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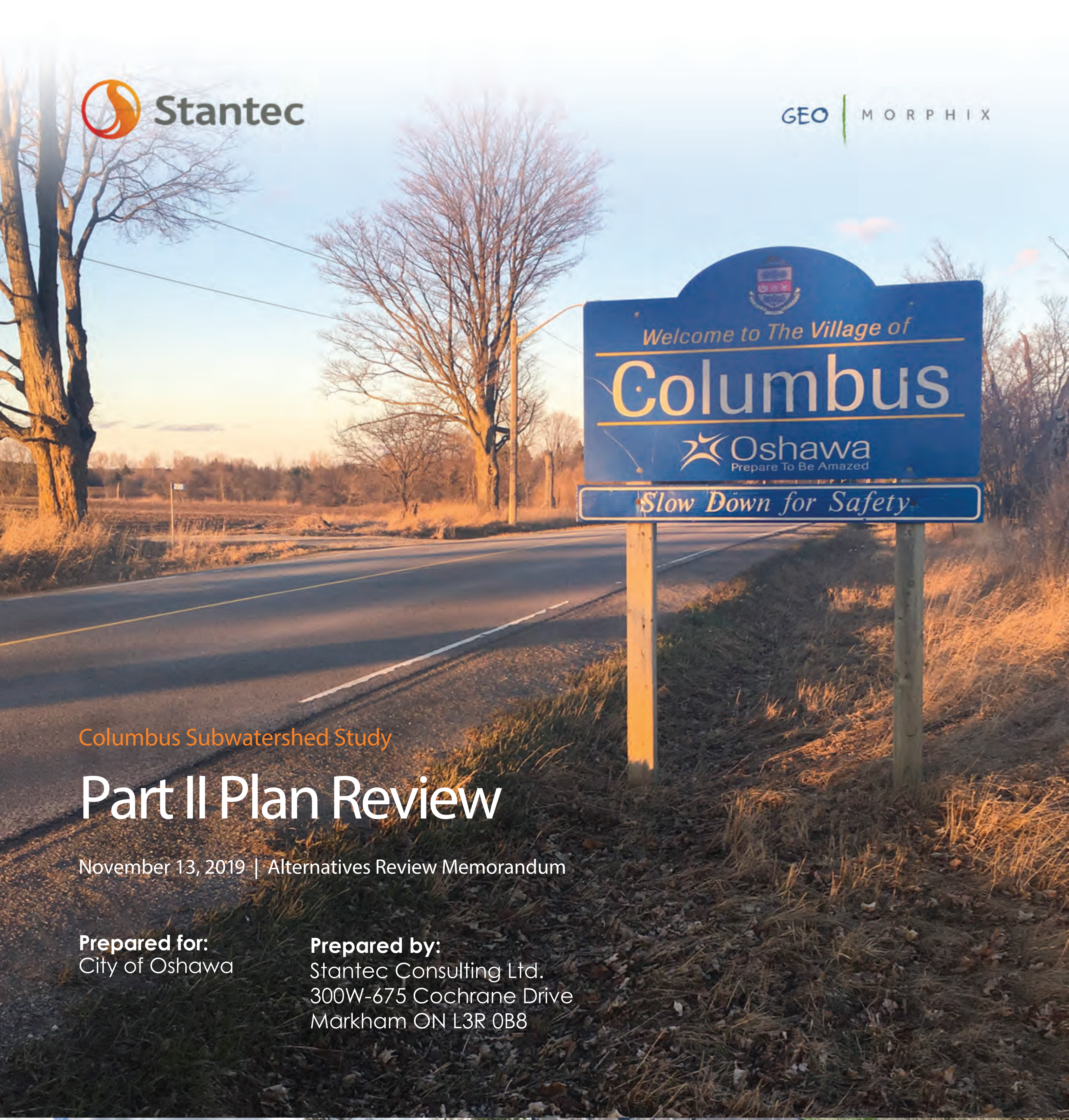

Columbus Subwatershed Study

Part II Plan Review

November 13, 2019 | Alternatives Review Memorandum

Prepared for:
City of Oshawa

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Sign-off Sheet

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1.0 Introduction

Stantec Consulting Ltd. (Stantec) has been requested by the City of Oshawa (City) to review and provide preliminary comments, as they relate to natural environmental considerations, for three (3) land use and road plan alternatives that are currently being evaluated for the future Part II Planning Area in Columbus. Stantec had previously provided the City, Central Lake Ontario Conservation Authority (C.L.O.C.A.) and Regional Municipality of Durham (Region) with a revised Columbus Subwatershed Study (Phase 1) Report in January 2019, which characterized the existing natural environment (terrestrial & aquatic ecology), fluvial geomorphology (Geo Morphix), surface water and hydrogeological conditions within a 916.5 ha area identified therein as the 'Boundary Area'.

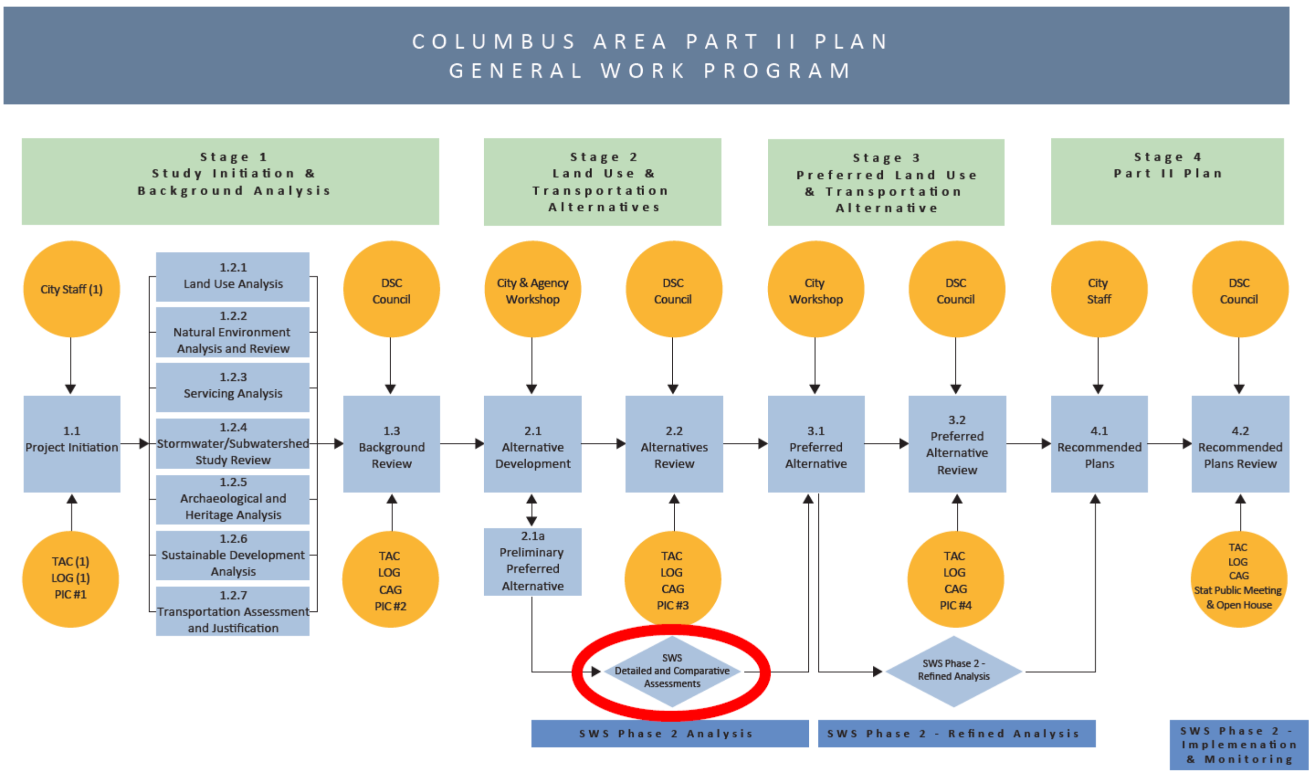
The City retained Macaulay Shiomi Howson Ltd. (MSH) in June 2018 to lead a team of consultants through the Part II Planning Phase to streamline the requirements for both the Planning Act and Municipal Class Environmental Assessment Act processes by conducting an integrated study for the lands in/around the existing community of Columbus. Other members of the Part II Planning Team include Wood, HDR and NRSI.

On March 8, 2019, a meeting was facilitated by the City to coordinate the ongoing efforts being undertaken by both the Part II Planning Team and Columbus Subwatershed Study (S.W.S.) Team. The Part II Planning Team prepared a revised work program to outline key milestones and points of interaction for parallel efforts related to the Part II Plan process and preparation of the Columbus S.W.S. (Phase 1 & 2 Reports), which are illustrated in **Figure 1.1** below. This memorandum has been prepared to communicate the Columbus S.W.S. Team's preliminary findings regarding anticipated environmental impacts for the three (3) land use and road plan alternatives and to recommended mitigation strategies to offset or minimize potential environmental impacts within the Boundary Area. It is Stantec's understanding that the contents of this memorandum will help inform the Part II Planning Team and enable a broader evaluation of the land use planning alternatives that have been developed and ultimately determine a 'preferred' alternative. This memorandum has been prepared following the step in the process (circled in red) on the flowchart presented in **Figure 1.1.**

The City and Part II Planning Team originally provided three (3) land use and road plan alternatives in a digital format on June 5, 2019. These alternatives were subsequently modified, and revised versions were provided on August 13, 2019. The most recent land use and road plan alternatives have been analyzed by the Columbus S.W.S. Team, which are provide in **Appendix A** for reference. In line with previous discussions, the Columbus S.W.S. Team have proceeded to undertake a quantitative analysis of one randomly selected alternative (Alternative 2) and 'comparative' qualitative analysis of Alternatives 1 and 3. The results of the terrestrial/aquatic ecology, fluvial geomorphology, surface water and hydrogeology analyses and preliminary mitigation recommendations are presented herein. The Columbus S.W.S. Team will remain available to the City and the Part II Planning Team, as needed, to coordinate any exchange of additional information, to provide clarification and general support, as desired, with determining the eventual preferred land use alternative.

Upon receiving a confirmed 'preferred' alternative from the Part II Planning Team, which is anticipated to occur in/around Winter 2020, the Columbus S.W.S. Team will proceed to prepare the Columbus S.W.S. Phase 2 Report for submission to the City, C.L.O.C.A. and Region for their review.

Figure 1.1 Columbus Area Part II Plan: General Work Program



2.0 Background

As outlined above, the City provided the Columbus S.W.S. Team with three (3) revised land use and road plan alternatives for analysis on August 13, 2019. These alternatives can be referenced in **Appendix A**. A summary of the various proposed land uses for each alternative under consideration is summarized in **Table 2.1.** It is important to note that the overall area (916.5 ha) coincides with the 'Boundary Area', as presented in the Columbus S.W.S. Phase 1 Report.

Table 2.1 Land Use and Road Plan Summary by Alternative

Land Use	Alternative 1 (ha)	Alternative 2 (ha)	Alternative 3 (ha)
C.S.W.S. Natural Heritage System	124.4	**124.2**	123.6
Columbus Site Plan Application (S.P.A.)	41.1	**41.5**	41.4
Employment	105.3	**104.6**	107.2
Existing Arterial Road	21.3	**21.3**	21.3
Existing Local Road	4.6	**4.6**	4.6
Greenbelt Protected Countryside	174.5	**173.8**	170.6
High Density Res	3.2	**2.6**	7.5
Low Density Res	183.4	**183.1**	190.5
Medium Density Res I	65.8	**71.2**	75.1
Medium Density Res II	73.4	**70.8**	49.5
Mixed Use	25.2	**24.4**	25.8
Ministry of Transportation Species at Risk (M.T.O. S.A.R.) Compensation Lands	34.5	**34.5**	34.5
Prime Agricultural	3.1	**3.1**	3.1
Proposed Arterial	26.2	**26.7**	30.5
Proposed Collector	18.6	**18.4**	19.4
Proposed Enhancement Area	3.9	**3.9**	4.0
Proposed Linkage Area	7.8	**7.9**	7.9
Total =	**916.5**	**916.5**	**916.5**

Note: Alternative 2 is the land use that has been quantitatively assessed. Alternatives 1 and 3 have been evaluated on a comparative/qualitative basis.

As the areas summarized in **Table 2.1** indicate, the provided alternatives do not present significant variations of proposed land use conditions within the Boundary Area. A such, it would appear that the adopted approach of undertaking a detailed assessment of one alternative (Alternative 2), with general comparison to the other proposed alternatives (Alternative 1 and 3), is a very reasonable approach at this stage of the planning process. A quantitative analysis of the eventual preferred alternative will be revisited, confirmed and documented in the Columbus S.W.S. Phase 2 Report.

Based on typical percent impervious cover by land use, the aggregate total impervious area for each alternative is expected to be approximately 379 ha, 376 ha and 379 ha for Alternatives 1, 2 and 3, respectively. These values suggest that approximately 41.4%, 41.0% and 41.4% of the overall Boundary Area may ultimately become impervious cover under the full buildout condition. By comparison, the existing surface cover within the Boundary Area is estimated to consist of approximately 39 ha or 4.2% impervious cover, which is largely comprised of existing rural residential areas, roadways and localized commercial use. The level of impervious cover is anticipated to increase by approximately 10x when comparing pre-development to full post-development condition. Based on these general metrics, the future development of lands within the Columbus Part II Planning Area have the potential to adversely affect the existing natural environment without proper mitigation planning.

The following Sections further examine the future development alternatives, highlights specific areas of sensitive environmental interests and provides preliminary recommendations for mitigation strategies to offset potential adverse impacts associated with the proposed development, in general accordance with the objectives of the Oshawa Creek Watershed Management Plan (C.L.O.C.A., Feb 2013).

3.0 Terrestrial Natural Heritage

3.1 Overview of Existing Conditions

A terrestrial natural heritage assessment was conducted as part of the Columbus Subwatershed Study (Stantec, 2019) to characterize the existing natural features, using available secondary source information and field investigations, and identify constraints associated with natural heritage features for future development planning purposes within the Boundary Area.

The Columbus S.W.S. Phase 1 Report indicated that natural vegetation communities occupied approximately 202 ha (22%) of the Boundary Area, and agriculture occupied approximately 574 ha (63%). The remaining approximately 140 ha (15%) was constructed land use types, including rural residential, commercial, manicured greenspace, transportation and utility infrastructure. Existing land cover metrics are summarized in **Table 3.1** below.

Table 3.1 Existing Land Cover in the Boundary Area (Stantec, 2019)

Feature	Area (ha)	Percent (%)
Columbus Subwatershed Boundary Area	916.5	100.0%
Existing natural cover	202.3	22.1%
Forest	145.5	15.9%
Wetland	18.6	2.0%
Bluff	0.1	0.0%
Meadow	29.7	3.2%
Hedgerow	8.4	0.9%
Existing agriculture	573.7	62.6%
Annual row crops	405.1	44.2%
Existing perennial cover crops and pasture	168.6	18.4%

Terrestrial constraints to development were identified using policies of the Provincial Policy Statement (MMAH, 2014), the City of Oshawa Official Plan 2019, as amended, and guidance documents including Developing C.L.O.C.A.'s Natural Heritage System: A Methodology (C.L.O.C.A., 2011) and the Wildlife Corridor Protection & Enhancement Plan (C.L.O.C.A., 2015). Recommended buffers, or Minimum Vegetated Protection Zones (M.V.P.Z.s) were established using City of Oshawa Official Plan 2019, as amended, and the Greenbelt Plan.

Terrestrial constraints and M.V.P.Z.s identified for the Boundary Area are summarized in **Table 3.2** below.

