



December 13, 2016

Reference No.: 11139258-01

Jeff Chesher
1447147 Ontario Inc. Granite Ridge Estates
134 Melody Bay Road, P.O. Box 100
Buckhorn, ON K0L 1J0

Dear Mr. Chesher:

**Re: Hydrogeological Update
Granite Ridge Subdivision Phase 2 – Part Lot 8, Concession 9
Municipality of Trent Lakes, County of Peterborough
Buckhorn, ON**

1. Introduction

GHD Limited (GHD) was retained by Granite Ridge Estates to update the hydrogeological report with respect to the water quantities and nitrate impact assessment for the proposed development as a result of adding two (2) lots to the subdivision to the 18.98 hectare property. There are now 34 lots proposed for residential development.

A hydrogeological assessment report was previously completed by Geo-Logic Inc. (now GHD) in November 2010 and revised in September 2014 following peer review comments were addressed. The report was completed for a proposed 32-lot development (to be developed on the 18.98 hectare parcel). The report indicated that the shallow soils were sand overlying bedrock. A water sample was collected from a piezometer installed at the Site for nitrate which indicated that nitrate was non-detect. Three drilled wells were pumped at rates ranging from 13.6 L/min to 40.9 L/min (3 Imperial gallons per minute (lgpm) to 9 lgpm). The report concluded that there was ample water for the proposed development of 32 lots. The projected nitrate concentration based upon the proposed 32 lots was 9.5 mg/L meeting the nitrate criterion of 10 mg/L.

The property is located on Part Lot 8, Concession 9 in Buckhorn, ON within the Municipality of Trent Lakes and County of Peterborough (herein referred to as “the Site”). The location of the Site is shown on the Vicinity Plan, Figure 1 with additional details provided on the Site Plan, Figure 2 and Plot Plan, Figure 3. The proposed development concept is provided on Figure 4. Mapping is provided within the Enclosures. The development is to be serviced by private wells and septic systems.

The following paragraphs detail the review of the water quantity required and the nitrate impact assessment for the proposed 34 lots.

GHD Limited

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2. Water Quantity Assessment

Based on the pumping tests conducted in 2010, the drilled wells, TW-1, TW-2 and TW-3 were rated to have a safe conservative operational yield of 3.0 Igpm (13.6 L/min or 0.23 L/s); 9.0 Igpm (40.9 L/min or 0.68 L/s); and 7.0 Igpm (31.8 L/min or 0.53 L/s), respectively.

Minimum well yield requirements are defined in MOE Procedure D-5-5. Ideally, the wells in the development should be capable of supplying water at a rate of 18.75 L/min (4.1 Igpm) for a period of 6 hours (a rate of not less than 3.0 Igpm must be attained). The ideal rate is based on a peak demand rate of 3.75 L/min/person and five persons per well. The minimum well yield is equivalent to a total flow of 229,500 L/day for the proposed 34-lot development. This figure equates to a continuous flow of 159 L/min (35.1 Igpm).

The three (3) wells that were part of this study were capable of providing a combined yield of 86.3 L/min (19.0 Igpm) based upon the testing conducted. As indicated on the MOE well records (TW-2 and TW-3) and observed during the pumping tests, test wells TW-2 and TW-3 are capable of higher yields. The well records indicate on the order of 68.1 L/min (15 Igpm) each and calculations using specific capacity values suggest even greater yields. Based upon design values from the Ontario Building Code, a three (3) bedroom home drawing on the order of 1,600 L/day or 54,500 L/day for the entire proposed development would need about 38 L/min (8.3 Igpm). As indicated above, TW-2 is capable of producing sufficient water to supply the subdivision. The available well data confirms that adequate groundwater resources are available to meet the needs of the proposed development.

