = 3.0:Tp  .54]
*
** CALIB NASHYD      0109  1  2.0   42.23    .10  4.10   2.67  .04   .000
   [CN=51.4        ]
   [ N = 3.0:Tp 1.23]
*
** CALIB NASHYD      0106  1  2.0    4.14    .02  3.63   4.01  .06   .000
   [CN=57.9        ]
   [ N = 3.0:Tp 1.03]
*
   ADD [0101 + 0103] 0001  3  2.0   15.39    .61  1.63  17.32  n/a   .000
*
   ADD [1051 + 0105] 0002  3  2.0    7.67    .17  2.27  16.06  n/a   .000
*
   ADD [0102 + 0104] 0006  3  2.0   15.24    .44  2.17  19.87  n/a   .000
*
   ADD [0109 + 0106] 0005  3  2.0   46.37    .12  4.07   2.79  n/a   .000
*
   ADD [0001 + 0002] 0003  3  2.0   23.06    .69  1.70  16.90  n/a   .000
*
   ADD [0108 + 0006] 0007  3  2.0   20.45    .52  2.03  17.91  n/a   .000
*
   ADD [0107 + 0003] 0004  3  2.0   37.06   1.29  1.73  18.01  n/a   .000
*
   RESRVR [ 2 : 0004] 0501  1  2.0   37.06    .56  2.70  18.00  n/a   .000
   {ST=   .28 ha.m }
```

```
****************************
** SIMULATION NUMBER:  10 **
****************************

W/E COMMAND          HYD ID   DT    AREA  Qpeak Tpeak  R.V. R.C.  Qbase
                         min   ha    cms   hrs    mm          cms

  START @  .00 hrs
  ------------------
  READ STORM              5.0
  [ Ptot= 76.81 mm ]
  fname : D:\Otthymo - backup to G when finished editing\2361 Otthymo\Peterborough\100YR 4HR CHI Peterborough
  remark: Peterborough 100 Yr 4 Hour Chicago Distribution
*
** CALIB NASHYD     0107  1  2.0   14.00   .75  1.77  23.91  .31   .000
  [CN=67.1       ]
  [ N = 3.0:Tp  .31]
*
** CALIB NASHYD     0101  1  2.0    4.25   .16  2.07  22.27  .29   .000
  [CN=63.6       ]
  [ N = 3.0:Tp  .51]
*
** CALIB NASHYD     0103  1  2.0   11.14   .65  1.60  20.41  .27   .000
  [CN=60.8       ]
  [ N = 3.0:Tp  .19]
*
** CALIB NASHYD     1051  1  2.0     .71   .00   .00    .00  .00   .000
  [CN=56.8       ]
  [ N = 3.0:Tp  .08]
*
** CALIB NASHYD     0105  1  2.0    6.96   .21  2.27  21.36  .28   .000
  [CN=62.1       ]
  [ N = 3.0:Tp  .66]
*
** CALIB NASHYD     0108  1  2.0    5.21   .23  1.57  14.96  .19   .000
  [CN=52.3       ]
  [ N = 3.0:Tp  .17]
*
** CALIB NASHYD     0102  1  2.0    8.38   .19  2.40  17.78  .23   .000
  [CN=56.6       ]
  [ N = 3.0:Tp  .74]
*
** CALIB NASHYD     0104  1  2.0    6.86   .36  2.07  31.13  .41   .000
  [CN=73.7       ]
  [ N = 3.0:Tp  .54]
*
** CALIB NASHYD     0109  1  2.0   42.23   .15  3.93   4.20  .05   .000
  [CN=51.4       ]
  [ N = 3.0:Tp 1.23]
*
** CALIB NASHYD     0106  1  2.0    4.14   .02  3.43   6.03  .08   .000
  [CN=57.9       ]
  [ N = 3.0:Tp 1.03]
*
  ADD [0101 + 0103] 0001  3  2.0   15.39   .74  1.63  20.92  n/a   .000
*
  ADD [1051 + 0105] 0002  3  2.0    7.67   .21  2.27  19.39  n/a   .000
*
  ADD [0102 + 0104] 0006  3  2.0   15.24   .53  2.13  23.79  n/a   .000
*
  ADD [0109 + 0106] 0005  3  2.0   46.37   .18  3.87   4.36  n/a   .000
*
  ADD [0001 + 0002] 0003  3  2.0   23.06   .84  1.67  20.41  n/a   .000
*
  ADD [0108 + 0006] 0007  3  2.0   20.45   .63  2.03  21.54  n/a   .000
*
  ADD [0107 + 0003] 0004  3  2.0   37.06  1.57  1.73  21.73  n/a   .000
*
  RESRVR [ 2 : 0004] 0501  1  2.0  37.06   .68  2.70  21.73  n/a   .000
  {ST=  .34 ha.m }
```

```
==========================================================================================
=========

    V   V  I   SSSSS  U   U   A   L
    V   V  I   SS     U   U  A A  L
     V V   I    SS    U   U AAAAA L
     V V   I     SS   U   U A   A L
      VV   I  SSSSS  UUUUU  A   A LLLLL

     OOO  TTTTT TTTTT H   H Y   Y M   M  OOO
    O   O   T     T   H   H  Y Y  MM MM O   O
    O   O   T     T   H   H   Y   M   M O   O
     OOO    T     T   H   H   Y   M   M  OOO
```

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```
        ***** S U M M A R Y   O U T P U T *****

 Input  filename: C:\Program Files (x86)\Visual OTTHYMO 2.3.2\voin.dat
 Output filename: D:\OTTHYM~1\2361OT~1\post development.out
 Summary filename: D:\OTTHYM~1\2361OT~1\post development.sum

DATE: 3/24/2016                TIME: 2:01:20 PM

USER:

COMMENTS:
```

