KGS GROUP

TORONTO AND REGION CONSERVATION AUTHORITY

Conservation Ontario Class Environmental Assessment for the Rehabilitation of the Pickering and Ajax Flood Control Dykes

Environmental Study Report

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KGS Group Project:

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Councillors, Ministers, Members of Parliament

EXECUTIVE SUMMARY

The Pickering and Ajax Dykes were constructed in the 1980's to mitigate the risk of flooding in areas of the City of Pickering and the Town of Ajax, within the communities of Village East and Notion Road Pickering Village. These areas are within the Regulatory Floodplain of West Duffins Creek and Duffins Creek and have a Special Policy Area (SPA) designation. The Pickering Dyke is approximately 1,150 m long and extends from Brock Rd to Kingston Rd W. The Ajax Dyke is approximately 340 m long and runs parallel to Church St S, approximately 165 m north of Highway 401. A study of the flood characterization of the area and the geotechnical conditions of these dykes, conducted in 2018, indicated that the dykes do not meet current engineering standards, and criteria for stability, and are at risk of failing during a flood event. The study also identified creek bank erosion and excessive woody vegetation as factors negatively affecting the dykes and contributing to its overall risk of failure.

Toronto and Region Conservation Authority (TRCA) retained KGS Group to carry out a Conservation Ontario Class Environmental Assessment for Remedial Flood and Erosion Control Projects to advance rehabilitation planning and design of the Pickering and Ajax Flood Control Dykes which will ensure that the dykes meet current engineering standards and factors of safety (FOS) and reduce the associated risk to public safety and loss of property.

While the original target level of flood protection, when the dykes were designed in the 1980's, was the 500-year storm flood, the 2018 study found that the current height of the dykes only allows protection up to a 100-year storm flood event (Pickering Dyke) and a 50-year storm flood event (Ajax Dyke). For greater flood events, including the 500-year and the Regulatory Flood, additional flooding mechanisms occur such that the dykes alone cannot provide flood protection during these events. Since the dykes alone cannot protect for these greater flood events, TRCA established that the objective for the dyke rehabilitation was to meet current engineering standards and FOS while providing at minimum the level of flood protection associated with the existing dyke crest elevations.

As part of the Conservation Ontario Class EA, a baseline inventory of the Project Study Area was carried out that included consideration of the physical, natural and built environment, cultural and socioeconomic environment, as well as technical engineering aspects. The project included the definition and evaluation of alternative solutions for the dyke rehabilitation and their refinement into design concepts. These were evaluated with criteria that reflected the various considerations identified during the baseline inventory and consultation process. A comprehensive consultation process was undertaken with stakeholder agencies, the public and three dedicated committees.

The preferred alternative solutions were:

- Hard Engineering Solution, consisting of dyke configurations that include a hard structural component to ensure achieving the required stability factors of safety for the dykes. This was selected for those areas of the Pickering Dyke where there is limited space for the rehabilitation works between the creek and private properties.
- Soft Engineering Solution, consisting of dyke configurations that do not include a hard structural component for stability; but instead rely on providing embankment slopes that are stable and more

gradual than those of the existing dykes. This was selected for areas of the Pickering Dyke where the space available for the rehabilitation work was wide enough to fit this solution without impacting private properties or the watercourses. This alternative solution was also selected as preferred for the entire Ajax Dyke.

It was also decided that these preferred solutions would be developed with the required dyke height to protect up to a 100-year storm flood protection for both the Pickering and Ajax Dykes.

Further development of the preferred alternative solutions included the definition and evaluation of design concepts that advanced these solutions to a 30% level of design. Various concepts were evaluated using criteria that included consideration of the physical, natural and built environment, cultural and socioeconomic environment, as well as technical engineering aspects. These criteria incorporated feedback received during the consultation process. The preferred design concepts were:

- For the hard engineering solution of the Pickering Dyke: the rehabilitation of the dyke with side slopes similar to existing, enhanced with a granular toe drain on the dry side slope and internal sheet pile combined with a vegetated rock buttress on the wet side slope.
- For the soft engineering solution of both the Pickering and Ajax Dykes: the rehabilitation of the dyke with more gradual slopes of maximum 4H:1V, a wider dyke and the incorporation of a granular filter on the dry side slope.

Recommendations were provided for further development of the design concepts during the detailed design phase that would occur after the completion of this Environmental Assessment Project.

Additional design concepts that were considered but not selected as preferred included the use of various types of sheet piles, concrete walls, mechanically stabilized earth walls (MSE), and various seepage cut-off methods.

The estimated capital cost of the preferred design concepts, including contingency values appropriate for a 30% level of design, were:

- $7.0 Million for the hard engineering solution on the segment of the Pickering Dyke with restricted space for the rehabilitation work
- $3.0 Million for the soft engineering solution on the segment of the Pickering Dyke without restricted space for the rehabilitation work
- $2.6 Million for the soft engineering solution of the Ajax Dyke

The consultation process included meetings with:

- A Technical Advisory Committee, with staff from the City of Pickering, Town of Ajax, Region of Durham and TRCA;
- An Executive Steering Committee, consisting of senior staff from the City of Pickering, Town of Ajax and TRCA;
- A Community Liaison Committee, consisting of members of the public with an interest in the project (typically that live in the vicinity of the dykes);
- Individual meetings with landowners adjacent to the dykes;

- It also included two Public Information Centres attended by members of the community within the Project Study Area and beyond.

The following Environmental Study Report (ESR) has been prepared as documentation of the decision-making approach used in determining the preferred alternative for the proposed rehabilitation work in order to achieve the objectives, mitigate negative effects and address concerns associated with the proposed work.

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STATEMENT OF LIMITATIONS AND CONDITIONS

Limitations

This report has been prepared for Toronto and Region Conservation Authority (TRCA) in accordance with the agreement between KGS Group and TRCA (the "Agreement"). This report represents KGS Group's professional judgment and exercising due care consistent with the preparation of similar reports. The information, data, recommendations and conclusions in this report are subject to the constraints and limitations in the Agreement and the qualifications in this report. This report must be read as a whole, and sections or parts should not be read out of context.

This report is based on information made available to KGS Group by TRCA. Unless stated otherwise, KGS Group has not verified the accuracy, completeness or validity of such information, makes no representation regarding its accuracy and hereby disclaims any liability in connection therewith. KGS Group shall not be responsible for conditions/issues it was not authorized or able to investigate or which were beyond the scope of its work. The information and conclusions provided in this report apply only as they existed at the time of KGS Group's work.

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Any use a third party makes of this report or any reliance on or decisions made based on it, are the responsibility of such third parties. KGS Group accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions undertaken based on this report.

Geo-Environmental Statement of Limitations

KGS Group prepared the geo-environmental conclusions and recommendations for this report in a professional manner using the degree of skill and care exercised for similar projects under similar conditions by reputable and competent environmental consultants. The information contained in this report is based on the information that was made available to KGS Group during the project and upon the services described, which were performed within the time and budgetary requirements of TRCA. As this report is based on the available information, some of its conclusions could be different if the information upon which it is based is determined to be false, inaccurate or contradicted by additional information. KGS Group makes no representation concerning the legal significance of its findings or the value of the property investigated.

Geotechnical Investigation Statement of Limitations

The geotechnical investigation findings and recommendations of this report were prepared in accordance with generally accepted professional engineering principles and practice. The findings and recommendations are based on the results of field and laboratory investigations, combined with an interpolation of soil and groundwater conditions found at and within the depth of the test holes drilled by KGS Group at the site at the time of drilling. If conditions encountered during construction appear to be different from those shown by the test holes drilled by KGS Group or if the assumptions stated herein are not in keeping with the design, KGS Group should be notified in order that the recommendations can be reviewed and modified if necessary.

Capital Cost Estimate Statement of Limitations

The cost estimates included with this report have been prepared by KGS Group using its professional judgment and exercising due care consistent with the level of detail required for the stage of the project for which the estimate has been developed. These estimates represent KGS Group's opinion of the probable costs and are based on factors over which KGS Group has no control. These factors include, without limitation, site conditions, availability of qualified labour and materials, present workload of the bidders at the time of tendering and overall market conditions. KGS Group does not assume any responsibility to TRCA, in contract, tort or otherwise in connection with such estimates and shall not be liable to TRCA if such estimates prove to be inaccurate or incorrect.

1.0 INTRODUCTION

Toronto and Region Conservation Authority (TRCA) is undertaking a Conservation Ontario Class Environmental Assessment for Remedial Flood and Erosion Control Projects (Conservation Ontario 2002, amended 2013) to restore the Pickering and Ajax Flood Control Dykes. The rehabilitation will ensure that the dykes meet current engineering standards and factors of safety (FOS), while maintaining at minimum the level of flood protection associated with the existing dyke heights, to reduce the risk to public safety and loss of property.

The following Environmental Study Report (ESR) has been prepared as documentation of the decision-making approach used in determining the preferred alternative for the proposed rehabilitation work in order to mitigate negative effects and address concerns associated with the proposed work.

The Pickering and Ajax Dykes were constructed in 1984 (Ajax Dyke) and 1985 (Pickering Dyke). The Pickering Dyke section is an approximately 1,150 metre (m) long structure from Brock Road at Highway 2 in the City of Pickering extending to the east, ending at Highway 2 (Kingston Rd W) within the Town of Ajax approximately 170 m east of Notion Road. The Ajax Dyke section is approximately 340 m long structure located west of Church Street South within the Town of Ajax, approximately 165 m north of Highway 401. Dyke locations are shown on Figure 1-1.

Recent studies undertaken by TRCA identified that the dykes do not meet current applicable engineering design standards and factors of safety (FOS). As such, there is a risk of dyke failure that needs to be addressed by upgrading them to those standards.

FIGURE 1-1: LOCATION OF PICKERING AND AJAX DYKES

1.1 Class Environmental Assessment

TRCA, under the *Conservation Authority Act,* is defined as a public body in Section 3 of Ontario Regulation 334/90 in the *Environmental Assessment Act (R.S.O.) 1990*. As such, the TRCA must conduct its remedial flood and erosion control projects in accordance with the *Environmental Assessment Act (EA Act).*

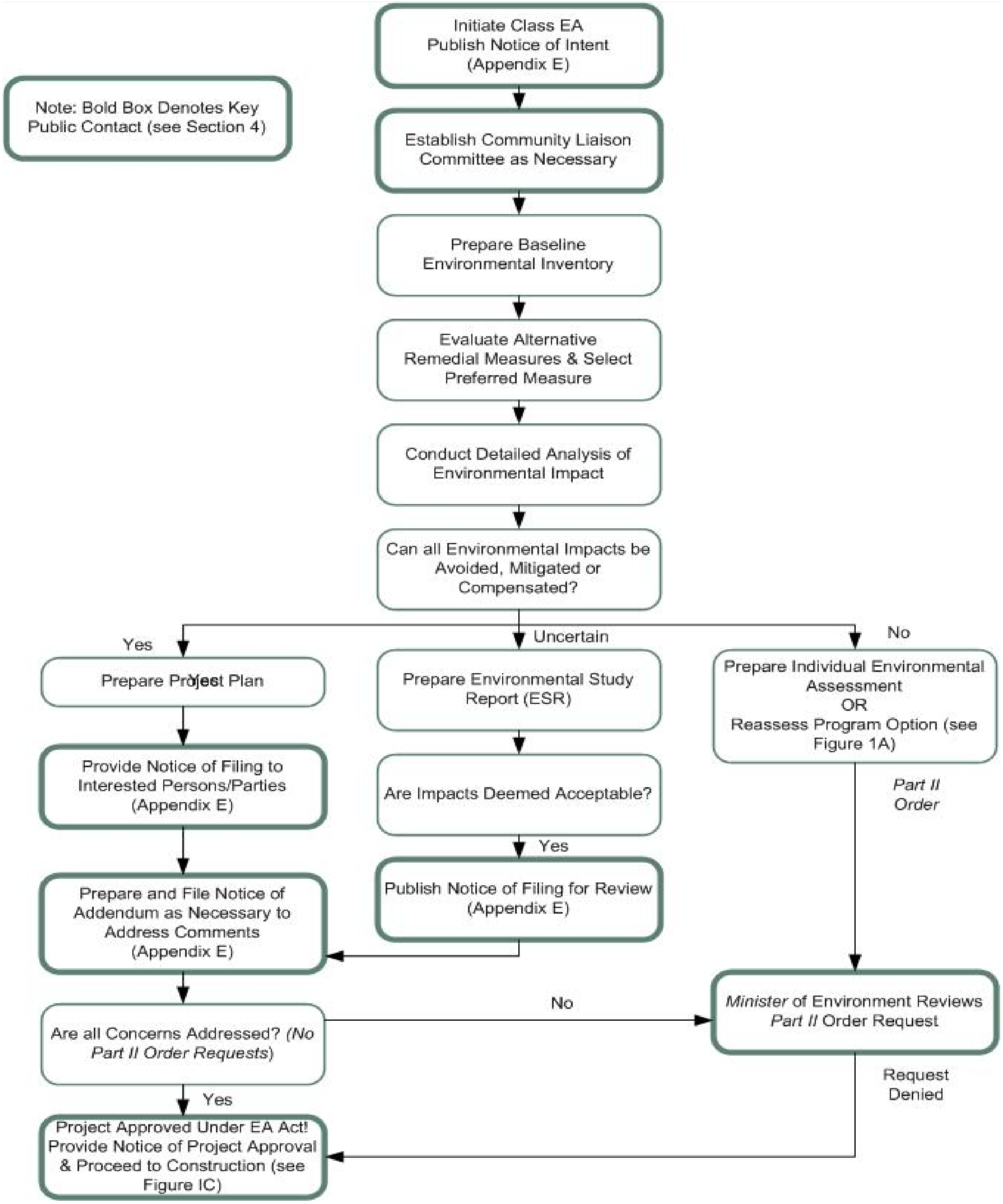
Recognizing that common elements exist in addressing flood and erosion problems, a co-ordinated approach to environmental assessments (EA's) was developed by Conservation Ontario for all Conservation Authorities, known as the *Class Environmental Assessment for Remedial and Erosion Control Projects* (Class EA) dated January 2002 and amended June 2013.

According to Section 2.0 of the Class EA document, Remedial Flood and Erosion Control Projects refer to those projects:

"...undertaken by Conservation Authorities, which are required to protect human life and property, in previously developed areas, from an impending flood or erosion problem. Such projects do not include works which facilitate or anticipate development. Major flood and erosion control undertakings which do not suit this definition, such as multipurpose projects, lie outside of the limits of this Class and require an Individual Environmental Assessment." (Conservation Ontario 2002, amended 2013)

Twenty years of experience have demonstrated that using the Class EA approach for dealing with flood and erosion control projects is an effective way of complying with the *EA Act* requirements (Conservation Ontario 2002, amended 2013). Approval of the Class EA allows Conservation Authorities to carry out these types of projects without applying for formal approval under the *EA Act*, on the condition that all other necessary provincial and federal approvals are obtained. Figure 1-2 provides a chart illustrating the key steps of the Class EA planning and design.

FIGURE 1-2: CONSERVATION ONTARIO CLASS EA PLANNING AND DESIGN PROCESS (CONSERVATION ONTARIO 2013)



(Note: Figures and Appendices referenced in Figure 1-2 are found in the Class EA document)

1.2 Purpose of The Undertaking

The purpose of the Rehabilitation of the Pickering and Ajax Flood Control Dykes Class Environmental Assessment Project (the Project) is to restore flood protection for the adjacent communities.

The dykes were constructed in the 1980s to provide flood protection for the Village East community in Pickering and the Notion Road/Pickering Village community in Ajax, which are both designated Special Policy Areas (SPA).

Recent studies undertaken by TRCA identified that the dykes do not meet current applicable engineering design standards and factors of safety (FOS). As such, there is a risk of dyke failure that needs to be addressed by upgrading them to those standards.

Through the Project, the most appropriate rehabilitation and/or flood remediation option(s) to restore the Pickering and Ajax Dykes will be selected, so that the flood control dykes meet current engineering standards and factors of safety, while maintaining at a minimum the level of food protection associated with the existing dyke heights (50-yr storm event for the Ajax Dyke and 100-yr storm event for the Pickering Dyke).

The proposed undertaking will be carried out in accordance with The Living Cities Policies (LCP) (TRCA 2014). The LCP is issued under Section 20 of the Conservation Authorities Act and is an expression of current practice and is consistent with current legislative framework (TRCA 2014).

1.2.1 PROBLEM STATEMENT

The Pickering and Ajax Dykes were designed and constructed in the 1980's to provide flood protection for two Special Policy Areas (SPA) within the Region of Durham, one in the City of Pickering (Village East community) and one in the Town of Ajax (Notion Road/Pickering Village community). The dykes were intended to protect the SPAs against floods along the West Duffins and Duffins creeks up to a 500-year storm event. Recent engineering studies, using modern analytical techniques and current data, have identified that the probable creek water level during a 500-year storm event is now higher than the current top of the dykes. The elevation of the existing top of the Pickering Dyke protects for a 100-year storm event and the elevation of the current top of the Ajax Dyke protects up to a 50-year storm event. Recent engineering studies also determined that the existing dykes do not meet the current applicable engineering design standards, including factors of safety (FOS). As such, there is a risk the dykes will fail during a flood.

It should be noted that in several areas the dykes have a narrow crest width, which limits access to complete required maintenance work. Large portions of the dykes are now covered with woody vegetation including trees. Unfortunately, the trees have compromised the integrity of the dykes due to root penetration. The issue is exacerbated when the trees become damaged and fall over, because the roots loosen and dislodge dyke material. In several locations along the Pickering dyke, the creek banks have significant erosion issues and are nearby the dyke so this poses a risk of compromising the dyke structure.

1.2.2 OPPORTUNITY STATEMENT

Toronto and Region Conservation Authority (TRCA) has a mandate to provide programs that will protect life and property from natural hazards such as flooding and erosion. As such, TRCA is actively exploring options to rehabilitate the existing dykes to meet the current applicable engineering design standards to provide reliable flood protection for the Pickering and Ajax Special Policy Areas. The rehabilitation of the dykes will provide the same, or greater, level of flood protection associated with the current dyke crest elevation (minimum 100-year storm event protection by the Pickering Dyke and 50-year storm event protection by the Ajax Dyke).

Undertaking rehabilitation of the dykes would provide additional opportunities including, but not limited to, the improvement of recreational features, ecological conditions, and accessibility to the dykes during a flood event and for regular maintenance. This project would also provide an opportunity to develop and implement long-term erosion mitigation measures to protect the dykes from damage due to channel bank erosion. Most importantly, the rehabilitation design can provide the opportunity to build flexibility and resiliency into the dykes, which allows for future modifications and improvements to community flood protection measures to increase the level of flood protection provided.

This project will follow the *Conservation Ontario Class Environmental Assessment for Remedial Flood and Erosion Control Projects* (Conservation Ontario 2002, amended 2013) to determine the best-suited remediation strategy for both the Pickering and Ajax Dykes. The EA process provides the opportunity for a more in-depth examination of rehabilitation options that consider adjacent properties, public safety, cultural/socioeconomic impacts, the environment, cost, constructability, and functionality.

1.3 Study Area

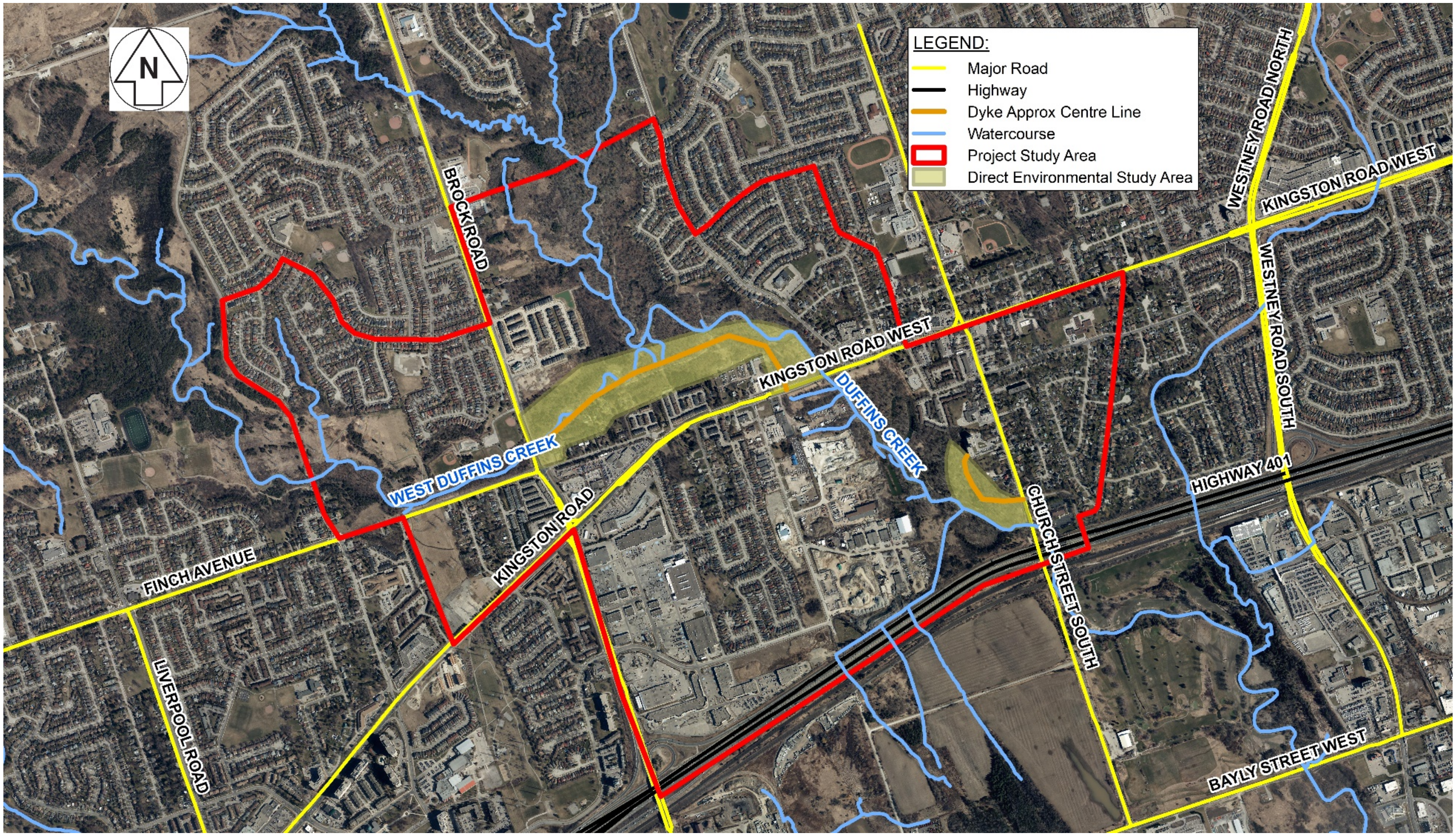
1.3.1 PROJECT STUDY AREA

The Project Study Area includes the (indirectly affected) environments within the City of Pickering and Town of Ajax, where the proposed works are likely to have an impact, and need to be considered as part of the EA. The Project Study Area limits are delineated by the red line on Figure 1-3. The study area includes the Pickering and Ajax Dykes, private properties adjacent to the dykes, the road network surrounding the dykes, valley lands surrounding the dykes and the Pickering and Ajax Special Policy Areas (SPA's). Duffins Creek and West Duffins Creek flow through the Project Study Area. The Project Study Area was defined to fully encompass the SPAs and the potential haul routes and nearby park space and residential neighborhoods that are close enough to have a higher likelihood of using the open space/green space within the Direct Environmental Study Area

1.3.2 DIRECT ENVIRONMENTAL STUDY AREA

The Direct Environmental Study Area includes the environment within the bounds of the flood or erosion control problem where remedial works would be located (area of the dykes), Duffins and West Duffins Creek, the access or construction route and private properties immediately adjacent to the area and portions of private properties , and was the focus of the majority of the investigation and analysis conducted as part of the EA. The Direct Environmental Study Area limits are delineated with a yellow-green highlight on Figure 1-3 and incorporate the areas immediately adjacent to both the Pickering and Ajax Dykes that will be directly impacted by construction activities. Both dykes are primarily located on land owned by TRCA. The Direct Environmental Study Area was defined as the area within which construction activities will likely take place or will be directly affected by construction activities. This was estimated by applying a buffer to the dykes and adjusted based on land features (e.g. private property, Duffin's Creek).

FIGURE 1-3: PROJECT AND DIRECT ENVIRONMENTAL STUDY AREAS



1.4 General Description of the Undertaking

There are four (4) situations in which remedial flood and erosion control projects may be undertaken within the Class EA (Conservation Ontario 2002, amended 2013):

1. Riverine Flooding
2. Riverine and Valley Slope Erosion
3. Shoreline Flooding
4. Shoreline Erosion

The primary objective of the Project is to provide long-term protection against Riverine Flooding.

In accordance with the Class EA planning process, a full range of alternatives must be developed, including both traditional and innovative approaches. The type and range of alternatives developed will be based on the nature, cause and extent of the Project and must be tailored to the individual characteristics of the Project Study Area.

The environmental planning and design principles of the Class EA outlined by Conservation Ontario requires an emphasis not only on the prevention and mitigation of environmental impacts but also on environmental enhancement. This goal is promoted through a number of principles outlined in the Class EA document:

- Remedial works shall be carried out only for the protection of existing development. These works will not be implemented for the sole purpose of facilitating future development.
- Alternative methods which replicate the natural environment shall be given preference over "hard" alternatives wherever possible, and, all projects should evaluate opportunities of enhancement of terrestrial or aquatic habitats as part of project design.
- Detailed technical design, as well as specific requirements for supervision and monitoring of projects shall be completed by a multidisciplinary team. Collectively this team should possess all of the necessary qualifications to address technical issues surrounding the implementation of the undertaking.
- Remedial project design shall strive to re-establish, maintain or enhance the natural function (both biological and physical) and appearance of the watercourse or shoreline and associated features (floodplain, valley, wetlands, beaches etc.) while recognizing and preserving existing cultural and archaeological features of significance in the project's study area.
- Where remedial works are necessary in a riverine situation, the solution shall be developed based upon an appropriate river reach or valley system.
- During rehabilitation, provide for the re-establishment of vegetative cover within the valley system, particularly adjacent to the watercourse (riparian zone). Vegetation re-establishment shall be compatible with the existing, local, or disrupted community and efforts should be made to use native species of the local flora.
- The design of remedial works, involving migratory corridors, shall strive to ensure preservation or enhancement of the migratory character of the feature for flora, fauna and human activity where appropriate. This includes the valley system and watercourse interface both for terrestrial and aquatic fauna.
- In identifying the objectives for the aquatic/terrestrial environment, the potential quality of the ecosystem, as well as its existing condition, shall be considered.

- In all cases, the design of the flood protection works must meet the requirements of all applicable regulatory agencies, including TRCA's.

The decision-making approach used in selecting the preferred alternative is documented in detail in Section 5.0 of this report. The proposed undertakings meet all TRCA planning and policy objectives, meets the needs of TRCA's municipal partners, and considers the concerns of potentially affected property owners and general public.

1.4.1 RATIONALE OF THE UNDERTAKING

The Project is being undertaken for the following reasons:

- The Pickering and Ajax Dykes do not meet present-day engineering standards and factors of safety. This poses a risk that the dykes could fail
- In the area of the Pickering Dyke there is channel bank erosion, and areas of high erosion risk, near or adjacent to the dykes. If this erosion progresses it could result in a dyke failure
- There are trees on the dykes and areas of overgrown vegetation. These could create seepage paths and debilitate the dykes, also initiating dyke failure.
- The crest of the dykes is very narrow in some areas. This impedes or limits safe access for maintenance and for management of potential flood or dyke failure emergencies.

1.5 Review of The Class EA Decision

The Class EA approach is considered an appropriate means for planning this Project based on the following:

- The Project fits within the definition of "Remedial Flood and Erosion Control Project" as described in the Class EA (Conservation Ontario, 2002, amended 2013).
- The Project is similar to other flood and erosion control projects in that they have similar planning, design, approval, construction, operation and monitoring requirements.
- The Project is expected to have predictable environmental effects that are generally responsive to standard mitigation measures.
- The Project is being conducted to mitigate potential risk to human life and property in a developed area (City of Pickering and Town of Ajax Special Policy Areas) from potential riverine flooding.
- The Class EA applies to several problem situations including Riverine Flooding where, similar to this Project, remedial measures include preventing the entry of flood waters into an area. These include structural methods (berms/dykes) that require capital works.
- The Class EA process provides a consistent, stream-lined process that ensures compliance with *Environmental Assessment Act* requirements.

1.6 Justification of Conservation Authority Involvement

TRCA has a mandate to carry out remedial flood control works as set out in Section 20 of *the Conservation Authorities Act* (R.S.O. 1990):

"*The objects of an authority are to provide, in the area over which it has jurisdiction, programs and services designed to further the conservation, restoration, development and management of natural resources other than gas, oil, coal and minerals (R.S.O. 1990, C.27, s.20).*"

As part of this broad mandate, Conservation Authorities are considered to have prime responsibility over water management in terms of water quantity and related hazards through administrative and regulatory powers.

TRCA has the power *"to control the flow of surface waters in order to prevent floods or pollution or to reduce the adverse effects thereof (R.S.O. 1990, C.27, s.21)."* as set out in Section 21 of the Conservation Authorities Act.

2.0 BACKGROUND

The Pickering and Ajax Dykes were designed and constructed in the 1980's to provide flood protection for the Village East (Pickering) and Notion Road/Pickering Village (Ajax) Special Policy Areas (SPA) within the City of Pickering and Town of Ajax. Historically, flooding in the area occurred almost on a seasonal basis, with property damage and personal inconvenience common to the area (Simcoe 1982). The dykes were intended to protect the SPA against flood events along West Duffins and Duffins Creeks up to a 500-year design event. Recent engineering studies, using modern analytical techniques and current data, have identified that the probable creek level during a 500-year design event is now higher than the current top of dyke elevations. It was also determined that the existing dykes do not meet the current and applicable engineering design standards. The current top of dyke elevations are such that the Pickering and the Ajax Dykes could protect up to a 100-year and 50-year water level, respectively.

The following sections provide background information pertaining to the area as well as the planning and recent investigations conducted for the dykes.

2.1 Special Policy Area (SPA)

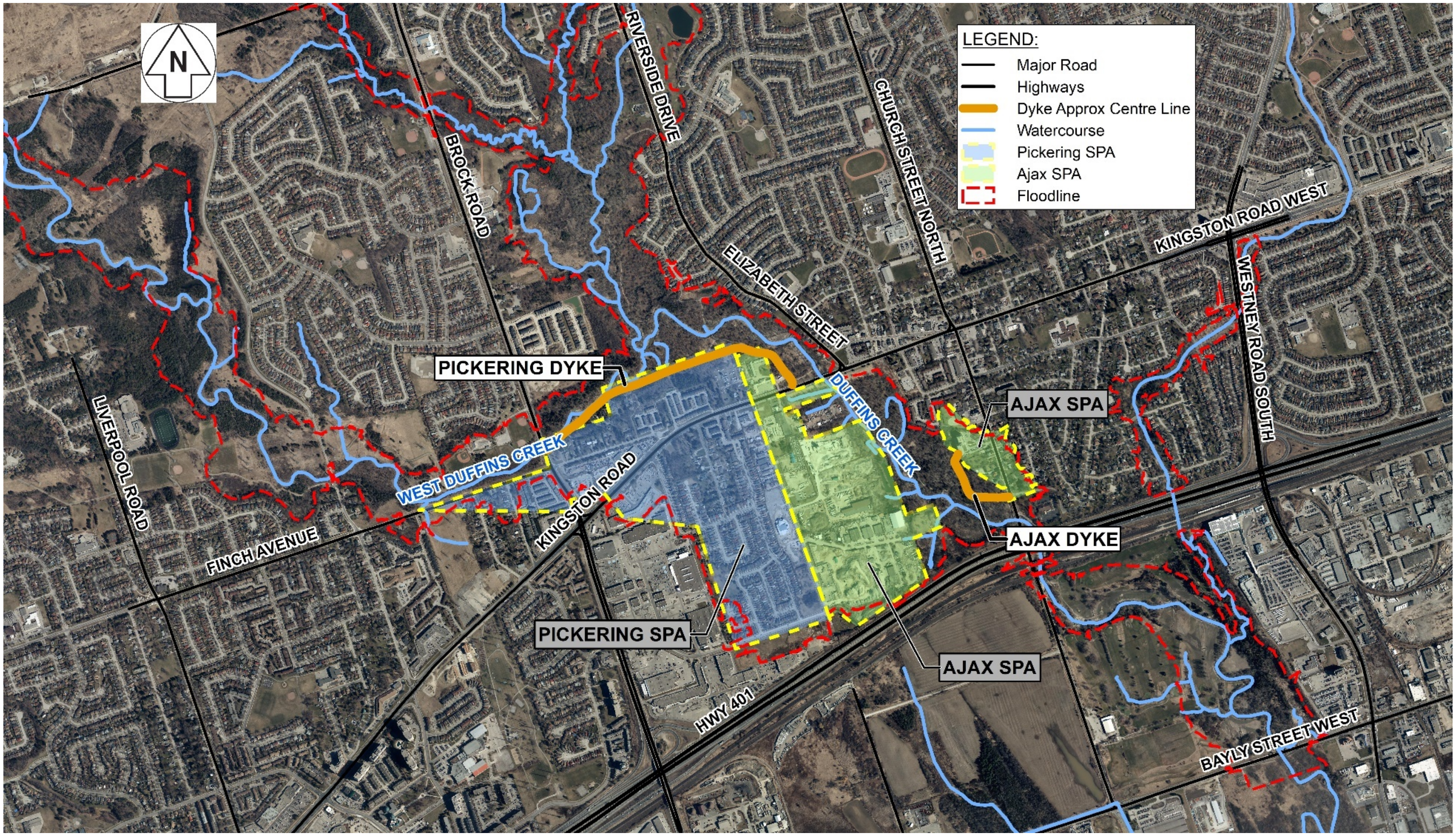
The Village East community in the City of Pickering (Ward 3) and the Notion Road/Pickering Village community in the Town of Ajax (Ward 1) are located within the regulatory flood plain of the Duffins Creek watershed. These areas have a long history of flooding and were designated as SPAs.

SPAs are developed areas that historically existed in a flood plain and where site specific policies, approved by both the Ministry of Natural Resources and Forestry and the Ministry of Municipal Affairs and Housing, are intended to provide continued viability of existing uses, which are generally small in scale.

SPAs address the significant social and economic hardships that would result within a community from strict adherence to Provincial policies concerning development within a regulatory flood plain. Criteria and procedures for approval are established by the Province. A SPA is not intended to allow for new or intensified development and site alterations if a community has feasible opportunities for development outside of the flood plain.

Figure 2-1 shows the boundaries of both the Village East (Pickering) and Notion Road/Pickering Village (Ajax) SPAs along with the boundary of the regulatory flood plain. Policies governing these SPAs are found in the Pickering Official Plan (City of Pickering, 2018) and the Ajax Official Plan (Town of Ajax, 2016). The presence and function of the Pickering and Ajax Dykes do not influence the extent of the SPAs or the applicable SPA policy provisions.

FIGURE 2-1: LOCATION OF PICKERING AND AJAX SPECIAL POLICY AREAS



2.2 Studies and Reports

Several studies and reports have been completed detailing the design and subsequent evaluation of the Pickering and Ajax Dykes. The following sections provide a summary of significant results and recommendations provided in these reports.

2.2.1 PRELIMINARY ENGINEERING REPORT FOR FLOOD PROTECTION ON THE DUFFIN CREEK IN THE PICKERING AJAX AREA (1982)

In the early 1980's, the Metropolitan Toronto and Region Conservation Authority, now the TRCA, identified the Pickering and Ajax area along the banks of West Duffins Creek and Duffins Creek, between Brock Road and Church Street South, as one of the top priority "Flood Damage Centres". In order to reduce the risk of flooding within this area, Simcoe Engineering Ltd. was retained to undertake a preliminary study. This study (Simcoe Engineering Ltd., 1982) identified several alternatives to provide flood protection and recommended a two-dyke system designed for the 500 - year storm event.

