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August 15, 2023

Via: Email

Mr. Paul Bigioni
c/o Mr. Maurizio Rogato (Blackthorn Development Corp.)
869547 Ontario Inc.
25 Buggey Lane
Ajax ON L1Z 1X4

Dear Mr. Bigioni/Mr. Rogato:

Re: Frisque Lands
Updated Water Balance Assessment
Project No.: 300056041.0000

R.J. Burnside & Associates Limited (Burnside) previously submitted a *Water Balance Assessment (February 2023)* for the Frisque Lands located at 3225 Fifth Concession Road (3225 Balsam Road/Sideline 4), Pickering, Ontario. The Frisque Lands are bounded by Balsam Road/Sideline 4 to the west, natural heritage areas to the west, north and east, and a golf course (Deer Creek Golf & Banquet Facility) to the south.

Candevcon East Limited (CDC) has finalized the *Functional Servicing and Stormwater Management Report* for the Frisque Lands and has advised Burnside of the updated stormwater management strategy. CDC has requested that water balance calculations prepared for the Frisque Lands be updated to reflect the changes and submitted as part of the detailed design engineering submission.

The water balance presented herein reflects the updated stormwater management strategy for the Frisque Lands. The water balance is based on our understanding of the hydrogeological characteristics in this area and uses the same climate data, water balance component values and calculation methodology as reported in the initial *Water Balance Assessment (Burnside, February 2023).*

1.0 Water Balance Calculations

CDC has provided an updated stormwater management strategy for the Frisque Lands as documented in the *Functional Servicing and Stormwater Management Report (July 2023)*.
To assess potential land development impacts on the local groundwater conditions, a detailed water balance analysis has been completed for the Frisque Lands to determine the pre-development infiltration volumes (based on existing land use conditions) and the post-development infiltration volumes that would be expected based on the development concept. The analytical approach to calculate the water balance involves monthly soil-moisture balance calculations to determine the pre-development and post-development infiltration

volumes. The land use areas are presented in the water balance calculations provided in Appendix A.

Tables A-1, A-2, A-4 and A-5 (Appendix A) detail the monthly potential evapotranspiration calculations accounting for latitude and climate, and the actual evapotranspiration and water surplus components of the water balance based on the monthly precipitation and soil moisture conditions for the existing land uses. The total area of the Frisque Lands is about 179,000 m^2 and consists of vacant/undeveloped lands that are designated for residential use. The calculated water balance components were used to assess the pre-development infiltration volume based on the existing land uses. In summary from Table A-7 (Appendix A), the total calculated pre-development infiltration volume is about 30,600 m^3/year.

A post-development water balance has been calculated for the Frisque Lands to reflect the updated stormwater management strategy (refer to Table A-7, Appendix A). This calculation uses water balance components calculated as shown on Tables A-3 and A-6 (Appendix A) that accounts for cleared land, and considers increases in runoff related to impervious areas such as the roads, driveways and roof areas. Evaporation from impervious areas has been estimated to be 15% of precipitation, so the remaining 85% of the precipitation that falls on impervious surfaces is assumed to become runoff (i.e., about 741 mm/year). To assess the potential impact on infiltration as a result of the construction of the proposed development, the post-development infiltration volume was calculated, assuming no measures in place to mitigate runoff. Comparing the existing and post-development infiltration volumes in Table A-7 (Appendix A), the water balance calculations show the proposed development has the potential to reduce the natural infiltration by about 4%. It is acknowledged that infiltration depends on the hydraulic conductivity of soils that may naturally vary over several orders of magnitude, so the margins of error on the calculations may be high. As such the calculated infiltration volumes are considered as general estimates only.

2.0 Proposed Stormwater Management and LID Strategy

The stormwater management strategy proposed by CDC for the Frisque Lands includes low impact development (LID) measures to reduce runoff and promote infiltration and are presented in the *Functional Servicing and Stormwater Management Report (CDC, July 2023)*. Based on the design information from CDC, it is our understanding that the proposed LID measures will include (refer to CDC Fig. 4 (attached)):

- Extra depth topsoil has been proposed across the Frisque Lands. This is a measure intended to retain more stormwater, to delay runoff and allow more opportunity for infiltration to occur. It is noted that extra depth topsoil is not a LID measure that is quantified in the water balance calculations.

- Approximately 2,890 m^2 of select roofs will be disconnected and directed to lawn areas (1,701 m^2 to sandy loam and 1,189 m^2 to sandy silt till). Directing the extra water to pervious areas maximizes the potential for infiltration in these areas. As per the estimation provided in the *Low Impact Development Stormwater Management Planning and Design Guide (CVC and TRCA, 2010)*, and the type of surficial soils encountered on the Frisque Lands, it is assumed that where roof areas are directed to sandy loam soils, 50% of the roof runoff will infiltrate, and where roof areas are directed to sandy silt till soils, 25% of the roof runoff will infiltrate.