Proposed Conditions Model
2, 5, 25, 50 and 100 year return periods
City of Peterborough 4 hour Chicago & 24 Hour SCS Distributions

```
 ****************************
 ** SIMULATION NUMBER:   1 **
 ****************************

 W/E COMMAND          HYD ID  DT   AREA  Qpeak Tpeak  R.V. R.C.  Qbase
                      min    ha   cms  hrs   mm       cms

   START @  .00 hrs
   ----------------------
   READ STORM              6.0
   [ Ptot= 48.22 mm ]
   fname : D:\Otthymo - backup to G when finished editing\2361 Otthymo\Peterborough\2YR 24 SCS Peterborough.stm
   remark: Peterborough 2Yr 24 Hour SCS Distribution
*
 ** CALIB NASHYD     1051  1  2.0    .71    .00   .00    .00  .00   .000
   [CN=56.8       ]
   [ N = 3.0:Tp  .08]
*
 ** CALIB NASHYD     0105  1  2.0   6.96    .06 12.63   8.43  .17   .000
   [CN=62.1       ]
   [ N = 3.0:Tp  .66]
*
 ** CALIB NASHYD     0201  1  2.0   4.58    .11 12.00   8.32  .17   .000
   [CN=61.6       ]
   [ N = 3.0:Tp  .09]
*
 ** CALIB NASHYD     0204  1  2.0    .43    .02 12.03  14.25  .30   .000
   [CN=73.1       ]
```

```
    [ N = 3.0:Tp  .12]
*
 ** CALIB NASHYD      0202  1  2.0   2.12    .07 12.00  10.46  .22   .000
    [CN=64.7       ]
    [ N = 3.0:Tp  .07]
*
 ** CALIB NASHYD      0103  1  2.0  11.14    .19 12.07   7.97  .17   .000
    [CN=60.8       ]
    [ N = 3.0:Tp  .19]
*
 ** CALIB NASHYD      0101  1  2.0   4.25    .04 12.57   8.83  .18   .000
    [CN=63.6       ]
    [ N = 3.0:Tp  .60]
*
 ** CALIB NASHYD      0205  1  2.0   8.25    .08 13.03  12.55  .26   .000
    [CN=69.6       ]
    [ N = 3.0:Tp 1.03]
*
 ** CALIB NASHYD      0106  1  2.0   4.14    .00 24.13    .33  .01  .000
    [CN=57.9       ]
    [ N = 3.0:Tp 1.03]
*
 ** CALIB NASHYD      0109  1  2.0  42.23    .00 24.27    .12  .00   .000
    [CN=51.4       ]
    [ N = 3.0:Tp 1.23]
*
 ** CALIB NASHYD      0203  1  2.0   3.80    .08 12.00   5.70  .12   .000
    [CN=55.1       ]
    [ N = 3.0:Tp  .03]
*
 ** CALIB NASHYD      0104  1  2.0   6.86    .11 12.47  13.47  .28   .000
    [CN=73.7       ]
    [ N = 3.0:Tp  .54]
*
 ** CALIB NASHYD      0102  1  2.0   8.38    .05 12.73   6.76  .14   .000
    [CN=56.6       ]
    [ N = 3.0:Tp  .74]
*
    ADD [1051 + 0105] 0002  3  2.0   7.67   .06 12.63   7.65  n/a   .000
*
    ADD [0002 + 0201] 0004  3  2.0  12.25    .13 12.00   7.90  n/a   .000
*
    ADD [0103 + 0101] 0001  3  2.0  15.39    .22 12.10   8.20  n/a   .000
*
    ADD [0106 + 0109] 0011  3  2.0  46.37    .00 24.23    .13  n/a  .000
*
    ADD [0104 + 0102] 0009  3  2.0  15.24    .16 12.53   9.78  n/a   .000
*
    ADD [0202 + 0001] 0003  3  2.0  17.51    .27 12.03   8.48  n/a   .000
*
    ADD [0203 + 0009] 0010  3  2.0  19.04    .17 12.50   8.97  n/a   .000
*
    ADD [0003 + 0205] 0005  3  2.0  25.76    .29 12.03   9.78  n/a   .000
*
    ADD [0204 + 0005] 0006  3  2.0  26.19    .30 12.03   9.86  n/a   .000
*
    ADD [0004 + 0006] 0007  3  2.0  38.44    .44 12.03   9.23  n/a   .000
*
    RESRVR [ 2 : 0007] 0502  1  2.0  38.44   .08 14.73   9.22  n/a   .000
    {ST=   .16 ha.m }
*
```

```
******************************
** SIMULATION NUMBER:  2 **
******************************

W/E COMMAND           HYD ID  DT   AREA  Qpeak Tpeak  R.V. R.C.  Qbase
                  min   ha   cms  hrs   mm        cms

 START @  .00 hrs
 ---------------------
 READ STORM           6.0
 [ Ptot= 62.87 mm ]
 fname : D:\Otthymo - backup to G when finished editing\2361 Otthymo\Peterborough\5YR 24 SCS Peterborough.stm
 remark: Peterborough 5Yr 24 Hour SCS Distribution
*
** CALIB NASHYD     1051  1 2.0    .71   .00  .00   .00 .00  .000
 [CN=56.8       ]
 [ N = 3.0:Tp  .08]
*
** CALIB NASHYD     0105  1 2.0   6.96   .10 12.60 14.53 .23  .000
 [CN=62.1       ]
 [ N = 3.0:Tp  .66]
*
** CALIB NASHYD     0201  1 2.0   4.58   .20 12.00 14.33 .23  .000
 [CN=61.6       ]
 [ N = 3.0:Tp  .09]
*
** CALIB NASHYD     0204  1 2.0    .43   .03 12.03 22.80 .36  .000
 [CN=73.1       ]
 [ N = 3.0:Tp  .12]
*
** CALIB NASHYD     0202  1 2.0   2.12   .11 12.00 17.25 .27  .000
 [CN=64.7       ]
 [ N = 3.0:Tp  .07]
*
** CALIB NASHYD     0103  1 2.0  11.14   .35 12.07 13.81 .22  .000
 [CN=60.8       ]
 [ N = 3.0:Tp  .19]
*
** CALIB NASHYD     0101  1 2.0   4.25   .07 12.53 15.18 .24  .000
 [CN=63.6       ]
 [ N = 3.0:Tp  .60]
*
** CALIB NASHYD     0205  1 2.0   8.25   .13 13.03 20.35 .32  .000
 [CN=69.6       ]
 [ N = 3.0:Tp 1.03]
*
** CALIB NASHYD     0106  1 2.0   4.14   .00 15.00  2.46 .04  .000
 [CN=57.9       ]
 [ N = 3.0:Tp 1.03]
*
** CALIB NASHYD     0109  1 2.0  42.23   .02 16.37  1.53 .02  .000
 [CN=51.4       ]
 [ N = 3.0:Tp 1.23]
*
** CALIB NASHYD     0203  1 2.0   3.80   .13 12.00 10.18 .16  .000
 [CN=55.1       ]
 [ N = 3.0:Tp  .03]
*
** CALIB NASHYD     0104  1 2.0   6.86   .18 12.43 21.99 .35  .000
 [CN=73.7       ]
 [ N = 3.0:Tp  .54]
*
** CALIB NASHYD     0102  1 2.0   8.38   .09 12.73 11.90 .19  .000
 [CN=56.6       ]
 [ N = 3.0:Tp  .74]
*
 ADD [1051 + 0105]  0002  3 2.0   7.67   .10 12.60 13.18 n/a  .000
*
```

```
   ADD [0002 + 0201]  0004  3  2.0   12.25    .24 12.00  13.61  n/a   .000
 *
   ADD [0103 + 0101]  0001  3  2.0   15.39    .39 12.10  14.19  n/a   .000
 *
   ADD [0106 + 0109]  0011  3  2.0   46.37    .02 16.33   1.62  n/a   .000
 *
   ADD [0104 + 0102]  0009  3  2.0   15.24    .27 12.53  16.44  n/a   .000
 *
   ADD [0202 + 0001]  0003  3  2.0   17.51    .47 12.03  14.56  n/a   .000
 *
   ADD [0203 + 0009]  0010  3  2.0   19.04    .29 12.50  15.19  n/a   .000
 *
   ADD [0003 + 0205]  0005  3  2.0   25.76    .51 12.03  16.42  n/a   .000
 *
   ADD [0204 + 0005]  0006  3  2.0   26.19    .54 12.03  16.52  n/a   .000
 *
   ADD [0004 + 0006]  0007  3  2.0   38.44    .77 12.03  15.59  n/a   .000
 *
   RESRVR [ 2 : 0007] 0502  1  2.0   38.44    .16 14.40  15.58  n/a   .000
   {ST=   .26 ha.m }
 *
 *****************************
 ** SIMULATION NUMBER:   3 **
 *****************************

 W/E COMMAND          HYD ID  DT    AREA  Qpeak Tpeak  R.V. R.C.  Qbase
                        min    ha    cms   hrs    mm         cms

   START @   .00 hrs
   --------------------
   READ STORM              6.0
   [ Ptot= 84.47 mm ]
   fname : D:\Otthymo - backup to G when finished editing\2361 Otthymo\Peterborough\25YR 24 SCS Peterborough.st
   remark: Peterborough 25Yr 24 Hour SCS Distribution
 *
 **  CALIB NASHYD      1051  1  2.0    .71    .00   .00    .00  .00   .000
   [CN=56.8      ]
   [ N = 3.0:Tp  .08]
 *
 **  CALIB NASHYD      0105  1  2.0   6.96    .19 12.60  25.48  .30   .000
   [CN=62.1      ]
   [ N = 3.0:Tp  .66]
 *
 **  CALIB NASHYD      0201  1  2.0   4.58    .35 12.00  25.15  .30   .000
   [CN=61.6      ]
   [ N = 3.0:Tp  .09]
 *
 **  CALIB NASHYD      0204  1  2.0    .43    .04 12.03  37.29  .44   .000
   [CN=73.1      ]
   [ N = 3.0:Tp  .12]
 *
 **  CALIB NASHYD      0202  1  2.0   2.12    .19 12.00  29.19  .35   .000
   [CN=64.7      ]
   [ N = 3.0:Tp  .07]
 *
 **  CALIB NASHYD      0103  1  2.0  11.14    .63 12.07  24.39  .29   .000
   [CN=60.8      ]
   [ N = 3.0:Tp  .19]
 *
 **  CALIB NASHYD      0101  1  2.0   4.25    .13 12.53  26.53  .31   .000
   [CN=63.6      ]
   [ N = 3.0:Tp  .60]
 *
 **  CALIB NASHYD      0205  1  2.0   8.25    .21 13.00  33.76  .40   .000
   [CN=69.6      ]
   [ N = 3.0:Tp 1.03]
 *
 **  CALIB NASHYD      0106  1  2.0   4.14    .02 13.37   8.52  .10   .000
   [CN=57.9      ]
   [ N = 3.0:Tp 1.03]
```

```
*
** CALIB NASHYD     0109  1  2.0   42.23    .10 14.40   6.13  .07    .000
   [CN=51.4       ]
   [ N = 3.0:Tp 1.23]
*
** CALIB NASHYD     0203  1  2.0    3.80    .24 12.00  18.50  .22    .000
   [CN=55.1       ]
   [ N = 3.0:Tp  .03]
*
** CALIB NASHYD     0104  1  2.0    6.86    .31 12.43  36.48  .43    .000
   [CN=73.7       ]
   [ N = 3.0:Tp  .54]
*
** CALIB NASHYD     0102  1  2.0    8.38    .17 12.70  21.37  .25    .000
   [CN=56.6       ]
   [ N = 3.0:Tp  .74]
*
   ADD [1051 + 0105] 0002  3  2.0   7.67    .19 12.60  23.12  n/a   .000
*
   ADD [0002 + 0201] 0004  3  2.0  12.25    .43 12.00  23.88  n/a   .000
*
   ADD [0103 + 0101] 0001  3  2.0  15.39    .70 12.10  24.98  n/a   .000
*
   ADD [0106 + 0109] 0011  3  2.0  46.37    .11 14.33   6.35  n/a   .000
*
   ADD [0104 + 0102] 0009  3  2.0  15.24    .47 12.50  28.17  n/a   .000
*
   ADD [0202 + 0001] 0003  3  2.0  17.51    .85 12.03  25.49  n/a   .000
*
   ADD [0203 + 0009] 0010  3  2.0  19.04    .51 12.50  26.24  n/a   .000
*
   ADD [0003 + 0205] 0005  3  2.0  25.76    .92 12.03  28.14  n/a   .000
*
   ADD [0204 + 0005] 0006  3  2.0  26.19    .96 12.03  28.29  n/a   .000
*
   ADD [0004 + 0006] 0007  3  2.0  38.44   1.38 12.03  26.89  n/a   .000
*
   RESRVR [ 2 : 0007] 0502  1  2.0  38.44    .32 14.20  26.87  n/a   .000
   {ST=   .44 ha.m }
*
*****************************
** SIMULATION NUMBER:   4 **
*****************************

W/E COMMAND          HYD ID   DT    AREA   Qpeak Tpeak   R.V. R.C.  Qbase
                         min    ha     cms   hrs    mm          cms

   START @   .00 hrs
   --------------------
   READ STORM              6.0
   [ Ptot= 93.54 mm ]
   fname : D:\Otthymo - backup to G when finished editing\2361 Otthymo\Peterborough\50YR 24 SCS Peterborough.st
   remark: Peterborough 50Yr 24 Hour SCS Distribution
*
** CALIB NASHYD     1051  1  2.0    .71    .00   .00    .00  .00   .000
   [CN=56.8       ]
   [ N = 3.0:Tp  .08]
*
** CALIB NASHYD     0105  1  2.0   6.96    .22 12.60  30.65  .33   .000
   [CN=62.1       ]
   [ N = 3.0:Tp  .66]
*
** CALIB NASHYD     0201  1  2.0   4.58    .42 12.00  30.26  .32   .000
   [CN=61.6       ]
   [ N = 3.0:Tp  .09]
*
** CALIB NASHYD     0204  1  2.0    .43    .05 12.00  43.87  .47   .000
   [CN=73.1       ]