2.2.2 GEOTECHNICAL INVESTIGATION PROPOSED DYKING DUFFIN CREEK PICKERING, ONTARIO (AJAX DYKE) (1984)

Geo-Canada Ltd. (Geo-Canada) was retained by the Metropolitan Toronto and Region Conservation Authority through their consultant, Simcoe Engineering Ltd. to investigate the subsurface and foundation conditions at the site of the proposed dyke near the intersection of Duffins Creek and Church Street in the Town of Pickering (Geo-Canada Ltd., 1984).

Three (3) exploratory boreholes were drilled on the alignment of the proposed Ajax Dyke. The boreholes showed that the typical subsurface profile consisted of approximately 0.3 metres (m) of topsoil, underlain by very loose to loose organic silt to a depth of 2.6 to 3 m, and compact silty sand and gravel.

Geo-Canada indicated that the foundation conditions were marginal, but that a 3 m high dyke, constructed with 2:1 side slopes would provide a safety factor of approximately 2.0, which was considered adequate. Settlement was estimated to be in the order of 0.1 m and recommendations were made to overbuild the dyke by this amount so that the final elevation of the dyke, after settlement, would be at the same level as the design flood water level (top of dyke elevation of 81.3 m).

Geo-Canada also indicated that the dykes could be threatened by uplift due to high water pressure developing in a capped sand and gravel soil layer below the dikes and subsurface erosion. However, in their opinion, design measures to prevent these from occurring were not required due to the short duration that water would be at flood levels and the time lag required for critical piping and uplift conditions to develop.

2.2.3 SUBSURFACE INVESTIGATION PROPOSED DYKING DUFFIN CREEK PICKERING, ONTARIO. (PICKERING DYKE) (1985)

Geo-Canada Ltd. (Geo-Canada) was retained by the Metropolitan Toronto and Region Conservation Authority through their consultant, Simcoe Engineering Ltd. to investigate the subsurface and foundation conditions at the site of the proposed dyke for a section of Duffins Creek, extending from Brock Road to Highway 2 in the Town of Pickering (Geo-Canada Ltd., 1985).

Seven (7) exploratory boreholes were drilled along the proposed Pickering dyke alignment. Soil was found to be a variable sequence of sand, silt, and sand and gravel deposits, which are underlain in places by silty clay till or interbedded with a layer of organic silt

Stability analysis indicated that a 3 m high dyke, constructed with 2:1 side slopes would provide a safety factor for general foundation failure of greater than 2.0, which was considered adequate. Settlement was estimated to be in the order of 0.1 m and recommendations were made to overbuild the dyke by this amount so that the final elevation of the dyke, after settlement, would be 0.3 m higher than the design flood water level (top of dyke elevation varied from 83.0 to 84.4 m).

Geo-Canada also indicated that the dykes could be threatened by uplift due to high water pressure developing in a capped sand and gravel soil layer below the dikes and subsurface erosion. However, in their opinion design measures to prevent these from occurring were not required due to the short duration that water would be at flood levels and the time lag required for critical piping and uplift conditions to develop. They did however recommend that the area behind the dyke be observed during flood conditions to determine if and where remedial measures to prevent piping or uplift were necessary.

2.2.4 DUFFINS CREEK FLOOD PROTECTION DYKE EROSION RISK, LEVEL OF SERVICE ASSESSMENT AND MAINTENANCE AND IMPROVEMENT STUDY (2009)

TRCA retained Geomorphic Solutions in 2009 to provide consulting services for the Duffins Creek Flood Protection Dyke (Geomorphic Solutions, 2009). The scope of the study was to:

- Assess the condition of the Duffins Creek Dykes.
- Develop strategies to provide long-term protection to the dyke from erosion and geotechnical failure.
- Assess and improve, if necessary, the level of flood protection that the dyke provides.

Geomorphic Solutions concluded, based on a visual inspection, that the Ajax Dyke was in good condition with only minor issues to be addressed and that the Pickering Dyke was in poor condition, showing several locations of concern. The following recommendations were provided:

Section 1: Northeast of Finch Avenue and Brock Road (Pickering Dyke)

- The subsurface information around Areas 1-a, 1-b and 1-c (Appendix A) identified in the slope stability investigation for the Pickering Dyke should be investigated through drilling and sampling. Representative cross sections should then be studied using site-specific geotechnical parameters in order to assess the quality of the berm material forming the dyke.
- Boreholes should be drilled within the vicinity of foreign materials (i.e. Concrete, etc.) to confirm the construction of the dykes.
- Spot elevations should be taken along the length of the Pickering Dyke to compare with the design drawings to determine the amount of compaction that has occurred in the 20+ years since construction.

Section 2: West of Church Street and North of Highway 401 (Ajax Dyke)

- For Area 2-a on the Ajax Dyke (Appendix A), the side slope is recommended to be flattened to 2H:1V or flatter and protected against surface erosion.

2.2.5 2012 DUFFINS CREEK HYDROLOGY UPDATE (2012)

Aquafor Beech Limited was retained by the City of Pickering and the TRCA to undertake a Hydrology Update Study for Duffins Creek in 2012 (Aquafor Beech Ltd. 2012). The objectives of the study were as follows:

- Update the hydrological modelling to reflect land use changes since 2002;
- Calibrate the updated model using rainfall-runoff data from recent storm events;
- Test and update the stormwater management criteria developed as part of the previous 2002 study;
- Assess impacts to Regional Storm flows associated with proposed future urban development; and
- Develop flood (quantity) control criteria to be implemented within proposed future development lands.

Design flows for the 2-year to 100-year return periods and the Regional Storm were estimated for three scenarios using land use information from TRCA's GIS database:

- Existing land use;
- Future land uses as defined in the Municipal Official Plans; and
- Future Land uses with Airport which included a conservative assessment of the development of the Airport Lands

Based on the Future (Official Plan) land use scenario, without stormwater management controls, large increases in peak flows were anticipated where significant future development is planned within smaller tributaries. Negligible changes were predicted for the major tributary reaches.

Based on the Future Land use with Airport scenario, without stormwater management, peak flows increases are expected at most locations throughout the watershed for both 100-year event and Regional Storm.

2.2.6 PICKERING / AJAX SPECIAL POLICY AREA (SPA) TWO-DIMENSIONAL (2D) HYDRAULIC MODEL AND DYKES ASSESSMENT STUDY (2018)

Valdor Engineering Inc. (Valdor) was retained by TRCA to complete a study that included hydraulic modelling, analysis of flood mechanisms and flood mitigation measures in the area that includes the Pickering and Ajax SPAs. The results of that study were provided in the three reports described in this section.

2.2.6.1 MIKE Flood 1D-2D Model Development and Regulatory Floodplain Mapping Pickering / Ajax SPA's

Valdor developed a 1D-2D coupled hydraulic model, using the software MIKE Flood, for the area that included the Pickering and Ajax Dykes (Valdor Engineering Inc. 2018a).

The results of the MIKE Flood model were used to delineate the extent of flooding for the Regional Storm (Hurricane Hazel), which are used to prepare flood plain mapping, the 500-yr and 350-yr storm as well as events ranging between the 2-yr throughout 100-yr storm events.

Based on the results of the MIKE Flood model, it was determined that the intended level of flood protection of the dykes (500-yr storm) was not provided. The study found that the Pickering Dyke would be overtopped by the flood resulting from events greater than the 100-yr storm and the Ajax Dyke would be overtopped by the flood resulting from events greater than the 50-yr storm.

Valdor provided new floodplain map sheets to replace those existing in the area, and recommended that:

- A characterization and risk assessment of the floodplain be undertaken to identify the flood processes to identify low and high-risk areas.
- An analysis of flood flows and flooding process be undertaken to determine key hydraulic constraints contributing to flooding within the Pickering and Ajax SPA's, including the potential presence of undersized hydraulic structures, channels with poor conveyance and topographic constraints such as spill points and low terrain areas.
- Options to rehabilitate the existing dykes and reinstate the intended 500-yr level of flood protection be investigated for future consideration and implementation.
- As a minimum requirement, the intended level of flood protection be reinstated, within the Pickering and Ajax SPA's, to ensure the area is protected from flood events up to and including the 500-yr storm, and to minimize the risk to life and property.
- Opportunities to improve the level of flood protection beyond the 500-yr storm be investigated at a high level of assessment to confirm if such an undertaking is practical.

2.2.6.2 Dyke Level of Service and Rehabilitation Report Pickering / Ajax SPA's

Valdor conducted an assessment of the geotechnical performance of the Pickering and Ajax Dykes (Valdor Engineering Inc. 2018b). The evaluation of the geotechnical performance of both dykes in terms of stability under a number of loading conditions/failure modes, as well as a general assessment of other related flood control infrastructure resulted in a list of identified deficiencies for both the Pickering and Ajax Dykes. Deficiencies identified in that study included: excessive vegetation, erosion issues, deteriorating dyke toe protection, improper dyke construction materials, blocked flap gates, accumulated sediment and debris in drainage culverts, slope stability issues, settlement/low areas on top of the dykes and the presence of unapproved culverts through the dyke.

The results of the geotechnical analysis indicated that the current dykes do not provide the requisite Factor of Safety (FOS) as indicated in the bulletins associated with the Lakes and Rivers Improvement Act Administrative Guide (Ministry of Natural Resources, 2011) under a number of conditions including: long-term steady state seepage and normal water course level, Inflow Design Flood and rapid drawdown. It was noted that the FOS for the rapid drawdown loading condition was less than 1.0 for all dyke sections, which Valdor considered a significant deficiency of the current dykes that could lead to dyke failure.

A comparison of LiDAR and design dyke crest elevations carried out in the Valdor (2018b) study showed that the Pickering Dyke is lower than the design elevations at many locations by up to 0.1 meters (m) and the Ajax Dyke is lower than the design elevations at many locations by up to 0.33 m.

Nine (9) dyke rehabilitation options were identified by Valdor for preliminary review. These included:

- Option 1: Do Nothing
- Option 2: Dyke Retrofit Using Partial Clay and Rip Rap
- Option 3: Full Dyke Reconstruction Using Clay Core
- Option 4: Dyke Retrofit Using Sheet Pile Wall Installed at Top of Wet Side Slope
- Option 5: Dyke Retrofit Using Retaining Walls
- Option 6: Dyke Retrofit Using Sheet Pile Wall Installed at Toe of Wet Side Slope
- Option 7: Dyke Retrofit Using Rip Rap

- Option 8: Dyke Retrofit Using Sheet Pile Wall Installed at Mid-Point of Wet Side Slope Including Modified Dry Side Slope
- Option 9: Dyke Retrofit Using Sheet Pile Wall Installed at Mid-Point of Wet Side Slope and Retain Dry Side Slope Largely Undisturbed

Option 9 was selected as the recommended alternative for the following reasons:

- It allows achieving the FOS values indicated in MNR (2011) for all identified loading conditions/failure modes, with the exception of the steady state seepage and normal pond level loading scenarios. For the latter scenarios, Option 9 allowed a FOS of 1.3, which, while less than the 1.5 indicated in MNR (2011), was considered acceptable by Valdor.
- It fits within the existing dyke footprint and does not require the acquisition of additional lands or easements.
- It allows for a balance between cuts and fills such that the current conveyance within the watercourse is not reduced.
- It minimizes the disturbance of trees on the dry side of the dykes, which may be better received by adjacent landowners.
- It limits the environmental disturbance to more-or less the existing dyke footprint.
- Its estimated construction costs are high but less than the cost to implement other options with similar benefits.

The recommended Option 9 consisted of the installation of a sheet pile wall part way down the existing wet side of the dykes with a granular filled trench installed on the dry side of the dyke. The sheet pile wall would extend for the entire length of both the Pickering and Ajax Dykes (Appendix A). All work would be completed within the existing footprint of the dykes and would not require the acquisition of any land.

The estimated cost of the proposed construction works to rehabilitate the flood dykes as per Option 9 was approximately $6,200,000 for the Pickering Dyke and $2,400,000 for the Ajax Dyke including a 20% contingency and excluding HST.

Valdor recommended that a further study be undertaken in accordance with the Conservation Authority Class Environmental Assessment (EA) for Remedial Flood and Erosion Control Projects (Conservation Ontario 2013) for the purpose of revisiting, and evaluating in greater detail, dyke rehabilitation alternatives including the recommended Option 9. They also recommended to further investigate and evaluate flood remediation options to achieve the 500-yr or Regional Storm level of flood protection through a separate EA study. Additionally, Valdor recommended that basic repairs and maintenance items identified in the study be completed prior to completion of the Class EA project.

2.2.6.3 Flood Characterization and Preliminary Remediation Investigations Pickering / Ajax SPA's

Valdor characterized the flooding mechanisms and assessed the ensuing flooding risks within the Pickering and Ajax SPA's Study Area. This study (Valdor Engineering Inc. 2018c) applied the results from the MIKE Flood model prepared as part of the regulatory floodplain mapping update study (Valdor Engineering Inc, 2018a).

The flood characterization study found that under existing conditions the Pickering Dyke would be overtopped during the flood resulting from the 350-yr storm but not the 100-yr storm, and that the Ajax Dyke would be overtopped during the flood resulting from the 100-yr storm but not the 50-yr storm. Model results carried out in this study also showed that flooding within the Pickering and Ajax SPA's became extensive for the 350-yr and 500-yr storms as well as the Regional Storm flood events. Appendix A shows the extent of flooding obtained with the model for the various flood events investigated.

Valdor (2018c) used the 2x2 Rule criteria, as indicated in the Technical Guide River & Stream Systems Flood Hazard Limit (MNR, 2002), to define areas of "high flood risk", and reported the following number of buildings that were found to be within those areas:

- Pickering (Village East) SPA – 500-yr storm flood event: 15 residential type buildings and 2 industrial/commercial buildings.
- Pickering (Village East) SPA – Regional Storm flood event: over 400 residential and 12 industrial/commercial buildings.
- Ajax (Notion Rd Pickering Village) SPA – 500-yr storm flood event: approximately 13 residential type buildings and 3 industrial/commercial buildings.
- Ajax (Notion Rd Pickering Village) SPA – Regional Storm flood event: approximately 23 residential type buildings and 25 industrial/commercial buildings.

In addition to overtopping of the Pickering Dyke, Valdor reported that one key cause for flooding within the Pickering (Village East) SPA and the west portion of the Ajax (Notion Rd Pickering Village) SPA during the 500-yr storm flood was spilling along low areas on the west bank of Duffins Creek, between Kingston Rd and the Hwy 401. Additional flooding mechanisms and hydraulic constraints were found to come into play during the Regional Storm flood event, including:

- Bridge conveyance limitations associated with CN Rail, Go Transit, eastbound and westbound Highway 401, Church Street, Kingston Road and Brock Road.
- Channel conveyance constrictions primarily associated with the noted bridge crossings.
- Low points along the existing flood dyke between Brock Road and Kingston Road.
- Low areas along the north side of Finch Avenue west and Brock Road.
- Low area along Brock Road north of Finch Avenue.
- Low areas along the west side of Duffins Creek between Kingston Road and Highway 401.
- Low areas along Kingston Road west of Duffins Creek.

In addition to overtopping the Ajax Dyke, Valdor reported that flooding mechanisms contributing to flooding the east portion of the Ajax (Notion Rd Pickering Village) SPA during the 500-yr storm flood included spilling across low areas along Church Street and south of Mill Street. Additional flooding mechanisms and hydraulic constraints were found to come into play during the Regional storm, including:

- Bridge conveyance limitations associated with CN Rail, Go Transit, eastbound and westbound Highway 401 and Church Street.
- Channel conveyance constrictions primarily associated with the noted bridge crossings.
- Low points along the existing flood dyke west of Church Street.
- Low area along Church Street south of Mill Street.
- Low areas south of Mill Street and east of Church Street.

As part of the study, three (3) flood remediation options were investigated. The first option, referred to as "Full Flood Remediation – 500-yr, consisted of raising the existing dykes and roads and constructing new dykes (Appendix A). The model results showed that this would protect the two SPA's entirely from flooding resulting from storm events up to and including the 500-yr storm. The second option, "Partial Flood Remediation – Regional", consisted of conveyance improvements on crossings and channels (widening bridges and the channel) (Appendix A). This option did not provide full protection for the Regional Storm flood event; but the model results showed that it would prevent flooding on a large number of buildings. The third option, "Full Flood Remediation – Regional", included conveyance improvements (widening bridges and the channel) as well as raising the existing dykes and roads and constructing new dykes (Appendix A). The model results showed that it would protect the two SPA's entirely from flooding resulting from storm events up to and including the Regional Storm.

Valdor indicated that these flood remediation options would be extensive and costly and required further consideration and analysis that was beyond the scope of their study. Valdor recommended that further study be undertaken in accordance with the Conservation Authority Class EA for Remedial Flood and Erosion Control Projects (Conservation Ontario, 2013) to review in further detail, evaluate and select the preferred solution to achieve dyke rehabilitation and flood remediation for the 500-yr and/or Regional storms. They also recommended that basic repairs and maintenance items identified in the study be completed prior to completion of the Class EA project.

2.3 General Repair and Maintenance

Based on recommendations made in the Dyke Level of Service and Rehabilitation Report (Valdor Engineering Inc., 2018), TRCA undertook the following maintenance and repair work in 2018 in response to noted deficiencies:

- All flap gates were cleaned and exercised.
- The drainage ditch to Duffins Creek at the Ajax Dyke was improved by digging it deeper to ensure water flows unimpeded.
- A culvert with pipe separation was repaired.
- All culverts were partially cleaned.

Also, in 2008 emergency erosion repair/channel bank stabilization was completed along the West Duffins Creek because the southern channel bank erosion was a risk to the Pickering Dyke. This work occurred in two areas: 1) behind 1780 Bluebird Crescent and 2) behind 1760 and 1748 Finch Avenue.

TRCA completes annual inspections of the dykes.

3.0 BASELINE ENVIRONMENTAL CONDITIONS

The baseline environmental inventory for the Project provides information needed to evaluate the alternatives developed through the Class EA process, and a baseline from which to monitor the types and levels of environmental impacts that may result from implementing the preferred alternative or alternatives. This inventory involves the examination and documentation of the following within the Project and Direct Environmental Study Areas:

- Existing site conditions including physical, biological, cultural and socioeconomic characteristics;
- Engineering/Technical aspects to be considered; and
- Previous work undertaken.

3.1 Site Location

The site is located within the City of Pickering and the Town of Ajax (Figure 3-1).

3.2 Project Study Area and Direct Environmental Study Area

The Study Area includes both directly affected (Direct Environmental Study Area) and indirectly affected environments (Project Study Area) within the City of Pickering and the Town of Ajax and is within the Duffins Creek Watershed (Figure 3-2). The Direct Environmental Study Area includes the environment within the bounds of the flood or erosion control problem where remedial works would be located (area of the dykes), Duffins and West Duffins Creek, the access or construction route and private properties immediately adjacent to the area and portions of private properties. The Project Study Area includes the (indirectly affected) environments within the City of Pickering and Town of Ajax, where the proposed works are likely to have an impact.

FIGURE 3-1: SITE LOCATION

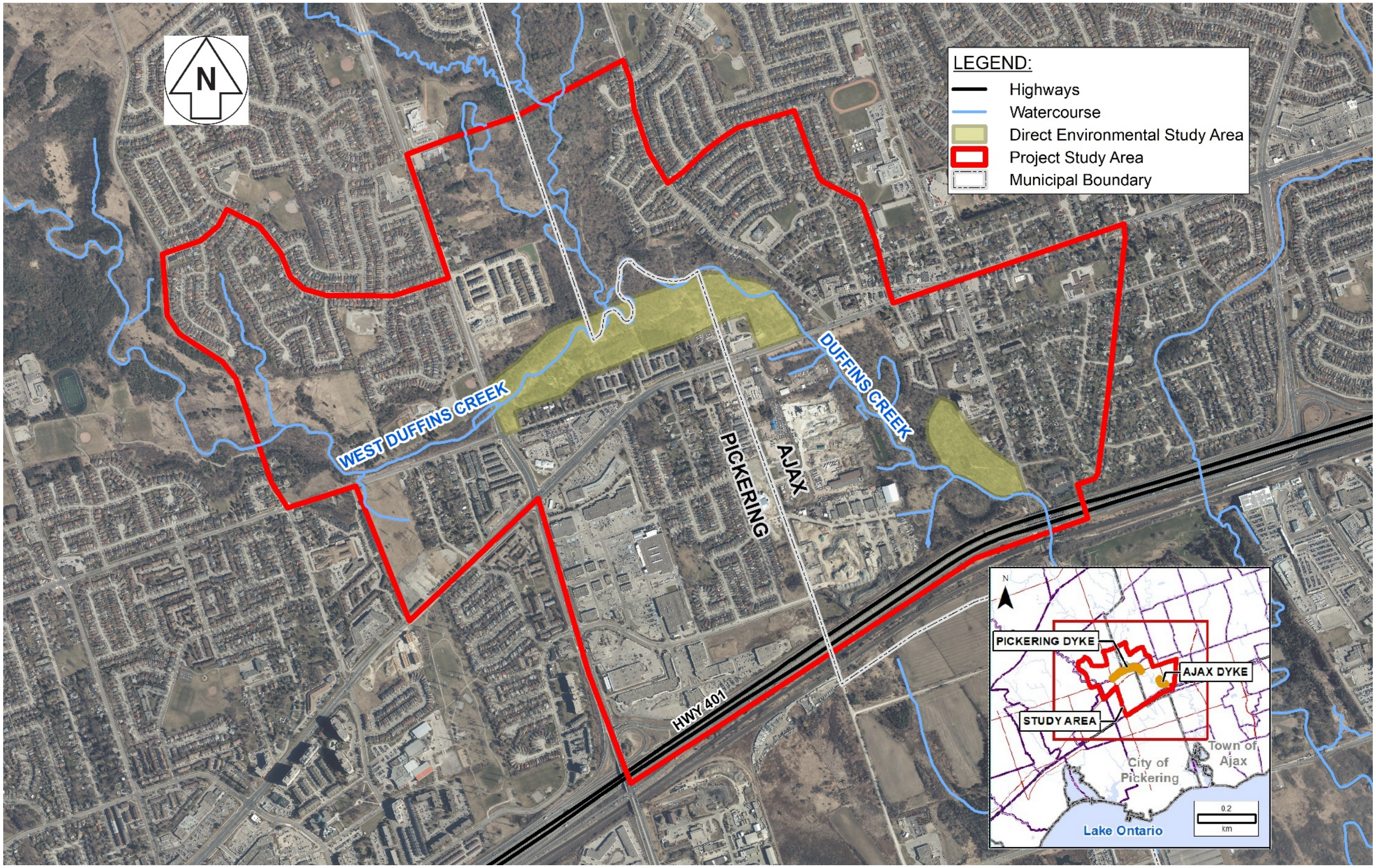
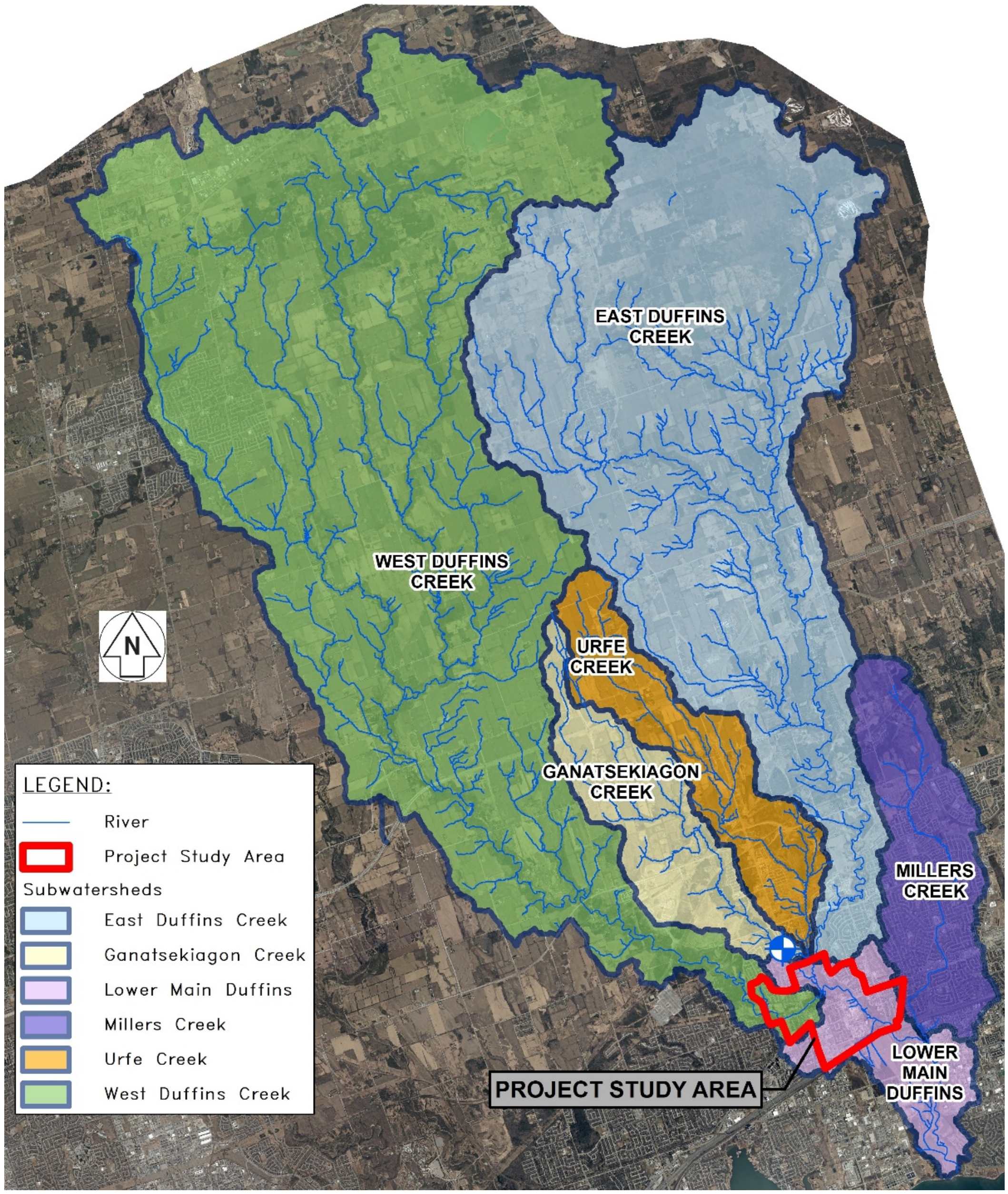


FIGURE 3-2: SITE LOCATION WITHIN DUFFINS CREEK WATERSHED



3.3 Physical

3.3.1 UNIQUE LANDFORMS

There are no unique landforms within the Project or Direct Environmental Study Areas.

3.3.2 EXISTING MINERAL OR AGGREGATE RESOURCES EXTRACTION INDUSTRIES

There are no mineral or aggregate resource extraction industries within the Project or Direct Environmental Study Areas.

3.3.3 EARTH SCIENCE – AREAS OF NATURAL AND SCIENTIFIC INTEREST (ANSI'S)

There are no earth science ANSI's within the Project or Direct Environmental Study Areas.

3.3.4 SPECIALTY CROP AREAS

There are no specialty crop areas within the Project or Direct Environmental Study Areas.

3.3.5 AGRICULTURAL LANDS OR PRODUCTION

There are no agricultural lands or production within the Project or Direct Environmental Study Areas.

3.3.6 NIAGARA ESCARPMENT

The Project Study Area is not located within the area of the Niagara Escarpment. The Niagara Escarpment is located to the west of Pickering, and west of Lake Ontario.

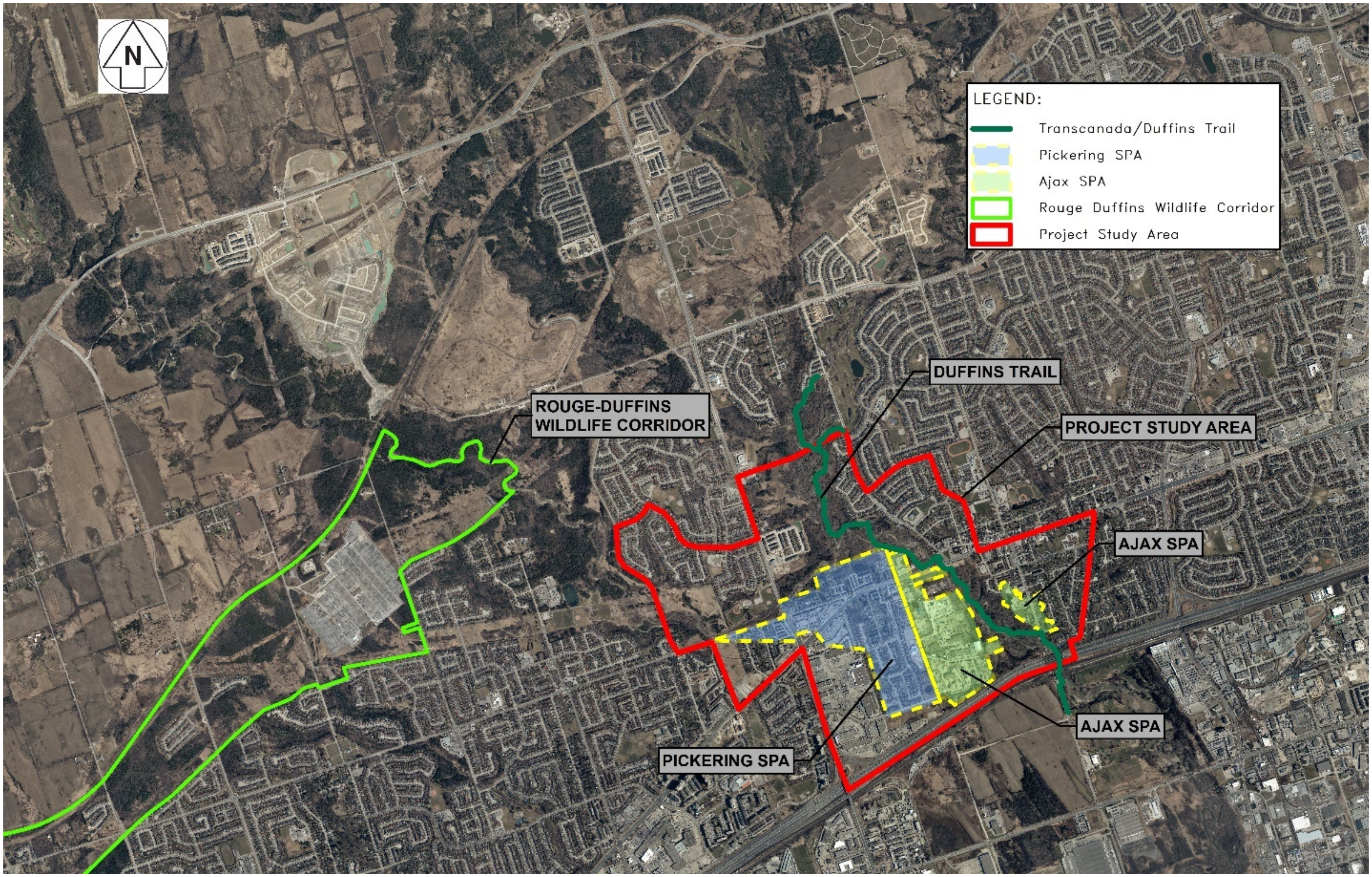
3.3.7 OAK RIDGES MORAINE

The Project Study Area is not located within the area of the Oak Ridges Moraine. A portion of the Oak Ridges Moraine is located to the north of the Project Study Area, and the headwaters of Duffins Creek originate within the Oak Ridges Moraine area.

3.3.8 ENVIRONMENTALLY SENSITIVE / SIGNIFICANT AREAS – PHYSICAL

The Project Study Area is considered part of an environmentally significant area. The Duffins Creek Corridor has an Environmental Protection Area designation, which protects natural areas, such as stream and valley corridors and the Rouge-Duffins Wildlife Corridor, that passes through the urban areas (TRCA 2003) (Figure 3-3). Portions of the developed areas are located within the regulatory floodplain and have been designated as SPAs in the City of Pickering and the City of Ajax Official Plans to allow for continued development in existing communities. Duffins Creek enters Lake Ontario at the Duffins Marsh. The Duffins Marsh and Lake Ontario Shoreline consist of publicly owned lands adjacent to the valley system, which are protected by the Town of Ajax (Ajax 2015) and City of Pickering Official Plans (Pickering 2018) as Environmental Protection Areas and Natural Areas respectively. These are located downstream and not within the Project Study Area.

FIGURE 3-3: ENVIRONMENTALLY SIGNIFICANT AREAS ADJACENT TO THE PROJECT STUDY AREA



3.3.9 AIR QUALITY

The Project Study Area is located within the Greater Toronto Area and is expected to experience similar air quality conditions as the City of Toronto, which is the closest analogous area with air quality monitoring stations.

In 2015, in partnership with Environment Canada, The Ministry of Environment, Conservation and Parks (MECP) adopted the Air Quality Health Index (AQHI) to report air quality in Ontario. The AQHI is a new approach to communicating about air quality that offers more protective health information and represents the immediate health risk of combined effects of the air pollution (smog) mixture (MECP 2019).

The AQHI communicates four primary elements (MECP 2019):

- Measures the air quality in relation to health risk to people on a scale of 1 to 10. The higher the number, the greater the health risk associated with the air quality. When the amount of air pollution is high, the number is reported as 10+.
- Assigns a category that describes the level of health risk associated with the index reading (e.g. Low, Moderate, High, or Very High Health Risk).
- Provides health messages customized to each category for both the general population and 'at risk' population.
- Shows current hourly AQHI readings and maximum forecast values for the current day, current night and next day.

The formula developed to calculate the AQHI is based on research conducted by Health Canada using health and air quality data collected in major cities across Canada (MECP 2019).

The AQHI represents the relative risk of a mixture of common air pollutants which are known to harm human health. Three pollutants were chosen as indicators of overall outdoor air mixture (MECP 2019):

- Ground Level Ozone
- Fine Particulate Matter
- Nitrogen Dioxide

The AQHI is measured on a scale ranging from 1 to 10+

- 1-3 = Low health risk.
- 4-6 = Moderate health risk.
- 7-10 = High health risk
- Above 10 = very high health risk.

In areas of Ontario where there are more than one AQHI monitoring stations, Environment Canada reports and forecasts a community value. This value is produced by averaging information from the air monitoring stations in the local area. For example, Environment Canada's Toronto community value is based on averaging the Toronto Downtown, Toronto East, Toronto North and Toronto West monitoring stations. Ontario reports the AQHI values for each station and adopts the community forecast provided by Environment Canada. Average monthly data indicates that the AQHI for the Toronto community ranges from approximately 2 to 3.5 (low to moderate health risk). Monthly maximums are typically greater than 4 (moderate health risk), with some values reaching 7 (high health risk).

3.3.10 AGRICULTURAL TILE OR SURFACE DRAINS

There are no agricultural tile or surface drains within the Project or Direct Environmental Study Areas.

3.3.11 NOISE LEVELS AND VIBRATIONS

Noise and vibrations within the Project and Direct Environmental Study Areas are typical of an urban environment. Local sources of noise and vibration are generated from various sources including:

- Traffic on local residential streets, arterial roads, and Highway 401.
- Periodic maintenance work including street sweeping, trail maintenance and grass cutting.
- Periodic general construction related activities within the Project Study Area.

3.3.12 HIGH/STORM WATER FLOW REGIME

The Project Study Area is within the Duffins Creek watershed and includes portions of the West Duffins Creek and the Lower Main Duffins sub watersheds (Figure 3-2). The Duffins Creek watershed has a drainage area of approximately 280 km^2 and extends from the Oak Ridges Moraine to Lake Ontario.

