“The Crossing” Ashburn Road Development

Conceptual Design Report

Storm Water Management Strategy and Stream Hydraulics and Hydrology

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Concept Design

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The Crossing Ashburn Road Development

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1.0 Introduction and Scope of the Work

EXP Services Inc. (EXP) was retained by Horizon Management Limited to complete hydraulic and hydrologic modeling and storm and flood water management strategy for the proposed 50-hectare "The Crossing" commercial development (Figure 1). The proposed development is located on the Little Marsh Creek which is a tributary of Marsh Creek. Construction of the development will displace significant flood water storage in the Marsh Creek drainage basin. To compensate for displaced floodwater storage, compensatory flood storage will be constructed, both on the development site as well as offsite. To evaluate and demonstrate the proposed development's compensatory storage volume and location will not negatively impact existing infrastructure and property in the watershed, a deterministic hydraulic and hydrologic model has been completed of the Marsh Creek drainage system. Figure 2 shows the modeled Marsh Creek system, catchment area and the development location.

The proposed development will also replace existing vegetated areas with hard surfaces such as roofs and asphalt which will significantly increase rainfall runoff. To counteract the impact of increased runoff, storm water from the site will be attenuated to pre-development rates. Existing and proposed site development catchment hydrology and hydraulics were reviewed and analyzed to generate appropriate storm water attenuation size and configuration options and demonstrate that the development can meet or exceed City of Saint John requirements.

Glossary of Terms:

Following is a Glossary of Terms and Acronyms Used in this Report:

Catchment Areas: The total area of land radiating from a reference point, including all drainage work and stream channels, contributing storm water runoff.

Design Storm: A specified amount of storm rainfall, with its areal and temporal distribution, used to estimate a design discharge

Land Use: The surface condition of a catchment area (e.g. natural, farm land, residential properties, etc.)

Return period: The average period in years between the occurrences of consecutive events (e.g. rainfall events) of a given magnitude (also termed Recurrence Interval)

Stormwater Runoff: Is the portion of rainfall that moves over the ground toward a lower elevation and does not infiltrate into the soil

USSCS (Also SCS): United States Soil Conservation Service

Figure 1 - Revised Conceptual Rendering of the Developed Site Plan

2.0 Stream Hydraulic and Hydrologic Models – Marsh Creek System

The existing Marsh Creek and proposed site development catchment hydrology and hydraulics were reviewed and analyzed to generate water surface profiles and elevations at stream "Control Points" for various existing and proposed development scenarios to determine appropriate compensatory flood storage volume and locations and to demonstrate that:

- the development can meet or exceed City of Saint John and Provincial requirements; and
- will not negatively affect upstream and downstream infrastructure and property.

Marsh Creek Catchment Hydrology and Runoff:

Development Catchment areas, land use and runoff characteristics were evaluated using existing mapping data. Rainfall Runoff was generated using the USSCS runoff model. SCS 6 hour and 24-hour Type III storms were used to generate runoff from each of the catchments.

Design Criteria:

Design frequencies or return periods of 100 years were used to generate existing condition and proposed condition models; target design criteria for development and proposed flood compensatory options for this study were as follows:

- Net zero increase of Post-Development storm water discharge for the design storms; and
- Zero water level elevation increase at study control points.

Effects of Climate Change:

Rainfall:
Modeled Rainfall included the following:

- Existing 100yr rainfall (Environment Canada Station Saint John A)
- Predicted 100yr Rainfall for the year 2050 (Based on University of Western Ontario Climate Change Model, Station Saint John A, Scenario RCP2.6)

Tide:
Tidal curves were generated in the model for the Marsh Creek Outlet/Floodgates at Courtenay Bay for 100-year return period events and included Surge Residuals of 1.14m. Tidal HHWLT scenarios modeled included:

- Existing (2010) HHWLT + Storm Surge = 5.74m
- Predicted year 2050 HHWLT = Storm Surge = 6.19m

Design Software:

Autodesk SSA software program was utilized to create the runoff and hydraulic models. Autodesk SSA Hydraulic network modeling is performed by the Kinematic Wave or Hydrodynamic (Saint Venant equation) routing methods. The Hydrodynamic Wave routing method was selected in this case as Hydrodynamic routing solves the complete St. Venant equation throughout the drainage network and includes modeling of backwater effects, flow reversal, surcharging, looped connections, tidal outfalls, and interconnected ponds.