   [ N = 3.0:Tp  .12]
*
```

```
** CALIB NASHYD      0202  1  2.0    2.12    .23 12.00  34.74  .37    .000
   [CN=64.7        ]
   [ N = 3.0:Tp  .07]
*
** CALIB NASHYD      0103  1  2.0   11.14    .76 12.07  29.40  .31    .000
   [CN=60.8        ]
   [ N = 3.0:Tp  .19]
*
** CALIB NASHYD      0101  1  2.0    4.25    .15 12.53  31.87  .34    .000
   [CN=63.6        ]
   [ N = 3.0:Tp  .60]
*
** CALIB NASHYD      0205  1  2.0    8.25    .25 13.00  39.92  .43    .000
   [CN=69.6        ]
   [ N = 3.0:Tp 1.03]
*
** CALIB NASHYD      0106  1  2.0    4.14    .03 13.33  11.91  .13    .000
   [CN=57.9        ]
   [ N = 3.0:Tp 1.03]
*
** CALIB NASHYD      0109  1  2.0   42.23    .15 13.60   8.82  .09    .000
   [CN=51.4        ]
   [ N = 3.0:Tp 1.23]
*
** CALIB NASHYD      0203  1  2.0    3.80    .29 12.00  22.50  .24    .000
   [CN=55.1        ]
   [ N = 3.0:Tp  .03]
*
** CALIB NASHYD      0104  1  2.0    6.86    .37 12.43  43.08  .46    .000
   [CN=73.7        ]
   [ N = 3.0:Tp  .54]
*
** CALIB NASHYD      0102  1  2.0    8.38    .21 12.70  25.90  .28    .000
   [CN=56.6        ]
   [ N = 3.0:Tp  .74]
*
   ADD [1051 + 0105] 0002  3  2.0    7.67    .22 12.60  27.81  n/a    .000
*
   ADD [0002 + 0201] 0004  3  2.0   12.25    .51 12.00  28.73  n/a    .000
*
   ADD [0103 + 0101] 0001  3  2.0   15.39    .85 12.07  30.09  n/a    .000
*
   ADD [0106 + 0109] 0011  3  2.0   46.37    .18 13.53   9.09  n/a    .000
*
   ADD [0104 + 0102] 0009  3  2.0   15.24    .56 12.50  33.63  n/a    .000
*
   ADD [0202 + 0001] 0003  3  2.0   17.51   1.02 12.03  30.65  n/a    .000
*
   ADD [0203 + 0009] 0010  3  2.0   19.04    .61 12.50  31.41  n/a    .000
*
   ADD [0003 + 0205] 0005  3  2.0   25.76   1.10 12.03  33.62  n/a    .000
*
   ADD [0204 + 0005] 0006  3  2.0   26.19   1.16 12.03  33.79  n/a    .000
*
   ADD [0004 + 0006] 0007  3  2.0   38.44   1.66 12.03  32.17  n/a    .000
*
   RESRVR [ 2 : 0007] 0502 1  2.0   38.44    .40 14.17  32.16  n/a    .000
   {ST=   .51 ha.m }
*
```

```
****************************
** SIMULATION NUMBER:  5 **
****************************

W/E COMMAND          HYD ID  DT   AREA  Qpeak Tpeak  R.V. R.C.  Qbase
                    min    ha    cms  hrs   mm        cms

   START @  .00 hrs
   -------------------
   READ STORM            6.0
   [ Ptot=102.77 mm ]
   fname : D:\Otthymo - backup to G when finished editing\2361 Otthymo\Peterborough\100YR 24 SCS Peterborough.s
   remark: Peterborough 100Yr 24 Hour SCS Distribution
*
** CALIB NASHYD     1051  1  2.0    .71    .00  .00   .00  .00   .000
   [CN=56.8       ]
   [ N = 3.0:Tp  .08]
*
** CALIB NASHYD     0105  1  2.0   6.96    .27 12.60  36.20  .35   .000
   [CN=62.1       ]
   [ N = 3.0:Tp  .66]
*
** CALIB NASHYD     0201  1  2.0   4.58    .50 12.00  35.75  .35   .000
   [CN=61.6       ]
   [ N = 3.0:Tp  .09]
*
** CALIB NASHYD     0204  1  2.0    .43    .06 12.00  50.80  .49   .000
   [CN=73.1       ]
   [ N = 3.0:Tp  .12]
*
** CALIB NASHYD     0202  1  2.0   2.12    .27 12.00  40.67  .40   .000
   [CN=64.7       ]
   [ N = 3.0:Tp  .07]
*
** CALIB NASHYD     0103  1  2.0  11.14    .90 12.07  34.80  .34   .000
   [CN=60.8       ]
   [ N = 3.0:Tp  .19]
*
** CALIB NASHYD     0101  1  2.0   4.25    .18 12.53  37.59  .37   .000
   [CN=63.6       ]
   [ N = 3.0:Tp  .60]
*
** CALIB NASHYD     0205  1  2.0   8.25    .30 13.00  46.45  .45   .000
   [CN=69.6       ]
   [ N = 3.0:Tp 1.03]
*
** CALIB NASHYD     0106  1  2.0   4.14    .04 13.27  15.79  .15   .000
   [CN=57.9       ]
   [ N = 3.0:Tp 1.03]
*
** CALIB NASHYD     0109  1  2.0  42.23    .23 13.53  11.95  .12   .000
   [CN=51.4       ]
   [ N = 3.0:Tp 1.23]
*
** CALIB NASHYD     0203  1  2.0   3.80    .35 12.00  26.84  .26   .000
   [CN=55.1       ]
   [ N = 3.0:Tp  .03]
*
** CALIB NASHYD     0104  1  2.0   6.86    .43 12.43  50.04  .49   .000
   [CN=73.7       ]
   [ N = 3.0:Tp  .54]
*
** CALIB NASHYD     0102  1  2.0   8.38    .25 12.70  30.80  .30   .000
   [CN=56.6       ]
   [ N = 3.0:Tp  .74]
*
   ADD [1051 + 0105] 0002  3  2.0   7.67    .27 12.60  32.85  n/a   .000
*
```

```
  ADD [0002 + 0201] 0004  3  2.0   12.25    .61 12.00  33.93  n/a   .000
*
  ADD [0103 + 0101] 0001  3  2.0   15.39   1.00 12.07  35.57  n/a   .000
*
  ADD [0106 + 0109] 0011  3  2.0   46.37    .26 13.47  12.29  n/a   .000
*
  ADD [0104 + 0102] 0009  3  2.0   15.24    .66 12.50  39.46  n/a   .000
*
  ADD [0202 + 0001] 0003  3  2.0   17.51   1.21 12.03  36.19  n/a   .000
*
  ADD [0203 + 0009] 0010  3  2.0   19.04    .72 12.50  36.94  n/a   .000
*
  ADD [0003 + 0205] 0005  3  2.0   25.76   1.31 12.03  39.47  n/a   .000
*
  ADD [0204 + 0005] 0006  3  2.0   26.19   1.37 12.03  39.66  n/a   .000
*
  ADD [0004 + 0006] 0007  3  2.0   38.44   1.96 12.03  37.83  n/a   .000
*
  RESRVR [ 2 : 0007] 0502  1  2.0   38.44    .48 14.10  37.82  n/a   .000
  {ST=   .59 ha.m }
*
******************************
** SIMULATION NUMBER:   6 **
******************************

W/E COMMAND          HYD ID  DT   AREA  Qpeak Tpeak  R.V. R.C.  Qbase
                        min   ha   cms  hrs   mm         cms

  START @   .00 hrs
  -------------------
  READ STORM               5.0
  [ Ptot= 33.04 mm ]
  fname : D:\Otthymo - backup to G when finished editing\2361 Otthymo\Peterborough\2YR 4HR CHI Peterborough.st
  remark: Peterborough 2 Yr 4 Hour Chicago Distribution
*
** CALIB NASHYD     1051  1  2.0    .71    .00   .00    .00  .00   .000
  [CN=56.8        ]
  [ N = 3.0:Tp  .08]
*
** CALIB NASHYD     0105  1  2.0   6.96    .03  2.37   3.59  .11   .000
  [CN=62.1        ]
  [ N = 3.0:Tp  .66]
*
** CALIB NASHYD     0201  1  2.0   4.58    .05  1.47   3.54  .11   .000
  [CN=61.6        ]
  [ N = 3.0:Tp  .09]
*
** CALIB NASHYD     0204  1  2.0    .43    .01  1.50   6.92  .21   .000
  [CN=73.1        ]
  [ N = 3.0:Tp  .12]
*
** CALIB NASHYD     0202  1  2.0   2.12    .04  1.40   4.86  .15   .000
  [CN=64.7        ]
  [ N = 3.0:Tp  .07]
*
** CALIB NASHYD     0103  1  2.0  11.14    .09  1.63   3.34  .10   .000
  [CN=60.8        ]
  [ N = 3.0:Tp  .19]
*
** CALIB NASHYD     0101  1  2.0   4.25    .02  2.30   3.76  .11   .000
  [CN=63.6        ]
  [ N = 3.0:Tp  .60]
*
** CALIB NASHYD     0205  1  2.0   8.25    .05  2.80   5.99  .18   .000
  [CN=69.6        ]
  [ N = 3.0:Tp 1.03]
*
** CALIB NASHYD     0106  1  2.0   4.14    .00   .00    .00  .00   .000
  [CN=57.9        ]
  [ N = 3.0:Tp 1.03]
```

```
*
** CALIB NASHYD     0109  1 2.0  42.23   .00  .00   .00 .00   .000
   [CN=51.4        ]
   [ N = 3.0:Tp 1.23]
*
** CALIB NASHYD     0203  1 2.0   3.80   .03 1.33  2.27 .07   .000
   [CN=55.1        ]
   [ N = 3.0:Tp  .03]
*
** CALIB NASHYD     0104  1 2.0   6.86   .06 2.13  6.25 .19   .000
   [CN=73.7        ]
   [ N = 3.0:Tp  .54]
*
** CALIB NASHYD     0102  1 2.0   8.38   .03 2.53  2.77 .08   .000
   [CN=56.6        ]
   [ N = 3.0:Tp  .74]
*
   ADD [1051 + 0105] 0002  3 2.0   7.67   .03 2.37  3.25 n/a   .000
*
   ADD [0002 + 0201] 0004  3 2.0  12.25   .06 1.50  3.36 n/a   .000
*
   ADD [0103 + 0101] 0001  3 2.0  15.39   .10 1.67  3.46 n/a   .000
*
   ADD [0106 + 0109] 0011  3 2.0  46.37   .00  .00   .00 n/a   .000
*
   ADD [0104 + 0102] 0009  3 2.0  15.24   .09 2.23  4.34 n/a   .000
*
   ADD [0202 + 0001] 0003  3 2.0  17.51   .12 1.63  3.63 n/a   .000
*
   ADD [0203 + 0009] 0010  3 2.0  19.04   .09 2.17  3.92 n/a   .000
*
   ADD [0003 + 0205] 0005  3 2.0  25.76   .13 1.67  4.38 n/a   .000
*
   ADD [0204 + 0005] 0006  3 2.0  26.19   .14 1.67  4.43 n/a   .000
*
   ADD [0004 + 0006] 0007  3 2.0  38.44   .19 1.60  4.09 n/a   .000
*
   RESRVR [ 2 : 0007] 0502  1 2.0  38.44   .04 4.50  4.07 n/a   .000
   {ST=   .11 ha.m }
*
****************************
** SIMULATION NUMBER:   7 **
****************************

W/E COMMAND          HYD ID  DT   AREA  Qpeak Tpeak  R.V. R.C.  Qbase
                        min   ha   cms   hrs   mm         cms

   START @   .00 hrs
   --------------------
   READ STORM            5.0
   [ Ptot= 44.81 mm ]
   fname : D:\Otthymo - backup to G when finished editing\2361 Otthymo\Peterborough\5YR 4HR CHI Peterborough.st
   remark: Peterborough 5 Yr 4 Hour Chicago Distribution
*
** CALIB NASHYD     1051  1 2.0    .71   .00  .00   .00 .00   .000
   [CN=56.8        ]
   [ N = 3.0:Tp  .08]
*
** CALIB NASHYD     0105  1 2.0   6.96   .07 2.30  7.20 .16   .000
   [CN=62.1        ]
   [ N = 3.0:Tp  .66]
*
** CALIB NASHYD     0201  1 2.0   4.58   .12 1.47  7.11 .16   .000
   [CN=61.6        ]
   [ N = 3.0:Tp  .09]
*
** CALIB NASHYD     0204  1 2.0    .43   .02 1.50 12.45 .28   .000
   [CN=73.1        ]
   [ N = 3.0:Tp  .12]
*
```

```
** CALIB NASHYD      0202  1  2.0    2.12    .08  1.40   9.06  .20   .000
   [CN=64.7        ]
   [ N = 3.0:Tp  .07]
*
** CALIB NASHYD      0103  1  2.0   11.14    .20  1.63   6.79  .15   .000
   [CN=60.8        ]
   [ N = 3.0:Tp  .19]
*
** CALIB NASHYD      0101  1  2.0    4.25    .04  2.23   7.55  .17   .000
   [CN=63.6        ]
   [ N = 3.0:Tp  .60]
*
** CALIB NASHYD      0205  1  2.0    8.25    .09  2.77  10.93  .24   .000
   [CN=69.6        ]
   [ N = 3.0:Tp 1.03]
*
** CALIB NASHYD      0106  1  2.0    4.14    .00  4.60    .11  .00   .000
   [CN=57.9        ]
   [ N = 3.0:Tp 1.03]
*
** CALIB NASHYD      0109  1  2.0   42.23    .00  5.00    .02  .00   .000
   [CN=51.4        ]
   [ N = 3.0:Tp 1.23]
*
** CALIB NASHYD      0203  1  2.0    3.80    .09  1.33   4.82  .11   .000
   [CN=55.1        ]
   [ N = 3.0:Tp  .03]
*
** CALIB NASHYD      0104  1  2.0    6.86    .13  2.10  11.69  .26   .000
   [CN=73.7        ]
   [ N = 3.0:Tp  .54]
*
