7.0 GRADING, DRAINAGE AND STORMWATER MANAGEMENT

7.1 OPA 272 and NOCSS Recommendations

Preparation of the SWM Plan for the Subject Lands has been guided by OPA 272 and the NOCSS recommendations.

OPA 272 policy 7.4.5 states that,

"The management of water resources within the North Oakville East Planning Area shall be undertaken in accordance with the directions established in the North Oakville Creeks Subwatershed Study. No amendments to the Secondary Plan shall be required to implement the recommendations of the Subwatershed Study or for changes to the number or location of stormwater management facilities in accordance with the policies of Section 7.6.2.2 a) of this Plan".

Section 6.0 of the NOCSS presents the recommended Management Strategy for North Oakville. It includes strategies for natural heritage protection, SWM, terrestrial and wetland resources management, riparian corridor management, rehabilitation plans, remediation plans and monitoring. The goals, objectives, and targets of the Management Strategy are set out in Section 6.2 of the NOCSS.

The recommended NOCSS Management Strategy addresses the development of an approach to SWM that will, "…*protect and enhance environmental characteristics through managing stormwater response and conveyance processes*".

The NOCSS Section 6.3.6 discusses the SWM component of the Management Strategy. It includes discussion on hydrology, peak flow control, hydrogeology, water quality, fisheries protection, LID, source pollution protection and various types of SWM measures.

The NOCSS Management Strategy presents the following recommendations regarding the design of SWM systems in support of development in North Oakville:

Peak Flow Control – The NOCSS recommends that SWM systems be designed to control post development peak flows to target unit flow rates presented in NOCSS Table 5.4.1 for the 2 year to 100 year events and Regional Storm. No new hydrologic modelling of existing conditions in the subcatchment is necessary to establish existing conditions target peak flows; however, the NOCSS notes that more accurate topographic information is required to define subcatchment boundaries. Target peak flows for the full range of events are to be calculated at the EIR/FSS stage on the basis of update subcatchment boundaries.

Sections 7.2 and **7.3** of this EIR/FSS address drainage boundaries and present target peak flows for the East Morrison Creek Subcatchment EM4 at Trafalgar Road.

OPA 272 Policy 7.4.13.2 and the NOCSS Addendum identify that within East Morrison Creek Regional Storm controls are necessary. **Section 7.5** addresses the requirement for Regional

Storm controls.

Role of Topographic Depressions/Hydrologic Features A and B – The NOCSS Analysis Report and Management Strategy address the hydrologic function of terrestrial features (woodlands, wetlands) and stream riparian corridors in the formulation of the recommended NHS and SWM systems. These reports also identified numerous topographic depressions across the landscape in North Oakville. The NOCSS GAWSER hydrologic model accounted for the storage function of these topographic depressions in the simulation of existing conditions peak flows and the setting of target unit flow rates for SWM facility design. The NOCSS Addendum recommends that the storage functions of these depressions be confirmed through the completion of the EIR/FSS when more detailed topographic information would be available.

Some topographic depressions that are wetland or pond features were noted to be Hydrologic Features A and B. Wetlands or ponds that were located online or within the stream corridor of a Medium or High Constraint Stream generally were defined to be a Hydrologic Feature A; all others were defined to be Hydrologic Feature B.

The NOCSS recommended that the form and function of Hydrologic Feature A be carefully considered as part of the EIR studies. If relocating these features, the form and function must be maintained.

With respect to Hydrologic Feature B, the NOCSS notes that their preservation is encouraged but not required. If they are proposed for removal, the active storage volume of these features must be addressed as part of the SWM facility design. Requirements for the replacement of storage were further clarified in the Mediation Agreement on Depression Storage dated May 30, 2007 (see Section 7.12.2) and include providing the 2-year depressional storage volume within the total water quality (extended detention / permanent pool) volume of the pond and the greater of the 100-year / Regional storm depressional storage volume within the total storage volume of the SWM facility (permanent pool and active storage).

There are no Hydrologic Features A or B on the Subject Lands, although a depression area has been noted within the wetland at the south limit of the property (this will not be altered).

Erosion Control – The NOCSS identifies the need to complete erosion threshold and erosion control analyses as part of an EIR/FSS so that existing channel erosion or aggradation is not exacerbated by development. The recommended approach to erosion threshold analyses is set out in the NOCSS Addendum.

Section 7.6 of this EIR/FSS presents the erosion threshold analyses and erosion control modelling required to address the NOCSS erosion control requirements.

Erosion targets were established in the approved EM4 EIR/FSS and used in the design of the approved / constructed Pond 32 on the DTI lands to the south.

Water Quality Control – The NOCSS recommendations for water quality control focus on the management of phosphorus, suspended solids, chloride, dissolved oxygen and temperature. The focus on these water quality parameters is, "… *intended to provide controls to the meet the objective of not permitting further enrichment of the streams (i.e., nutrient* *control), fisheries protection and overall water quality protection".* It further notes that SWM systems are to be designed to meet targets set out in NOCSS Section 6.0 and outlined in NOCSS Table 6.2.1.

With respect to each of these water quality parameters, the following are NOCSS recommendations, specific to East Morrison Creek:

- Provide Enhanced Level of water quality protection. This level of control provides for the removal of 80% of suspended solids, will meet the target of no net increase in phosphorus loading and will provide the recommended control for overall water quality protection. No further analysis of phosphorus loading is necessary.

- Dissolved oxygen and temperature recommendations as per NOCSS Table 6.2.1 and the Mediation Agreement on these topics.

- Chloride recommendations relate to the Town's management of salt applications and do not require any further analyses in the EIR/FSS.

Water quality control for the west side of the Subject Lands will be provided by the existing Pond 32. Future phases, east of the NHS, will require other quality control measures including, but not limited to, on-site filtration, retention/infiltration, oil/grit separators and LID measures, subject to site constraints and a future EIR/FSS Addendum.

Infiltration - The NOCSS notes that the management of groundwater resources focuses on the management of the hydrologic cycle. For groundwater, the overall goal was stated, "*to maintain infiltration as close to current levels as possible*". It further notes that the soils in North Oakville are, "… *poorly permeable, resulting in little infiltration*" and that the "*infiltration targets are very difficult to meet*". As such, best efforts are to be made to address maintenance of groundwater recharge.

Section 8.0 of this EIR/FSS addresses the post-development water balance and discusses LID techniques for promoting groundwater recharge.

SWM Facility Numbers/Locations – The NOCSS completed a preliminary assessment of the required numbers and locations of SWM ponds to meet the SWM design criteria. It presented preliminary locations for ponds in each subcatchment in North Oakville East. NOCSS Figure 7.4.6 illustrates no potential SWM ponds on the Subject Lands. The western portion of the Subject Lands flow to Pond 32, which was designed to accept the flows from this portion of the Subject Lands (albeit at a lower imperviousness than what is currently proposed). As part of the future development phases, the eastern portion of the Subject Lands, the majority of which are already within the EM4 catchment area, will drain directly into MOC-6 after quality and quantity control measures are applied. Under interim conditions (i.e., prior to development of the future phases) no stormwater management measures are required east of the PSW or on the west side of the PSW on 3301 Trafalgar Road. Stormwater management for the future phases will be addressed through a future Addendum as outlined in **Section 13**.

Floodplain Mapping - The NOCSS analyses included preliminary floodline mapping along each of the watercourses in North Oakville. However, recommendations were made that final floodlines be determined through the EIR/FSS. It was acknowledged in the NOCSS that the existing conditions hydrology (peak flows) could be utilized for the determination of existing conditions floodlines. If Regional Storm controls were concluded not to be necessary, future conditions hydrology models would be prepared to calculate uncontrolled Regional Storm flows for use in establishing future floodlines. Regional Storm controls are necessary for the East Morrison Creek Tributaries.

Section 5 of this Addendum presents floodline mapping for the East Morrison Creek Tributary through the Subject Lands.

Evaluation of SWM Measures, LIDs and Source Pollution Prevention – While the NOCSS identifies the requirement for end-of-pipe SWM facilities for water quality and quantity control, it also recommends that consideration be given to alternative management measures to meet the SWM objectives and targets. In this regard, the NOCSS discusses alternative LID techniques, various source pollution protection programs and alternative SWM practices to be considered. **Section 7.3** herein presents the evaluation of alternative SWM measures.