3. Nitrate Impact Assessment

The following nitrate impact assessment was completed in accordance with Ministry of the Environment Procedure D-5-4. Nitrate is considered to be the indicator parameter to assess the impact of sewage effluent on groundwater. The drinking water objective for nitrate is 10 mg/L or less for developments on individual private septic systems. The dilution model is used by Procedure D-5-4 that assumes the following:

- Residential homes discharge an average of 1,000 L/day of sewage effluent with a maximum of 40 mg/L nitrate as nitrogen for conventional sewage disposal systems.
- Attenuation of the septic effluent is limited to dilution by infiltration of rainfall that occurs on the lands for the development (any additional lands owned by the applicant).

Background nitrate concentrations at the Site are non-detect based upon testing previously conducted. Water surplus is considered to be 288.8 mm/year based upon data from the Peterborough Trent U (1981 – 2010) weather station about 20.6 km to the south.



GHD has revised the infiltration factor utilizing a revised water balance that was completed as part of this updated hydrogeological assessment. The water balance is provided in Appendix A. The following assumptions were made for the water balance:

- House footprints (including garage) assumed to cover about 15% of the residential lots;
- Driveways are assumed to be gravel and cover 36 m² (4 m by 9 m);
- Evaporation from rooftops and asphalt assumed to be 20% based upon Hydrogeological Assessment Submissions document (Conservation Authority guidelines to support development applications dated June 2013);
- Based upon downspout disconnection, infiltration of rooftop runoff water was assumed to be 50% of precipitation falling upon the roof tops based upon documentation provided within the Low Impact Development Stormwater Management Planning and Design Guide, 2010);
- Lot levelling improvements to the pre-development grading. The lots are considered to be flatter than in pre-development due to filling. An intermediate value between hilly and rolling was selected (factor of 0.15 used);
- Soil factor assumed to be 0.35 due to the shallow coarse sand in this area; and,
- Vegetation factor of 0.15 assumed for the lawns.

Based upon these assumptions, the infiltration is 199 mm/year (same as used in the peer reviewed Hydrogeological Assessment from 2010) for the development including the lawns and rooftops. There was no infiltration from the asphalt roads.

Utilizing infiltration of 199 mm/year for the development area of 18.98 hectares, the projected nitrate concentration will be 9.9 mg/L. These calculations are provided in Appendix A.

4. Conclusions and Recommendations

Based upon the work completed by GHD and documented within this report, the following conclusions and recommendations are provided based upon a developable area of 18.98 hectares and the proposed development of 34 lots to be serviced on private well and septic systems:

- Projected nitrate concentration for the 34 lots is estimated to be 9.9 mg/L for conventional septic systems based upon nitrate concentration of 40 mg/L in the septic effluent.
- We recommend that the septic leaching bed systems be constructed to minimize the potential of cross-contamination of the wells from the septic tile beds.
- Based upon pumping tests previously completed of three (3) wells at the Site, it is our opinion that there are adequate groundwater resources available to meet the needs of the proposed 34-lot development.



- It is our professional opinion that the addition of 34 lots will have that no impact to the on-site or off-site wells that tap the local aquifer.

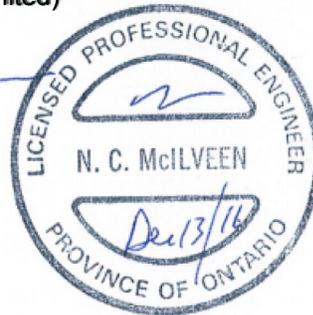
We trust that this letter meets with your immediate requirements. Should you have any questions, please contact our office.

