

## APPENDIX I - Stormwater Management Report



# Boxwood Industrial Subdivision Stormwater Management Report



JUNE 2009

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**Figure 4.1 Conceptual Stormwater Management Plan**

**Figure 4.2 Typical Conveyance Based Infiltration – Infiltration Promoting Ditches and Swales**

**Figure 4.3 SWMF MC1 and Outlet Conceptual Plan**

**Figure 4.4 SWMF WC1 and Outlet Conceptual Plan**

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APPENDIX A QUANTITY CONTROL FLOW TARGETS CALCULATION

APPENDIX B PRELIMINARY HYDROLOGIC MODEL

## 1.0 Background

This report is to support the Stormwater Management Servicing Design Process for the Boxwood Industrial Lands Servicing Environmental Assessment. An integrated stormwater management plan is required for the preferred concept plan. The Hespeler West Subwatersheds Study (HWSS) provides the planning framework for development and stormwater management planning. A hydro geological study as well as a natural heritage study was conducted as a part of the Boxwood Industrial Lands Servicing Environmental Assessment. These detailed studies provided additional background that is essential to developing a functional stormwater management plan. They also provide more site specific information with respect to the ecological and hydrogeological targets presented in the HWSS.

The Boxwood Industrial Subdivision is a 88 ha parcel of land owned by the City of Cambridge. Current land uses are open space, and agricultural. Middle Creek runs through the property along the Eastern half of the North boundary of the property. West Creek runs through the property in the southern section. Much of the property has development constraints identified in the Hespeler West Subwatersheds Study.

The City of Cambridge will be branding this site as an eco-industrial subdivision. As such on-site measures that enhance infiltration, or re-use stormwater for non-potable plumbing requirements or for irrigation will be encouraged in this development.

In addition, the City of Cambridge has proposed to minimize any impacts on the Natural Heritage features identified in the HWSS. In general the stormwater management plan has located the SWM facilities outside the natural heritage buffers. Some conveyance measures go through the buffers and through the Natural Heritage features where it is unavoidable.

The most significant portions of development constraints include the two Creek corridors, as well as a large wetland patch in the western portion of the property. Of the 88 ha owned by the City, there is a total of approximately 50 ha that will develop under intensive industrial land use including the road network under the preferred concept plan. The remaining land is dedicated to open space or to be maintained for ecological value. These areas include the two creek corridors of West Creek and Middle Creek, as well as the wetland patch in the western portion of the property.

Conceptual stormwater management needs were initially developed for the various concept plans, and a functional plan is provided in this report that is based on the recommended alternative.

### 1.1 Drainage Areas

The developable portion of the site is split into 3 major drainage areas as shown in Figure 4.1.

- There is a 20.7 ha area (BOXMC1) that is directed to the North East into Middle Creek.
- There is a 27.1 ha area that is directed to West Creek from the north side (BOXWC2).
- There is an 8.0 ha area (BOXWC3) directed into West Creek from the south side, the Hespeler West Subwatersheds study identifies that all of this area drains to West Creek. However there is a small area on the south portion that goes South through a culvert across Royal Oak Road.

In addition to the developable land, there is approximately 31.6 ha of lands that constitute natural heritage features and buffers. All of this area, with the exception of WCN1, is situated downstream of the development. The design will ensure that WCN1 can continue to drain naturally to the watercourse and by-pass any new SWM facilities.

### 1.2 Major & Minor Drainage

In keeping with the eco-industrial development approach, a road cross section that facilitates transit and pedestrian uses, an urban curb and gutter road cross section will be used for this subdivision. The minor flow conveyance will generally be through the storm sewer system and the major storm conveyance will be through the roads. Rear lot drainage will be through ditches at the edge of the developable portion of the site.

## 2.0 Stormwater Management Servicing Criteria

Stormwater Management Criteria for this site originates with the recommendations of the HWSS and are refined by the Natural Heritage Study and the Hydrogeological Study.

1. **Water Quality:** The HWSS recommends improvement of the quality of urban runoff to Ministry of Environment – Enhanced criteria. This requirement is based on the removal of 80% of total suspended solids.
2. **Infiltration / Recharge:** The HWSS recommends maintaining existing recharge rates. Estimates based on Ontario Soils Maps were used in the HWSS for estimating the existing recharge that occurs on the site. A more detailed Hydrogeological Study assessed the average recharge rates on the site as being 15 cm/year in the Northern portion draining to Middle Creek, and approximately 20 cm/year for the portions draining to West Creek<sup>1</sup>.
3. **Stormwater Quantity Remediation (Flood Control)**

The HWSS established existing baseline conditions unit flow rates (l/s/ha) for the drainage areas on the Boxwood Lands. The goal of the quantity control system is to maintain the baseline conditions. As such flow targets for the developable portion have been developed based on these baseline conditions. For the purpose of developing a comprehensive quantity control target for the Boxwood subdivision, a weighted average for all of the West Creek drainage areas was developed. The study team generated a few baseline flows for comparison purposes and it was determined that the HWSS baseline unit flow rates were reasonable. They are therefore adopted as the target flow rates to be utilized for this development. Drainage areas coinciding with the developable land were used for determining the weighted average. The Middle Creek drainage area has only one applicable area (Catchment 2155) from the HWSS which was adopted for this project.