- Approximately 2,770 m^2 of driveways will be directed to lawn areas (1,298 m^2 to sandy loam and 1,472 m^2 to sandy silt till). Directing the extra water to pervious areas maximizes the potential for infiltration in these areas. As per the estimation provided in the *Low Impact Development Stormwater Management Planning and Design Guide (CVC and TRCA, 2010)*, and the type of surficial soils encountered on the Frisque Lands, it is assumed that where driveways are directed to sandy loam soils, 50% of the runoff will infiltrate, and where driveways are directed to sandy silt till soils, 25% of the runoff will infiltrate.

- Runoff from select roofs (2,750 m^2) will be directed to soakaway pits designed to accommodate the 5 mm storm event. To calculate the annual infiltration volumes in the proposed soakaway pits, the Toronto Wet Weather Flow Management Guidelines (City of Toronto, 2006) was used to relate the storm event size these facilities are designed to infiltrate to a percentage of the average annual rainfall depth. This percentage was then applied to the roof area runoff directed to these soakaway pits to calculate an infiltration volume, as shown in Table A-8, Appendix A.

Comparing the pre-development infiltration volume to the post-development infiltration volume with mitigation measures in place, the calculations show that there is approximately a 4% increase of the pre-development annual infiltration volume, and that the proposed LID measures can mitigate the infiltration deficit. These calculations show the significant benefit of the proposed LID measures in increasing recharge volumes within the developed area (Table A-8, Appendix A).

We trust this is the information you require at this time. Should you have any questions, please do not hesitate to contact us.

Yours truly,

R.J. Burnside & Associates Limited

Travis Mikel, P.Geo.
Senior Hydrogeologist

Jackie Shaw, P.Eng.
Groundwater Resources Engineer

TM/JS:cl

Enclosure(s) Appendix A (Tables A-1 to A-8)
CDC Figure 4 Low Impact Development (LID) Measure Location Plan

cc: Ryan Brockie, Candevcon East Limited (enc.) (Via: Email)

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Appendix A

Water Balance Calculations

TABLE A-1

Pre-Development Monthly Water Balance Components

Based on Thornthwaite's Soil Moisture Balance Approach with a Soil Moisture Retention of 150 mm (pasture and shrubs in sandy loam soils)

Precipitation data from Oshawa WPCP Climate Station (1981 - 2010)

Potential Evapotranspiration Calculation	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Average Temperature (Degree C)	-4.80	-3.60	0.40	6.60	12.30	17.60	20.60	20.00	15.90	9.50	4.20	-1.20	**8.1**
Heat index: $i = (t/5)^{1.514}$	0.00	0.00	0.02	1.52	3.91	6.72	8.53	8.16	5.76	2.64	0.77	0.00	**38.0**
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	1.36	29.28	57.92	85.79	101.94	98.69	76.75	43.64	17.84	0.00	**513**
Adjusting Factor for U (Latitude 43° 40' N)	0.81	0.82	1.02	1.13	1.27	1.29	1.3	1.2	1.04	0.95	0.8	0.76	
Adjusted Potential Evapotranspiration PET (mm)	0	0	1	33	74	111	133	118	80	41	14	0	**605**
COMPONENTS	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Precipitation (P)	66	57	54	73	79	74	73	77	94	70	85	71	**872**
Potential Evapotranspiration (PET)	0	0	1	33	74	111	133	118	80	41	14	0	**605**
P - PET	66	57	53	40	5	-37	-59	-41	14	29	71	71	**267**
Change in Soil Moisture Storage	0	0	0	0	0	-37	-59	-41	14	29	71	24	**0**
Soil Moisture Storage max 150 mm	150	150	150	150	150	113	54	13	27	56	126	150	
Actual Evapotranspiration (AET)	0	0	1	33	74	111	133	118	80	41	14	0	**605**
Soil Moisture Deficit max 150 mm	0	0	0	0	0	37	96	137	123	94	24	0	
Water Surplus - available for infiltration or runoff	66	57	53	40	5	0	0	0	0	0	0	47	**267**
Potential Infiltration (based on MOE metholodogy*; independent of temperature)	49	42	40	30	4	0	0	0	0	0	0	35	**200**
Potential Direct Surface Water Runoff (independent of temperature)	16	14	13	10	1	0	0	0	0	0	0	12	**67**
IMPERVIOUS AREA WATER SURPLUS													
Precipitation (P)	872	mm/year											
Potential Evaporation (PE) from impervious areas (assume 15%)	131	mm/year											
P-PE (surplus available for runoff from impervious areas)	741	mm/year											