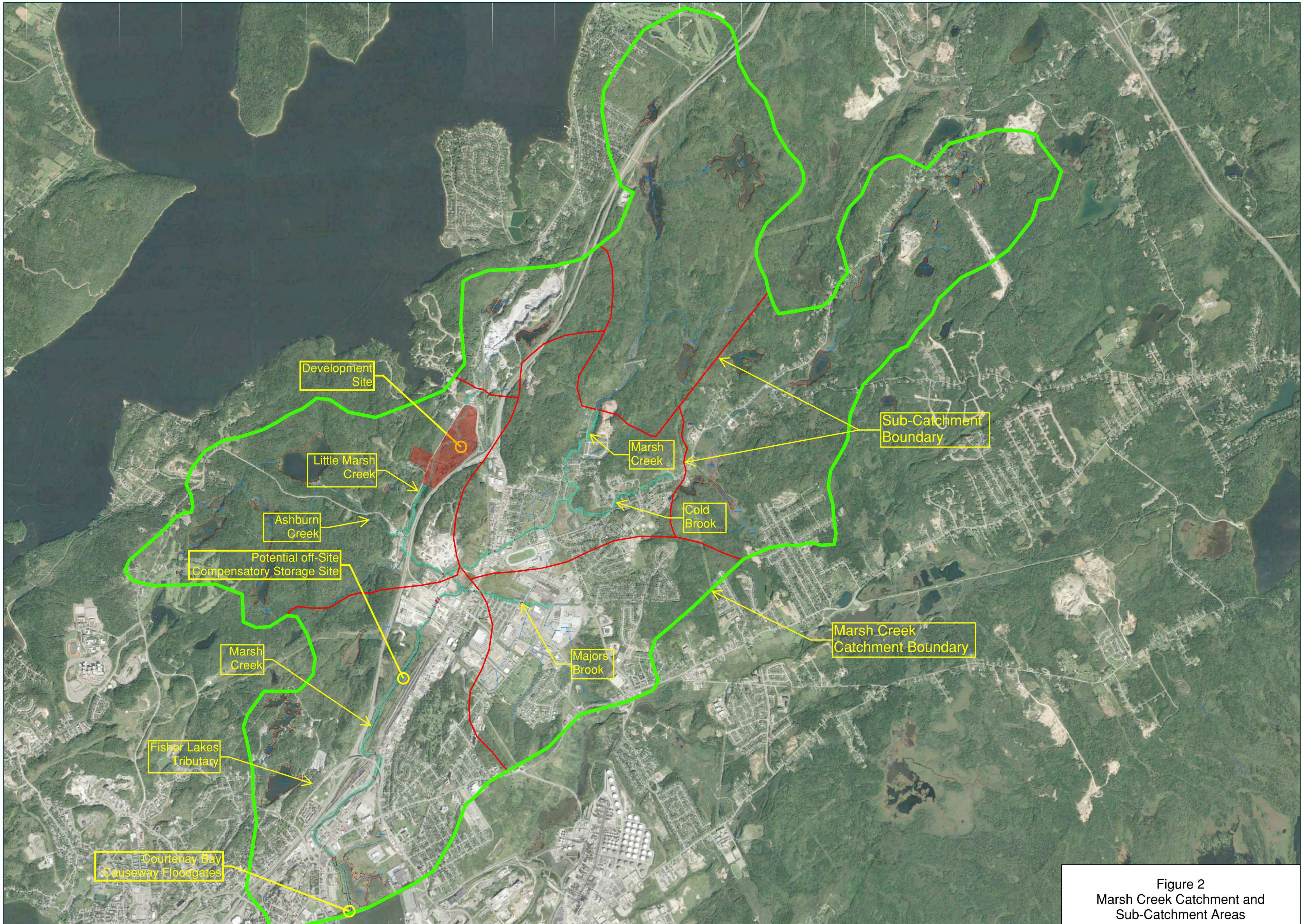

Figure 2
Marsh Creek Catchment and
Sub-Catchment Areas

The software can model various flow regimes, such as:

- Subcritical, critical, and supercritical flow regimes
- Gravity and pressurized (surcharged) flow
- Flow reversals
- Flow splits and combines
- Branched, dendritic, and looped systems
- Tailwater submergence (backwater) effects
- Interconnected ponds and storage elements
- Tidal outfalls

2.1 Analysis and Review

An initial "existing conditions" model was developed for the Marsh Creek and its tributaries. The model was completed using a combination of; Lidar data; existing and new survey data; record information for hydraulic structures and aerial photography for catchment land use and runoff characteristics.

An iterative approach was utilized to determine allowable offsite compensatory volume for the development. Based on the development's current proposed footprint it is estimated that 87,500 m3 of existing flood storage would be eliminated below the 100-year flood elevation. The proponent has proposed to provide a portion of the flood compensatory volume off site at a location downstream of the development site.