The quantity control system will be designed to provide the following flow targets for the developed lands. A complete copy of the calculated flow targets is included in Appendix A.

Flow Targets / Quantity Control <sup>2</sup>		
	Middle Creek	West Creek
2 year	8.0 l/s/ha	7.2 l/s/ha
5 year	14.4 l/s/ha	16.3 l/s/ha
10 year	23.3 l/s/ha	28.9 l/s/ha
25 year	32.0 l/s/ha	40.7 l/s/ha
50 year	37.7 l/s/ha	49.2 l/s/ha
100 year	54.4 l/s/ha	71.6 l/s/ha
Regional Flood	76.2 l/s/ha	86.8 l/s/ha

The total volume requirements for quantity control were established using an OTTHYMO model. The model is included in Appendix B. The model considers the impacts of the developable portion only. An imperviousness level of 90% is assumed for the developable lands. Infiltration measures are not included in the quantity control model as they have little impact on the infrequent high intensity storm events considered for quantity control.

Modeling used design storms based on previous work in the City of Cambridge. Modeling of the system will be updated when the design storms utilized for the HWSS are made available to ensure consistency with the baseline conditions.

No flow controls are proposed for lands that will remain undeveloped or be developed as new greenspace as they will generate runoff similarly to the existing condition.

<sup>1</sup> Hydro geological Investigation – Boxwood Development – Cambridge Ontario – (Anderson GeoLogic May 2008)

<sup>2</sup> Based on Table 5.4.3.1 of Appendix B.3 of the HWSS as updated by Memo from City of Cambridge (April Souwand) dated March 9 2005

**4. Ecological Opportunities**

Opportunities to improve the ecology and function of land through stormwater management planning are to be provided where practical.

**5. System Integration**

The ultimate development should have an integrated stormwater management solution that provides the best stormwater solution from a cost benefit perspective.

### 3.0 Stormwater Management Options

For practical reasons, the stormwater management options are broken out into the various stormwater management objectives. The final proposed stormwater management solution will be a combination of the options listed below.

- Water Quality Options
- Infiltration Options
- Stormwater Quantity and Flood Control Options

#### 3.1 Water Quality Options

In order to meet the MOE- enhanced water quality targets of achieving 80% total suspended solids removal, the following options are considered:

##### 1. Infiltration Based

Infiltration measures have a direct impact on achieving the MOE water quality criteria. They reduce the total water arriving to pipe facilities and thus improve the performance of water quality measures which function during low flow situations. Any flow that passes through the provides 100 % suspended solids removal as it would return to the creek systems as base flow.

Infiltration measures will not eliminate the requirement of an end-of-pipe facility in achieving the stated criteria.

##### 2. The Permanent Pool Component of a Stormwater Management Facility (wet pond)

In order to meet the MOE-Enhanced targets as required in the HWSS with a stormwater management pond, a permanent pool is required. The water quality component of a stormwater management facility typically consists of a permanent pool with a small extended detention portion designed to retain a minor storm for a period of 24 to 72 hours. The permanent pool allows for settlement of solids and the dilution of influent with cleaner water in the permanent pool.

The permanent pool requirement of a wet pond designed to achieve *Enhanced* (80% Total Suspended Solids Removal) Water Quality is 210 m<sup>3</sup>/ha.<sup>3</sup> This yields the following requirement for this Site:

Middle Creek Drainage – 4,300 m<sup>3</sup>  
West Creek North Areas – 5,800 m<sup>3</sup>  
West Creek North Areas – 1,700 m<sup>3</sup>

##### 3. Hydrodynamic Separation Units for Sediment Removal

Hydrodynamic separation is a process where by stormwater is routed through a swirl system that is usually located in an underground swirl chamber. The swirl chamber is designed to create a vortex when water flows through it such that the centripetal forces direct any solids to be carried to the center and where the water outlets on the outside of the swirl. Hydrodynamic separation typically achieves the suspended solids removal targets in a smaller footprint than a stormwater management wet pond facility. The underground chamber systems also have a maintenance advantage in that they can be easily cleaned out with a vacuum truck and do not require much heavy equipment such as a grader / back hoe.

##### 4. Conveyance Based Methods

Conveyance through ditches and swales has a direct impact on achieving the MOE water quality criteria. However it is insufficient for achieving MOE – Enhanced 80% suspended solids removal. The ditch system will improve the performance of end-of-pipe measures.

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<sup>3</sup> Based on *Stormwater Management Planning and Design Manual (MOE 2003) Table 3.2*

## 3.2 Infiltration Options

### 1. Conveyance-Based Infiltration

#### *Storm Sewer System*

A conventional storm sewer is generally an impervious pipe system that does not provide infiltration.

#### *Ditches*

The use of ditch based conveyance will provide infiltration capacity on its own. The ditches on this site generally have light slopes which provides for slower moving water and increased opportunities for infiltration. This capacity can be enhanced with some additional features included in the ditching.