A hydrologic study of the watershed, entitled “2012 Duffins Creek Hydrology Update”, was completed in 2012 by Aquafor Beech. The results of that study were used to evaluate hydraulic conditions in the Project Study Area, in a study entitled “MIKE Flood 1D-2D Model Development and Regulatory Floodplain Mapping Pickering/Ajax SPA” (Valdor Engineering Inc, 2018a). As part of the hydrology update study, hydrographs for various recurrent events and for the Regional Storm flood were prepared using a hydrologic model of the watershed. Some of the hydrometric stations shown in Figure 3-4 were used for calibration of that model. The peak flows for Duffins Creek at the Kingston Rd W crossing (near Station 02HC006 in Figure 3-4) are shown in Table 3-1. The values in that table for flood events ranging from the 2-year to 100-year design storms and for the Regional Storm flood were obtained from the hydrologic report (Aquafor Beech, 2012), and the values for the 350-year and 500-year, from the hydraulic report prepared by Valdor (2018a). The numbers have been rounded to better reflect the precision of hydrologic models.

TABLE 3-1: ESTIMATED PEAK FLOWS FOR DUFFINS CREEK UP STREAM OF THE KINGSTON RD WEST CROSSING

Flood Even	Peak Flow (m^3/s)
	Duffins Creek Upstream of Kingston Rd W
2-Yr Storm	50
5-Yr Storm	80
10-Yr Storm	90
25-Yr Storm	120
50-Yr Storm	140

Flood Even	Peak Flow (m^3/s)
	Duffins Creek Upstream of Kingston Rd W
100-Yr Storm	160
350-Yr Storm	230
500-Yr Storm	250
Regional Storm	650

The values in this table correspond to flows at the crossing of Kingston Rd W over Duffins Creek. This location is referred to as Node 26.4 in Aquafor Beech (2012) and Valdor (2018a). The 2012 report provides flows for four different land use scenarios. The scenario referred to as "Existing Landuses (2012)" was used for this table, for events up to the 100-Yr Storm. The scenario referred to as "Future (Official Plan) Landuses" was used for the Regional Storm. These were the scenarios subsequently adopted in the 2018 report. In addition, the 2018 report includes flow values for the 350-yr and 500-Yr design storms. However, it does not provide the total flow at Node 26.4. Instead, it indicates "incremental flows" for the various input flow locations used in the hydraulic model prepared in that study. To complete Table 3-1, KGS Group estimated the total flows at Kingston Rd W (near Node 26.4) from those incremental flow values, in a way that matched the totals for other flood events. The values in Table 3-1 are all rounded to the nearest tenth.

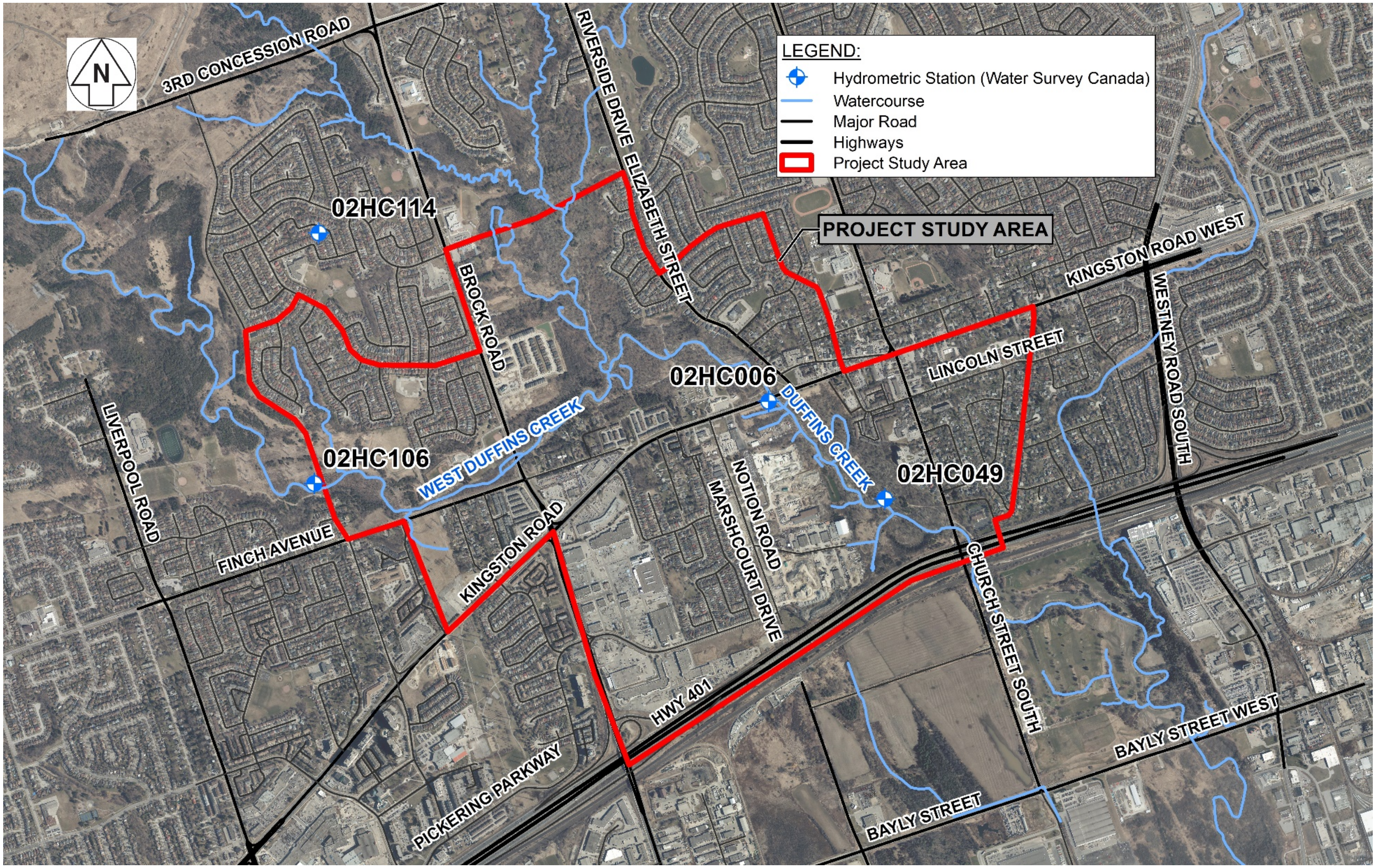
The most recent study of flood conditions in the Project Study Area is provided in Valdor (2018a). As part of that study the extent of flooding for the various flood events listed in Table 3-1 was obtained using a coupled 1D-2D hydraulic model prepared with the software MIKE Flood. The results from this study with regards to flooding conditions are discussed in Section 1.5.3.

3.3.13 LOW/BASE WATER FLOW REGIME

There are a number of flow gauges operated by Water Survey of Canada (WSC) in the Duffins Creek watershed. WSC Station 02HC006 was located at the Kingston Rd W crossing and collected flow data for 45 years from 1945 to 1989. It was replaced by WSC Station 02HV049, which is located at the Sea Lamprey barrier (weir) between Kingston Rd W and Church St South. This station has been in operation since 1989 and provides continuous flow and water level values.

The flow measurements from these two WSC stations are consistent and indicate low (base) flow values of approximately 1 m^3/s.

FIGURE 3-4: WATER SURVEY OF CANADA GAUGE LOCATIONS



3.3.14 EXISTING SURFACE DRAINAGE AND GROUNDWATER SEEPAGE

Duffins Creek and its main branches and tributaries (West and East Duffins Creek, Reesors Creek, Ganetsekiagon Creek, Urfe Creek, Brougham Creek, Mitchell Creek) flow from north to south. According to the 2018 Watershed Report Card (TRCA, 2018) the distribution of the land cover in the watershed is 42% natural, 40% rural and 18% urban, the urbanized areas are located in the southern portions of the watershed, near Lake Ontario and in the north west section of the Stouffville Creek subwatershed (Town of Stouffville). The Seaton development, which is in the final planning and design stages, will increase the amount of urban development in the watershed by a planned 70,000 people (Town of Pickering 2020). The urbanized portion of the watershed has separate sanitary and stormwater sewer systems.

3.3.14.1 Local Surface Drainage

Surface drainage from the dry side of the dykes is conveyed through the Pickering and Ajax Dykes under non-flood conditions via culverts and storm sewer lines. The location of the culverts and storm sewer lines within the Pickering and Ajax Dykes are provided in Appendix G.

Six culverts are located beneath the Pickering Dyke and one culvert is located beneath the Ajax Dyke. These culverts have flap gates that stop flood flow from the creek from passing through the culverts to the dry side of the dykes. Only surface water drainage from the dry side of the dykes can flow through the culverts. Surface water from the dry side of the dykes is directed by existing ditching to the culverts. These culverts are the most probable locations for groundwater seepage through the dyke and for foundation soils to collect or back-up during highwater events.

The 2018 Dyke Level of Service and Rehabilitation Report (Valdor 2018c), indicated that most of the thru-dyke culverts, at the time of the study, had obstructions impeding the proper operation of their flap gates, one culvert had a pipe separation and most culverts had accumulations of sediment and/or debris. TRCA has since addressed these deficiencies by cleaning and exercising the flap gates, repairing the observed pipe separation, and cleaning out accumulated sediment and debris from the culverts. At the time of the repairs, drainage improvements were made to an existing ditch that conveys runoff from the outlet of the culvert at the Ajax Dyke to Duffins Creek.

A discharge line for the sump of a private residence is also known to be present through the Pickering Dyke (Appendix G- Drawings 19-2939-003_SK09 and 19-2939-003_SK10). The pipe is not outfitted with any flap-gate, but it is understood that the pipe is outfitted with a backflow prevention mechanism. No issues with this line have been reported during high water events but further investigations are required to determine the nature of the backflow prevention mechanism and also to ensure that the resident is maintaining the backflow mechanism.

3.3.14.2 Local Groundwater Seepage

Groundwater conditions within the Direct Environmental Study Area were investigated as part of a Geotechnical Study conducted in 2019 by KGS Group (Appendix B). Four (4) standpipe piezometers installed as part of this geotechnical investigation as well as five (5) of the GeoPro Consulting Ltd. standpipe piezometers installed in 2017 were read at least once as part of this assignment between August 6th, 2019 and August 22nd, 2019 (Appendix B). Table 3-2 summarizes the groundwater monitoring results.

Groundwater monitoring results for the Pickering Dyke varied from elevation 79.1 to 82.0 with a gradient that is assumed to closely follow the hydraulic gradient of Duffin's Creek (i.e. in a north to south direction).

Groundwater monitoring results for the Ajax Dyke varied from elevation 76.5 to 77.5. No clear groundwater gradient is apparent in the recent readings due to an anomalously higher reading in BHA1, located between TH19A-01 and TH19A-02.

TABLE 3-2: PIEZOMETRIC MONITORING RESULTS

Dyke Name:	Ajax Dyke			Pickering Dyke					
TEST HOLE:	**THA19-01**	**BHA1**	**THA19-02**	**BHP1**	**BHP4**	**THP19-02**	**BHP6**	**BHP7**	**THP19-03**
Approximate Station:	0+160	0+100	0+060	1+030	0+890	0+825	0+745	0+585	0+280
Ground Elevation[(2)] (m):	81.00	81.25	81.00	84.50	84.00	83.75	83.75	83.50	81.25
Tip Elevation (m):	71.90	75.15	73.40	79.90	79.40	77.65	79.15	77.40	73.55
Monitoring Zone:	**Sand**	**Sandy Silt / Clayey Silt**	**Sand with Gravel**	**Sand and Gravel**	**Silty Sand / Silt Till**	**Clayey Silt Till**	**Sand and Gravel**	**Sand and Gravel**	**Sand with Gravel**
Date	**Groundwater Elevation**								
06-Aug-19				82.02	81.22		80.75	79.86	
07-Aug-19		77.45		82.00	81.25		80.75	80.00	
19-Aug-19	76.53		76.94						
22-Aug-19		77.37		82.02	81.35	81.33	80.73	79.86	79.10

Notes:

1. Standpipe piezometer at test hole BHA1, BHP1, BHP4, BHP6, BHP7 were installed by GeoProConsulting in 2017.
2. The ground elevations at all test holes are approximate and based on interpretation of the available topography survey (2017) and LiDAR (2015) provided by TRCA.
3. Tip elevation and groundwater elevation are relative to the recorded ground elevation.

Falling head tests were completed on the following monitoring wells:

- THA19-01 (Ajax Dyke)
- BHA1 (Ajax Dyke)

- THA19-02 (Ajax Dyke)
- BHP1 (Pickering Dyke)
- BHP4 (Pickering Dyke)
- THP19-02 (Pickering Dyke)
- BHP6 (Pickering Dyke)
- BHP7 (Pickering Dyke)
- THP19-03 (Pickering Dyke)

The falling head tests were completed according to the Hvorslev Slug-Test method. The standpipe piezometers selected for the falling head tests were chosen specifically because the screened length of the standpipe was completely saturated prior to the tests. The results of the falling head tests (i.e. the estimated saturated hydraulic conductivity – K_{sat}) are summarized in Table 3-3 and detailed test results are included in Appendix B.

The estimated K_{sat} value of one of the falling head tests (BHP4) could not be determined because the monitoring well could not be filled without immediately dissipating the excess head pressure. The high permeability in the underlying sand and gravel layers for the Pickering Dyke is based on the free draining conditions observed in BHP4.

TABLE 3-3: FALLING HEAD TEST RESULTS AND EXPECTED PERMEABILITY COMPARISON

Dyke	Test Hole Id (Monitoring Zone)	Station	Screen Depth Range (M)	Static Water Level Depth (M)	Falling Head Test K_{sat} (Cm/S)
Ajax Dyke	THA19-01 (Sand)	0+160	7.6 - 9.1	3.43	3.8E-04
	BHA1 (Sandy Silt / Clayey Silt)	0+100	4.6 - 6.1	3.65	2.0E-06
	THA19-02 (Sand with Gravel)	0+060	4.6 - 6.1	3.84	7.7E-04
Pickering Dyke	BHP1 (Sand and Gravel)	1+030	3.1 - 4.6	2.33	3.8E-03
	BHP4 Silty Sand / Silt Till)	0+890	3.1 - 4.6	2.49	N/A
	THP19-02 (Clayey Silt Till)	0+825	4.6 - 6.1	2.21	5.5E-04
	BHP6 (Sand and Gravel)	0+745	3.1 - 4.6	2.94	2.7E-03

Dyke	Test Hole Id (Monitoring Zone)	Station	Screen Depth Range (M)	Static Water Level Depth (M)	Falling Head Test K_{sat} (Cm/S)
	BHP7 (Sand and Gravel)	0+585	4.6 - 6.1	3.47	4.8E-04
	THP19-03 (Sand with Gravel)	0+280	6.1 - 7.6	1.99	2.8E-03

3.3.15 GROUNDWATER RECHARGE/DISCHARGE ZONES

Groundwater recharge occurs over most of the area of the Duffins Creek Watershed (Figure 3-2) excluding stream reaches and areas of increased topographic gradients associated with the south slope of the Oak Ridges Moraine and Lake Iroquois shoreline (TRCA 2003). Approximately 25 to 30 percent of the total annual precipitation recharges the groundwater flow system (TRCA 2003).

The Project Study Area is located within the southern part of the Duffins Creek Watershed south of the Lake Iroquois Shoreline. In this area groundwater flow from the deeper aquifer system is vertically upwards coincident with groundwater discharge from these aquifer systems to the river network (TRCA 2003). Local groundwater flow within the Direct Environmental Study Area is expected to discharge to Duffins Creek and West Duffins Creek.

3.3.15.1 Groundwater Use

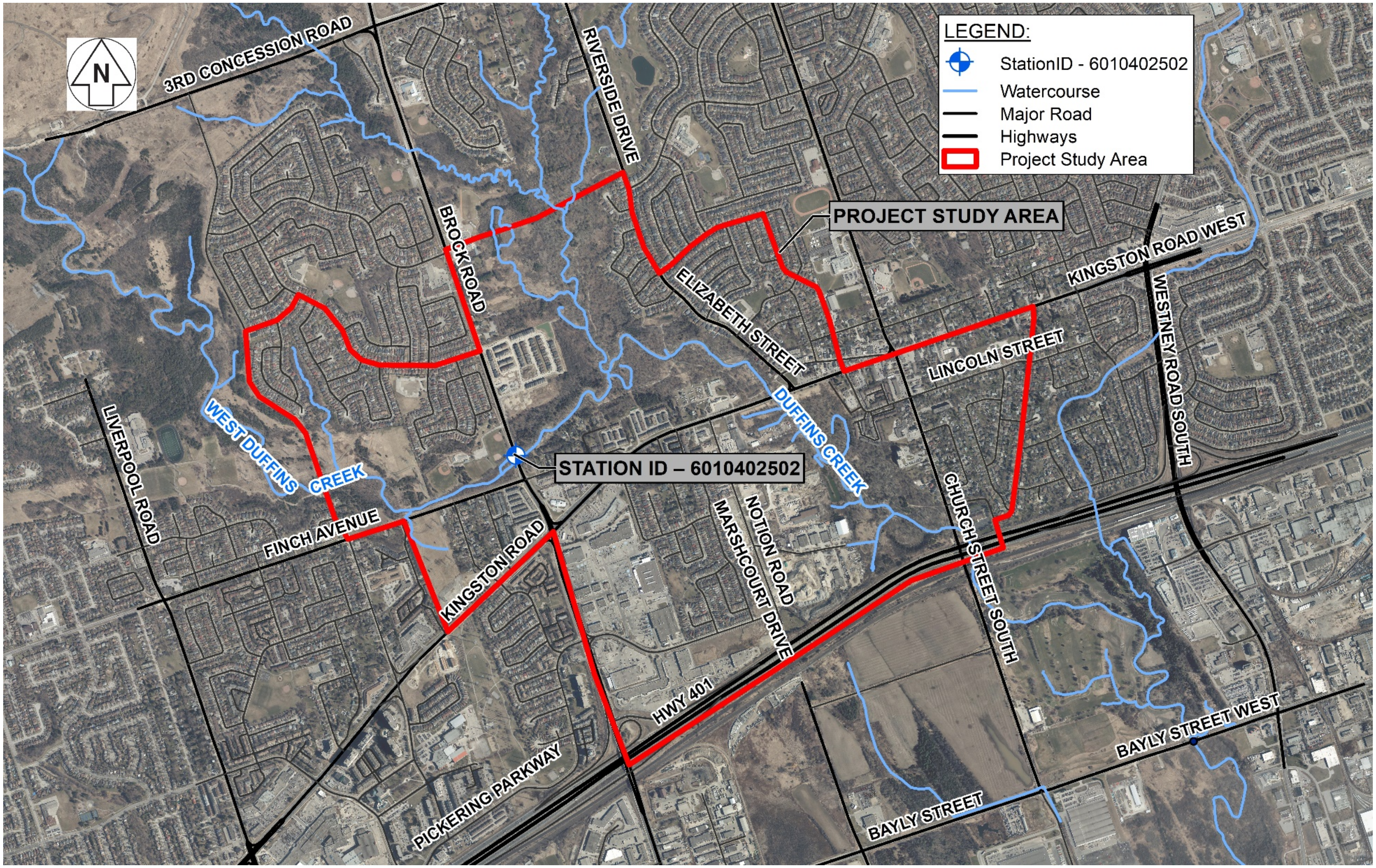
Groundwater within the Project Study Area is generally not utilized for domestic or potable use, as water is municipally supplied by the Region of Durham. However, some residences in the area have utilized groundwater for domestic use. Presently there is a dug well located at 1760 Blue Bird Cres. Based on information provided by the homeowner, the well may have been constructed as early as 1967. The well is 0.76 m in diameter, and approximately 4.5 to 6.0 m in depth. The static groundwater level ranges from approximately 2.7 to 4.2 m below ground surface. Water from the well is used for domestic purposes but not as a potable supply. There have been historic issues with both water quality and quantity.

3.3.16 WATER QUALITY

Surface water quality within the Duffins Creek Watershed is among the highest in the Toronto Region, and has been graded as “C” or “Fair” according to the provincially scaled scoring system (TRCA 2018). The West and Lower Main Duffins sub watersheds received a “C” or “Fair” rating (TRCA 2018).

The TRCA monitors water quality in Duffins Creek at several locations. The monitoring location closest to the Project Study Area is on the west arm of Duffins Creek at the bridge on Brock Road (Station ID – 6010402502) (TRCA 2019a) Figure 3-5.

FIGURE 3-5: WATER QUALITY MONITORING STATION LOCATION



General parameters monitored include nutrients, metals and inorganics and general water quality parameters (TRCA 2019b). Table 3-4 provides the most recent data from TRCA's Open Data site for typical water quality indicator parameters.

TABLE 3-4: 2015 -2016 WATER QUALITY INDICATOR PARAMETERS – DUFFINS CREEK

Month	Parameter							
	Conductivity µs/Cm	Total Kedjal Nitrogen (Mg/L)	Dissolved Oxygen (Mg/L)	Ph	Total Phosphorous (Mg/L)	Total Dissolved Solids (Mg/L)	Temperature (°C)	Turbidity (N.T.U.)
2015								
January	725	0.56	24.95	8.2	0.13	462	0.02	4.13
February	672	0.36	21.49	8.2	0.02	403	0	6.72
March	720	0.75	-	8.2	0.06	437	0	10.6
April	518	2.12	15.93	8.0	0.81	633	6	1230
May	586	0.37	14.79	8.4	0.018	369	18	3.62
Jun	630	0.33	12.56	8.5	0.013	377	21	2.3
July	597	0.53	7.14	8.4	0.013	352	23	2.76
August	563	0.31	9.48	8.4	0.022	355	24	7.41
September	565	0.35	10.9	8.4	0.02	364	14	7.32
October	592	0.32	14.27	8.5	0.11	334	5.2	1.77
November	682	0.29	15.15	8.5	0.01	414	1.2	1.74
December	647	0.29	13.29	8.5	0.01	368	6.7	1.32
2016								
January	813	0.46	14.5	8.3	0.011	482	0	3.17
February	783	0.20	13.5	8.3	0.22	490	-0.06	3.32
March	631	1.72	12.6	8.4	0.96	372	4.32	721
April	672	0.40	11.9	8.5	0.015	389	11.6	2.6
May	666	0.63	16.8	8.5	0.01	400	9.8	1.75

Month	Parameter							
	Conductivity µs/Cm	Total Kedjal Nitrogen (Mg/L)	Dissolved Oxygen (Mg/L)	Ph	Total Phosphorous (Mg/L)	Total Dissolved Solids (Mg/L)	Temperature (°C)	Turbidity (N.T.U.)
Jun	563	0.34	-	8.4	0.015	335	23.4	2.77
July	494	0.32	9.56	8.4	0.01	315	25	3.28
August	525	0.43	12.16	8.4	0.023	331	20.1	4.8
September	500	0.39	12.15	8.4	0.016	305	19.5	5.53
October	561	0.27	10.6	8.4	0.015	348	13.2	3.38
November	603	0.34	15.26	8.4	0.014	371	1.3	1.44
December	826	0.31	14.6	8.3	0.01	476	-0.4	3.98

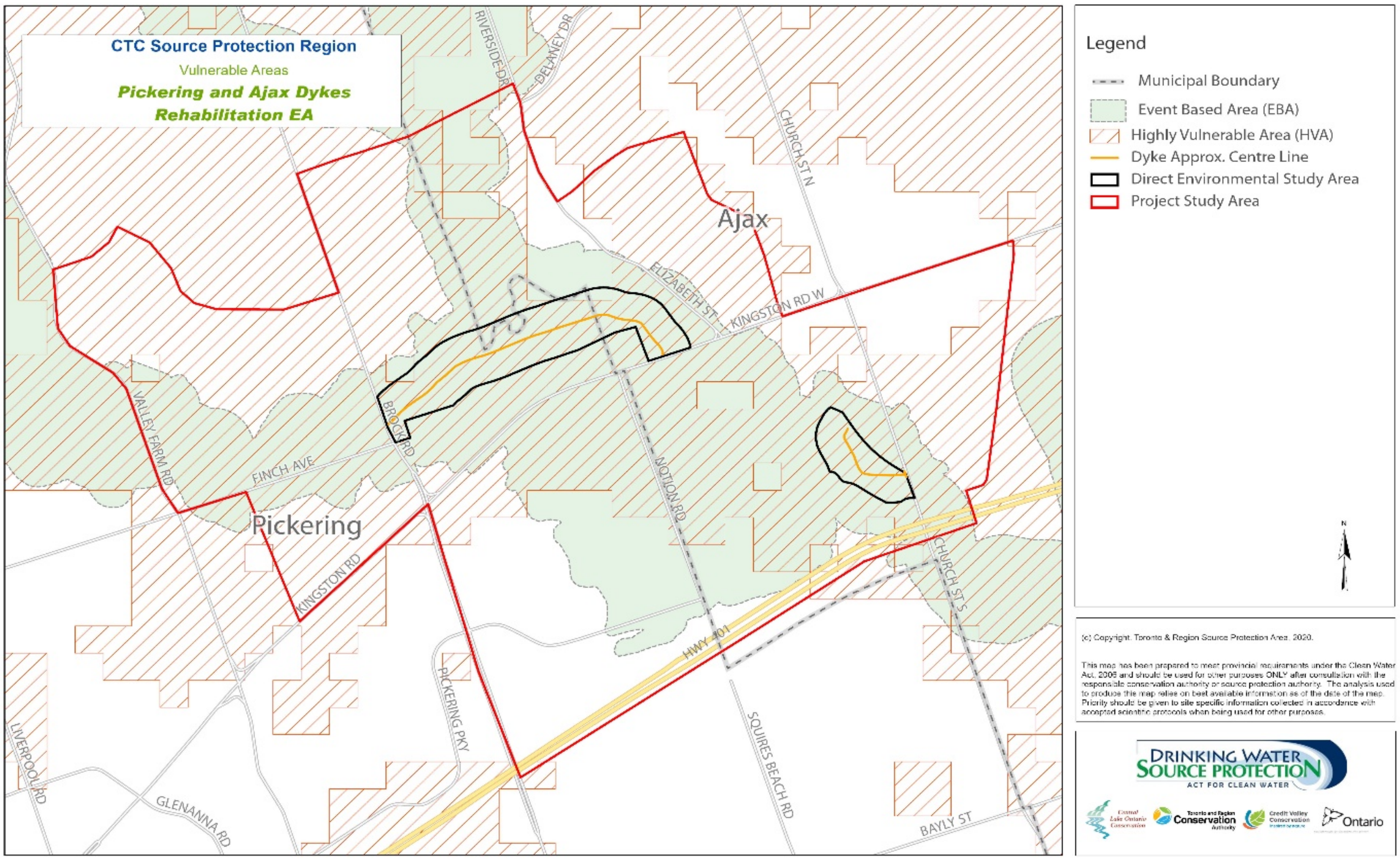
The TRCA has noted that chloride concentrations have been increasing over time (TRCA 2018). Chloride from road salt and elevated chloride concentrations can harm aquatic life.

3.3.17 FALLS WITHIN VULBERABLE AREA AS DEFINED BY THE CLEAN WATER ACT

The Project Study Area falls within the boundaries of the Toronto and Region Source Protection Area. Two distinct vulnerable areas under the *Clean Water Act, 2006* are transected by the project area (Figure 3-6). The project area transects the Event-Based Area for the Ajax Drinking Water System. An Event Based Area (EBA) is delineated if numerical modelling demonstrates that a spill from a specific activity may be transported to an intake and represents an activity that poses a significant threat to drinking water. Since the primary objective of this project is to provide long-term protection against riverine flooding, none of the activities expected to be carried out during the length of the completion of this project would result in a significant drinking water threat. Therefore, no policies in the Credit Valley – Toronto and Region – Central Lake Ontario (CTC) Source Protection Plan (SPP) would apply.

The second vulnerable area through which this project area transects is a highly vulnerable aquifer (HVA). An HVA can be easily changed or affected by contamination from both human activities and human process as a result of its intrinsic susceptibility (as a function of the thickness and permeability of overlaying layers), or by preferential pathways to the aquifer. Only moderate and low drinking water threats can occur within an HVA. Moderate and low threat policies in the CTC SPP only address three different prescribed threats as outlined in Ontario Regulation 287/07 under the *Clean Water Act, 2006.* None of these activities are expected to take place during the length of this rehabilitation of the Pickering and Ajax Flood Control Dykes, therefore, no policies in the CTC SPP apply to this undertaking.

FIGURE 3-6: TORONTO AND REGION SOURCE WATER PROTECTION AREA- PROJECT STUDY AREA RELATIVE TO VULNERABLE AREAS



3.3.18 LITORAL DRIFT

Littoral drift is not applicable to the Project Study Area.

3.3.19 OTHER COASTAL PROCESS

Coastal process are not applicable to the Project Study Area.

3.3.20 SOIL/FILL QUALITY

A soil quality sampling program was completed as part of the Geotechnical Investigation (Appendix B). Composite soil samples were collected from test holes THP19-01, THP19-02, THP19-05 and THP19-06 on the Pickering Dyke and test holes THA-01 and THA-02 on the Ajax Dyke. Test hole locations are shown on Figures GR-01 and GR-02 and observations made at the time of drilling are provided on the stratigraphic logs provided within the Geotechnical Report (Appendix B). Observation made at the time of drilling showed no visual (hydrocarbon staining) or olfactory (hydrocarbon odour) evidence of soil contamination.

All soil samples were provided under chain of custody to AGAT Laboratory in Mississauga Ontario. The samples were submitted for toxicity characteristic leaching procedure (TCLP) for inorganic and metal parameters as per Ontario Regulation 558.

Table 3-5 provides a summary of the results as compared to O.Reg 558 Schedule 4 Leachate Quality Criteria.

TABLE 3-5: TCLP RESULTS SOIL

Leachate Parameter	Laboratory Results (Mg/L)						O. Reg. 558 – Schedule 4 Leachate Quality Criteria
	THA-01	THA-02	THP-01	THP-02	THP-05	HPP-06	
Arsenic	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	2.5
Barium	0.74	0.688	0.623	0.611	0.675	0.688	100
Boron	0.053	<0.05	0.059	0.05	0.06	0.067	500
Cadmium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.5
Chromium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	5
Lead	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	5
Mercury	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.1
Selenium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1
Silver	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	5

Leachate Parameter	Laboratory Results (Mg/L)						O. Reg. 558 – Schedule 4 Leachate Quality Criteria
	THA-01	THA-02	THP-01	THP-02	THP-05	HPP-06	
Uranium	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	10
Fluoride	0.21	0.21	0.13	0.17	0.09	0.16	150
Cyanide	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	20
Nitrate+Nitrite as N	<0.70	<0.70	<0.70	<0.70	<0.70	<0.70	1000

TCLP is a chemical analysis process used to determine whether there are hazardous elements present in a material, in this case soil. The test involves a simulation of leaching through a landfill and can provide a rating that can prove if the soil is leachate toxic. Leachate toxic means producing leachate containing any of the contaminants listed in Schedule 4 of O.Reg 588 at a concentration equal to or in excess of the concentration specified for that contaminant in Schedule 4 using the TCLP Method 1311 that appears in the United States Environmental Protection Agency Publication SW-846 entitled "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods", as amended from time to time, or an equivalent test method approved by the Ministry of Environment Conservation and Parks.

All TCLP results were below their respective O.Reg 588 Schedule 4 criteria, with most below reported detection limits, indicating that soils sampled from the Pickering and Ajax are not leachate toxic.

3.3.21 CONTAMINATED SOILS/SEDIMENTS/SEEPS

Contamination of soil within urban settings may occur from activities related to waste disposal areas, raw material and petroleum hydrocarbon storage, automotive repair and service stations, chronic or acute spillage of petroleum hydrocarbons, solvents or other anthropogenic substances. Within the Project Study Area there are two gas stations, three auto repair facilities and five dry cleaners.

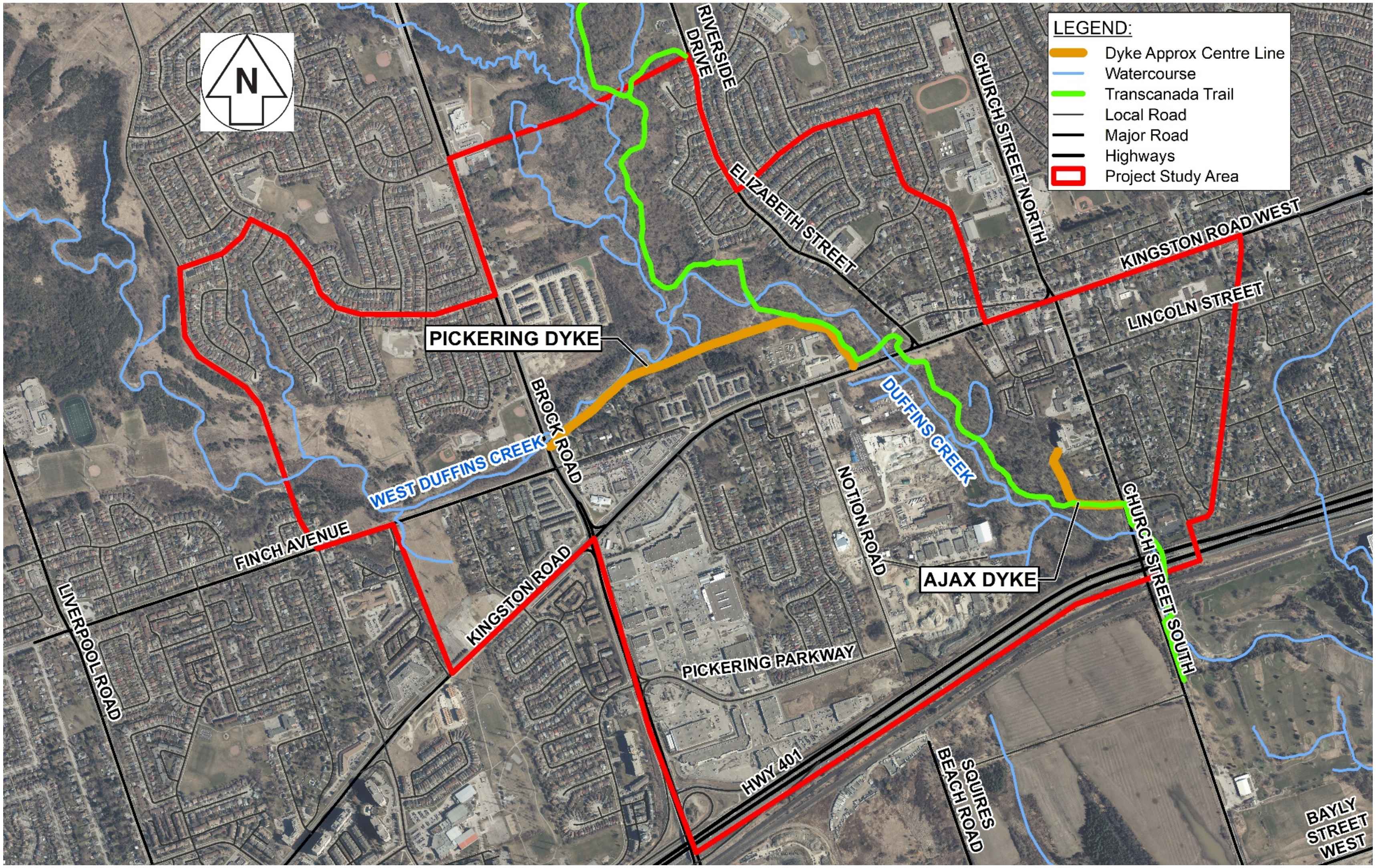
Investigations conducted within the Direct Environmental Study Area in 2018 (refer to section 3.3.16 and Appendix B) did not show the presence of contaminated soils within the areas of the Pickering and Ajax Dykes investigated.