** CALIB NASHYD      0102  1  2.0    8.38    .06  2.47   5.74  .13   .000
   [CN=56.6        ]
   [ N = 3.0:Tp  .74]
*
   ADD [1051 + 0105] 0002  3  2.0    7.67    .07  2.30   6.54  n/a   .000
*
   ADD [0002 + 0201] 0004  3  2.0   12.25    .13  1.47   6.75  n/a   .000
*
   ADD [0103 + 0101] 0001  3  2.0   15.39    .22  1.67   7.00  n/a   .000
*
   ADD [0106 + 0109] 0011  3  2.0   46.37    .00  4.83    .02  n/a   .000
*
   ADD [0104 + 0102] 0009  3  2.0   15.24    .18  2.20   8.41  n/a   .000
*
   ADD [0202 + 0001] 0003  3  2.0   17.51    .26  1.60   7.25  n/a   .000
*
   ADD [0203 + 0009] 0010  3  2.0   19.04    .19  2.17   7.70  n/a   .000
*
   ADD [0003 + 0205] 0005  3  2.0   25.76    .28  1.63   8.43  n/a   .000
*
   ADD [0204 + 0005] 0006  3  2.0   26.19    .29  1.63   8.49  n/a   .000
*
   ADD [0004 + 0006] 0007  3  2.0   38.44    .40  1.57   7.94  n/a   .000
*
   RESRVR [ 2 : 0007] 0502  1  2.0  38.44    .11  4.20   7.92  n/a   .000
   {ST=   .20 ha.m }
*
```

```
*****************************
** SIMULATION NUMBER:   8 **
*****************************

W/E COMMAND          HYD ID  DT   AREA  Qpeak Tpeak  R.V. R.C.  Qbase
                      min   ha   cms  hrs   mm         cms

   START @  .00 hrs
   ----------------
   READ STORM            5.0
   [ Ptot= 62.46 mm ]
   fname : D:\Otthymo - backup to G when finished editing\2361 Otthymo\Peterborough\25YR 4HR CHI Peterborough.s
   remark: Peterborough 25 Yr 4 Hour Chicago Distribution
*
** CALIB NASHYD     1051  1  2.0    .71    .00  .00   .00  .00   .000
   [CN=56.8        ]
   [ N = 3.0:Tp  .08]
*
** CALIB NASHYD     0105  1  2.0   6.96    .14  2.27  14.34  .23   .000
   [CN=62.1        ]
   [ N = 3.0:Tp  .66]
*
** CALIB NASHYD     0201  1  2.0   4.58    .25  1.43  14.14  .23   .000
   [CN=61.6        ]
   [ N = 3.0:Tp  .09]
*
** CALIB NASHYD     0204  1  2.0    .43    .04  1.50  22.55  .36   .000
   [CN=73.1        ]
   [ N = 3.0:Tp  .12]
*
** CALIB NASHYD     0202  1  2.0   2.12    .15  1.40  17.05  .27   .000
   [CN=64.7        ]
   [ N = 3.0:Tp  .07]
*
** CALIB NASHYD     0103  1  2.0  11.14    .42  1.60  13.63  .22   .000
   [CN=60.8        ]
   [ N = 3.0:Tp  .19]
*
** CALIB NASHYD     0101  1  2.0   4.25    .09  2.20  14.98  .24   .000
   [CN=63.6        ]
   [ N = 3.0:Tp  .60]
*
** CALIB NASHYD     0205  1  2.0   8.25    .17  2.73  20.12  .32   .000
   [CN=69.6        ]
   [ N = 3.0:Tp 1.03]
*
** CALIB NASHYD     0106  1  2.0   4.14    .01  3.93   2.37  .04   .000
   [CN=57.9        ]
   [ N = 3.0:Tp 1.03]
*
** CALIB NASHYD     0109  1  2.0  42.23    .06  4.27   1.47  .02   .000
   [CN=51.4        ]
   [ N = 3.0:Tp 1.23]
*
** CALIB NASHYD     0203  1  2.0   3.80    .20  1.33  10.04  .16   .000
   [CN=55.1        ]
   [ N = 3.0:Tp  .03]
*
** CALIB NASHYD     0104  1  2.0   6.86    .25  2.07  21.73  .35   .000
   [CN=73.7        ]
   [ N = 3.0:Tp  .54]
*
** CALIB NASHYD     0102  1  2.0   8.38    .12  2.40  11.75  .19   .000
   [CN=56.6        ]
   [ N = 3.0:Tp  .74]
*
   ADD [1051 + 0105] 0002  3  2.0   7.67    .14  2.27  13.01  n/a   .000
*
```

```
  ADD [0002 + 0201] 0004 3 2.0  12.25   .27 1.47 13.44 n/a   .000
*
  ADD [0103 + 0101] 0001 3 2.0  15.39   .47 1.63 14.01 n/a   .000
*
  ADD [0106 + 0109] 0011 3 2.0  46.37   .07 4.23  1.55 n/a   .000
*
  ADD [0104 + 0102] 0009 3 2.0  15.24   .36 2.17 16.24 n/a   .000
*
  ADD [0202 + 0001] 0003 3 2.0  17.51   .55 1.60 14.38 n/a   .000
*
  ADD [0203 + 0009] 0010 3 2.0  19.04   .39 2.17 15.00 n/a   .000
*
  ADD [0003 + 0205] 0005 3 2.0  25.76   .59 1.63 16.21 n/a   .000
*
  ADD [0204 + 0005] 0006 3 2.0  26.19   .62 1.60 16.32 n/a   .000
*
  ADD [0004 + 0006] 0007 3 2.0  38.44   .86 1.57 15.40 n/a   .000
*
  RESRVR [ 2 : 0007] 0502 1 2.0  38.44   .25 4.07 15.38 n/a   .000
  {ST=   .37 ha.m }
*
*****************************
** SIMULATION NUMBER:   9 **
*****************************

W/E COMMAND          HYD ID  DT   AREA  Qpeak Tpeak  R.V. R.C.  Qbase
                        min   ha   cms  hrs   mm        cms

  START @   .00 hrs
  --------------------
  READ STORM            5.0
  [ Ptot= 69.58 mm ]
  fname : G:\Projects-1\OTTHYMO  FILES\Peterborough\50YR 4HR CHI Peterborough.stm
  remark: Peterborough 50 Yr 4 Hour Chicago Distribution
*
** CALIB NASHYD      1051  1 2.0    .71    .00  .00   .00 .00   .000
  [CN=56.8       ]
  [ N = 3.0:Tp  .08]
*
** CALIB NASHYD      0105  1 2.0   6.96    .17 2.27 17.70 .25   .000
  [CN=62.1       ]
  [ N = 3.0:Tp  .66]
*
** CALIB NASHYD      0201  1 2.0   4.58    .31 1.43 17.46 .25   .000
  [CN=61.6       ]
  [ N = 3.0:Tp  .09]
*
** CALIB NASHYD      0204  1 2.0    .43    .04 1.47 27.10 .39   .000
  [CN=73.1       ]
  [ N = 3.0:Tp  .12]
*
** CALIB NASHYD      0202  1 2.0   2.12    .19 1.40 20.74 .30   .000
  [CN=64.7       ]
  [ N = 3.0:Tp  .07]
*
** CALIB NASHYD      0103  1 2.0  11.14    .53 1.60 16.88 .24   .000
  [CN=60.8       ]
  [ N = 3.0:Tp  .19]
*
** CALIB NASHYD      0101  1 2.0   4.25    .12 2.20 18.48 .27   .000
  [CN=63.6       ]
  [ N = 3.0:Tp  .60]
*
** CALIB NASHYD      0205  1 2.0   8.25    .21 2.70 24.30 .35   .000
  [CN=69.6       ]
  [ N = 3.0:Tp 1.03]
*
** CALIB NASHYD      0106  1 2.0   4.14    .02 3.63  4.01 .06   .000
  [CN=57.9       ]
  [ N = 3.0:Tp 1.03]
```

```
*
** CALIB NASHYD      0109  1  2.0  42.23    .10  4.10   2.67  .04   .000
   [CN=51.4       ]
   [ N = 3.0:Tp 1.23]
*
** CALIB NASHYD      0203  1  2.0   3.80    .26  1.33  12.57  .18   .000
   [CN=55.1       ]
   [ N = 3.0:Tp  .03]
*
** CALIB NASHYD      0104  1  2.0   6.86    .30  2.07  26.28  .38   .000
   [CN=73.7       ]
   [ N = 3.0:Tp  .54]
*
** CALIB NASHYD      0102  1  2.0   8.38    .16  2.40  14.62  .21   .000
   [CN=56.6       ]
   [ N = 3.0:Tp  .74]
*
   ADD [1051 + 0105] 0002  3  2.0   7.67    .17  2.27  16.06  n/a   .000
*
   ADD [0002 + 0201] 0004  3  2.0  12.25    .34  1.47  16.59  n/a   .000
*
   ADD [0103 + 0101] 0001  3  2.0  15.39    .59  1.63  17.32  n/a   .000
*
   ADD [0106 + 0109] 0011  3  2.0  46.37    .12  4.07   2.79  n/a   .000
*
   ADD [0104 + 0102] 0009  3  2.0  15.24    .44  2.17  19.87  n/a   .000
*
   ADD [0202 + 0001] 0003  3  2.0  17.51    .69  1.60  17.73  n/a   .000
*
   ADD [0203 + 0009] 0010  3  2.0  19.04    .48  2.10  18.41  n/a   .000
*
   ADD [0003 + 0205] 0005  3  2.0  25.76    .74  1.60  19.84  n/a   .000
*
   ADD [0204 + 0005] 0006  3  2.0  26.19    .78  1.60  19.96  n/a   .000
*
   ADD [0004 + 0006] 0007  3  2.0  38.44   1.07  1.53  18.88  n/a   .000
*
   RESRVR [ 2 : 0007] 0502  1  2.0  38.44   .32  4.00  18.87  n/a   .000
   {ST=   .44 ha.m }
*
******************************
** SIMULATION NUMBER:  10 **
******************************

W/E COMMAND          HYD ID   DT   AREA  Qpeak Tpeak  R.V. R.C.  Qbase
                          min   ha    cms   hrs    mm         cms

   START @   .00 hrs
   --------------------
   READ STORM              5.0
   [ Ptot= 76.81 mm ]
   fname : D:\Otthymo - backup to G when finished editing\2361 Otthymo\Peterborough\100YR 4HR CHI Peterborough.
   remark: Peterborough 100 Yr 4 Hour Chicago Distribution
*
** CALIB NASHYD      1051  1  2.0    .71    .00   .00    .00  .00   .000
   [CN=56.8       ]
   [ N = 3.0:Tp  .08]
*
** CALIB NASHYD      0105  1  2.0   6.96    .21  2.27  21.36  .28   .000
   [CN=62.1       ]
   [ N = 3.0:Tp  .66]
*
** CALIB NASHYD      0201  1  2.0   4.58    .38  1.43  21.08  .27   .000
   [CN=61.6       ]
   [ N = 3.0:Tp  .09]
*
** CALIB NASHYD      0204  1  2.0    .43    .05  1.47  31.94  .42   .000
   [CN=73.1       ]
   [ N = 3.0:Tp  .12]
*
```

```
 ** CALIB NASHYD      0202  1  2.0    2.12    .23  1.40  24.73  .32    .000
    [CN=64.7      ]
    [ N = 3.0:Tp  .07]
*
 ** CALIB NASHYD      0103  1  2.0   11.14    .65  1.60  20.41  .27    .000
    [CN=60.8      ]
    [ N = 3.0:Tp  .19]
*
 ** CALIB NASHYD      0101  1  2.0    4.25    .14  2.17  22.27  .29    .000
    [CN=63.6      ]
    [ N = 3.0:Tp  .60]
*
 ** CALIB NASHYD      0205  1  2.0    8.25    .25  2.70  28.79  .37    .000
    [CN=69.6      ]
    [ N = 3.0:Tp 1.03]
*
 ** CALIB NASHYD      0106  1  2.0    4.14    .02  3.43   6.03  .08    .000
    [CN=57.9      ]
    [ N = 3.0:Tp 1.03]
*
 ** CALIB NASHYD      0109  1  2.0   42.23    .15  3.93   4.20  .05    .000
    [CN=51.4      ]
    [ N = 3.0:Tp 1.23]
*
 ** CALIB NASHYD      0203  1  2.0    3.80    .32  1.33  15.34  .20    .000
    [CN=55.1      ]
    [ N = 3.0:Tp  .03]
*
 ** CALIB NASHYD      0104  1  2.0    6.86    .36  2.07  31.13  .41    .000
    [CN=73.7      ]
    [ N = 3.0:Tp  .54]
*
 ** CALIB NASHYD      0102  1  2.0    8.38    .19  2.40  17.78  .23    .000
    [CN=56.6      ]
    [ N = 3.0:Tp  .74]
*
    ADD [1051 + 0105] 0002  3  2.0    7.67    .21  2.27  19.39  n/a    .000
*
    ADD [0002 + 0201] 0004  3  2.0   12.25    .41  1.47  20.02  n/a    .000
*
    ADD [0103 + 0101] 0001  3  2.0   15.39    .72  1.63  20.92  n/a    .000
*
    ADD [0106 + 0109] 0011  3  2.0   46.37    .18  3.87   4.36  n/a    .000
*
    ADD [0104 + 0102] 0009  3  2.0   15.24    .53  2.13  23.79  n/a    .000
*
    ADD [0202 + 0001] 0003  3  2.0   17.51    .85  1.60  21.38  n/a    .000
*
    ADD [0203 + 0009] 0010  3  2.0   19.04    .58  2.10  22.10  n/a    .000
*
    ADD [0003 + 0205] 0005  3  2.0   25.76    .90  1.60  23.76  n/a    .000
*
    ADD [0204 + 0005] 0006  3  2.0   26.19    .94  1.60  23.89  n/a    .000
*
    ADD [0004 + 0006] 0007  3  2.0   38.44   1.31  1.53  22.66  n/a    .000
*
    RESRVR [ 2 : 0007] 0502  1  2.0   38.44    .40  3.90  22.64  n/a    .000
    {ST=   .51 ha.m }
*
 FINISH

==========================================================================================
=========
```