7.2 Pre-Development Flows at Culvert Crossings

7.2.1 Pre-Development Flows

The NOCSS established target unit peak flows for the 2 year to 100 year events and the Regional Storm utilizing the GAWSER model. It is also noted that further modelling of existing conditions target flows is not required at the EIR/FSS stage. In accordance with the NOCSS recommendations, NOCSS unit flow rates have been utilized, along with the updated pre-development drainage areas based on LiDAR mapping, to calculate pre-development peak flows at Dundas Street for the EM4 subcatchment. The NOCSS unit flow rates and the resulting pre-development flows at Trafalgar Road and Dundas Street are summarized in **Table 7.1.**

Table 7.1 – NOCSS Unit Rates for EM Subcatchment at Key Nodes

		Return Period						
		2	5	10	25	50	100	REG
		Unit Rates [$m^3/s/ha$]*						
NOCSS Unit Rates at ME-D3		**0.005**	**0.008**	**0.01**	**0.013**	**0.015**	**0.016**	**0.044**
Location	**Area [ha]**	**Existing (Target) Flow [m^3/s]**						
East Morrison Creek subwatershed (to culvert ME-T1) lands east of Trafalgar Road (For Pond 32 target setting)	65.38	0.327	0.523	0.654	0.850	0.981	1.046	2.877
Total Area to ME-T1	144.07	0.72	1.15	1.44	1.87	2.16	2.31	6.34
East Morrison Creek Drainage Area at future EM-1 confluence / Node B	147.89	0.739	1.183	1.479	1.923	2.218	2.366	6.507
East Morrison Creek Drainage Area at ME-D3 / EIR/FSS Node A	310.10	1.551	2.481	3.101	4.031	4.652	4.962	13.644

*Note: these rates represent the 'rounded' NOCSS rates

These pre-development flows were used in the *Lower EM4 EIR/FSS* for assessing culvert capacities at Trafalgar Road and Dundas Street for the purposes of mapping the existing floodlines and defining the allowable peak flows.

7.3 Stormwater Management Plan Selection Process

As required by the NOCSS and the EIR/FSS TOR, alternative approaches to SWM have been identified and evaluated to assess and incorporate appropriate stormwater management practices in the development design to satisfy NOCSS SWM goals, objectives and targets. SWM for the west portion of the Subject Lands will be provided in the existing Pond 32 as originally intended. A separate SWM strategy will be required for the future phases east of PSW 25.

Stormwater management practices are specific planning and technical measures that are implemented to manage the quantity and quality of urban runoff. The SWM measures specifically required to manage urban runoff and mitigate potential drainage impacts are able to be grouped into three main categories:

- lot level, or source control measures (i.e., reduced lot grades, roof drainage control or storage, porous pavements, rain gardens, grassed swales, etc.);
- infiltration or LID measures (i.e., infiltration basins and trenches, exfiltration pipes or porous pavement, etc.); and,
- end-of-pipe measures (i.e., detention wet ponds or wetlands, oil/grit separators, etc.).

In reviewing these options for inclusion in the proposed SWM plan, these alternatives were evaluated on the basis of capabilities, limitations and physical constraints associated with their implementation. This included the following factors:

- their ability to meet SWM goals, objectives and targets discussed in **Section 7.1** herein and listed in **Table 7.1**;
- suitability of soils and groundwater conditions;
- site topography and size of contributing drainage areas;
- compatibility with urban form and natural features; and,
- municipal servicing requirements.

The evaluation of alternative stormwater management measures has made use of guidelines in the *MOE Stormwater Management Planning and Design Manual, March 2003,* (referred to here as the MOE SWMP Design Manual) and has considered the practical feasibility of implementing alternative Low Impact Development (LID) techniques as outlined in the TRCA/CVC LID Guidelines (2014).

LID is a comprehensive land planning and engineering design approach, the goals of which include preserving natural heritage areas and managing stormwater to minimize increases in surface flow and pollutants. The LID approach combines planning with micro-management techniques to reach these goals.

The NOCSS identified examples of LID measures to include conservation of natural features (i.e., Hydrologic Features B), reducing impervious areas, bioretention areas, rain gardens, green roofs, use of rain barrels and cisterns, vegetated filter strips and permeable pavements.

The proposed development will introduce impervious areas in the form of medium and high-density residential uses, institutional uses, parking lots and roads with an overall density higher than traditional single family housing developments. The proposed urban form, as set out in OPA 272, combines the protection of large tracts of lands in the NHS along with higher density development in the remaining areas for development. In this regard, the NOCSS and OPA 272 provide for the retention and enhancement of significant environmental areas and features to maintain and enhance the existing environmental functions and linkages throughout North Oakville. Preserve Core Areas, Linkage Preserve Areas, and High and Medium Constraint Stream Corridors combine to provide a large, connected NHS covering 603 ha or 27% of North Oakville East; all development is confined to areas outside of the NHS. This approach results in more compact forms of development with generally smaller lots, higher density residential products and reduced setbacks. The reduced building setbacks result in relatively small yard surfaces limiting the practical feasibility of at-source measures. Due to the housing form, which includes vast areas of underground parking, opportunities to provide lot level controls are somewhat limited but could include: disconnected roof leaders, green roofs, infiltration measures and water re-use. The ability to implement these measures must be assessed at detailed design based on the geotechnical / hydrogeological conditions, building form, building setbacks, location of impervious surfaces, and the ability to direct flows away from areas where there is the potential for icing problems. For the purpose of providing a site wide water balance, the LID measures that have been identified include disconnected roof leaders within the townhouse units and tree pits within the William Coltson ROW.

From a conveyance perspective, the density of development required in OPA 272 is not compatible with the use of rural road cross-sections with ditch/swale systems. In all areas, urban road cross-sections are proposed, compatible with higher density housing forms proposed in OPA 272 and Town standards.

With respect to the LID measure of "reduced impervious areas", as discussed above, the implementation of the proposed NHS has resulted in a more compact built form on lands outside the NHS. This is achieved through higher density residential product and reduced building setbacks. As a result, the total development is confined to a smaller footprint. While the total building coverage may not be reduced, the amount of road required to serve the development is reduced. As such, the total impervious area associated with the roads has been reduced.

In addition to the proposed urban form, the natural soil and groundwater conditions provide important considerations for the selection of effective SWM measures. Consistent with the findings of the NOCSS, the drilling and soil testing completed in this Addendum have confirmed that the Subject Lands are characterized by silty clay till with traces of gravel, occasional sand and silt seams, cobbles, boulders and shale fragments, with limited opportunity for infiltration.

The existing end-of-pipe SWM Pond 32 is proposed to provide the required Enhanced Level of water quality control, erosion control and flood control storage volume requirements for the western portion of the Subject Lands. The eastern portion of the Subject Lands (east of the NHS), including the small area (0.51 ha) currently within the JC9 catchment area, will be directed to MOC-6. This diversion has no negative impacts to the JC-9 catchment since it is a small fraction (<0.4%) of the total JC-9 catchment area (>140 ha). Since the area and imperviousness of the western parcel are similar to the area and imperviousness accounted for in the approved Pond 32 detailed design, the need for on-site controls of the west parcel is minimized. A GAWSER verification was completed to assess the following:

1) the impact of the development on the west side of the Subject Lands on Pond 32;
2) the impact of the development on the east side of the Subject Lands on the downstream watercourse; and,
3) the impact of the proposed development on the downstream targets at Dundas Street.

Appendix E-2 includes the GAWSER model verification, which concludes that there is no impact to Pond 32, no impact on flows in the existing watercourse and associated hazard mapping and no impact to the target flows at Dundas Street (ME-D3).

With respect to Source Pollution Prevention, the NOCSS identifies a number of source pollution prevention measures including reduced fertilizer and pesticide use, alternate lawn practices, pet litter control, street cleaning, salt management, and sewer use by-law enforcement. Many of these measures are the responsibility of the municipality. The preparation of a homeowner's manual is recommended to provide information to new homeowners on reduced fertilizer/pesticide use, alternate lawn practices, rain gardens, rain barrels, pet litter control, and environmental sensitivities of the NHS.

7.4 Downstream Investigations Regional Storm Controls

Policy 7.4.13.2 of OPA 272 states,

> "*The North Oakville Creeks Subwatershed Study recommends that stormwater targets include control of the peak flow to predevelopment levels for various return periods, including the Regional Storm. Through the land development application process, an investigation of the potential increase to flood risk may be carried out to confirm if Regional Storm controls are necessary, in accordance with the directions established in the North Oakville Creeks Subwatershed Study*."

NOCSS recommends that SWM targets include the control of peak flows to pre-development levels for the 2 year to 100 year return period events and the Regional Storm. However, it notes that future land use applications may carry out an investigation of the potential increase to flood risk to confirm if Regional Storm controls are necessary. This analysis is to include the increase in risk to life and to private, municipal, regional, provincial and federal property under Regional Storm conditions.

Through discussions with the Town, it has been agreed, in principle, that SWM facilities be utilized to control peak flows from the Regional Storm by providing additional runoff storage above the 100 year extended detention elevation. The Town and CH do not accept Regional storage on private site plan areas.

Pond 32 was studied, designed, and approved through the *Lower EM4 EIR/FSS* and detailed subdivision design process for the DTI lands. This facility was designed to accommodate flows from the western portion of the Subject Lands (draining to the south). Based on the foregoing, the existing SWM controls in Pond 32 will control peak flows to the NOCSS Addendum unit target flows rates for the 2 year to 100 year events and the Regional Storm for the western portion of the Subject Lands. Refer to **Section 7.6.1** for additional details pertaining to the analysis of the imperviousness level assumptions in the design of Pond 32 as compared to the proposed imperviousness level on the western portion of the Subject Lands.

The future phase / eastern portion of the Subject Lands will discharge directly into MOC-6. The GAWSER model verification analysis has confirmed the associated storage requirements to avoid impacts to the MOC-2 / MOC-4 channel flows and target flows downstream. Refer to **Section 7.6.1** for additional details.