3.3.22 EXISTING TRANSPORTATION ROUTES

Existing transportation routes within the Project Study Area are shown on Figure 3-7. Transportation routes include:

- Duffins Trail/Trans Canada Trail System
- Local / Residential Roadways
- Major Roadways/Arterials (Finch Av., Brock Rd, Kingston Rd. West, Church St. South)
- Highways (Hwy. 401)

FIGURE 3-7: TRANSPORTATION ROUTES



3.3.23 CONSTRUCTED CROSSINGS

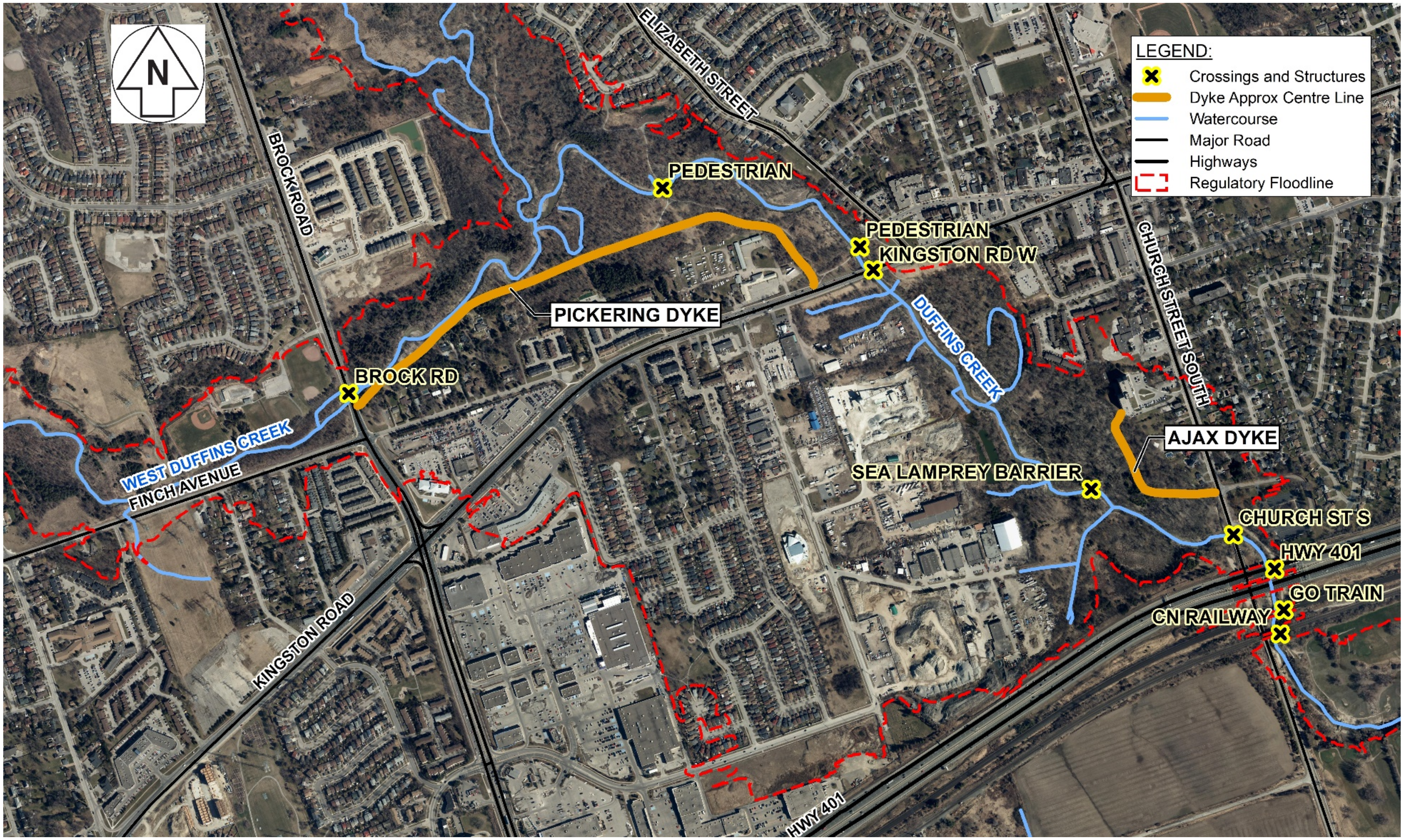
The following six crossings over the West Duffins Creek and Duffins Creek are located in the Project Study Area:

- Concrete bridge at Brock Rd, with a maximum opening width of approximately 35 m and opening height of 3.2 m
- Steel pedestrian bridge approximately 1.1 km downstream of Brock Rd (distance along the creek alignment) and 550 m upstream of Kingston Rd W, with a maximum opening width of approximately 29 m and height of 3.0 m
  - There has been ongoing bank erosion occurring at this bridge's south abutment, that has continued over the course of the EA study. A significant storm in January of 2020 caused additional severe erosion at the bridge abutment. The erosion at the abutment has compromised the bridge, so that it has been closed for use. A separate project is being undertaken by the Town of Ajax to restore the bridge through erosion control and/or relocation of the bridge. Addressing erosion in the area of this bridge is not within the scope of the Dykes Rehabilitation EA project, which only considers erosion issues that could compromise the dykes. Since the bridge is located outside of the proposed construction area for the dykes rehabilitation works, the two projects (bridge and dyke rehabilitation) will not impact each other and can proceed independently. However, TRCA and the Town are in communication regarding the two projects to coordinate and find efficiencies where possible.
- Steel pedestrian bridge approximately 50 m upstream of Kingston Rd W, with a maximum opening width of approximately 44 m and height of 4.2 m
- Concrete bridge at Kingston Rd W, with a maximum opening width of approximately 60 m and opening height of 7.5 m
- Concrete bridge at Church St S, with a maximum opening width of approximately 40 m and opening height of 4.6 m
- Concrete bridges at Hwy 401 at the downstream end of the study area. This is a larger structure that spans approximately 150 m and has five rows of piers

There are also railway bridges located within 100 m downstream of Hwy 401 for the Go Transit and the CN Railway systems. These are large structures with approximate spans of 120 m and 70 m and with piers in the flood plain. The Valdor (2018c) study identified conveyance restrictions at these road and railway crossings and at their associated creek channel sections that come into play during large flood events such as the Regional Storm Flood.

There is also a weir that acts as a Sea Lamprey barrier, located approximately 340 m upstream of Church St S, within the study area. Figure 3-8 shows the locations of these structures.

FIGURE 3-8: CONSTRUCTED CROSSINGS AND STRUCTURES



3.3.24 GEOMORPHOLOGY

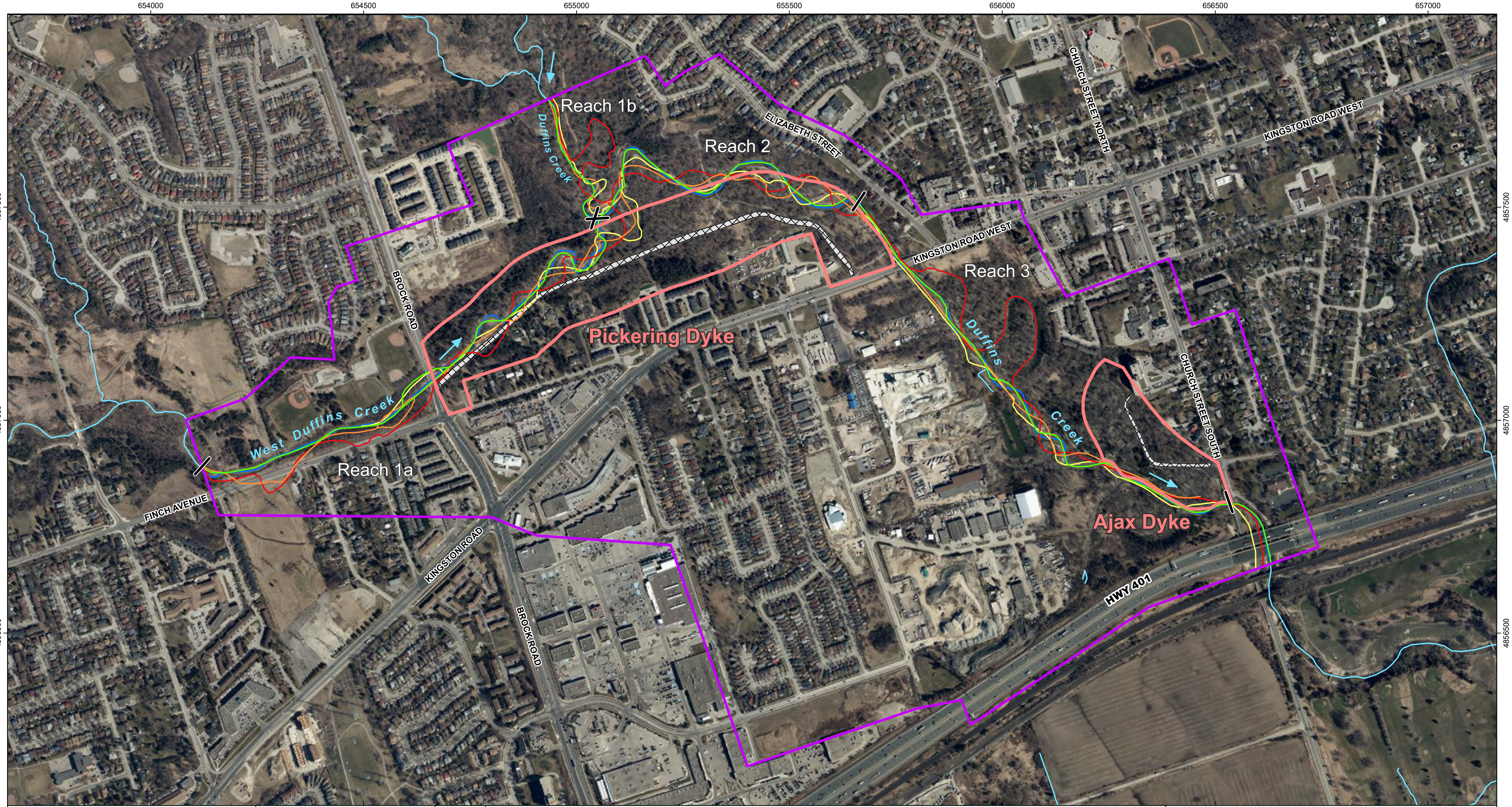
A fluvial geomorphology assessment of the Project Study Area was completed by Palmer Environmental Consulting Group Inc (PECG). The technical memo summarizing the geomorphology assessment is included in Appendix C. Rapid field assessments (RGA, RSAT) were completed and meander belt widths were established as part of a previous fluvial geomorphology assessment commissioned by TRCA (Geomorphic Solutions, 2009).

The fluvial geomorphology of the Duffins Creek watershed was assessed through a combination of desktop and field investigations. Background information sources for the study area were obtained, including TRCA's *A Watershed Plan for Duffins Creek and Carruthers Creek* (2003); existing Ontario Geological Survey surficial geology mapping (Ontario Geological Survey, 2010); and LiDAR-derived elevation data and 0.25 m contour topographic data provided by TRCA. Historic and recent aerial photography (1946, 1954, 1967, 1971, 1977, 1978, 1981, 1983, 1988, 1993, 2002, 2018) from TRCA and Google Earth (2002, 2004, 2007, 2009, 2013, 2015, 2016, 2017, 2018) was studied to characterize historical channel conditions and previous anthropogenic disturbances. This information also provided a basis for forecasting future channel adjustments within the Project Study Area.

Select historical aerial photography (1946, 1967, 1981, 1988, 2002, and 2009) were georeferenced to the 2018 ortho-imagery using standard georeferencing tools in ArcGIS. At least four control points were used in each case to optimize the spatial match within the study areas. Errors in the georeferenced historical imagery differ slightly across the images but generally do not exceed a few metres in comparison to the ortho-imagery. Channel thalwegs, which are typically the deepest portion of a channel, were approximated in order to support interpretations of patterns in bank erosion and meander dynamics. In the absence of channel bathymetry, the thalweg was inferred to be approximately mid-channel through riffles and near the outer bend of the channel through pools (typically asymmetric in cross-section). The location and morphology of gravel bars, fluvial terraces, and valley walls helped guide the delineation of the thalweg in each set of aerial photography and ortho-imagery. Where possible, the position of the channel thalweg in the most recent imagery at each site was calibrated using field photographs and mapping.

Field reconnaissance was completed on August 1, 2019 by PECG's Fluvial Geomorphologists. Flow conditions were slightly above baseflow due to 24 mm of cumulative precipitation over the four previous days as measured at the Oshawa Executive Airport. The purpose of the field reconnaissance was to examine patterns and processes of local erosion (with particular attention given to the two dykes), verify channel reach breaks and bankfull measurements, observe bed and bank materials, and ground truth aerial photograph-based interpretations.

The Project Study Area includes four distinct reaches of West Duffins Creek and Duffins Creek (Figure 3-9). Reach 1a (West Duffins Creek) extends from the upstream limit of historical channel realignment to the confluence with Duffins Creek. Reach 1a is gradually readopting a meandering planform but is confined to the south by Finch Avenue and the Pickering Dyke. Reach 1b (Duffins Creek) extends from the confluence with Urfe Creek downstream to the confluence with West Duffins Creek. Reach 2 extends from the Duffins Creek-West Duffins Creek confluence to the onset of the historical channel straightening upstream of Kingston Road. Reach 3 extends from just north of Kingston Road downstream to Church Street, where the watercourse transitions into a concrete-lined channel. Reach 3 has been straightened but is gradually readopting a meandering planform. The extents of the reaches are similar to the reaches established as part of the previous fluvial geomorphological assessment (Geomorphic Solutions, 2009). A description of channel morphology and erosional processes along each reach is provided in the subsections below. The location of meanders, referred to with the letter M and a consecutive number assigned from upstream to downstream, is shown in the Figures 3-10 and 3-11.



CLIENT: KGS GROUP

PREPARED BY: Palmer™

0 100 200 300
metres

PROJECT: Pickering-Ajax Dykes EA

PROJECT NO.	1903601	REVISION:	1
DATE:	Mar 24, 2020	SCALE:	1:8500
DRAWN:	BE	DATUM:	NAD 1983
CHECKED:	DM	PROJECTION:	UTM zone 17

LEGEND:

- Direct Study Area
- Indirect Study Area
- Dyke
- Watercourse
- Reach Break

Historical Channel

- 2018
- 2009
- 1981
- 1967
- 1946

NOTES:
(1) 1981 and 2002 channel delineation were excluded from figure for ease of interpretation.
(2) Study Areas determined by TRCA.
(3) Watercourses and dyke locations provided by TRCA.
(4) Base imagery (2018) provided by TRCA web map service.

Key Map

Geomorphology Study Areas and Reaches

Figure 3-9

Document Path: C:\Egnyte\Shared\Projects\Active\19036 - KGS Group\1903601 - Pickering-Ajax Dykes EA\Mapping\Figures\5_ArcGIS\Geomorphology\1903601_3-7-1_Study Area.mxd

3.3.24.1 Reach 1a

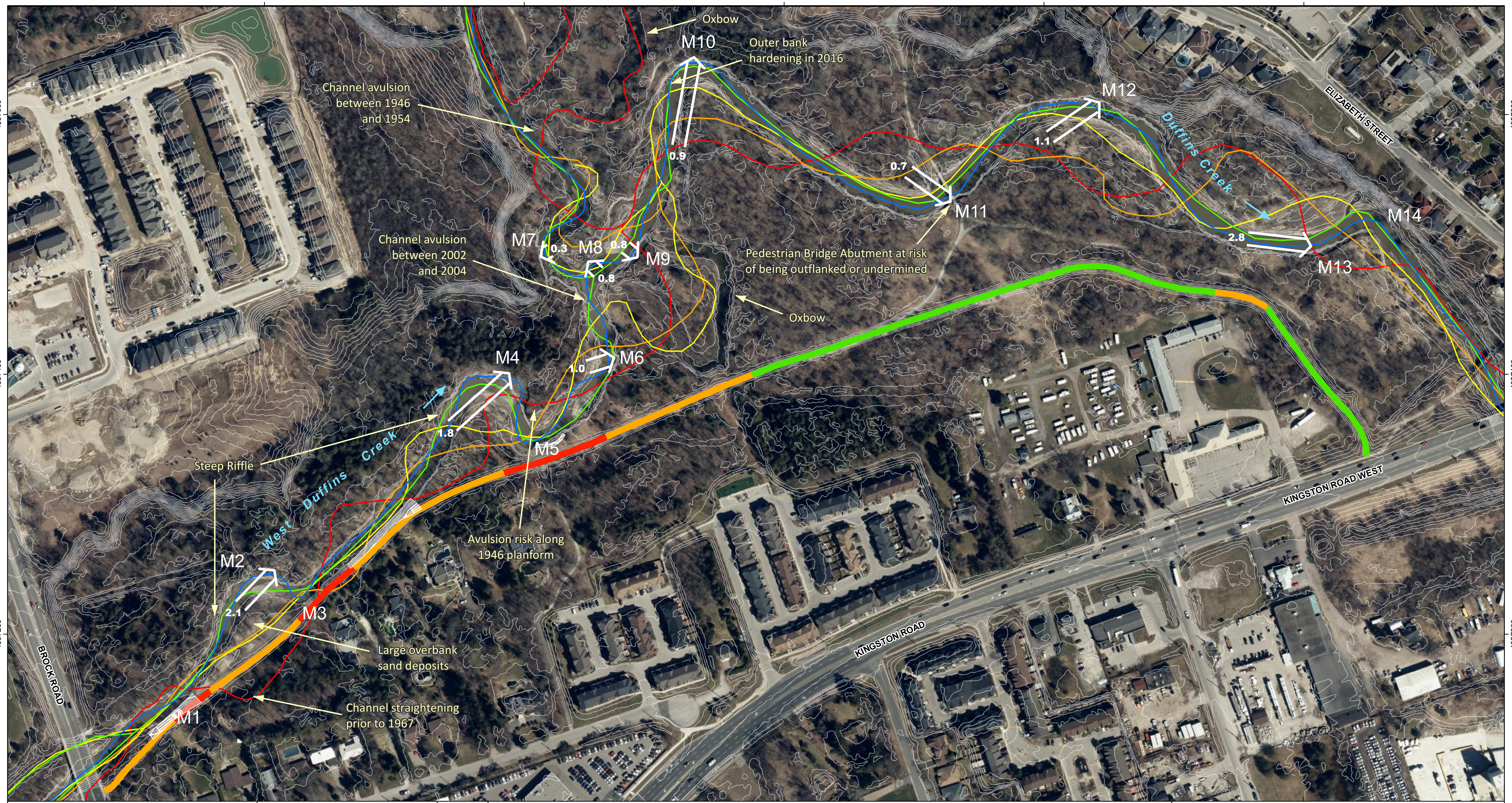
Reach 1a was realigned and straightened prior to 1988 to accommodate the widening and relocation of Finch Avenue, residential development to the south of West Duffins Creek, and the construction of the Pickering Dyke (Figure 3-9). The planform development is confined to the south by the Finch Avenue embankment and the Pickering Dyke. Reach 1a is readopting an irregular meander pattern. However, the existing meanders are undersized relative to undisturbed and unconfined meanders upstream of the reach or near the downstream extent of the reach (e.g. oxbow near the confluence with Duffins Creek). A large medial deposit upstream of Brock Road has bifurcated flow. Since 2009, most of the flow is conveyed along one channel through the south cell of the Brock Road crossing. Additionally, an avulsion between 2002 and 2004 led to the formation of an oxbow and shifted the confluence with Duffins Creek approximately 45 m upstream.

Upstream of Brock Road, the channel has a riffle-glide bed morphology. The previous straightening and associated bed and bank armouring have led to the formation of these steeper geomorphological units. Downstream of Brock Road, the channel has regained some sinuosity and re-established a pool-riffle bed morphology. Two prominent riffles (upstream of M2 and upstream of M4 (Figure 3-10) act as natural grade controls and strongly influence the upstream and downstream energy gradients. The formation of medial and lateral gravel bars and overbank sand deposits throughout the reach suggest the channel is likely aggrading, which corroborates the findings of the previous geomorphic assessment of the reach (Geomorphic Solutions, 2009)

Bankfull width and bankfull depth are approximately 17 m and 1.6 m, respectively (average based on spot measurements). The cross-sections in the glide and riffle units are nearly symmetrical. The pool units, which are situated near the apices of meanders, are asymmetrical. Two large gravel point bars have formed along the inner bank of M2 and M4. The lack of vegetation colonization and the accumulation of large wood atop these point bars suggest they are frequently wetted.

The channel banks are composed of alluvial sands, except where the banks have locally been hardened to prevent channel migration (i.e. near Brock Road crossing, M1, M3, M5 (Figure 3-10). Bed material in the riffles is mostly gravel and cobble. Some lag boulders and reworked riprap from localized erosion protection are present in the riffles. The coarser cobble particles in the riffles are commonly covered in aquatic lichens and mosses, indicating they have not been recently entrained. Bed material in pools is mostly fine gravels and coarse sands. Silty-textured glaciolacustrine sediments are present within an anomalously deep pool along the outer (north) bank of M4. Large sand deposits have formed (i.e. concave-bank benches) along the upstream limb where meanders are locally confined by the Pickering Dyke (M1, M3, M5).

Riparian vegetation is a mixture of young and mature deciduous trees and shrubs. Locally, the riparian areas have been cleared of vegetation between M1 and M3. Large wood is present throughout the reach. Significant accumulations of large wood were observed on the point bars at M2 and M4. Large wood embedded in the riffles upstream of the M2 and M4 stores sediment upstream and locally steepens the channel downstream. At M4, many large wood pieces had been cut with a chainsaw and discarded on the point bar.



CLIENT: **KGS GROUP**

PREPARED BY: **Palmer™**

0 25 50 75 100 metres

N

PROJECT: Pickering-Ajax Dykes EA

PROJECT NO.	1903601	REVISION:	2
DATE:	Mar 24, 2020	SCALE:	1:2800
DRAWN:	BE	DATUM:	NAD 1983
CHECKED:	DM	PROJECTION:	UTM zone 17

LEGEND:

Meander Migration Trajectory and Rate (m/yr)

Existing Riprap Protection

0.5 m Contour

Dyke Erosion Risk

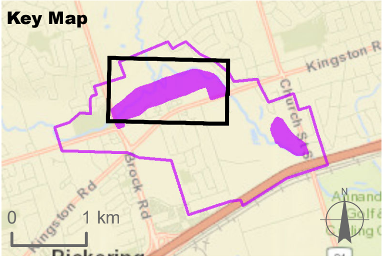
- Low
- Moderate
- High

Historical Channel

- 2018
- 2009
- 1988
- 1967
- 1946

NOTES:
(1) 1981 and 2002 channel delineation were excluded from figure for ease of interpretation.
(2) Base imagery (2018) provided by TRCA web map service.

Key Map



Dyke Erosion Risk: Pickering Dyke

Figure 3-10

Document Path: C:\Egnyte\Shared\Projects\Active\19036 - KGS Group\1903601 - Pickering-Ajax Dykes EA\Mapping\Figures\5_ArcGIS\Geomorphology\1903601_3-19-1_Pickering Dyke.mxd

3.3.24.2 Reach 1b

Reach 1b was straightened between 1946 and 1954 (Figure 3-9). A channel avulsion (perhaps anthropogenically induced) immediately upstream of M7 between 1946 and 1954 led to the formation of a large oxbow in the eastern floodplain. Other oxbows formed prior to 1946 are noted within the valley bottom. Since 1967, Reach 1b has readopted an irregular meandering planform. The reach is mostly unconfined, which has allowed it to readopt a sinuous planform more quickly relative to the partly confined Reach 1a.

Reach 1b has a defined pool-riffle bed morphology, with pools located near the apices of meanders. Small point bars and a medial gravel bar are present in the reach. Bankfull width and bankfull depth are approximately 16 m and 1.6 m, respectively. The cross-sections in the riffles are nearly symmetrical, whereas the pool units, which are situated near the apices of meanders, are asymmetrical. Localized overbank sand deposits suggest the channel has good connection to its floodplain.

The channel banks are composed of alluvial sands. Bed material in the riffles are mostly gravels and some cobble. Bed material in pools are mostly fine gravels and coarse sands. Bed material in Reach 1b is finer than that in Reach 1a. Riparian vegetation is a mixture of young and mature deciduous trees, coniferous trees, and shrubs. Large wood is present throughout the reach.

3.3.24.3 Reach 2

In the 1946 imagery, reach 2 appears to have been recently straightened (Figure 3-9). Removal of riparian vegetation led to over-widening. Since 1946, the reach has been mostly undisturbed and has re-adopted an irregular meandering pattern with large meander amplitudes relative to those along Reach 1a and Reach 1b. Reach 2 is unconfined, which has allowed the formation of the well-developed meanders. Meanders have migrated both laterally and longitudinally (i.e. down-valley). Systematic channel migration and extension of meander M10 has occurred over the entire period of photographic record. Migration was arrested in 2016 when the outer bank of the apex of M10 was armoured with boulders and woody debris to protect the nearby walking trail.

Reach 2 has a defined pool-riffle bed morphology, with pools located near meander apices. Large point, medial and lateral gravel bars are present throughout the reach. The large gravel deposits could be sourced from the channel avulsion that occurred near the West Duffins Creek-Duffins Creek confluence between 2002 and 2004. Some localized overbank sand deposits are present; however, the reach appears to be more entrenched than upstream reaches (i.e. floodplain is less accessible).

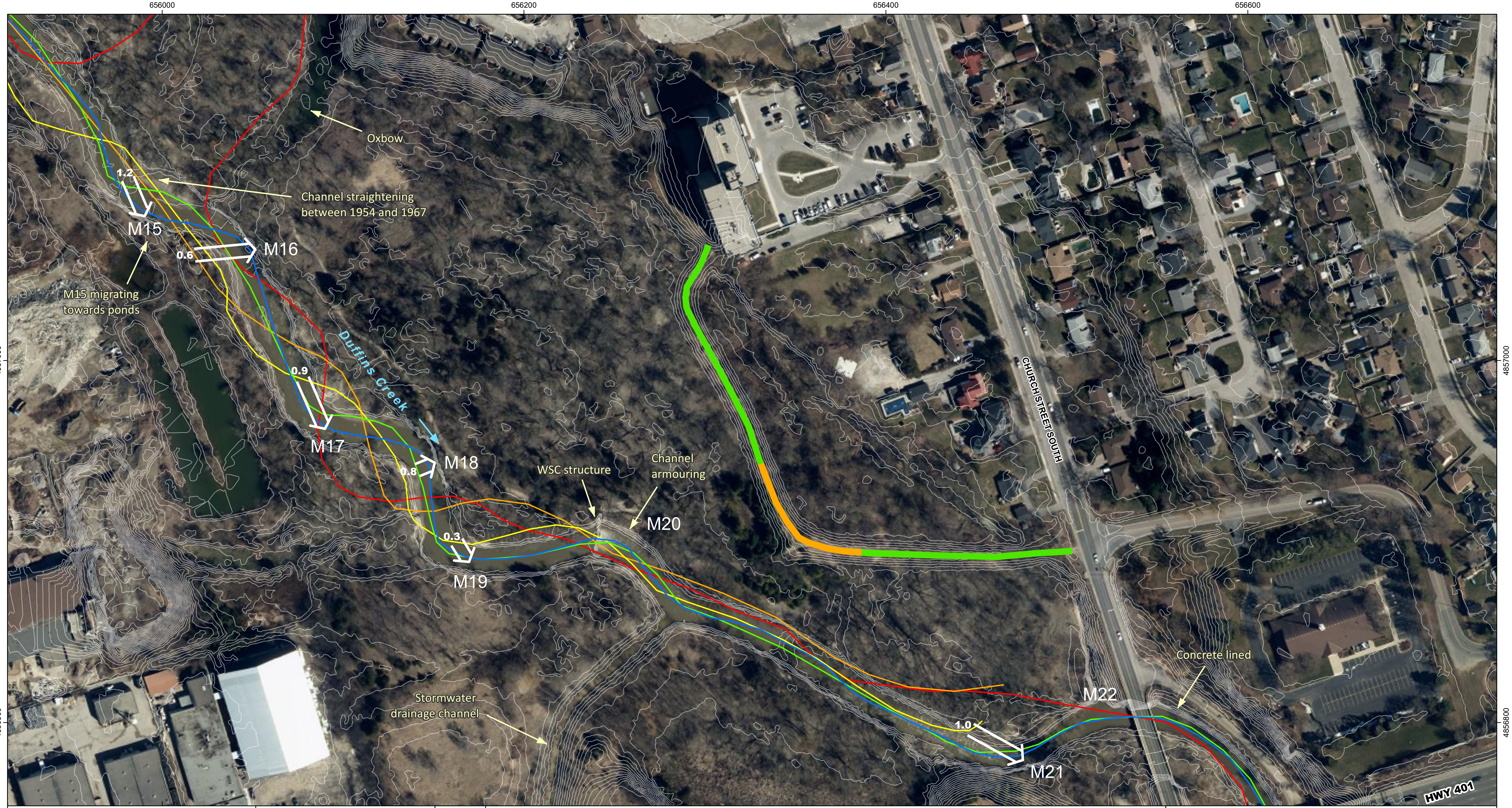
Bankfull width and bankfull depth are approximately 19 m and 1.9 m, respectively. The cross-sections in the riffles are nearly symmetrical, whereas the pool units, which are situated near the apices of meanders, are asymmetrical. The channel banks are mostly composed of alluvial sands. Ice-marginal glaciolacustrine sediments are present along the outer (south) bank at M11 (Figure 3-10). Bed material in the riffles are mostly gravel and cobble. The coarser cobble particles are commonly covered in aquatic lichens and mosses, indicating they have not been recently entrained. Bed material in pools is mostly fine gravels and coarse sands. Riparian vegetation is a mixture of young and mature deciduous trees, coniferous trees, and shrubs. Large wood is present along the channel periphery throughout the reach.

3.3.24.4 Reach 3

Prior to 1954, Reach 3 had an irregular meandering planform with large meander amplitudes relative to those along upstream reaches (Figure 3-9). Reach 3 was straightened between 1954 and 1967, which coincided with residential and industrial development along both sides of the channel. Since 1967, Reach 3 has been gradually readopting an irregular meander pattern. The channel is locally confined on the west in the mid to lower portions of the reach by industrial development and is locally confined on the east in the upper portion of the reach by residential development. This confinement has slowed meander development relative to the unconfined Reach 2. Downstream of Church Street South (i.e. downstream reach break) the channel is lined with concrete, which limits channel migration in the lower portion of Reach 3.

Reach 3 has a pool-run bed morphology, with pools located near apices of meanders. The overall gradient of the reach is less than that of the upper reaches. Point, medial and lateral sand and/or gravel bars are present throughout the reach. Sand has deposited along the toes of the banks throughout the reach. Some localized overbank sand deposits are present; however, the reach appears to be more entrenched than upstream reaches (i.e. floodplain is less accessible). A Water Survey of Canada (WSC) concrete structure at M20 (which is also a barrier to Sea Lamprey) is a grade control (Figure 3-11). Downstream of the WSC structure, the outer bank is armoured with a vegetated geo-cell wall. A grade control structure in the 1967 aerial photograph (i.e. soon after channel straightening) approximately 250 m downstream of Kingston Road is not observable in more recent imagery.

Bankfull width and bankfull depth are approximately 22 m and 2 m, respectively. The cross-sections in the runs are nearly symmetrical, whereas the pool units, which are situated near the apices of meanders, are asymmetrical. The channel banks are composed of alluvial sands and silts. Bed material in the runs is mostly gravel. Bed material in pools is mostly fine gravels and coarse sands. Riparian vegetation is a mixture of young and mature deciduous trees and shrubs. Large wood is present along the channel periphery throughout the reach.



CLIENT:

KGS GROUP

PREPARED BY:

Palmer™

0 20 40 60 80
metres

N

PROJECT:	Pickering-Ajax Dykes EA		
PROJECT NO.	1903601	REVISION:	1
DATE:	Mar 24, 2020	SCALE:	1:2000
DRAWN:	BE	DATUM:	NAD 1983
CHECKED:	DM	PROJECTION:	UTM zone 17

LEGEND:

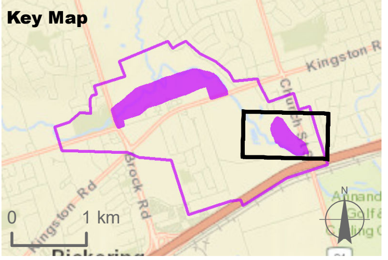
Meander Migration Trajectory and Rate (m/yr)

0.5 m Contour

Dyke Erosion Risk
- Low
- Moderate
- High

Historical Channel
- 2018
- 2009
- 1988
- 1967
- 1946

NOTES:
(1) 1981 and 2002 channel delineation were excluded from figure for ease of interpretation.
(2) Base imagery (2018) provided by TRCA web map service.



Dyke Erosion Risk: Ajax Dyke

Figure 3-11

Document Path: C:\Egnyte\Shared\Projects\Active\19036 - KGS Group\1903601 - Pickering-Ajax Dykes EA\Mapping\Figures\5_ArcGIS\Geomorphology\1903601_3-20-1_Ajax Dyke.mxd

3.3.25 LAKE SIMCOE WATERSHED

The Project Study Area is not located within the Lake Simcoe Watershed.

3.4 Biological

An ecological assessment of the Project Study Area and Direct Environmental Study Areas was completed by Palmer. The findings are summarized below, and further detail can be found in the technical memo in Appendix D. References cited in the following sections are also found in Appendix D.

3.4.1 METHODOLOGY

Background information on the natural environment along with mapping of designated natural areas and rare species was obtained from several sources:

- TRCA flora and fauna data for the Project Study Area;
- TRCA Ecological Land Classification data of the Direct Study Environmental Study Area;
- TRCA fisheries data obtained from their open data portal;
- Ontario Ministry of Natural Resources and Forestry's (MNRF) Make-a-Map online website;
- Aquatic species at risk (SAR) information obtained using Fisheries and Oceans Canada (DFO) online mapping tool and discussions with the Ontario Ministry of Environment, Conservation and Parks (MECP);
- The document *A Watershed Plan for Duffins and Carruthers Creek* (Toronto and Region Conservation Authority, 2003); and
- The document *Fisheries Management Plan for Duffins and Carruthers Creek* (TRCA, 2004).

This past spring (2019), the TRCA Environmental Monitoring and Data Management (EMDM) Group staff completed a biological inventory of the Project Study Area, collecting data for the following:

- Flora Species;
- Frogs and Nocturnal Spring Birds;
- Breeding Songbirds; and
- Aquatic habitat information for a portion of West Duffins Creek near the Pickering Dyke; and
- Vegetation Communities (Direct Environmental Study Areas only).

Information about the TRCA's data collection methods are available in Appendix A of the Natural Environment Existing Conditions Technical Memo prepared by Palmer (Appendix D). A butternut health assessment (BHA) was also completed by Palmer on August 12, 2019. The results of these surveys are demonstrated in the Figures contained within this section (Figures 3-12 to 3-17).

3.4.2 WILDLIFE HABITAT

3.4.2.1 General Wildlife Habitat

In the Project Study Area, the West Duffins and Duffins Creeks flow through a diversity of forested habitats, which also contain inclusions of beach bars along the creeks, and open habitats, small wetlands and oxbow ponds within the mix of deciduous and coniferous trees. This wide range of natural features provides habitats for mammals, herptiles, birds and invertebrates. West Duffins Creek joins Duffins Creek near the

Pickering Dyke, and Duffins Creek outlets into the Lower Duffins Creek Wetland Complex and the Duffins Creek Coastal Wetland, providing a connection between Lake Ontario and natural areas north of the Pickering/Ajax urban boundaries.

3.4.2.2 Significant Wildlife Habitat

Significant Wildlife Habitat (SWH) is considered a significant feature in Provincial, Regional, and Municipal policies, following implementation of the Provincial Policy Statement (Ontario Ministry of Municipal Affairs and Housing, 2014). Significant Wildlife Habitat (SWH) is defined by the MNRF in the Significant Wildlife Habitat Technical Guide (OMNR, 2000) and includes the following broad categories:

- seasonal concentration areas;
- rare vegetation communities or specialized habitats for wildlife;
- habitats of species of conservation concern, excluding the habitats of endangered and threatened species; and
- animal movement corridors.

Criteria for the identification of these features are also provided in the *Significant Wildlife Habitat Criteria Schedules for Ecoregion 6E* (Ontario Ministry of Natural Resources and Forestry, 2015). These criteria were used to screen wildlife habitat within the Project Study Area for potentially significant wildlife habitat.