Figure 4.2 shows two examples of ditch enhancements that can be considered:

**a – Flow check dams:** The principle behind this system is that low flows in the ditch are slowed down by way of a weir which increases the time that water is in the ditch during the low frequency rain fall events. In larger frequency rain fall events, the ditch capacity is not constrained as the check dams are overtopped.

**b – Modified Etobicoke System:** The City of Cambridge presented the Etobicoke System concept at the eco-industrial workshop of February 12<sup>th</sup> 2009. This system is primarily an enhancement for storm sewers, however the concept could be modified to apply to a ditch system. The principle behind this is to provide a perforated pipe with stone media below the ditch allowing for infiltration to occur without introducing any restriction to the actual ditch capacity.

These methods would be suitable in locations where the ditch has a light slope (< .40%) and is situated on suitable soil.

On-site infiltration diminishes the total amount of run off directed to the end-of-pipe facilities. Hydrogeological investigation confirmed that conveyance based infiltration measures such as enhanced ditches will provide infiltration. Preliminary design of ditch based conveyance based infiltration features confirms that it is possible to partly meet the infiltration target. The final location of infiltration enhancements will be considered in detail design.

### 2. Active Underground Infiltration Measures

This includes soak-away pits or other measures receiving water directly from a drainage route. The City of Cambridge has expressed some concern over the use of such facilities as they can pose a maintenance issue. Approvals agencies may require that “clean” water or treated water (non-road drainage) be directed to active infiltration facilities.

### 3. Infiltration Ponds

End of pipe facilities designed to be layed on sandy soils are a feasible alternative. Approvals agencies may require that “clean” water or treated water (non-road drainage) be directed to active infiltration facilities. Large areas are also typically required to achieve the desired level of infiltration.

### 4. Direct to Greenspace

Water from the subdivision could be directed to existing wetlands for infiltration. Approvals agencies may require that “clean” water or treated water (non-road drainage) be directed to the greenspace. Much of the greenspace consists of wetlands. Typically wetlands are on soil of lesser permeability and are locations of exfiltration. As such, these measures may not be suitable.

### 5. Lot level Controls

Lot level controls could be required through the site development process. This could include the following:

- Direct runoff from lots toward swales on permeable soil;
- Permeable Pavement Parking lots;

Lot level controls would be required through the site development process.

### 3.3 Stormwater Quantity and Flood Control Options

The quantity control volume requirements are established in Appendix A. The extended detention portion of the quality control (not permanent pool) has been combined with the quantity control requirement as it represents a very small portion of the non permanent pool portion of the pond (less than 5%).

The total volume requirements to meet the HWSS are as follows:

Middle Creek Drainage – 14,600 m<sup>3</sup>  
West Creek North Areas – 25,100 m<sup>3</sup>  
West Creek South Areas – 6,100 m<sup>3</sup>

#### 1. The Non-Permanent Pool Portion of Stormwater Management Ponds;

This is a practical and relatively inexpensive way of providing new storage that cannot be found in other portions of the system. A regional pond also provides the flexibility to properly coordinate quantity control in the system.

The City of Cambridge has a policy that limits the depth allowable to the extended detention portion of stormwater management facilities to 1.8 m. This may not be necessary. Increasing the allowable depth to 3 m is practical in this case due to the height differential between the subdivision and the creek. This would cut the total land required by stormwater management facilities down from approximately 5 ha to 3 ha for the entire development. A typical stormwater management pond section is shown in Figure 4.2.

An overview of the pond footprint requirements is provided in section 4.

#### 2. Use of Existing Features

A review of existing features was conducted. There is one feature that is considered of some value from a quantity control perspective and is described below:

##### Existing West Creek Pond

There was a pond, that was created around 1970, which was likely used for irrigation to support the agricultural land use. This pond is now considered part of the constraint areas due to its “natural” characteristics. It is well within the buffer zones identified for protection and within the flood plain. This pond is approximately 8000 m<sup>2</sup> in size and could be used for quantity control. The Natural Heritage Study recommends that water directed through this pond requires quality control. The improved flushing that could be provided to this feature would be considered an ecological enhancement. There are two scenarios that were considered.

**Scenario a)** Construct a control structure on the South East corner of the irrigation pond. This would allow for the pond to control approximately 8000 m<sup>3</sup> of water during major events and would partly reduce the volume requirement in the upstream stormwater management facilities.

**Scenario b)** Reconstruct an elevated berm on the South Side of the pond bordering West Creek and construct a control structure on the South East corner of the irrigation pond. This would allow for the pond to control approximately 16,000 m<sup>3</sup> of water during major events.

Both alternatives would partly reduce the volume requirement in the upstream stormwater management facilities. These options were both considered in the ecological analysis and are discussed in the Natural Heritage Study.

#### 3. Underground Storage

Underground facilities such as PVC raintanks or concrete vaults could be utilized for quantity control. They are expensive and complicated to integrate into a coordinated outlet control system to achieve the desired quantity control at the stream level.

#### 4. On Site Storage

Development conditions could be placed on the industrial lots to require on-site storage to be included in the design of the system. In order to meet the quantity control requirements by on-site storage alone, there would be a need for approximately 500 m<sup>3</sup> per hectare of land. In addition there is still a requirement to provide quantity control for roads.

The quantity control requirement can only partly be achieved by lot controls.