Sincerely,

GHD



Robert Neck, M.Eng., P.Geo. (Limited)



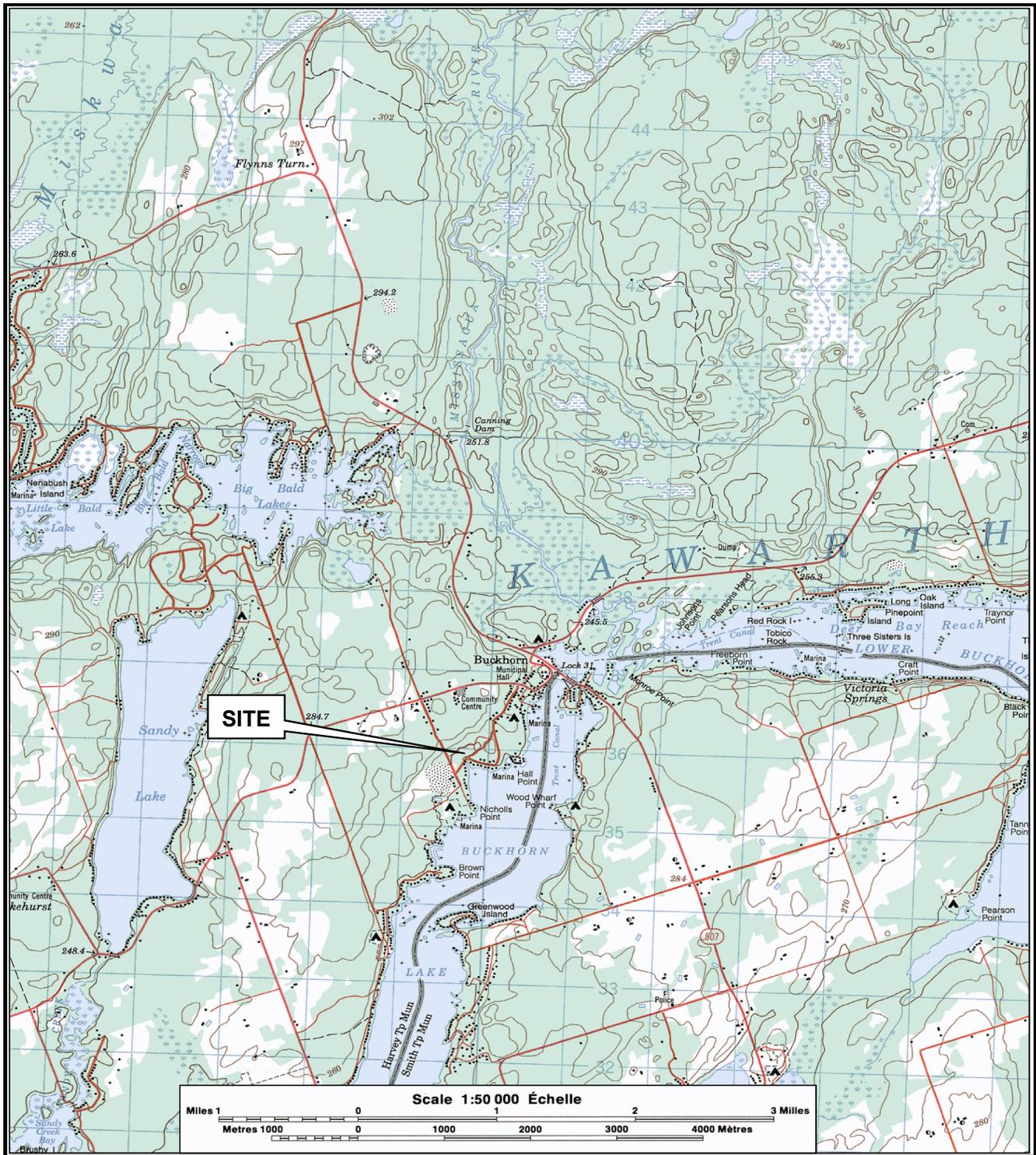
Nyle McIlveen, P. Eng.

BN/nmc/1

Encl.:

Appendix A – Water Balance & Nitrate Impact Assessment Calculations

Enclosures



Source: Base map compiled from Centre for Mapping, Natural Resources Canada. Map 31 D/9. Aerial photography dated 1989, published 1994.

Scale:
1:50000
Coordinate System
NAD 1983 UTM



Granite Ridge Estates - Phase 2
Part Lot 8, Conc. 9, Trent Lakes
Hydrogeologic Update

1113958-01
December 2016

Vicinity Plan

FIGURE 1



Source: Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2014.