Potential SWH present within the Project Study Area would be associated with the large forested blocks, and riparian corridors which function as a local landscape feature providing wildlife movement functions and connectivity between Lake Ontario and upstream habitats. The SWH criteria were reviewed, and the Project Study Area has potential to contain the following types of candidate habitat:

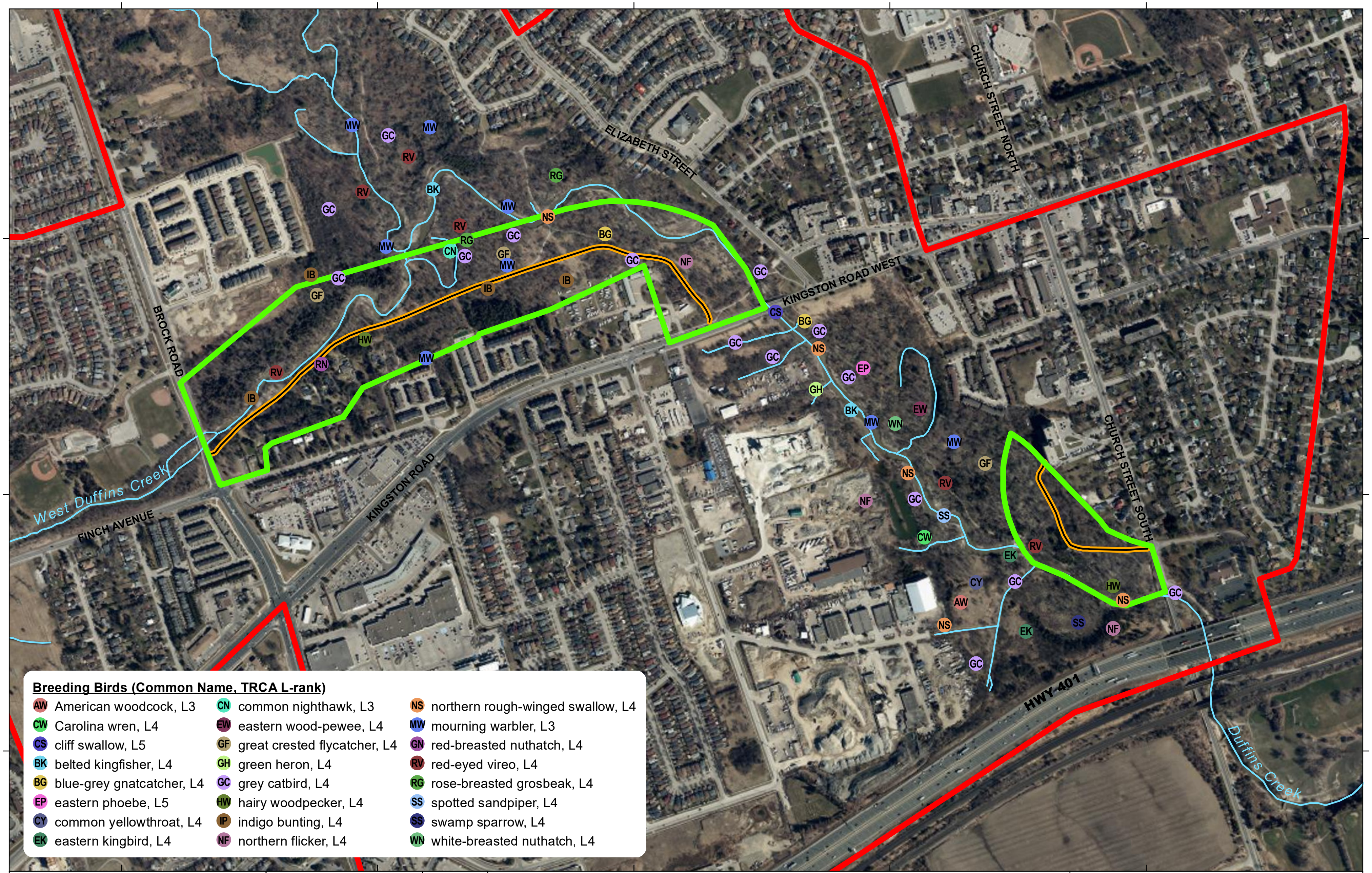
- **Raptor Wintering Area:** The forested creek corridors provide linkages to the open meadow communities to the north and may be attractive for birds of prey.
- **Bat Maternity Colonies:** Many of the forested areas contain large, older trees near a water source. Older trees tend to have features such as loose bark and cavities that may function as roost opportunities.
- **Turtle Wintering Areas:** The oxbow pond may provide still waters and loose gravel needed by turtles to hibernate.
- **Landbird Migratory Stopover Areas:** The Project Study Area is part of a large woodland within 5 km of Lake Ontario, with a variety of habitats.
- **Rare Vegetation Communities:** Fresh – Moist Black Walnut Lowland Deciduous Forest Type (FOD7-4), noted in the available Ecological Land Classification data to occur within the Direct Environmental Study Area, is ranked as S2S3 by the Natural Heritage Information Centre (NHIC) (Ministry of Natural Resources and Forestry, 2019).
- **Bald Eagle and Osprey Nesting, Foraging and Perching Habitat:** The Project Study Area includes tall trees available for perches, adjacent to a watercourse.
- **Amphibian Breeding Habitat (Woodland):** The oxbow pond provides an open water habitat >500 m^2 within a forested area. Frogs have been incidentally observed in the Project Study Area.

- **Special Concern and Rare Wildlife Species:** Snapping Turtle had previously been identified in the Project Study Area and the 2019 TRCA field surveys identified the presence of Eastern Wood-pewee (*Contopus virens*). Both species are classified as Special Concern under the Species at Risk in Ontario (SARO) list.

This assessment is based on the available data listed in section 3.5.1. The study team did not complete surveys to confirm the presence of SWH.

3.4.2.3 Habitat Linkages or Corridors

The West Duffins and Duffins Creeks are considered Urban River Valleys that connect the Greenbelt Plan area north of Pickering/Ajax to Lake Ontario. Due to the presence of water and a variety of treed habitats, these areas provide a wildlife corridor for a variety of species moving between these two areas (Figures 3-12 and 3-13).

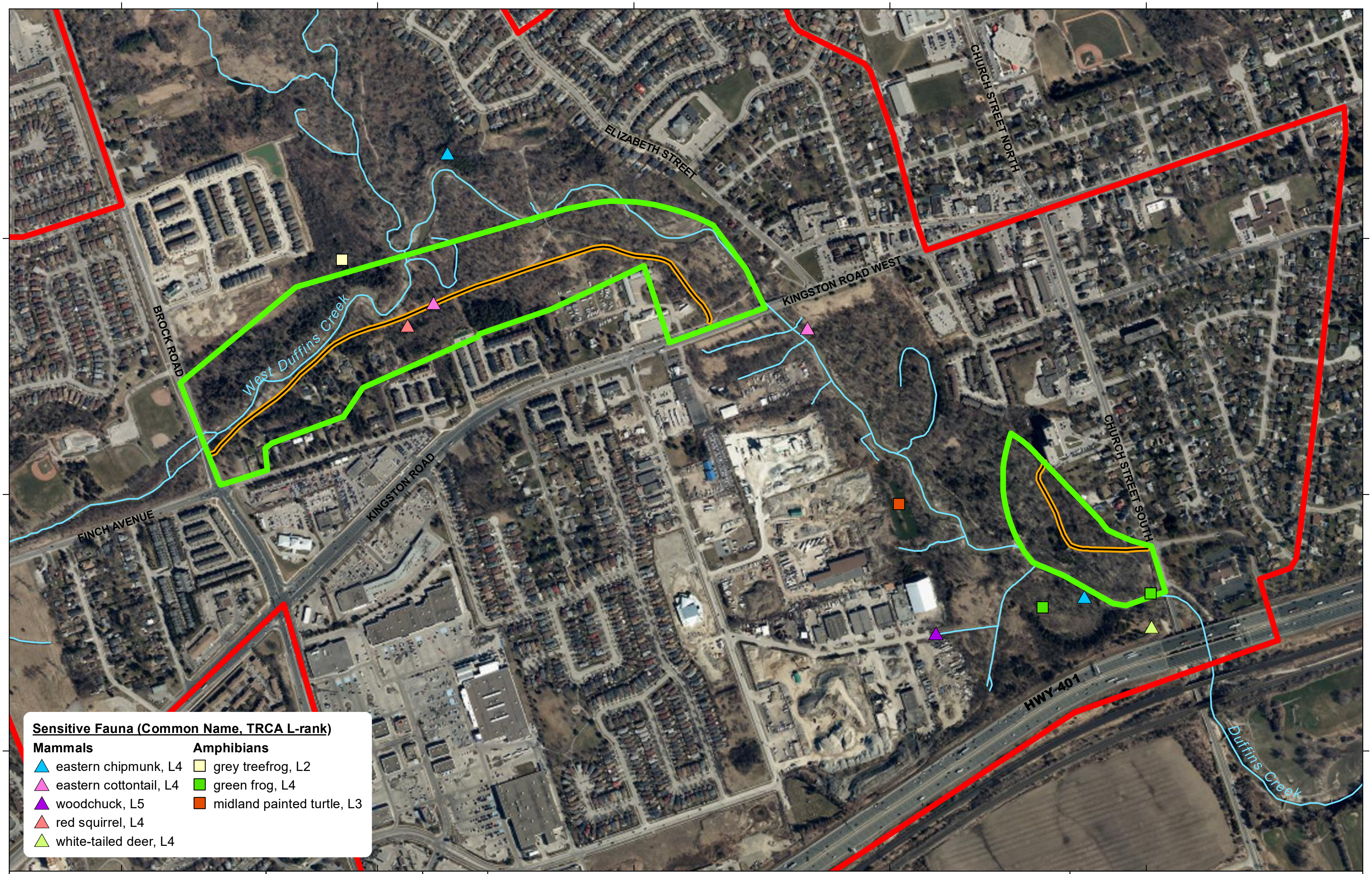


CLIENT: KGS Group	0 50 100 150 200 metres	LEGEND:	TITLE:
PROJECT: Pickering-Ajax Dykes EA		Project Study Area	**Terrestrial Resources – Breeding Birds**
PREPARED BY: Palmer	PROJECT NO. 1903601	REVISION: 1-2	
	DATE: Mar 23, 2020	SCALE: 1:10000	
	DRAWN: BE	DATUM: NAD 1983	
	CHECKED: AA	PROJECTION: UTM zone 17	**Figure 3-12**

LEGEND:
- Project Study Area
- Direct Study Area
- Dyke Centre Line (Approx.)
- Watercourse (TRCA)

Imagery (2018) provided by TRCA

Document Path: C:\Egnyte\Shared\Projects\Active\19036 - KGS Group\1903601 - Pickering-Ajax Dykes EA\Mapping\Figures\5_ArcGIS\Ecology\1903601_6-1-1_Terrestrial Breeding Birds.mxd



CLIENT:	KGS Group
PROJECT:	Pickering-Ajax Dykes EA
PREPARED BY:	Palmer™

0 50 100 150 200
metres

N

PROJECT NO.	1903601	REVISION:	1-3
DATE:	Mar 23, 2020	SCALE:	1:10000
DRAWN:	BE	DATUM:	NAD 1983
CHECKED:	AA	PROJECTION:	UTM zone 17

LEGEND:

- Project Study Area
- Direct Study Area
- Dyke Centre Line (Approx.)
- Watercourse (TRCA)

Imagery (2018) provided by TRCA

TITLE:

Terrestrial Resources – Sensitive Fauna

Figure 3-13

Document Path: C:\Egnyte\Shared\Projects\Active\19036 - KGS Group\1903601 - Pickering-Ajax Dykes EA\Mapping\Figures\5_ArcGIS\Ecology\1903601_7-1-1_Terrestrial Sensitive Fauna.mxd

3.4.3 SIGNIFICANT VEGETATION COMMUNITIES

3.4.3.1 General Vegetation Communities

Ecological Land Classification (ELC) mapping provided by TRCA has been compiled and mapped for the Direct Environmental Study Area and is presented in Figures 3-14 and 3-15. The ELC classification is based on the *Ecological Land Classification for Southern Ontario* (Lee, et al., 1998); however, some codes have been altered to describe site-specific conditions (e.g. CUT1-c, refer to Figures 3-14 and 3-15 for the definition of each code noted herein).

The Pickering Dyke is surrounded by a mix of deciduous forest (e.g. FOD7, FOD8) and culturally modified but re-naturalizing communities (e.g. CUP, CUT, CUW), particularly on the south side of the dyke. This is reflective of the observed conditions, where forested communities contain large trees and natural species compositions, yet a certain degree of cultural influences are seen within most communities. A beach bar (BBO) is found within a meander of West Duffins Creek, as is an isolated oxbow pond (OAO), both within 25 m of the north side of the Pickering Dyke.

The Ajax Dyke is also surrounded by deciduous forest, along with a small patch of deciduous swamp on the east side of the dyke. There is a high degree of visible cultural influence, as the dominant tree in the area is Manitoba Maple (FOD7-a, CUT1-b, CUW1-b), which is considered non-native in Ontario. A patch of planted coniferous trees stands out among the surrounding mainly deciduous landscape to the west side of the dyke.

3.4.3.2 Rare Vegetation Community

Of the ELC types mapped in the Direct Study Areas, the Fresh – Moist Black Walnut Lowland Deciduous Forest Type (FOD7-4) is ranked as S2S3 by the Natural Heritage Information Centre (NHIC) (Ministry of Natural Resources and Forestry, 2019). This community type is found north of Duffins Creek, on the opposite side of the creek from the Pickering Dyke. An S2S3 ranking shows that this community type is considered between “Imperiled” and “Vulnerable” in southern Ontario. For the FOD7-4 type, this is likely due to a limited habitat range, as it is largely associated with riparian habitats (Lee, et al., 1998), but also potentially from cultural influences.

3.4.3.3 Significant Woodlands

Following the Provincial Policy Statement (PPS), the Pickering and Ajax Official Plans define Significant Woodlands as “an area which is ecologically important in terms of features such as species composition, age of trees and stand history; functionally important due to its contribution to the broader landscape because of its location, size, or due to site quality, species composition, or past management history”. Criteria for determining significant woodlands are recommended by the Ministry of Natural Resources and Forestry (Ontario Ministry of Natural Resources, 2010), but an approach developed by a municipality that achieves or exceeds the same objective may also be used.

CLIENT: KGS Group

PROJECT: Pickering-Ajax Dykes EA

PREPARED BY: Palmer

0 25 50 75 100 metres

N

LEGEND:
- Direct Study Area
- ELC Community (TRCA)
- Dyke Centre Line (Approx.)

Imagery (2018) provided by TRCA

Key Map: Pickering, Ajax

PROJECT NO.	1903601	REVISION:	1-2
DATE:	Mar 24, 2020	SCALE:	1:4500
DRAWN:	BE	DATUM:	NAD 1983
CHECKED:	AA	PROJECTION:	UTM zone 17

TITLE:
Terrestrial Resources - Pickering Dyke Environmental Land Classification

Figure 3-14

Document Path: C:\Egnyte\Shared\Projects\Active\19036 - KGS Group\1903601 - Pickering-Ajax Dykes EA\Mapping\Figures\5_ArcGIS\Ecology\1903601_3-1-1_Terrestrial Pickering ELC.mxd

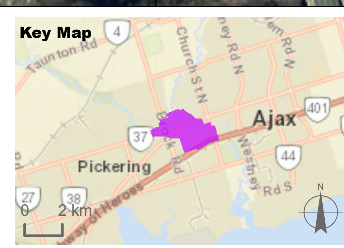
CLIENT:	KGS Group		
PROJECT:	Pickering-Ajax Dykes EA		
PREPARED BY:	Palmer		
PROJECT NO.	1903601	REVISION:	1-2
DATE:	Mar 24, 2020	SCALE:	1:2200
DRAWN:	BE	DATUM:	NAD 1983
CHECKED:	AA	PROJECTION:	UTM zone 17

0 10 20 30 40 50
metres

N

LEGEND:
- Direct Study Area
- ELC Community (TRCA)
- Dyke Centre Line (Approx.)

Imagery (2018) provided by TRCA



TITLE:
Terrestrial Resources - Ajax Dyke Environmental Land Classification

Figure 3-15

Document Path: C:\Egnyte\Shared\Projects\Active\19036 - KGS Group\1903601 - Pickering-Ajax Dykes EA\Mapping\Figures\5_ArcGIS\Ecology\1903601_4-1-1_Terrestrial Ajax ELC.mxd

The woodlands in the Direct Environmental Study Area are large and diverse (Figures 3-14 and 3-15). The buffering and protection they provide the West Duffins and Duffins Creeks and the potential wildlife habitats and movement corridor opportunities are important functions of these woodlands. Therefore, these woodlands areas would likely meet the Ministry of Natural Resources and Forestry definitions of Significant Woodlands and are mapped as part of the Natural Heritage System and Environmental Protection lands within the Pickering and Ajax Official Plans.

3.4.4 SIGNIFICANT FLORA SPECIES

Within the Project Study Area, the TRCA recorded flora Species of Regional Concern (ranked L1 to L3) and Urban Concern (L4) (Toronto and Region Conservation Authority, 2016). The species are listed in Table 3-6. All species noted during TRCA field studies were L3 or L4 (with no L1 or L2 species). Species of Regional Concern are flagged as being at risk within the entire TRCA jurisdiction over the long term. Those species with an L3 rank may not currently be rare, but they are highly sensitive to habitat loss and disturbances associated with changes in the surrounding landscape (Figure 3-16). Species and communities assigned an L4 rank are those that are widespread regionally but are vulnerable to long-term declines in urban areas.

Of these species, butternut (*Juglans cinerea*) is also listed on the SARO list as Endangered, and is protected by the *Endangered Species Act* (ESA (*Endangered Species Act* 2007)).

TABLE 3-6: TRCA FLORA SPECIES OF REGIONAL CONCERN

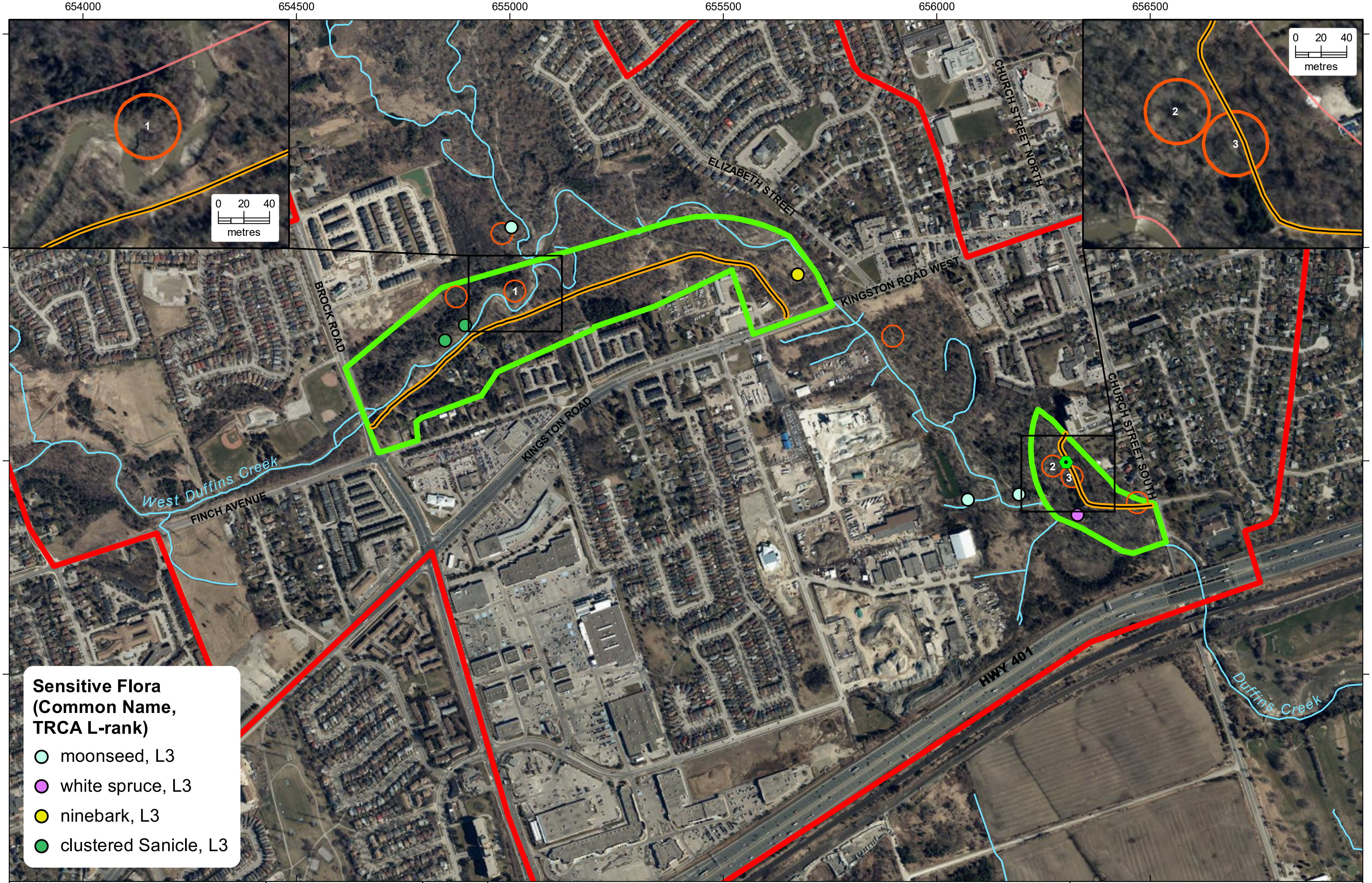
Common Name	Scientific Name	TRCA L-Rank	SARO
blue beech	*Carpinus caroliniana* ssp. *virginiana*	L4	
broad-leaved toothwort	*Cardamine diphylla*	L4	
bulblet fern	*Cystopteris bulbifera*	L4	
butternut	*Juglans cinerea*	L3	Endangered
clustered sanicle	*Sanicula odorata*	L3	
false nettle	*Boehmeria cylindrica*	L4	
long-styled blue cohosh	*Caulophyllum giganteum*	L4	
moonseed	*Menispermum canadense*	L3	
ninebark	*Physocarpus opulifolius*	L3	
paper birch	*Betula papyrifera*	L4	
red oak	*Quercus rubra*	L4	
silver maple	*Acer saccharinum*	L4	
white pine	*Pinus strobus*	L4	
white spruce	*Picea glauca*	L3	

Common Name	Scientific Name	TRCA L-Rank	SARO
wild ginger	*Asarum canadense*	L4	

TRCA L-rank: L1 to L3 considered to be of 'regional concern'

L4 considered to be of 'urban concern'

L5 considered to be 'not of concern'



CLIENT: KGS Group

PROJECT: Pickering-Ajax Dykes EA

PREPARED BY: Palmer™

0 100 200 300 metres

N

PROJECT NO. 1903601	REVISION: 1-3
DATE: Mar 24, 2020	SCALE: 1:12000
DRAWN: BE	DATUM: NAD 1983
CHECKED: AA	PROJECTION: UTM zone 17

LEGEND:

- Project Study Area
- Direct Study Area
- Dyke Centre Line (Approx.)
- Watercourse (TRCA)
- Hybrid Walnut Species (Palmer)
- Butternut Tree General Location

Imagery (2018) provided by TRCA

TITLE:

Terrestrial Resources – Sensitive Flora

Figure 3-16

Document Path: C:\Egnyte\Shared\Projects\Active\19036 - KGS Group\1903601 - Pickering-Ajax Dykes EA\Mapping\Figures\5_ArcGIS\Ecology\1903601_5-1-2_Terrestrial Sensitive Flora.mxd

3.4.5 ENVIRONMENTALLY SENSITIVE/SIGNIFICANT AREAS – BIOLOGICAL

In the Project Study Area, the Duffins Creek corridor between Brock Road and Kingston Road has been identified as the Major-Spink Environmentally Significant Area (Toronto and Region Conservation Authority, 1982). While available mapping and information specific to the Environmentally Significant Area is limited, this report demonstrates natural heritage features and functions that would justify an Environmentally Significant Area designation.

3.4.6 FISH HABITAT

Both dykes are located in the Duffins Creek watershed (Toronto and Region Conservation Authority , 2004). The Ajax Dyke is located in the Lower Duffins subwatershed and the Pickering Dyke spans both the West Duffins and Lower Duffins subwatersheds (refer to Figure 3-2 for subwatersheds). Within the Lower Duffins subwatershed, the main Duffins Creek is classified as large riverine; and within the West Duffins subwatershed, the streams are classified as intermediate riverine coldwater. The management target fish species for the Lower Duffins subwatershed is Smallmouth Bass (*Micropterus dolomie*u) and the target species for the West Duffins subwatershed is Redside Dace (*Clinostomus elongatus*) and Rainbow Trout (*Oncorhynchus mykiss*) (Toronto and Region Conservation Authority , 2004).

There is a Sea Lamprey barrier and trap located on the Lower Duffins Creek just west of Church and Mill Street in Ajax. Sea Lamprey dams are either historical or purpose-built and prevent anadromous adult Lamprey from entering watercourses to spawn. Similarly, larva and juvenile Lamprey require stream habitat for rearing and metamorphosis, and access to downstream lakes to complete its lifecycle to a parasitic adult. Freshwater fish in the great lakes that the Sea Lamprey parasitizes benefit from these dams, particularly the salmonids as the dams limit the reproductive capability of the lamprey and as such the Lamprey populations are controlled.

Habitat for the section of the Duffins and West Duffins creek in the vicinity of the Pickering Dyke is generally represented by riffle-run-pool stream morphology with a variety of in-stream habitat features, dense riparian areas and a larger surrounding natural feature. Fish habitat within these areas is considered of good quality and should be protected.

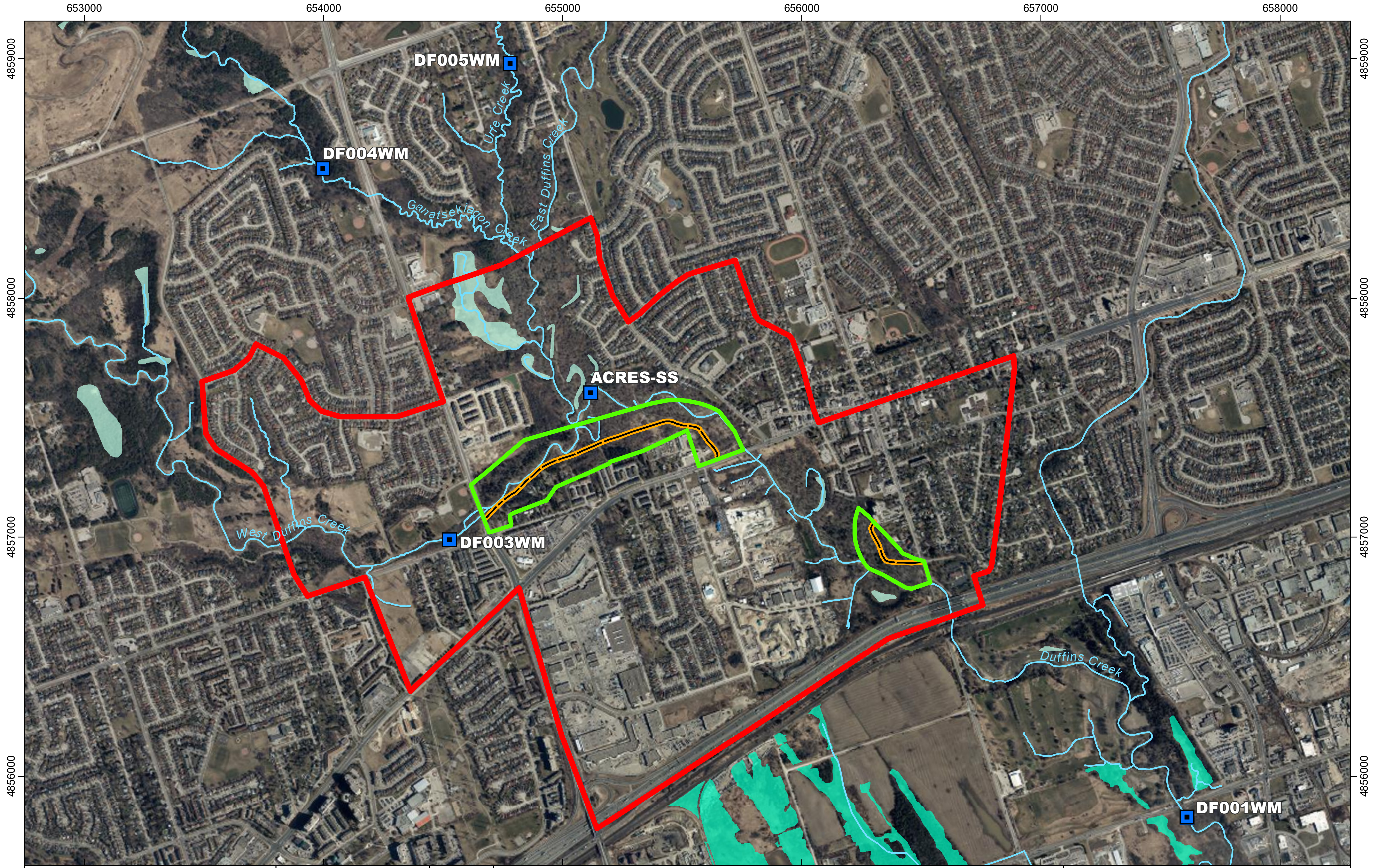
The West Duffins Creek near DF003WM (Figure 3-17) meanders through woodland with undercut eroded banks and point bars on most meanders. Iron deposits were detected on the banks of the watercourse in this stretch of the creek, suggesting the presence of springs or seeps. Aggradation in the watercourse is evidenced by riffles containing embedded coarse materials, the presence of medial bars and accretion on point bars. Some anthropogenic influence is present including armorstone walls installed on the south bank and undermined gabion basket. The creek is up to 500 mm deep in pools, with riffle depth averaging 230 mm during the TRCA 2019 field investigations. In-stream aquatic vegetation is limited to filamentous and non-filamentous algae, with riparian grasses and shrubs and overhanging trees. In-stream fish habitat includes cover by woody debris and refuge in pools. The embedded coarse materials in the riffles may provide habitat to spawning salmon or salmonid species.

Downstream at the confluence of the West Duffins is a large oxbow on Duffins Creek. Duffins Creek has a wetted width of up to 7 m through this section with mid-channel depths of up to 250 mm. Duffins contains a less prominent riffle-run-pool morphology, featuring longer stretches of runs. Fish habitat includes undercut banks, point bars and significant in-stream woody debris in this section of the watercourse. Aquatic vegetation is more abundant than in the West Duffins, with macrophytes and floating algae occurring though much of the watercourse.

The TRCA Open Data portal includes fish data for five sites in the general vicinity of the dykes (Figure 3-17), with two sites in the immediate vicinity of the Pickering Dyke: DF003WM and ACRES-SS (Figure 3-17). Site DF003WM is located west of Brock Road, approximately 150 metres (m) from the end of the Pickering Dyke on West Duffins Creek. This site is part of the TRCA's Regional Watershed Monitoring Program (RWMP) and is sampled on a three-year rotation. Sampling is conducted according to the Ontario Stream Assessment Protocol (OSAP) using a backpack electrofisher. Site DF003WM was sampled in 2003, 2006, 2009, 2012, 2015, and 2018. During those six sampling events, 12 fish species have been caught (Table 3-7).

The ACRESS-SS site on the main Duffins Creek was sampled once in 2015 (Table 3-8). Eleven fish species were caught including Atlantic Salmon (*Salmo salar*). Atlantic Salmon were extirpated from Lake Ontario but have been stocked in Duffins Creek in an attempt to reintroduce the species.

The nearest RWMP site routinely sampled on the main Duffins Creek is DF001WM (downstream of Highway 401). DF001WM is approximately 1.7 km downstream from the Ajax Dyke. Because DF001WM is fairly close to Lake Ontario and the associated *Lower Duffins Creek Wetland Complex* (Figure 3-17), the fish species at this site are likely influenced by the Lake and are not representative of the Project Study Area.



CLIENT:	KGS Group
PROJECT:	Pickering-Ajax Dykes EA
PREPARED BY:	Palmer™
PROJECT NO.	1903601
REVISION:	1-2
DATE:	Mar 23, 2020
SCALE:	1:21000
DRAWN:	BE
DATUM:	NAD 1983
CHECKED:	AA
PROJECTION:	UTM zone 17

0 100 200 300 400
metres

N

LEGEND:

- Project Study Area
- Direct Study Area
- Dyke Centre Line (Approx.)
- Watercourse (TRCA)
- Fish Station (TRCA)
- Provincially Significant Wetland
- Wetland (Not Evaluated)

Imagery (2018) provided by TRCA

TITLE:

Aquatic Resources

Figure 3-17

Document Path: C:\Egnyte\Shared\Projects\Active\19036 - KGS Group\1903601 - Pickering-Ajax Dykes EA\Mapping\Figures\5_ArcGIS\Ecology\1903601_2-1-1_Aquatic Resources.mxd

TABLE 3-7: TRCA FISHERIES DATA NEAR THE PICKERING AND AJAX DYKES – OBSERVED SPECIES

Fish	Main Duffins Creek	West Duffins Creek					
	ACRESS-SS	DF003WM					
	2015	2003	2006	2009	2012	2015	2018
Atlantic Salmon	X						
Blacknose Dace	X	X	X	X	X	X	X
Brook Stickleback	X						
Brown Trout						X	
Common Shiner	X	X	X	X			X
Creek Chub	X	X		X	X	X	X
Fathead Minnow	X						
Johnny Darter	X	X	X	X		X	X
Longnose Dace	X	X	X	X	X	X	X
Pumpkinseed		X		X			
Rainbow Darter	X	X	X	X	X	X	X
Rainbow Trout	X		X	X	X	X	
Smallmouth Bass		X					
Stonecat	X	X		X	X		
White Sucker		X	X	X	X	X	X

DFO aquatic Species at Risk (SAR) online mapping (accessed July 25, 2019) indicated that there was Redside Dace (provincially and federally Endangered) in Urfe and Ganatsekiagon Creeks, approximately 1 km north of the Project Study Area. Correspondence with the Ontario Ministry of Environment, Conservation, and Parks (MECP) indicated that the DFO map is out-of-date. During recent sampling in spring 2019, Redside Dace were caught by the MECP in the main Duffins Creek and the main Duffins Creek through the Project Study Area is now considered 'Occupied' habitat (J. Andersen, MECP, *pers. comm*.).

3.4.7 SPECIES OF CONCERN

Information obtained from the MNRF Natural Areas Make-a-Map website (Ministry of Natural Resources and Forestry, 2019) indicated that there were five Threatened or Endangered SAR species within the Project Study Area, and one species of Special Concern, which include:

- American Eel (*Anguilla rostrate*) – Threatened
- Bank Swallow (*Riparia riparia*) – Threatened
- Butternut (*Juglans cinereal*) – Endangered
- Red Mulberry (*Morus rubra*) – Endangered
- Redside Dace (*Clinostomus elongatus*) – Endangered
- Snapping Turtle (*Chelydra serpentine*) – Special Concern

In addition, the 2019 TRCA data indicated that the following species were observed in the Project Study Area:

- Chimney Swift (*Chaetura pelagica*) – Threatened
- Eastern Wood-pewee (*Contopus virens*) – Special Concern

In addition, there are three Endangered bat species in Ontario that could possibly inhabit a variety of forest habitats in southern Ontario:

- Little Brown Myotis (*Myotis lucifugus*) – Endangered
- Northern Myotis (*Myotis septentrionalis*) – Endangered
- Tri-colored Bat (*Perimyotis subflavus*) – Endangered

Protection provisions for species and their habitat within the *ESA* apply only to those species listed as Endangered or Threatened on the SARO list. The habitats of species of Special Concern may be protected under the Provincial Policy Statement (Ontario Ministry of Municipal Affairs and Housing, 2014).