To determine the maximum allowable off-site compensatory storage that could be provided without negative impact on upstream, downstream or adjacent properties, a variety of scenarios with compensatory volumes onsite and at the offsite location were modeled until the maximum offsite volume was determined. The maximum allowable offsite volume was determined by comparing water surface elevations for pre and post development scenario conditions. Modeled post development scenarios deemed acceptable were those that resulted in water surface elevations at all control points equal to or lower than existing (undeveloped) condition scenarios.

Study Control Points:

As noted above, water surface elevations at several control points were used as the basis for comparing existing conditions to proposed development compensatory flood volume storage location scenarios. Control Point Locations evaluated were:

- Marco Polo Bridge – Marsh Creek
- CNR Crossing Near Russell Street – Marsh Creek
- Strescon Building – Marsh Creek
- Marsh Creek and Little Marsh Creek Confluence
- Foster Thurston Culvert – Little Marsh Creek
- Simpson Drive Culvert – Marsh Creek

Figure 3 shows the control point locations on the Marsh Creek System.

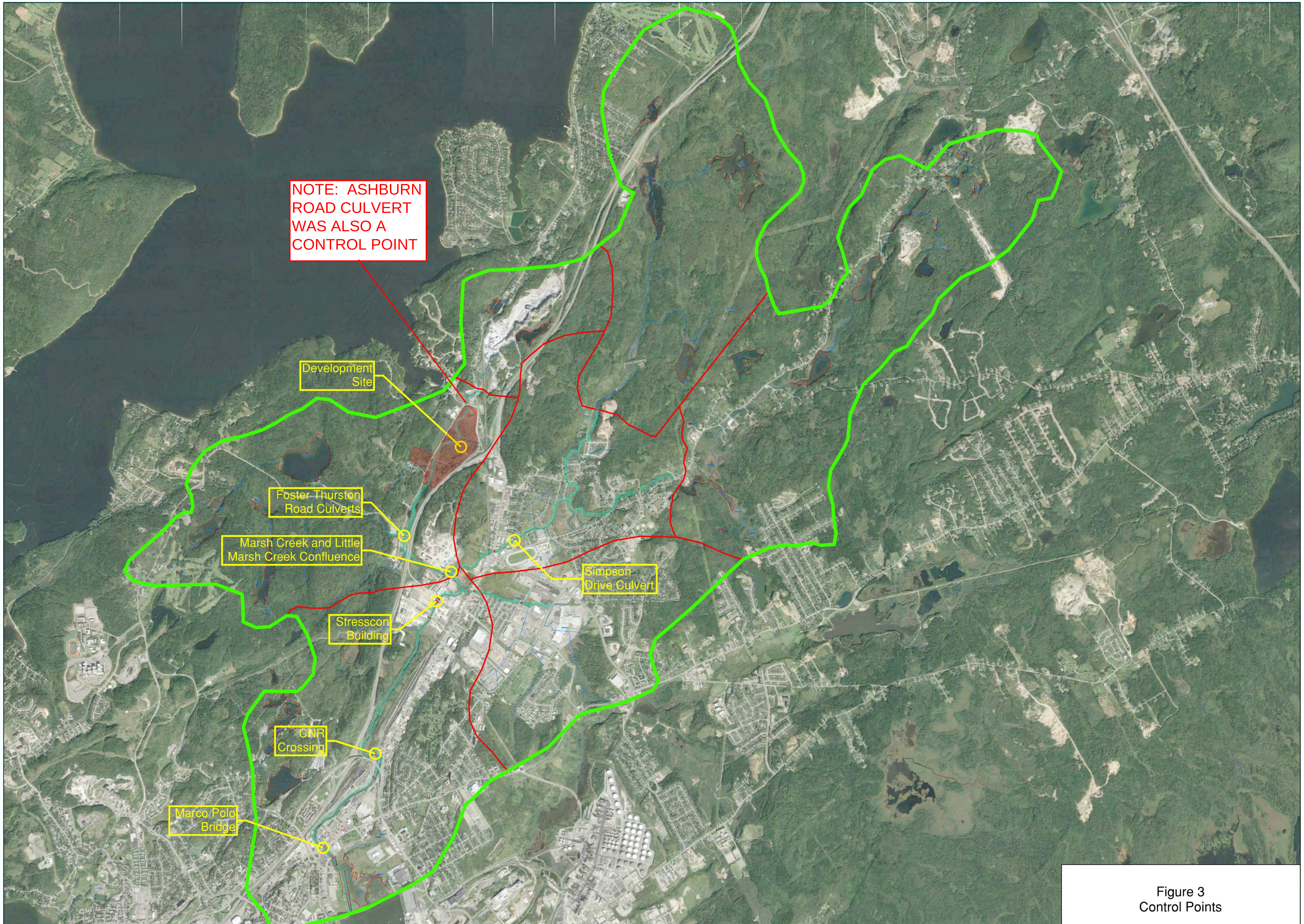

Figure 3
Control Points

Compensatory Storage:

Modeled scenarios indicated the maximum offsite-downstream compensatory flood storage that could be used without negative flooding impact on the Marsh Creek System was 17,500m3. The remaining 70,000m3 of compensatory storage required will be constructed on site, potentially in a variety of ways. Required compensatory storage for the final study scenario was successfully modeled as follows:

- Onsite- Constructed Channel Storage: 20,160m3
- Onsite- Rock Fill Void Storage (assumed Void Ratio = 0.2): 17,400m3
- Onsite Constructed Pond: 32,800m3
- Offsite Downstream Location: 17,500m3

Total Constructed Compensatory Flood Storage: 87,860m3

Review of topographic data for the proposed development site, and the off-site compensatory flood storage site, indicate the required site compensatory storage can be physically accommodated on lands owned by the proponent.

Final Modeled Scenarios:

The final modeled scenarios presented below will include the following:

- S1 - Existing Conditions (Pre-Development);
- S2 - Existing Conditions (Pre-Development) adjusted for Climate Change (Rainfall, Sea-Level Rise and Coastal Flooding Climate Change to the year 2050, typical for all Climate Change Scenarios):
- S3 – Development Scenario Without Compensatory Storage;
- S4 – Development Scenario Without Compensatory Storage, adjusted for Climate Change;
- S5 – Development Scenario with Compensatory Storage
- S6 – Development Scenario with Compensatory Storage and adjusted for Climate Change

Table 2.1 below summarises the modeled final scenario results:

Table 2.1

	Scenario					
	S1 - Existing Conditions	S2 - Adjusted for Climate Change	S3 - Development without Compensatory Storage	S4 - Development without Compensatory Storage and adjusted for Climate Change	S5- Development with Compensatory Storage 1	S6- development with Compensatory Storage 2 and climate change
Control Point	Modeled Water Surface Elevation (Geodetic in meters)					
Marsh Creek Marco Polo Bridge	3.41	3.51	3.41	3.49	3.41	3.48
Marsh Creek CNR Crossing Situate Russell Street	3.42	3.52	3.42	3.5	3.41	3.49
Marsh Creek Stresscon Bldg	3.75	3.83	3.83	3.86	3.71	3.82
Marsh Creek and Little Marsh Creek Confluence	3.91	3.96	4.05	4.11	3.9	3.96
Little Marsh Creek Foster Thurston Culvert	4.03	4.26	5.02	5.22	4.03	4.25
Marsh Creek - Simpson Drive Box Culvert	4.26	4.31	4.35	4.43	4.26	4.31

Ashburn Road Culvert (Upstream) Results
S1, 4.12m; S2, 4.25 m; S5, 4.12m; S6, 4.24 m

2.2 Conclusions

Modeling of the proposed development in the Marsh Creek system indicates that, with the planned compensatory storage scenario presented herein;

- water surface elevations will remain at or below existing levels for Post-Development conditions; and,
- the development will not negatively affect upstream, downstream or adjacent property or infrastructure for the modeled design storms.

It is expected that development of the site will occur in several phases over a period of 10 to 15 years. At each phase of development, the associated displaced flood volume and compensation volume scenarios will be re-evaluated and updated to ensure a volume balance is maintained and Marsh Creek water surface elevations are not negatively affected.

3.0 Storm Water Management Strategy

Catchment Hydrology and Runoff:
Development Catchment areas, land use and runoff characteristics were evaluated using existing mapping data. Rainfall Runoff was generated using the USSCS runoff model. 2-hour and 24-hour duration Chicago storms were used to generate runoff from each of the catchments.

Design Criteria:
Design frequency or return period of 100 year + 20% was used to generate proposed attenuation models; target design criteria for proposed attenuation options for this study were as follows:

- Net zero increase of Post-Development storm water discharge for the 100 year + 20% return period storms.