Assume January storage is 100% of Soil Moisture Storage		
Soil Moisture Storage (pasture/shrubs in fine sandy loam)	150 mm	<-- See "Water Holding Capacity" values in Table 3.1, MOE SWMPDM, 2003
*MOE SWM infiltration calculations		
topography - rolling land	0.2	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
soils - silty sand (open sandy loam)	0.4	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
cover - pasture and shrubs	0.15	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
Infiltration factor	**0.75**	
Latitude of site (or climate station)	44 ° N	

TABLE A-2

Pre-Development Monthly Water Balance Components

Based on Thornthwaite's Soil Moisture Balance Approach with a Soil Moisture Retention of 300 mm (wooded lands in sandy loam soils)

Precipitation data from Oshawa WPCP Climate Station (1981 - 2010)

Potential Evapotranspiration Calculation	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Average Temperature (Degree C)	-4.80	-3.60	0.40	6.60	12.30	17.60	20.60	20.00	15.90	9.50	4.20	-1.20	**8.1**
Heat index: $i = (t/5)^{1.514}$	0.00	0.00	0.02	1.52	3.91	6.72	8.53	8.16	5.76	2.64	0.77	0.00	**38.0**
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	1.36	29.28	57.92	85.79	101.94	98.69	76.75	43.64	17.84	0.00	**513**
Adjusting Factor for U (Latitude 43° 40' N)	0.81	0.82	1.02	1.13	1.27	1.29	1.3	1.2	1.04	0.95	0.8	0.76	
Adjusted Potential Evapotranspiration PET (mm)	0	0	1	33	74	111	133	118	80	41	14	0	**605**
COMPONENTS	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Precipitation (P)	66	57	54	73	79	74	73	77	94	70	85	71	**872**
Potential Evapotranspiration (PET)	0	0	1	33	74	111	133	118	80	41	14	0	**605**
P - PET	66	57	53	40	5	-37	-59	-41	14	29	71	71	**267**
Change in Soil Moisture Storage	0	0	0	0	0	-37	-59	-41	14	29	71	24	**0**
Soil Moisture Storage max 300 mm	300	300	300	300	300	263	204	163	177	206	276	300	
Actual Evapotranspiration (AET)	0	0	1	33	74	111	133	118	80	41	14	0	**605**
Soil Moisture Deficit max 300 mm	0	0	0	0	0	37	96	137	123	94	24	0	
Water Surplus - available for infiltration or runoff	66	57	53	40	5	0	0	0	0	0	0	47	**267**
Potential Infiltration (based on MOE metholodogy*; independent of temperature)	49	42	40	30	4	0	0	0	0	0	0	35	**200**
Potential Direct Surface Water Runoff (independent of temperature)	16	14	13	10	1	0	0	0	0	0	0	12	**67**
IMPERVIOUS AREA WATER SURPLUS													
Precipitation (P)	872	mm/year											
Potential Evaporation (PE) from impervious areas (assume 15%)	131	mm/year											
P-PE (surplus available for runoff from impervious areas)	741	mm/year											

Assume January storage is 100% of Soil Moisture Storage
Soil Moisture Storage (mature forests in fine sandy loam) 300 mm <-- See "Water Holding Capacity" values in Table 3.1, MOE SWMPDM, 2003

*MOE SWM infiltration calculations

topography - rolling to hilly land	0.15	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
soils - silty sand (open sandy loam)	0.4	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
cover - wooded lands	0.2	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
Infiltration factor	**0.75**	

Latitude of site (or climate station) 44 ° N

TABLE A-3

Post-Development Monthly Water Balance Components

Based on Thornthwaite's Soil Moisture Balance Approach with a Soil Moisture Retention of 75 mm (urban lawns in sandy loam soils) - graded

Precipitation data from Oshawa WPCP Climate Station (1981 - 2010)