The TRCA noted that two Butternut trees (Endangered) were present in the Direct Environmental Study Area, one near each of the dykes. A Butternut Health Assessment (BHA) was completed by Palmer on August 12, 2019, during which an additional Butternut tree was observed on the Ajax Dyke (Appendix D). Butternut trees suffer from a highly transmissible fungal disease called butternut canker (*Ophiognomonia clavigignenti-juglandacearum*). Butternut canker is causing very rapid decline in this tree species across its native range. The fungal disease is easily transmitted by wind and is very difficult to prevent. Trees often die within a few years of infection by butternut canker (Ontario Ministry of Natural Resources and Forestry, 2014).

The BHA indicated that the Butternut tree near the Pickering Dyke and the tree directly on the Ajax Dyke (trees #1 and #3 – Figure 3-16) are Category 1 trees (non-retainable), while the tree further from the Ajax Dyke (tree #2) is a Category 2 tree (retainable) (Ministry of Natural Resources and Forestry, 2014). A hybrid butternut/walnut tree was also identified on the Ajax Dyke; hybrids are not protected under the *ESA*.

The locations of the Butternut trees and the hybrid Butternut/Walnut tree in the Project Study Area are indicated in Figure 3-16, based on information provided by TRCA. The figure shows, with numbers, the trees that were included in the BHA. It shows one additional Butternut tree near Church St S, in the proximity of the Ajax Dyke, that was not identified at the time of the BHA. Its location and condition should be assessed in subsequent design stages.

In summary, there are nine listed SARO species and two Special Concern species with potential or confirmed habitat within the Project Study Area. A habitat suitability screening is provided below, contrasting the list of potential SAR in the general vicinity of the proposed works with the observed species and available habitats (Table 3-8).

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TABLE 3-8: SAR HABITAT SCREENING FOR NHIC SAR RECORDS WITHIN THE PROJECT STUDY AREA

Species	Habitat Requirement Overview	Habitat Suitability
American Eel – Threatened	In fresh water, preferred habitat can be found in lakes and rivers including all waters extending from the high-water mark down to at least a 10 m depth.	Possible
Bank Swallow – Threatened	The Bank Swallow readily breeds in a wide variety of low-elevation (< 900 masl) natural and anthropogenic habitats, including: lake and ocean bluffs; stream and riverbanks; sand and gravel pits; roadcuts; and piles of sand, topsoil, sawdust, coal ash, and other materials. Nest burrows are nearly always in a vertical or near-vertical bank.	Possible / Probable
Butternut – Endangered	Butternut trees, which at one time were much more common to the south extending to the northern aspect of zone 6E, have been declining due to factors including forest loss and disease.	Confirmed by species presence

Species	Habitat Requirement Overview	Habitat Suitability
Chimney Swift – Threatened	The chimney swift is a Threatened species which breeds in Ontario and winters in northwestern South America. It is found mostly near urban areas where the presence of chimneys or other manmade structures provide nesting and roosting habitat. Prior to settlement, the chimney swift would mainly nest in cave walls and hollow tress. The chimney swift initially benefitted from human settlement; however, recent declines in flying insects and the modernization of chimneys are factors attributed to their current population declines.	Confirmed by species presence in appropriate habitat.
Eastern Wood-pewee – Special Concern	The eastern wood-pewee population has been gradually declining since the mid-1960's (The Cornell Lab of Ornithology, 2015). The eastern wood-pewee is a "flycatcher", a bird that eats flying insects, that lives in the mid-canopy layer of forest clearings and edges of deciduous and mixed forests. It prefers intermediate-age forest stands with little understory vegetation. Threats to the population are largely unknown; however, causes may include loss of habitat due to urban development and decreases in the availability of flying insect prey (Ministry of Natural Resources and Forestry, 2014).	Confirmed by species presence in appropriate habitat.
Red Mulberry – Endangered	In Canada, red mulberry is only found in the Carolinian Zone (the small area of Ontario southwest of Toronto to Sarnia down to the shores of Lake Erie) near rivers, the shores of Lake Erie, and the slopes of the Niagara Escarpment (Ministry of Natural Resources and Forestry, 2015). In Ontario, red mulberry grows in moist forested habitats on both sandy and limestone-based loamy soils. It prefers areas where the forest canopy is open, allowing sunlight to reach the forest floor, but will tolerate some shade	Absent (Last recorded in project study area in 1894)
Redside Dace – Endangered	Redside Dace prefer small streams and headwater areas with a gravel bottom. Overhanging grasses and shrubs provide ideal habitat as this species is adapted to jumping up to 10 cm out of the water to feed on insects. Changes to stream flow and shape resulting in loss of habitat caused by urban and agricultural channel alterations are the most significant threats to this species (Ministry of Natural Resources and Forestry, 2014).	Confirmed by MECP sampling event.

Species	Habitat Requirement Overview	Habitat Suitability
Snapping Turtle – Special Concern	Snapping turtles spend most of their lives in water and travel slightly upland to gravel or sandy embankments or beaches to lay their eggs (Ontario Ministry of Natural Resources and Forestry, 2014).	Probable
Little Brown Myotis – Endangered	Maternal Roosts: Often associated with buildings (attics, barns etc.). Occasionally found in trees (25-44 cm in diameter at breast height [DBH]).	Possible
Northern Myotis – Endangered	Maternity Roosts: Often associated with cavities of large diameter trees (25-44 cm DBH). Occasionally found in structures (attics, barns etc.)	Possible
Tri-coloured Bat – Endangered	Maternity Roosts: Can be in trees or dead clusters of leaves or arboreal lichens on trees. May also use barns or similar structures	Possible

3.4.8 EXOTIC/ALIEN AND INVASIVE SPECIES

The municipalities of Pickering and Ajax are part of the Greater Toronto Area (GTA), and as a consequence contain a high percentage of exotic and non-native species. The Early Detection and Distribution Mapping for the Pickering and Ajax municipalities was reviewed (EDDmapS Ontario, 2019). Of the species recorded, the following flora species may be present within the Duffins Creek valley system with a noted degree of invasiveness:

- dog-strangling vine, European swallowwort - *Vincetoxicum rossicum;*
- European buckthorn - *Rhamnus cathartica;*
- European common reed - *Phragmites australis* ssp. *australis;*
- European frog-bit - *Hydrocharis morsus-ranae;*
- garlic mustard - *Alliaria petiolata;*
- giant hogweed - *Heracleum mantegazzianum;* and
- purple loosestrife - *Lythrum salicaria.*

The following aquatic and semi-aquatic species have been recorded in Pickering and Ajax, and may be present within the Duffins Creeks themselves:

- goldfish - Carassius auratus;
- rainbow smelt - Osmerus mordax;
- round goby - Neogobius melanostomus;
- threespine stickleback - Gasterosteus aculeatus;
- white perch - Morone americana;
- amazon sailfin catfish - Pterygoplichthys pardalis

- rusty crayfish - Orconectes rusticus; and
- bloody red shrimp - Hemimysis anomala.

3.4.9 WILDLIFE POPULATIONS

3.4.9.1 Birds

The TRCA recorded 37 bird species during their 2019 field visits in the Project Study Area. Of the 38 species, three (3) were considered exotic species (L+) and 19 were considered 'not of concern' (L5). The L3 and L4 species are listed in Table 3-9. Bird species with a breeding status of 'probable' or 'confirmed' are shown on Figure 3-12.

TABLE 3-9: TRCA BIRD SPECIES OF REGIONAL CONCERN- PROJECT STUDY AREA

Scientific	Common Name	TRCA L-Rank	Saro	Breeding Status
Geothlypis philadelphia	mourning warbler	L3		Probable
Dumetella carolinensis	grey catbird	L4		Probable
Pheucticus ludovicianus	rose-breasted grosbeak	L4		Confirmed
Colaptes auratus	northern flicker	L4		Probable
Contopus virens	eastern wood-pewee	L4	Special Concern	Probable
Sitta carolinensis	white-breasted nuthatch	L4		Possible
Setophaga ruticilla	American redstart	L4		Probable
Vireo olivaceus	red-eyed vireo	L4		Probable
Corvus corax	common raven	L4		Non-breeding
Archilochus colubris	ruby-throated hummingbird	L4		Uncertain
Passerina cyanea	indigo bunting	L4		Probable
Ceryle alcyon	belted kingfisher	L4		Possible
Myiarchus crinitus	great crested flycatcher	L4		Possible
Picoides villosus	hairy woodpecker	L4		Possible
Chaetura pelagica	chimney swift	L4	Threatened	Possible

TRCA L-Rank: L1 to L3 considered to be of 'regional concern'

L4 considered to be of 'urban concern'

L5 considered to be 'not of concern'

3.4.9.2 Herptiles

The TRCA completed frog monitoring of the Project Study Area in spring of 2019. Within the Direct Environmental Study Areas, the TRCA staff observed two frog species – grey treefrog (*Hyla versicolor*) near the Pickering Dyke and green frog (*Lithobates clamitans*) near the Ajax Dyke (Figure 3-13). Midland painted turtle (*Chrysemys picta*) was also recorded in the Project Study Area, north of the Ajax Dyke.

The TRCA has categorized the grey treefrog as 'L2' and considers it as a species of 'regional concern'. "*Grey treefrogs live in a variety of forest habitats but require permanent or ephemeral wetlands for breeding* (Canadian Herpetological Society, 2017). *The wetlands are usually in open-canopy areas in close proximity to forest habitats* (e.g. the oxbow pond near the Pickering Dyke). *Breeding sites are typically fish-free, and the introduction of predatory fish can result in the loss of the grey treefrog from the site".*

The TRCA has categorized the green frog as 'L4' which means it is a species of 'urban concern'. This means that the species is common to rural/forested areas, but it is not usually found / no longer found within urban habitats within the TRCA jurisdiction. "*Green Frogs can be found in most aquatic habitats, ranging from large lakes and rivers to small creeks and ponds, but they require permanent bodies of water for breeding and hibernation*" (Canadian Herpetological Society, 2017).

Midland painted turtle is considered 'L3' by the TRCA, being of regional concern. "*Painted Turtles prefer shallow aquatic habitats with slow-moving water, soft bottoms, aquatic vegetation, and abundant basking sites. Painted Turtles overwinter at the bottom of water bodies or under submerged undercut banks*" (Canadian Herpetological Society, 2017).

The TRCA also recorded two other frog species north of the Project Study Area: Northern leopard frog (*Lithobates pipiens*) and wood frog (*Lithobates sylvaticus)* (Figure 3-13). Northern leopard frog has been ranked as a L3 species and wood frog are ranked as a L2 species.

All four of these frog species and midland painted turtle are considered 'Secure' (S5) in Ontario by the NHIC and are not listed under SARO (Ministry of Natural Resources and Forestry, 2019).

3.4.9.3 Other Wildlife

During their 2019 site visits of the Project Study Area, TRCA staff recorded five species incidentally: eastern chipmunk (*Tamias striatus*), eastern cottontail (*Sylvilagus floridanus*), woodchuck (*Marmota monax*), red squirrel (*Tamiasciurus hudsonicus*), and white-tailed deer (*Odocoileus virginianus*) (Figure 3-13).

All of these species are common, generalist and urban-adapted species. Other urban-adapted species such as grey squirrel (*Sciurus carolinensis*), striped skunk (*Mephitis mephitis*) and racoon (*Procyon lotor*) are also expected to be present.

3.4.10 WETLANDS

Provincially Significant Wetlands (PSW) are not found in the Project Study Area. The Lower Duffins Creek Wetlands Complex PSW (Figure 3-17) is found south of the Project Study Area, merging with the Duffins Creek Coastal Wetland PSW at Lake Ontario. Several smaller unevaluated wetlands are found within the Duffins Creek system within the Project Study Area (Figure 3-17), though these are not in the general vicinity of the dykes, with all being >120 m distant. However, a small inclusion of Silver Maple Mineral Deciduous Swamp (SWD3-2) was mapped on the east side of the Ajax Dyke during 2019 TRCA field surveys (Figure 3-15).

3.4.11 MICROCLIMATE

No microclimates of significance of scale were identified within the Project Study Area.

3.4.12 LIFE SCIENCE ANSI'S

No Life Science ANSI's were identified within the Project Study Area

3.4.13 UNIQUE HABITATS

No unique habitats were identified within the Project Study Area.

3.5 Cultural

3.5.1 TRADITIONAL LAND USES

Archaeological work conducted within the Direct Environmental Study Area in 2019 (TRCA 2019c; Appendix E) indicates that Indigenous peoples may have previously inhabited or utilized the area. The surrounding ravine of the Duffins Creek would have offered rich resources such as fish, waterfowl, and game that would have been exploited as part of a people's seasonal round (TRCA 2019c).

3.5.2 ABORIGINAL RESERVE OR COMMUNITY

There are no Aboriginal Reserves or Communities located within the Project Study Area. The closest First Nations to the Project Study Area is the Mississauga of Scugog Island First Nation located approximately 40 km to the North East near the Town of Port Perry.

3.5.3 OUTSTANDING NATIVE LAND CLAIM

The Project Study Area is not within the limits of any outstanding Native Land Claims, however, it is located within the Williams Treaty Area. Previous to 2018, there was ongoing litigation pertaining to the Williams Treaty (1923), which included seven First Nations:

- Alderville First Nation
- Cheppewas of Georgina Island
- Cheppewas of Mnjikanging (Rama)
- Chippewas of Christian Island
- Curve Lake First Nation
- Hiawatha First Nation
- Mississaugas of Scugog Island First Nation

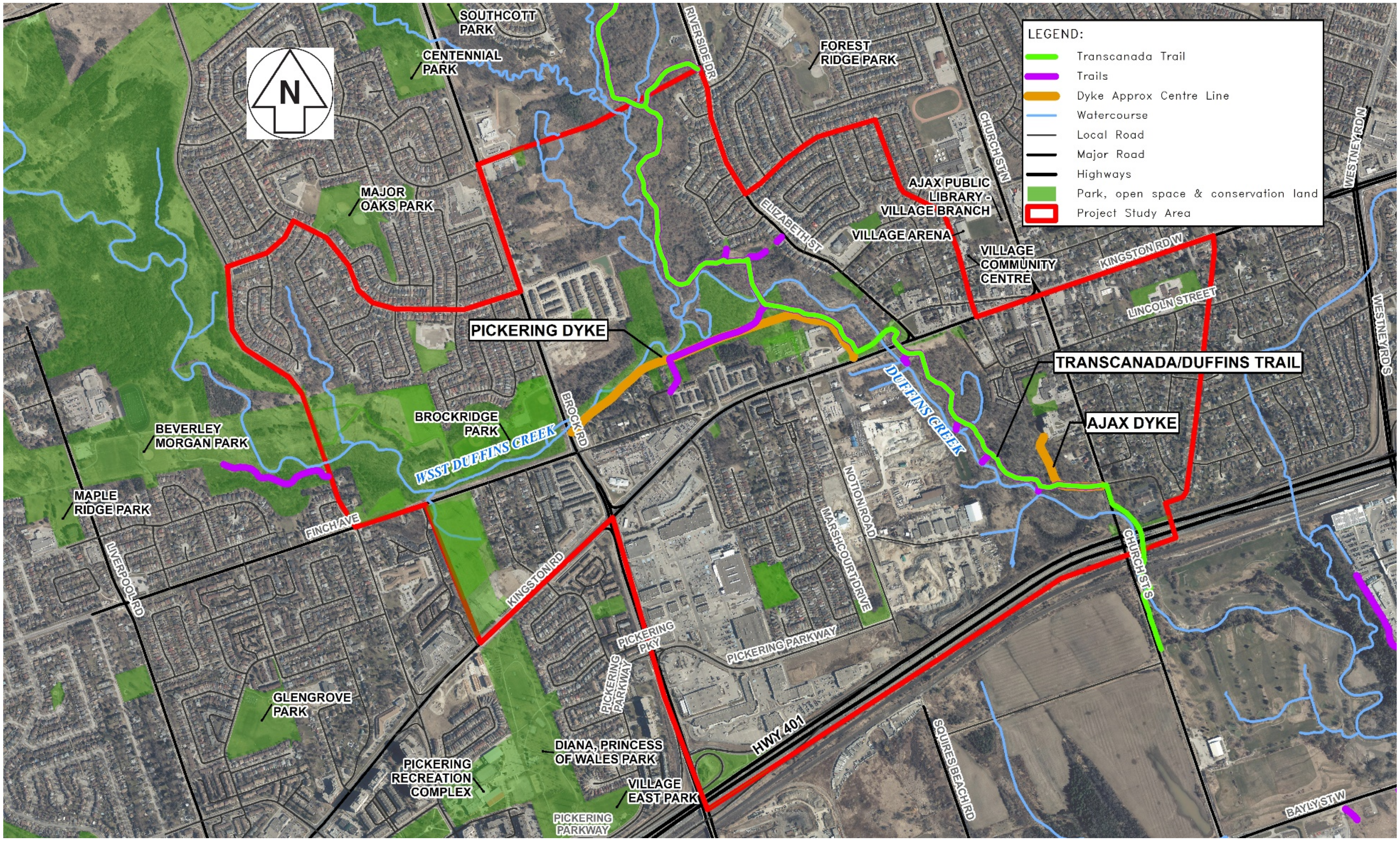
In August 2018 both the Ontario Provincial Government and Federal Government (Government of Canada 2018) signed a settlement which included):

- Recognition of pre-existing Treaty harvesting rights;
- Federal and Provincial apologies for the negative impacts of the Williams Treaties on First Nations People;
- Financial Compensation; and
- Additional Reserve Lands.

3.5.4 RIPARIAN USES

The Trans-Canada trail traverses both the City of Pickering and The Town of Ajax, with a portion of the trail located within both the Project and Direct Environmental Study Areas (Figure 3- 18). Trails are used for walking/hiking as well as biking. Several parks are also located within both study areas, and the creek offers opportunities for canoeing and kayaking, as well as fishing. There are residential properties near to the creek, but none own a portion of the creek or the land immediately adjacent to the creek. However, these residents currently enjoy and value the access they have to the river from their properties. There are no cottages or other waterfront properties.

FIGURE 3-18: TRANS-CANADA TRAIL AND PARKS



3.5.5 AESTHETIC OR SCENIC LANDSCAPES OR VIEWS

The Project Study Area is mostly urbanized with limited aesthetic or scenic views. Within the Direct Environmental Study Area, the meanders of Duffins Creek and the surrounding canopy, understory and forest corridor contribute to the scenic landscape.

3.5.6 ARCHAEOLOGICAL RESOURCES

A Stage 1 Archaeological Assessment was completed by TRCA's Archaeology Resources Management Services in June 2019 (Appendix E). This assessment was completed for the Direct Environmental Study Area located along the dykes within Lot 15, Concession I, and Lots 16-18, Concession II in the Geographic Township of Pickering, historic Ontario County in the City of Pickering and Town of Ajax, Regional Municipality of Durham.

The report concluded that the area has the potential for intact cultural heritage resources, in the form of archaeological sites, to be present. The surrounding ravine of the Duffins Creek would have offered rich resources such as fish, waterfowl and game that would have been exploited as part of a people's seasonal rounds. As a result, there is very high potential for encountering Indigenous and historic sites within the Direct Environmental Study Area. Based on the proximity to water, former historic structures, roadways, a watercourse, a grist mill, mill pond and mill races, a church and cemetery, a blacksmith shop, and the historic village of Duffins Creek, the area is expected to demonstrate a high potential for encountering historic Euro-Canadian sites. A Stage 2 Archaeological Assessment will be conducted prior to the start of any rehabilitation work at the dykes.

3.5.7 HISTORIC CANALS

There are no historic canals within the Project Study Area.

3.5.8 FEDERAL PROPERTIES

There are no federal properties within the Project Study Area.

3.5.9 HERITAGE RIVER SYSTEMS

Duffins Creek is not listed under the Canadian Heritage Rivers System.

3.6 Socioeconomic

3.6.1 SURROUNDING NEIGHBORHOOD OR COMMUNITY

According to Pickering's Official Plan (Pickering 2018) small portions of the Project Study Area are located within the neighborhoods of City Centre and Liverpool, while the majority of the southern portion of the Study area is located within a portion of the Village East neighborhood, and the northern portion is located within the neighborhood of Brock Ridge. The Ajax Official Plan (Ajax 2016) indicates that the eastern portion of the Study area is located within the neighborhoods of Village and Riverside. Figure 3-19 shows the boundary of the neighborhoods relative to the Project Study Area, while Table 3-10 shows the total Project Study Area within of each of the neighborhoods.

FIGURE 3-19: SURROUNDING NEIGHBORHOODS AND COMMUNITIES

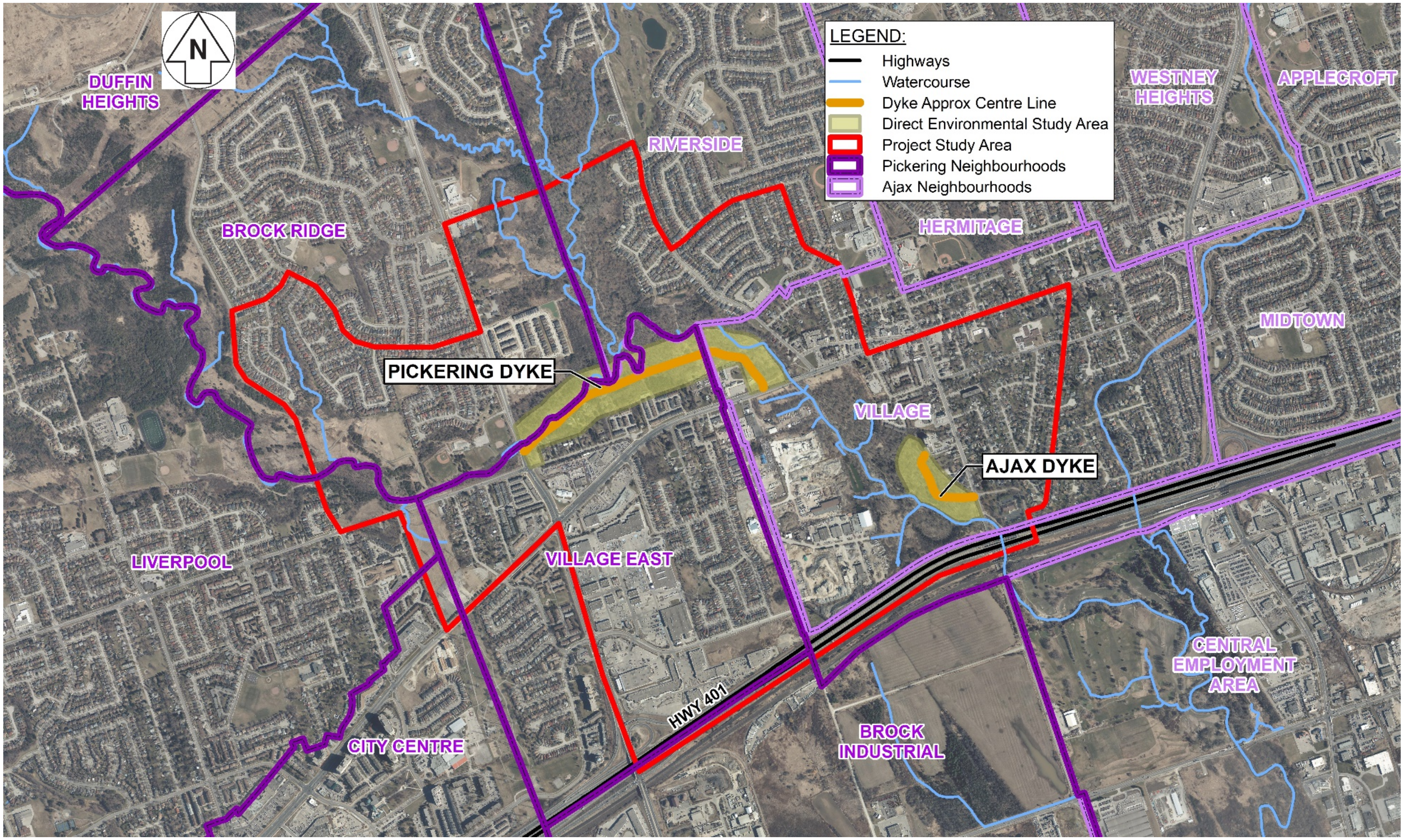


TABLE 3-10: PROJECT STUDY AREA NEIGHBORHOODS

City/Town	Neighbourhood	M^2	Ha
Ajax	Village	1,326,459	132
Ajax	Riverside	522,675	52
Pickering	Brock Industrial	26,633	2.6
Pickering	Brock Ridge	964,920	96
Pickering	City Centre	22,206	2.2
Pickering	Liverpool	84,358	8.4
Pickering	Village East	1,356,363	135

The Village East neighborhood is bounded by the Ontario Hydro transmission corridor, the West Duffins Creek, the Ajax-Pickering boundary, and Highway 401. It consists of a mix of detached, semi-detached, townhouses and apartment dwellings. It includes four neighborhood parks plus part of the 'Diana, Princess of Wales Park', a cemetery and police station. The population within the Village East grew from 4,900 to 7,500 between 1996 and 2016.

Brock Ridge is bounded by the West Duffins Creek, the Ontario Hydro transmission corridor, and the Ajax-Pickering Boundary. It includes open space lands associated with the West and East Duffins Creek. Most of the area has been developed since the 1970's and consists of detached dwellings. It also includes three elementary schools, two neighborhood parks and one place of worship. Environmentally sensitive areas are associated with the West and East Duffins Creek as well as with Ganatsekiagon Creek. The population within Brock Ridge increased from 5,600 to 9,300 between 1996 and 2016.

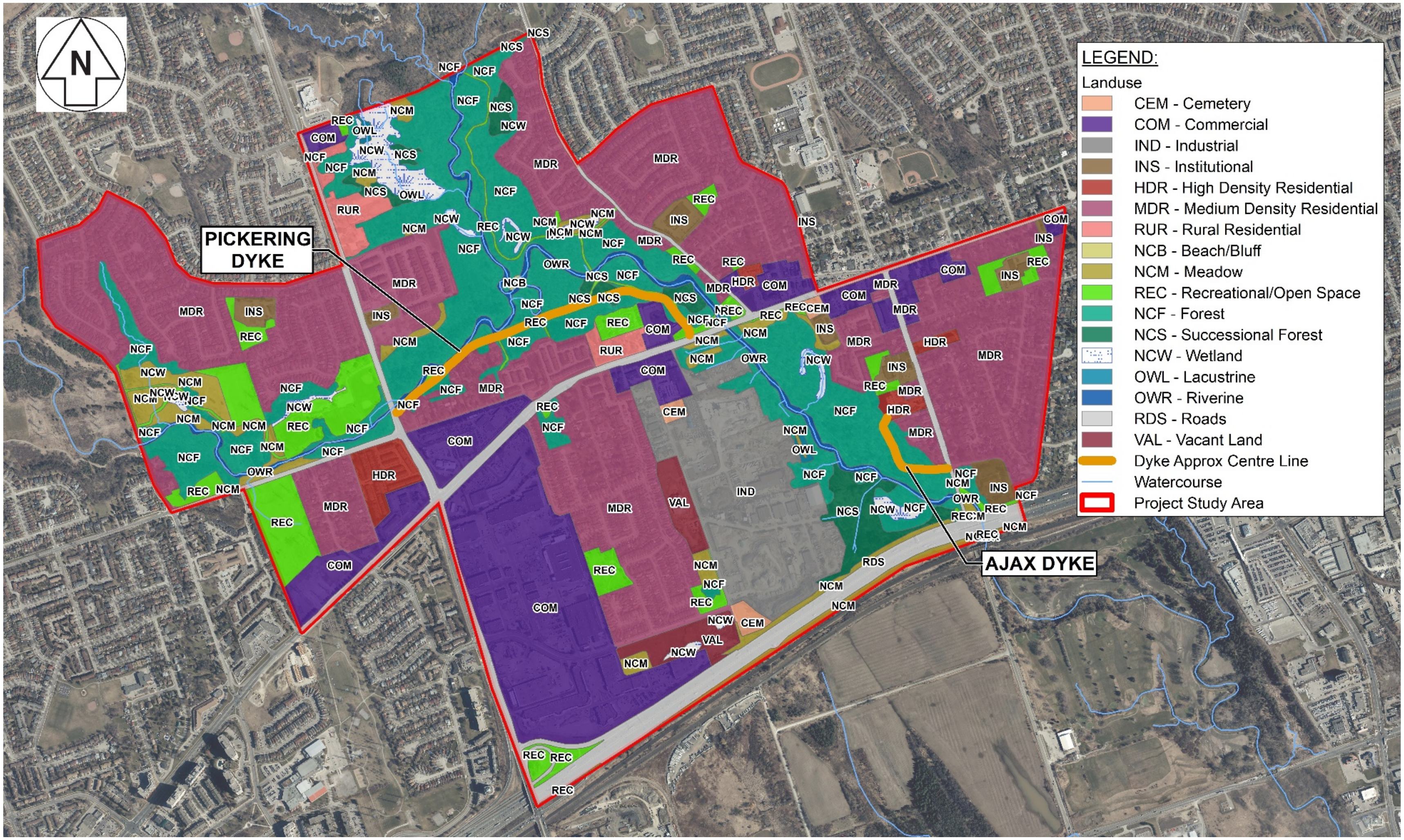
Approximately 2 hectares of the Project Study Area are located within the City Centre Neighborhood. This area is open space. Within the 8 hectares of the Project Study Area located within the Liverpool Neighborhood there are three homes, with the remainder being undeveloped lands along the West Duffins Creek.

The Pickering Village is a community within the Town of Ajax and located within the Village Neighborhood. Development within the area is typically low density residential with some medium density residential. The population is estimated at 15,105, which includes the area of Denis O'Connor. Pickering Village is an area with significant cultural heritage resources. As such, the Town of Ajax is considering preparing a Heritage Conservation District Plan that will review the heritage character of the area and establish more detailed planning policies and engineering standards aimed at protecting this area. Concurrent to the preparation of the Heritage Conservation District Plan, the Town may also prepare a Community Improvement Plan to provide financial programs to assist landowners to implement the Town's planning vision for the area.

3.6.2 SURROUNDING LAND USES OR GROWTH PRESSURES

Land Use within the Project Study the Direct Environmental Study Area's are shown on Figure 3-20.

FIGURE 3-20: SURROUNDING LANDUSE



Land use within the Project Study Area consists of mostly medium density residential with commercial, institutional and recreational land uses as well. Within the Direct Environmental Study Area land use is designated as forest with some medium density residential, recreational and commercial land south of the Pickering Dyke. Some high and medium density land use borders the Ajax Dyke.

The Project Study Area is located within the Southern Pickering Urban Area (Pickering 2018). In 1996, the Southern Pickering Urban Area had a population of over 70,000 people and an estimated 25,000 jobs. Forecasts around that time projected an increase of about 30,000 people and 24,500 jobs in South Pickering by 2021.

The Ajax Official Plan (Ajax 2015) indicates that intensification is expected to occur throughout areas within Ajax's built boundary, however the majority will be directed to the following centres and corridors, all of which are outside of the Project Study Area:

- Downtown Regional Centre
- Uptown Regional Centre
- Village Centre
- GO Transit Station Mixed Use Area
- Midtown Corridor

The Village Centre is the closest identified intensification area, located east of the Project Study Area. This area has the potential to provide an additional 150 units with a population increase of 275 to 2031.

3.6.2.1 Durham-Scarborough BRT

The Durham-Scarborough Bus Rapid Transit (BRT) project proposes approximately 36 kilometers of dedicated transit infrastructure, connecting downtown Oshawa, Whitby, Ajax, Pickering and Scarborough. This project builds upon the existing PULSE service and will provide a more dedicated transit infrastructure along Highway 2, which passes through the Project Study Area. The Highway 2 BRT is a crucial transportation corridor connecting people through the Region of Durham and Scarborough. The corridor has varied traffic, land use conditions and constraints.

With rapid growth in the past decade and an expectation for this growth to continue into the future, demand for travel along the corridor is expected to continue to increase, and a higher capacity form of transit will be needed to link communities and employment (https://www.metrolinxengage.com/sites/default/files/final_boards_pic1_2019-05-31_accessible.pdf).

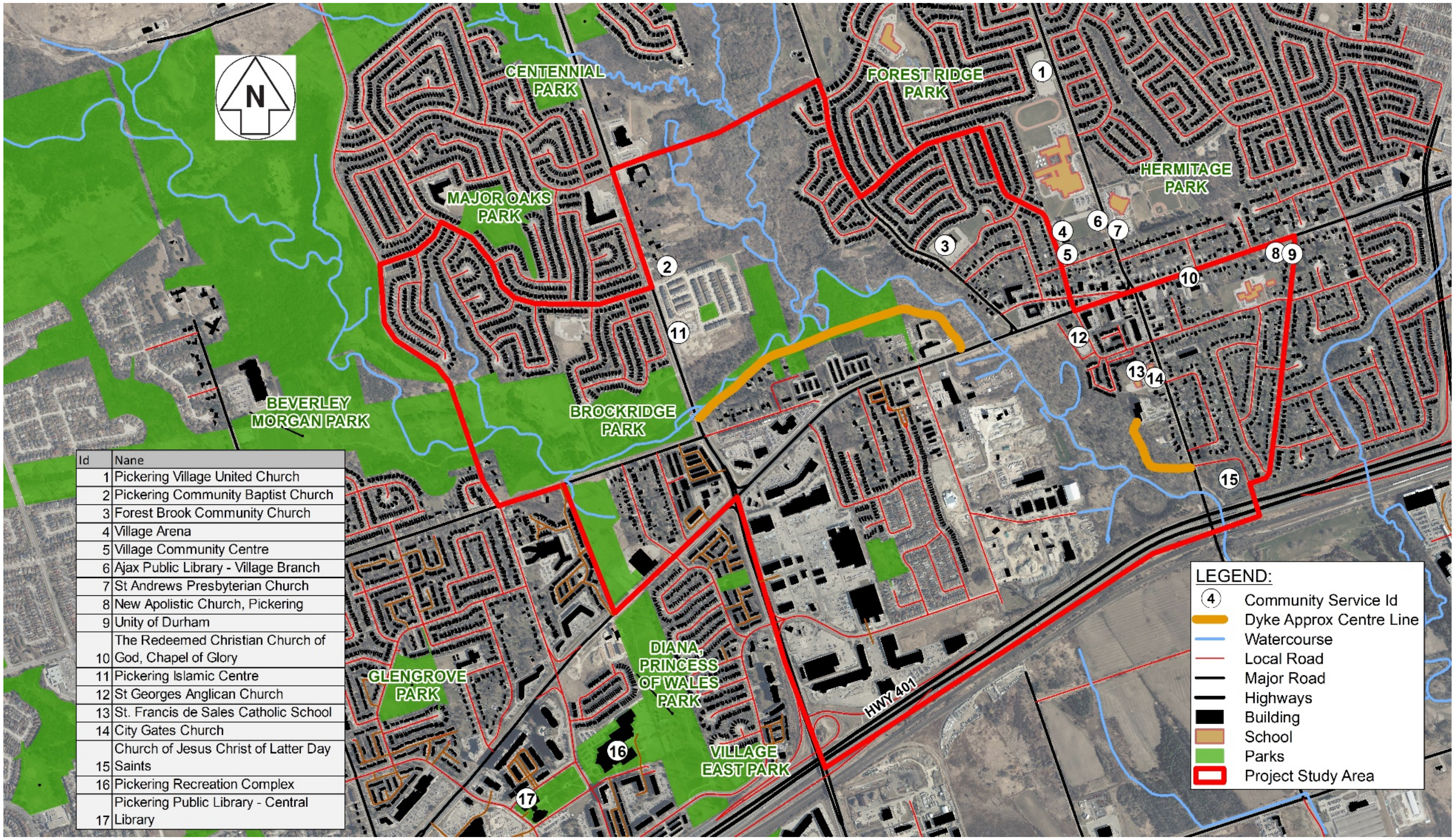
3.6.2.2 Special Policy Areas (SPAs)

The Project Study Area is located within the boundaries of both the Village East (Pickering) and Notion Road/Pickering Village (Ajax) SPAs. The SPAs have been discussed in section 2.1.