Table 3.2 Terrestrial Constraints and M.V.P.Z.s in the Boundary Area (Stantec, 2019)

Feature	M.V.P.Z. (City of Oshawa Official Plan 2019)	Minimum Buffers (Oshawa Creek Watershed Plan)	M.V.P.Z. (Greenbelt Plan)
Wetlands (non-provincially significant)	All land within 15 m of any part of the feature Source: City of Oshawa (2016) Official Plan, as amended	15 m from the edge of the feature Source: C.L.O.C.A. (2013)	30 m measured from the outside boundary of the feature Source: Greenbelt Plan (MMAH 2017)
Significant woodland	All land within 30 m of the base of the outermost tree trunks within the woodland Source: City of Oshawa (2016), as amended	30 m measured from dripline Source: C.L.O.C.A. (2013)	30 m measured from the outside boundary of the feature Source: Greenbelt Plan (MMAH 2017)
Other woodlands	All land within 10 m of the feature and 15 m if associated with a wetland Source: City of Oshawa (2016), as amended	10 m measured from dripline Source: C.L.O.C.A. (2013)	N/A
Habitat of endangered and threatened species	To be determined via site-specific study and consultation with MNRF Source: City of Oshawa (2016), as amended	N/A	To be determined via site-specific study and consultation with MNRF Source: Greenbelt Plan (MMAH 2017)

Table 3.2 Terrestrial Constraints and M.V.P.Z.s in the Boundary Area (Stantec, 2019)

Feature	M.V.P.Z. (City of Oshawa Official Plan 2019)	Minimum Buffers (Oshawa Creek Watershed Plan)	M.V.P.Z. (Greenbelt Plan)
Significant valleyland	All land within 30 m of stable top of bank; features to be delineated via site-specific study Source: City of Oshawa (2016), as amended	N/A	To be determined via site-specific study Source: Greenbelt Plan (MMAH 2017)
Significant wildlife habitat	All land within 30 m of any part of the feature; features to be identified and delineated via site-specific study. Source: City of Oshawa (2016), as amended	30 m measured from the edge of the feature Source: C.L.O.C.A. (2013)	30 m measured from the outside boundary of the feature Source: Greenbelt Plan (MMAH 2017)
Riparian corridors	All land within 30 m buffer of wetted width; the Oshawa OP provides for a reducing to 15 m for warm water streams if conditions are met (see Section 5.3.2, 5.4.8 and 5.4.9) Source: City of Oshawa (2016), as amended C.L.O.C.A. (2011)	30 m from the stream edge Source: C.L.O.C.A. (2013)	N/A

3.2 Watershed Targets and Applied Buffers

The Oshawa Creek Watershed Plan (C.L.O.C.A., 2013) established targets to achieve a healthy watershed, including minimum targets of 30% for natural cover, and 10% for wetlands (6% minimum per Subwatershed). To achieve the targets, a Watershed Management (Figure 13 of C.L.O.C.A, 2013) was developed "to map components for the watershed for protection, restoration and enhancement," which included a Natural Heritage System of connected natural features, riparian corridors, and wildlife movement corridors. Feature buffers were not mapped as part of the Natural Heritage System, except for riparian buffers. The Natural Heritage System was adopted by the City of Oshawa Official Plan 2019, as amended, and is shown on Schedule D-1. The area of the Natural Heritage System within the Boundary Area was calculated to represent the area of the natural cover that is required to achieve the targets set out in the Oshawa Creek Watershed Plan. **Table 3.3** indicates that a least 26.3% natural cover is needed in the Boundary Area to achieve the Oshawa Creek Watershed as a whole.

Table 3.3 City Oshawa Official Plan Natural Heritage System (Schedule D-1) cover in the Boundary Area

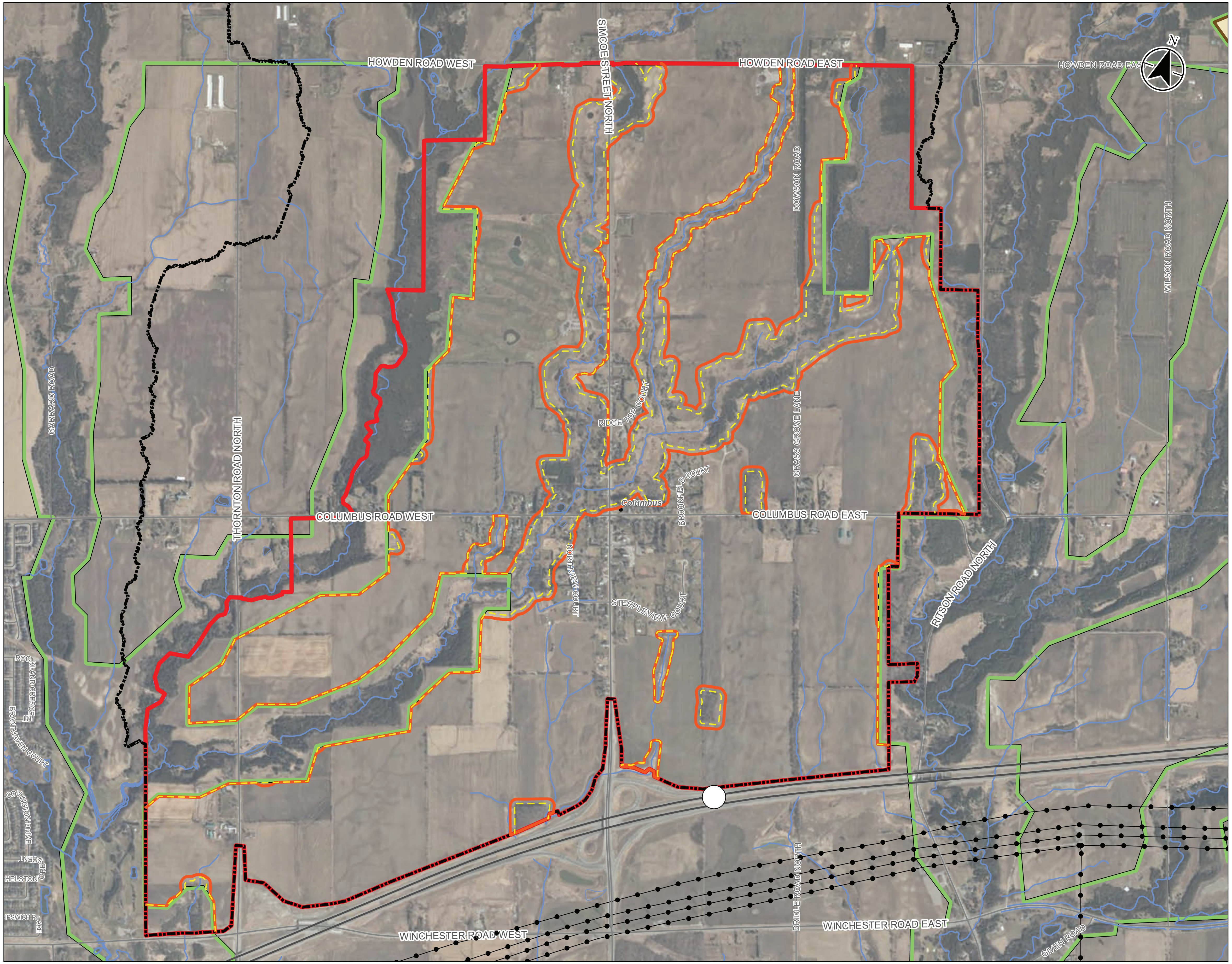
	Area (ha)	Percent (%) of Boundary Area
Function Natural Heritage System	224.3	24.5%
Target Natural Heritage System	16.7	1.8%
Total Natural Heritage System	241.0	26.3%

As reported above, the existing natural and wetland cover documented in the Columbus Subwatershed Study was 22% and 2%, respectively, which is below the watershed targets set out in the Oshawa Creek Watershed Plan and the portion of the Boundary Area that is designated Natural Heritage System in the City of Oshawa Official Plan 2019, as amended. However, natural land cover will be increased by establishing a natural heritage system that incorporates existing natural features (including Significant Woodlands, Significant Valleylands, wetlands and riparian corridors), and enhancement areas, including minimum vegetation protections zones, natural heritage linkages, and other enhancement areas. Collectively, the existing features and enhancement areas will be referred to as the Targeted Natural Heritage System (T.N.H.S.).

Table 3.4 below quantifies the Natural Heritage System (N.H.S.) and compares it to the watershed targets established in the Watershed Management Plan (C.L.O.C.A., 2013) under two land cover scenarios (**Figure 3.1**). The existing natural features are the same under both scenarios; however, the M.V.P.Z.s are applied differently, as follows:

1. M.V.P.Z.s identified in City of Oshawa Official Plan 2019, as amended (see **Table 3.2** above) are applied, including 30m MVPVs for Significant Woodlands and Significant Valleylands outside the Greenbelt Protected Countryside.

2. M.V.P.Z.s identified in City of Oshawa Official Plan 2019, as amended (see **Table 3.2** above) are applied for all features except Significant Woodlands and Significant Valleylands outside the Greenbelt Protected Countryside. A 10-m buffer was applied to Significant Woodlands and Significant Valleylands outside the Greenbelt Protected Countryside as described in Table 1 of C.L.O.C.A.'s (2014) *Policy and Procedural Document for Regulation and Plan Review.*



Stantec

Legend

- NHS Buffer Scenario 1
- NHS Buffer Scenario 2
- Boundary Area
- Study Area
- Highway
- Major Road
- Minor Road
- Hydro Line
- Watercourse (CSWS)
- Waterbody

Greenbelt Natural Heritage System

- Oak Ridges Moraine Conservation Plan
- Protected Countryside

0 320 640 metres

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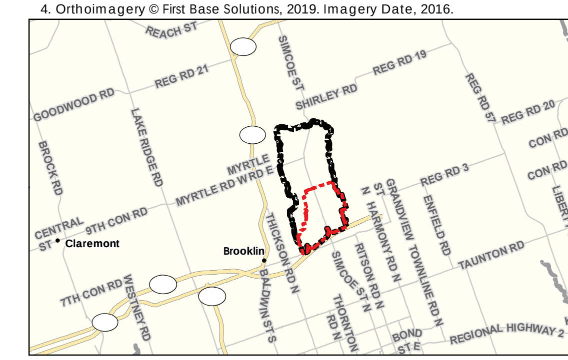
Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2016, CLOCA, 2016.
3. ELC Boundary comprised of Stantec and CLOCA data.
4. Orthoimagery © First Base Solutions, 2019. Imagery Date, 2016.



Project Location
City of Oshawa

160622416 REVB
Prepared by SPE on 2019-09-13
Checked by TPG on 2019-09-13

Client/Project
COLUMBUS LANDOWNERS GROUP
COLUMBUS SUBWATERSHED STUDY

Figure No.
3.1

Title
Comparison of NHS Buffer Scenarios

Other enhancement areas are the same in both scenarios, including Proposed Linkage Areas, Proposed Enhancement Areas, and the M.T.O. S.A.R. Compensation Lands as shown on Alternative 2. The area of the M.T.O. S.A.R. Compensation Lands is presented in **Table 3.4** but is excluded from the total T.N.H.S. calculation because the compensation habitat may be managed as a temporary use.

The analysis in **Table 3.4** indicates that the natural cover increases by 117.3 ha (12.8% of the Boundary Area) under scenario 1 and 88.4 ha (9.6% of the Boundary Area) in scenario 2. The watershed target for natural cover (30%) is exceeded under both scenarios (34.9% natural cover for scenario 1 and 31.7% for scenario 2).

Table 3.4 Comparison of Land Cover Scenarios and Watershed Targets

	Scenario 1		Scenario 2	
	Area (ha)	**Percent (%) of Boundary Area**	**Area (ha)**	**Percent (%) of Boundary Area**
Boundary Area	916.5	100.0%	916.5	100.0%
Existing natural cover	202.3	22.1%	202.3	22.1%
Existing features (Significant Woodland, Significant Valleylands, wetlands, riparian corridors)	191.5	20.9%	191.5	20.9%
Proposed M.V.P.Z.	117.3	12.8%	87.4	9.5%
Proposed Enhancement Areas (Land Use and Road Plan Alternative 2)	2.9	0.3%	3.9	0.4%
Proposed Linkage Area (Land Use and Road Plan Alternative 2)	7.9	0.9%	7.9	0.9%
TOTAL T.N.H.S.	**319.6**	**34.9%**	**290.7**	**31.7%**
Net Increase in Natural Cover (T.N.H.S. - Existing natural cover)	**117.3**	**12.8%**	**88.4**	**9.6%**
M.T.O. S.A.R. compensation lands	34.6	3.8%	34.6	3.8%

Alternatives 1, 2 and 3 were overlaid on the natural heritage feature constraints and M.V.P.Z.s (scenario 1 described above) to quantify direct loss to the T.N.H.S. The feature constraints and M.V.P.Z.s are shown on Figure 5.1 of the Columbus S.W.S. Phase 1 Report (provided in **Appendix B**).

The Land Use and Road Plan alternatives do not encroach into the natural heritage feature constraints or M.V.P.Z.s, except where new roads are proposed, including arterial and collector road crossings of Significant Valleylands, riparian corridors, and associated Significant Woodlands and wetlands.

Table 3.5 quantifies direct loss to the T.N.H.S., Greenbelt Protected Countryside, Proposed Enhancement Areas and Linkage Areas, and M.T.O. S.A.R. Compensation Lands for each the proposed Land Use and Road Plan alternatives. It also quantifies direct loss to Significant Woodlands and wetlands, which are contained within the T.N.H.S. and Greenbelt.

This analysis indicated that Alternative 1 results in the least direct loss to the T.N.H.S. and Greenbelt (1.84 ha and 0.51 ha respectively), Alternative 2 results in moderate direct loss (2.06 ha and 0.96 ha respectively), and Alternative 3 results in the most direct loss (2.71 ha and 5.65 ha respectively). Total direct loss (T.N.H.S. plus Greenbelt) is presented in **Table 3.6.** The total direct loss associated with all alternatives is less than 1% of the Boundary Area, and do not affect the ability of the Columbus Part II Plan area to meet the watershed target of 30% natural cover discussed above.

Total direct loss of wetlands is greatest in Alternative 2, which is an important consideration because the Columbus S.W.S. Phase 1 Report indicated that existing wetland cover loss is 2% of the Boundary Area, which is below the Oshawa Creek Watershed Plan (C.L.O.C.A., 2013) target of 10% (and 6% minimum per Subwatershed).

Table 3.5 Proposed Area of Direct Loss by Land Use Alternative (ha)

	Alternative 1	**Alternative 2**	**Alternative 3**
C.S.W.S. Natural Heritage System (T.N.H.S.)			
Proposed Arterial	1.63	1.86	2.20
Proposed Collector	0.20	0.19	0.51
Total	*1.84*	*2.06*	*2.71*
Greenbelt Protected Countryside			
Proposed Arterial	0.51	0.96	5.65
Significant Woodlands			
Proposed Arterial	0.10	0.35	2.69
Wetlands			
Proposed Arterial	0.09	0.21	0.09
Proposed Collector	0.06	0.04	0.12
Total	*0.15*	*0.25*	*0.21*
Proposed Enhancement Area			
Proposed Arterial	0.06	0.06	0.06

Table 3.5 Proposed Area of Direct Loss by Land Use Alternative (ha)

	Alternative 1	Alternative 2	Alternative 3
Proposed Linkage Area			
Proposed Arterial	0.00	0.00	0.00
Proposed Collector	0.10	0.09	0.07
Total	*0.10*	*0.09*	*0.07*
M.T.O. S.A.R. Compensation Lands			
Proposed Arterial	0.03	0.04	0.00

Table 3.6 Total Direct Loss by Land Use Alternative as a Percent of the Boundary Area

	Alternative 1	Alternative 2	Alternative 3
T.N.H.S.	1.84	2.06	2.71
Greenbelt Protected Countryside	0.51	0.96	5.65
Total Direct Loss	2.35	3.01	8.36
Total Direct Loss as a Percent of the Boundary Area	0.26%	0.33%	0.91%

The Land Use and Road Plan alternatives were also assessed to determine the number of new proposed crossings of the T.N.H.S., Greenbelt Protected Countryside, Proposed Enhancement Areas and Linkage Areas, and M.T.O. S.A.R. Compensation Lands. **Table 3.7** summarizes the crossings by reach name identified in the Columbus S.W.S. Phase 1 Report (Figure 4.2.2) where appropriate. Figure 4.2.2 is provided in **Appendix B** of this memorandum for reference. This analysis indicates that Alternative 1 results in the lowest amount of fragmentation (five (5) new crossings of the T.N.H.S. and 1 new crossing of the Greenbelt), Alternative 2 results in a moderate amount of fragmentation (five (5) new crossings of the T.N.H.S. and two (2) new crossings of the Greenbelt), and Alternative 3 results in the most amount of fragmentation (eight (8) new crossings of the T.N.H.S. and two (2) new crossings of the Greenbelt). Negative effects of fragmentation would be most pronounced in the Greenbelt because the Columbus S.W.S. Phase 1 Report documented the largest, most diverse natural features in those areas.