Phasing will be an issue as the subdivision land will develop and the site plan quantity controls will not be implemented until the individual lots are purchased and developed. Therefore additional quantity controls will be required on a temporary basis.

Site plan conditions would require a development management process in which landowners would be required to present individual stormwater management plans for review by the City. Site plan controls would also require additional enforcement and municipal management to ensure that landowners are in compliance with their proposals.

In order to function properly all of the site plan controls need to be integrated such that they provide the coordinated control to meet the flow targets as required in the stream.

#### 5. In Stream Measures

This would involve the construction of a flood control system within West Creek or Middle Creek.

It was suggested in the course of the study that there may be an existing weir in Middle Creek somewhere downstream of the site. Given that floodplain mapping was not reviewed as a part of this study, and that quantity control targets were established in the HWSS, this was not investigated as part of this study.

### 3.4 Evaluation of Options

#### 3.4.1 Water Quality

The evaluation of water quality options is provided in the table below.

Soft measures such as conveyance based water quality control in the ditches are retained. These measures alone do not eliminate the need for active water quality control which can be provided by stormwater management ponds or hydrodynamic separation. Hydrodynamic separators typically work with curb, gutter and storm sewer drainage when other end-of-pipe measures are not available. There would be several required in order to provide service to the developable land.

As there is a significant requirement for quantity control that will be met with stormwater management facilities, the addition of a permanent pool which is below the quantity control portion requires no additional lands.

**Table 3.4.1 – Rationale for Water Quality Options**

Water Quality Options		Comments / Reasons
Infiltration Measures	✓	As there are already infiltration measures proposed they are also included as a water quality measure.
Permanent Pool in SWM Pond	✓✓	Retained as the principal means of achieving the water quality criteria. Given that water quantity is required with large volumes for extended detention. The incorporation of permanent pools that meet and exceed the volume requirements for quality control can be done without increasing the area dedicated to stormwater management facilities
Underground Hydrodynamic Separation	×	Typically work with curb, gutter and storm sewer drainage when other end-of-pipe measures are not available. Cannot be combined with quantity controls and typically requires more regular maintenance than a permanent pool.
Conveyance Based	✓	As ditches are a means conveyance, they are included as a water quality measure.

- ✓✓ indicates the measure is retained as the primary means of achieving requirement
- ✓ indicates that the measure is retained in the stormwater management strategy
- ✗ indicates that the measure is not retained in the stormwater management strategy

### 3.4.2 Infiltration

The evaluation of infiltration options is provided in the table below.

Rear yard ditches provide an opportunity to promote a conveyance based infiltration system. The use of underground soak-away pits would require maintenance from future landowners. The use of infiltration ponds is not preferred as it requires a large area. Clean water such as rear yard and roof top drainage can be directed to the existing greenspace.

**Table 3.4.2- Rationale for Infiltration Options**

Infiltration Options		Comments / Reasons
Conveyance Based	✓	Retained due to practicality, low risk and low cost. It is recommended to implement in all ditch locations where there is sandy soil.
Lot Level Controls	✓✓	Retained due to practicality, low risk and low cost. All site developers will need to present an infiltration plan for the site.
Underground Soak-Away	✗	Discarded due to low reliability. Presents a potential risk to property.
Infiltration Ponds	✗	Discarded as additional land dedicated to infiltration ponds is required.
Existing Green Space	✗	Discarded as natural heritage features are typically wet locations of exfiltration.

- ✓✓ indicates the measure is retained as the primary means of achieving requirement
- ✓ indicates that the measure is retained in the stormwater management strategy
- ✗ indicates that the measure is not retained in the stormwater management strategy

### 3.4.3 Water Quantity

The evaluation of water quantity options is provided in the table below.

All of the soft-measures that could be required of the system do not eliminate the need for a stormwater management facility with quantity control. While every little bit could reduce the volume, a much greater savings on the area can be achieved if the extended detention depth can be increased to 3.0 m vs. 1.8 m. On-site controls are the only other reasonable alternative. Coordinating on-site controls will be a difficult task and the reliability of the system will be questionable as the system will depend on components that are located on lots that are privately owned by many different owners. The use of the West Creek pond is retained as an option. It will depend on the final concept layout and the results of the Natural Heritage Study.

**Table 3.4.3 – Rationale for Water Quantity Options**

Water Quantity Options		Comments / Reasons
Non permanent pool portion of SWM facility	✓✓	Large volumes of well controlled storage are required to meet the design criteria. The most inexpensive way of providing storage at the ends of ditch is through the use of stormwater management ponds. In addition locating the quantity control at the end is a reliable method of ensuring that storage is utilized to provide the desired flow controls.
Use Existing Irrigation Pond	✓	The Natural Heritage Study recommends that the existing irrigation pond be enhanced by directing treated water through it. Therefore option 2a) can be implemented with an outlet structure consisting of a berm and culvert on the South West Corner to be constructed.
Underground Storage	✗	This is the most expensive means of providing storage, additionally, as there is to be a ditch based conveyance system, the underground storage would likely need to be in the same vicinity as the stormwater management facilities, i.e. in the low areas near the outlets.
On-Site Storage	✗	On-site storage requirements could be required of future landowners.