Scale:
Refer to Scale Bar
Coordinate System:
NAD 1983 UTM Zone 17



Granite Ridge Estates - Phase 2
Part Lot 8, Conc. 9, Trent Lakes
Hydrogeologic Update

Site Plan

11139258-01
December 2016

FIGURE 2



Source: Google Earth. © 2016 Google. Image © 2016 DigitalGlobe

Scale:
 Refer to Scale Bar
 Coordinate System:
 NAD 1983 UTM Zone 17

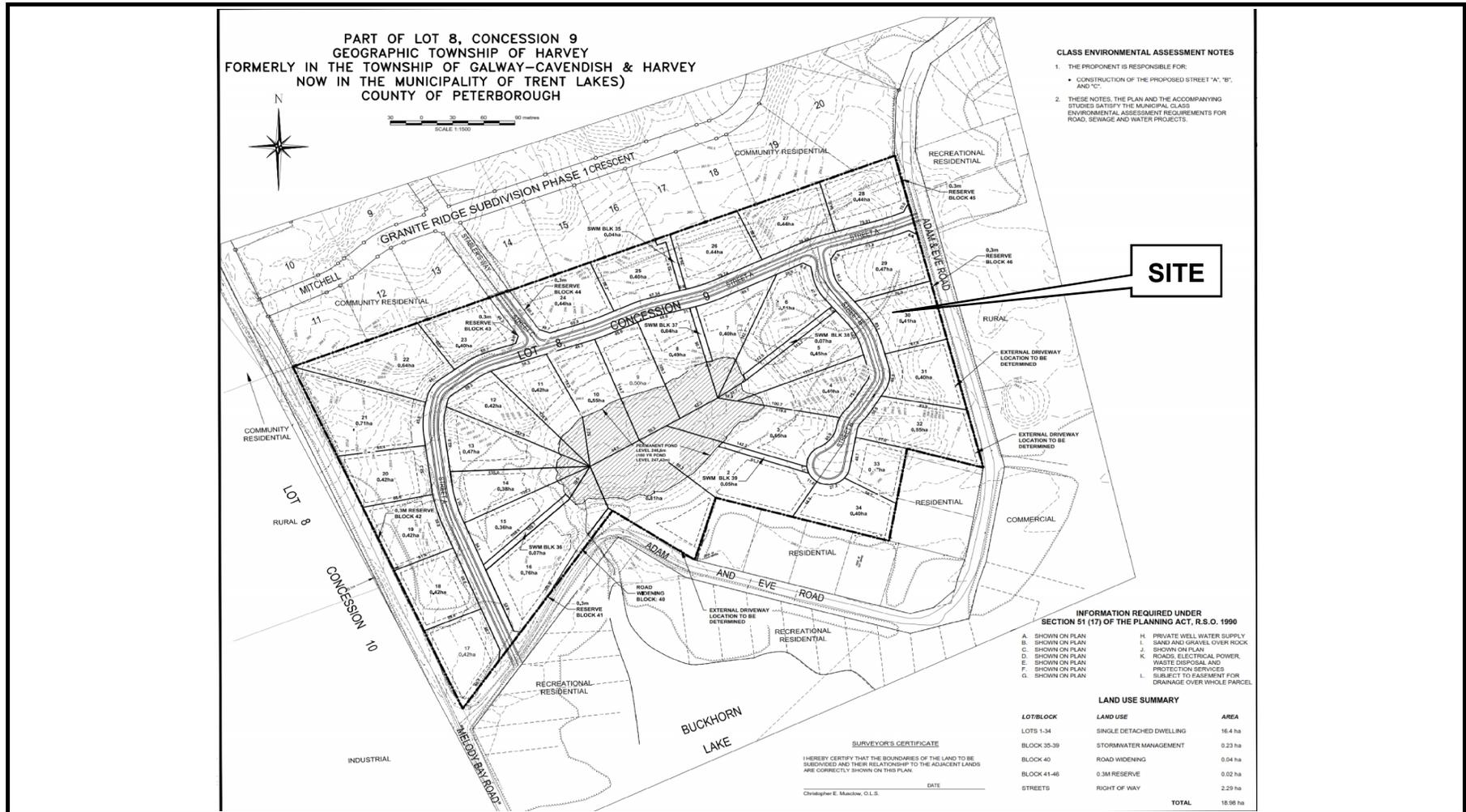


Granite Ridge Estates - Phase 2
 Part Lot 8, Conc. 9, Trent Lakes
 Hydrogeologic Update

Plot Plan

11139258-01
 December 2016

FIGURE 3



Source: Skelton Brumwell dated May 2012. Drawing no. 2361-DP entitled Granite Ridge Subdivision Phase 2.

Scale:
Refer to Scale Bar
Coordinate System:
NAD 1983 UTM Zone 17



Granite Ridge Estates - Phase 2
Part Lot 8, Conc. 9, Trent Lakes
Hydrogeologic Update

Conceptual Plan

11139258-01
December 2016

FIGURE 4

Appendix A

Water Balance & Nitrate Impact Assessment Calculations

Appendix A.1

Water Budget (Thornthwaite Method 1948) - Average Values*

Peterborough Trent U

Elevation: 198 masl

Distance Away:

~ 20.6 km south of site

Month	Mean Temperature (°C)	Heat Index	Potential ET (mm)	Daylight Correction Factor	Adjusted ET (mm)	Total Precipitation (mm)	Surplus (mm)	Deficit (mm)
January	-8.4	0	0	0.82	0	57.3	57.30	
February	-6.5	0	0	0.82	0	48.8	48.80	