APPENDIX F

Major Road Crossing Culvert Sizing

Bryan Bolivar

From: Kari Stevenson <KStevenson@trentlakes.ca>
Sent: Tuesday, March 29, 2016 10:52 AM
To: Bryan Bolivar
Subject: RE: PN 2361 - Granite Ridge Subdivision Phase II

I have checked with Public Works and the criteria that you have used with other rural municipalities listed below would be appropriate for this proposed subdivision.
Thank you,
Kari

From: Bryan Bolivar [mailto:bbolivar@skeltonbrumwell.ca]
Sent: Thursday, March 24, 2016 4:32 PM
To: Kari Stevenson <KStevenson@trentlakes.ca>
Cc: Michael Wynia <mwynia@skeltonbrumwell.ca>
Subject: PN 2361 - Granite Ridge Subdivision Phase II

Kari

We are updating the SWM design in response to comments from WSP dated December 9, 2014 (William Heywood). There is a request to confirm road crossing culvert criteria. This really needs to be confirmed by the Municipality

In the past when we have done work with other rural municipalities the road crossing culvert criteria has been similar to the following:

Culvert crossings must be design to achieve the following flow criteria

1. Convey the peak 1 in 25 year flow under free flow conditions.
2. Convey the peak 1 in 100 year flow without causing overtopping of the roadway.

Can the Township please confirm the required criteria for sizing of road crossing culverts?

Thank-you.

Bryan W. Bolivar, P.Eng | Senior Project Engineer
Skelton, Brumwell & Associates Inc.
Engineering Planning Environmental Consultants
93 Bell Farm Rd, Suite 107, Barrie, ON L4M 5G1
Tel: 705-726-1141*114 | Toll Free: 877-726-1141
Cell: 705-715-6997
www.skeltonbrumwell.ca
"Adding Value to Your Enterprise"

Design Chart 2.01: Manning Roughness Coefficient

	Manning Roughness Coefficients
I. Sewers	
A. Concrete pipe storm sewers	0.011 - 0.013
B. Verified clay pipe	0.012 - 0.014
C. Steel pipe (smooth)	0.009 - 0.011
D. Monolithic concrete:	
1. Wood forms, rough	0.015 - 0.017
2. Wood forms, smooth	0.012 - 0.014
3. Steel forms	0.012 - 0.013
E. Cemented rubble masonry walls:	
1. Concrete floor and top	0.017 - 0.022
2. Natural floor	0.019 - 0.025
F. Laminated treated wood	0.015 - 0.017
G. Smooth walled polyethylene pipe	0.011 - 0.013
Corrugated interior polyethylene pipe (tentative)	0.024
H. Corrugated steel pipe or pipe arch	
68 x 13 mm corrugation (riveted, annular)	
Unpaved	0.024
25% paved	0.021
100% paved	0.012
68 x 13 mm helical	
Unpaved: 600 to 1525 mm ϕ range:	0.016 - 0.024
25% paved: 600 to 1525 mm ϕ range:	0.015 - 0.021
100% paved: all sizes	0.012
68 x 25 mm riveted (annular)	
Unpaved	0.027
25% paved	0.023
100% paved	0.012
76 x 25 mm helical	
Unpaved: 900 to 1980 mm dia.:	0.021 - 0.027
25% paved: 900 to 1980 mm dia.:	0.019 - 0.023
100% paved: all sizes	0.012
152 x 51 mm corrugation (annular)	
Unpaved 1550 - 4500 mm dia.or	0.030 - 0.033
1900 to 5050 mm span	0.026
25% paved	
II. Road Gutters	0.012
A. Concrete gutter, trowelled finish	
B. Asphalt pavement:	0.013
1. Smooth texture	0.016
2. Rough texture	
C. Concrete gutter with asphalt pavement:	
1. Smooth	0.013
2. Rough	0.015

MTO Drainage Management Manual

Culverts Flowing in Inlet Control

Sketches of inlet control flow for both unsubmerged and submerged projecting entrances are shown in Figure 8.30 a and b. Figure 8.30 c shows a mitered entrance flowing submerged with inlet control. An increase in barrel slope reduces headwater only to a small degree, and can normally be neglected for conventional culverts flowing in inlet control.

When the headwater (HW) exceeds 1.5D, true orifice flow exists and can be represented by:

$$Q = C_d A \sqrt{2g\,[HW-D/2]} \qquad (8.80)$$

where:

- C_d = coefficient of discharge (see Table 8.6)
- A = cross section area of discharge of the culvert, m^2
- g = the acceleration due to gravity, m/s^2
- HW = headwater depth, m (refer to Figure 8.30)
- D = diameter of the culvert, m

Table 8.6: Inlet Loss Coefficients (C_d)

Inlet Type	Discharge Coefficient
Thin Walled Projecting (CSP)	0.50 *
Flush Headwall	0.60
Cylinder Inlet (1.25 D)	0.67
Socket Inlet (RCP)	0.70
Bellmouth Inlet	0.97

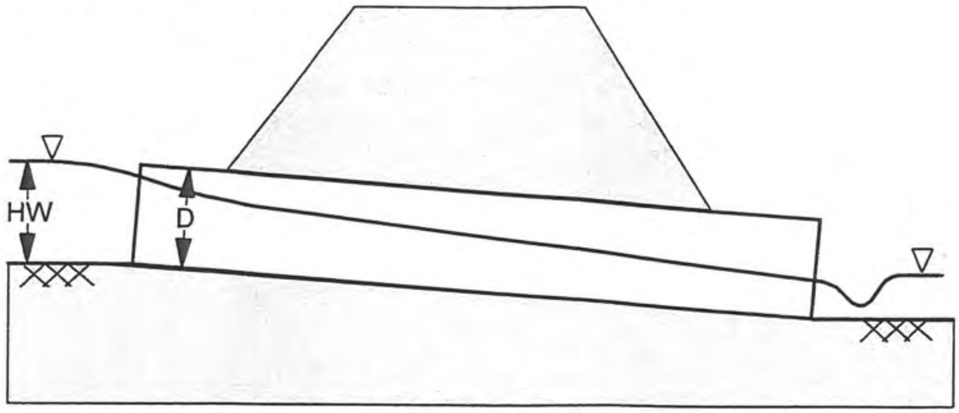
Design Charts 5.39 to 5.45 can be applied in place of Equation 8.80.

When the headwater HW is less than 1.5D, the culvert acts as a weir with a circular cross section; however, the weir equation cannot be solved analytically for such an application and it is not used in practice. Design Charts 2.31 to 2.33 and 5.39 to 5.45 can be used in such cases.

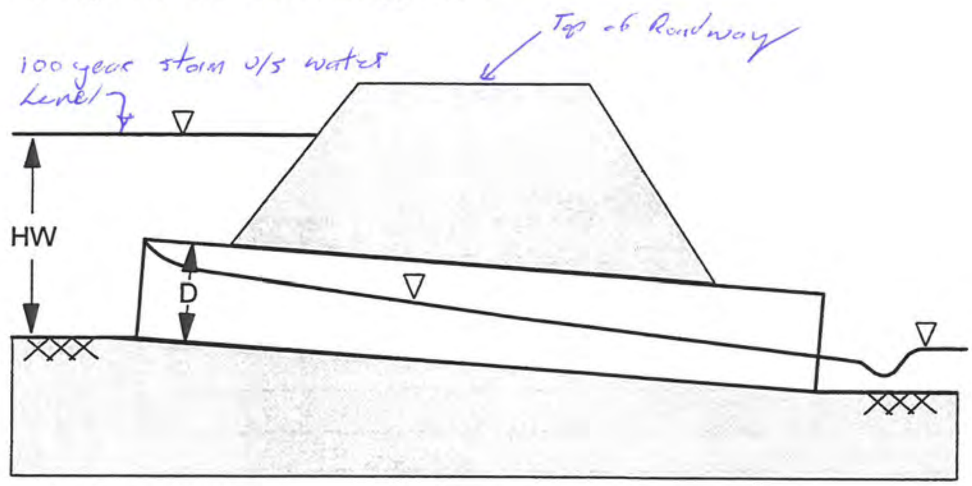
In all culvert design applications, it is important to recognize that headwater, or depth of ponding at the entrance to a culvert, is an important factor in culvert capacity. The headwater depth (HW) is the vertical distance from the culvert invert at the entrance to the energy gradeline of the headwater pool (depth + velocity head - refer to Figure 8.30). Because of the low velocities in most entrance pools, the water surface and the energy line at the entrance are usually assumed to be coincident, thus the headwater depths given by the inlet control charts (Design Charts 2.31 to 2.33 and 5.59 to 5.46) will be higher than will actually occur, by the amount of the velocity head $V^2/2g$ (refer to Figure 8.32). The difference may be ignored unless the approach velocity V_1 is exceptionally high.

