Barrhaven South Urban Expansion Study Area

Environmental Management Plan

Ottawa, Ontario

Presented to:

Minto Communities Canada

Mattamy Homes

City of Ottawa

February 2, 2018

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Barrhaven South Urban Expansion Study Area

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1. INTRODUCTION

Minto Communities and Mattamy Homes have initiated a Community Design Plan (CDP) study for the Barrhaven South Urban Expansion Study Area (BSUESA) as required by Section 3.11 of the City of Ottawa's Official Plan (OP) and in keeping with the requirements described in Section 2.5.6 of the OP. The Expansion Area boundaries were established by the City of Ottawa and the Ontario Municipal Board (OMB) as part of the 2009 Official Plan review (implemented through Official Plan Amendment 76) to accommodate projected future population growth in the community.

The Barrhaven South Urban Expansion Area is located adjacent to and south of the existing Barrhaven community. It is situated east of the Veterans Memorial Highway 416 and southwest of the confluence of the Jock River and the Rideau River. Barnsdale Road runs along the southern limit boundary of the Expansion Area. Other major roads in the vicinity that provide access to the expanded urban area include Cambrian Road, which is located to the north and Greenback Road which runs in a north-south direction connecting directly to Barnsdale Road.

Prior to bringing expansion lands into the urban area, Section 3.11 of the Official Plan requires a comprehensive study, in this case, in the form of a CDP. To support the CDP, a comprehensive Land Use Plan, a Transportation Master Study (TMS), a Master Servicing Study (MSS), and an Environmental Management Plan (EMP) are required.

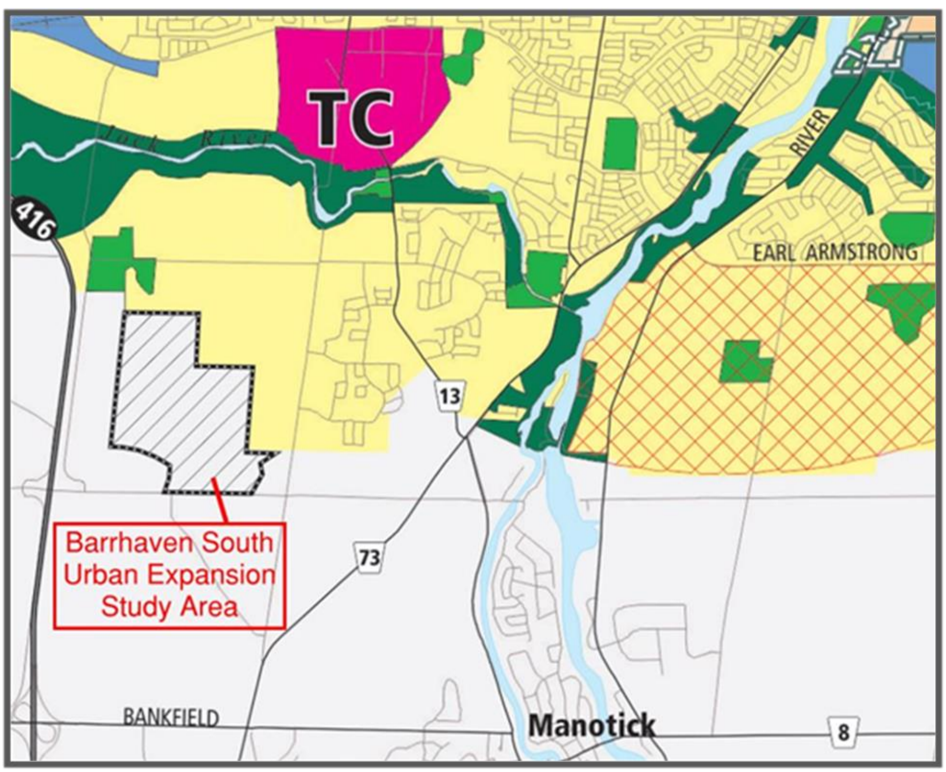


FIGURE 1-1: OFFICIAL PLAN SCHEDULE B – CITY OF OTTAWA URBAN POLICY PLAN

1.1 STUDY OBJECTIVES

The objective of this work was to prepare an EMP for the BSUESA that:

- Maps the development limits based on natural features;
- Identies environmental constraints and opportunities in terms of natural heritage and natural hazards;
- Consides the impacts of any land use activities on natural features;
- Identifies measures to mitigate negative effects; and
- Develops a plan to mitigate adverse effects; and to protect, enhance or restore the natural system for the pleasure of all.

The EMP has been developed to support the preparation of the overall CDP and servicing plans, including the Master Servicing Study (MSS), and the Transportation Master Study (TMS), which were undertaken in accordance with the Municipal Class Environmental Assessment (EA) process. The planning and coordination of the infrastructure and environmental management requirements for the CDP were done in consultation with the community, to assist in ensuring that the objectives of the City, the community and other approval authorities are being fulfilled.

1.2 STUDY AREA

The CDP Area Boundary was adjusted to remove lands that are impacted by a 300 metre influence area associated with active aggregate extraction operations within the BSUESA. Presently, there are two licensed open sand and gravel pit operations (Brazeau Pit and Drummond Pit), both of which have been in operation since before 1990 and continue to operate to supply pit sand and gravel for the Ottawa area.

In replacement of the removed section, lands designated “General Rural” at the intersection of Greenbank Road and Barnsdale Role were added to the BSUESA. Consequently, the southern limit of the CDP Area Boundary was extended east to Greenbank Road, with additional minor adjustments in the western limit. The adjustments to boundaries yielded no-net-gain to the developable area of the CDP and produced efficient development blocks and infrastructure connections. Figure 1-2 shows the Study Area that was carried forward for the BSUESA CDP planning process.

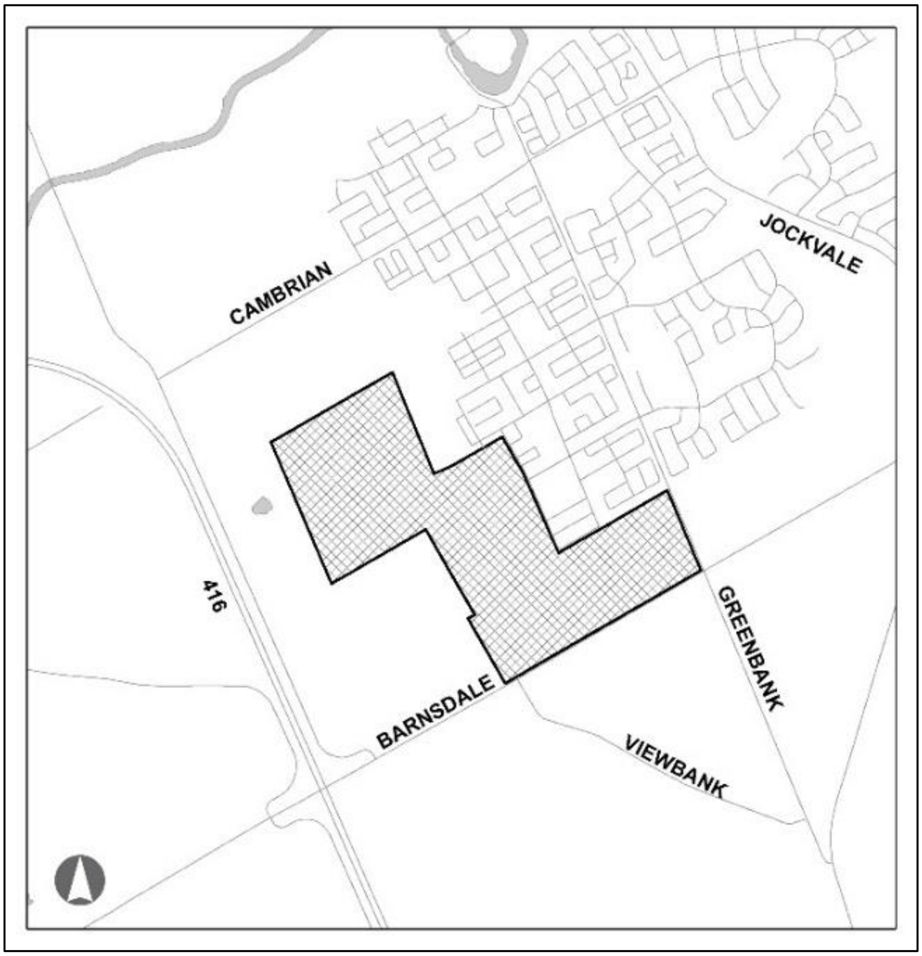


FIGURE 1-2: REVISED CDP AREA BOUNDARY

There is no existing servicing infrastructure within the CDP Area Boundary and the CDP lands consist of primarily undeveloped lands, with the exception of the licensed sand and gravel pits. Key existing surrounding land uses include the Trail Road Solid Waste Disposal Facility to the west of Highway 416 and vacant urban lands (designated General Urban Lands on Schedule B, City of Ottawa OP) directly to the north of the CDP area. All existing servicing infrastructure is located to the north and east of the CDP Area Boundary in the existing Barrhaven South Community. Future area transportation plans include a realignment of Greenbank Road across the Jock River extending to Barnsdale Road. Realigned Greenbank Road would be situated west of the existing Greenbank Road. This new arterial road will also include dedicated cycling facilities and Bus Rapid Transit. A future Transit Station and a Park and Ride Lot are planned along the realigned Greenbank Road, north of Barnsdale Road.

The EMP Study Area encompassed the CDP Area Boundary recognizing that adjacent areas may be affected by future land and infrastructure development. Accordingly, the spatial boundaries for the EMP varied, depending upon the environmental feature under consideration when addressing environmental effects and operational issues. For example, future stormwater management facilities associated with the CDP Area Boundary could have upstream and/or downstream impacts. In addition, given that optimally, contiguous wildlife corridors would be maintained as part of the natural environment, any potential disruptions to wildlife corridors could have impacts beyond the CDP Area Boundary and thus were duly considered.

The EMP Study Area also incorporated a coordination of relevant on-going studies and projects; as well as ensured an accommodation of infrastructure needs and future connections. Any identified potential impacts beyond the EMP Area would be constructively addressed to identify appropriate mechanisms for moving forward.

1.3 STUDY TEAM

The organization of the CDP included a number of Committees and Teams to enable a collaborative study process, which encompassed a range of stakeholders.

1.3.1 LANDOWNERS

The BSUESA is currently comprised of four major landowners (see Table 1-1). The participating Landowners Group was established with the responsibility for the comprehensive planning of the CDP Study Area. While the CDP was a developer-initiated and funded project, the City of Ottawa remained as the key stakeholder and provided the regulatory framework within which the CDP was completed.

TABLE 1-1: BSUEA LANDOWNERSHIP

Drummond	**20 ha (16%)**
Brazeau	**25 ha (21%)**
Mattamy	**11 ha (9%)**
Minto	**66 ha (54%)**
TOTAL	**121 ha (100%)**

The BSUESA comprises approximately 120 gross hectares of land. “Sponsoring Landowners” include Minto Communities Canada and Mattamy Homes. Consultation with non-participating landowners within the BSUESA was undertaken as part of the CDP Study.

1.3.2 CORE PROJECT TEAM

A Core Project Team (CPT) was established for the CDP Study, which comprised of the Sponsoring Landowners, the Consultant Team, and City of Ottawa staff from the Planning, Infrastructure and Economic Development Department. The primary function of the CPT was to resolve issues and achieve consensus at each step of the CDP work program.

The City of Ottawa provided an internal project manager for coordination and guidance. The CPT generally met on a monthly basis in accordance with the work program and contained representatives from the following:

Sponsoring Landowners

- Minto Communities; and
- Mattamy Homes

City of Ottawa

- City of Ottawa's CDP Project Manager;
- Natural Systems & Environmental Protection Unit;
- Infrastructure Planning Unit; and
- Other City of Ottawa staff as required.

Consulting Team

- Land Use Planning and Urban Design – FOTENN;
- Integrated Environmental Assessment – Morrison Hershfield;
- Master Servicing Study – JL Richards;
- Transportation Master Study – Stantec Inc.;
- Environmental Management Plan – Morrison Hershfield;
- Natural Heritage – Dillon Consulting Limited;
- Geotechnical, Hydrogeology – Paterson Group; and
- Archaeology and Heritage – Golder & Associates.

1.3.3 TECHNICAL ADVISORY COMMITTEE

A Technical Advisory Committee (TAC) was also established and was involved on an as-needed basis (generally one meeting for each study process phase) to review information and deliverables. Four TAC meetings took place as part of the implementation of the work program.

Representatives of the following organizations were invited to participate on the TAC:

- CPT Members (as needed);
- City of Ottawa Traffic and Parking Operations;
- City of Ottawa Parks and Recreation Branch;
- City of Ottawa Infrastructure Services;
- City of Ottawa Infrastructure Planning;
- City of Ottawa Utility Services Branch;
- City of Ottawa Transit Services;
- City of Ottawa Development Approvals Section;
- City of Ottawa Natural Systems & Environmental Protection Unit;
- City of Ottawa Community Planning & Urban Design Unit;
- School Boards;
- Rideau Valley Conservation Authority (RVCA);
- Ontario Hydro and Hydro Ottawa; and
- Government review agencies (such as Conservation Authorities, Ontario Ministry of the Environment and Climate Change (MOECC); Ontario Ministry of Natural Resources and Forestry (MNRF); Ontario Ministry of Tourism, Culture and Sport (MTCS); Ontario Ministry of Aboriginal Affairs (MAA); and Ontario Ministry of Municipal Affairs and Housing (MMAH).

The level of participation varied depending upon the role and level of interest of the individual government review agency. For example, some government review agencies did not wish to attend all TAC meetings. Nonetheless, all agencies were invited to provide comments on materials during each phase of the study process.

2. POLICY FRAMEWORK

2.1 OFFICIAL PLAN POLICIES

City of Ottawa Official Plan policies respecting lands designated 'Urban Expansion Study Area' require that a CDP or concept plan be approved by City Council, prior to development proceeding (Section 3.11). Such urban areas are primarily intended to be developed for residential land uses, although minor, non-intended residential uses may also be established to meet the needs of the community. To support the CDP, a comprehensive Land Use Plan, a TMS, a MSS and an EMP are required. Upon completion of the CDP for the expansion area, an Official Plan Amendment would be required for the redesignation of lands in keeping with the direction of the CDP. The OPA will also establish the required transportation, infrastructure, environmental and open space policies for the CDP Study Area. Several OP policies apply to the CDP process and the supporting studies, including:

- From Section 2.3.3, Drainage and Stormwater Management Services – "The provision of appropriate drainage and stormwater management services requires coordination with land-use planning, and assessment of receiving watercourses (including municipal drains), environmental features and natural hazards, all of which is typically achieved through environmental management plans."
- Section 2.4.3, Watershed and Subwatershed Plans - "An environmental management plan will address such matters as: (a) Delineation of setbacks from surface water features; (b) Specific mitigation measures to protect significant features, identified for preservation at the subwatershed level; (c) Conceptual and functional design of stormwater management facilities and creek corridor restoration and enhancement."
- Section 4.7.5, Protection of Groundwater Resources - "When reviewing development applications, the City will consider the potential for impact on groundwater resources. (a) a groundwater impact assessment may be required where the City has identified that the lands play a role in the management of the groundwater resource or the need is indicated in other available information such as subwatershed plans or local knowledge; and (b) a groundwater impact assessment may be required where the proposed use has the potential to negatively impact the groundwater resource. In either case, the proposed use will not be permitted without a favourable impact assessment." and
- Section 4.7.6, Stormwater Management policies that require 2" (b) Base flow in the watercourse is not reduced; (c) The quality of water that supports aquatic life and fish habitat is not adversely affected; and (c) Groundwater is not negatively impacted".

2.2 PROVINCIAL POLICY STATEMENT

The 2014 Provincial Policy Statement (PPS) under the *Planning Act* provides policy direction on matters of provincial interest as they relate to land use planning and development and supports the goal to enhance the quality of life for all Ontarians. Planning Act decisions need to be consistent with the PPS. The following PPS policies were considered in carrying out the EMP:

- Policy 2.2.1, Planning authorities shall protect, improve or restore the quality and quantity of water by:
  - a) using the watershed as the ecologically meaningful scale for integrated and long-term planning, which can be a foundation for considering cumulative impacts of development;
  - b) minimizing potential negative impacts, including cross-jurisdictional and cross-watershed impacts;
  - c) identifying water resource systems consisting of ground water features, hydrologic functions, natural heritage features and areas, and surface water features including shoreline areas, which are necessary for the ecological and hydrological integrity of the watershed;
  - d) maintaining linkages and related functions among ground water features, hydrologic functions, natural heritage features and areas, and surface water features including shoreline areas;
  - e) implementing necessary restrictions on development and site alteration to:
    1. protect all municipal drinking water supplies and designated vulnerable areas; and
    2. protect, improve or restore vulnerable surface and ground water, sensitive surface water features and sensitive ground water features, and their hydrologic functions.
- Policy 2.2.2, Development and site alteration shall be restricted in or near sensitive surface water features and sensitive ground water features such that these features and their related hydrologic functions will be protected, improved or restored. Mitigative measures and/or alternative development approaches may be required in order to protect, improve or restore sensitive surface water features, sensitive ground water features, and their hydrologic functions.

2.3 INTEGRATED PLANNING ACT AND MUNICIPAL CLASS ENIRONMENTAL ASSESSMENT PROCESS.

The EMP formed part of the CDP study process, which integrated both the Provincial Land Use Planning and Municipal Class EA processes. In effect, all infrastructure studies have been prepared in accordance with the requirements of the Class EA. Figure 2-1 shows the integration of the Class EA, CDP, and Official Plan amendment processes.