- ✓✓ indicates the measure is retained as the primary means of achieving requirement
- ✓ indicates that the measure is retained in the stormwater management strategy
- × indicates that the measure is not retained in the stormwater management strategy

## 4.0 Proposed Stormwater Management Solution

### 4.1 Elements of the Proposed Stormwater Management Plan

The proposed stormwater Management Solution is shown in Figure 4 .1. It consists of the following:

#### 4.1.1 Conveyance System

The lots and roads are serviced by a network of roadside ditches that direct runoff to the SWMF's. The ditches provide infiltration. The infiltration capacity may be enhanced in key locations using rock check dams or a modified etobicoke system. The site will be designed to meet the 15 cm / year and 20 cm / year targets.

#### 4.1.2 Rear Yard & Roof top Drainage to the Western Woodlot (Area WCN1)

Rear yard drainage and rooftop drainage will be directed to the Western Woodlot near Boxwood Drive to provide a flushing function. There will be less surface water directed to WCN1 than is existing. The Natural Heritage Study suggested that excess water to this area would be detrimental to the ecology of the wetland due to its existing condition as having poor drainage<sup>4</sup>.

#### 4.1.3 Stormwater Management Facility MC1

The facility including outlet location is shown in Figure 4.3.

This facility will receive the drainage from the roads and industrial lots in the North East Drainage Area. It will have a water quality and a water quantity component.

The outlet for this facility will be one of the two outlets considered in the Natural Heritage Study. It will outlet through a ditch along Speedsville Road.

#### 4.1.4 Stormwater Management Facility WC1

The facility including outlet location is shown in Figure 4.4.

This facility will receive the drainage from the roads and industrial lots in the Drainage Areas to the North of West Creek. It will have a water quality and a water quantity component. Depending on the selected concept plan it may be split into two facilities

This pond will outlet through a ditch and a series of drop structures that direct it to the existing water feature on the North side of West Creek. In order to function, the outlet must cross a small portion of the natural feature. Construction within the natural feature will be limited to an 8 m wide disturbance area. The outlet route is selected specifically in an area of limited vegetation.

#### 4.1.5 Stormwater Management Facility WC2

The facility including outlet location is shown in Figure 4.5.

This facility will receive the drainage from the roads and industrial lots in the Drainage Area to the South of West Creek. It will have a water quality and a water quantity component.

This pond will outlet through a ditch and a series of drop structures that direct it to the South side of West Creek. In order to function, the outlet must cross a small portion of the natural feature. Construction within the natural feature will be limited to an 8 m wide disturbance area. The outlet route is selected specifically in an area of limited vegetation.

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<sup>4</sup> Boxwood Industrial Subdivision *Natural Heritage Study* p.15 (BioLogic 2008)

#### **4.1.6 Drainage across Royal Oak Road**

Grading will reduce the total portion of BOXWC3 that is directed to Royal Oak Road. This will allow post development flows to match pre-development flows. Site planning will be required to incorporate a swale system to provide quality control for this area. No active end of pipe water quality facility is proposed for this area as it represents less than 1.0 ha.

## **5.0 Erosion and Sediment Control During Construction**

During the construction period, when topsoil and vegetation is removed from the surface, the soil is much more susceptible to erosion than at any other time. As such, measures are required to ensure that site erosion, as well as sediment transport to the watercourses is minimized.

An erosion and sediment control plan will be prepared in the detail design that will include:

- Identification of construction phases and erosion potential of each phase;
- Identification of measures to prevent sediment transport such as the use of temporary basins, filter cloth, straw bales and grading techniques;
- Consider the early construction of SWM facilities prior to stripping of contributing drainage areas.
- Provide site controls for lots that may remain undeveloped while site services are constructed, such as temporary sodding, grading to internal depressions or sediment basin.