F4

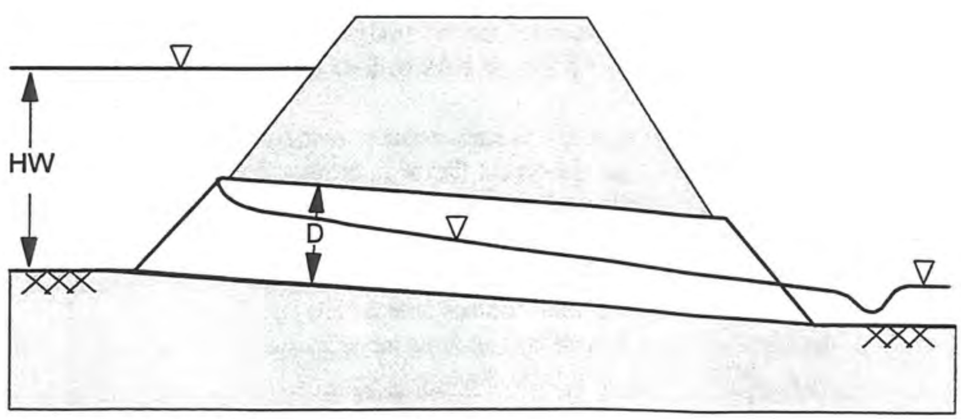
Figure 8.30: Flow Profiles for Culvert in Inlet Control



a. Projected End - Unsubmerged Inlet



b. Projected End - Submerged Inlet



c. Mitered End - Submerged Inlet

PN 06-2361 Granite Ridge Subdivison - Phase II March 28, 2016

Sizing Road Crossing Culverts

Culvert Sizing Criteria:

Road crossing culverts are designed to convey the peak 1 in 25 year storm flow under free flow conditions AND are designed to convey the peak 1 in 100 year storm flow under inlet control conditions such that the road is not overtopped

Culvert at Street A, Sta 0+225, peak flow calculated at Hydrograph 004 (Otthymo)

Storm Event	**Flow Rate (cms)**		**Design Flow (cms)**
2 yr SCS	0.134		
5 yr SCS	0.237		
25 yr SCS	*0.426*		**0.426**
50 yr SCS	0.513		
100 yr SCS	*0.608*		**0.608**
2 yr Chicago	0.057		
5 yr Chicago	0.127		
25 yr Chicago	0.269		
50 yr Chicago	0.338		
100 yr Chicag	*0.413*		

SCS 25yr storm flow is larger than Chicago 25 yr

SCS 100yr storm flow is larger than Chicago 100 yr

Culvert at Street A, Sta 0+578, peak flow calculated at Hydrograph 003 (Otthymo)

Storm Event	**Flow Rate (cms)**		**Design Flow (cms)**
2 yr SCS	0.266		
5 yr SCS	0.471		
25 yr SCS	*0.848*		**0.848**
50 yr SCS	1.022		
100 yr SCS	*1.210*		**1.21**
2 yr Chicago	0.117		
5 yr Chicago	0.26		
25 yr Chicago	*0.555*		
50 yr Chicago	0.695		
100 yr Chicag	*0.845*		

SCS 25yr storm flow is larger than Chicago 25 yr

SCS 100yr storm flow is larger than Chicago 100 yr

PN 06-236 Granite Ridge Subdivison - Phase II March 28, 2016

Sizing Road Crossing Culverts

Street A, Station 0+578, Hydrograph 003

Flow capacity criteria:	Convey 25yr peak under free flow conditions	**0.848**	**cms**
	Convey 100yr peak flow without overtopping roadway	**1.21**	**cms**

Mannings Calculation for Culvert Capacity

A) Solve for Flow (Q)

N factors		
	Concrete	0.013
	PVC	0.013
	CSP	**0.024**

N	0.024	
DIAMETER D	0.600	m
SLOPE S	1	%
Q	0.333	cms
V	1.176	m/s
Number of culverts	3	

$$Q = \left(\frac{1}{N}\right) * \left(\frac{D}{4}\right)^{0.667} * S^{0.5} * \pi * (\frac{D}{2})\text{^}2$$

Total Q **0.998 cms** **Convyes 25 year peak under free flow conditons**

Inlet Control

Projecting C.S.P: **0.50** MTO Drainage Mangement Manual, Table 8.6

COMPUTE DISCHARGE

Pipe Diameter (m) D:	0.6	Total # of culverts:	3
Coefficient C:	0.5	Total culvert flow:	1.328
Total Head (m) H:	0.8	Pipe invert to top of road shoulder	
DISCHARGE per culvert (cms):	0.44		

$$Q = \left(\sqrt{2 * 9.81 * \left(H - \left(\frac{D}{2}\right)\right)}\right) * C * \pi * (\frac{D}{2})\text{^}2$$

Total flow for all culverts **1.328 cms** **Conveys 100 year flow without overtopping road**

Recommended Culvert Design: 3, 680x500mm CSPA Culverts (600mm equivalent), min slope 1.0%

PN 06-236 | Granite Ridge Subdivison - Phase II | March 28, 2016

Sizing Road Crossing Culverts

Street A, Station 0+225, Hydrograph 004

Flow capacity criteria:	Convey 25yr peak under free flow conditions	**0.426 cms**
	Convey 100yr peak flow without overtopping roadway	**0.608 cms**

Mannings Calculation for Culvert Capacity

A) Solve for Flow (Q)

N	0.024		
DIAMETER D	0.500 m		
SLOPE S	1.1 %		
Q	0.215 cms		
V	1.093 m/s		
Number of culverts	2		

N factors

Concrete	0.013
PVC	0.013
CSP	0.024

$$Q = \left(\frac{1}{N}\right) * \left(\frac{D}{4}\right)^{0.667} * S^{0.5} * \pi * (\frac{D}{2})^{\wedge}2$$

Total Q **0.429 cms** **Conveys 25 year peak under free flow conditons**

Inlet Control

Projecting C.S.P: 0.50 MTO Drainage Mangement Manual, Table 8.6

COMPUTE DISCHARGE

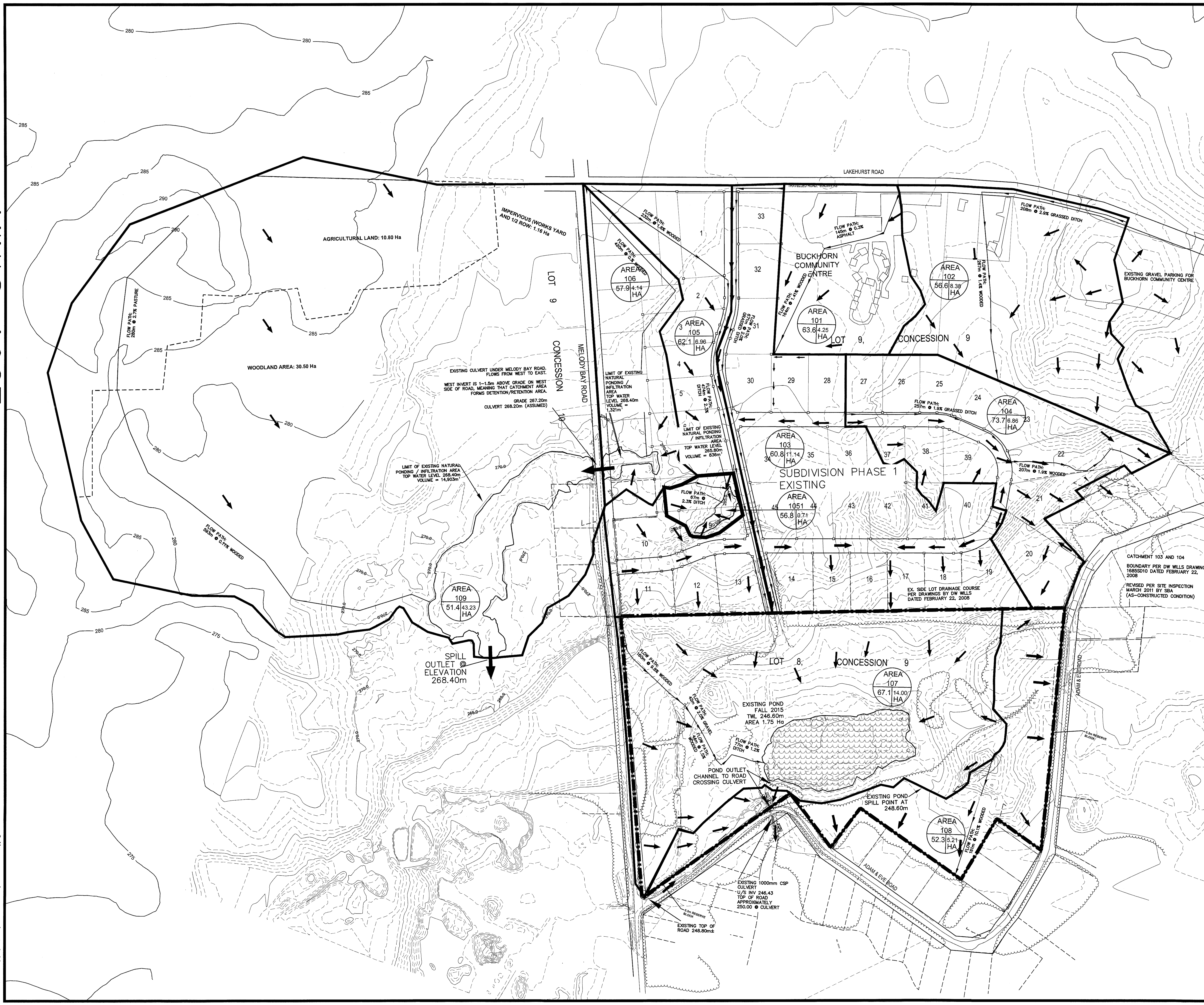
Pipe Diameter(m) D:	0.5	Total # of culverts:	2
Coefficient c:	0.5	Total culvert flow:	0.645
Total Head (m) H:	0.8	Pipe invert to top of road shoulder	
DISCHARGE (cms):	0.32		

$$Q = \left(\sqrt{2 * 9.81 * (H - \left(\frac{D}{2}\right)}\right) * C * \pi * (\frac{D}{2})^{\wedge}2$$

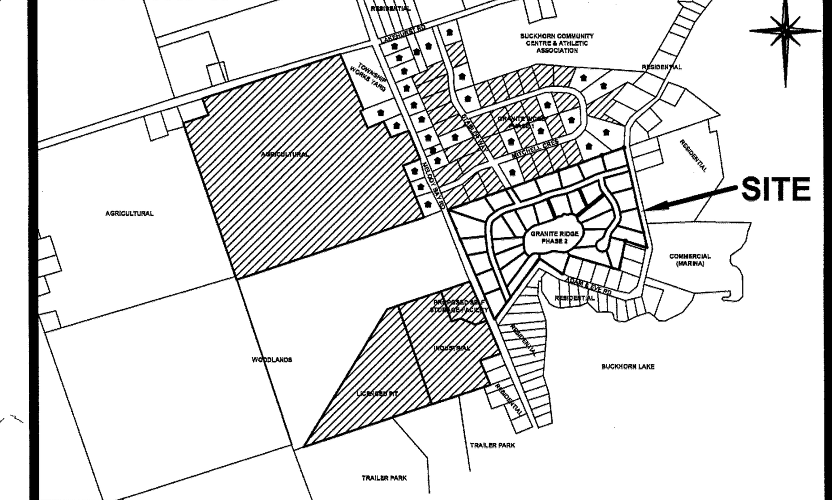
Total flow for all culverts **0.645 cms** **Conveys 100 year flow without overtopping road**