Potential Evapotranspiration Calculation	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Average Temperature (Degree C)	-4.80	-3.60	0.40	6.60	12.30	17.60	20.60	20.00	15.90	9.50	4.20	-1.20	**8.1**
Heat index: $i = (t/5)^{1.514}$	0.00	0.00	0.02	1.52	3.91	6.72	8.53	8.16	5.76	2.64	0.77	0.00	**38.0**
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	1.36	29.28	57.92	85.79	101.94	98.69	76.75	43.64	17.84	0.00	**513**
Adjusting Factor for U (Latitude 43^{o} 40' N)	0.81	0.82	1.02	1.13	1.27	1.29	1.3	1.2	1.04	0.95	0.8	0.76	
Adjusted Potential Evapotranspiration PET (mm)	0	0	1	33	74	111	133	118	80	41	14	0	**605**
COMPONENTS	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Precipitation (P)	66	57	54	73	79	74	73	77	94	70	85	71	**872**
Potential Evapotranspiration (PET)	0	0	1	33	74	111	133	118	80	41	14	0	**605**
P - PET	66	57	53	40	5	-37	-59	-41	14	29	71	71	**267**
Change in Soil Moisture Storage	0	0	0	0	0	-37	-38	0	14	29	32	0	**0**
Soil Moisture Storage max 75 mm	75	75	75	75	75	38	0	0	14	43	75	75	
Actual Evapotranspiration (AET)	0	0	1	33	74	111	111	77	80	41	14	0	**543**
Soil Moisture Deficit max 75 mm	0	0	0	0	0	37	75	75	61	32	0	0	
Water Surplus - available for infiltration or runoff	66	57	53	40	5	0	0	0	0	0	38	71	**329**
Potential Infiltration (based on MOE metholodogy*; independent of temperature)	49	42	40	30	4	0	0	0	0	0	29	53	**247**
Potential Direct Surface Water Runoff (independent of temperature)	16	14	13	10	1	0	0	0	0	0	10	18	**82**
IMPERVIOUS AREA WATER SURPLUS													
Precipitation (P)	872	mm/year											
Potential Evaporation (PE) from impervious areas (assume 15%)	131	mm/year											
P-PE (surplus available for runoff from impervious areas)	741	mm/year											

Assume January storage is 100% of Soil Moisture Storage

Soil Moisture Storage (urban lawns in fine sandy loam)	75 mm	<-- See "Water Holding Capacity" values in Table 3.1, MOE SWMPDM, 2003
*MOE SWM infiltration calculations		
topography - rolling, graded	0.25	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
soils - silty sand (open sandy loam)	0.4	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
cover - urban lawns	0.1	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
Infiltration factor	**0.75**	
Latitude of site (or climate station)	44 ^{O} N	

TABLE A-4

Pre-Development Monthly Water Balance Components

Based on Thornthwaite's Soil Moisture Balance Approach with a Soil Moisture Retention of 250 mm (pasture and shrubs in silt to sandy silt till soils)

Precipitation data from Oshawa WPCP Climate Station (1981 - 2010)

Potential Evapotranspiration Calculation	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Average Temperature (Degree C)	-4.80	-3.60	0.40	6.60	12.30	17.60	20.60	20.00	15.90	9.50	4.20	-1.20	**8.1**
Heat index: $i = (t/5)^{1.514}$	0.00	0.00	0.02	1.52	3.91	6.72	8.53	8.16	5.76	2.64	0.77	0.00	**38.0**
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	1.36	29.28	57.92	85.79	101.94	98.69	76.75	43.64	17.84	0.00	**513**
Adjusting Factor for U (Latitude 43° 40' N)	0.81	0.82	1.02	1.13	1.27	1.29	1.3	1.2	1.04	0.95	0.8	0.76	
Adjusted Potential Evapotranspiration PET (mm)	0	0	1	33	74	111	133	118	80	41	14	0	**605**
COMPONENTS	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Precipitation (P)	66	57	54	73	79	74	73	77	94	70	85	71	**872**
Potential Evapotranspiration (PET)	0	0	1	33	74	111	133	118	80	41	14	0	**605**
P - PET	66	57	53	40	5	-37	-59	-41	14	29	71	71	**267**
Change in Soil Moisture Storage	0	0	0	0	0	-37	-59	-41	14	29	71	24	**0**
Soil Moisture Storage max 250 mm	250	250	250	250	250	213	154	113	127	156	226	250	
Actual Evapotranspiration (AET)	0	0	1	33	74	111	133	118	80	41	14	0	**605**
Soil Moisture Deficit max 250 mm	0	0	0	0	0	37	96	137	123	94	24	0	
Water Surplus - available for infiltration or runoff	66	57	53	40	5	0	0	0	0	0	0	47	**267**
Potential Infiltration (based on MOE metholodogy*; independent of temperature)	36	31	29	22	3	0	0	0	0	0	0	26	**147**
Potential Direct Surface Water Runoff (independent of temperature)	30	25	24	18	2	0	0	0	0	0	0	21	**120**
IMPERVIOUS AREA WATER SURPLUS													
Precipitation (P)	872	mm/year											
Potential Evaporation (PE) from impervious areas (assume 15%)	131	mm/year											
P-PE (surplus available for runoff from impervious areas)	741	mm/year											

Assume January storage is 100% of Soil Moisture Storage

Soil Moisture Storage (pasture/shrubs in silt loam)	250	mm	<-- See "Water Holding Capacity" values in Table 3.1, MOE SWMPDM, 2003
*MOE SWM infiltration calculations			
topography - rolling land	0.2		<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
soils - silt to sandy silt till (medium combinations of clay and loam)	0.2		<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
cover - pasture and shrubs	0.15		<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
Infiltration factor	**0.55**		
Latitude of site (or climate station)	44	° N	