Design Software:
Autodesk Storm and Sanitary Analysis (SSA) Program was utilized to create the runoff and hydraulic models. Autodesk SSA Hydraulic network modeling is performed by the Kinematic Wave or Hydrodynamic (Saint Venant equation) routing methods. The Hydrodynamic Wave routing method was selected in this case as Hydrodynamic routing solves the complete St. Venant equation throughout the drainage network and includes modeling of backwater effects, flow reversal, surcharging, looped connections, pressure flow, tidal outfalls, and interconnected ponds.

The software can model various flow regimes, such as:

- Subcritical, critical, and supercritical flow regimes
- Gravity and pressurized (surcharged) flow
- Flow reversals
- Flow splits and combines
- Branched, dendritic, and looped systems
- Tailwater submergence (backwater) effects
- Interconnected ponds
- Surface ponding at manholes
- Tidal outfalls

Preliminary Design Assumptions:

Following are assumptions used for the analysis and design of the proposed storm water management facilities:

- Proposed pond and storm sewer inverts, lengths and slope were based on limited topographic and proposed preliminary development data. Additional data will be required to complete detailed designs as the project develops:
- Considered attenuation methodology to be based on best practices for this region.

3.1 Analysis and Review

Proposed preliminary review and design results are summarised in the following sections. Detailed model reports are available if required upon request.

Attenuation Methodology:

Best management practices were reviewed against the site-specific constraints and an overall storm water management strategy was developed. The final recommended design scenario uses a combination of Parking Lot Ponding, Landscaped Dry Detention Ponds and Roof Rainwater Infiltration Galleries to attenuate storm water runoff.

The rationale in choosing this design is as follows:

- **Parking Lot Ponding**: Parking Lot Ponding provides an economic solution for the storage volume required to attenuate the design storms. In the lower lying areas of the site, where detention ponds are not feasible, the peak flows will be attenuated using this method.

  The proposed development concept has approximately 10 hectares of parking areas. Preliminary design calculations indicate parking lot ponding will require approximately 8.0 hectares of lot ponded area or approximately 80% of paved areas would be utilized to provide storm water attenuation storage during the 100 year + 20% return period design storms. Maximum parking lot ponded depth during the modeled design storm was 0.40m (16"). Ponded areas typically can be limited to low traffic zones away from building accesses as was the case in the concept model for this development.

- **Landscaped Dry Detention Ponds**: Landscaped Dry Detention Ponds typically provide detention and storm water quality treatment for most storm events and also provides landscaped areas within the development. Storm water quality treatment can be achieved by routing most parking lot and roadway runoff through the ponds prior to discharge to the municipal storm water system.

  In this case, detention ponds can only be used in the proposed residential development area to the north of Ashburn Lake Road, as the all storm water storage zones are required to be above the flood plain elevation of 4.1m. This is reasonable within the hillside area north of Ashburn Road, however on the remainder of the low-lying areas on the site, it would not be realistic to convey the storm water flows (by gravity) to detention ponds given the contemplated final grades of the development.

- **Roof Rainwater Infiltration Galleries:** Roof rainwater infiltration galleries were utilized in the designs to attenuate and infiltrate all storm water runoff from the developments roof areas. Infiltration of roof storm water greatly reduces the volume of storage required for dry detention ponds and lot ponding and contributes to ground water recharge. Storm water from roof areas is generally considered ‘clean’ as compared to runoff from paved areas, and its infiltration into the groundwater table is typically encouraged by many municipalities.

  Similarly, to the site restrictions on landscaped dry detention ponds, the roof rainwater infiltration gallery methods can only be used in the proposed residential development area to the north of Ashburn Lake Road, as the all storm water storage zones are required to be above the flood plain elevation of 4.1m. This is reasonable within the hillside area north of Ashburn Road, however on the remainder of the low-lying areas on the site, it would not be practicable to place these infiltration galleries below ground given the contemplated final grades of the development.

  Other Low Impact Design Attenuation Strategies such as rain gardens, bioswales and permeable pavement may also be considered at preliminary and detailed design stages of development.

Table 3.1 presents a summary comparison of modeled pre-development peak flows and post-development attenuated flows.

Table 3.1

Storm Duration	Return Period (yr)	Pre-Development Peak Flows (lps)	Post-Development Peak Flows (lps)	Pre/Post Controlled	Net Increase with Attenuation (lps)	% increase with Attenuation
24 Hour	100 + 20%	4407.00	4279.00	1.03	-128.00	-2.90%

3.2 Conclusions

Modeling of the proposed storm water management strategy indicates a combination of; Parking Lot Ponding, Landscaped Detention Ponds and/or Roof Rainwater Infiltration Galleries, and can meet City development storm water peak flow attenuation requirements of net zero increase in Post-Development storm water discharge for the 100 year + 20% return period storms.