3.6.3 EXISTING INFRASTRUCTURE, SUPPORT SERVICES, FACILITIES

Infrastructure within the Project Study Area includes roads and associated pedestrian walkways and bridges, hydro, gas, storm, sanitary and water. Several places of worship are located within the Project Study Area. One school, St. Frances des Sales Catholic School is located within the Ajax (Village) portion of the Project Study Area (Figure 3-21).

FIGURE 3-21: EXISTING INFRASTRUCTURE AND FACILITIES



In 2019, KGS Group completed a subsurface utility engineering investigation to a Quality Level D. The investigation revealed the presence of sanitary and water lines which run adjacent and beneath the Pickering Dyke within the Direct Environmental Study Area along with a private discharge line which runs through the dyke. A stormwater sewer line runs along Kingston Road West. At the Ajax Dyke a sanitary line runs through the dyke within the Direct Environmental Study Area and a water line runs along Church St. Reference sketches in Appendix G for locations.

As-Built drawings for the area were provided by the Region of Durham (Appendix F) and potential utility interactions with respect to the proposed dyke rehabilitations were discussed during a meeting with TRCA. During this meeting the Region of Durham confirmed the presence of a sanitary sewer crossing the Pickering Dyke at segments 4 and 5 and a possible watermain crossing the dyke at segment 5. Three sanitary sewers were noted as crossing the Ajax Dyke, with the possibility of a watermain crossing the dyke. The Region of Durham recommended a Quality Level B investigation be conducted at the detailed design stage, with a Quality Level A being conducted where required. A copy of the meeting minutes is provided in Appendix J.

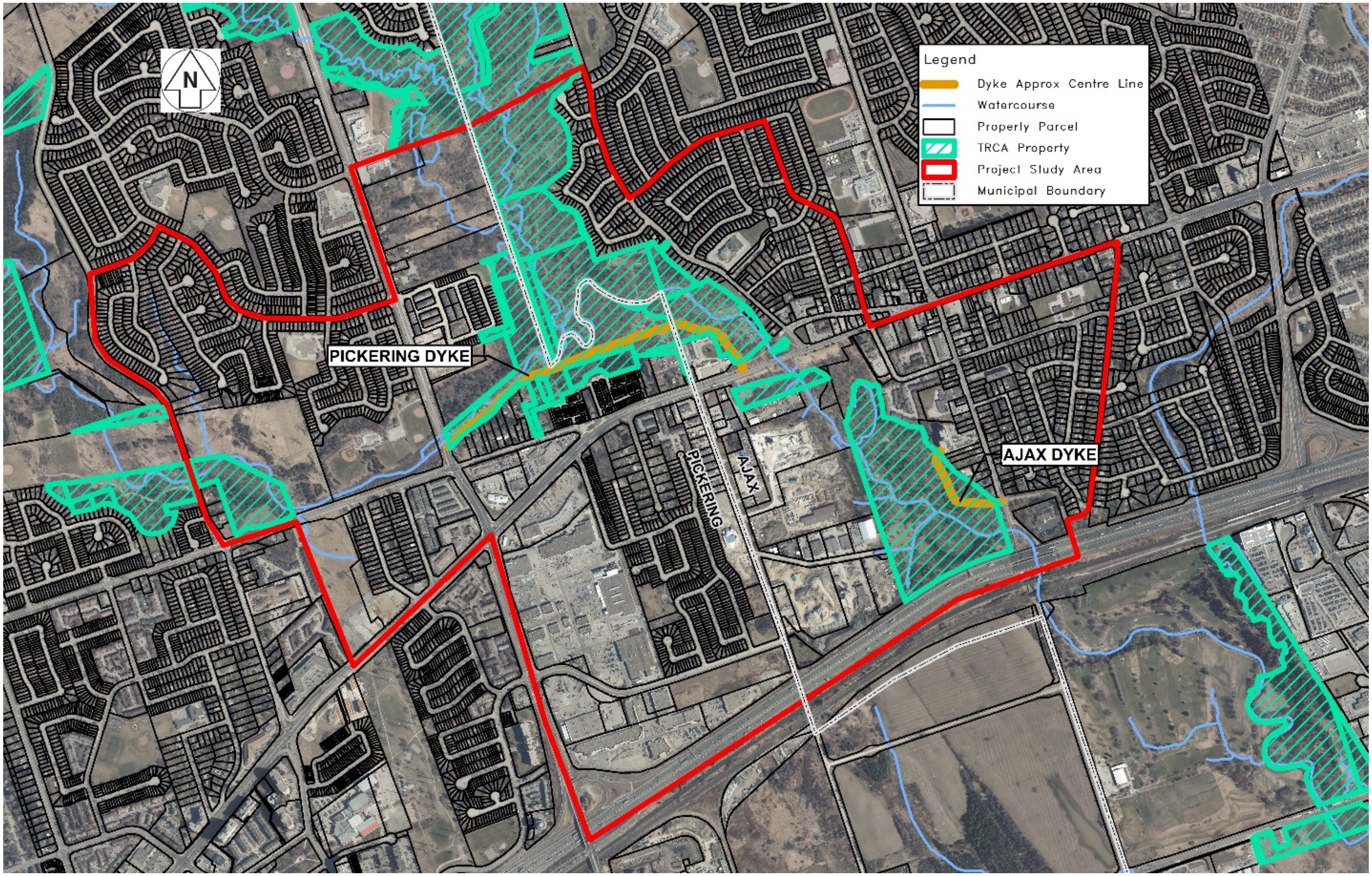
3.6.4 PEDESTRIAN TRAFFIC ROUTES

Pedestrian traffic within the Project Study Area is limited to sidewalks associated with major roadways/arterials as well as residential roads and municipal and Trans-Canada Trail systems (Figure 3-7 and Figure 3-18).

3.6.5 PROPERTY VALUE OR OWNERSHIP

Property owners within the Project Study Area include the TRCA, City of Pickering, Town of Ajax, Region of Durham as well as private owners. The TRCA owns the lands adjacent to the dykes within the Direct Environmental Study Area as shown on Figure 3-22.

FIGURE 3-22: TRCA PROPERTY LIMITS



3.6.6 EXISTING TOURISM OPERATIONS

There are no tourism operations within the Project Study Area.

3.6.7 PROPERTY/FARM ACCESSIBILITY

There are no zoned agricultural lands within the Project Study Area.

3.7 Technical / Engineering

3.7.1 RATE OF EROSION

Erosional processes pose a risk to the integrity of infrastructure situated near or under alluvial gravel-bed channels, especially in urban areas. Existing and future erosion risks to both dykes are documented in the following subsections. As well, depositional processes can impact flow conveyance and reduce the hydraulic capacity of both the main channel and the floodplain. Thus, deposition can influence channel migration processes and induce channel avulsions (i.e. a rapid shift in channel position).

The following sections provide a summary of the review of erosion processes/risk at the Pickering and Ajax Dykes. Detailed information is provided in Appendix C. Figures 3-10 and 3-11 were presented previously in this report.

3.7.1.1 Pickering Dyke – Erosion Risk

Rates of channel migration were documented at 14 meanders (Figure 3-10) near the Pickering Dyke. Time-averaged rates and the associated time period in which the meander displayed systematic channel migration are detailed in Table 3-8. Four existing meanders do not display systematic channel migration due to confinement by the Pickering dyke itself (M1, M3, M5) or by a valley wall (M14). High migrations rates were observed at M2 and M4 in Reach 1a and M13 in Reach 2. Both M2 and M4 are downstream of two prominent riffles that steepen the channel as it enters the meanders. Review of aerial imagery and field reconnaissance indicate the riffles have migrated, which has led to the subsequent down-valley migration at M2 and M4.

TABLE 3-11: CHANNEL MIGRATION RATES AND TRAJECTORIES NEAR PICKERING DYKE

Meander Id	Migration Rate (M/Yr)	Time Period[1]	Trajectory[2]	Lateral or Down Valley Migration?
M1	Confined by dyke	Not applicable	Not applicable	Not applicable
M2	2.1	2002 to 2018	NE	Down valley
M3	Confined by dyke	Not applicable	Not applicable	Not applicable
M4	1.8	1988 to 2018	NE	Down valley
M5	Confined by dyke	Not applicable	Not applicable	Not applicable
M6	1.0	2002 to 2018	ENE	Lateral

Meander Id	Migration Rate (M/Yr)	Time Period[1]	Trajectory[2]	Lateral or Down Valley Migration?
M7	0.3	2002 to 2018	WSW	Lateral
M8	0.8	2009 to 2018	NW	Lateral
M9	0.8	2009 to 2018	SE	Lateral
M10[3]	0.9	1946 to 2018	N	Both
M11	0.7	1967 to 2018	SE	Lateral
M12	1.1	1981 to 2018	NE	Lateral
M13	2.8	2002 to 2018	E	Down valley
M14	Confined by valley wall	Not applicable	Not applicable	Not applicable

1 – the time period of systematic migration from which the rate and trajectory were estimated

2 – cardinal direction

3 – outer bank is locally hardened

Geomorphic Solutions – Sernas Group Ltd. (2009) assessed five meanders (M2, M3, M5, M10, M11) near the Pickering Dyke as part of its detailed assessment. Similar to this current assessment, Geomorphic Solutions – Sernas Group Ltd. (2009) determined meanders M3 and M5 were confined by the dyke and not migrating. At M5, Geomorphic Solutions – Sernas Group Ltd. (2009) calculated a down-valley migration rate of 0.95 m/yr between 1978 and 2008. The current assessment documented a migration rate of 2.1 m/yr from 2002 to 2018 (the period that displayed systematic migration), suggesting channel migration is accelerating at M2. At M10, Geomorphic Solutions – Sernas Group Ltd. (2009) calculated a lateral migration rate of 0.64 m/yr between 1954 and 2008, which is slightly less than the migration rate (0.9 m/yr) calculated as part of the current assessment for 1946 to 2018. At M11, Geomorphic Solutions – Sernas Group Ltd. (2009) calculated a lateral migration rate of 0.57 m/yr and a longitudinal migration rate of 1.17 m/yr between 1954 and 2008. The current assessment documented a migration rate of 0.7 m/yr, which is less than the longitudinal migration rate calculated as part of the previous assessment. The south bank pedestrian bridge abutment, which is now exposed, may be slowing migration.

Based on historic and existing morphological conditions, the Pickering Dyke was divided into one of three erosion risk categories:

- **Low** – the channel is greater than 50 m from the dyke and it is unlikely to migrate or avulse within 50 m of the dyke in the next 25 years
- **Moderate** – the channel is within 50 m of the dyke or has the potential to be within 50 m of the dyke in the next 25 years as a result of channel migration or avulsion
- **High** – the channel abuts the dyke or has the potential to abut the dyke in the next 25 years as a result of channel migration or avulsion

Three high risk areas were delineated at M1, M3, and M5 (Figure 3-10). These are consistent with erosion areas documented in the previous geomorphic assessment (Geomorphic Solutions – Sernas Group, 2009).

The previous assessment noted failing erosion control blankets, localized soil loss and scour at these three sites. Review of aerial photography and site photographs from the previous assessment reveal growth of riparian vegetation on or near the dyke at all three encroachment sites. Riparian vegetation and associated root networks could increase the shear resistance of the bank to erosion. However, the vegetation could also locally displace the stone comprising the erosion protection. Although active erosion was not observed during field reconnaissance, erosion is expected at or near these locations in the future based on reach-scale planform adjustments. As well, toe erosion of the valley wall is likely to occur at M14 at a rate that could be estimated based on detailed site assessment.

During the recent field reconnaissance conducted by Palmer in 2019, the boulder revetment at M1 was intact and young deciduous trees and shrubs were growing atop and in the voids of the boulder revetment. The channel thalweg was located closer to the north (i.e. opposite) bank, which temporarily reduces erosion potential along the dyke. The energy gradient was low due to the prominent downstream riffle crest, which acts as a natural grade control. Some bank/dyke scour was noted at the downstream extent of the existing erosion protection. Lowering of the downstream riffle crest or a shift in the position of the thalweg adjacent the dyke could increase the erosion potential along the dyke at M1.

Similar to the energy gradient at M1, the energy gradient along M3 is low due to a prominent downstream riffle crest, which acts as a natural grade control. The boulder revetment along the downstream limb of M3 is intact and young deciduous trees and shrubs are growing atop and in the voids of the boulder revetment. Previous bank/dyke erosion was observed upstream of the boulder revetment near the upstream limb of M3, but recent down-valley channel migration of M2 has reduced the erosion severity at this site and has caused notable sand deposition adjacent the erosion. Lowering of the downstream riffle crest could increase erosion potential along the dyke at M3.

Many boulders in the localized revetment at M5 are displaced. The structure is less extensive than the erosion protection at M1 and M3. A down-valley shift in channel position could result in the thalweg abutting an unarmoured section of the dyke. Rapid channel migration at M4 has reduced the radius of curvature at both M4 and M5, which can increase erosion potential along both meanders. A large, high-relief sand deposit has formed at the upstream limb of M5 (concave-bank bench).

The rapid down-valley migration at M2 and M4, and associated reduction in radius of curvature (i.e. ‘tighter’ bends), could induce a channel avulsion near M3 and M5, respectively (Figure 3-10). In particular, a channel avulsion at M4/M5 could occur along the persistent topographic depression of the 1946 channel alignment. Avulsions and/or continued rapid channel migration could result in the channel abutting the bank/dyke downstream of existing erosion protection.

The large oxbow east of M6 is unlikely to be readopted in the short term because of the existing position of the Duffins Creek-West Duffins Creek confluence. If the oxbow is reoccupied, however, erosion protection will likely be required where the oxbow is within 10 m of the dyke. Downstream of the oxbow, Duffins Creek is sufficiently far from the dyke that erosion risk remains low. At M11, continued outer bank migration could undermine or outflank the south bank abutment of a pedestrian bridge (Figure 3-10). At M13, the channel is rapidly migrating, and the dyke is within 35 m of the channel. However, based on the down-valley migration trajectory, the channel is unlikely to migrate closer to the dyke.

3.7.1.2 Ajax Dyke – Erosion Risk

Rates of channel migration were documented at eight meanders (Figure 3-11) near the Ajax Dyke. Time averaged rates and the associated time period in which the meander displayed systematic channel migration are detailed in Table 3-12. Two meanders did not display systematic channel migration since 1988 (i.e. shortly after the dykes were constructed). M20 is confined by localized channel hardening downstream of the WSC structure. Lateral migration of M22 is hindered by the downstream Church Street South bridge. The other six meanders are migrating both laterally and longitudinally as Reach 3 readopts a more sinuous planform following channel straightening in the mid 20th century.

TABLE 3-12: CHANNEL MIGRATION RATES AND TRAJECTORIES NEAR AJAX DYKE

Meander ID	Migration rate (m/yr)	Time Period[1]	Trajectory[2]	Lateral or Down Valley Migration?
M15	1.2	2002 to 2018	SSE	Down valley
M16	0.6	1967 to 2018	E	Lateral
M17	0.9	1988 to 2018	SSE	Down valley
M18	0.8	2009 to 2018	ENE	Lateral
M19	0.3	1988 to 2018	SSE	Both
M20	Confined by bank protection	Not applicable	Not applicable	Not applicable
M21	1.0	1988 to 2018	SE	Down valley
M22	Confined by bridge inlet	Not applicable	Not applicable	Not applicable

1 – the time period of systematic migration from which the migration rate and trajectory were estimated

2 – cardinal direction

Geomorphic Solutions – Sernas Group Ltd. (2009) assessed one meander (M21) near the Ajax Dyke as part of its detailed assessment. At M21, Geomorphic Solutions – Sernas Group Ltd. (2009) calculated a down-valley migration rate of 1.01 m/yr between 1967 and 2008, which is nearly identical to the 1.0 m/yr migration rate calculated from 1988 to 2018 as part of the current assessment.

Based on historic and existing morphological conditions, the Ajax Dyke was divided into erosion risk categories (Figure 3-11). Most of the dyke is considered low risk because the dyke is greater than 50 m from the channel and there are no signs of migration toward the dyke. The dyke is locally within 40 m of the channel, however, the bank protection at M20 will hinder channel migration towards the dyke. M15 is migrating towards the stormwater ponds in the western floodplain. Migration of the channel into the ponds and the potential avulsion that could result would drastically alter channel dynamics and sediment supply downstream in the vicinity of the dyke. Migration of M15 should be monitored. The Church Street South crossing controls the channel location near M22 and, thus, channel migration is not expected at M22 unless the crossing is modified/replaced.

3.7.2 SEDIMENT DEPOSITION ZONES IN ECOSYSTEM

3.7.2.1 Pickering Dyke

Overbank sand deposition occurs throughout Reach 1a, Reach 1b, and Reach 2, suggesting high flows have good connection to the floodplain. In particular, a large overbank sand deposit was observed during field reconnaissance and in recent aerial imagery atop the south bank between M1 and M3 (Figure 3-23). Concave bank benches are present where the channel abuts the Pickering Dyke (e.g. M3 and M5). Gravel point, lateral, and medial bars are present throughout Reach 1a, Reach 1b, and Reach 2. Notable gravel bar deposits include the large point bars at M2 and M4, where the channel is actively migrating, and the lateral and medial bars downstream of the Duffins Creek-West Duffins Creek confluence. The riffles immediately upstream of M2 and M4 are significant deposition areas for gravel and cobble.

Reach 1a appears to be aggrading. Reach 1b and Reach 2 are also aggrading but to a lesser degree than Reach 1a, which is consistent with the findings of the previous geomorphic assessment (Geomorphic Solutions – Sernas Group, 2009). Aggradation in the active channel and deposition in the overland areas suggests the hydraulic capacity of the channel and floodplain could be decreasing. Reduction in the hydraulic capacity of the main channel can promote channel avulsions because the floodplain becomes more accessible during floods.

FIGURE: 3-23: OVERBANK SAND DEPOSITION BETWEEN M1 AND M3

3.7.2.2 Ajax Dyke

Numerous sand and/or fine gravel lateral and point bars are presented throughout Reach 3. Sand is deposited near the toe of banks throughout Reach 3 and locally atop the banks.

3.7.3 FLOOD RISK IN ECOSYSTEM

The study area includes two SPA's, designated[1] as such because they are developed areas that have historically existed within the Regulatory Flood Plain: Pickering (Village East) and Ajax (Notion Road Pickering Village). These urban areas would be flooded during the Regulatory Flood, which in this case is the flood resulting from the transposition of the Regional Storm (Hurricane Hazel) to the Duffins Creek watershed. They have been historically prone to flooding. The Pickering and Ajax Dykes were built in the 1980's to provide some level of flood protection for these SPA's, however not regulatory event flood protection.

3.7.3.1 2018 Flood Characterization and Remediation Studies

The Pickering and Ajax Dykes were designed to protect up to a flood event corresponding to a 500-yr return period. However, two recent studies: MIKE Flood 2D Model Development and Regulatory Floodplain Mapping Pickering/Ajax SPA (Valdor, 2018a) and Flood Characterization and Preliminary Remediation Investigations Pickering/Ajax SPA's (Valdor, 2018c) determined that, after evaluating the hydraulic conditions with modern hydraulic models and recent hydrologic data, and considering the current state of the dykes (which are lower than the original design by up to 0.1 m in the case of the Pickering Dyke and 0.33 m in the case of the Ajax Dyke), the intended level of flood protection is not achieved. One of the reasons is that the dykes would be overtopped even by floods of a lesser magnitude than a 500-yr event; but in addition, Valdor found that during a 500-yr event the SPA's would also be flooded from low areas where there are no dykes. These low areas are located between Kingston Rd and the Hwy 401, on the west creek bank, and on Church St and south of Mill St, on the east bank of the creek. This finding lead to the conclusion that the dykes alone could not provide protection for a 500-Year storm flood event.

With respect to the Regulatory Flood, which is even greater than the 500-yr flood event, Valdor found that in addition to the flooding mechanisms previously indicated, there are others that come into play, including additional low areas that are beyond the footprint of the existing dykes as well as conveyance restrictions at some of the crossings over the creek within the Project Study Area.

Appendix A shows the extent of the flooding, within the Project Study Area and beyond, as obtained in the previous study (Valdor, 2018a), for various flood events. The figures in Appendix A show extensive flooding in these areas, caused by events as small as the 350-yr storm flood.

The flood magnitude that would trigger overtopping differs for the two dykes:

- In the case of the Pickering Dyke, Valdor found that it would be overtopped by the flood resulting from the 350-yr storm; but not by that resulting from the 100-yr storm

[1] The designation of an SPA in Ontario requires approval by the Ministry of Municipal Affairs and Housing and the Ministry of Natural Resources and Forestry

- In the case of the Ajax Dyke, Valdor found that it would be overtopped by the flood resulting from the 100-yr storm; but not by that resulting from the 50-yr storm

Since the study by Valdor, which followed standard practice, only evaluated a number of discrete events, and did not include intermediate values between the 50-yr and 100-yr storm, or between the 100-yr and the 350-yr storm, it has been adopted that:

- The Pickering Dyke provides protection up to the 100-yr storm flood event
- The Ajax Dyke provides protection up to the 50-yr storm flood event

To characterize the hazard posed to people in the flood zone, Valdor used the criteria indicated in Appendix 6 of the Technical Guide River and Stream Systems: Flooding Hazard Limit MNR (2002) to define the conditions that would render a typical adult, exposed to floodwaters, unstable. These criteria are commonly referred to as the “2x2 Rule” and correspond to:

- Maximum depth of flooding of 0.8 m
- Maximum flow velocity of 1.7 m/s
- Maximum depth-velocity product of 0.37 m^2/s

Since the parameters used to define the 2x2 Rule also determine the availability of safe or unsafe conditions for ingress to and egress from flooded areas, Valdor divided the areas identified as flooded into three categories of risk to people:

- Low Risk, consisting of areas where the flow depth is less than 0.3 m and in which vehicular and pedestrian ingress and egress are available (this is also based on the provisions indicated in Appendix 6 of MNR (2002)
- Moderate Risk, consisting of areas where the flow depth is more than 0.3 m, but the values of flow depth, velocity and depth-velocity product are lower or equal than those defined by the 2x2 Rule. In this area ingress and egress is available for pedestrian but not for vehicles
- High Risk, consisting of those areas where the values defined by the 2x2 Rule are exceeded, and where ingress and egress are not available for pedestrians or for vehicles.

Valdor then estimated the extent of the areas within each risk category and for each SPA in the Project Study Area. The results are summarized in Table 3-10 and 3-11 for the 500-year storm flood and the Regional Storm flood. The Valdor 2018 reports did not include similar tables for flows of lesser magnitudes.

TABLE 3-13: PICKERING (VILLAGE EAST) SPA – EXTENT OF AREAS IN EACH FLOOD CATEGORY

Flood Event	Not Flooded	Low Risk	Moderate Risk	High Risk
500-yr Storm Flood	46.35 ha or 67.8% of SPA	8.94 ha or 13.0% of SPA	4.57 ha or 6.7 % of SPA	8.56 ha or 12.5% of SPA
Regulatory Flood (Regional)	4.07 ha or 6.0% of SPA	5.54 ha or 8.1% of SPA	8.90 ha or 13.0 % of SPA	49.88 ha or 72.9% of SPA

TABLE 3-14: AJAX (NOTION RD-PICKERING VILLAGE) SPA – EXTENT OF AREAS IN EACH FLOOD RISK CATEGORY

Flood Event	Not Flooded	Low Risk	Moderate Risk	High Risk
500-yr Storm Flood	14.19 ha or 32.8% of SPA	9.28 ha or 21.4% of SPA	8.44 ha or 19.5 % of SPA	11.4 ha or 26.3% of SPA
Regulatory Flood (Regional)	1.06 ha or 2.5% of SPA	0.99 ha or 2.3% of SPA	0.65 ha or 1.5 % of SPA	40.61 ha or 93.8% of SPA

The study (Valdor, 2018c) also reported the number of buildings in the area categorized as High Risk, which are summarized in Table 3-15.

TABLE 3-15: BUILDINGS IN THE AREA OF HIGH FLOOD RISK CATEGORY

Pickering SPA		Ajax SPA		Building Type
500-Yr Storm Flood	Regulatory Flood (Regional)	500-Yr Storm Flood	Regulatory Flood (Regional)	
15	400	13	23	Residential
2	12	3	25	Commercial

As part of the Valdor study, three (3) flood remediation options were investigated. These were directed to mitigate the flooding caused by the 500-year Storm and the Regional Storm, and include not only remediation of the existing dykes but also enhancements of the flood protection system in the Project Study Area, such as additional dykes and conveyance enhancements.

The components of these flood remediation options are shown in Appendix A. The cost of implementing these options was found by Valdor to be large and, in the case of the options for mitigating the Regulatory Flood, caused by the Regional Storm, prohibitive.

Valdor recommended that further study be undertaken in accordance with the Conservation Authority Class EA for Remedial Flood and Erosion Control Projects (Conservation Ontario, 2013) to review the conditions of the dykes in further detail, evaluate and select the preferred solution to achieve dyke rehabilitation and flood remediation for the 500-yr and/or Regional storms. They also recommended that basic repairs and maintenance items identified in the study be completed prior to completion of the Class EA project.

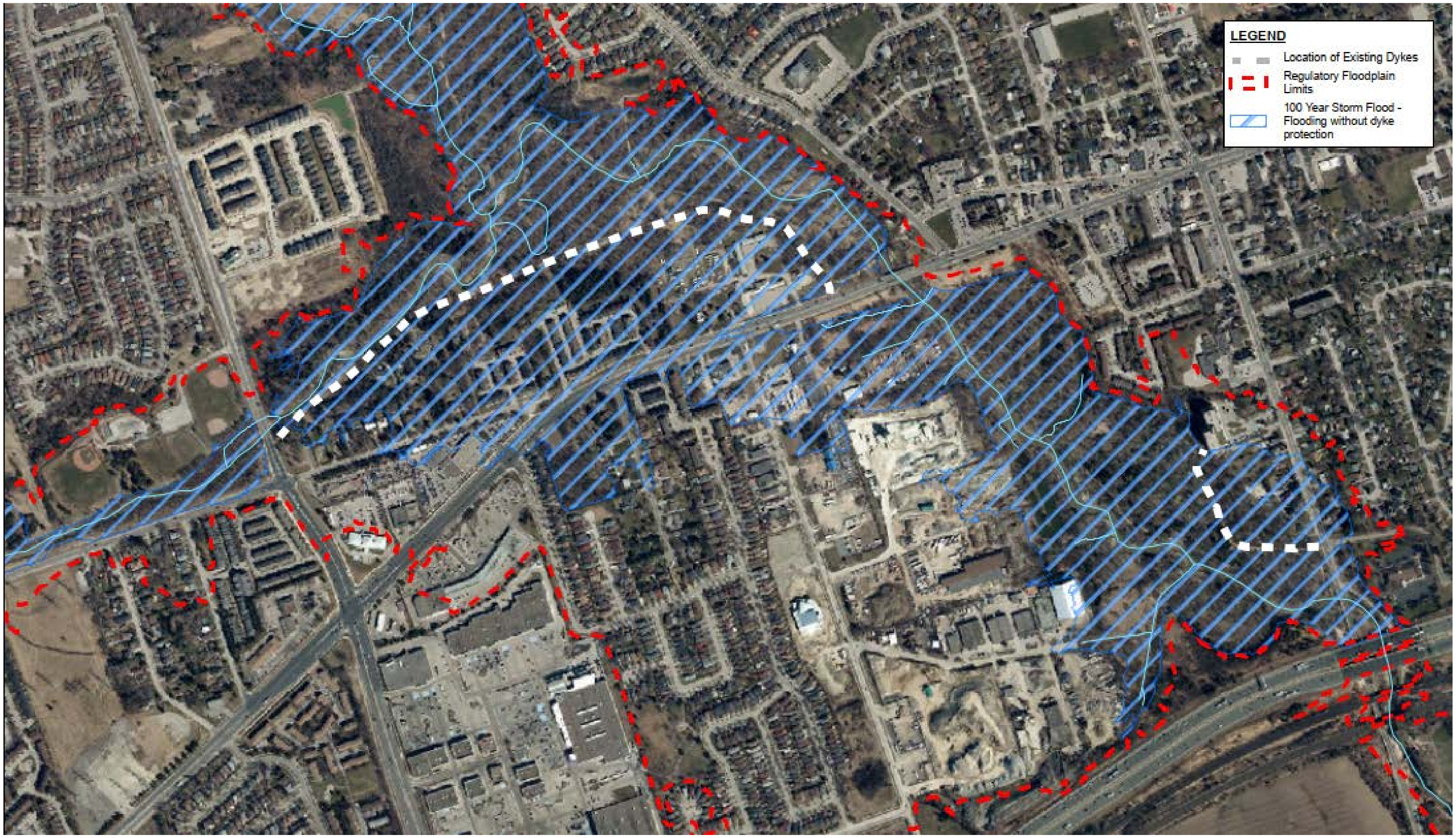
3.7.3.2 Additional Flood Analyses

As part of the evaluation of flooding conditions in the Project Study Area, TRCA carried out simulations of various scenarios using a MIKE Flood model of the Duffins and West Duffins Creeks (Appendix H). These included a simulation of the conditions during the flood caused by the 100-Yr design storm, and without the dykes in place. The results are shown in Figure 3-24.

Figure 3-24 shows that without the Pickering and Ajax Dykes or if these dykes were to fail, the flooding would extend south of Kingston Rd W (Pickering Dyke area) and west of Church St S (Ajax Dyke area). This would directly impact the properties adjacent to the dykes, where there could be damages to the buildings, ancillary structures and contents, depending on the elevation and characteristics of each property. The population living on the affected houses would most certainly need to be evacuated while hazardous conditions persist. A similar situation could be experienced at properties south of Kingston Rd W and east of Church St S, that are shown within the estimated flooded area in Figure 3-24. The flooding would include portions of these and other adjacent roads, causing interruption to traffic and transportation services. Damage to infrastructure could also occur (trails, pipes, communication lines, etc.) that could cause service interruptions and would require repair measures. In the event of a dyke failure, the dyke would need to be reconstructed. Other associated costs would include the emergency response as well as the post-flood necessary cleaning.

The flooding depicted in Figure 3-24 would cause economic damages; and, perhaps more critically, would put people in hazardous conditions, and could cause anxiety in the population and negatively impact the health and well being of the community in the Project Study Area.

FIGURE 3-24: ESTIMATED EXTENT OF FLOODING IN THE PROJECT STUDY AREA WITHOUT THE PROTECTION PROVIDED BY THE PICKERING AND AJAX DYKES – 100 YEAR STORM FLOOD



3.7.3.3 Ice Jam Related Flooding

In the past there have been winter flooding events in the Project Study Area associated with river ice conditions. These have not been rigorously studied, but anecdotal information and photos provided by TRCA indicate that ice jams can form at various locations along the creek within the area and cause water levels that exceed the banks of the creek. During the spring of 2019, an ice jam event occurred, that raised the water levels beyond the river banks and against the wet slope of the dykes.

Figures 3-25 and 3-26 show photos obtained during that event, in March 15 of 2019. The photos correspond to the Pickering Dyke in the areas near West Duffins Creek. They show flooding of the overbank areas that reached approximately within 1 m of the dyke crest. Such a flooding would have extended across the banks, likely with a width of more than 50 m on the West Duffins Creek and more than 100 m on Duffins Creek.

Anecdotal information provided in discussions with TRCA indicate that ice jams have occurred in the past at the crossing of Church St S over Duffins Creek. Photos of the March 2019 event, from downstream of the Project Study Area, show high water levels that reached the girder at the Bayly St Bridge, which suggests that ice jamming could also occur downstream of this location, approximately 2 km downstream of the Church St S crossing, that could impact the conditions in the Project Study Area. It must be noted that the dykes were not designed and built with consideration of ice jam conditions.

FIGURE 3-25: PICKERING DYKE DURING ICE JAM FLOODING – MARCH 15, 2019. WATER AGAINST THE WET SIDE OF THE DYKE

FIGURE 3-26: PICKERING DYKE DURING ICE JAM FLOODING – MARCH 15, 2019 ICE REMNANTS ON THE CREEK OVERBANK AREAS

3.7.4 DYKE SLOPE STABILITY

This section provides a general description of the dykes as well as previous geotechnical investigations and findings regarding the stability of the dyke slope as it compares to the performance criteria as described in Ontario's Lakes and Rivers Improvement Act (LRIA).

The Pickering Dyke extends for approximately 1,150 m from Brock Rd at its west tie-in to Kingston Rd W at its east end. Along the first 400 m from Brock Rd it runs on a narrow strip of land between private properties on the south (dry side) and West Duffins Creek on the north (wet side). This stretch of the dyke features creek bank rip-rap protection that was implemented in 2008. Beyond 400 m east of Brock Rd, the Pickering Dyke has a walking trail on the crest for approximately 300 m. Along that stretch the West Duffins Creek joins the Duffins Creek. The space between the creeks and private properties is wider from 400 m east of Brock Rd to the end of the dyke at Kingston Rd W. For approximately the last 240 m from Kingston Rd the Trans Canada Trail runs along the wet toe of the dyke. Photos M1 to M15, in Appendix F, show selected locations of the Pickering Dyke.

The Ajax Dyke extends for approximately 340 m from its tie-in at Church St S to the condo property at 92 Church St S. For approximately 150 m from the tie-in at Church St S, the Trans Canada Trail runs along the dyke's crest. Photos M16 to M20, in Appendix F, show selected locations of the Ajax Dyke.

3.7.4.1 Previous Geotechnical Investigations

The earliest geotechnical design documents for the dykes in the study area were geotechnical investigation reports prepared by Geo-Canada Ltd in 1984 and 1985 for the Ajax and Pickering Dykes, respectively. The investigations were completed prior to the design and construction of the dykes. A detailed slope stability assessment of the dykes was not completed, but the design was checked to determine the estimated factor of safety (FOS) against potential bearing capacity failures. Those reports also provided the following engineering information:

- the dyke freeboard recommendations for the water surface profile that was understood to be applicable at that time for the 1:500 year storm event;
- the estimated settlement that could be anticipated following construction of the dykes; and
- the duration of a flood event that would be necessary before the dykes could fail by uplift and/or internal erosion (or "piping").

Based on these reports, it is understood by KGS Group that the original design conclusions for the dykes were that:

- both dykes had an estimated FOS against bearing capacity failure of at least 2.0,
- the Pickering Dyke would have 0.3 m of freeboard for the 1:500 year storm event,
- the Ajax Dyke would have no freeboard for the 1:500 year storm event,
- both dykes could settle by 0.1 m,
- both dykes could theoretically fail by internal erosion (or "piping") and/or uplift under the design flood event if the flood peak was sustained longer than one or two days and
- design measures to mitigate the risk of potential dyke failures by internal erosion and/or uplift were not necessary based on a consideration of the probable duration of flooding on Duffin's Creek being less than one or two days and also considering the assumed soil permeability conditions.

Critical to the original design assumption was a comparison of the time-dependent nature of flood events relative to the anticipated soil permeability conditions. The reports did conclude that internal erosion could threaten the stability of the dykes if the near surface foundation soils beneath the Ajax Dyke were subjected to the design flood for a one-month period. In other words the dykes were not designed for steady state seepage conditions to develop.

Similarly, it was concluded that the foundation soils beneath the Pickering Dyke would only sustain a one week flood event. The reports also commented that a confined sand and gravel layer, typically encountered in the foundation soils 2 m to 3 m below they dyke fill, could allow flood waters to induce high uplift pressures in as little as one day under flood conditions. Ultimately, it was concluded that remediation measures to address potential seepage deficiencies were not necessary, based on the probable flood duration being in the order of hours. It was recommended instead to monitor the wet side toe of dyke for performance during flood events.