7.5 Erosion Control Analysis

The NOCSS identifies the need to complete erosion threshold and erosion control analyses as part of the EIR/FSS so that existing channel erosion or aggradation is not exacerbated by development. Analysis of erosion thresholds along East Morrison Creek and continuous hydrologic modelling were completed as part of the *Lower EM4 EIR/FSS* to determine appropriate levels of discharge control for the downstream SWM pond to ensure that erosion and aggradation are not exacerbated in receiving stream system. The analysis was also utilized to evaluate the potential implications of changes in peak flows and velocities along stream reach MOC-4 and PSW 74 based on implementation of the proposed realignment and redesign of MOC-2 and MOC-2a. Additional erosion control analysis including an assessment of Cumulative Effective Work (CEW) and Cumulative Effective Discharge (CED) was completed prior to draft plan approval. This analysis, including additional continuous hydrologic modelling, was presented in two EIR/FSS Response Documents dated April 30, 2014, and June 11, 2014 that accompanied the approved Lower EM4 EIR/FSS.

7.5.1 Erosion Thresholds

The NOCSS identifies the need to complete erosion threshold and erosion control analyses as part of the EIR/FSS so that existing channel erosion or aggradation is not exacerbated by development. Analysis of erosion thresholds along East Morrison Creek was completed as part of the *Lower EM4 EIR/FSS* to determine appropriate levels of discharge control for SWM Pond 32 to ensure that erosion and aggradation are not exacerbated in the receiving stream system. As documented in **Section 7.6** below, no impacts to the operation of Pond 32 are anticipated to result from the proposed development and as such, no additional analysis is required.

7.6 Proposed SWM Controls and Post-Development Hydrology

7.6.1 Hydrologic Modelling

Updates to the most recent GAWSER model for the East Morrison Creek catchment were made to assess impacts to SWM Pond 32 resulting from a higher level of imperviousness for the west side of the Subject Lands as compared to the original assumptions in the *Lower EM4 EIR/FSS* (and verification of flows at Dundas Street).

Two scenarios were evaluated. In both cases, all areas are developed and SWM ponds are assumed to be in place, with the exception of the ~29 ha area tributary to future Pond 29 on the StarOak lands:

Interim "A" - both the 3275 Trafalgar Road and 3301 Trafalgar Road properties on the **west** side of the Subject Lands were assumed to be developed to evaluate the maximum potential impact to Pond 32. Since the proposed development area on the west side of the Subject Lands is slightly more impervious, albeit a smaller area than was originally assumed in the *Lower EM4 EIR/FSS* and detailed subdivision design, there are only marginal impacts to Pond 32 downstream as shown in **Table 7.2** below.

Interim "B" – the entirety of the 3275 Trafalgar Road and 3301 Trafalgar Road properties on the east and west sides of PSW 25 were assumed to be developed to assess the maximum potential impact downstream at Dundas Street (due to uncontrolled release of Regional flows through from the east portion of the Subject Lands). Refer to **Table 7.4** for the impacts at Dundas Street.

Interim "A" scenario was used to assess the impacts to Pond 32, since the east portion of the Subject Lands does not drain to Pond 32. This table compares the approved Pond 32 targets, as well as the as-built volumes to the updated results based on the proposed development on the west side of the Subject Lands.

Development of the west portion of the Subject Lands was always considered in the Pond 32 drainage area (as 2.17 ha at 78.6% imperviousness = 1.71 imp ha; the new area is 1.88 ha at 93% imperviousness = 1.75 imp ha). Overall, the total area to Pond 32 becomes slightly more impervious.

The original drainage area based on the approved design was 66.38 ha at 69.2% imperviousness, for a total impervious area of 45.93 ha.

The updated drainage area is 66.09 ha at 69.7% imperviousness, for a total impervious area of 46.06 ha, which is marginally higher . Pond 32 was modelled with an imperviousness of 70% as a conservative measure.

Note that the GAWSER model updates were based on the as-built rating curve for Pond 32 that was described in the approved September 2016 certification letter, which provided more storage than the original design.

Table 7.2 – Confirmation of Pond 32 Performance (no tailwater scenario)

Events	Approved Design Flow	Approved As-built Flow	Proposed Update	Approved Design (Volume Used)	Provided As-built Volume	Proposed Update
	Final DTI Inc. SWM Report (Sept 2016)	As-constructed Certification (Sept 2016)		Final DTI Inc. SWM Report (Sept 2016)	As-constructed Certification (Sept 2016)	
	(m^3/s)	(m^3/s)	(m^3/s)	(m^3)	(m^3)	(m^3)
Extended Detention	0.03	0.03	0.03	12,125 (10,760)*	12,198	12,125 (10,803)*

Events	Approved Design Flow	Approved As-built Flow	Proposed Update	Approved Design (Volume Used)	Provided As-built Volume	Proposed Update
	Final DTI Inc. SWM Report (Sept 2016)	As-constructed Certification (Sept 2016)		Final DTI Inc. SWM Report (Sept 2016)	As-constructed Certification (Sept 2016)	
	(m^3/s)	(m^3/s)	(m^3/s)	(m^3)	(m^3)	(m^3)
2-year	0.34	0.377	0.340	16,514	16,932	16,415
5-year	0.52	0.54	0.529	20,396	20,579	20,268
10-year	0.65	0.67	0.657	22,829	23,692	22,846
25-year	0.77	0.80	0.789	26,955	27,168	26,898
50-year	0.90	0.92	0.912	29,405	29,525	29,299
100-year	1.04	1.07	1.055	32,082	32,404	31,970
Regional	2.40	2.40	2.362	81,970	82,935	81,541

*Note – 12,125m^3 is the extended detention volume at the extended detention elevation used for drawdown time calculations. Value in brackets is the GAWSER model volume required for the 25mm event.

As shown in **Table 7.2**, the updated flows are slightly lower than the previously approved as-built model flows and continue to be below overall targets for this facility. Similarly, the required volumes under the proposed conditions can be provided within the as-constructed volumes. No water level changes are anticipated.

The preliminary storage volumes on the east side of the Subject Lands, which were not considered to be developed in the *Lower EM4 EIR/FSS* or subsequent detailed design submissions, have been established as follows according to the NOCSS unit rates. These targets will be re-evaluated as the subsequent phases of the development proceed through a future EIR/FSS Addendum process. The Interim "B" scenario was used for this scenario. Water quality control measures will be evaluated through the future EIR/FSS Addendum for the eastern portion / Phase 2 of the Subject Lands. As per current Town and CH recommendations, Regional Storm control will not be proposed for the private site plan areas. The target flows are based on 1.89 ha, which is the proposed developed drainage area (2.4 ha) less the 0.51 ha drainage area that drains to JC9 under existing conditions.

Table 7.3 – East Parcel Target Flow and Storage

East Parcel Flow & Storage Targets		
Storm Event	**Target Flow (m^3/s) (based on NOCSS unit rates x 1.89 ha drainage area)**	**Required Storage Volume (m^3)**
Extended Detention	0.009	354
2-year	0.010	658
5-year	0.015	878
10-year	0.019	994

East Parcel Flow & Storage Targets		
Storm Event	**Target Flow (m³/s) (based on NOCSS unit rates x 1.89 ha drainage area)**	**Required Storage Volume (m³)**
25-year	0.025	1169
50-year	0.029	1273
100-year	0.031	~~1462~~1399

Note that the Regional flow at Dundas Street / Node ME-D3 was evaluated assuming that there is no storage on the private site plan area. ~~discharges from the storage with negligible peak flow routing (0.223 m³/s inflow, 0.222 m³/s outflow). This was deemed acceptable for assessing the uncontrolled regional flow impacts downstream.~~

At Node ME-D3 (Dundas Street), the updated flows (assuming full build-out of the EM4 catchment) have been evaluated against the NOCSS targets. As shown in **Table 7.4**, the targets are not exceeded under ultimate conditions. Note that the ultimate conditions results will be updated through completion of the EM4 Addendum supporting the Star Oak / Crystal Homes lands including Pond 29; the ultimate results noted in **Table 7.4** are therefore considered preliminary/work-in-progress. The ultimate conditions flows are also included with the addition of the proposed permanent dewatering flows that drain through / to the Pond 32 outfall pipe from the surrounding high-rise developments as documented in the May 26, 2024 memo to Town staff regarding the BC Trafalgar Limited development.