TABLE A-5

Pre-Development Monthly Water Balance Components

Based on Thornthwaite's Soil Moisture Balance Approach with a Soil Moisture Retention of 400 mm (wooded lands in silt to sandy silt till soils)

Precipitation data from Oshawa WPCP Climate Station (1981 - 2010)

Potential Evapotranspiration Calculation	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Average Temperature (Degree C)	-4.80	-3.60	0.40	6.60	12.30	17.60	20.60	20.00	15.90	9.50	4.20	-1.20	**8.1**
Heat index: $i = (t/5)^{1.514}$	0.00	0.00	0.02	1.52	3.91	6.72	8.53	8.16	5.76	2.64	0.77	0.00	**38.0**
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	1.36	29.28	57.92	85.79	101.94	98.69	76.75	43.64	17.84	0.00	**513**
Adjusting Factor for U (Latitude 43° 40' N)	0.81	0.82	1.02	1.13	1.27	1.29	1.3	1.2	1.04	0.95	0.8	0.76	
Adjusted Potential Evapotranspiration PET (mm)	0	0	1	33	74	111	133	118	80	41	14	0	**605**
COMPONENTS	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Precipitation (P)	66	57	54	73	79	74	73	77	94	70	85	71	**872**
Potential Evapotranspiration (PET)	0	0	1	33	74	111	133	118	80	41	14	0	**605**
P - PET	66	57	53	40	5	-37	-59	-41	14	29	71	71	**267**
Change in Soil Moisture Storage	0	0	0	0	0	-37	-59	-41	14	29	71	24	**0**
Soil Moisture Storage max 400 mm	400	400	400	400	400	363	304	263	277	306	376	400	
Actual Evapotranspiration (AET)	0	0	1	33	74	111	133	118	80	41	14	0	**605**
Soil Moisture Deficit max 400 mm	0	0	0	0	0	37	96	137	123	94	24	0	
Water Surplus - available for infiltration or runoff	66	57	53	40	5	0	0	0	0	0	0	47	**267**
Potential Infiltration (based on MOE metholodogy*; independent of temperature)	36	31	29	22	3	0	0	0	0	0	0	26	**147**
Potential Direct Surface Water Runoff (independent of temperature)	30	25	24	18	2	0	0	0	0	0	0	21	**120**
IMPERVIOUS AREA WATER SURPLUS													
Precipitation (P)	872	mm/year											
Potential Evaporation (PE) from impervious areas (assume 15%)	131	mm/year											
P-PE (surplus available for runoff from impervious areas)	741	mm/year											

Assume January storage is 100% of Soil Moisture Storage

Soil Moisture Storage (mature forests in silt loam)	400	mm	<-- See "Water Holding Capacity" values in Table 3.1, MOE SWMPDM, 2003
*MOE SWM infiltration calculations			
topography - rolling to hilly land	0.15		<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
soils - silt to sandy silt till (medium combinations of clay and loam)	0.2		<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
cover - wooded lands	0.2		<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
Infiltration factor	**0.55**		
Latitude of site (or climate station)	44	° N	

TABLE A-6

Post-Development Monthly Water Balance Components

Based on Thornthwaite's Soil Moisture Balance Approach with a Soil Moisture Retention of 125 mm (urban lawns in silt to sandy silt till soils) - graded

Precipitation data from Oshawa WPCP Climate Station (1981 - 2010)

Potential Evapotranspiration Calculation	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Average Temperature (Degree C)	-4.80	-3.60	0.40	6.60	12.30	17.60	20.60	20.00	15.90	9.50	4.20	-1.20	**8.1**
Heat index: $i = (t/5)^{1.514}$	0.00	0.00	0.02	1.52	3.91	6.72	8.53	8.16	5.76	2.64	0.77	0.00	**38.0**
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	1.36	29.28	57.92	85.79	101.94	98.69	76.75	43.64	17.84	0.00	**513**
Adjusting Factor for U (Latitude 43^{o} 40' N)	0.81	0.82	1.02	1.13	1.27	1.29	1.3	1.2	1.04	0.95	0.8	0.76	
Adjusted Potential Evapotranspiration PET (mm)	0	0	1	33	74	111	133	118	80	41	14	0	**605**
COMPONENTS	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**
Precipitation (P)	66	57	54	73	79	74	73	77	94	70	85	71	**872**
Potential Evapotranspiration (PET)	0	0	1	33	74	111	133	118	80	41	14	0	**605**
P - PET	66	57	53	40	5	-37	-59	-41	14	29	71	71	**267**
Change in Soil Moisture Storage	0	0	0	0	0	-37	-59	-29	14	29	71	12	**0**
Soil Moisture Storage max 125 mm	125	125	125	125	125	88	29	0	14	43	113	125	
Actual Evapotranspiration (AET)	0	0	1	33	74	111	133	106	80	41	14	0	**593**
Soil Moisture Deficit max 125 mm	0	0	0	0	0	37	96	125	111	82	12	0	
Water Surplus - available for infiltration or runoff	66	57	53	40	5	0	0	0	0	0	0	59	**279**
Potential Infiltration (based on MOE metholodogy*; independent of temperature)	36	31	29	22	3	0	0	0	0	0	0	32	**153**
Potential Direct Surface Water Runoff (independent of temperature)	30	25	24	18	2	0	0	0	0	0	0	27	**126**
IMPERVIOUS AREA WATER SURPLUS													
Precipitation (P)	872	mm/year											
Potential Evaporation (PE) from impervious areas (assume 15%)	131	mm/year											
P-PE (surplus available for runoff from impervious areas)	741	mm/year											