Recommended Culvert Design: 2, 500mm CSP Culverts (600mm equivalent), min slope 1.1%

2361-SWM1



KEY MAP



LEGEND

- EXISTING 5m CONTOUR
- EXISTING 1m CONTOUR
- EXISTING LOT LINE
- EXISTING R.O.W.
- PROPERTY BOUNDARY
- EXISTING TREE LINE
- POND LIMIT
- CATCHMENT FLOW PATH
- AREA 108 — CATCHMENT ID
- 50.4 — SCS RUNOFF CURVE NUMBER (CN)
- 4.19 HA — CATCHMENT AREA
- OVERLAND FLOW DIRECTON
- CATCHMENT BOUNDARY

SCHEDULE OF REVISIONS

NO.	DATE	DESCRIPTION	CHECKED
1.	MARCH 11, 2014	REVISED SITE PLAN	BWB
2.	APRIL 12, 2016	EXISTING POND UPDATED	BWB

LICENSED PROFESSIONAL ENGINEER
April 14/16
B.W. BOLIVAR
PROVINCE OF ONTARIO

GRANITE RIDGE PHASE 2
MUNICIPALITY OF TRENT LAKES

EXISTING DRAINAGE CATCHMENTS

PROJECT NO. 09-2361	DRWG NO. 2361-SWM1
DATE JUNE 2011	SCALE: 1:2,500
DRAWN: CAP/BWB	CHECKED: / APPROVED:

Skelton Brumwell & Associates Inc.
ENGINEERING PLANNING ENVIRONMENTAL CONSULTANTS
93 BELL FARM ROAD, SUITE 107
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TELEPHONE (705) 726-1141
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TOLL FREE (877) 726-1141

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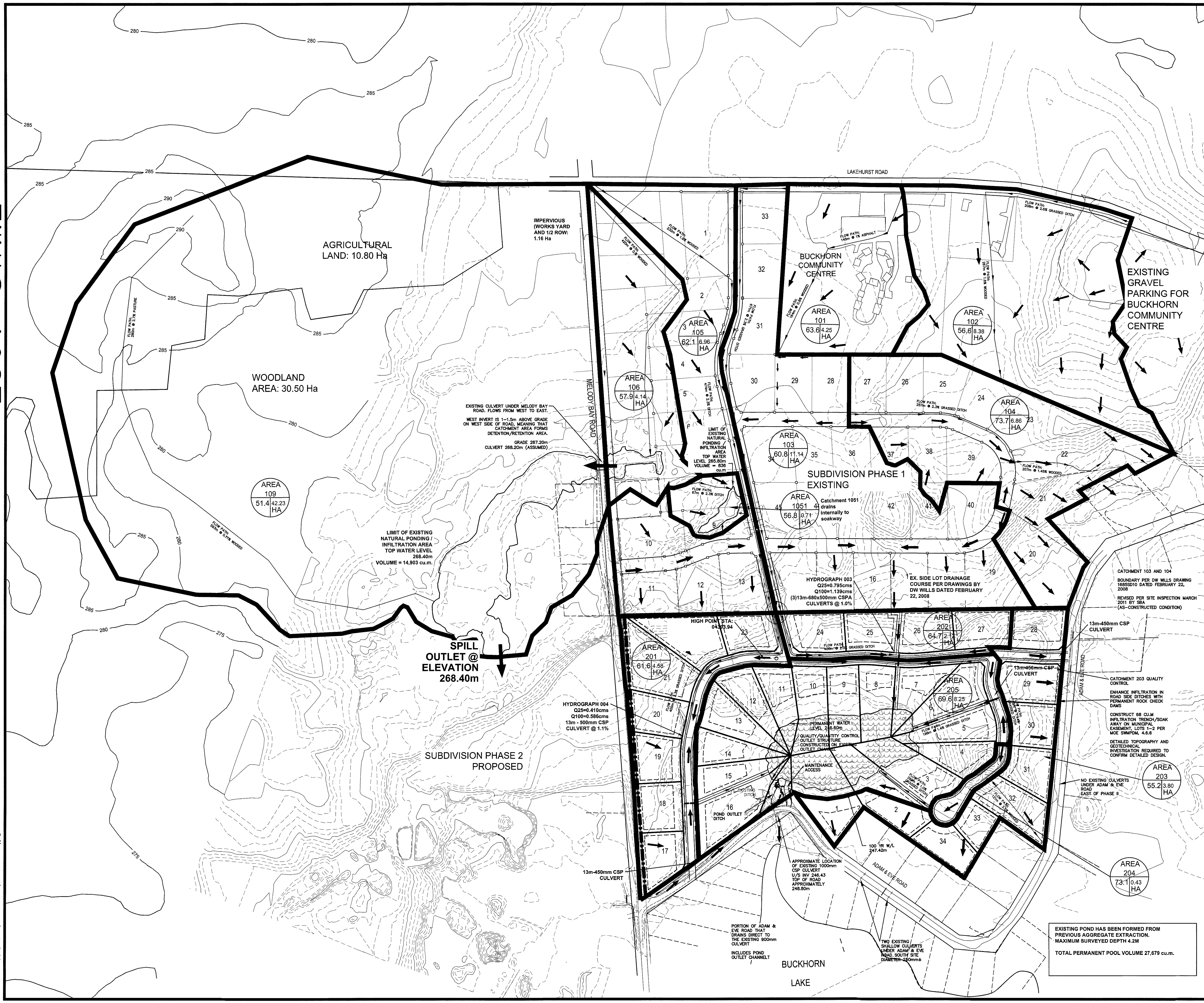
2361–SWM2



KEY MAP

LEGEND

- EXISTING 5m CONTOUR
- EXISTING 1m CONTOUR
- EXISTING LOT LINE
- EXISTING R.O.W.
- PROPERTY BOUNDARY
- EXISTING TREE LINE
- EXISTING POND LIMIT
- CATCHMENT FLOW PATH
- AREA 101 — CATCHMENT ID; 63.7 — SCS RUNOFF CURVE NUMBER (CN); 4.25 HA — CATCHMENT AREA
- OVERLAND FLOW DIRECTON
- CATCHMENT BOUNDARY

SCHEDULE OF REVISIONS

NO.	DATE	DESCRIPTION	CHECKED
1.	MARCH 11, 2013	REVISED SITE PLAN	BWB
2.	APRIL 12, 2016	REVISED SITE PLAN / UPDATED EX. POND	BWB
3.	JUNE 10, 2016	POND OUTLET REVISIONS	

LICENSED PROFESSIONAL ENGINEER
B.W. BOLIVAR
PROVINCE OF ONTARIO

GRANITE RIDGE PHASE 2
MUNICIPALITY OF TRENT LAKES

PROPOSED DRAINAGE CATCHMENTS

PROJECT NO. 09-2361	DRWG NO. 2361-SWM2
DATE JANUARY 2011	SCALE: 1:2,500
DRAWN: CAP/BWB CHECKED:	APPROVED:

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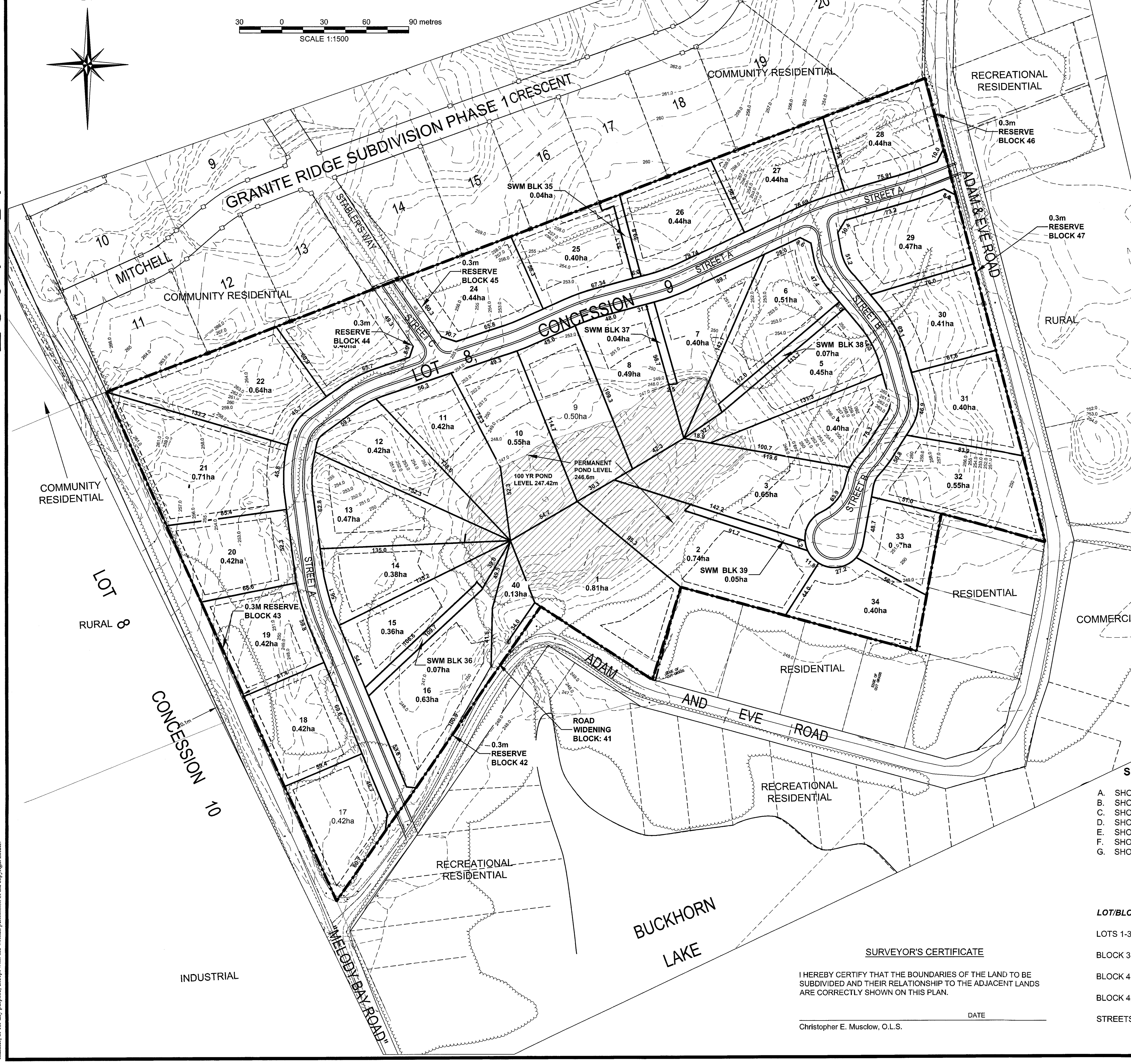
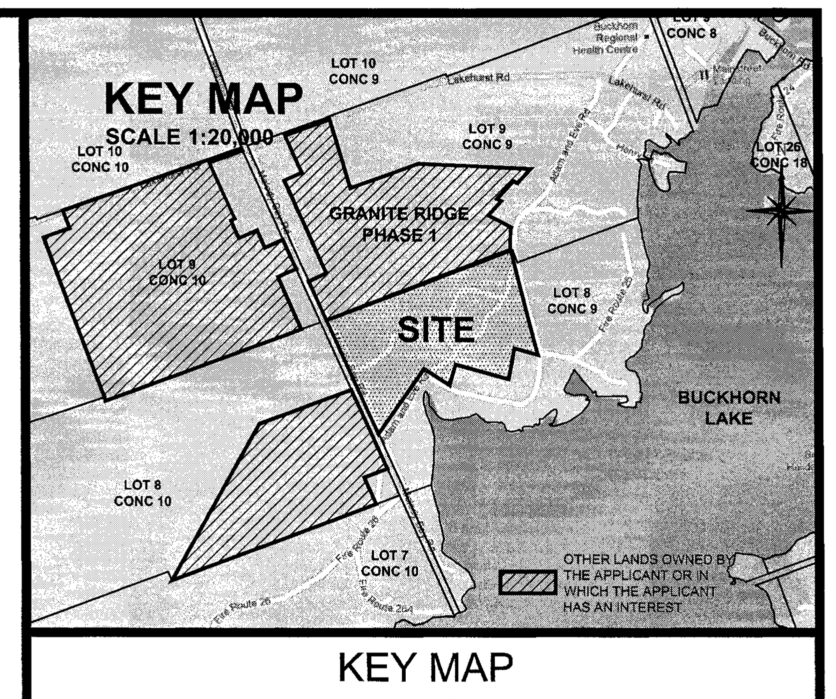
PART OF LOT 8, CONCESSION 9
GEOGRAPHIC TOWNSHIP OF HARVEY
FORMERLY IN THE TOWNSHIP OF GALWAY–CAVENDISH & HARVEY
NOW IN THE MUNICIPALITY OF TRENT LAKES)
COUNTY OF PETERBOROUGH