Table 7.4 – Comparison of Flows at ME-D3

		Return Period						
		2	**5**	**10**	**25**	**50**	**100**	**REG**
		Unit Rates [m³/s/ha]*						
NOCSS Unit Rates at ME-D3		**0.005**	**0.008**	**0.01**	**0.013**	**0.015**	**0.016**	**0.044**
Location	**Area [ha]**	**Existing (Target) Flow [m³/s]**						
East Morrison Creek Drainage Area at ME-D3 / EIR/FSS Node A	310.10	1.551	2.481	3.101	4.031	4.652	4.962	13.644
Interim "A" – Flows at ME-D3 / EIR/FSS Node A	329.16~~31~~	1.244~~0~~	2.264	2.~~858~~875	3.727~~18~~	4.278	5.002~~0~~	14.270~~83~~
Interim "B" - Flows at ME-D3 / EIR/FSS Node A	329.~~80~~	1.244~~0~~	2.259~~8~~	2.869~~51~~	3.~~707~~715	4.269	4.990~~88~~	14.332~~49~~

		Return Period						
		2	**5**	**10**	**25**	**50**	**100**	**REG**
		Unit Rates [m³/s/ha]*						
NOCSS Unit Rates at ME-D3		**0.005**	**0.008**	**0.01**	**0.013**	**0.015**	**0.016**	**0.044**
Location	**Area [ha]**	**Existing (Target) Flow [m³/s]**						
Ultimate – Flows at ME-D3 / EIR/FSS Node A	325.99	1.233	2.211	2.753	3.574	4.111	4.743	13.581~~6~~
Ultimate- Flows at ME-D3/ EIR/ FSS Node A + permanent dewatering flows via Pond 32: OV 4A &4B (3.8 L/s) + OV 4C & 4D & 4E (4.8 L/s) + Daniels/ EMSHI (6.4 L/s) + Blocks 23/24 (0.82 L/s)	325.99	1.249	2.227	2.769	3.590	4.127	4.759	13.597~~602~~

Under interim conditions, there are exceedances of the 100-year and Regional storm targets. However, this exceedance is not attributed to the development of the Subject Lands, but rather the combination of peak flow timing between existing and developed areas. This was described as follows in the approved SWM report for Pond 32 (September 2016).

Under interim conditions, a portion of the catchment is developed and controlled by SWM facilities while the rest of the catchment (i.e., approximately 29 ha west of Trafalgar Road) is considered as existing conditions. Therefore, one would intuitively assume that the smaller drainage area, reduced imperviousness, and partial SWM control plus pre-development areas would result in lower peak than the ultimate conditions model. However, as shown in the preceding tables, the interim peak flows at Point A exceed the target flows for the infrequent events.

The following items were considered and *ruled out* as the source of the increase in flows:

- **Insufficient SWM controls** - All development areas are controlled by SWM facilities that restrict flows to the NOCSS unit rates for node ME-D3 or lower. For example, Pond 32 provides overcontrol beyond the NOCSS targets. Therefore, the increase in interim flows is not caused by insufficient SWM controls.

- **Increased Drainage Area** - The effects of the larger drainage area (compared to pre-development conditions) is eliminated by the SWM facilities, which control post-development flows to the pre-development targets for the pre-development drainage areas. Therefore, the increase in interim flows is not caused by a larger drainage area.

The cause of the increase was linked to changes in undeveloped areas. The remaining pre-development drainage areas are less than or equal to the pre-development areas and have been disaggregated from the original NOCSS (larger) catchments. A significant difference was noted between flows generated by the pre-development catchments tributary to the MOC-2 and MOC-4 watercourse and the discretized NHS areas modelled under interim conditions (i.e., the C1 / C2 areas). Despite the fact that these areas are modelled with pre-development parameters, the fact that they have been discretized / modelled as separate catchments compared to the pre-development NOCSS model results in unit rates higher than the pre-development values.

The Pond 32 SWM report completed for DTI (September 2016) includes a detailed comparison of unit rates calculated for the disaggregated catchments vs the applicable NOCSS targets. The increase in interim peak flow results from the GAWSER model interpretation of the discretized areas versus the pre-development lumped areas, specifically the NHS / open channel corridor area which has been divided into multiple catchments to generate peak flows at different points along the channel. The interim flow exceedance is an artifact of the modelling approach only, rather than a result of insufficient SWM controls or the addition of uncontrolled, developed areas. Due to the changes in the GAWSER model hydrology resulting from discretization of the natural heritage areas, the interim flows increase slightly, but only due to the modelling approach. If the existing drainage area was similarly discretized, it is expected that the existing peak flow targets would be consistent with the modelled interim peak flows. This issue is resolved under ultimate conditions.

7.7 Conveyance of Minor System Flows

The Subject Lands will be serviced by a conventional storm sewer system designed in accordance with the Town’s standards. The storm sewers will be sized using a 5-year return frequency and the Town’s IDF curves. The storm sewer design has taken into account the major system capture areas / low points where all surface flows must be directed into the minor system. These areas are illustrated on **Drawing 7.4**. The minor system design calculations are included in **Appendix F-1.**

The storm flows on the west side of the Subject Lands will be directed to the existing Pond 32 (north corner of Dundas Street East and Trafalgar Road), where the runoff will be treated for water quality and quantity control.

The storm flows on the eastern side of the Subject Lands will not drain to Pond 32 due to grading constraints. Storm flows from this area will be directed to MOC-6 / PSW 25 via quantity and quality controls.

External storm flows are conveyed from Street A and future development lands to the north (Tribaden Investments Inc.) and west of Trafalgar Road (Mel-Oak) directed to PSW 25 via quantity and quality controls, including future SWM Pond 29 (SWMP 29). Sizing of external infrastructure will be refined in the future in coordination with upcoming EM4 addendum(s) associated with future development lands.

The conceptual storm servicing scheme is illustrated in **Drawing 7.4.**

7.8 Conveyance of Major System Flows

A continuous overland flow route has been provided on the Subject Lands in order to safely convey major system flows in excess of the minor system up to the 100 year event. The excess flows will be contained within either the private right-of-ways or on public roads or easements. For all classes of roads, the product of depth of water (m) at the gutter times the velocity of flow (m/s) shall not exceed $0.65m^2/s$.

The storm flows on the west side of the Subject Lands will be directed to the existing Pond 32 where the runoff will be treated for water quality and quantity control.

The storm flows on the east side of the Subject Lands will not drain to Pond 32 due to grading constraints. Storm flows from this area will be directed to PSW 25 via quantity and quality controls.

External storm flows are conveyed from Street A and future development lands to the north (Tribaden Investments Inc.) and west of Trafalgar Road (Mel-Oak) directed to PSW 25 via quantity and quality controls, including future SWMP 29. Sizing of external infrastructure will be refined in the future in coordination with upcoming EM4 addendum(s) associated with future development lands.

Should the major system flow exceed the conveyance capacity of any given road, the storm sewer will be sized to accommodate the excess flows such that the road capacity is not exceeded. Calculations for the critical locations on site (i.e., narrowest right-of-way vs. highest accumulated flow) are included in **Appendix F-1.**

The conceptual major storm system is illustrated in **Drawing 7.4**.

7.9 PSW Drainage

One PSW (PSW 25) is located within the Addendum EIR Subcatchment Area. This PSW has been studied to address potential impacts of changes to runoff volumes resulting from development in its surface water catchment and identify mitigative measures under both interim (Phase 1) and ultimate development condition in the EM4 subcatchment. Refer to **Section 8.9** for additional discussion on this PSW.

The surface water inputs to PSW 25 were evaluated under existing and interim (Phase 1) conditions. **Section 8.9** describes the water balance analysis, results, and required mitigation to ensure that the post-development runoff discharged into the PSW is consistent with existing conditions such that the form and function of the PSW is not negatively impacted.

7.10 Preliminary Grading Plans

A preliminary grading plan has been prepared for the Subject Lands based on the engineering constraints such as NHS limits, servicing and proposed road patterns. The conceptual grading is illustrated in **Drawing 7.1** and conceptual grading cross sections are provided in **Drawing 7.2**.

The grading strategy is consistent with the Town's standards and compatible with the NOCSS recommendations for grading adjacent to the NHS. In this regard, preliminary grading of all lots/blocks adjacent to Cores include appropriate freeboard from the regulatory floodline along the existing (and future) NHS boundaries. Based on the Town's North Oakville Trails Plan, a trail surrounding the perimeter of the NHS is required (i.e., within the 30 m wetland buffer, within the 10 m woodland dripline buffer and within 7.5 m of the greater of the Regional Storm flood plain or the meander belt).

Once detailed design proceeds, changes to the preliminary grading plan may result in additional grading into the buffers and will be implemented in accordance with NOCSS recommendations (i.e., no grading within 1 m of dripline or within 10 m of a PSW and grades not to exceed 3:1 slopes).

8.0 WATER BALANCE

In order to assess potential development impacts of Phase 1 on the local groundwater resources, a site wide water balance and a feature-based water balance analysis have been completed to determine the pre-development recharge volumes (based on existing land use conditions) and the post-development recharge volumes that would be expected based on the proposed land use plan. The detailed site wide water balance calculations are provided in **Appendix C-5**. The detailed feature-based water balance calculations are provided in **Appendix D-3**.

The Thornthwaite water balance (Thornthwaite, 1948; Mather, 1978; 1979) is an accounting type method used to analyze the allocation of water among various components of the hydrologic cycle. Inputs to the model are monthly temperature, site latitude, precipitation, and stormwater run-on. Outputs include monthly potential and actual evapotranspiration, evaporation, water surplus, total infiltration, and total runoff.