Table 3.7 Number of New Road Crossing of the T.N.H.S. by Land Use Alternative

	Alternative 1		**Alternative 2**		**Alternative 3**	
	No. of New Crossings	**Reach Name**	**No. of New Crossings**	**Reach Name**	**No. of New Crossings**	**Reach Name**
T.N.H.S.						
Proposed Arterial	4	OCRB9-3b OCRB9-8 OCWB10-5 OCRB14	4	OCRB9-3b OCRB9-8 OCWB10-5 OCRB14	6	OCRB9-3b OCRB9-7 OCRB9-8a OCRB9-9 OCWB10-5 OCRB13
Proposed Collector	1	OCRB9-3d	1	OCRB9-3d	2	OCRB9-3d OCBR9-3e
Total	*5*		*5*		*8*	
Greenbelt Protected Countryside						
Proposed Arterial	1	OCEB8	2	OCRB7i OCEB85	6	OCRB3-9 OCRB7ii (N-S) OCRB7ii (E-W) OCRB9-9 OCEB14-2 OCEB8
Proposed Enhancement Area						
Proposed Arterial	1 (edge only)	East of OCWB10-4	1 (edge only)	East of OCWB10-4	1 (edge only)	East of OCWB10-4
Proposed Linkage Area						
Proposed Collector	0	None	1	OCKB12i	0	None
Proposed Arterial	1	OCKB12	1	OCKB12ii	1	OCKB12i

3.3 Preliminary Mitigation Measures

The impact assessment found that all three (3) Land use and road plan alternatives are able to meet the watershed target of 30% natural cover discussed above, with the least direct loss and fragment affects associated with Alternative 1, moderate direct loss and fragment affects associated with Alternative 2, and the most direct loss and fragment affects associated with Alternative 3. Existing wetland cover is 2% of the Boundary Area, which is below the Oshawa Creek Watershed Plan (C.L.O.C.A., 2013) target of 10% (and 6% minimum per Subwatershed); therefore, opportunities should be explored to create wetlands in M.V.P.Z.s and other enhancement and linkage areas, where feasible. Wetland creation could include bioretention features and other innovative design strategies such as engineered S.W.M. wetlands and possibly S.W.M. ponds.

Additional preliminary recommendations are provided below to protect and enhance the T.N.H.S., maintain and enhance feature and linkages outside the T.N.H.S., and address fragmentation of the T.N.H.S. and Greenbelt that will be created by proposed new roads.

Management recommendations to protect and enhance the T.N.H.S.:

- Develop policy or guidelines to protect and enhance the T.N.H.S., including a no net loss policy to address encroachment contemplated during site specific studies. The policy may permit encroachment in to the T.N.H.S. if supported by an Environmental Impact Study (E.I.S.) and compensated at another location that enhances the T.N.H.S.
- Development policy or guidelines for management of M.V.P.Z.s and enhancement areas including consideration of active restoration to improve native species biodiversity, and measures to control and prevent the spread of problematic invasive species documented in the Columbus S.W.S. Phase 1 Report, such as European buckthorn (*Rhamnus catharica*), Scots Pine (*Pinus sylvestris)* Canada Thistle (*Cirsium arvense*), Swallow-wort (*Cynanchum rossicum*), White Bedstraw (*Gallium mollugo*), and European reed (*Phragmites australis ssp. australis*).
- Landscaping (including streetscaping, parks and stormwater facilities) and active restoration should consider opportunities to address climate change by incorporating native species that tolerate extreme weather and sequester carbon at high rates, and layering vegetation vertically to increase biomass and ecosystem services.
- Establish a terrestrial natural heritage monitoring program to track occurrences and distribution of species, and effectiveness of active restoration, invasive species management, wildlife crossing structures and other recommendations.
- Restrict public access to the most sensitive areas to prevent trampling, garbage dumping, etc., including large intact forests in the Greenbelt. Provide guidelines for other potential effects associated with increased human population, such as light encroachment into natural areas and outdoor domestic cats.
- Provide education and promote positive natural heritage stewardship, particularly for properties that are in close proximity to the T.N.H.S.

Recommendations to maintain and enhance features and linkages outside the T.N.H.S. and Greenbelt:

- All three (3) alternatives include a Proposed Linkage Area along reach OCKB13 in the southeastern part of the Boundary Area. The north part of the linkage near Columbus Road East should be moved to the east to abut and enhance the Greenbelt Plan Protected Countryside, if possible, from a storm drainage grading/servicing perspective.
- All three (3) Land use and road plan alternatives propose a new north-south arterial road along the existing Dowson Road in the north-eastern part of the Boundary Area. There is an existing mature coniferous hedgerow that is a prominent landscape feature and can be seen from several kilometers away. Design of the new arterial road should consider preservation of all or parts of the hedgerow.

Recommendations to address fragmentation of the T.N.H.S. and Greenbelt that will be created by proposed new roads:

- Newly created edges that are cut along existing natural features should be addressed with edge management plans to protect and mitigate for potential negative effects, such as increased sunlight penetration, susceptibility to wind through, desiccation, grading and soil compaction, and spread of invasive species. The edge management plans should include a detailed inventory of existing trees and vegetation, strategies to reduce removals, specifications for tree protection, and post-construction restoration plans. Restoration plans should use native species that are tolerant of the site conditions, including urban stresses such as salt, pollution and soil compaction. Restoration should include seed broadcast to replace seed banks that are lost, as well as woody shrubs and trees to create vertical structure. Monitoring plans should track survivorship and effectiveness of restoration plans and include recommendations to adapt management as appropriate.
- Wildlife crossing structures are recommended to reduce road impacts to wildlife where they will cross the T.N.H.S., Greenbelt Protected Countryside, Proposed Enhancement Areas and Linkage Areas. Potential impacts include fragmentation of wildlife populations, barriers to migration and dispersal, and road morality. The following design parameters are recommended:
  - Structures longer than 25-m should be large structures such as overpasses, multi-span bridges or viaducts (MNRF, 2016) if possible, to improve field of view and facilitate use by wildlife. If large structures are not possible, box culverts or other tunnels greater than 3 m wide are recommended to allow as much light to enter as possible.
  - Structures 25-m long or less may be open-bottom box or arch tunnel culverts.
  - Box or arch tunnel culverts with open-grates or other open-top design considerations are recommended to permit light to enter the structure and allow for consistent moisture and temperature (MNRF, 2016).
  - Structures should be sized to permit passage of a large mammals if located in the T.N.H.S. or Greenbelt, or medium sized mammals / reptiles if located along proposed enhancements or linkages. Recommended design parameters (length, width and

openness ratio) are shown in **Table 3.7**. If recommended openness ratios (width x height / length) are not feasible, open-top design should be incorporated to permit light to enter the structure and allow for consistent moisture and temperature (MNRF, 2016).

- Structures should include dry passage for wildlife on both sides of drainage that passes through the culvert.
- Existing structures in the T.N.H.S. and Greenbelt should be reviewed when rehabilitation and/or reconstruction is needed to upsize and/or enhance them for improved wildlife passage.
- Structures should be combined with fencing to keep wildlife off roads and direct them to crossing structures. Fencing should be designed to prevent access of small amphibians and reptiles (e.g., ¼ inch mesh) and larger mammals (e.g., 2.4 m high large animal mesh fence) (MNRF, 2016).

Table 3.8 Design Recommendations for Wildlife Crossing Structures

Target Wildlife	Minimum Width	Minimum Height	Minimum Openness Ratio ((W x H)/L)	Reach Name
Large mammals (white-tailed deer)	3.0 m (MNRF, 2016)	1.8 m (Cavallaro, Sanden, Schellhase, and Tanaka, 2005)	0.90 (Cavallaro, Sanden, Schellhase, and Tanaka, 2005)	OCRB3-8 OCRB6 (N-S) OCRB6 (E-W) OCRB9-3b OCRB9-3d OCBR9-3e OCRB9-7 OCRB9-9 OCWB10-5 OCRB13 OCEB14-2 East branch from OCRB9-8 West of OCEB8
Medium mammals (skunk, raccoon, fox, rabbit, opossum), reptiles and amphibians	2.0 m (MNRF, 2016)	1.0 m (MNRF, 2016)	0.40 (Cavallaro, Sanden, Schellhase, and Tanaka, 2005)	OCKB12 OCKB12-2 East of OCWB10-4

3.3.1 Site Specific Studies

Some features must be delineated during site-specific studies and could not be mapped as part of the Columbus S.W.S. Phase 1 Report, including habitat of endangered and threatened species, significant valleylands and significant wildlife habitat. Other features documented in the Columbus S.W.S. Phase 1 Report should be updated during site-specific study, including assessments to update significance of woodland features, and boundary delineations of woodlands and wetlands. Site-specific studies will serve to refine natural feature boundaries as appropriate, but also identify detailed environmental protection and mitigation recommendations including recommendations for M.V.P.Z.s.

4.0 Fluvial Geomorphology

4.1 Overview of Existing Conditions

The Columbus S.W.S. Phase 1 Report provided a characterization and inventory of all watercourse features following both a desktop and field approach. The study included a thorough background review of existing documentation related to the Columbus Boundary Area, watercourse reach delineation, an assessment of channel evolution over time through historical aerial photo analysis, rapid and detailed geomorphological field assessments, erosion hazard delineation, and erosion threshold calculations. The Columbus S.W.S. Phase 1 Report also outlined preliminary crossing recommendations for potential future road crossings over watercourses. This information, in part, informs the comparative analysis outlined below in association with the evaluation of the three (3) preliminary alternatives.

Since a large portion of the Study Area lies within the upstream limits of the Oshawa Creek Watershed, the majority of the watercourse features are low order streams or headwater drainage features. Within the most northern portion of the Study Area, headwater features within the tablelands tend to flow through active agricultural fields without riparian buffers. These channels are finer substrate dominated by silt and sand. Larger watercourses with the Study Area flow in a southerly direction and are often situated within forested ravines or valleys. These features are partially confined with moderate sinuosity and gradient. Substrate materials range from silt to sand in pools and gravel to small boulders in riffles. Since the Study Area is mostly rural, the larger watercourses within the ravines have not experienced extensive human modification. However, in most cases, headwater features and smaller watercourses would have been ditched and straightened in support of agricultural activities. This was especially evident through a review of historical aerial photographs.

To support the Columbus S.W.S. Phase 1 Report, reach delineation was completed for all features. A total of 110 reaches were delineated and confirmed based on a combined desktop and field approach. Rapid geomorphological field assessments were completed for watercourse features to assess general channel characteristics and overall channel stability. Active evidence of channel and valley erosion was also documented in the context of risk to existing infrastructure in order to understand the potential for future mitigation or remediation needs. All erosion sites were generally classified as low priority, suggesting that remedial works would either be unnecessary or not required for a minimum of 10 years.

Detailed geomorphological field assessments and erosion thresholds were also determined at three (3) locations generally situated downstream of major confluences or proposed future infrastructure (e.g., stormwater management facility). This information will support erosion mitigation planning under the Columbus S.W.S. Phase 2 Report.

Erosion hazard delineation was also completed for both confined and unconfined watercourses. Meander belt widths were defined for all unconfined watercourses by measuring the largest observed meander amplitude and adding a 20% factor of safety. For modified features or those where the channel could not be traced through aerial imagery, empirical models were applied to estimate the meander belt width. For confined watercourses, a toe erosion allowance/setback was defined to support erosion hazard delineation. A toe erosion allowance in the range of 5-15 m was defined for each reach depending on the materials observed on site. It should be noted that the hazard delineation for confined systems requires a toe erosion allowance and determination of stable top of slope. The stable top of slope should be defined through a valid geotechnical study. This is following the Ministry of Natural Resources and Forestry (MNRF) approach for evaluating hazards (MNRF, 2002).

Fluvial geomorphological requirements for watercourse crossings were also outlined under the Columbus S.W.S. Phase 1 Report. These are explored further as part of the impact assessment outlined below for the various crossing alternatives.

4.2 Crossing Impact Assessment

Crossings can have significant impacts on valley and stream corridors. Rivers and streams are also dynamic systems and can easily migrate across their floodplains over time impacting crossing infrastructure. Therefore, it is important to recognize and account for natural hazards in association with watercourse crossings. The assessment outlined herein is based on the guidance and recommendations outlined by the Toronto Region Conservation Authority (TRCA) Crossings Guideline for Valley and Stream Corridors (2015) and the Credit Valley Conservation (CVC) Authority Fish and Wildlife Crossing Guidelines (2017). These are standard and accepted approaches for crossing design and implementation.

From a fluvial geomorphological perspective, watercourse crossings should be designed to minimize the probability of channel contact with the crossing infrastructure while accounting for natural channel adjustment (i.e., migration, erosion, scour) (TRCA, 2015; CVC, 2017). In general, it is recommended that any proposed crossings address the following fluvial geomorphological considerations, where appropriate:

- Potential channel erosion and/or migration;
- Account for any local or upstream meanders;
- Cross the watercourse at a reasonably straight and stable section of channel;
- Cross the watercourse at a perpendicular angle;
- Maintain sediment transport processes; and
- Maintain velocity differentials for frequent storm events.

In addition to the above, the preferred approach would also be to minimize the number of crossings required and the number of crossings associated with major watercourses.

To support the Integrated Columbus Part II Planning Act and Municipal Class Environmental Assessment Act Study, a detailed and comparative review of proposed watercourse crossing locations was completed. It should be noted that each of the three (3) alternatives include multiple watercourse crossings across the Boundary Area. The subsequent section provides a comparative review of all crossing alternatives. Section 4.4 provides a more detailed impact assessment associated with only those crossings provided under Alternative 2.

4.3 Qualitative Assessment

As noted in Section 4.2, there are general requirements for watercourse crossings that address geomorphic hazards. These are directly related to channel migration and erosion as well as general crossing location and orientation. Given the scale of the Columbus Plan Area, there are numerous proposed channel crossings associated with each of the Alternatives. The proposed crossings are shown on Figure 4.2.2 (Overlay Series) in **Appendix A**. From a geomorphological perspective, it is also beneficial to reduce the number of watercourse crossings where possible. **Table 4.1** provides a comparison of the number of crossings and type of crossings for each of the three (3) alternatives.

Table 4.1 Total crossings and channel types for Alternatives 1, 2, and 3

	Number of Crossings	Number of Major Crossings (Main Watercourses)	Number of Minor Crossings (Headwater Drainage Features)
Alternative 1	13	5	8
Alternative 2	15	5	10
Alternative 3	21	12	9

Alternative 1 and Alternative 2 are preferred with regards to the number of crossings and the number of major watercourse crossings. Alternative 3 has substantially more crossings and over half of the crossings are situated along main watercourse features. Crossings along main watercourses are at a higher risk of erosion and would require larger infrastructure. As such, it is beneficial to limit the number of watercourse crossings.

All HDFs associated with proposed crossing locations in Alternatives 1, 2, and 3 have been classified as either *No Management* or *Mitigation* features meaning that they will either be removed from the landscape or have their features replicated in the post-development condition through stormwater management strategies. As such, the minor crossings associated with HDFs are not a concern for any of the proposed alternatives.

For additional comparison, crossing placements and orientations were also reviewed for Alternatives 1, 2, and 3. **Table 4.2** below summarizes the number of crossings where channels crossed at a difficult angle or were situated along a non-preferred section of creek (e.g., along a meander bend or highly eroding creek). A comparison of crossing orientations is provided for all three (3) alternatives.

Table 4.2 Number of crossings with non-preferred alignments for Alternatives 1, 2, and 3

	Number of Non-Preferred Crossing Alignments	Total Number of Crossings
Alternative 1	4	13
Alternative 2	5	15
Alternative 3	9	21

Alternatives 1 and 2 are also similar with regards to the number of poorly oriented crossings in relation to the overall total number of crossings. Alternative 3 has a higher number of crossings where erosion risk would be higher due to channel migration.

Overall, Alternative 1 and Alternative 2 are similar. They have fewer crossings, main watercourse crossings are limited, and crossing placement and orientation is generally favorable based on geomorphic considerations. Alternative 3 is not preferred given the substantially higher number of crossings and main watercourse crossings, as well as non-preferred crossing orientations. From a geomorphological perspective, there are no significant differences between Alternative 1 and 2, particularly with appropriate mitigation measures, and as such, both are acceptable.

4.4 Alternative 2 Detailed Impact Assessment

As documented in **Table 4.1,** 15 crossings are proposed for Alternative 2. Five (5) of the crossings are associated with main watercourse features (i.e., perennial streams with defined bed and banks). Ten (10) of the crossings are associated with headwater drainage features (HDF). Four (4) of the HDFs have been assigned management classifications of No Management Required as part of the Columbus S.W.S. Phase 1 Report. The remaining six (6) HDFs have been classified as Mitigation. Given that these features will likely be removed from the landscape and potentially replicated through stormwater management, there is no concern with the associated crossing locations.

To support a more detailed assessment of Alternative 2 crossing locations, additional considerations were made with regards to channel valley setting, evidence of erosion, density and type of riparian vegetation, channel size and stability, meander belt width, and position and amplitude of local or upstream meander bends. These factors can be used to identify whether a proposed crossing location may be sensitive to erosion or channel migration and therefore require more formal mitigation measures (TRCA, 2015).

Table 4.3 outlines the channel characteristics associated with each crossing and classifies each crossing as sensitive or not sensitive with regards to local channel form and function. The channel and reach information are a combination of field and desktop observations collected during the Columbus S.W.S. Phase 1 Report as well as additional field observations collected in August 2019 at the exact crossing locations proposed.