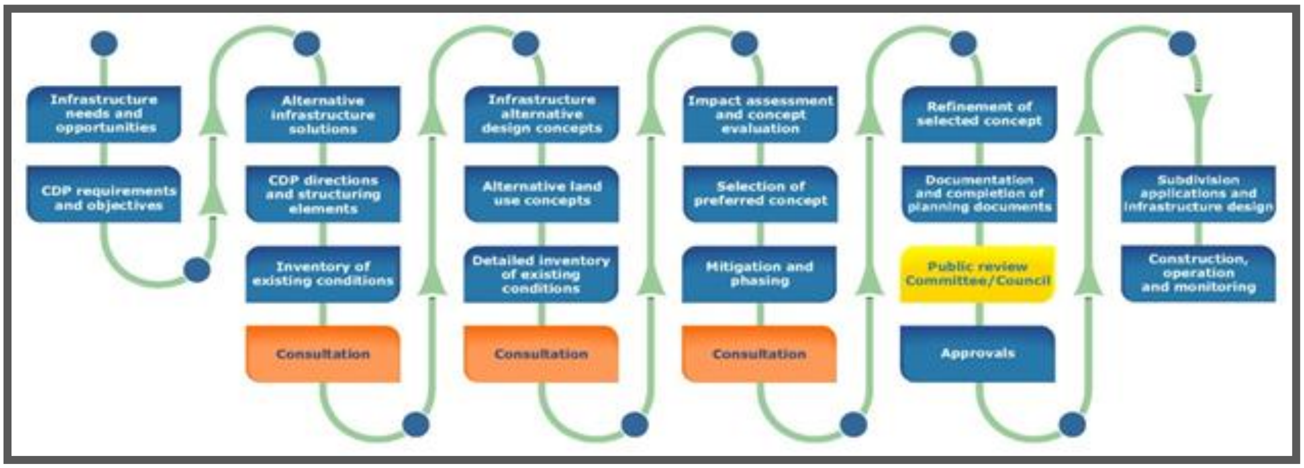


FIGURE 2-1: INTEGRATED COMMUNITY DESIGN PLAN AND MUNICIPAL CLASS EA PROCESSES

The required Class EA environmental planning tasks generally include:

- Identification of project need and opportunities;
- Characterization of the Existing Conditions;
- Consultation with potentially affected parties (including review agencies, and public and private interest groups);
- Identification and evaluation of alternatives;
- Identification and consideration of effects and mitigation; and
- Documentation of the planning and consultation process.

The integrated CDP and Class EA processes enabled the required approvals of municipal infrastructure to occur in conjunction with municipal planning approvals (i.e. approval of the CDP and adoption of an Official Plan Amendment). Examples of municipal infrastructure that were evaluated through the Class EA/integrated CDP process include:

- Construction of new roads, transit facilities and/or other linear paved facilities;

- Construction of new sewage systems/pumping station(s);
- Development of stormwater management systems; and
- Establishing, extending or enlarging a water distribution system and all works necessary to connect the system to an existing system or water source.

The Class EA requirements for infrastructure evaluation were addressed throughout the CDP process, such that as alternative designs were developed, each was evaluated to ensure environmental assessment requirements, if any, were met. The ability to co-ordinate the approval requirements of the *Environmental Assessment Act* and the *Planning Act* ensured an integrated approach to the planning and development of all aspects of the CDP, as well as a consolidated and simplified public review and approval process. The key benefits of following an integrated planning and environmental assessment process included:

- Improving the ability to meet the requirements of both the *Planning Act* and the Class EA effectively;
- Reducing the review and approval process duplication leading to faster implementation;
- Enhancing opportunities to co-ordinate infrastructure with land use planning;
- Improving the certainty for land use decision-making; and
- Coordinating the appeals and objections processes.

3. EXISTING ENVIRONMENTAL CONDITIONS

3.1 EMP WORK PROGRAM

Background information and results of the preliminary field studies were consolidated to determine environmental constraints and opportunities within the CDP Study Area. This review consolidation incorporated landform, soils and geology, surface water and groundwater resources, aquatic and fish habitat, wetlands, terrestrial vegetation, potential Species at Risk (SAR) and wildlife habitat, as well as any other identified development constraints. Opportunities included retention of some areas of natural features including woodlands, specimen trees, and protecting the Kars Esker, a regional sand and gravel feature with a full length of 21 kilometres, which functions as an important groundwater recharge area.

Natural heritage features and areas to be protected were identified through a set of maps, including minimum distance separation setbacks from the Trail Road landfill, and identification of an area of influence related to existing sand and gravel pits. Based on fieldwork, the EMP also identified areas that would require further study. In addition to minimum distance separation setbacks identified in the mapping and text, additional mitigation measures were included to address potential negative impacts on the Natural Heritage System or significant natural features such as the Kars Esker within the BSUESA.

The content of the EMP is based on the Terms of Reference that was reviewed and approved by City of Ottawa Staff in consultation with interested Government Review Agencies.

The key natural system features are included in this EMP. Each component included a background review, associated field studies, and an analysis. Recommendations are provided which support the findings and analyses from each component. The geographical extent of a survey area will vary depending on the component being considered. Boundaries were adjusted as necessary to appropriately reflect the nature of the feature. In general, the survey area extended beyond the CDP Study Area, as necessary, to consider factors such as major corridors, aggregate operations, drainage boundaries, natural features and watercourses.

Each environmental component was addressed by discipline experts and their discipline-specific reports are appended to this EMP. Refer to the appended reports for specific detailed information and background reference material, which has been summarized herein.

3.2 NATURAL HERITAGE FEATURES

The work detailed in this section was undertaken to identify the key natural heritage features, function and systems within the Study Area, and to provide a strategy for preservation, mitigation and implementation. The definition of the Natural Heritage System will affect the spatial form of the community and establish components of its overall character. Dillon Consulting Limited (Dillon) was retained to complete the Natural Heritage component of the EMP for the proposed BSUESA, which included investigations and assessment of:

- Wetlands;
- Woodlands;
- Areas of Natural and Scientific Interest (ANSI);
- Valleylands;
- Significant wildlife habitat;
- Species at Risk habitat;
- Fish habitat; and
- Water resources.

For the purposes of assessing the natural heritage features, an area larger than the BSUESA was surveyed in order to better understand the context of existing conditions. The limits of the natural heritage study area were Greenbank Road to the east, Borrisokane Road to the west, and Barnsdale Road to the south (Figure 3-1). The focus of the reporting, however, is the BSUESA. The complete Existing Conditions Report for the Natural Environment is attached as Appendix A.

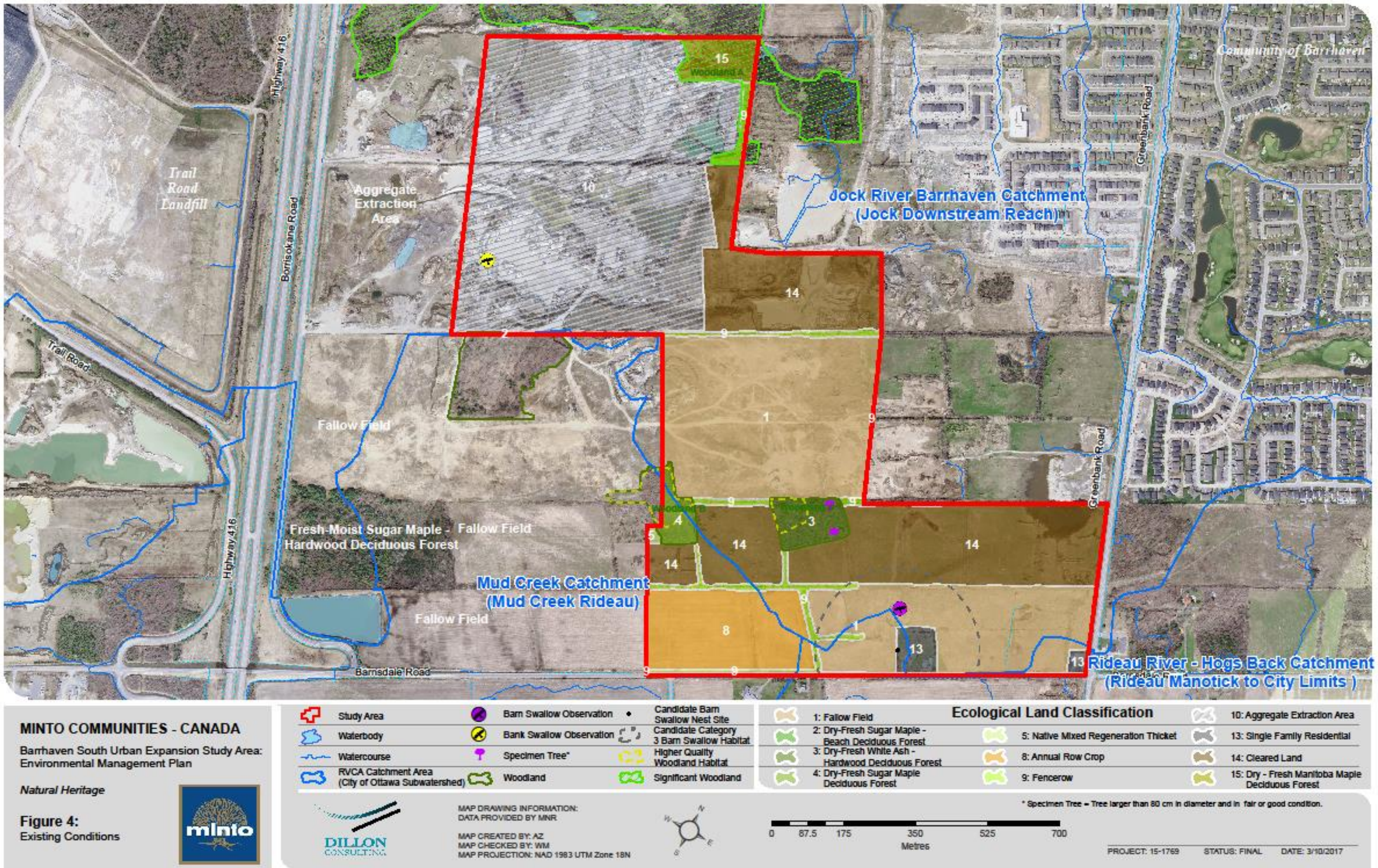
3.2.1 NATURAL HERITAGE FEATURES

A number of natural heritage features require consideration for protection under the Ontario PPS (2014). Protection measures are administered by the City of Ottawa and the Province of Ontario. Based on background information, the following features were identified:

- A patch of unevaluated wetland within the woodland along the western border of the BSUESA (shown on MNRF mapping).
- Patches of unevaluated woodland throughout the Study Area, including a portion of Cambrian Woods within the northern portion of the Study Area and hedgerows.

No Provincially Significant Wetlands (PSWs), Significant Valleylands, or Areas of Natural and Scientific Interest (ANSI) were identified.

FIGURE 3-1: NATURAL HERITAGE EXISTING CONDITIONS



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A review of aerial photos suggests that the BSUESA contains three deciduous wooded areas and approximately seven hedgerows that appear to contain a mix of mature and young trees (see Figure 3-1). A review of historic aerial photos indicated the age of the woodlots, as follows:

- A 1976 air photo shows all of the central east woodlot suggesting it is more than 40 years old. The current size of the woodlot is 2 ha.
- Part of the central west woodlot existed on the 1976 air photo. The current size is 1.9 ha.
- The northern woodlot, which also existed on the 1976 air photo, has an area of 57.4 ha.

Based on the evaluation criteria outlined in the MNRF's Natural Heritage Reference Manual (MNRF, 2010), the woodland within the northern portion of the BSUESA connected to the Cambrian Woods, a City of Ottawa Urban Natural Area, is considered significant. A review of aerial photography indicated that the boundaries of this woodland have not changed since 2013. As this area was not accessible during field visits in 2015, a subsequent field visit was conducted on July 22, 2016 to assess this portion of woodland inside the BSUESA boundary.

The portion of the Cambrian Woods within the BSUESA boundary consisted of mid-age Manitoba Maple (Acer negundo), Eastern White Cedar (Thuja occidentalis) and White Spruce (Picea glauca). The woodland was heavily disturbed with old fencerows, earth displacement, evidence of dumping, berms and pits. Part of the woodland consists of a coniferous plantation (White Spruce). The remainder of the woodland within the BSUESA was sparse with many gaps in the canopy.

The other woodlands were not deemed significant based on the evaluation criteria.

3.2.2 WILDLIFE

All species observed during field surveys are common to the Ottawa area and include Red-winged Blackbird, Blue Jay, American Robin, Green Frog, American Toad, Coyote, White-tailed Deer, Wild Turkey, and Eastern Chipmunk.

No significant wildlife habitat was identified and no rare species or species of conservation concern were observed during field surveys.

3.2.3 SPECIES AT RISK

Species at risk (SAR) surveys were conducted and identified the following:

- It is likely that a portion of Category 3 Habitat for Barn Swallow is located within the southern portion of the Study Area. It is also possible that Category 1 and 2 Habitat could be found within the private property along the southern portion of the Study Area. One Barn Swallow was observed as a flyover during breeding bird surveys.
- An active Bank Swallow colony was observed within the active portion of the extraction area.
- Woodlands within the BSUESA may provide suitable conditions for Butternut, however this species was not observed within the BSUESA during field surveys.
- No SAR bats or bat habitat were observed through ELC surveys, the tree inventory, or other field surveys completed within the Study Area.

3.2.4 WATER RESOURCES SYSTEM AND FISH HABITAT

The BSUESA lies within the Rideau Valley Conservation Authority's jurisdiction and drains to two subwatersheds delineated by the Conservation Authority: the Lower Rideau River and the Jock River. The portion of the BSUESA within the Jock River Subwatershed, drains to the north and is part of the Jock River Barrhaven Catchment area. The portions of the BSUESA within the Lower Rideau River Subwatershed include the Mud Creek Catchment area, which drains to the southwest, and the Rideau River–Hogs Back Catchment area, which drains to the southeast.

The following studies and reports were reviewed:

- Mud Creek Subwatershed Study (City of Ottawa, 2015);
- Lower Rideau Subwatershed Report (RVCA, 2012);
- Rideau River – Hogs Back Catchment Report (RVCA, 2012);
- Jock River Subwatershed Report (RVCA, 2010);
- Jock River Barrhaven Catchment Data Sheet (RVCA, 2010);
- Rideau River Hogsback Catchment Report (RVCA, 2012); and,
- Jock River Reach 1 Subwatershed Study (Stantec, 2007).

A large portion of the BSUESA is underlain by the Kars Esker, a regional sand and gravel feature, which functions as an important groundwater recharge area. It is recognized in the Mississippi-Rideau Source Protection Plan (MRSPP) as a Significant Groundwater Recharge Area (SGRA) and is a highly vulnerable area (HUV) under the Ontario Clean Water Act (2006).

Section 2.2.1(e) of the PPS (2014) states that planning authorities shall "implement necessary restrictions to development and site alteration to protect designated vulnerable areas." Section 2.2.2 states "mitigative measures and/or alternative development approaches may be required".

Background mapping suggests that several water bodies exist within the general area. In addition, there may be agricultural ditches within the BSUESA flowing into the Jock River and/or Mud Creek and subsequently the Rideau River that may provide fish habitat.

3.2.4.1 HEADWATER DRAINAGE FEATURES (HDF) ASSESSMENT

A HDF Assessment was conducted following the criteria in the *Evaluation, Classification and Management of Headwater Drainage Features* (Toronto Region Conservation Authority and Credit Valley Conservation, 2014), based on requirements from the RVCA. In accordance with the HDF Assessment requirements, the assessment comprised of a review of background documents and data, and subsequent site visits to collect field data regarding the flow, channel form, aquatic habitat, and vegetation of potential HDFs.

An HDF site visit occurred April 30th, 2015, during which time the Study Area was walked (where access was available) to inventory and assess any watercourses present.

No watercourses were identified within the BSUESA during the HDF Assessment. The only water features identified were man-made aggregate site ponds created as a result of mineral extraction. These features are not naturalized, and are not connected to any other waterbodies, and are not regulated by the City of Ottawa or the RVCA. There was also a large area of sheet water lying within agricultural fields to the east along Greenbank Road, but no flow was detected and there were no defined inlets our outlets. Based on the nature of these features, it is unlikely that they would support fish habitat.

In addition, there is a large man-made pond within the vicinity of the Study Area, located at the corner of Barnsdale Road and Borrisokane Road that was included in the 2015 field assessment. This is a large, naturalized pond containing both marsh and forested riparian areas with various resident fish, bird, reptile, and amphibian species. This waterbody is located greater than 120 metres outside of the BSUESA boundary and was not considered in the overall assessment.

The aggregate site ponds provide the only possible fish habitat within the Study Area; however, these ponds are isolated with no connection upstream or downstream. Further, these features are not naturalized and are not connected to any other waterbodies. Therefore, it is unlikely that they would support fish habitat. However, during the HDF assessment, many downstream receivers were found to have fish and provide breeding habitat for amphibians (amphibians observed during 2016 field visits).

It has been determined that no watercourses or waterbodies were identified within the BSUESA that would provide direct fish habitat or other HDF functions.

3.2.4.2 DOWNSTREAM AQUATIC HABITAT ASSESSMENT

The second aquatic habitat assessment was scoped in consultation with the RVCA to establish a baseline condition for receiving watercourses downstream of the Study Area. This baseline condition was then to be used to evaluate potential impacts that changes in flows, resulting from development of the CDP area, could have on those downstream receiving watercourses. The specific parameters assessed included:

- stream flow;
- vegetation characteristics;
- channel form;
- sediment transportation or deposition;
- the potential for fish and/or amphibian habitat;
- barriers to fish habitat; and,
- other relevant characteristics.

During the downstream aquatic habitat assessment, existing water crossings were chosen for evaluation based on hydrological connectivity to the Study Area. Data collected during this assessment, as well as a figure showing the locations of water crossings, are included in Appendix A. Many of the downstream receivers were found to contain fish in summer months or have the potential for fish habitat in the spring when water levels peak. In addition, many of the receivers had the potential to provide amphibian breeding habitat, and amphibians were heard or seen at some of the sites during the summer site visit. Only a few streams had low potential for fish habitat or were degraded to the point that they provided little to no habitat function.