8.1 Components of the Water Balance

A water balance is an accounting of the water resources within a given area. As a concept, the water balance is relatively simple and may be estimated from the following equation:

$$P = S + R + I + ET$$

where:

P	=	precipitation
S	=	change in groundwater storage
R	=	surface water runoff
I	=	infiltration
ET	=	evapotranspiration/evaporation

The components of the water balance vary in space and time and depend on climatic conditions as well as the soil and land cover conditions (e.g., rainfall intensity, land slope, soil hydraulic conductivity and vegetation). Runoff, for example, occurs particularly during periods of snowmelt when the ground is frozen, or during intense rainfall events. Precise measurement of some of the water balance components is difficult and as such, approximations and simplifications are made to characterize the water balance of a study area. Field observations of the drainage conditions, land cover and soil types, groundwater levels and local climatic records are important input considerations for the water balance calculations.

The water balance components are discussed below:

Precipitation (P)
The average annual precipitation for the area is 897 mm based on long-term data (1981 to 2010) from the Hamilton RBG climate station (Station 6153300 - 43°16.8′N, 79°52.8′W, elevation 102.1 masl) for the period between 1981 and 2010. The average monthly precipitation totals are provided on **Table 2** in **Appendix C-5**.

Storage (S)
Although there are groundwater storage gains and losses on a short-term basis, the net change

in groundwater storage on a long-term basis is assumed to be zero so this term is dropped from the equation.

Evapotranspiration (ET)
Evapotranspiration varies based on the land surface cover (e.g., type of vegetation, soil moisture conditions, impervious surfaces, etc.). Potential evapotranspiration (PET) refers to the water loss from a vegetated surface to the atmosphere under conditions of an unlimited water supply. The actual rate of evapotranspiration (AET) is generally less than the PET under dry conditions (e.g., during the summer when there is a soil moisture deficit). The mean annual ET has been calculated for this study using a monthly soil-moisture balance approach considering the local climate conditions.

Water Surplus (R + I)
The difference between the mean annual P and the mean annual ET is referred to as the water surplus. Part of the water surplus travels across the surface of the soil as surface or overland runoff (R) and the remainder infiltrates the surficial soil (I).

Infiltration is comprised of two components: shallow infiltration that migrates laterally through the shallow soil profile and discharges to surface at some short time following cessation of precipitation and a deeper infiltration that reaches the water table and recharges the groundwater flow system. The shallow infiltration component may be referred to as interflow or throughflow and the deeper component may be referred to as percolation, deep infiltration or net recharge. Interflow tends to move relatively quickly and often re-emerges locally as seepage at the ground surface. Typically, the horizontal hydraulic conductivity of the shallow soil profile tends to be higher than the vertical hydraulic conductivity, aiding lateral interflow. Fracture patterns in the relatively low hydraulic conductivity till that blankets the EIR Subcatchment Area may also affect the shallow water movement.

Interflow is more closely associated with runoff (because of its relatively short residence time) than with baseflow which is fed by groundwater (net recharge). As such, interflow is considered as an "indirect" component of runoff, as opposed to the "direct" component of surface runoff (overland flow) that occurs across the ground surface during precipitation or snowmelt events. The ability to precisely distinguish between interflow from direct runoff and baseflow is not a simple task. This is related to the complexity of subsurface geological and hydrogeological environments. Because of this, there has been a lack of adoption of a standard separation or partitioning method and therefore, interflow and direct surface (overland) flow are simply considered together as the total runoff component in this report.

8.2 Approach and Methodology

The analytical approach to calculate a water balance for Phase 1 involved monthly daily average temperature to determine the actual evapotranspiration and the corresponding water surplus components. A soil-moisture balance approach assumes that soil does not release water as "potential infiltration" while a soil moisture deficit exists. During wetter periods, any excess of precipitation over evapotranspiration first goes to restore soil moisture. Once the soil moisture deficit is overcome, any further excess water can then pass through the soil as infiltration and either become interflow (indirect runoff) or recharge (deep infiltration).

The water holding capacity of the surficial soils depends on the types of soil as well as the type of vegetation and rooting depth. A soil moisture storage capacity of 100 mm was utilized to represent the clayey silt till soils and predominantly short-rooted vegetation (grassy open space and agricultural fields) and a soil moisture capacity of 250 mm was used to represent the more deeply-rooted wooded areas within the EIR Subcatchment Area (i.e., the Core 10 area). Monthly Potential Evapotranspiration is provided **Appendix H of Appendix C-5** and details the monthly potential evapotranspiration calculations accounting for latitude and climate, and then calculate the actual evapotranspiration and water surplus components of the water balance based on the monthly precipitation and soil moisture conditions.

The infiltration and runoff volumes for Phase 1 were then calculated for the pre-development (based on the existing land use) and post-development (based on the proposed development concept plan) conditions. The MOE SWMP Design Manual (2003) methodology for calculating total infiltration based on topography, soil type and land cover, was used for the soil moisture storage conditions for both pre- and post-development conditions. The annual pre-development and post-development water balance component calculations are shown in **Tables 4 and 5** in **Appendix H of Appendix C-5**.

As noted in **Section 8.1**, the infiltration component will divide into shallow interflow and deeper groundwater recharge components. Although there is no specific methodology for calculating this division of flow and few studies have attempted to quantify this value with any degree of precision, reasonable estimates can be made based on the nature of the surficial soils. For soils underlain by very permeable sand, it is considered that the interflow component would likely approach 0% with most of the infiltrating water moving vertically to recharge the water table. For soils underlain by very low hydraulic conductivity sediments, the interflow component would likely approach 100%, with most of the water that infiltrates into the topsoil layer just seeping along the topsoil/till contact to re-emerge locally at surface. Although the topsoil in the EIR Subcatchment Area is underlain by low hydraulic conductivity till sediments, fracturing may improve the recharge capabilities. In water balance analyses completed for the North Oakville East Subwatershed Study (NOMI, 2004), an interflow component value of 50% of the total infiltration was found to correlate reasonably well with numerical modeling results of the regional groundwater flow conditions. Therefore, this estimate has been utilized in this study to calculate the effective recharge and total runoff components of the water balance (**Tables 4 and 5, Appendix C-5**).

The calculated water balance components are utilized to assess the pre-development infiltration volumes based on the existing land use characteristics within the Phase 1 Area. Then a post- development water balance scenario is calculated based on the proposed land development plan to assess the potential impacts of development on the local groundwater resources. It is noted that the calculations are completed assuming no mitigation strategies or LID measures for SWM and infiltration are in place (i.e., the calculations present a 'worst-case scenario' of the potential reductions in infiltration that may occur in the developed area). As noted in **Section 8.8** however, LID measures are recommended for the development; the worst-case scenario calculations are simply intended to identify the need for LIDs and aid in the analysis of potential impacts on natural features.

The post-development land uses have been broken down into land use categories and assigned an average percentage of imperviousness for the water balance calculations as summarized in **Table 8.1**.

Table 8.1 Water Balance Land Use Categories (Phases 1 & 2)

Land Use Category	Phase 1 Total Area (ha)	Phase 2 Total Area (ha)
Building Roofs	0.036	2.98 (assumed 85% imperviousness)
Impervious Area	0.699	
Landscape Area	0.300	0.53
Total Area ~~(Phase 1)~~	1.035	3.51

8.3 Component Values

The detailed calculations of the water balance components are provided in **Appendix H** in **Appendix C-5**. The calculations indicate that there is an annual water deficit of 68% as a result of the proposed Phase 1 development, and 83% ~~-~~as a result of Phase 2 (on a preliminary basis). The water balance calculations illustrate how infiltration occurs during periods when there is sufficient water available to overcome the soil moisture storage requirements.

The calculations provide estimates of the annual water balance component values (**Tables 4 and 5, Appendix C-5**). A summary of these values is provided in **Table 8.2** (note that the values from **Tables 4 and 5** in **Appendix C-5** have been rounded accounting for the minor variances in balance additions).

Table 8.2 Water Balance Component Values

Water Balance Component	Phase 1 – 1.035 ha (m^3)
Average Precipitation	9,285
Actual Evapotranspiration	1,889
Water Surplus	7,396
Recharge	150
Interflow (indirect runoff)	150
Total Infiltration	300
Direct Runoff	6,946
Total Runoff (direct and indirect components)	7,096 m^3/a

It is acknowledged that the recharge and runoff values presented in **Table 8.2** are estimates. Single values are utilized for the water balance calculations, but it is important to understand that infiltration rates are dependent upon the hydraulic conductivity of the surficial soils which may vary over several orders of magnitude. As such, the margins of error for the calculated infiltration and runoff component values are potentially quite large. These margins of error are recognized, but for the purposes of this assessment, the numbers used in the water balance calculations are considered reasonable estimates based on the site-specific conditions and useful for comparison of pre- to post-development conditions. The estimates for groundwater recharge are consistent with the previous subwatershed studies completed for the area, including the NOCSS (2006) and NOMI (2004) studies, and a comprehensive hydrogeological study of aquifers throughout the Region that included regional groundwater flow modeling by Holysh (1995).