March	-1.3	0	0	1.03	0	56.5	56.50	
April	6.3	1.42	28.62	1.12	32.05	66.4	34.35	
May	12.8	4.15	61.37	1.27	77.95	88.7	10.75	
June	18	6.95	88.58	1.28	113.38	83	0.00	30.38
July	20.7	8.59	102.96	1.3	133.85	73.6	0.00	60.25
August	19.4	7.79	96.02	1.2	115.22	87	0.00	28.22
September	15	5.28	72.80	1.04	75.71	92.4	16.69	
October	8.4	2.19	39.00	0.95	37.05	77	39.95	
November	2.4	0.33	10.13	0.81	8.20	85.5	77.30	
December	-4	0	0	0.78	0	66	66.00	
TOTAL	6.9	36.7	499.5		593.4	882.2	407.6	118.9
TOTAL WATER SURPLUS:						288.8	mm	

Notes:

Burketon McLaughlin weather station (1981 - 2010) utilized: 43° 55' N, 78° 40' W

*Average values of precipitation were used. Average values of temperature were also used.

Water budget adjusted for latitude and daylight

Total Water Surplus is calculated as total precipitation minus adjusted potential evapotranspiration

Total Moisture Surplus is calculated as total precipitation minus actual evapotranspiration

Formulas utilized:

$$I = (T_i/5)^{1.514}$$

$$E=0 \text{ when } T_i < 0 \text{ } ^\circ\text{C}$$

$$E=16(10T_i/I_{tot})^a \text{ when } 0 < T_i < 26.5 \text{ } ^\circ\text{C}$$

$$E=-415.85+32.24T_i-0.43T_i^2 \text{ when } T_i > 26.5 \text{ } ^\circ\text{C}$$

$$a=6.7 \times 10^{-7} I^3 - 7.71 \times 10^{-5} I^2 + 1.79 \times 10^{-2} I + 0.49$$