It has therefore been determined that several watercourses downstream of the BSUESA provide direct fish habitat and/or amphibian breeding habitat.

The overall characterization of Mud Creek in the Subwatershed Study is a cold/cool water system with 20 fish species observed. The Hogs Back Catchment contains warm/cool water recreational and baitfish fishery with 40 fish observed.

3.3 DRAINAGE AND HYDROLOGY

JL Richards prepared this component in conjunction with the Existing Conditions Report (Appendix B) for the Master Servicing Study. The purpose of this section is to identify and characterize the existing drainage patterns within the Study Area. This will provide an understanding of the hydrology and hydraulics of the BSUESA within the larger watershed. This information will be used to refine already established rural drainage boundaries and delineate ultimate (major and minor) drainage area boundaries. This evaluation will also assist in establishing quantity control flow points and to assist with ultimate SWM design.

The impact of the development area on the receiving waters will be a critical aspect in the development of the SWM strategy. The recommended SWM strategy will need to minimize any adverse impacts on downstream watercourses, and demonstrate that the impacts of development can be mitigated through the design of the SWM infrastructure recommended within the Study Area.

3.3.1 HYDROLOGICAL MODELS

Since the 1980s, hydrological models have become the principal tool to calculate flood flows under extreme conditions and assess flooding impacts along water bodies and within urban areas.

An understanding of the existing conditions in terms of capacity of the culverts and expected flow rates can be achieved from an accurate existing conditions hydrological model. To simulate the hydrological response of a given area, a hydrologic model should ideally be calibrated to actual monitored flows to ensure a true representation of the physical characteristics of the catchment area during the recorded storm events. For this project, surface flows were not monitored within the limits of the BSUESA and, consequently, the hydrological model was not calibrated. The model was developed based on generally accepted standard hydrological parameters that fairly represent the land use, soil characteristics, types of flow paths, and topography.

The SWMHYMO hydrological model for the BSUEA is a single event model for the purpose of estimating flood flows at the boundary control points of the site for storm events ranging from the 1:2 year and 1:100 year recurrence. The simulated area included the BSUESA as well as the lands up to the external boundary points; Cambrian Road, Borrisokane Road and Barnsdale Road. The model has been developed using the drainage areas delineated for the project.

The pre-development SWMHYMO simulation results, predicting flows at each of the culverts for the critical storm event, are shown in Table 3-1. The estimated capacity and level of service of each culvert is also provided. The details of culvert CR-C2, crossing Cambrian Road at Borrisokane Road, could not be obtained in the field due to obstructions and/or structural failure. Hence, the capacity and level of service at this culvert could not be confirmed.

FIGURE 3-2: EXISTING DRAINAGE CONDITIONS

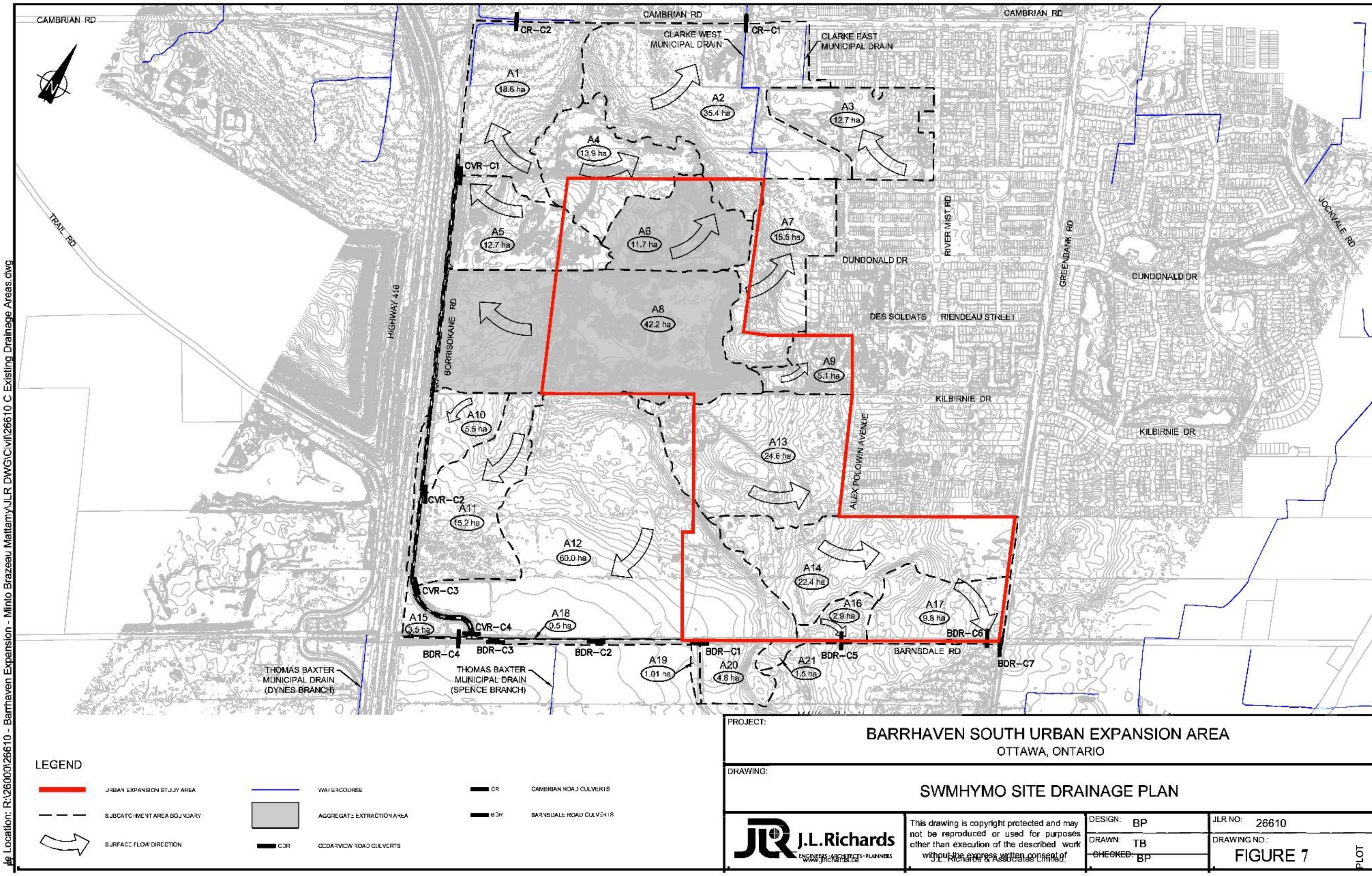


TABLE 3-1: HYDROLOGICAL SIMULATION RESULTS AT CULVERT LOCATIONS (12 HOUR SCS TYPE II STORM)

	Flow (m^3/s) at Culvert Location for Return Period (Recurrence)						Estimated Culvert Capacity (m^3/s)	Estimated Level of Service (years)
	1:2	1:5	1:10	1:25	1:50	1:100		
CR-C1	0.3	0.7	1.0	1.6	2.0	2.5	5.5	1:100
CR-C2	0.2	0.4	0.7	1.0	1.3	1.6	N/A	N/A
CVR-C1	0.1	0.3	0.5	0.8	1.0	1.3	0.4	1:5
CVR-C2	0.0	0.1	0.1	0.2	0.2	0.3	0.2	1:25
CVR-C3	0.0	0.1	0.2	0.2	0.3	0.4	0.3	1:50
CVR-C4	0.2	0.4	0.6	0.9	1.1	1.4	2.6	1:100
BDR-C1	0.0	0.0	0.1	0.1	0.1	0.2	0.2	1:100
BDR-C2	0.0	0.1	0.1	0.1	0.2	0.2	0.2	1:50
BDR-C3	0.1	0.1	0.1	0.2	0.2	0.3	0.5	1:100
BDR-C4	0.2	0.4	0.6	0.9	1.2	1.5	2.6	1:100
BDR-C5	0.0	0.0	0.0	0.0	0.0	0.1	0.3	1:100
BDR-C6	0.0	0.0	0.1	0.1	0.2	0.2	0.2	1:100
BDR-C7	0.1	0.1	0.1	0.2	0.3	0.4	0.3	1:50

The SWMHYMO model results show relatively low flow rates at each of the culverts, due to the high infiltration capability of the soils in the area and the low impervious ratio. In general, during larger and infrequent events, runoff will increase as the infiltration capability decreases due to saturation of the soils.

The culverts crossing the main boundary roads to the site (CR-C1, CR-C2, BDR-C4, BDR-C5 and BDR-C6) have high estimated levels of service (in excess of 1:100 years) with the exception of two culverts on Barnsdale Road and the culvert on Cambrian Road, which are unrecorded. Since these roads are classified as arterial or collector roads, they would be expected to have a higher level of service compared to the culverts internal to the site or under access roads south of Barnsdale Road.

Simulated flows for the Rideau River watershed via the Hawkins Municipal Drain were found to range between 0.1 m^3/s to 0.4 m^3/s for the 1:2 year and 1:100 year design storms, respectively. Simulated flows for the Mud Creek watershed via the Dynes Branch of the Thomas Baxter Municipal Drain were found to range between 0.2 m^3/s to 1.4 m^3/s for the 1:2 year and 1:100 year design storms, respectively.

The Thomas Baxter Municipal Drain is immediately south of the BSUESA at Barnsdale Road and carries flow from Barnsdale Road to Mud Creek. There are no plans to abandon or enclose the drain. Based on topography, approximately 11 ha of the southwestern portion of the BSUESA are tributary to Mud Creek via the Thomas Baxter Municipal Drain. Further detail is provided in Section 3.3.2 (Water Budget Analysis) and within Appendix B of the MSS Study.

Due to topography, the exact peak flows for the CDP areas impacting the Municipal Drains were not estimated given that an assumption of a vertical wall at the CDP limit would be an artificial boundary. The MSS provides details of the proposed reduction of flows for the Thomas Baxter Drain given that the areas will be reduced by approximately 11 ha.

3.3.2 WATER BUDGET ANALYSIS

The water budget of a given area is often studied by hydrologists and hydrogeologists to better understand the movement of water through its various stages. Natural watershed systems maintain a balance between precipitation, runoff to water bodies, infiltration to the groundwater system, evaporation from water surfaces, or transpiration from vegetation, completing the natural cycle back into atmospheric moisture and precipitation. The analysis of the water budget is often carried out to establish the baseline condition and assess any future changes in infiltration to subsurface water-bearing zones and, consequently, to surface runoff resulting from a significant land cover modification such as urbanization. It is also used to predict changes to the hydrological cycle that will result from urbanization of lands.

Figure 3-3 summarizes graphically the natural hydrological cycle describing the continuous movement of water on, above, and below the surface.

In simple terms, the general water budget assesses the change in water storage resulting from the difference in water inputs and outputs for a given area or watershed.

To estimate the water budget, the following simplified equation was used:

$$P = ET + SW + GW + \Delta S$$

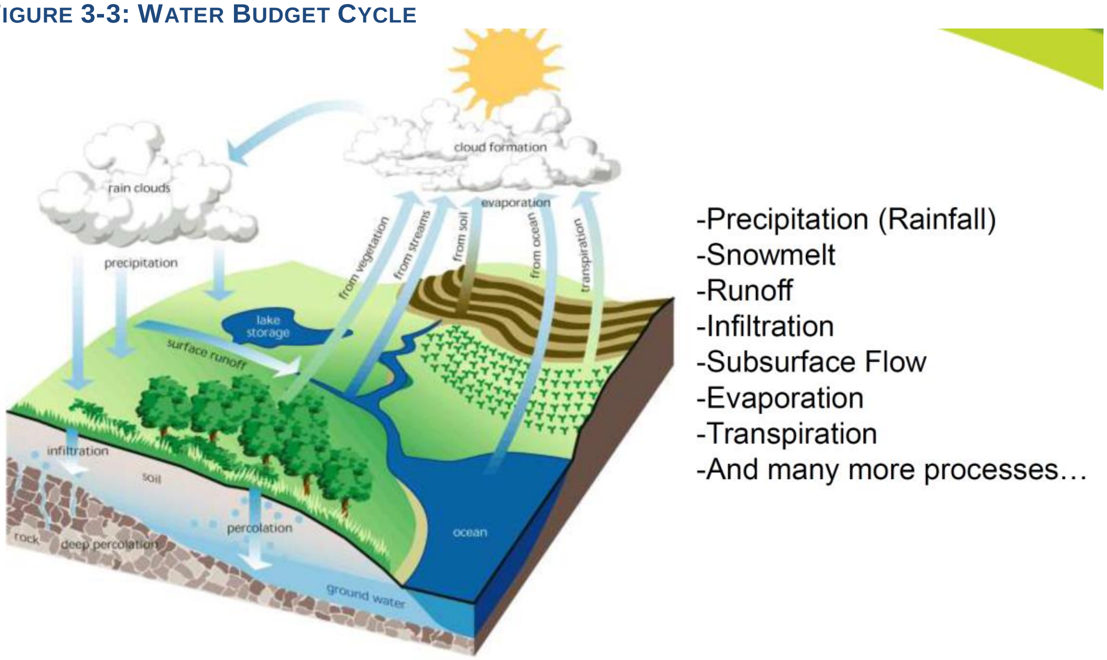
Where:

- P is precipitation;
- ET is evapotranspiration;
- SW is surface runoff;
- GW is groundwater; and
- ΔS is the difference in water storage.

As a fundamental requirement, the water budget developed for the existing conditions will be used as the baseline condition when assessing the effectiveness of any stormwater management (SWM) strategies under the post-development condition.

Future SWM strategies should adhere to recent Provincial direction from the MOECC in their publication entitled “Expectation interpretation bulletin, February 2015”, as well as relevant PPS policies. One of the objectives of the accompanying Master Servicing Study was to develop a storm servicing strategy that incorporates mitigation measures to minimize the water deficit in an effort to offset the potential impact of urbanization.

FIGURE 3-3: WATER BUDGET CYCLE



Continuous Simulation Modeling

An understanding of the water budget within a given study area can be gained through the use of a continuous hydrological model. The Toronto and Region Conservation Authority (TRCA), in their publication entitled “Stormwater Management Criteria, August 2012”, recommend the use of a continuous model such as QUALHYMO or PCSWMM.

The PCSWMM model was used for this study and included simplified groundwater and snowmelt modules that allow the continuous simulation of the water budget, including the elements of evapotranspiration, the groundwater table (lower saturated zone), snowfall, and snowmelt. Due to its capabilities and versatility, the PCSWMM modeling tool will also be used to assess the impact of development and effectiveness of the proposed Low Impact Development (LID).

Precipitation and Evaporation

The continuous simulation model was run using precipitation data from the Environment Canada weather stations at Ottawa Macdonald-Cartier International Airport and the Experimental Farm in Ottawa (approximately 10 km and 15 km from the BSUEA respectively). In excess of 30 years of hourly data, between January 1, 1960 and October 31, 1990, was used to undertake the water budget analysis. The average annual rainfall during this period was 844 mm, while the maximum and minimum daily temperatures from the same weather stations and time period were also used.

The model undertakes evaporation calculations based on average monthly rates of evaporation (as reported by Environment Canada (Figure 3-4) and from the available standing water that is "trapped" in natural depressions within the subcatchment surfaces as a result of the initial abstraction depth.

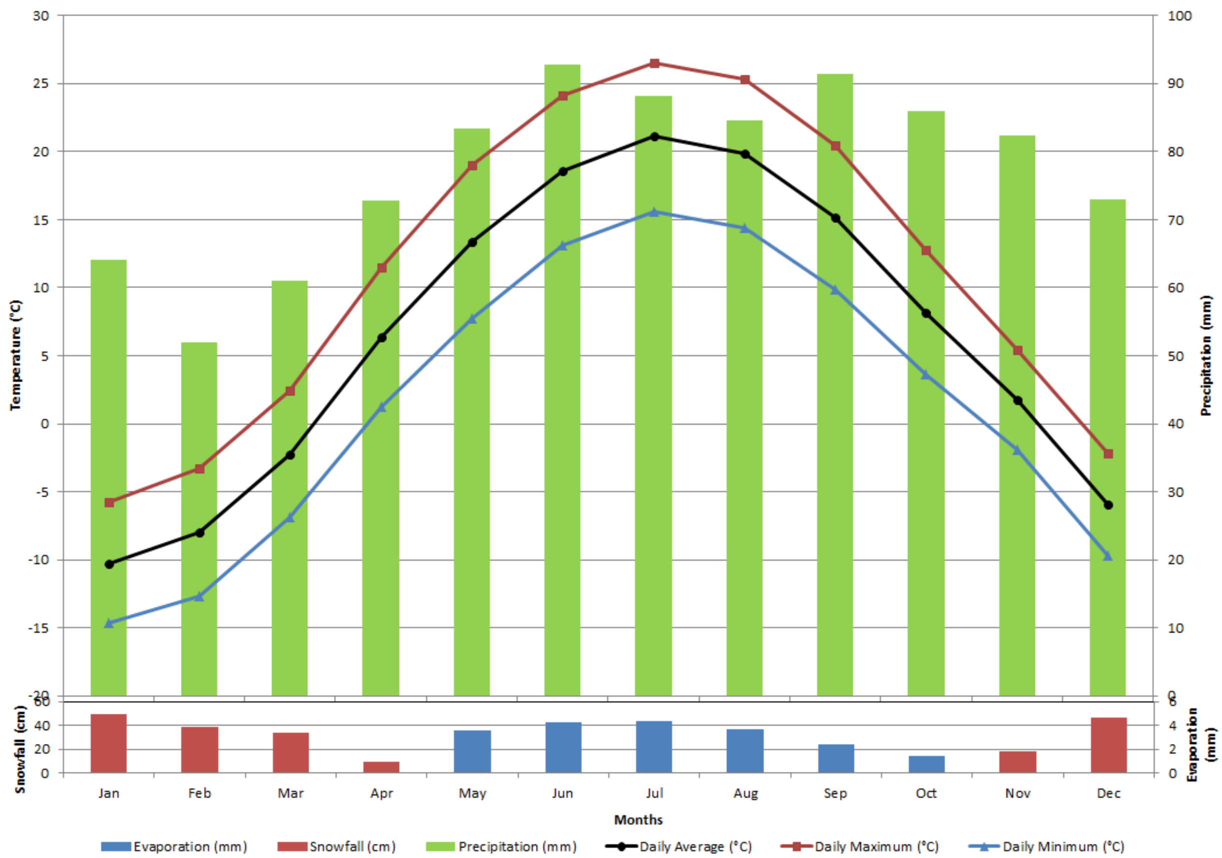


FIGURE 3-4: ENVIRONMENT CANADA, OTTAWA CLIMATE NORMALS

Groundwater

PCSWMM analyzes groundwater flow for each subcatchment independently. It represents the subsurface region beneath a subcatchment as an unsaturated upper zone that lies above a lower saturated zone. The elevation of the lower saturated zone, the water table, varies in time depending on the rates of inflow and outflow of the lower saturated zone. The flow to the lower saturated zone is controlled by percolation, which is dictated by the soil characteristics. The upper unsaturated soil zone receives water via infiltration from surface runoff. Evapotranspiration occurs from the upper unsaturated zone and can occur from the lower saturated zone depending on root depth. If the water table, or elevation of the lower saturated zone, reaches the surface level then all the soil is saturated and infiltration will no longer occur.