8.4 Pre-Development Water Balance (Existing Conditions)

A summary of the pre-development Phase 1 site coverage is provided in **Table 8.1**. The pre-development water balance calculations ,based on the existing land use, are presented in **Appendix H** of **C-5**. The building roof area, impervious area and landscaped areas of the site and the water balance component values from **Table 2, Appendix C-5** were used to calculate the average annual volume of recharge and run-off that occurs across the proposed Phase 1 development area. Based on the component values, the average pre-development recharge/infiltration volume is estimated to be approximately 936 m^3/year, while run-off was determined to be 2,452 m^3/year (**Table 4, Appendix C-5**). It is noted that recharge rates are based on estimated average component values and assumed consistent soil and drainage conditions across the Subject Lands. The calculated numbers are considered as reasonable representations of the magnitude of the recharge volume, not the precise volume that occurs.

While not the focus of this EIR/FSS, a preliminary water balance analysis was completed for Phase 2. The same water balance component values established for Phase 1 have been applied to the Phase 2 lands, which, under pre-development conditions, are approximately 3.51 ha at 15% imperviousness. Based on these values, the pre-development recharge/infiltration volume is approximately 2,984m^3/year. This assumes conditions identical to Phase 1.

8.5 Potential Development Impacts to Water Balance

Development of an area affects the natural water balance. The most significant difference is the addition of impervious surfaces as a type of surface cover (e.g., roads, parking lots, driveways, and rooftops). Impervious surfaces prevent infiltration of water into the soils and the removal of the vegetation removes the evapotranspiration component of the natural water balance. There is still an evaporation component from impervious surfaces; however, this is relatively minor (estimated to be 10% to 20% of precipitation) compared to the evapotranspiration component that occurs with vegetation (65% to 70% of precipitation) in this area. The net effect of the construction of impervious surfaces is that most of the precipitation that falls onto impervious surfaces becomes surplus water and direct runoff.

Therefore, the increase in run-off at the site is the result of developing and installing hard surfaced or impermeable areas within Phase 1.

Based on the water balance calculations, infiltration values were determined to decrease.

8.6 Post-Development Water Balance

The proposed Phase 1 development concept is provided on **Figure 6.1A**. As described in **Section 8.2**, the FSS Study Area has been broken down into proposed land use areas and each land use has been assigned an average percentage of imperviousness as summarized in

Table 8.1. As discussed in **Section 8.2**, these data have been used to calculate the potential post-development runoff and recharge volumes assuming no mitigation or LID measures are in place. The calculations are presented on **Table 2, Appendix C-5**.

The building roofs area, impervious area, and landscape area of the site, and the water balance component values from **Table 2, Appendix C-5** were used to calculate the average annual volume of recharge that occurs across the proposed Phase 1 development area. Based on the component values, the average post-development recharge/infiltration volume was estimated to be approximately 300 m^3/year, while the run-off was determined to be 7,096 m^3/year (**Table 5, Appendix H** of **Appendix C-5**). It should be noted that recharge rates are based on estimated average component values and assumed consistent soil and drainage conditions across the Subject Lands. The calculated numbers are considered as reasonable representations of the magnitude of the recharge volume, not the precise volume that occurs.

8.7 Comparison of Pre- and Post-Development Water Balance

A comparison of pre-and post- development water balance is presented in **Tables 8.3A and 8.3B.**

Table 8.3A Comparison of Pre and Post-Development Water Balance – Phase 1

Development Phase	Precipitation (m^3)	Evapotranspiration (m^3)	Infiltration (m^3)	Run-Off (m^3)
Pre-Development	9,285	5,896	936	2,452
Post-Development	9,285	1,889	300	7,096

Table 8.3B Comparison of Pre and Post-Development Water Balance – Phase 2

Development Phase	Precipitation (m^3)	Evapotranspiration (m^3)	Infiltration (m^3)	Run-Off (m^3)
Pre-Development (15% imperviousness)	31,488	18,766	2,984	9,738
Post-Development (85% imperviousness)	31,488	3,312	527	27,650

Comparatively, the pre- and post-development calculated volumes indicate that there is potential for a decrease in recharge to the groundwater regime of about 68% (from 936 m^3 to 300 m^3) for Phase 1, and 82% (from 2,984 m^3 to 527 m^3) for Phase 2.

The increase in run-off from 2,352 m^3 to 7,096 m^3 is the result of the construction of hard surfaces or impermeable areas within Phase 1, and similarly for Phase 2 (9,738 m^3 to 27,650

m^3). The post-development impermeable areas also result in the decrease of evapotranspiration and infiltration across Phases 1 and 2.

The above-noted values and associated detailed calculations presented in the detailed water balance calculations in **Appendix C-7** are considered to be conservative and based on the following assumptions:

- No infiltration will occur beneath the internal roads, public walkways, buildings or driveways.
- No evapotranspiration will occur from the internal roads, public walkways, buildings or parking areas.

The site is considered not to have significant amounts of groundwater recharge due to the relatively low-permeable soils encountered at surface. Infiltration value is expected to decrease from 936 m^3/year to 300 m^3/year, based on the water balance calculations detailed in **Appendix H** of **Appendix C-5** for Phase 1, and from 2,984 m^3 to 527 m^3 for Phase 2 (based on extension / assumption of Phase 1 values for the Phase 2 lands). ~~.~~ The assumptions for Phase 2 will be confirmed through a future EIR/FSS Addendum.

8.8 Low Impact Development (LID) Measures

Low impact development (LID) measures are proposed to be included in the design of the development towards addressing the infiltration deficit of 636 m^3. The LID measures to be implemented include roof leader disconnection with discharge to pervious area and tree pits on William Coltson Avenue within Phase 1.

8.8.1 Roof Leader Disconnection

Based on the Water Balance calculations in **Appendix H** of **Appendix C-5**, building roof run-off, from the townhouse units in Phase 1, was determined to be 327 m^3. This is regarded as contribution to recharge from roof leader disconnection and discharge and subsequent infiltration to pervious areas. At this time, it is uncertain how many building rooftops in Phase 2 will be able to provide recharge via roof leader disconnection; therefore, this mitigation measure has not been considered for Phase 2 but can be considered in a future Addendum.

8.8.2 Tree Pits

Tree Pits are proposed to make up for remaining 309 m^3 of infiltration deficit in Phase 1, and have been quantified for Phase 2.

It is understood that the typical tree pit will be 1.0 m in radius and typically 0.75 m deep. The storage capacity for tree pits is therefore approximately 0.72 m^3 based on a porosity value of 30% for the mainly clayey silt soils. With 48 events per year, the volume available for recharge per year from a tree is approximately 34.56 m^3/year.

It is anticipated that the tree pits will receive runoff from the area immediately around the tree pit and that the tree pits will receive the first 5 mm of every storm event. As per the climate normal data from the Hamilton RBG climate station, there are about 48 events per year that meet the greater than or equal to 5 mm threshold. This number of events was used to estimate the annual volume being infiltrated by the tree pits.

With 48 events of 5 mm storm events per year, the volume available for recharge per year from a tree is approximately 34.56 m^3/year. Based on the foregoing, approximately nine tree pits (309 m^3/year/34.56 m^3/year) will be required to meet the water balance deficit of 309 m^3.

However, the actual volume used varies based on the amount of drainage area directed to each tree pit. **Figure A** in **Appendix C** illustrates the approximate area that drains to each tree pit. The tree pit drainage areas consist of the boulevard and lot frontage upstream of the pit. The areas range from 70 m^2 to 150 m^2 with a runoff coefficient varying between 0.3 to 0.8. In a 5mm storm, each tree pit receives on average 0.36 m^3, which utilizes 50% of the available 0.72 m^3 tree pit storage. The preceding water balance calculations estimated that only 9 "full" tree pits would be required to achieve the annual recharge targets. There are more than 18 "half full" tree pits, which achieve the same annual recharge as 9 “full” tree pits. At detailed design, the drainage areas to the tree pits will be refined and the mitigation calculations will be updated.

For the Phase 2 lands, preliminary calculations suggest a recharge deficit of 2,457 m^3 per year. This could be achieved by approximately 71 “full” tree pits, or 142 “half full” tree pits. Based on the length of road in Phase 1 (100m), approximately 20 tree pits can be accommodated. There is approximately 360m of road in Phase 2, which could accommodate 72 tree pits, as well as a walkway block and other landscaped areas which could accommodate additional LIDs measures to enhance recharge.

Table 8.4 summarizes the post-development recharge with LID measures.

The tree pits are proposed along the future William Coltson Avenue as shown on **Figure 7**, **Appendix A** of **Appendix C-5** and are shown on the landscaping plans.

Table 8.4 Post-Development Recharge with LID Measures

Phase	**Post-Development Deficit (m^3/year)**	**Rooftop Downspout Disconnection (m^3/year)**	**Tree Pit (m^3/year)**	**Post Development Deficit (m^3/year)**
1	636	327	309 (based on 9 full tree pits / 18 half-full tree pits)	0
2	2,457	TBD	2,457 (based on 71 full tree pits / 142 half full tree pits	0

Based on the above a combination of downspout disconnections and tree pits will result in a recharge condition that meets the pre-development recharge condition. In addition to the tree pits within public property, the NHS itself will provide additional evapotranspiration and recharge opportunities. The private site plans may also incorporate some on-site retention or water re-use, which is understood to be not credited towards meeting recharge targets, but would provide additional retention.