## 6.0 Conclusions and Recommendations

### 6.1 Conclusions

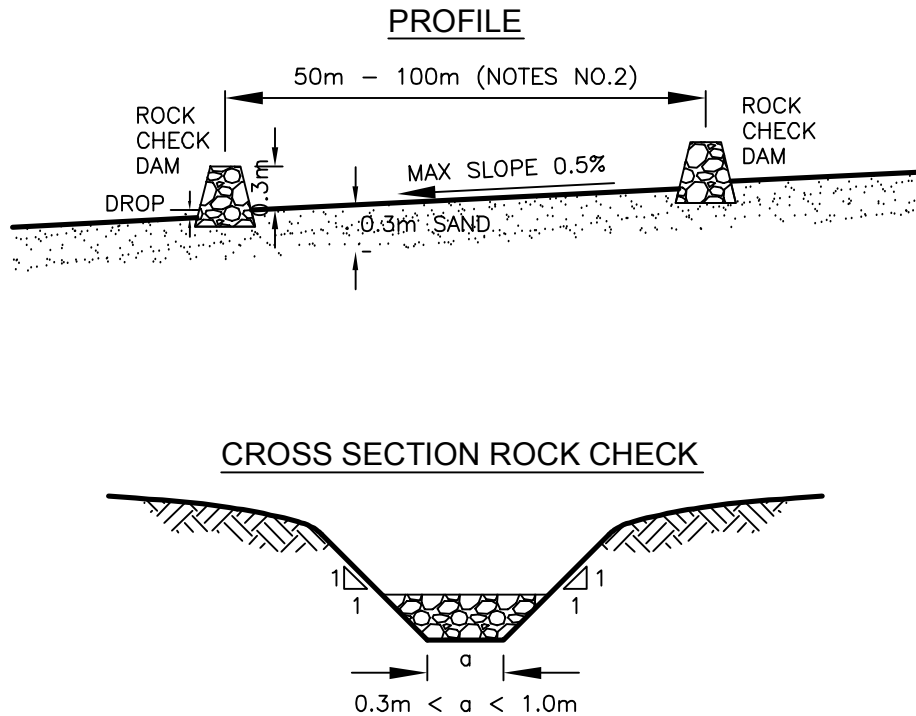
1. The functional stormwater management plan addresses the water quality, water quantity and water quality criteria developed in the *Hespeler West Subwatersheds Study (City of Cambridge 2004)*, and refined in the *Hydrogeological Investigation – Boxwood Development (Anderson Geologic 2008)* as well as the *Natural Heritage Study – Boxwood Subdivision (BioLogic 2008)*.
2. The recommended stormwater management plan is based on the following:
  - The use of regional stormwater management ponds to address quality and quantity requirements;
  - Requiring lot level controls to meet infiltration requirements;
  - Use of curb & gutter, storm sewer and ditch conveyance system;
  - ditches and swales include enhancements to promote infiltration;
  - Providing improvements to two ecological features, the west woodland and the irrigation pond, by providing clean water for flushing;
  - Servicing the preferred concept plan as determined in the EA process.

### 6.2 Recommendations

1. The detail design of the stormwater management elements as described in Section 4 should proceed to detail design of servicing;
2. A detailed sediment and erosion control plan is recommended to be implemented during the construction phase of the project;
3. A site stormwater management plan should be required for every site development to address infiltration requirements;
4. No phasing should be approved without the construction of the downstream stormwater management infrastructure.



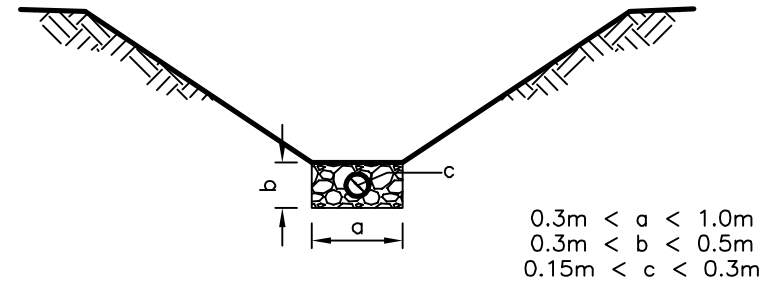
## ROCK CHECK DAMS



NOTES:

1. Drops at check dam as required by road profile.
2. Distance of 50 to 100 m between rock check dams.
3. Ditches to be built on sandy portions of site. In sections where there is till a 300 mm layer of sand is required in the base of the ditch.