For the purposes of modelling the water budget's existing condition, subcatchments have been delineated for the extent of each HSG within the BSUEA. In addition, subcatchment delineation also considered the properties currently operating as aggregate pits as separate catchments.

Snowmelt

Snowmelt is an additional mechanism by which runoff may be generated in a continuous simulation model. The current SWMM software platform utilizes the Canadian SWMM snowmelt routines with extensions for long term continuous modelling.

Snowfall rates are determined directly from hourly precipitation data by using a pre-set temperature: snowfall will occur when the temperature is below the pre-set point and rainfall when above. Snowmelt is handled differently by PCSWMM depending on the occurrence of rainfall. During rain on snowmelt events, the model takes into account the rainfall intensity and the air temperature as well as the saturation vapour pressure. When snowmelt occurs without any rainfall, the snowmelt is linearly proportional to the air temperature, which varies with the user supplied melt coefficients. For the existing condition model it has been assumed that all snow occurs on pervious land cover and there is no snow removal.

Continuous Simulation Results

A long-term simulation was carried out for the maximum, minimum, and median of each of the infiltration ranges of each block (Table 3-2) which has been grouped based on the above noted ranges of infiltration. These results show that there is no significant variation within the range of values for each set of infiltration values. This is expected, as the peak rainfall events over a 30-year simulation period are generally lower than the infiltration rates (ranging between ±50 mm/hr and ±105 mm/hr) within the frequent event ranges and are, therefore, not affected. Only the infrequent large peak rainfall events will be affected by the change in infiltration within the range of values.

TABLE 3-2: COMPARISON OF RESULTS WITH RANGE OF INFILTRATION VALUES

Annual Water Budget Components	Minimum Infiltration	Median Infiltration	Maximum Infiltration
Precipitation (mm/year)	**844**	**844**	**844**
Evapotranspiration (mm/year)	**506**	**506**	**506**
Infiltration (mm/year)	**336**	**337**	**338**
Surface Runoff (mm/year)	**2**	**1**	**1**

Since there is negligible variability in the simulation results shown above, only the median infiltration values will be considered going forward with the water budget analysis. Based on the medium infiltration, the continuous simulation results have been summarized for each of the three (3) subwatersheds as shown in Table 3-3**.**

TABLE 3-3: WATER BALANCE CONTINUOUS SIMULATION RESULTS

Annual Water Budget Component	Annual Average Depth (mm)				Budget %
	To Jock River	To Mud Creek	To Rideau River	Area Weighted Total	
Precipitation	844	844	844	844	100%
Evapotranspiration	506	506	506	506	60%
Infiltration	338	336	336	337	40%
Surface Runoff	1	2	2	1	0%

Based on the above long-term simulation results, infiltration accounts for approximately 40% of the total annual precipitation of 844 mm, while surface runoff accounts for approximately 0% on a yearly average. Specifically, surface runoff accounts, on average, for 1 mm per year out of the total annual precipitation of 844 mm, representing approximately 0.1%.

Although the average annual total depth of runoff is virtually non-existent percentage wise, the model computed surface flows when precipitation depths were encountered that exceeded a 1:5 year recurrence or when peak intensities were greater than a 1:2 year recurrence. Based on the review of the 30-year simulation results, a peak flow of 3.27 m^3/s was computed as the largest flow by the model. This peak flow was generated from the overall BSUESA and sheet flow draining towards the three (3) sub-watershed outlets. A peak flow of 2.44 m^3/s was computed as being directed to the Jock River.

The event resulting in the largest peak runoff occurred on August 4, 1988 and is one of the historical storms listed in the City of Ottawa Sewer Design Guidelines to be simulated to assess the performance of drainage systems. However, such large events are infrequent in nature, as witnessed by the peak flow generated on August 4, 1988 as occurring once during the 30-year simulation. Table 3-4, summarizes the five (5) greatest and smallest peak flow events generated by the model with the associated rainfall depth and peak intensity as well as its corresponding frequency.

TABLE 3-4: TOP FIVE LARGEST AND SMALLEST PEAK FLOW EVENTS

Date	Peak Runoff to Jock (m^3/s)	Peak Runoff to Mud (m^3/s)	Peak Runoff to Rideau (m^3/s)	Storm Duration (hrs)	Peak Rainfall Intensity (mm/hr)	Equivalent Return Period	Total Rainfall Volume (mm)	Equivalent Return Period
August 4, 1988	2.44	0.40	0.43	4	37.4	10 year	77.0	100 year
August 8, 1973	0.42	0.15	0.16	7	30.2	5 year	60.5	10 year
June 16, 1981	0.35	0.14	0.15	2	36.9	10 year	38.3	5 year
June 11, 1973	0.34	0.14	0.15	3	33	5 year	42.4	5 year
August 8, 1973	0.31	0.07	0.10	8	30.2	5 year	60.5	10 year
June 11, 1976	0.02	0.01	0.02	2	24.6	2 year	24.9	2 year
Sept. 12, 1963	0.01	0.01	0.01	8	10.2	< 2 year	52.4	5 year
Sept. 11, 1986	0.01	0.01	0.01	14	14	< 2 year	42.9	5 year
July 1, 1979	0	0	0	5	14.0	< 2 year	26.3	< 2 year

Note: shaded columns highlight the computed flows during two (2) historical storms.

The following conclusions can be drawn from the statistics summarized in the above table:

- The largest event, from a volumetric perspective, occurred on August 4, 1988 with a recorded volume of 77 mm over four (4) hours, which, compared to the City of Ottawa IDF curve, has a frequency greater than a 1:100 year; and
- From a peak intensity perspective, the August 4, 1988 event was the largest with a recorded peak intensity of 37 mm/hr, which, compared to the City of Ottawa IDF curve, has a frequency of 1:10 year.

Three (3) events were recorded with a peak intensity of between 36 and 37 mm/hour, which, given that this is approximately a 1:10 year return period event, is true to the statistics. Only two (2) of these recorded any runoff as the total volume of runoff was insufficient to trigger flow.

In terms of rainfall volume, none of the events over the 30-year simulation period were greater than a 1:10 year event, other than the one which resulted in the largest peak flow and one other 24-hour period, which did receive more rainfall than the 1:100 year volume; however, the peak intensity was 20 mm/hr, less than a 1:2 year event. Due to the low peak intensity, this other 1:100 year event did not trigger any runoff flows.

The City of Ottawa has three (3) historical events that are used to assess how a system would function under historical extreme events. The 1988 event triggered the largest runoff flow from the BSUESA; however, the 1979 event did not result in any runoff. The simulation uses hourly rainfall data that averages the intensities within the hour period and creates an average peak, which will be of less significance when compared to any peak intensities identified in the 5-minute data.

A preliminary high level scenario of a potential future water budget was simulated for a development having a total imperviousness of 65%, of which 58.5% is "Directly Connected Impervious" area (i.e., 90% of the total imperviousness was assumed to be directly connected) without any Best Management Practices to promote infiltration. The results indicate that the percentage of infiltration will reduce from 40% (existing condition) to 28% (post-development without BMPs) of the overall annual water budget. Simulation results have also shown reductions in evapotranspiration as a result of the decrease in vegetation, which, in turn, generates increases in surface runoff. *Consequently, stormwater management measures promoting infiltration will be necessary to meet the target of maintaining pre-development infiltration levels.*

Water Quantity Control

Water quantity criteria will be affected by site constraints and municipal and provincial requirements. Water quantity control for lands that drain to the Jock River will be governed by available capacity in existing and planned minor and major systems in the existing Barrhaven South Community.

Since the existing and planned infrastructure was designed to service lands up to the current Urban Boundary, there is limited or no available capacity in existing and planned minor and major systems. Table 3-5 summarizes the minimum residual capacity of trunk sewers, the minimum freeboard between USF, and the 1:100 year HGL and maximum street ponding depth for each stormwater management facility (SWMF) outlet. As shown in Table 3-5, all minor systems are either close to or exceeding the minimum allowable freeboard between HGL and USF of 0.30 m as required by the Design Guidelines. *Additionally, the major system through which the Todd Pond outlets does not meet the maximum allowable street ponding depth (static and dynamic) of 35 cm per Technical Bulletin PIEDTB-2016-01.*

TABLE 3-5: AVAILABLE CAPACITY IN EXISTING AND PLANNED MINOR AND MAJOR STORM SYSTEMS IN BARRHAVEN SOUTH

Outlet (SWMF)	Sewer Status	Minimum available capacity in trunk storm sewers	Minimum clearance (freeboard) between 1:100 yr & USF	Maximum street ponding (static + dynamic)
Corrigan Pond	Existing	735 L/s (MH 105-106A) (1)	0.32 m @ MH 104B on the existing Greenbank Road (2)	0.35m (3)
Todd Pond	Existing	136 L/s (MH 643-640) (5)	0 m (i.e., no freeboard, HGL is 0.23 m above USF and 0.02 m below basement floor) (5)	11 roadway sags with flow depth in excess 400 mm (5)
Clarke Pond	Planned	237 L/s (MH 211-211A) (6)	Not available - conceptual HGL at 0.08 m below T/G of MH 304 (4)	Information has not been reported
Cedarview Pond	Planned	165 L/s (MH 506-505) (6)	Not available, conceptual HGL at 0.20 m below T/G of MH 304 (6)	Information has not been reported
Greenbank Pond	Planned	167 L/s (MH415-409) (6)	Not available, conceptual HGL at 0.47m below T/G of MH N403A (6)	Information has not been reported

References
(1) IBI Storm Sewer Design Sheet Dated May 2010
(2) IBI SWM Barrhaven South October 2014
(3) JLR Quinn’s Pointe Site Servicing Report Dated July 29, 2016
(4) JFSA July 25, 2013 Todd Pond and Clarke Pond Model Keeper Analysis / Update of Half Moon Bay South Subdivision Plan
(5) JFSA April 2015 Todd Pond Model Keeper Re-Assessment of Existing System Capacity
(6) Stantec Draft 2014 BSMSSA

Within the BSUESA, the realigned Greenbank Road will be classified as an arterial road; major overland flow generated by events up to 1:100 year will, therefore, not be able to cross the realigned Greenbank Road. Since the realigned Greenbank Road will bisect the BSUESA, this restriction on overland flow conveyance will have implications for stormwater management within the development.

Water Quality Control

Water quality treatment will need to be provided in accordance with the relevant subwatershed studies. The Jock River Reach One Subwatershed Study states that, for areas tributary to the Jock River, an enhanced level of water quality treatment, in accordance with the MOE 2003 SWMPDM, is required. It is noted that currently existing and planned SWMFs in Barrhaven South exceed the MOECC water quality storage requirement to achieve an enhanced level of protection for their current drainage areas, as summarized in Table 3-6.

TABLE 3-6: WATER QUALITY STORAGE ASSESSMENT FOR EXISTING AND PLANNED SWMFS

SWMF	SWMF Status	Water Quality Storage (m3) in Excess of Minimum MOECC Requirements	
		Wet Permanent Pool	Extended Detention Volume
Corrigan Pond	Existing	1700 (1)	100 (1)
Todd Pond	Existing	6936 (2)	Information has not been reported
Clarke Pond	Planned	2804 (3)	Information has not been reported
Cedarview Pond	Planned	211 (4)	Information has not been reported
Greenbank Pond	Planned	582 (4)	Information has not been reported

Notes

(1) As per IBI June 9, 2015 Letter Report - Corrigan SWM Facility

(2) As per JFSA April 2015 Todd Pond Model Keeper Re-Assessment of Existing System Capacity (Appendix E)

(3) As per JFSA July 25, 2013 Todd Pond and Clarke Pond Model Keeper Analysis / Update of Half Moon Bay South Subdivision Plan

(4) As per Stantec Draft 2014 BSMSSA

The Mud Creek Subwatershed Study does not make any specific water quality protection requirements but states that surface water contamination from point and non-point sources must be managed. Additionally, the Lower Rideau Subwatershed Study has set an objective to manage the quality and quantity of non-point source runoff and to manage surface and groundwater contamination from point source discharges.

3.4 GEOTECHNICAL & HYDROGEOLOGICAL

The geotechnical and hydrogeological components of the EMP include a characterization of the local physiography and geology of the BSUESA, including details associated with the groundwater recharge and discharge conditions. Paterson Group Inc. (Paterson) was retained to conduct the geotechnical and hydrological investigations, which included test pit excavation, borehole drilling, monitoring well installation, groundwater level monitoring, and hydraulic conductivity testing. These investigations were completed by Paterson between 2015 and 2016. The full Geotechnical Investigation (Patterson, 2017) report is attached as Appendix C, with the Hydrogeological Existing Conditions Report provided as Appendix D. A summary of the existing geotechnical and hydrogeological conditions is provided in this section.

3.4.1 PHYSICAL SETTING, SURFICIAL AND BEDROCK GEOLOGY

The BSUESA is covered by a mix of undeveloped, former agricultural land, with limited forested areas, and two sand and gravel aggregate sites. Topographic relief across the site is significant with a general downward slope in a west-to-southeast direction (±110 m at its highest dropping to 101 to ±104 m in the southeast portion of the parcel). As previously mentioned, the only surface water features within the BSUESA are the aggregate site ponds associated with the two existing active pits within the northern portion of the Study Area. Multiple fill piles and large areas currently excavated to several meters below original grade were observed within the east portion of the CDP lands. Adjacent to the subject site is an unnamed temporary sediment control pond that connects to nearby municipal drains near the intersection of Borrisokane Road and Barnsdale Road.

According to available mapping, the subject site is largely located in the Ottawa Valley Kars Esker physiographic region (Chapman and Putnam, 1984) with portions of the site intersecting Sand Plains (glaciofluvial deposits) to the west (see Figure 3-5, Surficial Geology). Test investigations showed the sub-surface to consist of a sandy topsoil, or fine grained soil with significant root matting at ground surface followed by a predominantly coarse-grained deposit of till, glacial fluvial and silty fine sand and/or sandy silt. A silty sand overlying a silty clay was encountered within a small portion of the eastern CDP area. Silty sand deposits were encountered intermittently across the BSUESA (see Table 1 within Appendix C for detailed soil classification of the BSUESA). The silty sand, sandy silt deposits were noted to contain gravel, cobbles and boulders at several locations.

Digital geological mapping was reviewed to show the site's bedrock as consisting of dolomite of the Oxford Formation underlain by the March Formation (see Figure 3-6, Regional Bedrock). Bedrock was not encountered during field investigations. Overburden thickness during site investigations showed depths greater than 10 metres up to 16.8 metres depth across the BSUESA, which are consistent with available mapping showing relatively deep overburdens (15 to 25 metres) (see Figure 3-7, Drift

Thickness). A review of available water well records indicated bedrock at depths ranging from approximately 17.7 metres (within central BSUESA) to depths greater than 25 metres.

3.4.2 HYDROGEOLOGICAL SETTING

The majority of the BSUESA consists of moderate to high permeable material extending to the west Sand Plains and to the southeast glaciofluvial deposit zones. Clay plains are encountered to the north of the BSUESA and act as a confining layer for groundwater flowing northward toward the Jock River. As the Kars Esker formation consists of material of significantly higher permeability, the possibility exists that the clay layer could be underlain by a granular strata that is hydraulically connected with the fanning Esker material. The site-specific geological data and hydraulic conductivity testing confirmed the properties of the Esker as consisting of highly permeable material across the majority of the site.

Based on a review of MOECC water well record database, Paterson identified three aquifer systems in the vicinity of the study area. They consist of the underlying bedrock aquifer, the deeper overburden aquifer extending over the majority of the site and a localized shallow aquifer or a perched condition (area adjacent to Borehole (BH) 11-15). A review of the Ontario water well record database indicated that water supply wells in the vicinity of the subject site are generally completed in the bedrock with several accessing the Kars Esker and the adjacent Sand Plains (glaciofluvial deposits) at the overburden/bedrock aquifer interface.

In addition to a review of available mapping and the Ontario water well record database, 36 boreholes with 20 monitoring wells were installed in the overburden at the subject site and adjacent lands to provide general coverage. Figure 3-8 shows the borehole locations, including the boreholes with monitoring wells. Hydraulic conductivity testing and groundwater level monitoring were completed at these monitoring wells and boreholes to assess hydrogeological conditions in the overburden aquifer. This work allowed for a characterization of discharge and recharge conditions at the subject site.