As documented in **Table 4.3,** most of the crossings are situated along headwater drainage features that will likely be removed from the landscape. As such, the crossings do not create concern with regards to channel form and function. Two (2) of the main watercourse crossings are situated along smaller channels (OCRB9-8 and OCRB14). Where access was possible, one of the watercourse crossings only displayed very minor evidence of bank erosion. Although these two crossings are situated within confined valleys, they are located along straight sections of channel and are situated perpendicular to the channel planform. Given the small size of the creeks and the lack of planimetric form adjustment observed, there is little risk associated with these proposed crossing locations.

The remaining three (3) watercourse crossing locations were identified as sensitive locations (OCRB7i, OCRB9-3b, and OCRB9-3d). This was based on the larger size of the channels, evidence of channel erosion (i.e., undercut banks, exposed roots along banks), and large nearby meander bends. Each of the crossings are situated at a perpendicular angle to the creek and existing valley; however, the crossings are situated along meandering sections of channel. Section 4.5 outlines preliminary recommendations for mitigation measures associated with the sensitive crossings outlined here. Each Alternative 2 crossing is depicted on Figure 4.2.2.2 provided in **Appendix A**.

Table 4.3 Channel characteristics at each crossing location for Alternative 2 (based on reach name)

Crossing Location (See Figure 4.2.2.2 in Appendix A)	Type of Feature	Valley Type	Evidence of Erosion	Riparian Vegetation	Average Bankfull Channel Width (m)	Average Bankfull Channel Depth (m)	Largest Meander Amplitude Measured along Reach (m)*	Meander Belt Width (m)*	Crossing Located Along Straight Channel Section	Crossing Situated at Perpendicular Angle to Channel	Valley Configuration	HDF Management Classification	Sensitive Crossing Location	Rationale for Sensitivity Classification
OCRB7	Watercourse	Partially confined	Yes (bank undercutting)	Mature trees, grasses, herbaceous plants	3.43	0.68	45	54	No	Yes	Perpendicular to valley; crosses along wide section of valley; preferred alignment would be at valley pinch point slightly downstream	n/a	Yes	Evidence of erosion at crossing location; defined valley walls; established riparian vegetation; crossing located near meander bend
OCRB7-4	HDF	Partially confined	Minor bank erosion	Grasses	0.8	0.33	n/a	n/a	Yes	Yes	Perpendicular to valley; no impacts given that feature is mitigation	Mitigation	No	n/a
OCRB9-3b	Watercourse	Partially confined	Yes (bank undercutting, exposed roots)	Mature trees, grasses	1.35	0.45	8	10	No	Yes	Generally perpendicular to valley	n/a	Yes	Evidence of erosion at crossing location; defined valley walls; established riparian vegetation; crossing located near meander bend
OCRB9-3d	Watercourse	Unconfined	Yes (bank undercutting)	Trees, grasses	1.75	0.55	18	22	No	Yes	Slightly diagonal to valley; potential impact from east-west road proposed immediately north; intersection may interact with top of bank	n/a	Yes	Evidence of erosion at crossing location; continuous riparian vegetation; crossing located near meander bend

Table 4.3 Channel characteristics at each crossing location for Alternative 2 (based on reach name)

Crossing Location (See Figure 4.2.2.2 in Appendix A)	Type of Feature	Valley Type	Evidence of Erosion	Riparian Vegetation	Average Bankfull Channel Width (m)	Average Bankfull Channel Depth (m)	Largest Meander Amplitude Measured along Reach (m)*	Meander Belt Width (m)*	Crossing Located Along Straight Channel Section	Crossing Situated at Perpendicular Angle to Channel	Valley Configuration	HDF Management Classification	Sensitive Crossing Location	Rationale for Sensitivity Classification
OCRB9-6	Watercourse	Confined	Minor bank undercutting	Grasses, herbaceous plants	0.9	0.33	n/a	n/a	Yes	Yes	Slightly diagonal to valley, although existing crossing will be upgraded	n/a	No	n/a
OCRB14	Watercourse	Confined	No site access	Trees, grasses	No site access	No site access	n/a	n/a	Yes	Yes	Perpendicular to valley	n/a	No	n/a
OCWB10-8	HDF	n/a	No access	Grasses, agriculture	No site access	No site access	n/a	n/a	Yes	Yes	n/a	No Management	No	n/a
OCWB10-	HDF	n/a	No access	Grasses, agriculture	No site access	No site access	n/a	n/a	Yes	Yes	n/a	Mitigation	No	n/a
OCWB11	HDF	n/a	No access	Grasses, agriculture	No site access	No site access	n/a	n/a	Yes	Yes	n/a	No Management	No	n/a
OCKB12i	HDF	n/a	No access	Grasses, agriculture	No site access	No site access	n/a	n/a	Yes	Yes	n/a	Mitigation	No	n/a
OCKB12ii	HDF	n/a	No access	Grasses, agriculture	No site access	No site access	n/a	n/a	Yes	Yes	n/a	Mitigation	No	n/a
OCKB12-1i	HDF	n/a	No access	Grasses, agriculture	No site access	No site access	n/a	n/a	Yes	Yes	n/a	Mitigation	No	n/a
OCKB12-1ii	HDF	n/a	No access	Grasses, agriculture	No site access	No site access	n/a	n/a	Yes	No	n/a	Mitigation	No	n/a
OCEB4-5i	HDF	n/a	No access	Grasses, agriculture	No site access	No site access	n/a	n/a	Yes	No	n/a	No Management	No	n/a
OCEB4-5ii	HDF	n/a	No access	Grasses, agriculture	No site access	No site access	n/a	n/a	Yes	Yes	n/a	No Management	No	n/a

Note:
* Largest meander amplitude and meander belt width (m) defined under the Columbus S.W.S. Phase 1 Report

4.5 Preliminary Recommendation of Mitigation Measures

To support the impact assessment for Alternative 2, preliminary recommendations have been developed with regards to mitigation measures for all proposed crossings. **Table 4.4** provides an overview of recommendations associated with the three (3) sensitive crossings identified in Alternative 2. General recommendations are also summarized below to support all other proposed crossings.

Overall, crossing siting and design should aim to avoid damage to infrastructure and minimize channel contact with the crossing infrastructure to reduce erosion hazards. As such, the proposed crossings should all consider potential future channel erosion and/or migration, be aligned perpendicular to the channel, maintain sediment transport processes and velocity differentials, and be positioned within a relatively straight or stable section of channel. If disturbance of riparian vegetation is anticipated, it may also be beneficial to install a channel under the crossing that is reinforced with hydraulically sized and native materials. This will stabilize the channel and allow for fish passage across a range of conditions. Crossing configurations should also address valley setting. Where possible, crossings should be perpendicular to the valley and cross along the shortest path. In some cases where the channel is not parallel to the valley, it is difficult to have the crossing be perpendicular to both the valley and channel. In these cases, the crossing should be perpendicular to the watercourse and, where possible, take the shortest path across the valley. In these specific cases, configuration of crossing structures should be parallel to the significant hydraulics or flow pathways of major events. An effort should also be made to limit fill in the valley, where possible.

Given that most of the channels in the study area are low order streams or poorly defined headwater drainage features, there is no associated risk to infrastructure given the limited potential for channel migration. As such, a minimum crossing opening of three (3) times the bankfull channel width is considered to be appropriate. From a geomorphological perspective, this approach provides an adequate width to address channel migration, sediment transport continuity, and potential changes in velocity differentials.

It should be noted that the proposed crossings for HDFs are all associated with *Mitigation* or *No Management* features. Unless the maintenance of flow and sediment is prescribed as part of mitigation, it is likely that these crossings will not be required.

As part of the detailed impact assessment for Alternative 2, three (3) watercourse crossings were identified as sensitive based on several factors including channel valley setting, evidence of erosion, density and type of riparian vegetation, channel size and stability, meander belt width, and position and amplitude of local or upstream meander bends. Preliminary crossing sizes and mitigation recommendations are outlined for these crossings in **Table 4.4** below. Minimum watercourse crossing geometry requirements for terrestrial ecology (wildlife passage) and surface water conveyance should also be taken into full consideration.

Table 4.4 Mitigation measures for Alternative 2 sensitive crossing locations

Crossing Location (Reach Name)	Valley Type	Bankfull Width (m)	Meander Belt Width (m)*	Recommended Minimum Crossing Span (m)**
OCRB7	Partially confined	3.43	54	10.29
OCRB9-3b	Partially confined	1.35	10	4.05
OCRB9-3d	Unconfined	1.75	22	5.25

Notes:

* Based on Phase 1 S.W.S.

** Based on 3 times the bankfull channel width

Although the crossings outlined above were identified as sensitive, the channels are still considered to be reasonably small. A preliminary crossing size of three (3) times the bankfull channel width will likely address channel erosion and migration. The crossing sizes provided span a portion of the meander belt width. It should be noted that the meander belt widths determined under the Columbus S.W.S. Phase 1 Report were completed at a planning level. Given the scale of the analysis, it is likely that meander amplitude measurements were based on compound meanders. As such, there is an opportunity to refine meander belt widths during future planning stages.

The recommendations outlined here for the proposed crossing alignments are based solely on geomorphological and erosion considerations. Other disciplines will also need to be considered including terrestrial ecology and surface water conveyance requirements.

5.0 Aquatic Natural Heritage

5.1 Overview of Existing Conditions

The Columbus S.W.S. Phase 1 Report provided a characterization and inventory of aquatic habitat conditions of watercourse features using both desktop and field data collections. The study included a thorough background review of existing documentation related to the Oshawa Creek watershed and Columbus Planning Area. Field studies included headwater drainage feature assessments, continuous water temperature monitoring from June to December, aquatic habitat assessments, fish community sampling through electrofishing and benthic invertebrate sampling and analysis.

The results of the combined desktop and field data collection and analysis were used to complement previous characterization work completed by C.L.O.C.A., and identify habitat sensitivities to guide the establishment of appropriate setbacks to development as well as formulate recommendations for stormwater management and other mitigation approaches during future land use planning exercises.

The Boundary Area is flanked on its west and east limits by the Raglan West Branch (Columbus Road West and Thornton Road North) and East Oshawa Creek (Howden Road East and Ritson Road North), respectively. Both of these prominent tributaries are generally healthy coldwater systems supporting populations of salmonids. The Raglan Main Branch extending through the hamlet of Columbus is fed by the West, Central and East Tributaries draining from lands north of Columbus Road East. These Raglan tributaries within the confines of the Boundary Area exhibit groundwater discharge and cold to cool stream temperatures, habitat characteristics that are representative of coldwater fish habitat consistent with other areas of the C.L.O.C.A. jurisdiction within Oshawa Creek and other watersheds. However, the Grandy Pond, present on the Raglan Main Branch at Thornton Road North, forms a distinct barrier to fish that could potentially migrate into the Raglan tributaries to utilize areas exhibiting potential coldwater habitat conditions. The pond also has a thermal impact on the reaches of the Raglan Main Branch downstream of the dam. The Grandy Pond is an impediment to allowing coldwater fish communities access to the various Raglan tributaries within the hamlet of Columbus and the surrounding area.

Upstream of the Grandy Pond, habitat characteristics such as coarse substrates and woody debris cover are similar to those of the West Branch, although flow levels and volumes are generally less. Vertical upward groundwater gradients have been measured in the much of the Main Branch extending into Columbus, and the presence of watercress, marl and iron staining confirms that groundwater is contributing to flows. Based on the habitat conditions, it would be possible for coldwater species such as Brown Trout to move from the confluence area of the West and Main branches and utilize habitat similar to that which is being accessed in the West Branch, particularly in forested reaches below the confluence with the West Tributary. At a minimum, these reaches could serve as potential spawning areas and nursery habitat, providing recruitment back into the larger system of the West Branch and downstream of the confluence of the Main and West Branches. The Central Lake Ontario Fisheries Management Plan recommends managing for coldwater fish habitat in this area of Oshawa Creek (C.L.O.C.A., 2007).

Aquatic features that provide a constraint to development were identified in the Phase 1 assessment for the Boundary Area using policies of the PPS (MMAH, 2014), the City of Oshawa OP (2016), and guidance documents including Developing C.L.O.C.A.'s Natural Heritage System: A Methodology (C.L.O.C.A., 2011). Recommended M.V.P.Z.s follow the Oshawa OP unless otherwise stated and are subject to change as determined via site-specific study. Features and recommended M.V.P.Z.s related to aquatic habitat are summarized in **Table 5.1** below.

Table 5.1 Aquatic Habitat Constraints to Development and Buffer Recommendations

Feature	Present in Boundary Area (Y/N)	M.V.P.Z. (City of Oshawa Official Plan 2019)	M.V.P.Z. Source (Greenbelt Plan)
Fish habitat	Y	All land within 30 m of any part of the feature Source: City of Oshawa Official Plan 2019, as amended	30 m measured from the outside boundary of the feature Source: Greenbelt Plan (MMAH 2017)
Permanent and intermittent streams	Y	N/A	30 m measured from the outside boundary of the feature Source: Greenbelt Plan (MMAH 2017)
Significant valleyland	Y	All land within 30 m of stable top of bank; features to be delineated via site-specific study Source: City of Oshawa Official Plan 2019, as amended	To be determined via site-specific study Source: Greenbelt Plan (MMAH 2017)

In addition to the guidance provided in the documents identified in **Table 5.1** above, the Central Lake Ontario Fisheries Management Plan indicates that a 30 m vegetated buffer is required along streams supporting coldwater habitat, and that 30 m plus meander belt buffers should be encouraged where possible (C.L.O.C.A., 2007).

5.2 Alternative 2 Impact Assessment

As summarized in **Table 4.1,** 15 crossings are proposed for Alternative 2. Five (5) of the crossings are associated with main watercourse features which consist of the main distinct Raglan Tributaries. Ten (10) of the crossings are associated with headwater drainage features (HDF), of which four have been assigned management classifications of *No Management Required* during Phase 1 of the S.W.S. The primary function of the HDFs is to convey flow and potentially nutrients to downstream areas where fish are likely to be present. These functions will not be impaired by the establishment of a crossing provided appropriate infrastructure dimensions are taken into consideration.

The main difference between Alternative 1 and 2 with respect to main watercourse crossings is the proposed crossing of the Raglan Main Branch upstream of the Grandy Pond and downstream of the confluence with the West Tributary to the Raglan Main Branch. Under present conditions, this area does exhibit conditions similar to coldwater habitats, however the Grandy Pond precludes the migration of coldwater species upstream from the Raglan West Branch. One consideration may be to consider management options that mitigate the Grandy Pond barrier during construction of this potential crossing.

5.3 Qualitative Assessment

As noted in previous sections dealing with crossings from both T.N.H.S. and fluvial geomorphological perspectives, alternatives were assessed to determine the number of new proposed watercourse crossings and ultimately, the T.N.H.S., as watercourse channels and their associated riparian corridors generally form the spine(s) of the N.H.S., providing linkages between larger blocks of woodland and prominent vegetation communities. An important consideration when assessing alternatives of the transportation fabric of a proposed community layout is the total number of watercourse crossings, with the goal of minimizing that number to extent feasible while also considering community and neighbourhood traffic flow and connectivity in a practical manner. In light of these considerations, the components of terrestrial natural heritage (as it relates to riparian corridors), fluvial geomorphology considerations, and aquatic habitat are closely tied together in the desire to minimize crossings where possible.

The analyses completed in the previous sections determined that Alternatives 1 and 2 were similar with respect to the number of watercourse crossings and in particular, the number of major or main watercourse crossings. As noted, both Alternatives 1 and 2 have fewer crossings, and major watercourses crossings are limited. In contrast, Alternative 3 has a significantly greater number of crossings, with more impacts associated with main watercourse features such as the various branches of the Raglan drainage. Comparisons of these crossings have been provided in Sections 3 and 4 above, and because of the interrelationships previously mentioned, provide an accurate representation of the same issues associated with aquatic habitat when considering crossing impacts.

The quality of aquatic habitat includes the elements of physical habitat attributes such as channel dimensions, floodplain connectivity, pools, riffles, woody debris combined with the properties of water quantity and quality. With respect to road crossings, the effect on the physical habitat is the primary concern and is linked directly to the effect on fluvial geomorphology attributes. The analysis of crossing frequency and infrastructure considerations from a fluvial perspective is therefore a good surrogate for resulting effects on fish habitat.

As noted previously, there are no significant differences between Alternatives 1 and 2 from a fluvial perspective, and this carries through to a similar conclusion related to effects on physical aquatic habitat. Alternative 3 is not preferred given the frequency and orientation of the crossings proposed.

5.4 Preliminary Recommendation of Mitigation Measures

The primary preference for crossing orientation and design with respect to aquatic habitat is closely aligned with that for fluvial geomorphology, as the main consideration is to reduce impairment to the physical channel characteristics and functions to the extent feasible. This generally consists of orienting structures in a perpendicular fashion to the channel (generally at the thalweg crossover) in order to avoid erosive forces at meander bends.