Assume January storage is 100% of Soil Moisture Storage

Soil Moisture Storage (urban lawns in silt loam) 125 mm <-- See "Water Holding Capacity" values in Table 3.1, MOE SWMPDM, 2003

*MOE SWM infiltration calculations

topography - rolling, graded	0.25	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
soils - silt to sandy silt till (medium combinations of clay and loam)	0.2	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
cover - urban lawns	0.1	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
Infiltration factor	**0.55**	

Latitude of site (or climate station) 44 ^{O} N

TABLE A-7

Frisque Lands Water Balance - Existing Conditions and Post-Development with No Mitigation

Land Use**	Soil Type	Approx. Land Area (m^2)**	Estimated Impervious Fraction for Land Use**	Estimated Impervious Area (m^2)	Runoff from Impervious Area* (m/a)	Runoff Volume from Impervious Area (m^3/a)	Estimated Pervious Area (m^2)	Runoff from Pervious Area* (m/a)	Runoff Volume from Pervious Area (m^3/a)	Infiltration from Pervious Area* (m/a)	Infiltration Volume from Pervious Area (m^3/a)	Total Runoff Volume (m^3/a)	Total Infiltration Volume (m^3/a)
Existing Land Use													
Undeveloped Pasture / Shrub Lands (West)	Sandy Loam	58,500	0.00	0	0.741	0	58,500	0.067	3,902	0.200	11,706	3,902	11,706
Wooded Lands (West)	Sandy Loam	22,100	0.00	0	0.741	0	22,100	0.067	1,474	0.200	4,422	1,474	4,422
Undeveloped Pasture / Shrub Lands (East)	Sandy Silt Till	61,600	0.00	0	0.741	0	61,600	0.120	7,396	0.147	9,039	7,396	9,039
Wooded Lands (East)	Sandy Silt Till	36,800	0.00	0	0.741	0	36,800	0.120	4,418	0.147	5,400	4,418	5,400
TOTAL PRE-DEVELOPMENT		**179,000**	**-**	**0**		**0**	**179,000**	**-**	**17,190**	**-**	**30,568**	**17,190**	**30,568**
Post-Development Land Use													
Open Space & Buffer Area (Pasture/Shrub - West)	Sandy Loam	32,500	0.00	0	0.741	0	32,500	0.067	2,168	0.200	6,503	2,168	6,503
Wooded Lands (West)	Sandy Loam	22,100	0.00	0	0.741	0	22,100	0.067	1,474	0.200	4,422	1,474	4,422
Residential Lots & Roadways ** (West)	Sandy Loam	26,000	0.26	6,760	0.741	5,011	19,240	0.082	1,583	0.247	4,748	6,593	4,748
Open Space & Buffer Area (Pasture/Shrub - East)	Sandy Silt Till	27,300	0.00	0	0.741	0	27,300	0.120	3,278	0.147	4,006	3,278	4,006
Wooded Lands (East)	Sandy Silt Till	36,800	0.00	0	0.741	0	36,800	0.120	4,418	0.147	5,400	4,418	5,400
Residential Lots & Roadways ** (East)	Sandy Silt Till	34,300	0.20	6,860	0.741	5,085	27,440	0.126	3,445	0.153	4,211	8,530	4,211
TOTAL POST-DEVELOPMENT		**179,000**	**-**	**13,620**	**-**	**10,095**	**165,380**	**-**	**16,366**	**-**	**29,291**	**26,461**	**29,291**
% Change from Pre to Post												154	4
Effect of development (with no mitigation)												1.5 times increase	4% reduction in infiltration
To balance pre- to post infiltration target (m^3/a)=													**1,277**