FIGURE 3-5: SURFICIAL GEOLOGY

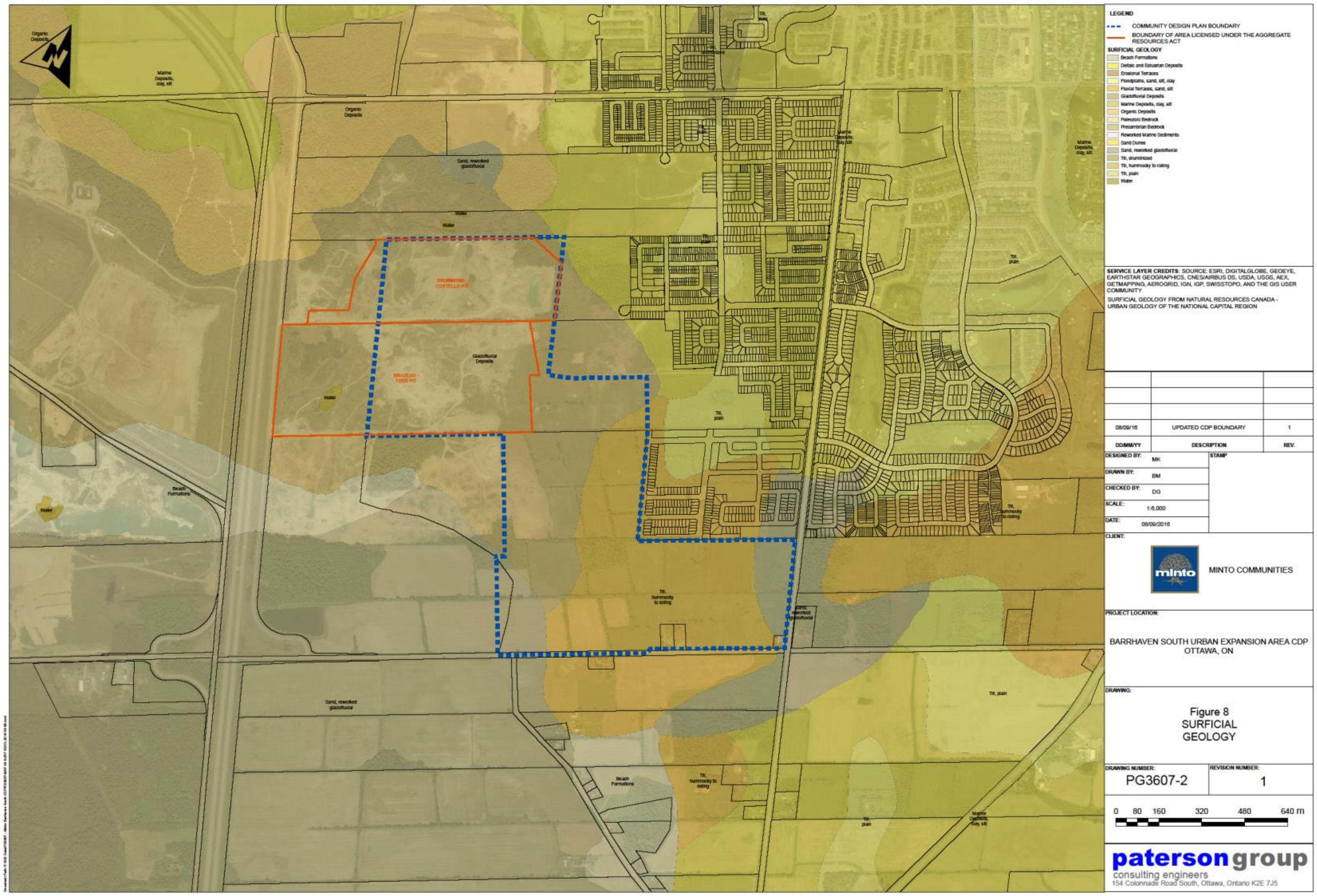


FIGURE 3-6: REGIONAL BEDROCK

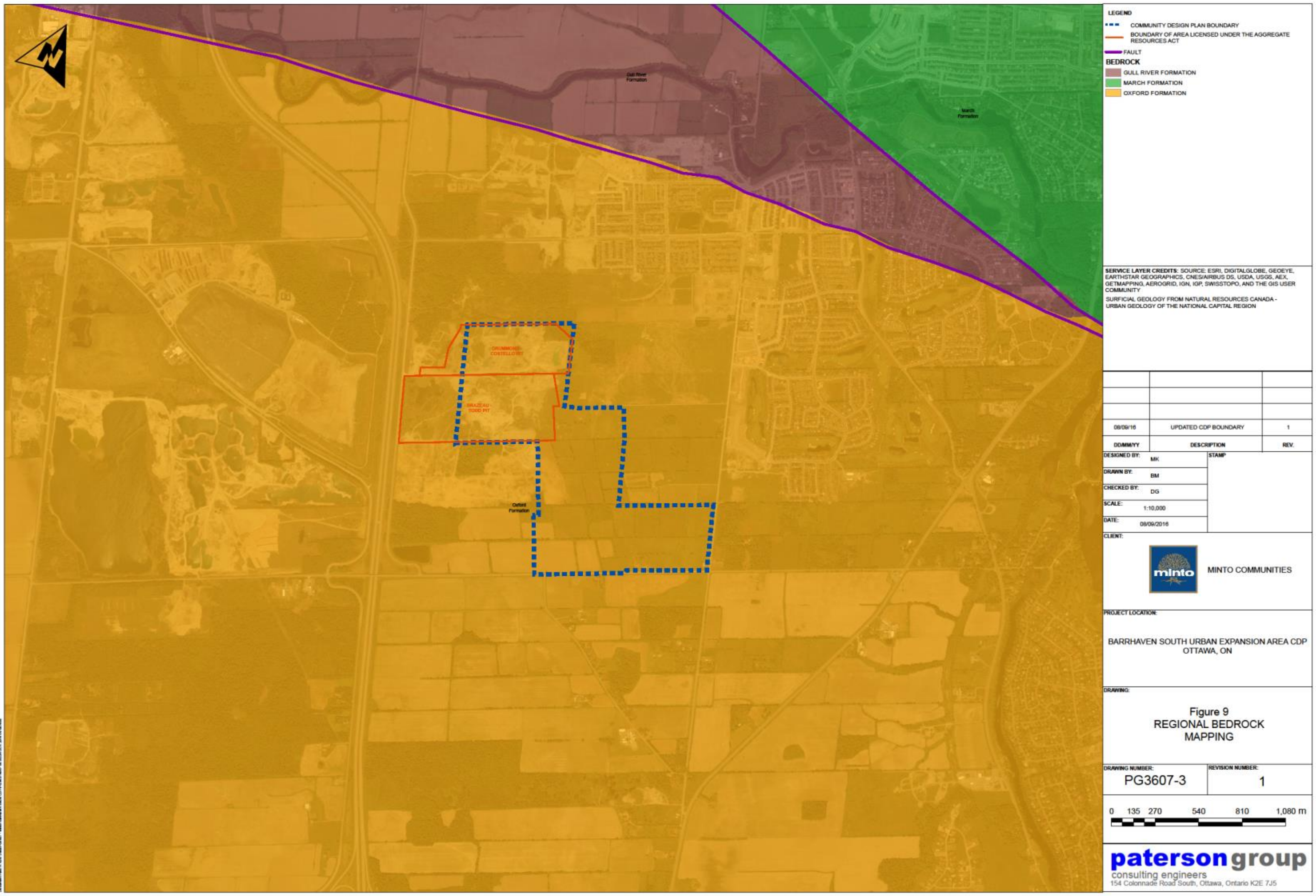


FIGURE 3-7: DRIFT THICKNESS

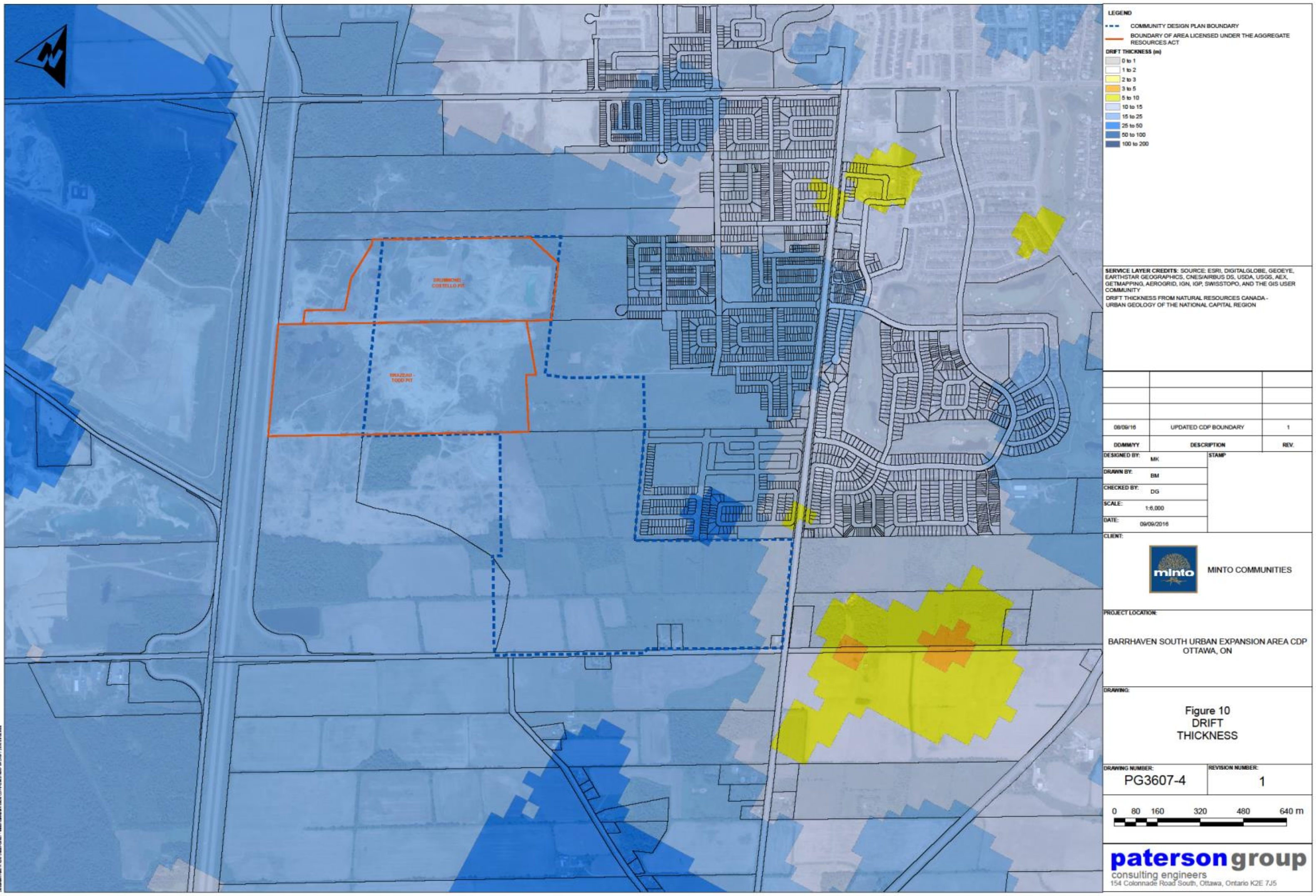


FIGURE 3-8: TEST HOLE LOCATIONS

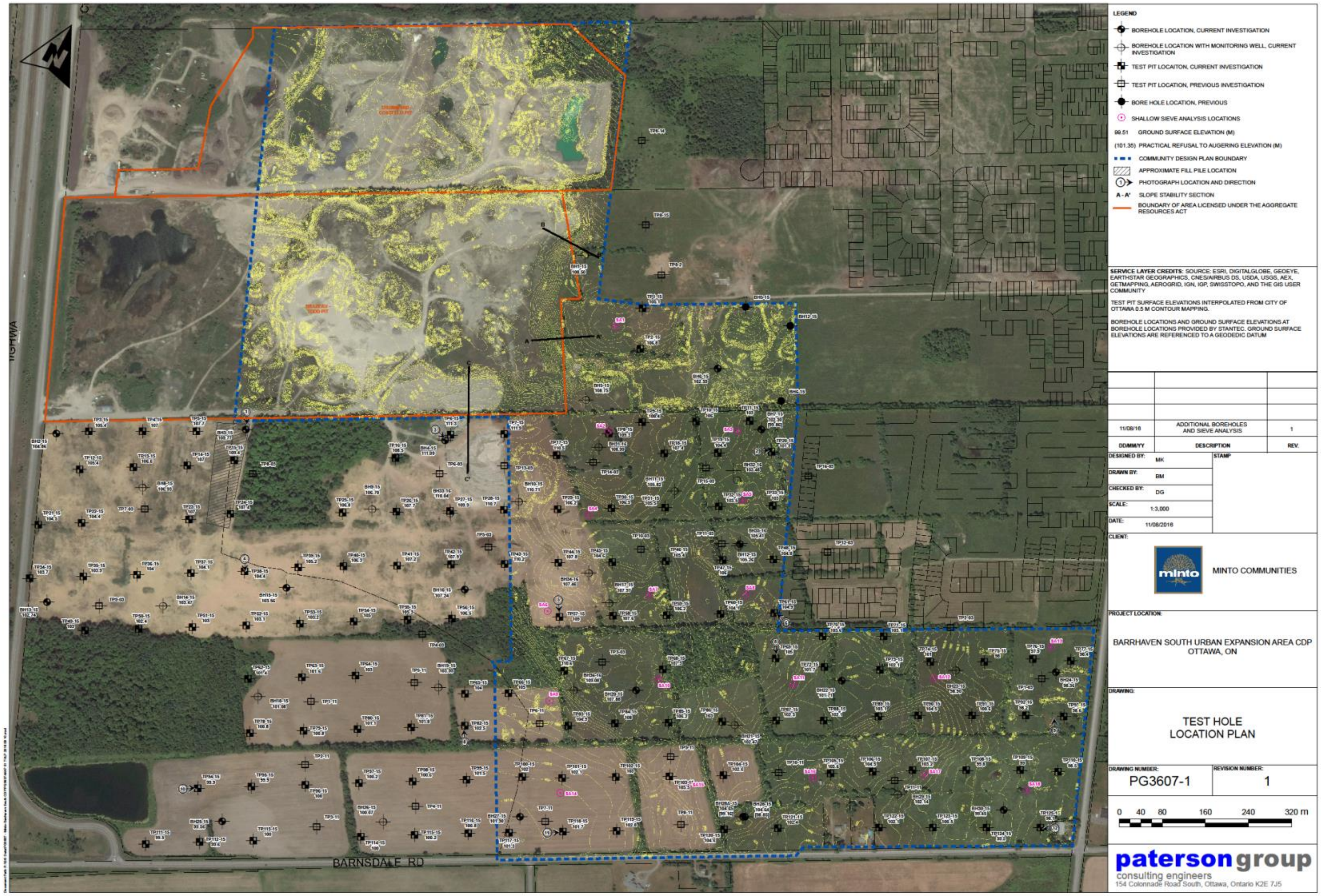
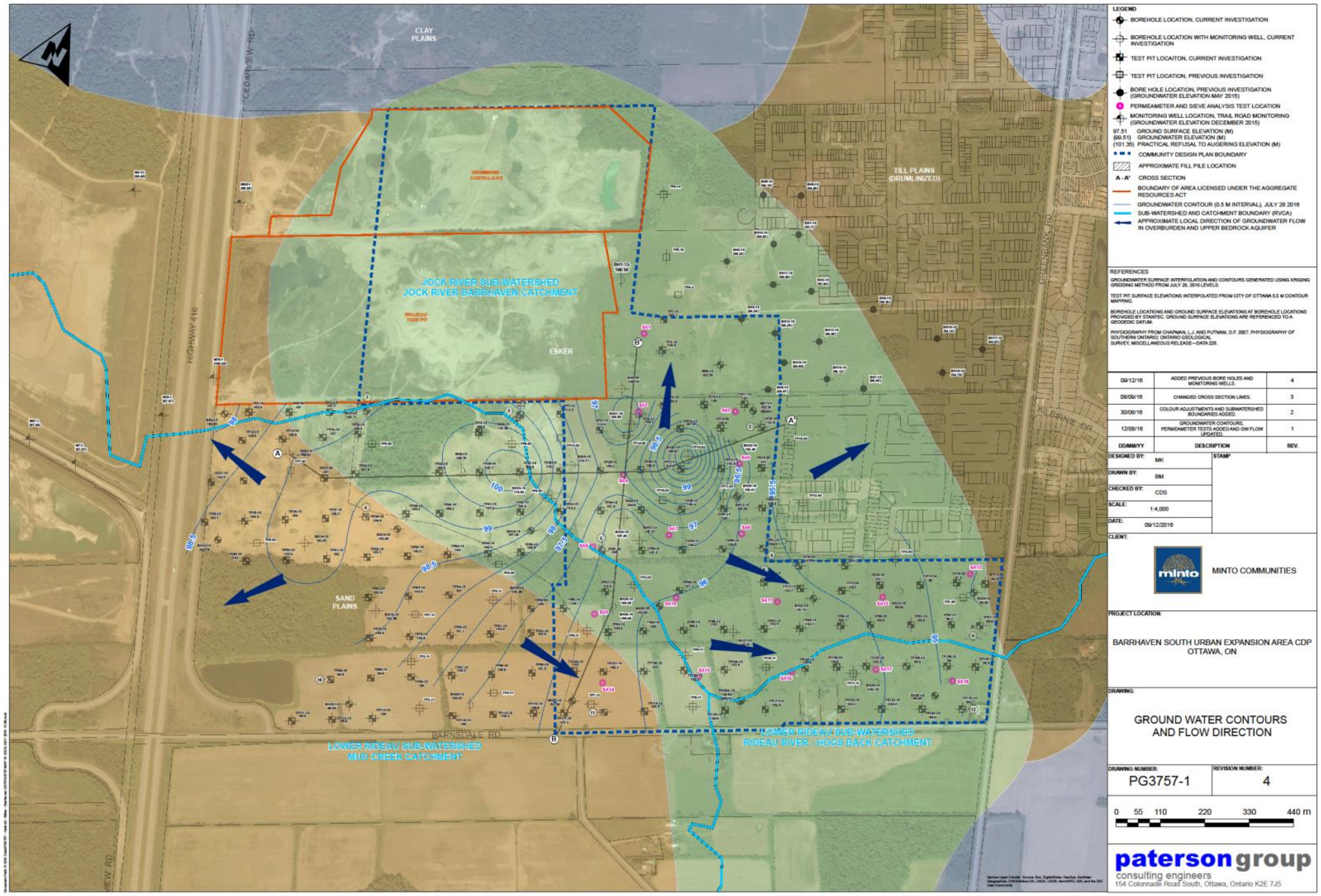


FIGURE 3-9: ESKER AND GROUNDWATER FLOW



Groundwater Conditions within Overburden Soils

This assessment addresses groundwater conditions in the overburden soils.