From an aquatic habitat perspective, crossing structures should allow for the passage of flow during high flows and under summer baseflow conditions, and should not create a barrier to fish passage in fish bearing streams under high flow conditions. Consideration should be given to providing structures that at least pass the bankfull flows (those flows that occur up to the point where the watercourse spills over its banks) and spans greater than bankfull are encouraged. The fluvial assessment recommends structures be designed to provide an opening that is at least of three (3) times the bankfull width, which is adequate to allow for fish passage under a variety of flow conditions, while also providing some floodplain function within the structure to reduce flow velocities and erosive forces.

Additional mitigation measures that could be incorporated into future watercourse crossing design include:

- Consideration for the use of open-bottom structures that allow for natural substrates on the channel bottom within the structure. Where open-bottom structures are not feasible due to cover requirements or other structural issues, crossings could be backfilled with substrate similar to the native material.
- Consideration for providing a staged or tiered low flow channel within the structure. Spans of three (3) times bankfull width should be provided with a low flow channel similar to existing channel dimensions to allow for concentrated flows that allow fish passage under low or baseflow conditions.
- For longer spans, consider establishing resting pools at upstream and downstream ends of the structure and within the structure to allow for pausing spots between swim bursts for fish passing through during high flows.

In general, the considerations outlined for terrestrial and fluvial mitigation will be equally beneficial to aquatic habitat form and function.

6.0 Surface Water

6.1 Overview of Existing Conditions

The Columbus S.W.S. Phase 1 Report included an updated existing conditions surface water assessment of lands situated within both the Study Area and Boundary Area. The 916.5 ha Boundary Area overlaps four (4) Oshawa Creek Subwatersheds including Raglan, Windfields, Kedron and Enfield. The Boundary Area Subwatershed composition can be broken down as Raglan (59.8%) and headwater areas of the Windfields (24.8%), Kedron (9.3%) and Enfield (6.1%). Refer to Figure 4.2.1 in the Columbus S.W.S. Phase 1 Report for subwatershed area delineations within the Boundary Area, which is provided in **Appendix B** of this memorandum. The prominent existing land uses within the Boundary Area consist of agricultural and natural open spaces with recreational, rural residential and localized commercial uses near the intersection of Columbus Road and Simcoe Street.

Water quality samples were collected by the Columbus S.W.S. Team at 13 monitoring stations during 2016. Water quality sampling identified instances of Provincial Water Quality Objective (P.W.Q.O.) exceedances for parameters including: phosphorus, iron, cadmium, chromium, cobalt, copper, lead, vanadium and zinc at select locations. High concentrations of total phosphorus and iron were observed at most of the monitoring stations with event mean concentrations of these two parameters exceeding P,W,Q,O limits. For the rest of the parameters stated above, individual exceedances of P,W,Q,O limits were observed. However, the mean concentrations calculated for all the stations were found to be below the P,W,Q,O limits. Refer to Figure 4.4.1 in the Columbus S.W.S. Phase 1 Report for monitoring station locations.

Streamflow and baseflow monitoring were also recorded at the same 13 monitoring stations. Average daily flows ranged from 0.0 L/s to 134 L/s while average baseflows ranged from 0.0 L/s to 131 L/s during the monitoring period. Headwater features within the Boundary Area are generally classified as ephemeral and main tributary features classified as perennial. The groundwater table is generally found to occur in the Oak Ridges Moraine (**ORM**) Deposits or slightly above these deposits near the base of the Halton Till. Overall, variations in local topography predominantly dictate groundwater depths across the Boundary Area, with the water table being shallowest near the valleys of the Raglan Main and West Branches, which tend to receive appreciable groundwater flow contributions in the surface water features throughout the year. Refer to Figure 4.4.1 in the Columbus S.W.S. Phase 1 Report for monitoring station locations.

The Columbus S.W.S. Team prepared an updated Visual OTTHYMO model for the Oshawa Creek Watershed to include an updated existing conditions simulation. The updated existing conditions model included additional subcatchment area discretization within the Study Area and Boundary Area. The Highway 407 corridor, Windfields East and Windfields West neighbourhoods (west of Windfields Tributary) and Kedron Part II Planning Area were considered to be fully constructed in the updated existing conditions model. Updated existing conditions peak flows for the 1-year through 100-year (12-hour Chicago Rainfall Distribution) and Regional Storm events were determined at discrete locations within the Study Area, Boundary Area and full Watershed.

An updated existing conditions HEC-RAS model was prepared for all watercourses that receive drainage from 125 ha areas (or greater) within the Boundary Area. Culvert and bridge geometries for all watercourse crossings within, and immediately adjacent to, the Boundary Area were confirmed by Stantec either through field inspection or more detailed topographic survey. Updated existing conditions peak-flows were inserted into the HEC-RAS model to simulate a more precise existing conditions hydraulic condition throughout the Boundary Area. Updated flood hazard mapping yielded slightly greater flood hazard extents when compared to background C.L.O.C.A. mapping. However, flood hazards are generally confined to the valley corridor system within the Boundary Area and generally not considered to be the most restrictive constraint/hazard to future development.

The conveyance capacity of all municipal roadway crossings within the Boundary Area were assessed. In general, 28 culverts were assessed indicating that 12 crossings are hydraulically sufficient and 16 crossings are considered to be deficient by current hydraulic engineering standards, as outlined in the S.W.S. Phase 1 Report. Additionally, the Highway 407 crossings were ‘unknown’ due to insufficient availability of background information along the corridor at that time. Detailed topographic survey of these four (4) existing culvert crossings underneath Highway 407 were subsequently captured in April 2019.

6.2 Alternative 2 Impact Assessment

It is generally recognized that new development in the Province of Ontario and within C.L.O.C.A.’s jurisdiction will need to demonstrate **water quality** treatment to achieve the Ministry of Environment, Conservation & Parks (M.E.C.P.) Enhanced (Level 1) treatment to achieve the long-term average removal of 80% Total Suspended Solids (T.S.S.). There are a variety of stormwater management (S.W.M.) solutions capable of satisfying this requirement to support land development. it is not the intent of this memorandum to prescribe an overall water quality strategy for the Boundary Area. The Columbus S.W.S. Phase 2 Report will provide a recommendation as it relates to suitable water quality treatment solutions for the preferred alternative.

Anticipated **water balance** related impacts and the unmitigated post-development rates of infiltration/runoff are summarized separately in Section 7. Low Impact Development (L.I.D.) alternatives will need to be utilized to reduce surface water runoff and promote infiltration to pre-development levels and support groundwater recharge functions throughout the Boundary Area. The maintenance of groundwater recharge functions in combination with preservation of the N.H.S. and implementation of stormwater management practices, offer the most beneficial solutions for mitigating runoff impacts, which in turn enhance surface water quality, improve aquatic habitat, and manage sediment supply and channel form. Similarly, it is not the intent of this memorandum to prescribe an overall water balance strategy for the Boundary Area. The Columbus S.W.S. Phase 2 Report will provide a recommendation as it relates to suitable criteria for the preferred alternative and future design. There will be a variety of L.I.D. solutions capable of satisfying this requirement to support future land development.

Similarly, **erosion control** requirements for the overall Boundary Area will be identified through an Erosion Threshold Analysis, which will be completed as part of the Columbus S.W.S. Phase 2 Report. A fluvial geomorphic assessment of the presented alternatives is provided in the preceding Section 4.

The primary focus of the quantitative impact assessment has been undertaken to address **water quantity** control and surface water conveyance requirements by simulating uncontrolled hydrologic conditions, various controlled hydrologic scenarios and assessing preliminary hydraulic crossing requirements for new watercourse crossings using either HEC-RAS or CulvertMaster.

6.2.1 Hydrologic Assessment

The Columbus S.W.S. Phase 2 Report existing conditions Visual OTTHYMO hydrologic model was used as the baseline existing conditions for the overall Watershed. Refer to the Columbus S.W.S. Phase 2 Report for background regarding the development of the existing conditions hydrologic model.

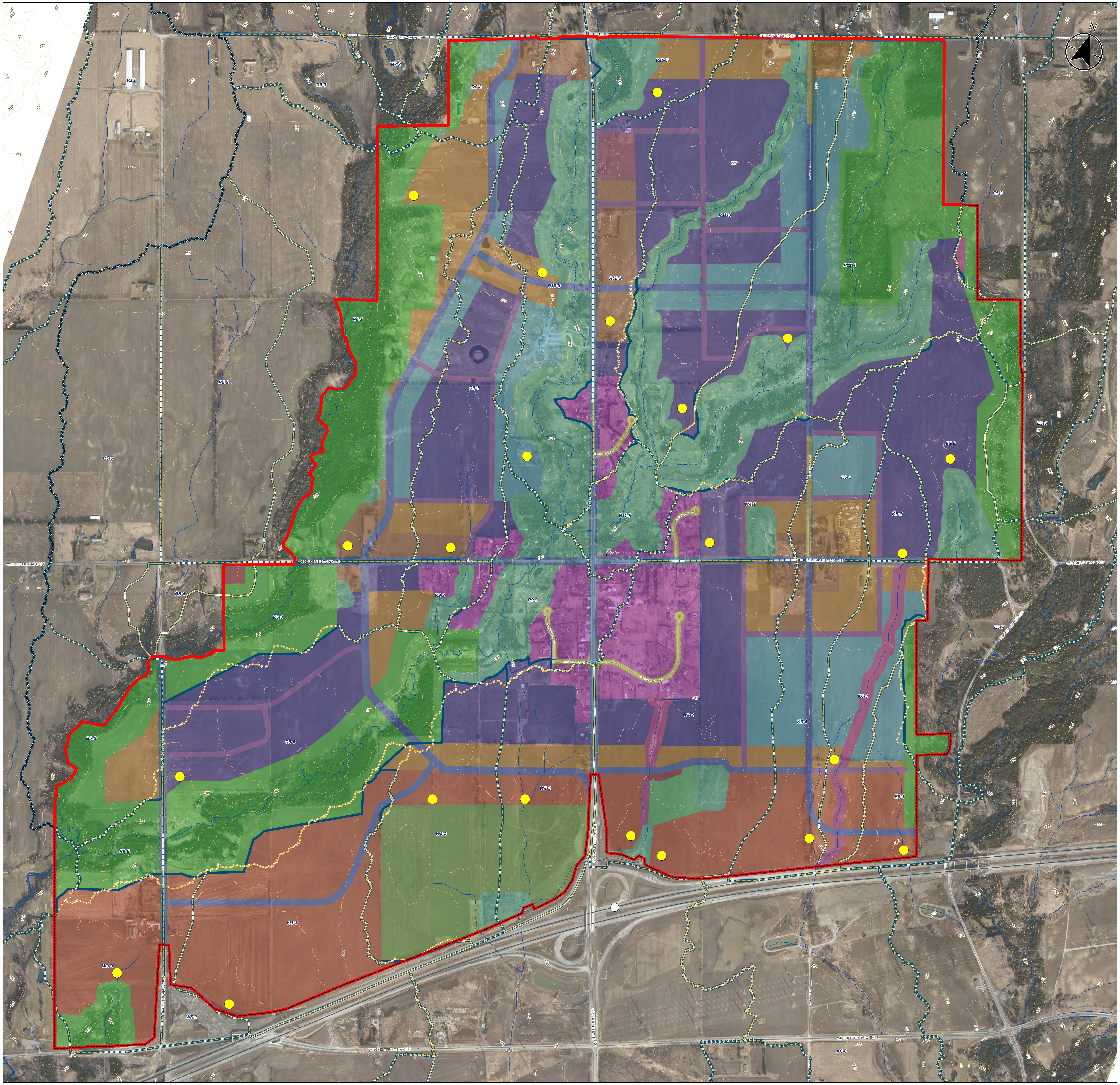
As part of the Alternative 2 hydrologic model update, Subcatchments within the Study Area were discretized to isolate N.H.S. areas from tableland areas. N.H.S. areas are denoted by the suffix ‘N’ for NashHYD and developed lands by the suffix ‘S’ for StanHYD. Subcatchment boundaries generally follow the existing conditions which were delineated using background topographic mapping provided by C.L.O.C.A. (First Base Solutions, 2010) and updated topographic mapping along the more recently constructed Highway 407 corridor. In instances where ‘orphaned’ development areas, less than 2 ha, straddled along a different subcatchment, these areas were merged with the larger connected development block and associated catchment to avoid excessive subcatchment fragmentation within a subwatershed scale hydrology model. The Columbus S.W.S. existing conditions hydrology model includes 112 subcatchments across the watershed while the proposed conditions Alternative 2 hydrology model includes 129 subcatchments. Subcatchments that did not abut against the Boundary Area were not adjusted under the proposed conditions simulation. The Windfields Secondary Plan Area and Kedron Part II Planning Area are fully developed under both existing and proposed conditions models.

Figure 6.1 illustrates the existing and proposed subcatchment area delineations overlaid on the Alternative 2 land uses. It is noted that all underlying existing land uses within the identified Special Policy Area have been carried forward under the proposed land use conditions. The ‘City Park Location Options’ presented on Alternative 2 have been fully excluded from the proposed conditions hydrologic analysis, which is considered to be a reasonable albeit slightly conservative assumption from a hydrologic standpoint. In addition, consistent with background hydrologic practices within the Oshawa Creek Watershed, high/medium/low density residential land uses have all been lumped under the category of 'urban residential' and apply the same runoff curve number by hydrologic soil group as previously applied.

For continuity purposes, subcatchment hydrologic model input parameters were recalculated using the same calculation methodology applied in the C.L.O.C.A. Hydrologic and Hydraulic update (C.L.O.C.A., 2014). Natural and rural subcatchments have been modeled using the Nashyd command (level of imperviousness <20%) and urban subcatchments using Standhyd (level of imperviousness >20%), which is consistent with the background modeling approaches. Runoff curve numbers (CN) and initial abstraction (IA) for Study Area and Boundary Area subcatchments were calculated on an area-weighted basis using background shapefiles including land uses for tableland areas, ecological land classification for natural areas and underlying hydrologic soils data for both. Time-of-concentration (Tc) and time-to-peak (Tp) were calculated either using the Bransby Williams or Airport method, depending on the calculated value of runoff coefficient for each unique subcatchment area. Bransby Williams equation is applied when the runoff coefficient is calculated to be more than 0.40 and the Airport equation is applied when runoff coefficient was found to be less than 0.40. Tc and Tp were recalculated for several areas within the Boundary Area due to the general discretization/separation of N.H.S. land and development lands within the proposed conditions model.

The baseline existing conditions and proposed conditions models consistently assume that the Windfields neighbourhoods are fully developed and without S.W.M. quantity control measures. Similarly, both existing and proposed models assume that Kedron Part II Planning Area is fully developed and S.W.M. quantity controls are in place for the 1-year through 100-year events. The drainage boundaries and hydrologic model input parameters presented in the Kedron Part II Planning Area MESP Addendum, dated May 2016, were utilized. Catchments and S.W.M. ponds discharging flows to Kedron Tributary 1 and Proposed Tributary 'A' realignment were lumped together to decrease the model resolution within the Kedron Part II Planning Area and to ensure general consistency with the background MESP model.

For continuity purposes, storm files used in the hydrology model continue to apply the 12-hour Chicago Distribution for the 2-year through 100-year events using the same C.L.O.C.A. applied total precipitation for the 2-year through 100-year events. In addition, the final 12-hours of the 48-hour Hurricane Hazel storm have been simulated as the Regional Storm for the Study Area. As per the C.L.O.C.A. Hydrologic and Hydraulic Update (C.L.O.C.A., 2014) an aerial adjustment factor of 95.4% was applied to Hurricane Hazel's rainfall data for the full 'downstream' watershed simulation. The applied CN's were increased for the 12-hour Hurricane Hazel simulation for both existing and proposed Regional Storm simulations to support the downstream assessment.



Stantec

GEO MORPHIX

Legend

- Conceptual Stormwater Pond Location
- Boundary Area
- Study Area
- Watercourse / Drainage Feature (CSWS)
- Major Road
- Minor Road

Catchment_Type

- Proposed Subcatchments (Stantec)
- Existing Subcatchments (Stantec)

Alternative 2 Land Use

- C.S.W.S. Natural Heritage System
- Columbus SPA
- Employment
- Existing Arterial
- Existing Local
- Green Belt Protected Countryside
- High Density Res
- Low Density Res
- MTO SAR Compensation Lands
- Medium Density Res I
- Medium Density Res II
- Mixed Use
- Prime Agricultural
- Proposed Arterial
- Proposed Collector
- Proposed Enhancement Area
- Proposed Linkage Area

0 250 500 metres

1:5,000 (At original document size of 34x44)

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2016, CLOCA, 2016.
3. Revised Alternative 2 information provided to Stantec from MSH on August 13, 2019.

Project Location

City of Oshawa

160622416 REVB

Prepared by SPE on 2019-09-13
Checked by TPG on 2019-09-13

Client/Project

COLUMBUS LANDOWNERS GROUP
COLUMBUS SUBWATERSHED STUDY

Figure No.