8.9 Water Balance Impact Assessment

8.9.1 Water Quantity

The increases in surface water runoff that will occur with urban development are typically addressed through the use of appropriate SWM techniques and best management practices to control the runoff volumes. Details of the proposed SWM plans for the FSS Study Area are provided in **Section 7**.

The predicted decreases in recharge that will occur due to the nature of the proposed urban development suggests that, without mitigation, the developed area will receive a reduction of about 68% to the current amount of average annual recharge (refer to **Section 8.6**). As discussed in **Section 4.6.4**, the natural recharge conditions in the subcatchment are limited due to the low hydraulic conductivity surficial soils and gradients. The reduction in recharge that may occur with land development is not expected to result in any significant impacts to the local groundwater flow patterns but there is potential to lower the groundwater table. During construction dewatering requirements are outlined in **Section 11.6**. Underground parking structures are proposed to be bathtubbed. As a result, no mitigation measures (i.e., foundation drain collection system) are required.

Monitoring that was completed as part of the *Lower EM4 EIR/FSS* illustrated that the seasonal high water table conditions are important for the vegetation in PSW 25, downstream of the Subject Lands, and for contributing to seasonal discharge in specific areas along the East Morrison Creek East Tributary watercourse (i.e., areas where the seasonally high water table intersects the ground surface of the channel resulting in seepage; refer to Sections 4.6.2 and 4.6.5 in the *Lower EM4 EIR/FSS*). Although the groundwater discharge volumes are also minor (because of the low hydraulic conductivity soils, gradients and limited recharge conditions), it is important to maintain the local groundwater table conditions along the watercourse channels such that the discharge conditions can be maintained. Therefore, it is recommended to minimize potential changes to the water balance, where possible, through the incorporation of LID measures into the stormwater management strategy for the development. These LID measures are discussed in **Section 8.8**. Of note, groundwater discharge was not identified along MOC-6 within the Subject Lands.

In addition to the loss of direct recharge, the construction of buried services below the water table has the potential to capture and redirect groundwater flow through more permeable fill materials typically placed in the base of excavated trenches. Over the long term, these impacts can lower the groundwater table across the subcatchment. Services will be constructed to prevent redirection of flow and overall lowering of the water table. This will involve the use of trench collars or clay plugs to provide barriers to flow and prevent groundwater flow along granular bedding material (**Section 11.3**).

In addition to buried services, underground parking structures will be bathtubbed (thereby having no impact on the groundwater)

8.9.2 Water Quality

Depending on land use, runoff from urban developments may contain a variety of dilute contaminants such as suspended solids, chloride from road salt, oil and grease, metals, pesticide residues, bacteria and viruses. With the exception of the dissolved constituents such as nitrogen and salt, most contaminants are attenuated by filtration during groundwater transport through the soils, and therefore, the potential for effects on local groundwater quality from infiltration in the urban areas is expected to be limited. The natural groundwater quality in this area is considered poor, and any potential changes to the groundwater quality would not be expected to influence conditions in surface water features where groundwater discharge occurs.

8.9.3 Private Services

The proposed development will be serviced by municipal water supply and wastewater services. As a result, there will be no impact on the local groundwater or surface water quantity and quality conditions related to any on-site groundwater supply pumping or disposal of septic effluent. Any existing wells and septic systems will be decommissioned or removed during the development process. Further discussion on interim monitoring and decommissioning of any active private wells is provided in **Section 11.10**.

8.10 Water Balance Mitigation Measures

LID techniques to minimize urban development impacts on the water balance will be incorporated into the SWM plans for the development. Techniques to maximize the water availability for infiltration, such as designing grades to direct roof runoff towards pervious areas where possible (e.g., lawns, side and rear yard swales predominantly associated with the church) and increasing topsoil thickness (to about 300 mm) to help to retain moisture for infiltration, can increase recharge in developed areas and reduce the volume of runoff directed to SWM facilities. Incorporating such SWM techniques into the development design can also help to minimize development impacts to the water balance by reducing the post-development groundwater recharge deficit. It is noted, however, that choosing such LID options in unsuitable soils can lead to undesirable wet soil conditions and possible water ponding at grade.

The relatively low hydraulic conductivity of the local surficial till and shale materials limit infiltration potential. Large engineered facilities or constructed 'active' infiltration measures, such as infiltration trenches, pervious storm pipe systems and infiltration pits, are generally not considered suitable for the development given this hydrogeological setting as well as the proposed underground parking which will occupy a significant area of the eastern and western portions of the Subject Lands. As noted earlier, opportunities to improve water balance include disconnected roof leaders / townhouse rooftops directed to pervious areas and the use of tree pits within the William Coltson ROW.

8.11 Feature Based Water Balance to Provincially Significant Wetland

8.11.1 Background

One PSW (PSW 25) is located within the EIR Subcatchment Area.

This PSW has been studied to address potential impacts of changes to runoff volumes resulting from development in its surface water catchment and identify mitigative measures under both interim and ultimate development conditions in the EM4 subcatchment.

The following report sections outline existing PSW drainage conditions, areas, water balance analyses, recommended mitigation and implications to wetland vegetation.

8.11.2 Existing PSW Conditions

Figure 5.2 illustrates the PSW 25 wetland vegetation units on the Subject Lands. The portion of PSW 25 located on the Subject Lands includes a Mineral Cattail Shallow Marsh (MAS2-1) community surrounding a Shallow Aquatic (SA) community. The MAS2-1 community is dominated by Hybrid Cattail (*Typha xglauca*), with Narrow-leaved Cattail (*Typha angustifolia*) also abundant. Other vegetation species within the community include Climbing Nightshade (*Solanum dulcamara*), Reed Canarygrass (*Phalaris arundinacea*), Purple Loosestrife (*Lythrum salicaria*), and Lance-leaved Aster (*Symphyotrichum lanceolatum*). Furthermore, a patch of Common Reed (*Phragmites australis* ssp. *australis*) is located at the southern end of the MAS2-1 and extends beyond its boundaries into an anthropogenically disturbed area. South of these communities, PSW 25 has been heavily impacted by pre-existing agricultural and other activities on the Subject Lands to the point where wetlands are no longer present until the Core 10 woodlands are reached.

Wildlife investigations completed on the Subject Lands determined that the SA community associated with the online (fire) pond is providing habitat for species of turtles and amphibians, with Midland Painted Turtle, Spring Peeper, American Toad, Gray Treefrog, and Green Frog recorded within the pond. Red-winged Blackbirds were observed calling from the MAS2-1 community associated with PSW 25, and both Barn Swallows and Tree Swallows were observed foraging over the SA community associated with the wetland.

Within Core 10, the *Lower EM4 EIR/FSS* described PSW 25 as follows:

- <u>The middle portion of PSW 25</u> (upper Reach MOC-2 between points B and C on Figure 7.2c of the *Lower EM4 EIR/FSS*) is defined by the watercourse flowing through a maple mineral swamp, west of primarily lowland deciduous forest types and east of dry-fresh to fresh-moist deciduous forest types. The channel is well defined at this location and enters portions of red-osier mineral thicket and silver maple swamps.

- <u>The lower portion of PSW 25</u> (upper Reach MOC-2 between points C and D on Figure 7.2c of the *Lower EM4 EIR/FSS*) occurs where the watercourse flows southwesterly through a riparian lobe at the south end of the wetland, comprising primarily reed canary grass/forb mineral marshes and some cattail shallow marsh in the wettest deepest portions. Individual trees (ash, elm, willow) are scattered along the well-defined, likely historically, ditched channel.

  Within the *Lower EM4 EIR/FSS*, it was noted that monitoring in the PSW found water in the spring, but on the other monitoring occasions throughout the year, the wetland did not exhibit surface water. As such, this wetland typically is flooded in the spring but dries out in the summer months, with occasional inputs of water during storm events. As discussed in the *Scoped EM4 EIR/SWM Report*, groundwater monitoring at piezometers installed along PSW 25 showed relatively high water table conditions in the wetland. The groundwater levels are seasonally at or above ground surface with the exception of the northern area of the wetland within Core 10, where the spring groundwater levels were found to remain about 1 m below grade. When the water table is below grade and there is standing water in this area, there is a downward gradient (i.e., upper portion of the wetland has a recharge function). Occasional seasonal groundwater discharge to surface has been observed in the lower portion of the PSW, but flow is rarely recorded down-gradient of the PSW indicating the discharge volumes are very limited and are either taken up by vegetation or simply re-infiltrated downstream along the channel.

It was concluded in the *Lower EM4 EIR/FSS* that the high water table conditions may assist in supporting the wetland vegetation; however, much of the wetland area generally loses water to the subsurface, and in those lower areas where seasonal discharge occurs, the groundwater discharge volumes are not sufficient to maintain standing water or baseflows. The wetland primarily relies on precipitation and surface water runoff for water supply.

The location of PSW 25 within the EM4 subcatchment is shown on **Figure 7.3** (pre-development drainage) and **Figures 7.5** and **7.5A** (interim and ultimate post-development drainage). As shown, a number of different tableland areas contribute overland flow to PSW 25, some of which contribute to other areas, and some of which are entirely within Core 10. **Figures 7.3**, **7.5** and **7.5A** (interim drainage) illustrate the portions of the Subject Lands directed to PSW 25. This does not include the total drainage area to the feature, which includes additional areas from the Shieldbay Inc. and DTI lands. **Table 8.3** is a high-level comparison between the various scenarios to indicate the size and location of the contributing areas associated with the study area only. There is an overall increase in impervious area (and hence, runoff) directed to PSW 25 as shown in **Table 8.5**.