In general, groundwater will follow the path of least resistance from areas of higher hydraulic head to areas of lower hydraulic head. While upward and downward hydraulic gradients may be indicative of areas of discharge and recharge respectively, other factors must be considered (Paterson, 2017).

Based on hydraulic conductivity testing undertaken in the overburden soils, and hydraulic conductivity estimates based on grain size analysis of overburden soils, the overburden soils within the BSUESA are considered to have a moderate to high hydraulic conductivity. Patterson reported that their findings suggested the permeable overburden zone is acting as a recharge area for the Esker and bedrock aquifers. At the localized shallow aquifer condition, the overburden material was found to contain a higher percentage of cohesive soils.

Patterson's subsurface investigations resulted in observations of overburden soils that were generally dry to moist, becoming wet with depth, with saturated conditions observed in the silty sand and lower layers. Patterson (2017) interpreted that saturated conditions in the permeable overburden soils as representing the long-term water table at the BSUESA. Groundwater levels in overburden soils are expected to vary seasonally and provide recharge to the underlying bedrock aquifer and area water features. Localized perched water conditions should lower during periods of low precipitation and increase during greater precipitation events.

Patterson's hydraulic conductivity testing results (2017) suggested that the till and silty sand generally act as a permeable layer to transmit groundwater in a horizontal and vertical direction and provide recharge to the bedrock layer below. Based on their interpretation, the groundwater will generally flow vertically downwards to the groundwater table before travelling laterally through the non-cohesive soil deposits in a direction dependent upon which subwatershed is the major influence. The site intersects three major subwatersheds and will have flow travelling in two general directions of the Rideau River and Jock River subwatersheds. See Figure 3-8 for the recharge area (Esker) and groundwater contours and flow direction.

Given the presence of overburden soils with moderate to high hydraulic conductivity overlying the bedrock aquifer units, these study area conditions are considered to provide the potential for significant groundwater recharge. The subject site represents a small portion of the existing zone identified by the Mississippi-Rideau Source Protection Region (MRSPR) as a zone of significant groundwater recharge area. Paterson noted that the BSUESA comprises approximately 121.6 hectares (12.2%) of the total Esker Area (996 hectares, mapped by Chapman and Putnam, 1984). Groundwater recharge from ground surface to the bedrock aquifer units are considered to occur in areas that extend well beyond the boundary of the study area.

3.4.2.1 GROUNDWATER QUALITY

Groundwater chemistry testing was performed at all monitoring well locations after completion of the initial field hydrogeological investigation. Lab results were compared with Ontario Drinking Water Quality Standards (O.Reg. 169/03). Results showed that there were no BTEX, (Benzene, Toluene, Ethylbenzene and Xylene), petroleum hydrocarbons (PHC) or volatile organic compounds (VOC) concentrations detected above laboratory detection limits. Turbidity exceedances were noted for all samples.

One well location exceeded for Nitrate and three well locations exceeded for Manganese, which is likely a naturally occurring source (Paterson, 2017). Seven borehole well locations exceeded for Total Coliforms. Testing for sodium and chlorides showed one well at approximately 81% of the Ontario Drinking Standards limit for Sodium. The assessment of the suitability of groundwater resources for the proposed development of the subject site was not considered, given that the proposed development will be serviced by municipally supplied water.

3.4.3 SURROUNDING WELLS

Paterson reviewed water well records in the vicinity of the subject site, using the MOECC's online water well record search tool. Well records within 200 m of the development limits were reviewed with higher priority placed upon wells within 75 m (in keeping with Paterson's calculated "radius of influence" of the possibility of dewatering in association with service trench excavations, which would be at a depth of 9 metres). Several residences were identified as located adjacent to the southern and southeastern boundary of the BSUESA.

Based on a review of the MOECC water well records, Paterson (2017) reported that a number of the water well locations may be inaccurate based upon original field well record forms and suggested that a field survey may be required to clarify locations. Paterson reported three water wells were mapped within the BSUESA, with two locations believed to be erroneous. Finally, the review found that the majority of water well records in the area indicated water was encountered at depths of 15 m or more, significantly below the deepest assumed servicing depth of 9 m.

3.4.4 EXISTING PERMITS TO TAKE WATER

There were four Permits to Take Water (PTTW) identified in the surrounding area of the BSUESA. Three of these permits were identified as construction dewatering permits that are used on an intermittent basis during the construction of site servicing and storm ponds related to new residential development in the area. The closest developments are anticipated to have completed the majority of the servicing requirements. Most water takings for the developments occurred at separate times during the 2015 year. The fourth permit is located at the Dewatering Pit north of the Trail Road facility. The pit collects groundwater and redirects it along the surface to the Jock River through a naturalized channel. The 2014 Monitoring and Operating Final Report indicated that the average flow leaving the pit is 22.4 L/sec.

3.5 POTENTIAL ENVIRONMENTAL CONCERNS

No environmental concerns within a search radius of greater than 2 km of the BSUESA were identified, based on a review of MOECC's Brownfield Environmental Site Registry. Based on observations of Paterson staff during field work of the hydrogeological investigation, no potential environmental concerns were identified with respect to the BSUESA, and no visual or olfactory evidence of contamination was observed in the soil, groundwater, or bedrock.

3.5.1 TRAIL ROAD SOLID WASTE FACILITY

The Trail Road Solid Waste facility is located west of the BSUESA and approximately 500 metres and 1 kilometre from the limits of the aggregate pits and the proposed residential lands uses of the CDP Study Area, respectively. Monitoring reports indicated that some leachate effects have been noted up to 300 m north of the Trail Landfill within the shallow overburden aquifer, which are limited to City property. The deep aquifer also displayed some leachate influences to the north in the direction of the Dewatering Pond (see Section 3.4.4). There were some increases in parameter concentrations, but are expected to be reduced once the final cover has been placed on the landfill. There were no reports of leachate impacts within the bedrock aquifer.

3.6 PREVIOUS LAND USES

Former land uses of the BSUESA include agriculture. A typical design for agricultural fields includes tile drains; however, tile drains may not have been installed due to the higher hydraulic conductivity of the overburden soils (Paterson, 2017). The presence of agricultural tile drains was not confirmed within the BSUESA during the hydrogeological and geotechnical investigations and are not expected to be encountered during future development.

Field observations indicated that there are currently three residences within the BSUESA that may have existing sewage systems, which will need to be decommissioned. As previously mentioned, total coliforms (see Section 3.4.3) were detected in multiple test boreholes.

4. ENVIRONMENTAL RECOMMENDATIONS

Based on the analysis of existing conditions, environmental constraints and opportunities were identified and evaluated. Constraints on the site are limited and several opportunities are present. The consolidated opportunities and constraints are shown on Figure 4-1 and presented in Section 4.1 below. Recommendations to address these opportunities and constraints (Section 4.2) are presented in Section 4.3.

4.1 SUMMARY OF OPPORTUNITITES AND CONSTRAINTS

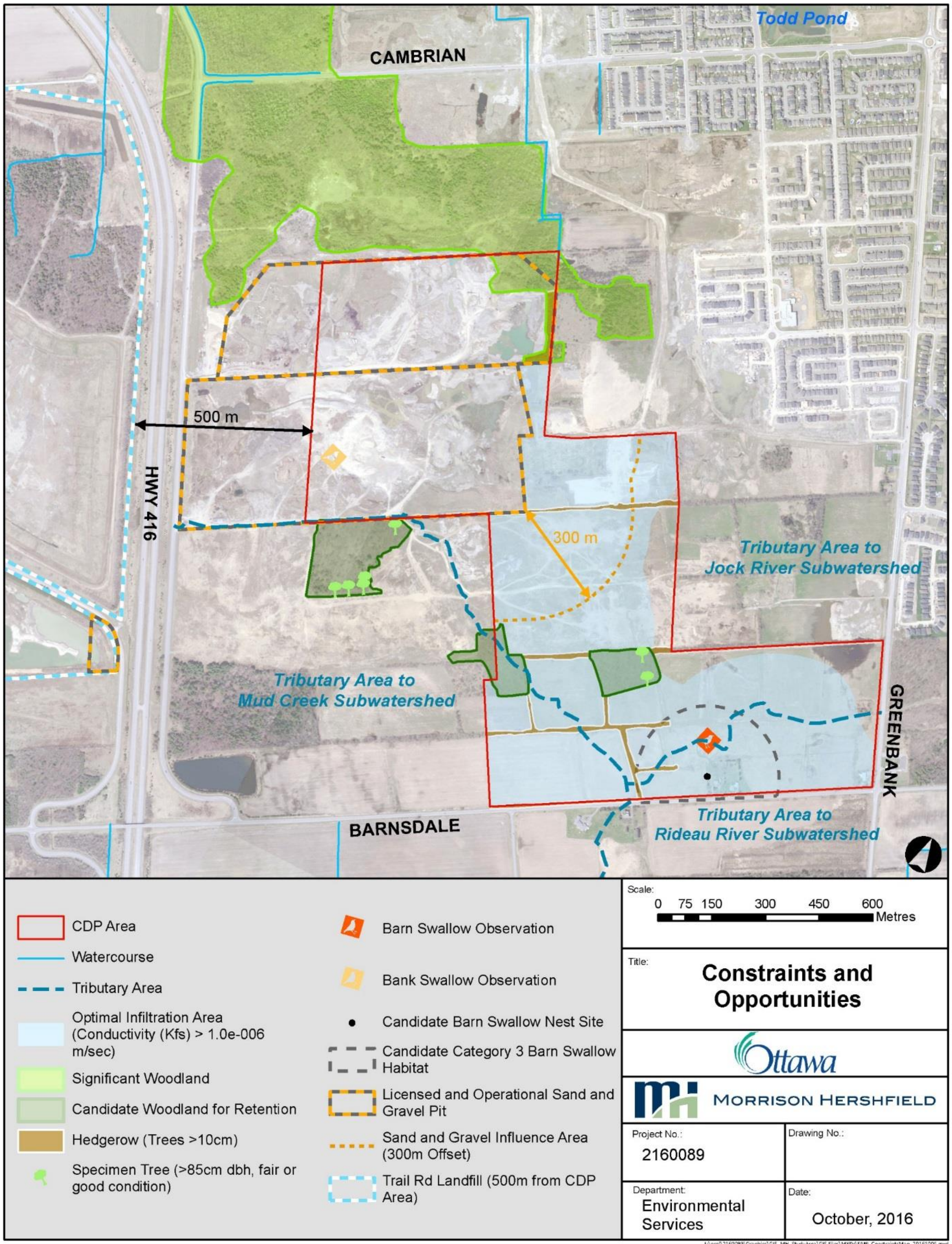
4.1.1 TREES AND WOODLANDS

The woodlands, hedgerows, and specimen trees in the BSUESA provide opportunities to integrate existing trees into the developing community, where tree condition and site grading permit. The retention of healthy native trees is strongly encouraged due to the current lack of tree cover across most of the study area. Transplantation of suitable stock may also be an option, where retention *in situ* is not possible. The species in the smaller woodlots, including Sugar Maple (Acer saccharum), Bitternut Hickory (Carya cordiformis), Basswood (Tilia americana), Eastern Hop-hornbeam (Ostrya virginiana), and Large-tooth Aspen (Populus grandidentata) are all suitable for parkland. Species in the hedgerows, such as Sugar Maple and Bur Oak (Quercus macrocarpa) are suitable for street trees or other open space uses (e.g., walkway blocks, stormwater management facilities).

The woodland within the northern portion of the Study Area, connected to the Cambrian Woods, is considered significant (see Figure 4-1). Under the City's policies for natural heritage system features in Urban Expansion Study Areas, development and site alteration may only be permitted in or adjacent to significant woodlands if there will be no negative impacts as a result. Otherwise, part or all of the woodland may need to be transferred to the City as non-developable lands. However, in this case, the woodland is located within the Drummond Pit extraction limit, and may therefore be removed at any time under the terms of the existing aggregate licence. In that case, it would no longer pose any constraint to future development, but the opportunity to integrate healthy trees into the community would be lost.

The City's Urban Tree Conservation By-law applies to lands within the City's urban boundary, as well as designated Urban Expansion Study Areas. Clearing of any non-retained trees and woodland areas must therefore be done in compliance with that by-law. Trees within the licenced aggregate extraction areas are not protected under the by-law while the licence remains in effect, however.

FIGURE 4-1: ENVIRONMENTAL CONSTRAINTS AND OPPORTUNITIES



The BSUESA offers significant opportunities for tree planting, with no restrictions on size at maturity, due to its well-drained sandy soils. Extensive tree planting within the parks, schoolyards and other greenspaces, as well as along the streets, would substantially improve the urban forest and tree canopy cover in this area of the City.

4.1.2 SPECIES AT RISK

Two threatened species were identified in the BSUESA (barn swallow and bank swallow) and the endangered butternut tree was previously found in the area and could potentially recolonize the site in future. These species and their habitats are protected under the Ontario Endangered Species Act, 2007. Under the PPS 2014, development and site alteration are only permitted to occur within the habitat of endangered or threatened species in accordance with provincial and federal legislation. Regulatory requirements must therefore be met prior to undertaking any onsite work that could affect these species or their habitats.

4.1.3 KARS ESKER

The BSUESA lies over the Kars Esker, which functions as a significant groundwater recharge area (SGRA), along with extensive areas offsite that extend along the Kars Esker to the south and the Sand Plains to the west. The groundwater provides recharge to both the overburden and bedrock aquifers in addition to base flow within the adjacent Jock River, Rideau River and Mud Creek (Paterson, 2017).

The water budget (see Section 3.3.2) provides information as to the existing condition for the quantity of water currently infiltrating. Balanced conditions would stipulate that there would be no negative consequences if the proposed development were to maintain the existing infiltration/exfiltration quantities. The protection of the overburden aquifer for quantity and quality of recharge (as per the water budget) is expected to, in turn, mitigate concerns related to alteration of baseflow to adjacent watercourses and bedrock aquifer recharge.

Paterson does not believe that the Esker poses a significant constraint beyond the requirement of needing to provide a balanced measure of recharge from pre-development to post development conditions while infiltrating captured clean water into the SGRA. The stormwater servicing for the BSUESA should be developed with infiltration measures to promote groundwater recharge in order to achieve a water balance and maintain the operation of the shallow overburden aquifer.

The Provincial Policy Statement (2014) and Mississippi-Rideau Source Protection Plan do not prohibit any of the land uses proposed for the BSUESA based upon the area's designation as a highly vulnerable aquifer and a significant groundwater recharge area.

4.1.4 SURFICIAL AND BEDROCK GEOLOGY

Overall, the BSUESA provides significant opportunities for development across the subject site from a geotechnical perspective. The soils profile encountered at the test hole locations allows for conventional building construction, road and service construction without soil improvement requirements or grade raise restrictions. The soils provide potential for significant groundwater recharge. No constraints are present from a geotechnical perspective for the majority of the site.

The construction of the below grade infrastructure is expected to be of typical design with compacted engineered fill in areas immediately adjacent to infrastructure and native backfill to surface. The compacted engineered fill is expected to have a much lower hydraulic conductivity than the surrounding native soils, meaning the prevention of creating gravity driven flow paths within the infrastructure backfill in areas where the infrastructure will be installed below the groundwater level. Nonetheless, detailed design will need to ensure best practices to reduce potential leaks into the sewer system and stormwater management pond infrastructure, if below the groundwater level.

4.1.5 HYDROLOGY AND AQUATIC HABITAT

There are three (3) subwatersheds within the Study area:

- Jock River Subwatershed
- Lower Rideau River Subwatershed, and
- Mud Creek Subwatershed.

No natural watercourses or waterbodies were identified within the Study Area. Man-made aggregate site ponds were observed within the mineral extraction area, but these are not connected to any other waterbodies and are not regulated by the City of Ottawa or the RVCA. In addition, based on the origin of these features, it is unlikely that they provide fish habitat.

Results of the aquatic habitat surveys downstream from the BSUESA identified fish and amphibian habitat within many of the downstream receivers, which has implications for stormwater management.

MAINTAINING PRE-DEVELOPMENT INFILTRATION LEVELS

A preliminary high level scenario of a potential future water budget was simulated for a development having a total imperviousness of 65%, of which 58.5% is “Directly Connected Impervious” area (i.e., 90% of the total imperviousness was assumed to be directly connected) without any Best Management Practices (BMP) to promote infiltration. The results indicate that the percentage of infiltration will reduce from 40% (existing condition) to 28% (post-development without BMPs) of the overall annual water budget. Simulation results have also shown reductions in evapotranspiration as a result of the decrease in vegetation, which, in turn, generates increases in surface runoff. Consequently, stormwater management measures promoting infiltration will be necessary to meet the target of maintaining pre-development infiltration levels.

LOW IMPACT DEVELOPMENT

Low impact development (LID) measures to promote infiltration can be incorporated as part of the overall servicing of the BSUESA to achieve the targeted water balance for each of the three (3) subwatersheds. Special attention should be devoted towards infiltrating “clean water” across the area of the Kars Esker, while Best Management Practices to reduce runoff should be included in all locations where there is an increase in imperviousness. Areas with large parking lots (i.e. Institutional lands and the City of Ottawa Park and Ride Lot) will provide opportunities to institute infiltration solutions. City parks, woodlots and sport facilities also present opportunities; however, there are many stakeholders that would need to be consulted prior to implementing or designing further LID solutions.