$$a = 1.076272213$$

Appendix A.2

Water Budget Pre-Development

Catchment Designation	PRE-DEVELOPMENT SITE			
	Treed	Pond	Undeveloped	Total
Area (m ²)	34000	19500	136300	189800
Pervious Area (m ²)	34000	0	136300	170300
Impervious Area (m ²)	0	19500	0	19500
INFILTRATION FACTORS				
Topography Infiltration Factor	0.12	0.12	0.12	
Soil Infiltration Factor	0.35	0.35	0.35	
Land Cover Infiltration Factor	0.2	0	0.125	
MOE Infiltration Factor	0.67	0.47	0.595	
Actual Infiltration Factor	0.67	0.2	0.595	
Runoff Coefficient	0.33	0.8	0.405	
Runoff from Impervious Surfaces*	0	0.8	0	
INPUTS (PER UNIT AREA)				
Precipitation (mm/yr)	882	882	882	882
Run On (mm/yr)	0	0	0	0
Other Inputs (mm/yr)	0	0	0	0
Total Inputs (mm/yr)	882	882	882	882
OUTPUTS (PER UNIT AREA)				
Precipitation Surplus (mm/yr)	289	706	289	332
Net Surplus (mm/yr)	289	706	289	332
Evapotranspiration (mm/yr)	593	176	593	551
Infiltration (mm/yr)	193	141	172	173
Rooftop Infiltration (mm/yr)	0	0	0	0
Total Infiltration (mm/yr)	193	141	172	173
Runoff Pervious Areas	95	0	117	101
Runoff Impervious Areas	0	565	0	58
Total Runoff (mm/yr)	95	565	117	159
Total Outputs (mm/yr)	882	882	882	882
Difference (Inputs - Outputs)	0	0	0	0
INPUTS (VOLUMES)				
Precipitation (m ³ /yr)	29995	17203	120244	167442
Run On (m ³ /yr)	0	0	0	0
Other Inputs (m ³ /yr)	0	0	0	0
Total Inputs (m³/yr)	29995	17203	120244	167442
OUTPUTS (VOLUMES)				
Precipitation Surplus (m ³ /yr)	9819	13762	39361	62942
Net Surplus (m ³ /yr)	9819	13762	39361	62942
Evapotranspiration (m ³ /yr)	20176	3441	80883	104500
Infiltration (m ³ /yr)	6578	2752	23420	32751
Rooftop Infiltration (m ³ /yr)	0	0	0	0
Total Infiltration (m ³ /yr)	6578	2752	23420	32751
Runoff Pervious Areas (m ³ /yr)	3240	0	15941	19181
Runoff Impervious Areas (m ³ /yr)	0	11010	0	11010
Total Runoff (m ³ /yr)	3240	11010	15941	30191
Total Outputs (m³/yr)	29995	17203	120244	167442
Difference (Inputs - Outputs)	0	0	0	0