6.1

Title

Proposed Subcatchment Mapping

Given the Study Area encompasses a total contributing drainage area that is less than 25 km^2, no aerial reduction factor has been applied in the existing/proposed conditions 1-year through 100-year and Regional Storm models (MNRF, 2002) when identifying preliminary sizing requirements for proposed watercourse crossings. The application of aerial reduction for the Regional Storm hydrology model as part of the Downstream Flood Impact Assessment utilizes the same aerial reduction factor applied by C.L.O.C.A. (95.4%) in the Oshawa Creek Hydrologic and Hydraulic Modeling Update (C.L.O.C.A., 2014).

The Watershed Plan indicated that further assessments are to be completed on a study/project specific basis to determine whether or not S.W.M. quantity controls are necessary to support future development. As such, three (3) separate proposed conditions hydrologic simulations have been prepared to better understand the varying consequences on downstream lands within the watershed and to determine an appropriate quantity control strategy for Columbus. It is noted, as a minimum, that 100-year quantity controls will be required for headwater tributaries that drain into the Highway 407 corridor (Windfields, Kedron and Enfield) in order to demonstrate no adverse impacts on the MTO lands. It is common expectation that the MTO will not permit development to increase peak flows toward their culvert/bridge infrastructure for events up to and including the 100-year storm.

The three (3) proposed hydrologic simulations for the developed Boundary Area lands are summarized below:

- Simulation #1: No quantity controls for the Raglan Subwatershed and 2-year through 100-year quantity controls for the Windfields, Kedron and Enfield Subwatersheds with no areal reduction factor (Study Area Focus).
- Simulation #2: 2-year through 100-year quantity controls for the Raglan, Windfields, Kedron and Enfield Subwatersheds with no areal reduction factor (Study Area Focus).
- Simulation #3: 2-year through Regional quantity controls for the Raglan, Windfields, Kedron and Enfield Subwatersheds with the 48-hour Hurricane Hazel distribution and no areal reduction factor (Study Area Focus).

Table 6.1 summarizes the existing conditions peak flows and resulting proposed conditions flows at key locations within the downstream watershed. Refer to Figure 4.4.2 in the Columbus S.W.S. Phase 1 Report for specific node locations within the Oshawa Creek Watershed (provided in **Appendix B** of this memorandum).

As outlined in **Table 6.1,** it appears that development on lands within the Raglan Subwatershed may be able to proceed without requiring water quantity controls (Simulation #1). As discussed, lands within the Windfields, Kedron and Enfield Subwatershed areas will be expected to provide 2-year through 100-year quantity controls in order to satisfy MTO expectations. Conceptual locations of proposed S.W.M. ponds are illustrated on **Figure 6.1**. It is fully expected that there will be opportunities to further refine the number of S.W.M. ponds, relocate S.W.M. ponds, combine S.W.M. ponds, etc. as part of the Columbus S.W.S. Phase 2 Report and future planning stages.

It is recommended that the Part II Planning Team explore the potential to relocate the proposed protected corridor along OCKB13 further to the east by attempting to abut directly against the Greenbelt limit. This may improve the storm drainage serviceability for the medium density residential ‘sliver’ of land between the proposed corridor and Greenbelt and could potentially reduce the need for a separate S.W.M. pond. There are also likely natural environmental benefits of having the corridor abut the Greenbelt to the east as opposed to development on both east and west sides of the proposed corridor.

It is noted that these findings are considered to be preliminary and will be subject to further review and discussion with C.L.O.C.A. and City staff prior to preparing the Columbus S.W.S. Phase 2 Report.

Table 6.1 Downstream Hydrologic Assessment

Location Description	Node I.D.	Drainage Area (ha)	Peak Flows (m3/s) 2-year Ex Cond	2-year Sim #1	2-year Sim #2	2-year Sim #3	5-year Ex Cond	5-year Sim #1	5-year Sim #2	5-year Sim #3	10-year Ex Cond	10-year Sim #1	10-year Sim #2	10-year Sim #3	25-year Ex Cond	25-year Sim #1	25-year Sim #2	25-year Sim #3
West Branch of Oshawa Creek @ Downstream Boundary Area	11	2,158.32	16.25	19.41	16.09	16.09	29.82	30.30	30.05	30.05	40.00	38.10	37.72	37.72	53.86	47.95	47.94	49.65
Highway 407	5	3,502.11	22.64	21.36	21.60	21.60	40.52	37.54	37.65	37.65	54.16	50.02	50.21	50.21	72.75	67.17	67.34	67.25
Taunton Road	34	9,416.30	42.02	40.97	40.82	40.82	70.93	69.88	69.43	69.43	93.18	91.79	91.36	91.36	124.03	122.37	121.89	121.79
Rossland Road	35	9,677.53	41.65	40.71	40.50	40.50	70.27	69.33	68.82	68.82	92.23	90.92	90.37	90.37	123.29	121.58	121.07	120.88
King Street	36	10,007.45	41.70	40.85	40.55	40.55	70.33	69.44	68.86	68.86	92.20	91.01	90.39	90.39	122.97	121.38	120.78	120.60
Highway 401	38	11,047.72	46.06	45.26	44.82	44.82	76.19	75.33	74.71	74.71	98.92	97.79	97.14	97.14	130.97	129.51	128.84	128.81
Lake Ontario	51	11,920.54	45.82	46.06	45.93	45.93	82.70	84.01	83.88	83.88	95.22	95.23	95.01	95.01	133.95	134.75	134.56	134.56

Location Description	Node I.D.	Drainage Area (ha)	Peak Flows (m3/s) 50-year Ex Cond	50-year Sim #1	50-year Sim #2	50-year Sim #3	100-year Ex Cond	100-year Sim #1	100-year Sim #2	100-year Sim #3	Regional Ex Cond	Regional Sim #3
West Branch of Oshawa Creek @ Downstream Boundary Area	11	2,158.32	64.95	57.81	57.50	57.50	76.54	68.00	67.28	67.28	197.29	187.95
Highway 407	5	3,502.11	87.47	80.78	81.40	81.40	102.87	94.75	95.62	95.62	287.36	282.77
Taunton Road	34	9,416.30	147.68	146.45	145.85	145.85	174.14	172.33	172.36	172.36	619.95	603.90
Rossland Road	35	9,677.53	146.59	145.25	144.61	144.61	172.68	170.78	170.68	170.68	626.63	607.32
King Street	36	10,007.45	146.46	145.14	144.52	144.52	172.40	170.56	170.24	170.24	634.92	612.26
Highway 401	38	11,047.72	155.49	154.43	153.54	153.54	182.16	180.53	180.27	180.27	692.50	667.56
Lake Ontario	51	11,920.54	162.44	162.69	162.49	162.49	183.17	183.30	183.08	183.08	696.49	679.01

(shaded) = Denotes increase in peak flow

6.2.2 Hydraulic Assessment

In light of the preliminary conclusions related to quantity controls summarized in Section 6.2.1, the proposed conditions (Simulation #1) was advanced forward to assess the potential hydraulic conveyance impacts and required mitigation measures to support the preliminary sizing of proposed watercourse crossings and to assess the potential effects on already existing watercourse crossings.

A preliminary geometric recommendation for proposed watercourse crossings within the Boundary Area is provided in **Table 6.2.** In the absence of an overall conceptual grading plan and proposed roadway plan/profile information, it has been assumed that the roadway profile will generally run from top-of-bank to top-of-bank for all proposed valleyland crossings. Proposed roadway crossings over headwater features on tablelands have been assumed to be approximately 2.5 m above the existing channel invert elevation. These assumptions will be subject to further refinement when the Columbus S.W.S. Phase 2 Report is prepared and upon receiving the confirmed 'preferred alternative'.

The proposed (conceptual) watercourse crossings presented in **Table 6.2** have been sized to convey the 100-year storm. Impacts to the Regional Storm water-surface profile will also need to be assessed to determine if crossing specific impacts can be tolerated or if additional watercourse crossing conveyance capacity will be required to maintain Regional floodplain limits within valleyland areas, eliminate potential Regional water-surface elevation increases on non-participating lands and/or to prevent the proposed Regional floodplain from becoming the governing development constraint. The Columbus S.W.S. Phase 2 Report will investigate the consequences of the Regional Storm conveyance and recommended hydraulic geometries will be modified, if required.

As outlined in **Table 6.3** and **Table 6.4,** only two (2) existing watercourse crossings within or immediately adjacent to the Boundary Area are expected to be adversely impacted by the proposed development. The Columbus S.W.S. Phase 2 Report will further investigate potential replacement requirements (to meet present day hydraulic standards) for existing watercourse crossings within the Boundary Area.

Table 6.2: Minimum Hydraulic Crossing Geometry for Alternative 2 (Preliminary)

Crossing Location (Reach Name)	Type of Feature	Valley Type	Existing Riparian Vegetation	Average Bankfull Channel Width (m)	Major System Conveyance Criteria	Major System Peak Flow (m3/s)	Minimum Preliminary Crossing Geometry	Maximum Regional Storm HW Increase (m)	Regional Storm Increase contained within Valley Corridor (yes/no)	Regional Storm Increase on Non-Participating Lands (yes/no)	Comments
OCRB7	Watercourse	Partially confined	Mature trees, grasses, herbaceous plants	3.43	100 Year	42.6	12 x 3	0.52	yes	no	Proposed Arterial,
OCRB7-4	HDF	Partially confined	Grasses	0.8	100 Year	15.33	2X3.6x1.8		yes	no	Proposed Arterial,
OCRB9-3b	Watercourse	Partially confined	Mature trees, grasses	1.35	100 Year	12.9	2x3.0x1.5		yes	no	Proposed Arterial,
OCRB9-3d	Watercourse	Unconfined	Trees, grasses	1.75	100-year	12.9	2x3.0x1.5		yes	no	Proposed Arterial,
OCRB9-6	Watercourse	Confined	Grasses, herbaceous plants	0.9	100-Year	7.3	6x 2.4	0.84	yes	no	Proposed Arterial,
OCRB14	Watercourse	Confined	Trees, grasses	No site access	100 Year	19.7	7 x 2.4	0.40	yes	no	Proposed Arterial,
OCWB10	HDF	n/a	Grasses, agriculture	No site access	100 Year	3.9	2x2.4x1.5		yes	no	Proposed Arterial,
OCWB10-4	HDF	n/a	Grasses, agriculture	No site access	100 Year	6.3	2x2.4x1.8		yes	no	Proposed Arterial,
OCWB11	HDF	n/a	Grasses, agriculture	No site access	50 Year	2.2	3.6x1.8		yes	no	Proposed Arterial,
OCKB12 (U/S)	HDF	n/a	Grasses, agriculture	No site access	100 Year	2.0	3.6x1.8		yes	no	Proposed Arterial,
OCKB12 (D/S)	HDF	n/a	Grasses, agriculture	No site access	100 Year	5.4	2x3.0x1.5		yes	no	Proposed Arterial,
OCKB12-1 (U/S)	HDF	n/a	Grasses, agriculture	No site access	50 Year	3.1	2.4x1.5		yes	no	Proposed Arterial,
OCKB12-1 (D/S)	HDF	n/a	Grasses, agriculture	No site access	50 Year	5.4	3.6x1.5		yes	no	Proposed Arterial,
OCEB4-5 (U/S)	HDF	n/a	Grasses, agriculture	No site access	50 Year	0.22	0.9		yes	no	Proposed Arterial,
OCEB4-5 (D/S)	HDF	n/a	Grasses, agriculture	No site access	50-year	0.22	0.9		yes	no	Proposed Arterial,

Table 6.3 Assessment of Existing Bridges/Culverts on Watercourses (WC-1)

Crossing I.D.	Conveyance Capacity		Adverse Hydraulic Impact (Yes/No)	Comments
	Existing Compliance	Future Compliance		
Rural Arterial, Collector Road (Total Span less than or equal to 6.0 m): 25-yr Conveyance Capacity				
HR1 (4)	✗	✗	No	Future Development will not increase flows
HR2 (3)	✗	✗	No	Future Development will not increase flows
HR3 (2)	✓	✓	No	Future Development will not increase flows
HR4 (6)	✓	✓	No	Future Development will not increase flows
CR2(22)	✓	✓	No	Future Development will not increase flows. Free board is ok (Box culvert 4.85x 2.76)
SS2 (21)	✓	✓	No	Future Development will increase both Regional and 100-year flows, upstream water elevations will raise slightly, but the free board is still ok. Flow is contained within valley (Box culvert 5.9x 2.91)
SS5 (66)	✓	✓	No	Future Development will decrease both Regional and 100-year flows. Slightly lower upstream water elevations and free board is ok for 100-year. Road slightly overtopping during Regional for both existing and proposed (Elliptic 2.5 x3)
RR2 (58)	✓	✓	No	Future Development will not increase flows
RR3 (24)	✗	✗	No	Future Development will not increase flows; Existing structure is currently deficient

Table 6.3 Assessment of Existing Bridges/Culverts on Watercourses (WC-1)

Crossing I.D.	Conveyance Capacity		Adverse Hydraulic Impact (Yes/No)	Comments
	Existing Compliance	Future Compliance		
Rural Arterial, Collector Road (Total Span greater than or equal to 6.0 m): 100-yr Conveyance Capacity				
CR4 (70)	✓	✓	No	Future Development will not increase flows; Existing structure is currently flooded during Regional storm
TR1 (63)	✓	✓	No	Future Development will not increase flows; Existing structure is currently flooded during Regional storm
TR2 (49)	✓	✓	No	Future Development will not increase flows; Existing structure is currently flooded during Regional storm

Note: Number in brackets denotes CLOCA's watercourse crossing I.D.

Table 6.4 Assessment of Bridges/Culverts Collecting Surface Drainage (SD-1)

Crossing I.D.	Existing Conditions		Future Conditions		Adverse Hydraulic Impact (Yes/No)	Comments
	Minor System	Major System	Minor System	Major System		
Freeway, Urban Arterial, Rural Arterial, Collector Road						
HR5	×	×	×	×	No	Future Development will not increase flows
HR6	×	×	×	×	No	Future Development will not increase flows
HR7	×	✓	×	✓	No	Future Development will not increase flows
HR8	✓	×	✓	×	No	Future Development will not increase flows
CR1	×	✓	×	✓	No	Future Development will not increase flows
CR3	×	×	×	×	Yes	Future Development will increase flows

Table 6.4 Assessment of Bridges/Culverts Collecting Surface Drainage (SD-1)

Crossing I.D.	Existing Conditions		Future Conditions		Adverse Hydraulic Impact (Yes/No)	Comments
	Minor System	Major System	Minor System	Major System		
CR5	✗	✗	✗	✗	No	Future Development will not increase flows
CR6	✗	✗	✗	✗	No	Future Development will not increase flows
CR7	✗	✗	✗	✗	No	Future Development will not increase flows
WR1	✓	✗	✓	✗	No	Future Development will not increase flows
WR2	✗	✗	✗	✗	No	Future Development will not increase flows
TR3	✓	✓	✓	✓	No	Future Development will not increase flows
SS1	✓	✓	✓	✓	No	Quantity Controls to be applied for all lands draining directly to MTO corridor
SS3	✗	✗	✗	✗	No	Future Development will not increase flows
SS4	✓	✓	✓	✓	No	Future Development will not increase flows
RR1	✓	✓	✓	✓	No	Future Development will not increase flows
407-1	✗	✗	✗	✗	No	Quantity Controls to be applied for all lands draining directly to MTO corridor. The culvert doesn't appear to have sufficient capacity.
407-2	✓	✓	✓	✓	No	Quantity Controls to be applied for all lands draining directly to MTO corridor. This culvert conveys local drainage
407-3	✓	✓	✓	✓	No	Quantity Controls to be applied for all lands

Table 6.4 Assessment of Bridges/Culverts Collecting Surface Drainage (SD-1)

Crossing I.D.	Existing Conditions		Future Conditions		Adverse Hydraulic Impact (Yes/No)	Comments
	Minor System	Major System	Minor System	Major System		
						draining directly to MTO corridor. The culvert has sufficient capacity to convey post development 100-year and Regional events
407-4	✓	✓	✓	✓	No	Quantity Controls to be applied for all lands draining directly to MTO corridor. The culvert has sufficient capacity to convey post development 100-year and Regional events

Note: The major and minor system flows are the 100-year and 10-year storms, respectively.

6.3 Qualitative Assessment

As outlined in Section 2.0 there are very subtle variations to the proposed land uses when comparing the three (3) alternatives at the Boundary Area scale. Based on typical percent impervious cover assumptions, the aggregate total impervious area for each alternative is expected to be approximately 379 ha, 376 ha and 379 ha for Alternatives 1, 2 and 3, respectively. These values suggest that approximately 41.4%, 41.0% and 41.4% of the overall 916.5 ha Boundary Area may become impervious cover under the full buildout condition. Albeit these are very small differences, it would appear that Alternative 2 proposes the least amount of impervious surface cover, which is generally preferable from a surface water perspective. However, it is highly unlikely that either Alternatives 1 and 3 would have the potential to significantly change the preliminary findings of the proposed conditions model simulations summarized herein to provide interim feedback to the Part II Planning Team.