PROHIBITION OF INFILTRATION OF RUNOFF FROM ROADS

The City of Ottawa winter road maintenance practice documents indicate that salt is applied on collector and arterial roads on a regular basis while local roads will only have salt applied in extreme temperatures and only on sections of the network, which are particularly high risk. Therefore, infiltration of runoff from collector and arterial roads should be prohibited. In addition servicing of land uses with potential high levels of winter salt application, such as commercial and institutional parking lots, should be developed without any infiltration measures; however, clean water runoff from areas such as roofs can still be infiltrated as they will not be impacted by salt contamination.

4.1.5 AGGREGATE RESOURCES

The sand and gravel pits were considered within the Geotechnical Report to assess their effects and potential implications on the Study Area. The aggregate extraction operations are expected to continue for at least another 10 years based on the availability of the resource materials remaining in the pits. Once the aggregate extraction operations are completed, consideration would be given to the closure of the pits. In doing so, it is expected that the sites would accept clean fill to backfill most of the area (Paterson, 2017).

Given the current and future potential operations of the sand and gravel pits, and in keeping with the PPS 2014 and the City’s Official Plan:

- ***Development within 300 metres*** of a Sand and Gravel Resource Area (i.e. the area of influence) requires completion of an impact assessment study to demonstrate that the mineral aggregate operation, including future expansion in depth or extent, will not be affected by the development.

- Mitigation measures or conditions may be developed to ensure the development provides adequate buffering and/or separation between the new proposed use and the aggregate operation(s).

4.1.6 POTENTIAL ENVIRONMENTAL CONCERNS

The City of Ottawa Official Plan identifies human health and safety as potentially being affected within an area of influence of an operating or non-operating solid waste disposal site. The most significant contaminant discharges and visual problems normally occur within 500 m of the perimeter of the fill area. The BSUESA meets the minimum separation distance of 500 metres, with the proposed residential development located at a distance of 1 kilometre. Other environmental concerns associated with the landfill are related to the potential for leachate to migrate towards the BSUESA. Reviews of monitoring reports indicate that existing groundwater flow from the landfill site is in a north to northwest direction, thereby limiting the potential for leachate effects to migrate toward the BSUESA (Paterson, 2017).

Other potential environmental concerns include road salt mitigation and total coliforms detected in multiple borehole samples within the BSUESA, which were considered as likely related to animal feces and septic systems (Paterson, 2017).

Based upon the designation of the BSUESA as a Significant Groundwater Recharge Area (SGRA) and a highly vulnerable area (HVA), the Mississippi-Rideau Source Protection Plan provides a list of activities that are prohibited, managed or encouraged to change depending upon the vulnerable area type. The anticipated land uses within the BSUESA are not expected to be amongst those prohibited within SGRA's or HVA's.

4.1.7 PREVIOUS LAND USES

Field observations identified three residences that may have existing sewage systems within the CDP study area, and also, that there may be agricultural tile drains associated with previous agricultural use of the land.

The BSUESA contains an least one existing water well with the potential of two other water wells (or they may be erroneously located on mapping). Decommissioning of existing on-site water wells, and on adjacent property that may be acquired in the future (wells on the north side of Barnsdale Road), would be required.

4.2 RECOMMENDED LAND USE PLAN

The existing conditions analysis and the identification of the site's opportunities and constraints informed the development of the alternative land use options and the selection and the refinement of the preferred option (Figure 4-2).

FIGURE 4-2: PREFERRED CONCEPT PLAN

The Preferred Concept Plan incorporates the following park, greenspace, stormwater management and connectivity features:

- City of Ottawa Parks Staff have identified the need for a senior level baseball diamond. Due to the substantial land requirements needed for this facility, the majority of the parkland dedication is planned to accommodate the facility within the park.
- Two additional public parks would allow for the potential retention/enhancement of portions of existing woodlots. The Parkette locations were deliberately chosen to coincide with the existing woodlots, providing opportunities for tree retention to complement and enhance the other park amenities.
- Parks linked to the overall greenspace network.

- Street tree planting to ultimately secure a tree canopy at maturity, shall be required in all residential and commercial areas for visual appeal and environmental benefits, including reduction of radiant and reflective heat; provision of shade; as well as providing an enhanced physical environment for residents.
- Landscaping plans will feature a broad range of native species, including those, which grow to a large size at maturity and are species currently found in the BSUESA (see Table 11 in Appendix A, DILLON Existing Conditions report).
- A stormwater management facility is proposed in the southeast corner, which is the lowest elevation in the Study Area. The area has a relatively high groundwater table and would therefore not represent a loss of area for good groundwater infiltration potential.
- Stormwater management systems include opportunities to incorporate measures to recharge the overburden aquifer. This is a result of extensive work and consultation with the both the City, the RVCA, and the MOECC. The recommended infiltration servicing strategy is the Etobicoke Exfiltration System (EES). The EES is a distributed infiltration system that has been accepted as effective in residential developments.
- In accordance with the principles of the City's Building Better and Smarter Suburbs initiative, the Neighbourhood Park is strategically located adjacent to the CECCE elementary school site in order to advantage of shared facilities, such as parking. The CECCE site may also accommodate a public library, which would create a central activity node for the community.
- The most southern BRT station identified on the Land Use Plan is strategically located at Kilbirnie Drive, which allows for the majority of the proposed residential units to be located within a five-minute walking distance of the station.
- Sidewalks are strategically placed around parks, stormwater management facilities, schools, and the Park and Ride Lot in order to facilitate pedestrian access to these important neighbourhood amenities.

More information on the Community Design Guidelines that provide the framework for the overall identity and structure of the proposed CDP area, as well as for the appearance of new buildings, streetscapes, and parks within the community, can be found in the *Barrhaven South Urban Expansion Study Area Community Design Plan* (Fotenn, 2017).

4.3 RECOMMENDATIONS FOR SITE DEVELOPMENT

4.3.1 TREES AND WOODLANDS

The Parkette locations were deliberately chosen to coincide with the existing woodlots, providing opportunities for tree retention to complement and enhance the other park amenities. Treed areas and healthy individual trees should be incorporated into the park design, where appropriate, in keeping with the direction provided for Parkettes in the Council-approved Park Development Manual (City of Ottawa, 2017). This would contribute towards early achievement of the 30% canopy cover target established in the Manual, and would also help to support the City's overall canopy cover goals.

Tree cover in the BSUESA is currently low, and should be enhanced by additional plantings of native species throughout the developing community. The existing sandy soil conditions in the BSUESA are characterised by excellent drainage, and do not pose the risk of subsidence as in other parts of the City where sensitive marine clay soils predominate. As such, there are no restrictions on the species, number, size or placement of trees in this study area, allowing for a much more diverse urban forest within the new community. Landscaping plans should feature a broad range of native species, including those which grow to a large size at maturity (see Table 11 in Appendix A, for a list of tree species found in the study area).

Tree Conservation Reports prepared in support of future development applications should provide site-specific recommendations for tree conservation, tree planting, and transplanting of existing trees, where appropriate. They should also address the potential for Butternut (see Section 4.3.2 below) and provide management recommendations for the removal and control of non-native invasive species such as Common Buckthorn, and the removal of dead or dying trees that could pose a public safety hazard or a risk to private property.

Clearing of non-retained trees and woodland areas must be done in compliance with the City's Urban Tree Conservation By-law. A site-specific wildlife protocol should be developed and implemented in conjunction with the Tree Conservation Report, to address the risks to wildlife during tree clearing and subsequent construction activity, in accordance with the City's Protocol for Wildlife Protection during Construction (City of Ottawa, 2015).

The portion of the Cambrian Woods significant woodland that extends into the BSUESA is located within the Drummond Pit extraction limit, and may be removed under the terms of the existing aggregate licence. If it were not removed, however, it would need to be addressed as part of the planning process for that area (see Section 4.3.5).

4.3.2 SPECIES AT RISK

While only two species at risk were identified in the Existing Conditions report (see Appendix A, for Natural Heritage Existing Conditions Report) for the BSUESA (i.e., Barn Swallow and Bank Swallow), new information on species occurrences or legal status may become available in future. Environmental Impact Statements should be completed in support of future development applications, to confirm the extent of any threatened species habitat and to address any other species at risk observed or potentially occurring within the study area, other than Butternut (which should be addressed in the Tree Conservation Report).

The MNRF should be consulted regarding potential requirements under the Endangered Species Act prior to undertaking any on-site works, which could impact endangered or threatened species or their habitat. It is likely that a Notice of Activity will be required to register the impact to Barn Swallow and its habitat in the southern end of the study area, for example.

Bank Swallows have been known to colonise soil stockpiles, resulting in additional constraints and significant construction delays. In order to reduce the risk of this happening during development of the BSUESA, soil stockpiles must be covered or actively managed to avoid the creation of steep exposed slopes that might attract swallows. The existing Bank Swallow colony in the aggregate pit will need to be addressed as part of the planning for that area (see also Section 4.3.5 below).

Butternut is a pioneering species that may quickly regenerate or move into areas that were previously cleared. It should be specifically searched for and addressed as part of the Tree Conservation Reports prepared in support of future development applications.

4.3.3 KARS ESKER

The development and implementation of the following best management practices will serve to protect and minimize the impact(s) to the Esker's hydrogeological functions as a Significant Groundwater Recharge Area (SGRA) and as a Highly Vulnerable Aquifer (HVA).

Construction Practices

Best construction practices should be reviewed to ensure all policies are followed to minimize any potential contamination of the overburden aquifer. Prior to and during site development, it is recommended that construction best practices with respect to fuels and chemical handling, spill prevention, and erosion and sediment control be followed, to minimize the potential for the introduction of contaminants to the soil, surface water, or groundwater at the subject site.

Salt Management Within Developed Area

The Kars Esker is a possible salt vulnerable area and a **Road Salt Management Plan**[1] is recommended for implementation to protect the SGRA and HVA from the negative effects of road salt application and snow storage within the CDP study area. Most recent guidelines for Road Salt Management Plans are available within a BMP series entitled "Syntheses of Best Practices – Road Salt Management" (SBPRSM) (produced by Transportation Association of Canada (TAC), 2013). In addition to a Salt Management Plan (1.0 of TAC's SBPRSM), Paterson (2017) referred to the full set of best practices for consideration in protecting the SGRA and HVA:

- Training (2.0 of TAC's SBPRSM)
- Road, Bridge and Facility Design (3.0 of TAC's SBPRSM)
- Drainage (4.0 of TAC's SBPRSM)
- Pavements and Salt Management (5.0 of TAC's SBPRSM)
- Vegetation Management (6.0 of TAC's SBPRSM)
- Design and Operation of Maintenance Yards (7.0 of TAC's SBPRSM)
- Snow Storage and Disposal (8.0 of TAC's SBPRSM)
- Winter Maintenance Equipment and Technologies (9.0 of TAC's SBPRSM), and
- Salt Use on Private Roads, Parking Lots and Walkways (10.0 of TAC's SBPRSM).

Maintaining Groundwater Recharge Levels at Pre-development Levels

During the preparation of the Master Servicing Study, it became evident that storm servicing for the BSUESA would need to incorporate measures to recharge the overburden aquifer. Measures to increase post-development recharge were reviewed by J.L.Richards and are presented in detail within the Services Existing Conditions Report (See Appendix B). Potential solutions included promoting infiltration from clean water sources such as rooftops and clean roadways. In addition, a distributed infiltration system within roadways that will allow infiltration as close to the source as possible in order to approximate the existing groundwater infiltration conditions has been accepted in principle by the RVCA and the City of Ottawa. Specific details would require further review during the detailed design phase.

The MOECC recommends, within the "Interpretation Bulletin Ontario Ministry of Environment and Climate Change Expectations RE: Stormwater Management", to

[1] In accordance with Environment Canada's (2004) Code of Practice for the Environmental Management of Road Salts (ECC PEMRS).

infiltrate clean captured precipitation through areas of recharge as close to the source as possible, as per appropriate Low Impact Development (LID) designs through a treatment train approach. The MOECC is expected to provide an LID stormwater management guidance document and it should be consulted once complete. The use of LID[2] measures in conjunction with BMP for stormwater quality and quantity control will assist in infiltrating clean water, treating salt impacted water where possible or redirecting salt impacted water away from the SGRA during seasonal periods with expected elevated salt levels.

Areas for potential infiltration were assessed based upon a conceptual grading plan for anticipated roadways, with consideration given to “depths to groundwater table”. Paterson (2017) recommends that the area adjacent to existing Greenbank Road should be reviewed at the detailed design stage to ensure there is sufficient depth of cover. If sufficient depth is lacking, other solutions such as directing the clean captured precipitation to an exfiltration pond could be reviewed. It is expected that the majority of the site will have adequate material to provide satisfactory depth for a distributed infiltration system.

In order to minimize the impact on the Kars Esker, infiltration of stormwater runoff should be preserved at current levels with LID and BMP infrastructure to promote infiltration in the post-development condition. The LID and BMP infrastructure should include means of distributed infiltration to mimic the pre-development infiltration as much as possible, should be located in public lands as much as possible to facilitate maintenance by the City, and should only accept clean water runoff from surfaces free of salt application in the winter.

In addition to LID measures, an infiltration servicing strategy incorporating the Etobicoke Exfiltration System (EES) is recommended to maximize stormwater infiltration rates (see Figure 4-3 for EES Design Details). The overall approach to stormwater management is to combine the EES with the conventional storm system to ensure that the pre-infiltration levels are preserved. For more information on the EES system refer to the Master Servicing Study (JLR 2017).

[2] LID is a stormwater management strategy that seeks to mitigate the impacts of increased runoff and stormwater pollution by managing runoff as close to its source as possible, with the goal of removing nutrients, pathogens and metals from runoff and reduce the volume and intensity of stormwater flows.

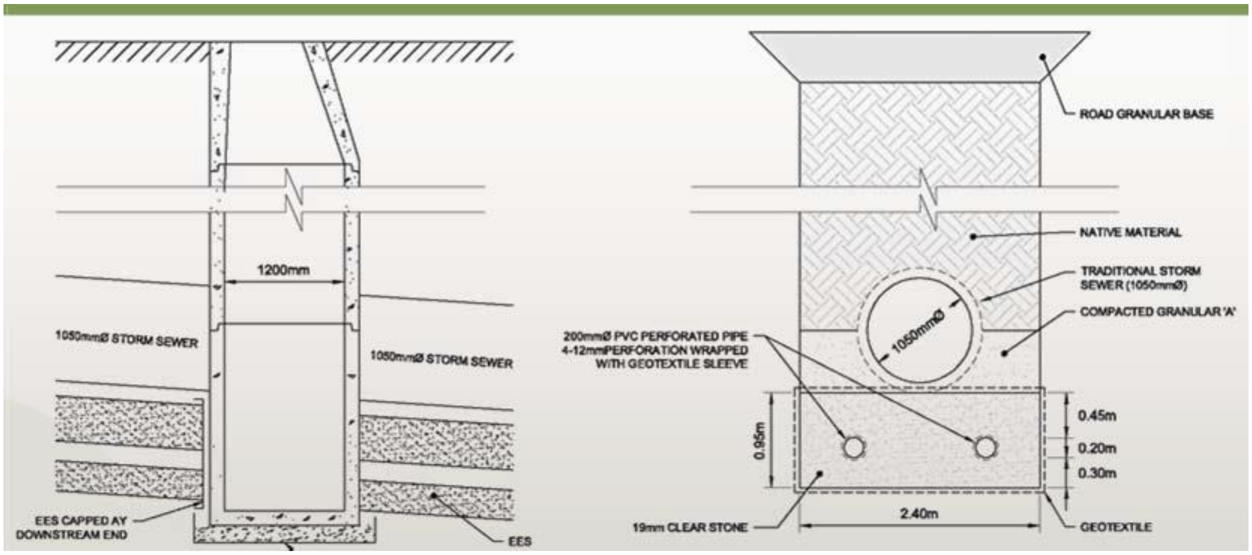


FIGURE 4-3: EES DESIGN DETAILS

Periodic maintenance and cleaning of the EES will be required. This includes a regular observation program to assess:

- Visual evidence of overflows at sewer, water marks at the manhole, integrity of mechanical plug at the downstream manhole.
- Repair of minor deficiencies such as debris accumulation at the catchbasins including cleanout of any filter traps at the catchbasins.
- Cleaning requirements (approximately every ten years)

The proposed distributed infiltration system is expected to meet the recommendations of the MOECC stormwater management bulletin.

Groundwater Mounding

Paterson (2017) identified the potential need for monitoring infiltration system(s) for potential groundwater mounding during operation. *Groundwater mounding* occurs "when the vertical movement of infiltrated water reaches the groundwater level and must travel horizontally within the aquifer". If the horizontal hydraulic conductivity is insufficient to dissipate the infiltrating volume, then a vertical mounding of groundwater will occur. Paterson carried out a sensitivity analysis and concluded that it is not expected that there will be negative effects related to groundwater mounding provided that there is sufficient separation between the high groundwater table and the base of the infiltration system. *Further review may be required at the detailed design stage.*

4.3.4 HYDROLOGY AND AQUATIC RESOURCES

The recommended servicing strategy will result in a redirection of flows from the municipal drains to the Jock River (via the Greenbank Road trunk storm sewer). Thus, the overall area draining to the municipal drains may be slightly reduced.

For lands that drain to Mud Creek, flows will need to be limited to the capacity of the Thomas Baxter Drain. Any additional flow discharge to the Thomas Baxter Drain should not aggravate the risk of flooding. Any modifications to this Drain or to its flow regime will need to be assessed and approved in accordance with Section 78 of the Drainage Act, Chapter D.17, R.S.O., 1990. This process under the Ontario Drainage Act has been initiated.

Similarly, lands tributary to the Rideau River will be subject to the capacity limits of the downstream watercourse, namely, the Hawkins Municipal Drain as well as the overland flow conveyance restrictions due to the arterial road. Any additional flow discharge to the Hawkins Municipal Drain should not aggravate the risk of flooding. Any modifications to this Drain will need to be assessed and approved in accordance with Section 78 of the Drainage Act, Chapter D.17, R.S.O., 1990.