## MODIFIED ETOBICOKE SYSTEM



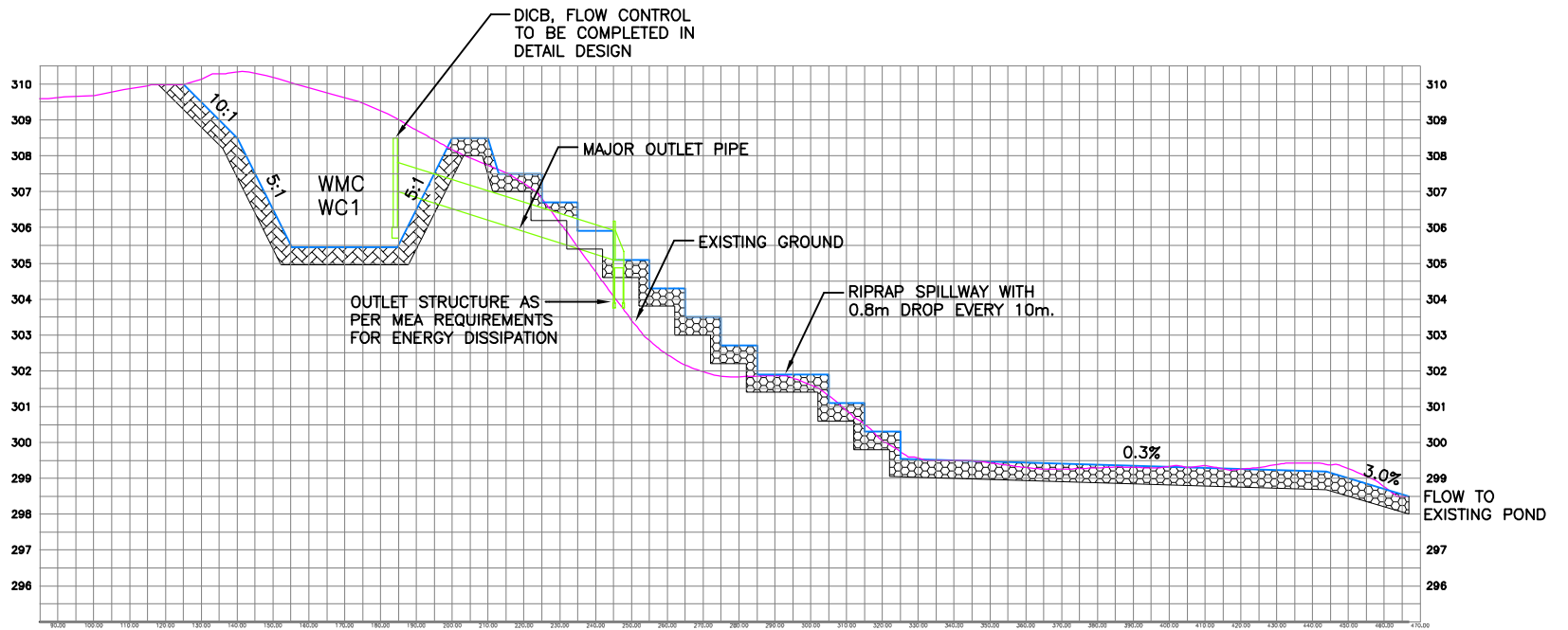
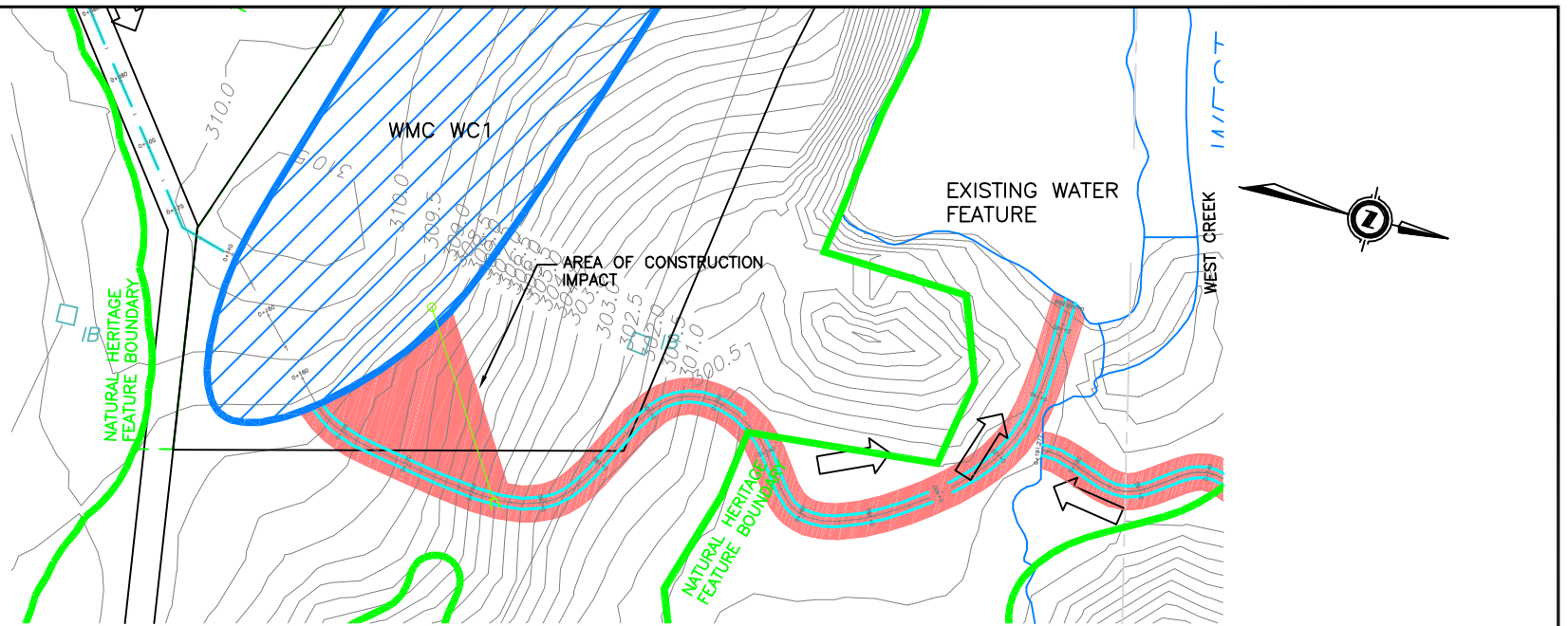
NOTES:

Ditches to be built as Modified Etobicoke System, which provides a perforated pipe with stone media below the ditch allowing for infiltration to occur without introducing any restriction to the actual ditch capacity. It would be suitable in locations where the ditch has a light slope (< .40%) and is situated on suitable soil.