* figures from Tables A-1 through A-6

** data provided by CDC

TABLE A-8

Frisque Lands Water Balance - Existing Conditions and Post-Development with Mitigation (with LIDs)

Land Use		Soil Type	Approx. Land Area (m^2)**	Estimated Impervious Fraction for Land Use**	Estimated Impervious Area (m^2)	Runoff from Impervious Area* (m/a)	Runoff Volume from Impervious Area (m^3/a)	Estimated Pervious Area (m^2)	Runoff from Pervious Area* (m/a)	Runoff Volume from Pervious Area (m^3/a)	Infiltration from Pervious Area* (m/a)	Infiltration Volume from Pervious Area (m^3/a)	Total Runoff Volume (m^3/a)	Total Infiltration Volume (m^3/a)
Existing Land Use														
Undeveloped Pasture / Shrub Lands (West)		Sandy Loam	58,500	0.00	0	0.741	0	58,500	0.067	3,902	0.200	11,706	3,902	11,706
Wooded Lands (West)		Sandy Loam	22,100	0.00	0	0.741	0	22,100	0.067	1,474	0.200	4,422	1,474	4,422
Undeveloped Pasture / Shrub Lands (East)		Sandy Silt Till	61,600	0.00	0	0.741	0	61,600	0.120	7,396	0.147	9,039	7,396	9,039
Wooded Lands (East)		Sandy Silt Till	36,800	0.00	0	0.741	0	36,800	0.120	4,418	0.147	5,400	4,418	5,400
TOTAL PRE-DEVELOPMENT			**179,000**	**-**	**0**		**0**	**179,000**	**-**	**17,190**	**-**	**30,568**	**17,190**	**30,568**
Post-Development Land Use														
Open Space & Buffer Area (Pasture/Shrub - West)		Sandy Loam	32,500	0.00	0	0.741	0	32,500	0.067	2,168	0.200	6,503	2,168	6,503
Wooded Lands (West)		Sandy Loam	22,100	0.00	0	0.741	0	22,100	0.067	1,474	0.200	4,422	1,474	4,422
Residential Lots (West)	Roof, Driveway and Pervious areas	Sandy Loam	23,001	0.16	3,761	0.741	2,788	19,240	0.082	1,583	0.247	4,748	4,063	4,748
	Roof to grass (assume 50% of runoff volume infiltrates[a])	Sandy Loam	1,701	1.00	1,701	0.741	1,261	0	0.082	0	0.247	0	630	630
	Driveway to grass (assume 50% of runoff volume infiltrates[a])	Sandy Loam	1,298	1.00	1,298	0.741	962	0	0.082	0	0.247	0	481	481
	Soakaway Pits - assume designed to accommodate 5 mm storm from 988 m^2 of roof area; 5 mm storms account for approximately 48% of total rainfall[b] (42% of precipitation); so assume 42% of runoff from impervious areas will infiltrate	Sandy Loam	NA	NA	NA	NA	NA	NA	NA	NA	NA	308	NA	308
Open Space & Buffer Area (Pasture/Shrub - East)		Sandy Silt Till	27,300	0.00	0	0.741	0	27,300	0.120	3,278	0.147	4,006	3,278	4,006
Wooded Lands (East)		Sandy Silt Till	36,800	0.00	0	0.741	0	36,800	0.120	4,418	0.147	5,400	4,418	5,400
Residential Lots (East)	Roof, Driveway and Pervious areas	Sandy Silt Till	31,639	0.13	4,199	0.741	3,112	27,440	0.126	3,445	0.153	4,211	6,009	4,211
	Roof to grass (assume 25% of runoff volume infiltrates[a])	Sandy Silt Till	1,189	1.00	1,189	0.741	881	0	0.126	0	0.153	0	661	220
	Driveway to grass (assume 25% of runoff volume infiltrates[a])	Sandy Silt Till	1,472	1.00	1,472	0.741	1,091	0	0.126	0	0.153	0	818	273
	Soakaway Pits - assume designed to accommodate 5 mm storm from 1,762 m^2 of roof area; 5 mm storms account for approximately 48% of total rainfall[b] (42% of precipitation); so assume 42% of runoff from impervious areas will infiltrate	Sandy Silt Till	NA	NA	NA	NA	NA	NA	NA	NA	NA	549	NA	549
TOTAL POST-DEVELOPMENT			**179,000**	**-**	**13,620**	**-**	**10,095**	**165,380**	**-**	**16,366**	**-**	**30,147**	**24,000**	**31,751**
												% Change from Pre to Post	140	-4
												Effect of development (with mitigation)	1.4 times increase	Maintains infiltration