Within the BSUESA, the realigned Greenbank Road will be classified as an arterial road; major overland flow generated by events up to 1:100 year will, therefore, not be able to cross the realigned Greenbank Road. Since the realigned Greenbank Road will bisect the BSUESA, this restriction on overland flow conveyance will have implications for stormwater management within the development. In addition, Barnsdale Road is classified as an arterial roadway, which means that major flow from events up to the 1:100 year may not be conveyed across it.

Water quality treatment will need to be provided in accordance with the relevant subwatershed studies:

- Jock River, an enhanced level
- Mud Creek Subwatershed Study: *States* water contamination from point and non-point sources must be managed.
- Lower Rideau Subwatershed Study: *Objective* is to manage the quality and quantity of non-point source runoff and to manage surface and groundwater contamination from point source discharges.

Any modifications to Municipal Drains or to their flow regimes will need to be assessed and approved in accordance with Section 78 of the *Drainage Act*, Chapter D.17, R.S.O., 1990. If downstream flows are to be changed, further assessments of Headwater Drainage Features and/or downstream aquatic habitat should be undertaken to determine what effects the change may have on identified downstream habitats.

Detailed design should review industry best practices to reduce potential leaks into the sewer system and stormwater management pond infrastructure (if below the groundwater level).

4.3.5 AGGREGATE RESOURCES

Slope Stability Review

During field investigations, slope conditions in areas adjacent to the aggregate pits were reviewed (Paterson, 2017). Subject slopes within the east end of the existing aggregate extraction operations were noted to vary between 8 to 10 m. The slopes were grass and lightly brush covered with minor surficial erosion noted. No signs of slope instability were observed.

Future Redevelopment of Sand and Gravel Pits

Any future redevelopment of the Pit Areas following the closure of the existing pits must consider the following issues:

- Any backfill of the pits would likely be using secondary quality materials from excess soil being transported to the subject site from off-site developments. The material will most likely be end dumped and spread using a bulldozer. The backfilled areas are expected to have loose to slightly compact material. Therefore, the material would not be considered suitable as an engineered fill capable of supporting conventional residential or commercial development;
- Due to the depth of the backfill within the pits (8 to 10 m below the existing surrounding grades), ground improvement techniques will be required for building structures while more conventional compaction methods would be possible for parks and SWMF development. Techniques such as dynamic compaction, surcharging and/or rapid impact compaction will be required to prepare the subsoil to support light development;
- There should be consideration for the utilization of clean permeable materials to aid in infiltration;
- The existing Bank Swallow colony in the aggregate pit will need to be addressed as part of the planning for that area in accordance with SAR permitting requirements; and
- If the significant woodland is still present following the closure of the Drummond Pit, it will need to be addressed in accordance with the policies of the City's Official Plan. If it is determined that part or all of the woodland does not need to be retained as part of the City's natural heritage system, opportunities for tree retention should still be considered.

4.3.6 GEOTECHNICAL AND HYDROGEOLOGICAL

Groundwater Quantity Monitoring

Water wells to the south and southeast of the BSUESA have been highlighted as potential areas to monitor for evidence of groundwater lowering. It is noted that the wells selected are not necessarily the wells closest to the limits of the development, but instead represent the wells within and near the estimated areas of influence, which are considered to have the greatest potential to be affected by site development activities.

A field survey may be required to confirm the location and well depths during the baseline testing program for residences that do not show a well location on the MOECC mapping or may be mapped at inaccurate locations. The potential exists that unknown wells along the southern development boundaries could be at a higher risk for negative impacts as the depth of the aquifer being accessed by these wells is unknown. Typically, wells accessing deeper aquifers are at lower risk of impacts by construction dewatering activities due to the greater vertical separation between the dewatering zone and the zone(s) at which water was encountered in these wells. As such, the field survey may suggest more wells within the zone of influence be monitored due to potential risks.

The proposed baseline monitoring program would consist of the following:

- A visual inspection of the well. Verification of the details of the well (location, casing type, address, well tag number) with the published well record, if possible. Any discrepancies will be noted.
- Survey of wells to a geodetic benchmark.
- A record of the water level at the well using an electronic water level meter that has been properly cleaned and disinfected in accordance with industry best practices.
- A water sample will be obtained either directly from the well or from a suitable tap prior to any treatment process (disinfection, softening, etc.).
- The water sample will be submitted for analytical testing for the City of Ottawa "subdivision package" suite of parameters.
- Based on the results of the above-noted methodology, specific wells may be selected for installation of automatic water level logging devices. Level loggers will be installed in accordance with industry best practices. Wells selected for level logger installation will be determined in consultation with landowners and the City of Ottawa.

If a groundwater lowering effect were to occur, the steady state radius of influence is expected to provide a minimal zone of influence. The minimal radius of influence is not expected to negatively impact existing adjacent water users, cause settlement or reduce baseflow to watercourses off site.

In summary, a baseline monitoring program is recommended to be completed at selected water wells in the vicinity of the BSUESA, including within the calculated “radius of influence”, to assess for potential risks of dewatering during excavation for service trenches (Paterson, 2017). The proposed baseline monitoring program would be reviewed with the City of Ottawa prior to the Commence Work authorization and appropriately certified personnel shall be used to perform the work within private wells.

Existing Water Wells

Existing water supply wells are completed at significant depths within the Oxford Formation and potentially extending into the March Formation bedrock aquifers. These wells are considered to have a relatively low potential to be impacted by construction dewatering activities at the subject site (Paterson). As a due diligence measure, prior to the commencement of site excavation works, Paterson has recommended a baseline monitoring program. In addition to the proposed monitoring program, baseline monitoring of on-site wells continued for the purpose of observing seasonal fluctuations in water levels prior to construction through to December 2017. The monitoring locations had been approved by the City of Ottawa and the RVCA.

Groundwater Control

The contractor should be prepared to direct water away from all bearing surfaces and subgrades, regardless of the source, to prevent disturbance to the founding medium. It is anticipated that pumping from open sumps will be sufficient to control the groundwater influx through the sides of shallow excavations.

A permit to take water (PTTW) may be required for this project. The requirements set out in the Environmental Activity and Sector Registry (EASR) regulation reflect current environmental standards. The EASR regulation for water takings related to construction site dewatering and road construction accomplishes the following:

- Prescribes surface water takings related to specific road construction purposes for registration on the EASR.
- Prescribes water takings of the total of ground water and storm water of more than 50,000 L/day but less than 400,000L/day for the purposes of construction site dewatering for registration on the EASR.

Groundwater Quality

Groundwater testing for Chloride and Bromide should be performed prior to the start of construction to establish baseline bromide and chloride effects of existing winter maintenance programs, and prior to construction. Future monitoring of chloride and Bromide levels will assess the effects of implementing alternative winter road maintenance with the SGRA.

4.3.7 POTENTIAL ENVIRONMENTAL CONCERNS

Land Use Restrictions

Development within the BSUESA would consist of primarily residential low density uses, institutional buildings, parks, a City Park and Ride lot, and a small potential commercial zone. Protection of the SGRA and HVA requires restriction of all land use activities that have the potential to contaminate soil, ground water and sediment. Table 2 contained within Schedule D of O.Reg 153/04 lists 59 potentially contaminating activities that should be prohibited within the BSUESA and include land uses such as storage of gasoline and related products in fixed tanks, commercial autobody shops, dry cleaning operations and salt manufacturing, processing and bulk storage.

Trail Road Landfill Facility

Monitoring reports of the Trail Road Landfill (Dillion, 2015 and 2016) indicate that some leachate effects have been noted up to 300 m north of the Trail Landfill within the shallow overburden aquifer. The shallow aquifer leachate effects are limited to City property. The deep aquifer also displayed some leachate influences to the north in the direction of the Dewatering Pond. There were some increases in parameter concentrations, but are expected to be reduced once the final cover has been placed on the landfill. There were no reports of leachate impacts within the bedrock aquifer.

It is not anticipated that leachate effects would migrate towards the BSUESA

based upon the existing groundwater flow direction towards the Jock River.

Ongoing groundwater monitoring by the City of Ottawa will continue to assess if there are any impacts that migrate off site.

4.3.8 PREVIOUS LAND USES

Existing private sewage systems, if encountered, within the BSUESA are recommended to be properly decommissioned by a qualified contractor prior to development. Similarly, given past agricultural uses on the BSUESA, any encountered tile drains are recommended to be removed and/or capped on an as-encountered basis.

5. IMPLEMENTATION AND APPROVALS

The environmental function of the existing natural features within the BSUESA can be managed and protected through initiatives identified in the Recommendations section. Additional permits and approvals will be needed prior to implementation, which will establish the required mitigation and management requirements to implement these initiatives.

5.1 DEVELOPMENT APPROVALS AND REQUIREMENTS

Various approvals and requirements will be required for infrastructure (water, sewer, stormwater) and land development to proceed including applications under:

Aggregate Resources Act – RSO 1990, c.A.8 – License surrender and site plan alterations for rehabilitation when aggregate uses cease.

- Section 28 of the *Conservation Authority Act* and Ontario Regulation 153/06 – Approvals required for drainage works, grading, filling, etc.

- Section 78 of the *Drainage Act, RSO 1990, c.D.17* – Approvals required for drainage works.

- *Environmental Protection Act, RSO 1990, Chapter E.19* - Environmental Compliance Approval (ECA) for sewer and water mains; and reference to O.Reg 153/04 – List of prohibited land uses for Zoning (Table 2, Appendix D).

- Section 53 of *Ontario Water Resources Act, RSO 1990, c.O.40* and *Regulation 903, Wells* – Decommissioning of water wells; Permit to Take Water if more than 4000,000 l/day or registration on the Environmental Activity and Sectory Registry (EASR) if between 50,000 to 400,000 l/day.

- *Clean Water Act, 2006, S.O. 2006, c.22* – Planning Act and Building Code Act Aplications under Section 59 application for review by Risk Management Official.

- *Endangered Species Act, 2007, S.O. 2007, c.6* – Registration of activities, permits or other authorization to conduct activities that may impact the following SAR or their habitats: Butternut trees, Barn Swallow and Bank Swallows.

- *Planning Act, RSO 1990, c.P.13* – Official Plan Amendment(s) to implement Community Design Plan and Zoning By-law Amendment(s) to implement site specific Zoning and to prohibit land uses that may have potential for soil, groundwater and sediment contamination. Future supporting studies, if required, will include an impact assessment and/or planning rationale to demonstrate that the existing and future operation of the sand / gravel pits will not be affected by the development of Plan of Subdivision(s) and Site Plan Approvals.

- *Safe Drinking Water Act*, O.Reg. 169/03 Ontario Drinking Water Quality Standards – groundwater monitoring program.

5.1.1 PLAN OF SUBDIVISION (S.52, PLANNING ACT)

Following approval of the Official Plan and Zoning By-law Amendments and other required permits and approvals as listed in previous section, development for lands within the Barrhaven South Urban Expansion Area will initially proceed by Plan of Subdivision in order to secure the necessary road network, servicing infrastructure and parkland dedication. Development applications will include all information required under Section 5.2 of the Official Plan. Applications for some development blocks may require Site Plan Control Approval as required by the City's Site Plan Control By-Law. The execution of development agreements will be required before development is allowed to proceed. Development agreements may address:

- Parks, open space and natural heritage features;
- Water, wastewater collection and stormwater management facilities;
- Road infrastructure including transit and widening of existing roads; and
- Telecommunications and other utilities.

The two active aggregate pits will be brought into the Urban Area through the Official Plan Amendment implementing the Community Design Plan. However, unlike the majority of the BSUESA, which will be redesignated to General Urban Area, the aggregate pits will remain designated Sand and Gravel Resource Area. In order to redesignate the aggregate pits (likely to General Urban Area), a Concept Plan is required in accordance with Section 2.5.6 of the Official Plan and would require approved by City Council.

5.1.2 PARKS, OPEN SPACE AND NATURAL HERITAGE FEATURES

The Greenspace system is comprised of a variety of elements, such as parkland, natural heritage features, and stormwater management facilities. The majority of the Greenspace will ultimately be in public ownership and the City will pursue acquisition of such lands through:

- Parkland and/or open space dedication through the development approvals process;
- Conveyance of completed stormwater management facilities;

Dependent upon confirmation of satisfactory agreements, it is intended that the Neighbourhood Park and Parkettes will be built concurrently with the development of lands within approved Draft Plans of Subdivision.

5.1.3 DEVELOPMENT PHASING

It is anticipated that within each individual phase, development will occur incrementally through Plans of Subdivision with associated infrastructure and services being installed. Generally, the development will proceed from east to west based a number of factors, including:

- The ability to connect to existing water and sanitary infrastructure with available capacity;
- The opportunity to connect the internal road network to existing Greenbank Road at existing intersection locations;
- The logical extension of new water and sanitary infrastructure;
- Installation of stormwater management facilities; and
- The 300 metre area of influence surrounding the active aggregate pits.

This phasing represents an orderly progression of development. However, it is possible that under certain circumstances, the preferred phasing cannot be followed, nor does a phase require completion before the next phase is initiated.

5.1.4 ACTION PLAN

An Action Plan for the implementation of the recommendations of the EMP and the associated responsibilities is outlined below.

TABLE 5-1: IMPLEMENTATION ACTION PLAN

Action	Responsibility	Timing/Process/*Permits and Approvals*
Protection of SGRA and HVA • Review current winter maintenance program. • Develop and implement a Road Salt Management Plan, including a review of proposed overland drainage/storm sewer systems (i.e. isolation of road salt laden drainage from future Greenbank Road) to protect SGRA and HVA. • Review management options within TAC's SBPRSM (Series 1.0 to 10) for salt management to protect SGRA. • Collect and analyze samples to provide a baseline bromide and chloride test on groundwater to provide a baseline against which to assess the effects related to existing roadway salt usage. • Monitor future groundwater quality for elevated bromide and chloride levels. • Apply under Clean Water Act for review by Risk Management Official. • Implement groundwater monitoring program.	**City of Ottawa** **School Boards** **Developers**	***Water Resources Act*** ***Mississippi-Rideau Source Protection Plan*** ***Clean Water Act*** ***Safe Drinking Water Act*** ***Ontario Drinking Water Quality Standards*** **Environment Canada's Code of Practice for the Environmental Management of Road Salts (ECC PEMRS) dated 2000** **Syntheses of Best Practices – Road Salt Management" (SBPRSM) (TAC, 2013)**
Drainage Works • Submit *appropriate applications for any modifications to Municipal Drain*s or to their flow regimes for assessment and approval in accordance with Section 78 of the Drainage Act and Section 28 of the Conservation Authority Act.	**Developers**	***Drainage Act*** ***Conservation Authority Act***
Woodlands and Forests • Review recommendation for retention of woodlots / trees and incorporation into Parkland.	**City of Ottawa**	**Parks Master Plan**

Action	Responsibility	Timing/Process/*Permits and Approvals*
Tree Conservation Report (TCR) and Landscape Plan • Search for regenerating Butternuts and address findings (presence/absence) in TCR. • Address opportunities for tree retention in high quality woodlots, specimen trees, and hedgerows. Consider transplanting where appropriate. • Provide tree planting recommendations to achieve 30% tree canopy in new parks and to enhance urban forest and canopy cover throughout the community, using native species.	**Developers**	**Plan of Subdivision** ***Endangered Species Act (if Butternut are present)*** ***Urban Tree Conservation By-law***
Environmental Impact Statement. • Complete EIS to confirm presence of known or potential SAR, extent of any SAR habitat, and associated mitigation / compensation requirements. • Submit Notice of Activity to MNRF to register the impact and required compensation for Barn Swallow and associated habitat. • Develop specific mitigation measures to prevent Bank Swallows nesting in development area (e.g., soil management)	**Developers**	**Plan of Subdivision** ***Endangered Species Act*** ***Environment Impact Statement***
Wildlife Protection • Develop site specific Protocol for Wildlife Protection.	**Developers**	**Plan of Subdivision** ***City of Ottawa Protocol for Wildlife Protection***
Water and Sewer • Apply for Environmental Compliance Approval (MOECC).	**Developers**	**Plan of Subdivision** ***Environmental Protection Act*** ***Environmental Compliance Approval (ECA) MOECC***

Action	Responsibility	Timing/Process/*Permits and Approvals*
Permit to Take Water (PTTW) • Permit to Take Water if more than 4000,000 l/day or registration on the Environmental Activity and Sectory Registry (EASR) if between 50,000 to 400,000 l/day.	**Developers**	***Ministry of the Environment and Climate Change*** ***Ontario Water Resources Act (OWRA)*** ***WaterTaking Regulation (O. Reg. 387/04)***
Previous Land Uses • Decommission wells. • Remove agricultural tile drains. • Remove septic systems.	**Developers**	***Environmental Protection Act*** ***Ontario Water Resources Act***
Planning Approvals Official Plan Amendment(s) to implement Community Design Plan and Zoning By-law Amendment(s) to implement site specific Zoning and to prohibit land uses that may have potential for soil, groundwater and sediment contamination. Plans of Subdivisions and Site Plan Applications, including all required supporting studies. Complete all future supporting studies, including an impact assessment and/or planning rationale to demonstrate that the existing and future operation of the sand / gravel pits will not be affected by the development of a Plan of Subdivision(s) and Site Plan Approvals.	**Developers** **City of Ottawa**	***Planning Act*** ***City of Ottawa Official Plan*** ***City of Ottawa Zoning By-law 2008-250*** ***City of Ottawa Site Plan Control By-law*** ***Plan of Subdivision***
Redevelopment of the Pit Areas • Update restoration plans. • Surrender License.	**Developers**	***Aggregate Resources Act***

Appendix A

Natural Heritage Existing Conditions Report
Prepared by Dillon Consulting Limited
March 14, 2017

Appendix B

Services Existing Conditions Report
Prepared by J.L. Richards and Associates
August 16, 2017

Appendix C

Geotechnical Investigation
Prepared by Paterson Group
July 5, 2017

Appendix D

Hydrogeological Existing Conditions Report
Prepared by Paterson Group
July 5, 2017