BOXWOOD INDUSTRIAL SUBDIVISION SERVICING CLASS ENVIRONMENTAL ASSESSMENT, CITY OF CAMBRIDGE

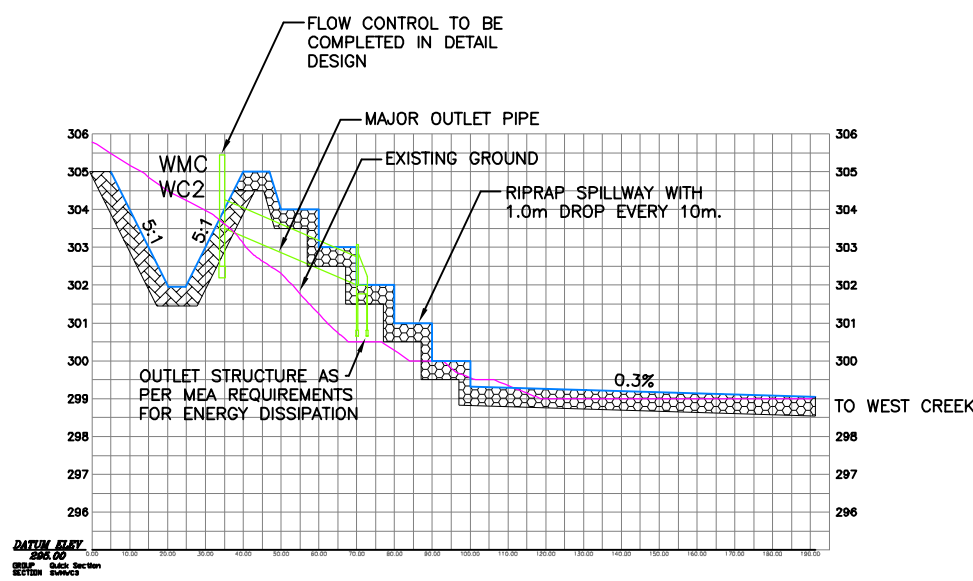
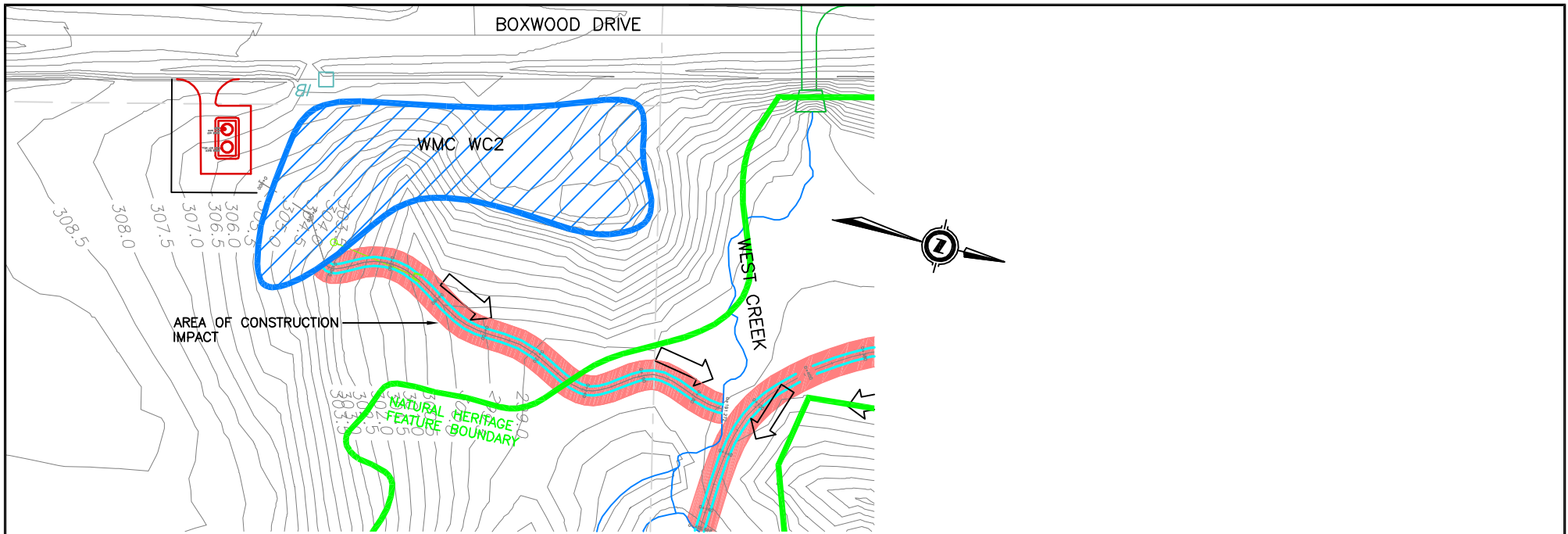
**FIG. 4.2: DITCH ENHANCEMENTS FOR PROVIDING INFILTRATION**





BOXWOOD INDUSTRIAL SUBDIVISION SERVICING CLASS ENVIRONMENTAL ASSESSMENT, CITY OF CAMBRIDGE

**FIG. 4.4 STORM WATER MANAGEMENT FACILITY WC1  
AND OUTLET CONCEPTUAL PLAN**



BOXWOOD INDUSTRIAL SUBDIVISION SERVICING CLASS ENVIRONMENTAL ASSESSMENT, CITY OF CAMBRIDGE

**FIG. 4.5 STORM WATER MANAGEMENT FACILITY WC2 AND OUTLET CONCEPTUAL PLAN**