Alternatives1 and 2 were similar with respect to the number of watercourse crossings and in particular, the number of main watercourse crossings. As already noted, both Alternatives 1 and 2 have fewer crossings, and major watercourses crossings are limited. In contrast, Alternative 3 has a significantly greater number of crossings, with more impacts associated with main watercourse features such as the various branches of the Raglan drainage. The floodplain conveyance capacity of a watercourse has the potential to experience localized disturbance during infrequent events due to watercourse crossings. Watercourse crossings are typically sized to ensure no adverse flood related impacts are experienced along the valley corridor; however, this comes at a higher cost with an increased number of proposed crossings. It is recommended that the Transportation Planning staff review the requirements for watercourse crossings and attempt to limit, to the greatest extent practicable, without adversely impacting the future transportation level-of-service within the Boundary Area.

In summary, there are no significant differences between Alternatives 1 and 2 from a flood conveyance perspective. Similar to preceding Sections, Alternative 3 is not preferred given the frequency and orientation of the crossings proposed.

6.4 Preliminary Recommendation of Mitigation Measures

To support the impact assessment for Alternative 2, preliminary recommendations have been developed with regards to mitigation measures. These mitigation measures have generally been provided regarding S.W.M., watercourse crossings and valley corridors. These recommendations are all considered to be ‘preliminary’ and will be subject to further review and adjustment as part of the Columbus S.W.S Phase 2 Report.

Stormwater Management:

- Preliminary siting of conceptual S.W.M. pond locations have been provided on **Figure 6.1.** These locations are considered to be very flexible and will be subject to further refinement during the Phase 2 Report work program. It is fully expected that there will be opportunities to further refine the number of S.W.M. ponds, relocate S.W.M. ponds, combine S.W.M. ponds, etc. as part of the Columbus S.W.S. Phase 2 Report and future planning stages.
- In general, opportunities to reduce the quantity of S.W.M. ponds, without impeding development phasing plans, should be considered. For example, if the future employment lands along the north side of the Highway 407 corridor are anticipated to lag residential development, then separate S.W.M. ponds within the same subcatchment area may be necessary to independently service the residential and employment lands. Alternatively, combined S.W.M. facilities closer to the Highway 407 corridor could be considered to minimize the number of future S.W.M. ponds if employment land and residential lands are anticipated to advance simultaneously or if the employment lands will develop within initial phase(s). If combined stormwater management facilities end up being proposed closer to Highway 407, consideration will need to be given to supporting upstream baseflow in watercourses.
- For block planning purposes, S.W.M. ponds that provide both water quality and quantity controls are typically expected to consume a block area that is roughly equivalent to 6-7% of the overall contributing drainage area. Block sizes for S.W.M. ponds that provide water quality and erosion controls only may be reduced to approximately 4% to 6% of the overall contributing drainage area. A conceptual grading/servicing plan(s) ultimately help to determine precise pond block requirements.
- Water quality controls will need to satisfy M.E.C.P. Enhanced (Level 1) requirements throughout the Boundary Area;

- Water quantity controls will appear to include 2-year through 100-year controls for lands within the Windfields, Kedron and Enfield subwatersheds in order to satisfy MTO expectations near the Highway 407 corridor. Preliminary modelling suggests that water quantity controls for lands within the Raglan subwatershed, which comprises approximately 59.8% of the overall Boundary Area, will not be required based on preliminary downstream hydrologic analyses. No Regional quantity controls are expected for the Boundary Area. Further assessment will be undertaken to determine if localized peak-flow increases during more frequent events (2-year, 5-year and 10-year storms) along downstream reaches will pose any unacceptable increased risks under 'Simulation #1'. In addition, it is expected that further discussion with C.L.O.C.A. and the City will be necessary to confirm an agreed upon final water quantity control criteria for the Boundary Area.

- Water balance requirements will need to consider distributed L.I.D. measures throughout the Boundary Area to offset anticipated impacts to existing infiltration rates/volumes. Section 7.0 provides a more focused review of unmitigated impacts when comparing Alternative 2 against existing conditions and outlines further water balance strategy considerations. There are opportunities to effectively implement L.I.D. measures by strategically siting within High Volume Recharge Areas (H.V.R.A.) and Ecologically Significant Groundwater Recharge Areas (E.S.G.R.A.) locations that are scattered throughout the Boundary Area. Opportunities to situate L.I.D.s within buffer areas also pose a significant opportunity to address water balance requirements;

- Erosion Control requirements will be determined through an Erosion Threshold Analysis, which will be prepared as part of the Part 2 Columbus S.W.S. Report. These recommendations will be derived to minimize potential for erosion within receiving systems within the Boundary Area and along downstream reaches.

- Thermal mitigation measures will need to be considered for end-of-pipe S.W.M. facilities to minimize impacts within receiving systems given the coldwater and coolwater classifications.

<u>Watercourse Crossings:</u>

Table 6.2 provides conceptual minimum hydraulic sizing recommendations for all new proposed watercourse crossings and **Table 6.3** and **Table 6.4** provides an overview of anticipated impacts to already existing watercourse crossings. Proposed new crossings and any proposed replacement crossings within the Boundary Area will generally be sized to convey the 100-year flow. Impacts to the Regional storm water-surface profile will also need to be assessed to determine if crossing specific impacts can be tolerated or if additional conveyance capacity will be required to maintain Regional floodplain limits within valleyland areas, eliminate increases on non-participating lands and/or to prevent the proposed Regional floodplain from becoming the governing development constraint. The Phase 2 Columbus S.W.S. Report will further assess watercourse crossing requirements for the preferred alternative and provide minimum hydraulic geometry recommendations.

Proposed Corridors:

It is recommended that the Part II Planning Team explore the potential to relocate the proposed protected corridor along OCKB13 further to the east by attempting to abut directly against the Greenbelt limit. This may improve the storm drainage serviceability for the medium density residential 'sliver' of land between the proposed corridor and Greenbelt and could potentially reduce the need for a separate S.W.M. pond.

7.0 Hydrogeology

7.1 Overview of Existing Conditions

Stantec completed a hydrogeological assessment of the Boundary Area as part of the Columbus S.W.S. Phase 1 Report to develop a conceptual understanding of existing hydrogeological conditions throughout this area. The assessment consisted of a desktop-level review of published geological and hydrogeological information sources coupled with the implementation of intensive field investigation program, which included the excavation of test pits, installation of monitoring wells and watercourse piezometers, seasonal monitoring of groundwater levels, and the performing of in-situ permeability testing of the surficial and subsurface soils. Ultimately, the purpose of the assessment is to evaluate how future development activities could potentially impact the form and/or function of the hydrogeological system and, particularly, how to preserve and/or enhance the existing the groundwater recharge function of the Boundary Area under the post-development condition (i.e., through the meeting of pre-development infiltration targets).

Results of the onsite drilling and test pitting program confirmed the distribution of surficial soils as presented in regional geological mapping for the Boundary Area to be accurate, as well as the regionally interpreted hydrostratographic conditions within the subsurface as presented in Kassenaar and Wexler (2006).

The subsurface investigation indicates that a layer of sandy silt topsoil covers the Boundary Area, ranging from 0.2 m to 1.5 m in thickness (average 0.4 m thick), which is typically underlain by 0.6 m to 10.7 m thick deposits Halton Till (i.e., sandy to clayey silt till) that could be as thick as 17 m based on regional model predictions. The thinnest deposits of Halton Till tend to occur along the valleys of the Raglan Main and West Branches and their associated tributaries. In several instances, these valleys cut through the Halton Till and directly intersect the underlying ORM Deposits (i.e., stratified sediment complex consisting of multiple sequences of fining upward deposits from glaciofluvial/outwash sands to glaciolacustrine silts and clays). Within some areas of the Boundary Area, glaciofluvial deposits of sand, silty sand and sandy silt form a thin surficial layer that overlies the Halton Till (0.3 to 1.7 m thick), extending along the top of the glacial till and connecting to alluvial deposits that occupy the valleys of the Raglan Main and West Branches, and the East and Central Tributaries to the Main Raglan Branch.

Throughout the Boundary Area, the water table is generally found to occur in the ORM Deposits or slightly above these deposits near the base of the Halton Till. Overall, variations in local topography predominantly dictate groundwater depths across the Boundary Area, with the water table being shallowest near the valleys of the Raglan Main and West Branches. Groundwater flow generally follows the overall topographic slope of the Boundary Area, moving in a south to southwestern direction from Howden Road East towards Highway 407, with a component of this flow being directed towards the various watercourses that occupy these lands.

In general, identified High Volume Recharge Areas (HVRA) overlap the surficial glaciolacustrine and alluvial deposits that cover the Boundary Area. These deposits likely provide a source of groundwater inputs to onsite watercourses through the process of interflow. In comparison, the Ecologically Significant Groundwater Recharge Areas (ESGRA) mapped within the Boundary Area represent the linkage between recharge areas and the ecological features sustained by this recharge such as streams, wetlands, or areas of scientific interest (ANSI). Although there is some overlap between the HVRAs and ESGRAs within the Boundary Area, the bulk of infiltration occurring within the ESGRAs appears to occur where the Halton Till is the predominant deposit.

Results of the pre-development water balance assessment completed for the landowner parcels that comprise the Boundary Area are presented in **Table 7.1** below. Details on the methods used to complete the water balance assessment and establish the pre-development infiltration targets are provided in Section 4.5.5.1 of the Columbus S.W.S. Phase 1 Report.

Table 7.1 Pre-Development Infiltration Targets

Water Balance Parcel	Precipitation		Evapotranspiration		Runoff		Infiltration	
	(m^3/yr)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)	(mm/yr)
1	47,344	921	28,684	558	12,677	246	5,982	116
2	55,923	921	33,736	555	13,027	214	9,163	151
3	149,921	921	90,878	558	35,379	217	23,665	145
4	242,569	921	146,853	557	65,406	248	30,312	115
5	331,002	921	200,292	557	84,192	234	46,518	129
6	366,399	921	222,733	560	71,039	178	72,632	182
7	43,218	921	25,974	553	7,329	156	9,914	211
8	144,060	921	87,174	557	34,123	218	22,763	145
9	556,942	921	332,442	549	140,600	232	83,899	139
10	417,950	921	253,697	559	100,134	221	64,121	141
11	90,597	921	55,081	560	20,598	209	14,918	152
12	650,742	921	394,422	558	157,988	223	98,332	139
13	35,172	921	21,337	558	9,222	241	4,612	121
14	454,792	921	275,194	557	81,408	165	98,190	199
15	91,994	921	55,435	555	17,524	175	19,035	190
16	91,392	921	55,184	556	20,920	211	15,289	154
17	72,854	921	43,751	553	19,337	244	9,767	123
18	910,468	921	550,166	556	179,136	181	181,188	183

Table 7.1 Pre-Development Infiltration Targets

Water Balance Parcel	Precipitation		Evapotranspiration		Runoff		Infiltration	
	(m^3/yr)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)	(mm/yr)
19	413,021	921	249,473	556	100,352	224	63,256	141
20	280,466	921	169,546	556	67,069	220	43,851	144
21	422,019	921	254,574	555	88,986	194	78,608	171
22	303,072	921	183,424	557	76,620	233	43,029	131
23	220,722	921	133,484	557	56,599	236	30,652	128
24	142,168	921	85,394	553	23,177	150	33,600	218
25	134,197	921	81,203	557	34,282	235	18,712	128
26	330,077	921	200,266	558	78,102	218	51,724	144
27	132,304	921	80,105	557	30,467	212	21,733	151
28	48,829	921	29,173	550	14,197	268	5,459	103
29	78,826	921	47,755	558	21,347	249	9,725	114
30	5,776	921	3,494	557	1,596	254	686	109
31	1,710	921	1,034	557	439	236	236	127
32	8,504	921	5,048	546	2,570	278	886	96
33	8,556	921	5,176	557	2,198	236	1,183	127
34	10,804	921	6,520	555	2,524	215	1,760	150
East Cluster	42,529	921	25,076	543	7,497	162	9,957	216
NE Cluster	210,872	921	126,303	551	48,467	212	36,102	158
North Cluster	29,612	921	17,564	546	8,928	278	3,119	97
NW Cluster	119,635	921	71,501	550	29,497	227	18,639	143
SE Cluster	192,436	921	113,926	545	54,863	262	23,647	113
SW Cluster	331,437	921	198,612	552	79,521	221	53,304	148
Total	**8,220,911 m^3/yr**		**4,961,683 m^3/yr**		**1,899,337 m^3/yr**		**1,360,171 m^3/yr**	

Annual infiltration rates range from 96 mm (Parcel 32) to 218 mm (Parcel 24). As per C.L.O.C.A. (2007), annual infiltration rates for the region in which the Boundary Area resides typically range from 100 mm to 200 mm. Overall, the annual volume of infiltration entering the subsurface within the landowner parcels under pre-development conditions ranges from approximately 240 m^3 (Parcel 31) to 181,190 m^3 (Parcel 18), for a total of 1,360,170 m^3 throughout the Boundary Area.

7.2 Alternative 2 Impact Assessment

As per the three (3) land use alternative development plans proposed for the Boundary Area, development is to consist of the construction of arterial and collector roadways, employment facilities, and low to high density residential homes and associated infrastructure. Associated with this development will be the introduction of impervious surfaces (e.g., rooftops, concrete/asphalt roadways, parking lots and walkways, etc.) and, subsequently, a corresponding reduction in the volume of water infiltrating to the subsurface.

Stantec performed a post-development water balance assessment for the Alternative 2 land development concept using the same methods utilized to complete the pre-development water balance. As with the pre-development water balance, each landowner parcel is broken down into a series of sub-areas based on topographic, soil type and land cover characteristics. For the calculations, Stantec assumed that the topographic slopes and underlying soils in each sub-area would remain relatively unchanged from pre-development conditions; however, land cover was adjusted to reflect the projected imperviousness cover percentages assigned to the various Land Use categories associated with the alternative development concept. Stantec also assumed that the remaining pervious areas for those land use categories containing impervious cover would consist of urban lawns and other vegetation associated with urban landscaping.

Results of the post-development water balance assessment completed for the Boundary Area are presented in **Table 7.2** below.

Table 7.2 Post-Development Infiltration (Unmitigated)

Water Balance Parcel	Precipitation		Evapotranspiration		Runoff		Infiltration	
	(m^3/yr)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)	(mm/yr)
1	47,344	921	21,666	421	20,435	397	5,242	102
2	55,923	921	11,318	186	41,488	683	3,117	51
3	149,921	921	51,700	317	84,848	521	13,373	82
4	242,569	921	69,231	263	158,212	600	15,125	57
5	331,002	921	87,423	243	223,667	622	19,912	55
6	366,399	921	177,889	447	132,790	334	55,720	140
7	43,218	921	21,480	458	12,787	272	8,951	191

Table 7.2 Post-Development Infiltration (Unmitigated)

Water Balance Parcel	Precipitation		Evapotranspiration		Runoff		Infiltration	
	(m³/yr)	(mm/yr)	(m³/yr)	(mm/yr)	(m³/yr)	(mm/yr)	(m³/yr)	(mm/yr)
8	144,060	921	57,122	365	71,707	458	15,231	97
9	556,954	921	218,714	361	278,996	461	59,244	98
10	417,950	921	147,371	325	230,724	508	39,855	88
11	90,598	921	52,173	530	23,550	239	14,875	151
12	650,742	921	266,099	376	311,623	441	73,020	103
13	35,172	921	16,018	419	15,293	400	3,861	101
14	454,792	921	150,216	304	253,826	514	50,750	103
15	91,994	921	35,708	357	44,245	443	12,041	120
16	91,392	921	25,543	257	58,388	588	7,235	75
17	72,854	921	14,292	181	55,618	703	2,945	37
18	910,468	921	290,091	293	513,740	519	106,637	108
19	413,021	921	75,173	168	320,440	714	17,409	39
20	280,466	921	84,728	278	173,273	569	22,465	74
21	422,019	921	110,951	242	272,936	595	38,132	83
22	303,076	921	155,227	471	107,222	326	40,627	123
23	220,725	921	61,025	254	144,469	602	15,232	64
24	142,168	921	25,622	166	106,214	688	10,332	67
25	134,197	921	42,499	292	81,307	558	10,391	71
26	330,077	921	110,576	308	186,436	520	33,065	92
27	132,304	921	71,407	497	42,541	296	18,357	128
28	48,829	921	17,342	327	27,120	511	4,367	82
29	78,832	921	47,996	560	19,756	231	11,081	129
30	5,776	921	342	54	5,387	859	47	8
31	1,710	921	251	135	1,392	749	66	36
32	8,504	921	503	54	7,932	859	69	8
33	8,556	921	2,082	224	5,880	633	595	64
34	10,804	921	6,359	542	2,440	208	2,006	171
East Cluster	42,529	921	3,182	69	38,244	828	1,103	24

Table 7.2 Post-Development Infiltration (Unmitigated)

Water Balance Parcel	Precipitation		Evapotranspiration		Runoff		Infiltration	
	(m^3/yr)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)	(mm/yr)	(m^3/yr)	(mm/yr)
NE Cluster	210,872	921	100,851	440	78,495	343	31,526	138
North Cluster	29,612	921	11,085	345	15,987	497	2,540	79
NW Cluster	119,635	921	65,053	501	34,836	268	19,745	152
SE Cluster	192,436	921	60,957	292	118,845	568	12,634	60
SW Cluster	331,437	921	126,036	350	168,654	468	36,752	102
Total	**8,220,937 m^3/yr**		**2,893,303 m^3/yr**		**4,491,740 m^3/yr**		**835,673 m^3/yr**	

Under the Alternative 2 development concept, annual infiltration volumes are projected to decline in the Boundary Area from an existing 1,360,170 m^3/year to 835,670 m^3/year, equating to an annual infiltration deficit within the Boundary Area of approximately 524,500 m^3/year in the absence of post-development infiltration mitigation measures (a 38.6% reduction of infiltration).