Appendix A.3

Water Budget Post-Development - With Roof Top Infiltration

Catchment Designation	POST-DEVELOPMENT SITE with ROOF TOP INFILTRATION					
	Lawn	Driveways	Asphalt Roads	Stormwater Pond	Rooftops Single Detached	Total
Area (m ²)	150738	1224	11850	2300	23688	189800
Pervious Area (m ²)	150738	0	0	0	0	150738
Impervious Area (m ²)	0	1224	11850	2300	23688	39062
INFILTRATION FACTORS						
Topography Infiltration Factor	0.15	0.15	0.15	0.15	0.15	
Soil Infiltration Factor	0.35	0.35	0.35	0.35	0.35	
Land Cover Infiltration Factor	0.15	0	0	0	0	
MOE Infiltration Factor	0.65	0.5	0.5	0.5	0.5	
Actual Infiltration Factor	0.65	0.4	0	0.2	0	
Runoff Coefficient	0.35	0.6	1	0.8	1	
Runoff from Impervious Surfaces*	0	0.8	0.8	0.8	0.8	
INPUTS (PER UNIT AREA)						
Precipitation (mm/yr)	882	882	882	882	882	882
Run On (mm/yr)	0	0	0	0	0	0
Other Inputs (mm/yr)	0	0	0	0	0	0
Total Inputs (mm/yr)	882	882	882	882	882	882
OUTPUTS (PER UNIT AREA)						
Precipitation Surplus (mm/yr)	289	706	706	706	706	375
Net Surplus (mm/yr)	289	706	706	706	706	375
Evapotranspiration (mm/yr)	593	176	176	176	176	508
Infiltration (mm/yr)	189	318	0	176	0	154
% Rooftop to infiltration	0	0	0	0	0.50	--
Rooftop Infiltration (mm/yr)	0	0	0	0	356	44
Total Infiltration (mm/yr)	189	318	0	176	356	199
Runoff Pervious Areas	100	0	0	0	0	79
Runoff Impervious Areas	0	388	706	529	349	97
Total Runoff (mm/yr)	100	388	706	529	349	176
Total Outputs (mm/yr)	882	882	882	882	882	882
Difference (Inputs - Outputs)	0	0	0	0	0	0
INPUTS (VOLUMES)						
Precipitation (m ³ /yr)	132981	1080	10454	2029	20897	167442
Run On (m ³ /yr)	0	0	0	0	0	0
Other Inputs (m ³ /yr)	0	0	0	0	0	0
Total Inputs (m³/yr)	132981	1080	10454	2029	20897	167442
OUTPUTS (VOLUMES)						
Precipitation Surplus (m ³ /yr)	43530	864	8363	1623	16718	71099
Net Surplus (m ³ /yr)	43530	864	8363	1623	16718	71099
Evapotranspiration (m ³ /yr)	89451	216	2091	406	4179	96343
Infiltration (m ³ /yr)	28512	389	0	406	0	29307
Rooftop Infiltration (m ³ /yr)	0	0	0	0	8442	8442
Total Infiltration (m ³ /yr)	28512	389	0	406	8442	37749
Runoff Pervious Areas (m ³ /yr)	15018	0	0	0	0	15018
Runoff Impervious Areas (m ³ /yr)	0	475	8363	1217	8275	18331
Total Runoff (m ³ /yr)	15018	475	8363	1217	8275	33349
Total Outputs (m³/yr)	132981	1080	10454	2029	20897	167442
Difference (Inputs - Outputs)	0	0	0	0	0	0

Notes:

*Evaporation from impervious areas was assumed to be 20% of precipitation.

Footprint of home and garage assumed to cover 15% of the lot (~750 m²)

Driveways assumed to cover 36 sq. m per lot (4 m by 9 m)

Assume lot leveling for residential lots

No infiltration for asphalt

Assumes 50% of roof top runoff is infiltrated as per LID design manual values

Appendix A.4

Nitrate Impact Assessment Calculations

Granite Ridge Estates Residential Development

Part of Lot 8, Concession 9, Trent Lakes, ON

Dilution Area

Proposed Development 18.98 ha

Dilution Factors

Annual Water Surplus	288.8 mm/yr	Peterborough Trent U.
Infiltration Factor	0.69	From water balance
Dilution Rate	198.9 mm/yr	Post-Development (50% of roof top runoff infiltrated)
Dilution Rate / hectare	5449.1 L/day/ha	
Dilution Volume / development (V_{gw})	103423.2 L/day	

Nitrate Impact Assessment

Background Nitrate Conc. (B_{nit})	0 mg/L
Effluent Nitrate Conc. (Eff_{nit})	40 mg/L
Recharge Nitrate Conc (R_{nit})	0 mg/L
Number of lots	34
Effluent Volume per lot	1000 L/day
Total Effluent Volume (V_{tot})	34000 L/day

Projected Property Boundary Nitrate Conc. (P_{nit})

$$P_{nit} = B_{nit} + [(Eff_{nit} \times V_{tot}) + (R_{nit} \times V_{gw})] / (V_{tot} + V_{gw})$$

$$P_{nit} = 9.9 \text{ mg/L}$$

Effluent nitrate concentration based on the use of a conventional Class 4 sewage disposal system