To balance pre- to post infiltration target (m^3/a)= **-1,184**

* figures from Tables A-1 through A-6

** data provided by CDC

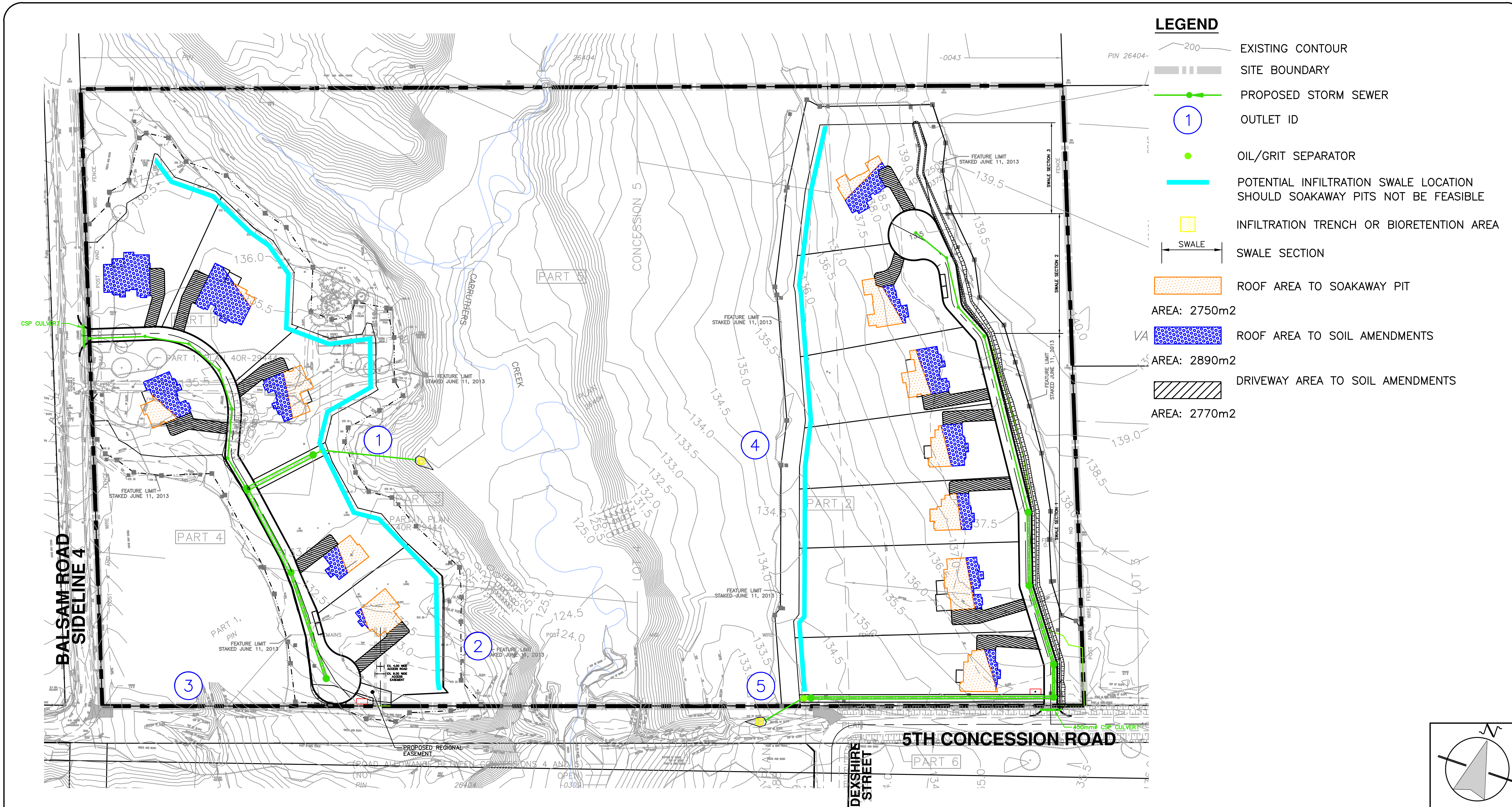
[a] based on estimation in the LID SWM Planning and Design Guide (CVC & TRCA, 2010) for hydrologic groups A, B, C & D

[b] based on the Toronto Wet Weather Flow Management Guidelines (City of Toronto, 2006)

[THE DIFFERENCE IS OUR PEOPLE]

CDC Figure 4

Low Impact Development (LID) Measure Location Plan



FRISQUE LANDS

THE CORPORATION OF THE CITY OF PICKERING

LOW IMPACT DEVELOPMENT (LID) MEASURE LOCATION PLAN

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Drawn By: J.R.	Checked By: A.K.	Proj. No. E21007
Designed By: J.R.	Checked By:	DWG. No. FIG.4
Scale: 1:2000	Date: July 11, 2023	

FILE: E21007-FIGURES.dwg