2361–DP

CLASS ENVIRONMENTAL ASSESSMENT NOTES

1. THE PROPONENT IS RESPONSIBLE FOR:
   - CONSTRUCTION OF THE PROPOSED STREET "A", "B", AND "C".
2. THESE NOTES, THE PLAN AND THE ACCOMPANYING STUDIES SATISFY THE MUNICIPAL CLASS ENVIRONMENTAL ASSESSMENT REQUIREMENTS FOR ROAD, SEWAGE AND WATER PROJECTS.



KEY MAP
N.T.S.

LEGEND

- PROPERTY BOUNDARY
- PROPOSED LOTS
- EXISTING LOTS
- EXISTING R.O.W.
- EXISTING ROAD
- PROPOSED EASEMENT
- EXISTING MAJOR CONTOUR
- EXISTING MINOR CONTOUR
- TREE LINE

TOPOGRAPHIC MAPPING BY FIRST BASE SOLUTIONS BASED ON 2008 AERIAL PHOTOGRAPHY. LIMIT OF POND FROM TOPOGRAPHIC SURVEY BY J.B. FLEGUEL O.L.S., 2010.

SCHEDULE OF REVISIONS

NO.	DATE	DESCRIPTION	CHECKED
1.	NOV 2012	REVISE KEY MAP	TPP
2.	JUNE 2016	REVISED LOTS	

MICHAEL J. WYNIA REGISTERED PROFESSIONAL PLANNER R.P.P.

Michael Wynia
June 13, 2016

INFORMATION REQUIRED UNDER SECTION 51 (17) OF THE PLANNING ACT, R.S.O. 1990

A. SHOWN ON PLAN
B. SHOWN ON PLAN
C. SHOWN ON PLAN
D. SHOWN ON PLAN
E. SHOWN ON PLAN
F. SHOWN ON PLAN
G. SHOWN ON PLAN
H. PRIVATE WELL WATER SUPPLY
I. SAND AND GRAVEL OVER ROCK
J. SHOWN ON PLAN
K. ROADS, ELECTRICAL POWER, WASTE DISPOSAL AND PROTECTION SERVICES
L. SUBJECT TO EASEMENT FOR DRAINAGE OVER WHOLE PARCEL

LAND USE SUMMARY

LOT/BLOCK	LAND USE	AREA
LOTS 1-34	SINGLE DETACHED DWELLING	16.3 ha
BLOCK 35-40	STORMWATER MANAGEMENT	0.36 ha
BLOCK 41	ROAD WIDENING	0.04 ha
BLOCK 42-47	0.3M RESERVE	0.02 ha
STREETS	RIGHT OF WAY	2.29 ha
	TOTAL	18.98 ha

SURVEYOR'S CERTIFICATE

I HEREBY CERTIFY THAT THE BOUNDARIES OF THE LAND TO BE SUBDIVIDED AND THEIR RELATIONSHIP TO THE ADJACENT LANDS ARE CORRECTLY SHOWN ON THIS PLAN.

DATE

Christopher E. Musclow, O.L.S.

GRANITE RIDGE SUBDIVISION PHASE 2
MUNICIPALITY OF TRENT LAKES

DRAFT PLAN OF SUBDIVISION

PROJECT NO. 09-2361		DRWG NO. 2361-DP	
DATE: MAY 2012		SCALE: 1:1500	
DRAWN: CAP	CHECKED:	APPROVED:	

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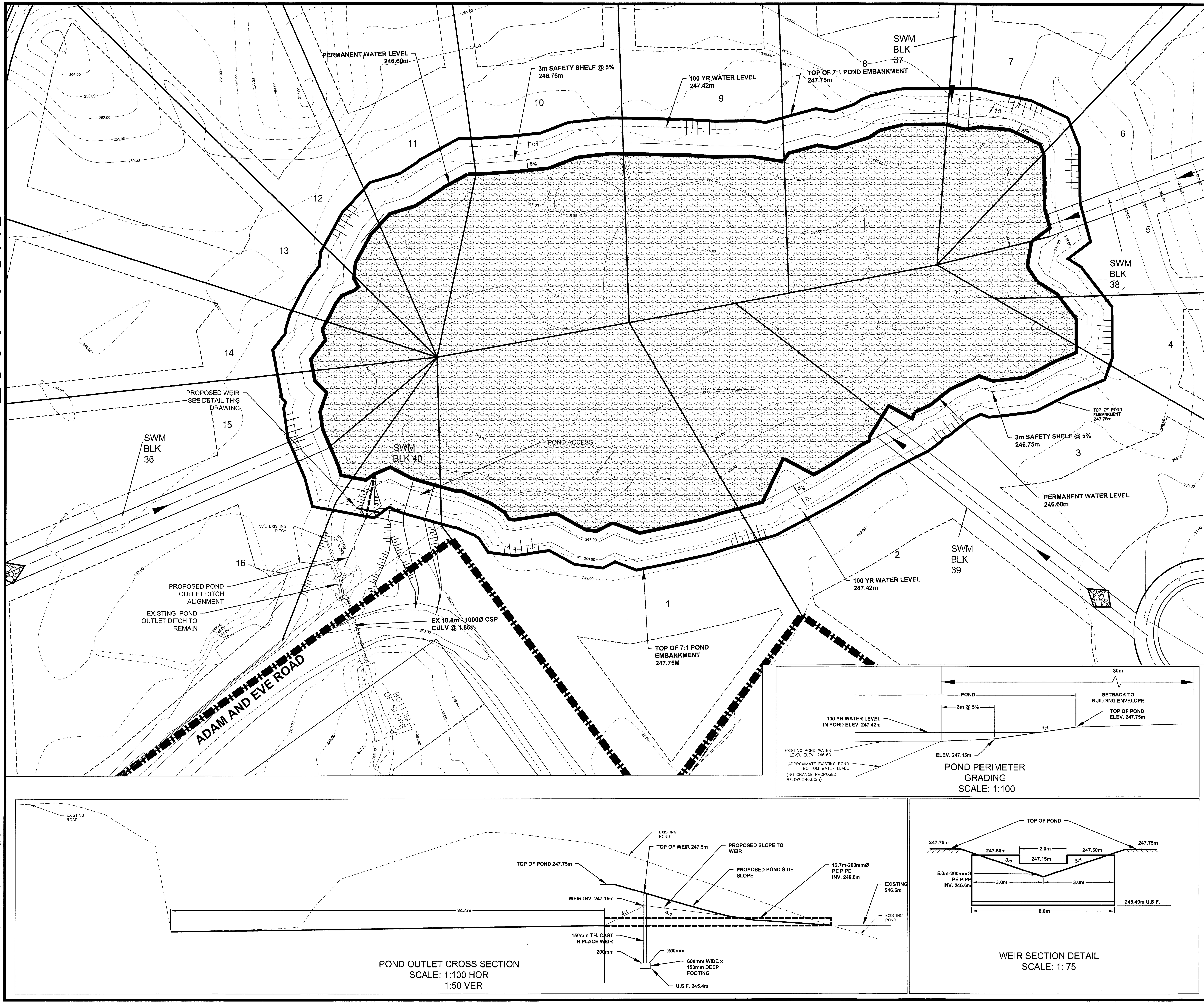
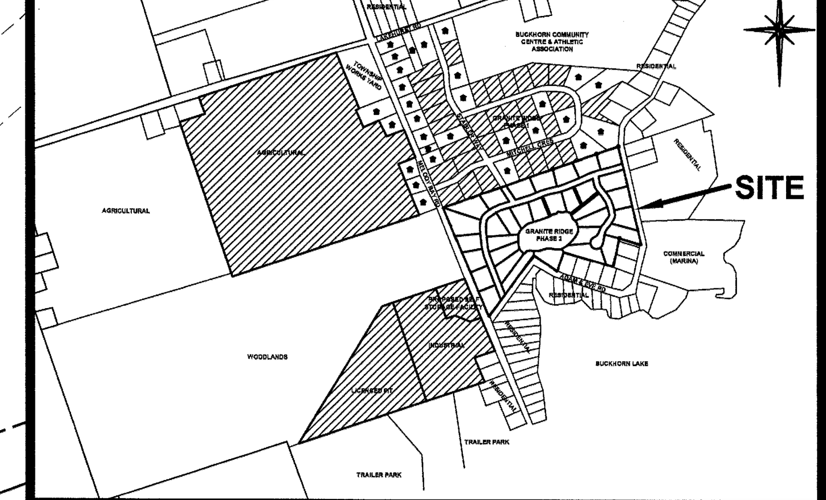
2361–POND



KEY MAP



255	EXISTING 5m CONTOUR
256	EXISTING 1m CONTOUR
	R.O.W. AND LOT LINES
	EXISTING POND LIMIT
	ROADWAY DRAINAGE OUTLET DITCH AND DIRECTION
	PROPOSED DEVELOPABLE AREA
4	LOT NUMBER
	LOT LINES
	ROCK CHECK DAM
	POND PERMANENT POOL

SCHEDULE OF REVISIONS

NO.	DATE	DESCRIPTION	CHECKED
1.	APRIL 14, 2016	REVISED SITE PLAN	BWB
2.	JUNE 10, 2016	POND OUTLET REVISED	BWB

LICENSED PROFESSIONAL ENGINEER
June 10/16
B.W. BOLIVAR
PROVINCE OF ONTARIO

GRANITE RIDGE PHASE 2

MUNICIPALITY OF TRENT LAKES

POND PLAN

PROJECT NO. 09-2361	DRWG NO. 2361-POND
DATE JANUARY 2011	SCALE: 1:2,500

DRAWN: CAP/BWB | CHECKED: | APPROVED:

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