7.3 Qualitative Assessment

As discussed in Section 2.0, based on typical percent impervious cover by land use, the aggregate total impervious area for each alternative is expected to be approximately 379 ha, 376 ha and 379 ha for Alternatives 1, 2 and 3, respectively. These values suggest that approximately 41.4%, 41.0% and 41.4% of the overall 916.5 ha Boundary Area may ultimately become impervious cover under the full buildout condition. As such, each alternative scenario is expected to present a similar magnitude of impact in terms of projected annual infiltration volume deficits throughout the Boundary Area between the pre- and post-development conditions.

7.4 Preliminary Recommendation of Mitigation Measures

As per C.L.O.C.A.'s Policy and Procedural Document (PDD) for Regulation and Plan Review (2014), a key component of the watershed planning process is the mitigating of potential development impacts to water resources (i.e., surface water and groundwater), which includes the consideration of using L.I.D. techniques to achieve this objective. The use of stormwater management L.I.D.s are encouraged, particularly in High Volume Recharge Areas (HVRA), to mitigate potential adverse effects of development (i.e., the construction of impervious surfaces) on groundwater recharge rates, which in turn support local natural heritage and/or hydrological features that rely on groundwater.

Previous water budget modeling work completed for the Oshawa Creek Watershed Plan (OCWP) (C.L.O.C.A., 2013), as per the requirements of the Oak Ridges Moraine Conservation Plan (ORMCP), also presented the following conclusions pertaining to the protecting of pre-development recharge rates as a fundamental mechanism to maintaining watershed health:

- Greater volumes of runoff from the increase in impervious surfaces resulting from development is likely to contribute to decreased stability and health of stream corridors.
- The loss in groundwater recharge function from increasing impervious cover will contribute to the lowering of groundwater levels unless this water is returned to the subsurface post-development.
- The maintaining of infiltration volumes associated with HVRAs will support the overall groundwater recharge function of the Oshawa Creek Watershed.
- The maintenance of groundwater recharge function in combination with preservation of the Natural Heritage System and implementation of stormwater management practices, offer the most beneficial solutions for mitigating runoff impacts, which in turn enhance surface water quality, improve aquatic habitat, and manage sediment supply and channel form.

As per the alternative development plans (i.e., Alternatives 1, 2 and 3) proposed within the Boundary Area, development is to consist of the construction of arterial and collector roadways, employment facilities, and low to high density residential homes and associated infrastructure. Associated with this development will be the introduction of impervious surfaces (e.g., rooftops, concrete/asphalt roadways, parking lots and walkways) and, subsequently, a corresponding reduction in the volume of water infiltrating to the subsurface. The potential impacts associated with the introduction of impervious surfaces on the recharge function of the Site are discussed below.

At full buildout, impervious surfaces are expected to cover approximately 41% of the Boundary Area (based on Alternative 2), resulting in a projected infiltration volume deficit of approximately 524,500 m^3/year (i.e., from 1,360,000 m^3/year to 814,500 m^3/year) (**Table 7.2**).

L.I.D. is a stormwater management strategy that seeks to mitigate the impacts of increased stormwater runoff by managing this runoff as close to source as possible, with the implementation of such strategies also providing the residual benefit of offsetting potential infiltration losses associated with the increase in impervious surfaces associated with a given development. Infiltration augmentation options (as described in CVC-TRCA Low Impact Development Stormwater Management Planning and Design Guide, 2010) that could potentially be available for use across the Boundary Area to assist in maximizing infiltration under the post-development condition include:

- Roof downspout disconnection
- Soakaways / infiltration trenches
- Bioretention cells
- Vegetated filter strips
- Grass swales or enhanced grassed swales

A key constraint in using several of the mentioned infiltration augmentation measures (i.e., soakaways / infiltration trenches, bioretention, vegetated filter strips, grass swales) is the positioning of the seasonally high groundwater table. As per CVC-TRCA (2010), the recommended vertical separation between the base of the given infiltration augmentation option and the high groundwater table is at least one meter; however, distances of less than one meter of separation in soils having higher infiltration potential may still be effective. Overall, a review of the water table depth mapping (refer to Figure 4.5.21 in the Columbus S.W.S. Phase 1 Report provided in **Appendix B** of this memorandum) suggests that groundwater will be encountered at depths greater than the one meter throughout most of the Boundary Area, presenting many opportunities for the utilization of post-development L.I.D. infiltration strategies in the landowner parcels.

L.I.D. infiltration facilities are to be targeted for installation in the individual landowner parcels in the following locations:

- Areas identified as HVRA, which is represented by the surficial glaciolacustrine and alluvial deposits that cover the Boundary Area. As recommended in the OCWP, HRVAs are the preferred choice for the location of L.I.D. infrastructure.
- Areas where the coarser-grained ORM Deposits (i.e., glaciofluvial/outwash sands) occur at or near final grades. In several instances, valleys containing the Raglan Main and West Branches appear to cut through the Halton Till and directly intersect the underlying ORM Deposits.
- Areas identified as ESGRA, noting that these areas may present greater challenges for the implementation of L.I.D. infiltration measures, given that these areas are typically underlain by lower permeability deposits of the Halton Till (i.e., sandy to clayey silt til).

The suitability of using the previously mentioned infiltration augmentation options within the individual landowner parcels within the Boundary Area will be evaluated in greater detail once the preferred alternative is selected. Overall, it is reasonable to conclude that the application of some or all the previously mentioned infiltration augmentation measures in those areas of the Boundary Area where the seasonally high groundwater table is greater than one meter below final grades will assist in achieving the maximum groundwater recharge possible throughout the Boundary Area under the post-development condition.

8.0 Summary of Findings & Recommendations

8.1 Terrestrial Natural Heritage Summary

The Land Use and Road Plans Alternatives 1-3 were overlaid on the natural heritage feature constraints and M.V.P.Z.s to quantify direct loss to the T.N.H.S. The assessment found that the Land Use and Road Plan alternatives do not encroach into the natural heritage feature constraints or M.V.P.Z.s, except where new roads are proposed, including crossings of Significant Valleylands, riparian corridors, and associated Significant Woodlands and wetlands. All three (3) Land use and road plan alternatives are able to meet the watershed target of 30% natural cover established by the Oshawa Creek Subwatershed Plan (C.L.O.C.A., 2014), with the least direct loss and fragment affects associated with Alternative 1, moderate direct loss and fragment affects associated with Alternative 2, and the most direct loss and fragment affects associated with Alternative 3. Existing wetland cover is below 2% within the Boundary Area (Stantec, 2019), which is below the Oshawa Creek Watershed Plan (C.L.O.C.A., 2013) target of 10% (and 6% minimum per Subwatershed); therefore, opportunities should be explored to create wetlands in M.V.P.Z.s and other enhancement and linkage areas, where feasible. Additional recommendations were provided to protect and enhance the T.N.H.S., maintain and enhance feature and linkages outside the T.N.H.S., and address fragmentation of the T.N.H.S. and Greenbelt that will be created by proposed new roads. Mitigation recommendations for new roads included design parameters for wildlife crossing structures. Design recommendations included minimum width, height and openness ratio for the crossing structures. The openness ratio (width x height/length) can only be determined once the structure lengths are known. If the recommended openness ratios cannot be achieved, measures to increase natural light inside the structures should be incorporated, such as open-top culverts.

8.2 Fluvial Geomorphology Summary

A large portion of the Study Area lies within the upstream limits of the Oshawa Creek Watershed. As a result, the majority of watercourse features are low order streams or headwater drainage features that typically flow through either agricultural fields or in forested ravine settings. To support the impact assessment for the proposed crossing alternatives, several factors were explored with regards to fluvial geomorphology. Crossings can have a significant impact on valley and stream corridors. Therefore, it is important to recognize and account for natural hazards in association with watercourse crossings.

A qualitative crossing assessment was completed to compare general characteristics of all crossings in each of the provided alternatives. This assessment included a review of the number and types of crossings proposed for each alternative as well as the crossing orientation in relation to the watercourse. It was found that Alternative 1 and Alternative 2 had the least number of crossings and were similar with regards to types and orientation of crossings. From a geomorphological perspective, it was determined that both Alternative 1 and Alternative 2 would be appropriate.

A more detailed impact assessment was completed for crossings associated with Alternative 2. This approach considered detailed factors such as watercourse valley setting, evidence of erosion or channel instability, local meander amplitudes, and density and type of riparian vegetation. Through the detailed impact assessment, three (3) crossings were identified as sensitive. Although, given the small size of streams in the study area, any impacts to crossing structures or watercourse form and function can be mitigated with a crossing size that is, at minimum, three (3) times the bankfull channel width.

8.3 Aquatic Natural Heritage Summary

The review of background information coupled with detailed field data collection indicated that the west and east limits of the Boundary Area are bounded by healthy coldwater streams supporting populations of salmonids. The Raglan Main Branch provides a connection from the Raglan West Branch upstream into the hamlet of Columbus and further upstream into a series of tributaries draining the lands around and to the north of the hamlet. The Main Branch and these tributaries exhibit groundwater discharge and cold to cool stream temperatures, habitat characteristics that are representative of coldwater fish habitat, however there are no salmonids present. The Grandy Pond at Thornton Road North is a barrier to fish that could potentially migrate into the Raglan tributaries to utilize areas of coldwater habitat, and also creates a thermal impact in the zone downstream of the pond.

Terrestrial habitat associated with the riparian corridor, fluvial geomorphological form and functions, and aquatic habitat are closely tied together when determining the effects of frequency, location and orientation of watercourse crossings in a watershed. Crossing effects are determined by the likelihood of changes in physical habitat attributes which are determined by fluvial geomorphological processes, so the analysis of crossing location and infrastructure design utilizing fluvial considerations will generally address the typical considerations for aquatic habitat.

With respect to the Land use and road plan alternatives and effects on aquatic habitat, Alternatives 1 and 2 are very similar, while Alternative 3 is not preferred given the number and orientation of the crossings proposed. The main difference between Alternative 1 and 2 with respect to main watercourse crossings is the proposed crossing of the Raglan Main Branch, however there may be an opportunity for barrier mitigation during construction of the Main Branch crossing.

Potential crossing mitigation approaches include orienting infrastructure to avoid current erosion prone areas and reduce the risk of future erosion issues, sizing structures to a minimum of three (3) times the bankfull width to encourage current channel functions to continue and allow fish passage during high flows, providing natural substrate through the crossing structure, and providing a low flow channel to allow for fish passage during baseflow conditions.

8.4 Surface Water Summary

To support the impact assessment for Alternative 2, preliminary recommendations have been developed with regards to mitigation measures. These mitigation measures have conceptually identified for S.W.M., watercourse crossings and valley corridors.

Preliminary siting of conceptual S.W.M. pond locations have been provided. These locations are considered to be flexible. It is fully expected that there will be opportunities to further refine the number of S.W.M. ponds, relocate S.W.M. ponds, combine S.W.M. ponds, etc. as part of the Columbus S.W.S. Phase 2 Report and future planning stages. In general, opportunities to reduce the quantity of S.W.M. ponds, without impeding development phasing plans, should be considered. For block planning purposes, S.W.M. ponds that provide both water quality and quantity controls are typically expected to consume a block area that is roughly equivalent to 6% to 7% of the overall contributing drainage area. Block sizes for S.W.M. ponds that provide water quality and erosion controls only may be reduced to approximately 4% to 6% of the overall contributing drainage area. A conceptual grading/servicing plan(s) will ultimately help to determine precise pond block requirements.

Water quantity controls will appear to include 2-year through 100-year controls for lands within the Windfields, Kedron and Enfield subwatersheds in order to satisfy MTO expectations near the Highway 407 corridor. Preliminary modelling suggests that water quantity controls for lands within the Raglan subwatershed will not be required based on preliminary downstream hydrologic analyses. No Regional quantity controls are expected for the Boundary Area.

Water quality controls will need to satisfy M.E.C.P. Enhanced (Level 1)requirements throughout the Boundary Area;

Water balance requirements will need to consider distributed L.I.D. measures throughout the Boundary Area to offset anticipated impacts to existing infiltration rates/volumes. There are opportunities to effectively implement L.I.D. measures by strategically siting within H.V.R.A. and E.S.G.R.A. locations that are scattered throughout the Boundary Area. Situating L.I.D.s within buffer areas also pose a significant opportunity to address water balance.

Erosion Control requirements will be determined through an Erosion Threshold Analysis, which will be prepared as part of the Part 2 Columbus S.W.S. Report. Similarly, thermal mitigation measures will need to be considered for end-of-pipe S.W.M. facilities to minimize impacts within receiving systems given the coldwater and coolwater classifications.

Conceptual minimum hydraulic sizing recommendations for all new proposed watercourse crossings and an overview of anticipated impacts to already existing watercourse crossings have been summarized. The Phase 2 Columbus S.W.S. Report will further assess watercourse crossing requirements for the preferred alternative and provide minimum hydraulic geometry recommendations.

Generally speaking, Alternative 1 or 2 would be considered preferable from a surface water perspective. Alternative 3 is less preferred largely due to the number of proposed watercourse crossings.

8.5 Hydrogeology Summary

Detailed review of the Alternative 2 development concept indicates that approximately 41% of the Boundary Area will be converted to impervious surfaces, resulting in annual infiltration volumes declining from an existing (pre-development) of 1,360,170 m^3/year to 835,670 m^3/year, equating to an annual infiltration deficit of approximately 524,500 m^3/year in the absence of post-development infiltration mitigation measures (a 38.6% reduction of infiltration). Given that the total impervious cover estimated to occur under Alternatives 1 and 3 will only be slightly higher than what is estimated for Alternative 2 (i.e., 41.4% vs. 41.0%), each alternative scenario is expected to present a similar magnitude of impact in terms of projected annual infiltration volume deficits throughout the Boundary Area between the pre- and post-development conditions.

Low impact development (L.I.D.) is a stormwater management strategy that seeks to mitigate the impacts of increased stormwater runoff by managing this runoff as close to source as possible, with the implementation of such strategies also providing the residual benefit of offsetting potential infiltration losses associated with the increase in impervious surfaces associated with a given development. Infiltration augmentation options that could potentially be available for use across the Boundary Area to assist in maximizing infiltration under the post-development condition include:

- Roof downspout disconnection
- Soakaways / infiltration trenches
- Bioretention cells
- Vegetated filter strips
- Grass swales or enhanced grassed swales

Seasonally high groundwater depths throughout most of the Boundary Area appear to be favourable for the utilization of post-development L.I.D. infiltration strategies in the landowner parcels. Moving forward, L.I.D. infiltration facilities are to be targeted for installation in the following locations:

- Areas identified as HVRA, which is represented by the surficial glaciolacustrine and alluvial deposits that cover the Boundary Area. As recommended in the OCWP, HRVAs are the preferred choice for the construction of L.I.D. infrastructure.

- Areas where the coarser-grained ORM Deposits (i.e., glaciofluvial/outwash sands) occur at or near final grades. In several instances, valleys containing the Raglan Main and West Branches appear to cut through the Halton Till and directly intersect the underlying ORM Deposits, with this unit providing a source of groundwater discharge to these watercourses.
- Areas identified as ESGRA, noting that these areas may present greater challenges for the implementation of L.I.D. infiltration measures, given that these areas are typically underlain by lower permeability deposits of Halton Till (i.e., sandy to clayey silt till).

The suitability of using the previously mentioned infiltration augmentation options within the individual landowner parcels within the Boundary Area, as well as the identification of preferred locations, will be evaluated in greater detail as part of the Columbus S.W.S. Phase 2 Report once the preferred alternative is selected.

9.0 References

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