Table 8.5 – Contributing Drainage Areas to PSW 25

Overview Description	Existing Area (ha) (Drawing 7.3)	Proposed / Interim Area (ha) (Drawing 7.5A)	Proposed / Ultimate Area (ha) (Drawing 7.5)
External to Subject Lands, the majority of which is located west of Trafalgar Road; developable; flow contributions to upstream end of PSW 25	34.2 (0% IMP)	33.95 (10% IMP)	29.2 ha (0% IMP) + 3.80 ha (90% IMP)
Study Area	7.42 (0% IMP)	6.13 (0% IMP) + 0.13 (65% IMP)	0.13 ha (65% IMP) + 2.4 ha (90% IMP) + 0.19 ha (25% IMP) + 3.12 ha (0%IMP)

Overview Description	Existing Area (ha) (Drawing 7.3)	Proposed / Interim Area (ha) (Drawing 7.5A)	Proposed / Ultimate Area (ha) (Drawing 7.5)
Total	41.62 ha 0%IMP *IMP Area = 0 ha*	40.21 ha 9% IMP *IMP Area = 3.61 ha*	38.84 ha 15% IMP *IMP Area = 5.83*

8.9.3 Water Balance Analyses

The potential changes in impervious cover and change in catchment size associated with the development of Phase 1 were assessed against the TRCA's Wetland Water Balance Risk Evaluation (TRCA 2017). Through this analysis it was determined that:

- There are no locally significant recharge areas identified;
- The development of Phase 1 would result in a low magnitude of change in impervious cover within the catchment area (Impervious Cover Score of 1.6% increase in impervious cover) and a low magnitude of change in catchment area for PSW 25 (2% reduction); and,
- The development of Phase 1 would have a low magnitude of water takings required (50,000 to 400,000 L/d for <6 months; see **Section 11.6**).

Given this, it was determined by the risk evaluation that there is a low magnitude of hydrological change, resulting in a low risk to PSW 25 from the changes to the water balance.

Notwithstanding this low risk, a water balance assessment was conducted to assess potential impacts to PSW 25 associated with the Phase 1 development within the Subject Lands. The upstream portion of PSW 25, located within the Subject Lands, was historically disturbed by activities from a previous landowner, resulting in a lack of wetland communities at this location. Therefore, the majority of the upper portion of PSW 25 is proposed for restoration as part of the ultimate development plan. Existing runoff to the upper, degraded portion of PSW 25 was compared against Phase 1 post-development runoff volumes to determine the extent and potential impact of the development on the wetland restoration plan and the downstream portions of PSW 25.

Under existing conditions, runoff to the upper portion of PSW 25 originates from the Upper EM4 subcatchment located west of Trafalgar Road, and from the Subject Lands. Pre-development, the entire Phase 1 development area (1.10 ha) drains to PSW 25 via overland flow. Following development of the Phase 1 lands, drainage to upper PSW 25 will consist of the Upper EM4 subcatchment, undeveloped lands within the Subject Lands, and a small portion (0.14 ha) of the Phase 1 lands. The remaining 0.96 ha from the Phase 1 lands will be directed south to SWM Pond 32. Under existing, Phase 1 and ultimate conditions (full development of the EM4 catchment), the total drainage areas to upper PSW 25 are 41.6 ha, 40.7 ha and 38.8 ha, respectively. The pre- and post-development contributing areas to PSW 25 are provided in **Table 8.6.**

Table 8.6 - Contributing Drainage Areas to the Upper Portion of PSW 25

Scenario	Total drainage to upper PSW 25	Phase 1 Lands	Proportion of Phase 1 drainage to upper PSW 25
Existing	41.6 ha	1.10 ha	2.64%
Phase 1 post-development	40.7 ha	0.14 ha	0.34%

Scenario	Total drainage to upper PSW 25	Phase 1 Lands	Proportion of Phase 1 drainage to upper PSW 25
Ultimate Scenario	38.8 ha	0.14 ha	0.364%

Existing runoff contributions to upper PSW 25 were assessed using the catchment-scale continuous hydrologic simulation model developed for the EM4 catchment as part of the urban planning review process for the DTI/SBI Final EIR/FSS. Existing runoff contributions specific to Phase 1 lands were derived from the site-wide water balance for the Subject Lands detailed in **Section 8.7**. To account for minor updates to the Phase 1 land-use breakdown following the completion of the Phase 1 site-wide water balance, a correction factor was applied to the results described in **Section 8.7.** This land-use correction resulted in minor increases in total site runoff of 4.4% under existing conditions, and of 8% under proposed conditions.

While the catchment-scale and site-wide models use different methods and are based on different spatial scales, the site-wide water balance estimates provide a reasonable estimate of Phase 1 contributions relative to the total catchment runoff to PSW 25 derived from the catchment-scale model. The results from the catchment-scale and site-scale hydrological models are summarized below as average annual and monthly runoff volumes in **Table 8.7.** The Phase 1 lands contribute 2.2% of the average annual growing season runoff (i.e. April-October) while covering approximately 2.6% of the total PSW 25 catchment area, indicating the runoff calculations from the site-wide water balance area are consistent with the Phase 1 contributing area size as a proportion of the total contributing area.

Table 8.7 – Runoff volumes (m^3) to PSW 25 – Existing Conditions

Period	Catchment-scale model EM4 (m^3)	Site-scale model Phase 1 lands (m^3)	Proportion of total catchment runoff Phase 1 (%)
"Annual" (April – October)	68,341	1,536	2.2%
Seasonal			
April	6,419	549	8.2%
May	8,764	174	2.0%
June	7,685	148	1.9%
July	13,480	169	1.3%
August	14,238	184	1.3%
September	11,150	165	1.5%
October	6,605	146	2.2%

Following the Phase 1 development, the contributing area to PSW 25 from Phase 1 lands will be reduced by 0.96 ha (87%). Although the proportional pre- to post-development reduction in Phase 1 contributing area to PSW 25 is significant, it is important to note that the Phase 1 lands occupy approximately 14% of the Subject Lands with the remaining portions either protected NHS areas or undeveloped lands.

To assess how the Phase 1 development reduces runoff to PSW25 at the catchment scale, the predicted runoff reductions from the Phase 1 lands were subtracted from the runoff estimates obtained from the catchment-scale model. This calculation provides a post-development estimate of total runoff to PSW25. The estimate is considered provisional as it does not account for future development within the PSW25 catchment area.

Results demonstrate that during the provisional condition, there is an estimated annual runoff reduction of 950 m^3 to PSW 25, representing a 1.4% reduction in total runoff to the upper portion of PSW 25 after development of the Phase 1 lands. The average monthly decrease in post-development runoff ranges from 5.3% in April to 0.8% in July, remaining within 5% of existing conditions throughout the year. The magnitude of these reductions suggests that the Phase 1 development will not negatively affect the proposed wetland restoration plan, nor are negative impacts anticipated on the downstream portions of PSW 25. Additionally, the predicted runoff reductions to PSW25 are expected to be temporary. It is the Study Team's understanding that once full development in the catchment area is complete (i.e., the 'ultimate' scenario) it is expected that the slight reductions in annual and monthly flows to PSW25 from the development of the Phase 1 lands will be offset by increased flows to PSW25 resulting from the proposed development within the Upper EM4 catchment. The potential impact of the increased flows to PSW25 resulting from the planned development of the Upper EM4 catchment area is currently being assessed by others. Total pre- and post-development runoff volumes to the upper portion of PSW 25 for the 'provisional' condition are provided in **Table**

8.8.

Table 8.8 – Catchment-scale Pre- and Post-Development Runoff to PSW 25 (Phase 1)

Period	Pre-development (m^3)	Post-development (m^3)	Pre- to Post-development change (m^3)	Pre- to Post-development change (%)
Annual (April – October)	68,341	67,391	-950	-1.4
Seasonal				
April	6,419	6,079	-340	-5.3
May	8,764	8,656	-108	-1.2
June	7,685	7,593	-92	-1.2
July	13,480	13,375	-105	-0.8
August	14,238	14,124	-114	-0.8
September	11,150	11,048	-102	-0.9
October	6,605	6,515	-90	-1.4

The feature-based water balance analysis conducted for PSW 25 detailed in this section demonstrates that any changes in runoff volumes to PSW 25 resulting from the Phase 1 development are minimal, staying within 5% of existing conditions, and are expected to be compensated for by runoff surplus from future developments within the EM4 catchment. Thus, impacts on the proposed restoration plan for PSW 25 or on the downstream wetland hydrological regime and wetland communities associated with the Phase 1 development are not anticipated. The ultimate post-development condition, which includes most of the planned development within the PSW 25 catchment, is expected to offset the slight reductions in runoff resulting from the developed Phase 1 lands. Additional details pertaining to the wetland water balance analysis can be found in **Appendix D-3**.