In 2018, Valdor completed a Dyke Level of Service and Rehabilitation Report for both the Pickering and Ajax Dykes. This was the first assessment in which a detailed slope stability assessment of the existing dykes was completed using numerical modelling techniques and the analysis of multiple potential slope stability slip surfaces under a variety of potential groundwater conditions. It was also the first time that the performance of the dykes was compared to the dam design criteria of the Lakes and Rivers Improvement Act (LRIA) Geotechnical Design and Factors of Safety Technical Bulletin. Detailed slope stability FOS values from that assessment for a number of cross-sections for both dykes can be found in the Valdor report. The key findings were:

- The dykes did not achieve a minimum FOS of 1.5 under normal operating conditions (i.e. non-flood conditions), but all dyke slopes had an estimated FOS greater than 1.0. A FOS of 1.0 or lower implies that a slope failure can occur under the model input assumptions. The dykes were concluded therefore to be analytically stable under normal conditions in that the forces resisting a slope movement were technically greater than the forces driving a slope movement; however, the ratio of forces resisting potential slope movements to those driving potential slope movements was not high enough to achieve the minimum design FOS recommended by the LRIA.
- The "dry" side slope of the dykes did not achieve a minimum FOS of 1.3 under the design flood event assuming that the flood event was sustained long enough to achieve steady-state seepage conditions through the dyke and foundation soils. Most sections of the dry side slope were concluded by Valdor to have a FOS less than 1.0 under this condition and could therefore become unstable under a sustained flood event.
- The "wet" side slope of the dykes did not achieve a minimum FOS of 1.3 under a potential rapid drawdown scenario immediately after the design flood event. All sections of the dyke were identified by Valdor as having a FOS less than 1.0 under this condition such that the dykes could therefore be unstable after a sustained flood event.
- All dyke slopes met or exceeded a minimum FOS of 1.0 under a seismic pseudo-static analysis condition. Based on satisfying this minimum FOS requirement and assessing the site soils to be suitably compact (i.e. not liquefiable), no further post-earthquake analyses was considered necessary. Additionally, because seismic design criteria are for a normal condition (i.e. when the dykes are not retaining water), this condition is not expected to govern the design, and there would be little risk of flooding should the dyke fail during an earthquake.

3.7.4.2 2019 Geotechnical Investigations

KGS Group completed a drilling and soil sampling program from July 6th to 7th, 2019. The locations and results of the investigations are included in the geotechnical report in Appendix B. A total of six test holes were drilled between the Ajax and Pickering Dyke sites. Four test holes were drilled at Pickering Dyke site and two test holes were drilled at the Ajax Dyke site. Samples of both dykes were tested for O.Reg 558 TCLP - Metals and Inorganics analyses.

The Pickering Dyke was found to consist of a clayey silt till fill and the foundation soils consist of variable layers of silty sand, clayey silt, sand with gravel, overlying a dense, hard clayey silt till. KGS Group's interpretation of the site stratigraphy along the Pickering Dyke profile is included in Figure GR-01 of Appendix B.

The Ajax Dyke was found to consist of a clayey silt till fill and the foundation soils consist of a layer of clayey silt, overlying sand and sand with gravel. KGS Group's interpretation of the site stratigraphy along the Ajax Dyke profile is included in Figure GR-02 of Appendix B. Interpretation of the most likely stratigraphic profiles considered the 2019 geotechnical investigation data, as well as previous geotechnical investigation data completed in 1984, 1985, and 2017.

Groundwater monitoring wells were installed as part of the 2019 investigations and falling head tests to measure soil permeability were completed in these wells as well as in select wells that were installed in 2017 as part of the Valdor study (Dyke Level of Service and Rehabilitation Report, 2018). The results of the falling head tests and the recommended geotechnical design parameters are included in the geotechnical report in Appendix B. All laboratory soil testing results are also included with the Appendix B report. It was found that the fill material for both dykes was not leachate toxic based on the samples tested. Observation at the time of drilling found no potential contamination of soil.

3.7.4.3 Stability Assessment

As part of this assignment, KGS Group has completed an independent seepage and slope stability analysis of the existing Ajax and Pickering Dykes. That assessment is presented in detail in the Appendix H Geotechnical Design Rationale memorandum. Appendix H includes the relevant design criteria, an assessment of the existing conditions, and an assessment of dyke rehabilitation Design Concepts presented in later sections of this report.

As summarized in the Appendix H Memorandum, we have come to similar conclusions regarding the dyke FOS values. KGS Group has also completed an independent investigation of the dyke and foundation soils and we believe that the in-situ dyke soils are suitable for the purpose of water retention. Fundamentally, the dykes are too steep on the dry side to satisfy LRIA slope stability FOS criteria under flood conditions. The dykes are also too steep on the wet side to satisfy LRIA slope stability FOS Criteria for a rapid drawdown from flood conditions to normal river levels. It would also not be sufficient to reconstruct the dykes entirely out of cohesive soils, as the overall footprint is too narrow to satisfy typical seepage exit gradient criteria without some form of seepage control (i.e. cut-offs or filters).

Transient drawdown curves for the 1:500 year design storm along Duffins Creek were also examined as part of the geotechnical slope stability analyses to assess the relative likelihood of the development of steady-state seepage conditions through the dyke and foundation soils and also to determine the likelihood of excess porewater pressures remaining elevated within the dyke and foundation soils as part of a rapid drawdown condition. While rates of flood staging can vary by location, the quickest rate of staging and drawdown for the design flood event amounts to approximately 3 mm per minute and the longest approximation of a flood peak at the 1:500 year level, lasts approximately 6 hours. Conservative transient flood hydrographs were therefore developed for seepage and slope stability models that assume a doubled rate of flood staging (6 mm per minute) and assumed a flood peak of 24 hour duration. The purpose was to assess whether or not alternate, time-dependent criteria could potentially be considered to develop more economical remediation solutions. It was found that:

- for the conservative-end soil saturated hydraulic conductivity values recommended in the geotechnical investigation report, steady-state seepage conditions could develop in the dyke foundation soils within 24 hours and,
- the performance of the dykes under the assumed rate of drawdown is improved with time-dependent pressure dissipation effects. Low end saturated hydraulic conductivity values do not allow significant porewater pressures in dyke fill to develop and high end saturated hydraulic conductivity values allow improved pressure dissipation during the drawdown. While some sections of the dykes that are closest to the creek are still analytically unstable during a drawdown with these assumptions, many other sections are analytically stable, but still deficient of drawdown FOS criteria.

For the above reasons, KGS Group completed falling head tests as part of this assignment to narrow down the potential range of site-specific permeability conditions. The hydraulic conductivity values recommended in the Appendix B documents can be considered when optimizing dyke remediation options during subsequent stages of design. Based on our preliminary analysis using the recommended hydraulic conductivity parameters in the geotechnical report, steady-state seepage conditions can develop within the dyke foundation soils within 24 hours while the dyke fill material is still saturating. This means that there may be room to optimize remediation measures during subsequent stages of design by considering a transient seepage analysis and a minimum desired flood duration for which the dykes can be considered reliable. If a transient analysis is completed to optimize the final design, the desired duration for which the optimized design can be considered reliable should be determined in consultation with TRCA. The minimum duration should not only consider the current 500-year flood hydrograph, but also an additional factor of safety to account for inherent variability in flood forecasting, changes to the drainage basin over time, changes from alterations to land use and development, and the effects of climate change. That duration should be stated as a limitation in the subsequent design brief for the optimized solution. If there is no tolerance for risk considering a conservatively assumed maximum duration of the design flood event, then detailed design should proceed according to the assumption of steady-state seepage conditions as required by LRIA geotechnical design and factors of safety.

3.7.5 EXISTING STRUCTURES

There are various types of infrastructure in the Project Study Area as well as some that pass near, through or under the dykes.

Roads in the Project Study Area and crossings over the creek have been described in Sections 3.2.16 and 3.2.17. The infrastructure in the direct environmental study area includes:

- sanitary sewer lines
- water mains
- storm and surface draining culverts
- one private pump discharge line

The alignment of these underground infrastructure is shown in the drawings provided in Appendix G and Appendix I.

3.7.6 HAZARDOUS LANDS/SITES

There are no hazardous lands/sites located within the Project or Direct Environmental Study Areas.

4.0 EVALUATION OF ALTERNATIVE SOLUTIONS

The purpose of this Environmental Assessment is to address the problem described in Section 1.2 within the baseline context described in Section 3.0 of this report. This was achieved by advancing solutions from a high-level stage (referred to as *alternative solutions)* to a more detailed stage (referred to as *design concepts)*. At the alternative solution level, general strategies to solve the problem were devised, without defining the specific components of the solution, which were then incorporated and supported with engineering analyses at the design concept level. It is important to note that the design concepts still need to go through more detailed design stages, subsequent to the EA completion, before they can be implemented.

This section of the report describes the alternative solutions considered as part of the EA and their design criteria, the basis established for their evaluation, and the results of that evaluation that led to the selection of preferred alternative solutions. The latter were subsequently developed into the Design Concepts described in Section 5.0.

4.1 Design Criteria and Objectives

To develop the alternative solutions, a set of design criteria were established, directed to address the problem as defined in Section 1.2.1. As per these design criteria, the solutions for the Pickering and Ajax Dykes must ensure that at minimum:

- The level of flood protection associated with the existing crest elevation of the dykes is at minimum maintained, or improved
- The rehabilitated dykes meet current applicable engineering design standards and FOS
- The creek bank erosion in the areas that can affect the stability of the dykes is controlled, at minimum for a 25-year horizon
- The crest width of the future dykes provides safe access for maintenance staff and equipment
- The future dykes are free of vegetation that could compromise their integrity

The dykes were originally intended to provide protection up to a 500-year storm flood event; but recent studies indicate that the existing crest levels correspond to lesser events: 100-year storm flood for the Pickering Dyke and 50-year storm flood for the Ajax Dyke. Those studies also indicate that protection for the current estimate of the 500-year storm flood is not possible by just raising the dykes higher; but rather requires additional measures beyond the scope of the dyke rehabilitation. It was then decided that the rehabilitated dykes would be structurally designed for the 500-year storm flood; but the criterion for crest level would be set at minimum at their current elevation. The dykes would then be suitable for a potential future enhancement to the 500-year storm flood level without full reconstruction.

Additional objectives of the EA include preserving or enhancing the environmental and ecological conditions in the area, as well as improving resiliency of the flood protection infrastructure and accessibility to the dykes during a flood event, while minimizing overall costs (capital, maintenance and flood damages were considered).

4.2 Description of Preliminary Alternative Solutions

A total of 5 preliminary alternative solutions were screened as part of this Class EA. These included the following:

- **"Hard" Engineering Solution (Structural) for 50, 100 and 500-year storm events** – Rehabilitation of the existing flood protection structure with a highly engineered structural solution. This solution includes a structural component (i.e. retaining walls and/or seepage-cutoff methods) to provide or contribute to the stability of the dyke and to allow achieving the required factors of safety (FOS). A general depiction of how a hard engineering solution could be achieved is provided in Figure 4-1.
- **"Soft" Engineering Solution (Embankment) for 50, 100 and 500-year storm events** – Rehabilitation of the existing flood protection structure with a softer, more natural looking stable berm (i.e. earth embankment with stable slopes). This solution does not include structural components for stability; but relies on the stability of the dyke slopes to achieve the required FOS. A general depiction of how a soft engineering solution could be achieved is provided in Figure 4-2.
- **Do Nothing** – keep existing flood protection structures in their current state. The risk of flooding due to dyke failure is not mitigated. This alternative includes ongoing repair works that would be required as conditions degrade, and the impacts of a dyke failure are included in the alternative evaluation.
- **Removal of Vegetation on Existing Flood Protection Structure** – Rehabilitation of the existing flood protection structure limited to the removal of all vegetation within the limit of the Dykes, with no other changes to their current state. The rationale being that the large woody vegetation damages the dykes. However, there are other deficiencies with the dykes, beyond just the damage caused by vegetation.
- **Removal of Existing Flood Protection Structure** – Decommissioning and removal of the existing flood protection structure.

FIGURE 4-1: "HARD" ENGINEERING SOLUTION (STRUCTURAL) – TYPICAL CROSS SECTION AND EXAMPLE APPEARANCE

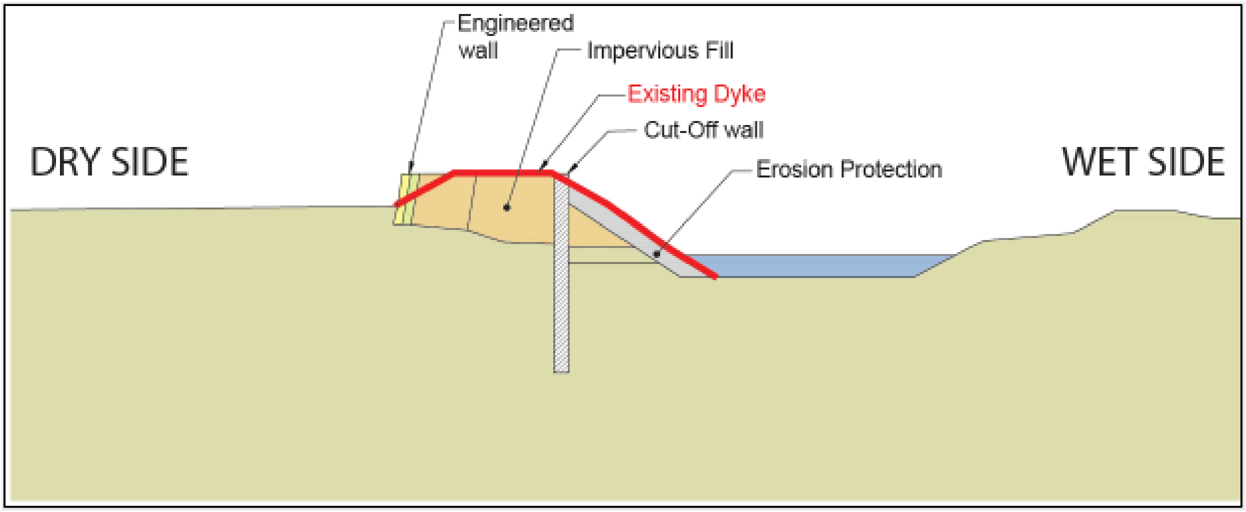
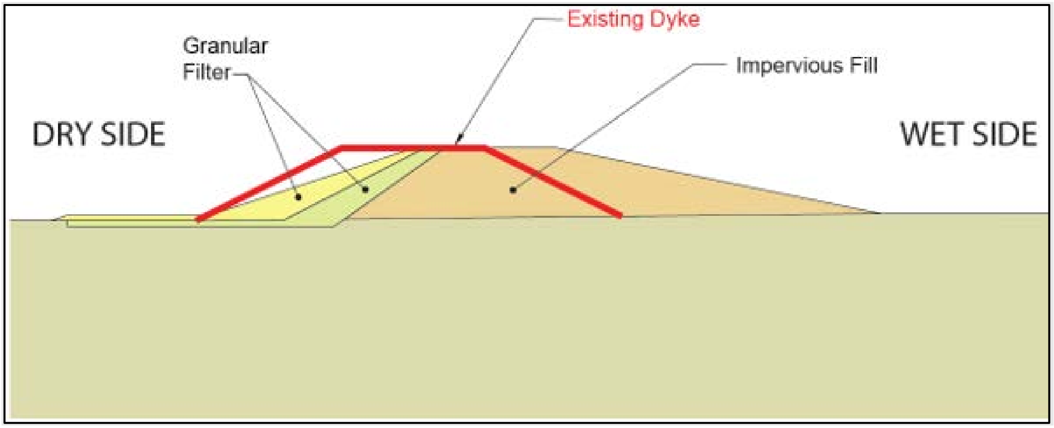


FIGURE 4-2: "SOFT" ENGINEERING SOLUTION (EMBANKMENT) – TYPICAL CROSS SECTION AND EXAMPLE APPEARANCE



4.3 Screening of Preliminary Alternative Solutions

The alternative solutions were screened to determine if they could address the problem and objective of project. Those that could not were dropped from further consideration. The following question was used to screen the alternatives:

Does this alternative ensure the performance of flood protection at the current crest levels, at minimum and does it meet current engineering design standards?

TABLE 4-1: SCREENING OF PRELIMINARY ALTERNATIVE SOLUTIONS

Alternative Solution	Answer to Screening Question		Rationale for Screening Results
	Pickering Dyke	Ajax Dyke	
"Soft" Engineering Solutions – 50-year storm event	No	Yes	While the solution allows achieving the FOS and meeting current standards, a 50-yr storm event on the Pickering Dyke would result in a reduction in flood protection with respect to the current crest level. The solution satisfies the screening criteria only for the Ajax Dyke.
"Soft" Engineering Solutions – 100 Year Storm Event	Yes	Yes	The solution satisfies the screening criteria for both dykes.
"Soft" Engineering Solution – 500 Year Storm Event	No	No	The 500-yr storm flood exceeds current crest levels of the existing dykes. Raising the dykes is not sufficient to protect against the 500-yr storm flood, since flooding during such an event would still occur due to additional flooding mechanisms that the dykes alone cannot prevent. Implementing additional flood protection measures is beyond the scope of this study.
"Hard" Engineering Solutions – 50-year Storm Event	No	Yes	While the solution allows achieving the FOS and meeting current standards, a 50-yr storm event on the Pickering Dyke would result in a reduction in flood protection with respect to the current crest level. The solution satisfies the screening criteria only for the Ajax Dyke.
"Hard" Engineering Solutions – 100 Year Storm Event	Yes	Yes	The solution satisfies the screening criteria for both dykes.
"Hard" Engineering Solution – 500 Year Storm Event	No	No	The 500-yr storm flood exceeds current crest levels of the existing dykes. Raising the dykes is not sufficient to protect against the 500-yr storm flood, since flooding during such an event would still occur due to additional flooding mechanisms that the dykes alone cannot prevent. Implementing additional flood protection measures is beyond the scope of this study.
Do Nothing	No	No	The dykes in current condition do not meet engineering design standards, and therefore do not mitigate the current risk of flooding due to a potential dyke failure. This solution does not satisfy the screening criteria; but will be used as a baseline for further evaluation of the alternative solutions.
Removal of Vegetation on Existing Flood Protection Structure	No	No	Removing the vegetation on the existing dykes is not sufficient to allow meeting design standards and mitigating dyke failure risk. This solution does not satisfy the screening criteria and was not further considered.
Removal of Existing Flood Protection Structure	No	No	Removal of the dykes would not allow achieving the flood protection level that they could provide with the current crest level. This solution does not satisfy the screening criteria and was not further considered.

4.4 Short Listed Alternative Solutions

Based on the preliminary screening completed as part of this EA, the following alternative solutions were selected for further evaluation.

- Do Nothing. This solution does not satisfy the screening criteria; but was used as a baseline for further evaluation of the alternative solutions.
- “Soft” Engineering Solution (Embankments) to protect up to the 50 year storm flood event for the Ajax Dyke
- “Soft” Engineering Solution (Embankments) to protect up to the 100 year storm flood event for both the Pickering and the Ajax Dyke
- “Hard” Engineering Solution (Structural) to protect up to the 50 year storm flood event for the Ajax Dyke
- “Hard” Engineering Solution (Structural) to protect up to the 100 year storm flood event for both the Pickering and the Ajax Dyke

4.5 Evaluation of Alternative Solutions

The pre-selected alternative solutions were evaluated with consideration of their impact to the natural environment, social environment, as well as technical aspects and their cost, based on a 10% level of design. To allow this evaluation, the dykes were divided into segments based on commonalities of specific stretches of these structures and their surroundings. This division allowed evaluation of the alternative solutions with specific consideration of the unique characteristics of each dyke segment, allowing for different solutions to be selected for different segments of the same dyke.

4.5.1 DYKE SEGMENTS

The Pickering Dyke was divided into five segments based on commonalities, within each segment, in terms of characteristics of the existing dyke or its surroundings, that would make a given solution more suitable. The five segments for the Pickering Dyke are described below. The limits of each segment are shown on Figures 4-3 and 4-4. References to dyke stations correspond to Sketch 15, for the Pickering Dyke, and Sketch 11, for the Ajax Dyke, in Appendix G.

Segment 1 extends from the west end of the dyke at Brock Rd (Station 1+161) to approximately Station 1+070, for a length of approximately 90 m. This segment is characterized by the reduced space available for the dyke between the West Duffins Creek and private properties. This segment of the dyke is adjacent to some stretches of creek that feature high bank erosion risk, some of which are already undergoing bank erosion. At those locations the dyke has a steep wet side slope with protective rip-rap that continues along the creek bank down to the channel bed. The dyke along this segment is generally low, with less than 2 m of height from toe to crest. There are no underground utilities along this segment and the substrate consists of high permeability material (sand and gravel) overlying a low permeability till within approximately 7 m from grade. There is one existing surface drainage culvert along this dyke segment. There is not an official walking trail along this dyke segment.

Segment 2 extends from the east end of Segment 1 (approximately Station 1+070) to approximately Station 0+730, for a length of approximately 340 m. This segment is for the most part similar to Segment 1, with reduced space between the West Duffins Creek and private properties, areas of high bank erosion risk and ongoing bank erosion that has been arrested with rip-rap protection at some locations. Also, like Segment 1, this segment is generally low, with less than 2 m of height from toe to crest, and with no underground utilities. What distinguishes this segment from Segment 1 is that the substrate, as found with available geotechnical investigation, includes a low permeability layer of clayey silt/silty sand on top of the sand and gravel high permeability material. The latter layer overlies a low permeability till. The till layer is in this case, closer to grade than in Segment 1, at approximately 4 m below grade. There is one existing surface drainage culvert, as well as one private pump discharge line, along this dyke segment. There is not an official walking trail along this dyke segment.

Segment 3 extends from the east end of Segment 2 (approximately Station 0+730) to approximately Station 0+530, for a length of approximately 200 m. The water courses along this dyke segment include West Duffins Creek upstream of the junction with Duffins Creek, and an oxbow left by the avulsion that moved the point where the two creeks used to join. Near Station 0+700 this dyke segment is adjacent to the West Duffins Creek, and has an area of high bank erosion risk and existing rip-rap protection, similar portions of Segments 1 and 2. The dyke along this segment is close to the water bodies; but there is ample space available, from it to the private properties, for the rehabilitation works. The height of the dyke is generally low along this segment, less than 2 m. The substrate is similar to that of Segment 2, with a layer of clayey silt/silty sand over a high permeability layer of sand and gravel, followed by a low permeability till layer that lies within 4 m from grade. There is one existing surface drainage culvert and one large drainage outlet along this dyke segment; but no underground utilities were identified. There is also a formal walking trail that runs along the crest of the dyke.

Segment 4 extends from the east end of Segment 3 (approximately Station 0+530) to approximately Station 0+230, for a length of approximately 300 m. This dyke segment is located on a wide floodplain area and has ample space for the rehabilitation works both on the wet side (from the dyke to Duffins Creek) and on the dry side (from it to the private properties). There are no areas identified as having high risk of bank erosion impacting this segment of the dyke. This segment features some of the highest portions of the Pickering Dyke, with more than 2 m from toe to crest. The substrate is somewhat similar to that of Segments 2 and 3, with the same three layers. In this case, however, the geotechnical investigations revealed a thicker upper layer of clayey silt to silty sand overlying the high permeability sand/gravel layer placed over the low permeability silt, which lies within 4 m from grade. There is one existing surface drainage culvert, as well as an underground sanitary sewer line. The location of the formal walking trail with respect to the dyke varies, with areas where the trail runs along the crest, areas where it runs along its toe and areas where the trail is located away from the dyke, between it and Duffins Creek.

Segment 5 extends from the east end of Segment 4 (approximately Station 0+230) to the end of the Pickering Dyke at Kingston Rd West (Station 0+000), for a length of approximately 230 m. Along this segment the dyke is close to private property; but there is ample space for the rehabilitation works from it to Duffins Creek. There are no areas identified as having high risk of bank erosion impacting this segment of the dyke. The height of the dyke along this segment is more than 2 m from toe to crest. The substrate features the upper layer of clayey silt to silty sand overlying the high permeability sand/gravel layer found on Segments 2 to 4; but the site investigations, up to approximately 8 m from grade, did not reveal a low permeability till layer. There is one existing surface drainage culvert on this segment. There is also, near Kingston Rd W, a water main that crosses under the dyke and a nearby storm sewer main. The formal walking trail runs along the toe of the dyke along this segment.

The entire Ajax Dyke was defined as a separate segment, labelled Segment 6. It has a length of approximately 340 m. This dyke segment is located relatively far from Duffins Creek, and from private properties, except at the ends of the dyke: at Church St S and at the condo building on 92 Church St S. In general, it has ample space for the rehabilitation works. There are no areas identified as having high risk of bank erosion impacting this segment of the dyke. The height of the dyke along this segment is more than 2 m from toe to crest. Similarly, to Segment 5, the substrate features an upper layer of clayey silt to silty sand overlying a high permeability sand and gravel layer, and the site investigations up to approximately 8 m from grade, did not reveal a low permeability till layer. There is one existing surface drainage culvert on this segment. There are also multiple sanitary sewer lines crossing under and running parallel to this dyke segment. The Trans-Canada Trail runs partially over the crest of this dyke segment. There is a butternut tree (protected) in this dyke segment (Appendix D).

FIGURE 4-3: PICKERING DYKE SEGMENTS 1-5

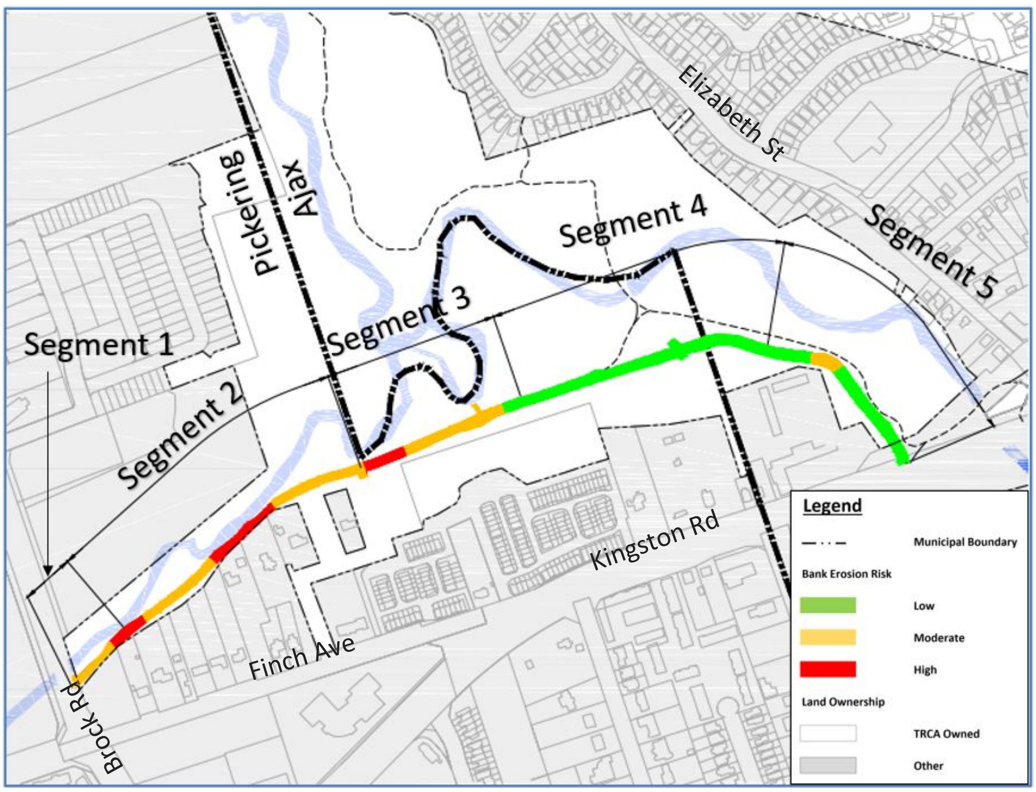
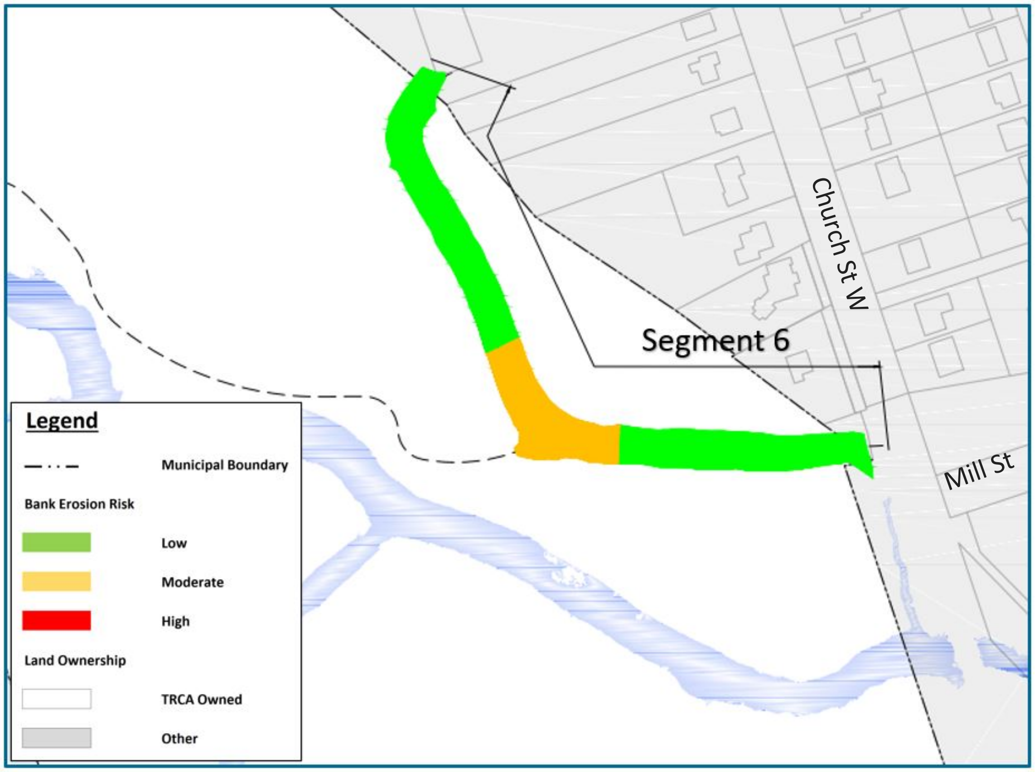


FIGURE 4-4: AJAX DYKE – SEGMENT 6



4.5.2 CRITERIA FOR EVALUATION OF ALTERNATIVE SOLUTIONS

The criteria adopted for the evaluation of alternative solutions was developed with input obtained from the project's Technical Advisory Committee, Executive Steering Committee, Community Liaison Committee, stakeholder agencies and from the general public during the project's first Public Information Centre. In these discussions input was received from representatives of the City of Pickering, the Town of Ajax, the Region of Durham, and the public. These criteria are listed below:

1. **Natural Environment**
   a. Removal, disturbance or enhancement of terrestrial habitat
   b. Removal, disturbance or enhancement of aquatic habitat

Alternative solutions that were assessed to have a greater degree of disturbance to the natural environment relative to other solutions were evaluated as less favourable solutions and vice-versa. The magnitude of disturbance was assessed based on comparing the expected area of the applicable habitat that would be disturbed by the construction of each solution (the yellow shading on the sketches in Appendix G shows the construction disturbance footprint). In general, soft engineering solutions, which have a wider footprint than the hard engineering solutions, would cause greater disturbance to terrestrial habitat. At this level of design there was no anticipated difference among those two solutions with respect to impact to aquatic habitat. In general, the "do-nothing" alternative was identified as not having immediate impact to the terrestrial or aquatic habitat; but posing a risk of disturbance if the dykes were to fail, that was factored in the evaluation.

2. **Social Environment**
    a. Mitigation of flood risk due to dyke failure
    b. Removal or disturbance to private and public property not owned by TRCA
    c. Effects on public recreational spaces
    d. Disruption caused by construction activities
    e. Effects to servicing, utilities and infrastructure
    f. Removal or disturbance of archeological resources

Alternative solutions that were assessed to have a greater degree of disturbance to the social environment relative to other solutions were evaluated as less preferred solutions and vice-versa. The solutions were assessed with respect to impact to the social environment on a high level, with consideration of the overall footprint (permanent and temporary during construction) of each alternative, as well as the extent of excavation required or the need for underground elements, which could impact, for instance, buried infrastructure. In evaluating the “do-nothing” alternative it was recognized that while it would cause the minimum impact on existing infrastructure and use of the area, it would not mitigate the flooding risk for the properties intended to be protected by the dykes.

Effects on public recreational spaces considered trails, public access to the creek, and hazards that may exist to the public using the space.

3. **Technical Aspects**
    a. Compliance with current engineering design criteria for target flood protection level
    b. Compliance with provincial policies, regulations and guidelines
    c. Allows for future enhancement to a higher level of flood protection
    d. Construction complexity and constraints

Alternative solutions that could more easily be upgraded to a higher flood protection level, had less complexity and constraints were assessed as most preferred and vice-versa. Alternative solutions without cut-offs were generally evaluated as easier to upgrade to a higher level of protection since less material zoning or extension of structural elements would need to be considered. Conventional earthwork construction was generally evaluated as less complex than other solutions requiring more finesse labour such as MSE wall construction or some cut-off solutions such as deep sheet-pile or bentonite slurry cut-offs that would require specialty construction equipment.

In terms of technical aspects, the “do-nothing” alternative clearly underperformed, as it would not satisfy criteria of compliance with current engineering design criteria for the target flood protection, nor would it allow compliance with regulations or future enhancements.

4. **Cost**
    a. Capital cost
    b. Operation and maintenance cost
    c. Cost associated with flood damages

Alternative solutions with higher capital cost and higher operation and maintenance costs were rated less preferable than other solutions. Alternative solutions that would result in lower flood damage costs (ie.

provide a higher level of flood protection) were rated preferable. Relative differences were considered when ranking solutions.

4.5.3 ALTERNATIVE SOLUTION EVALUATION

The evaluation matrices for Pickering Dyke Sections 1-5 and Ajax Section 6 are shown in Tables 4-2, 4-3 and 4-4. For evaluating the alternatives, the following assumptions were made:

- **Special Policy Area** – All alternative solutions will not change current limitations on development
- Construction Conditions – All alternative solutions will require full reconstruction of the dykes. Areas of disturbance adjacent to the footprint of the alternatives have been assumed based on typical construction methods.
- **Infrastructure Changes** – All alternative solutions sill require modification to existing trails and surface drainage infrastructure. Effects on underground utilities varies for the different alternative solutions.
- **Erosion Control** – All alternative solutions will require channel erosion control along the channel bank within the western portion of the Pickering Dyke.
- Natural Environment – All alternative solutions will include restoration plans. These will be assessed during the next phase of the study.

TABLE 4-2: EVALUATION MATRIX – PICKERING DYKE SEGMENTS 1 AND 2

EVALUATION CRITERIA	ALTERNATIVE 1: 'SOFT' ENGINEERING SOLUTION - 100-YR	ALTERNATIVE 2: 'HARD' ENGINEERING SOLUTION - 100-YR	ALTERNATIVE 3: DO-NOTHING
Social Environment			
Mitigation of flood risk due to dyke failure	• Mitigates flood risk by addressing slope stability and seepage deficiencies	• Mitigates flood risk by addressing slope stability and seepage deficiencies	• Dyke deficiencies remain • Risk of impact to several properties and people's safety
Removal or disturbance to private and public property	• Requires potential easements or acquisitions of private properties	• No permanent impact to private property but temporary disturbance during construction • Potential need for long-term maintenance easement	• No immediate impacts to private or public property • Potential for moderate property damage associated with dyke failure
Effects on public recreational spaces	• Temporary disturbance to informal trail • Opportunities for permanent trail improvements	• Temporary disturbance to informal trail Opportunities for permanent trail improvements	• Does not enhance public recreational spaces Moderate impacts if dyke fails
Disruption caused by construction activities	• Disturbance within and outside of existing dyke footprint • Typical temporary construction impacts (dust, noise, vibration, etc.)	• Disturbance within and outside of existing dyke footprint • Typical temporary construction impacts (dust, noise, vibration, etc.)	• No immediate construction impacts • Increased need for future repair work with associated construction disturbance
Effects to servicing, utilities, and infrastructure	• Potential unknown private utilities could be impacted	• Potential unknown private utilities could be impacted	• No impact on servicing and utilities Dyke failure would flood roads and could cause damages
Removal or disturbance of archaeological resources	• Poses potential for removal or disturbance of potential archaeological resources	• Poses potential for removal or disturbance of potential archaeological resources	• No disturbance or removal of potential archaeological resources
SUMMARY	**LEAST PREFERRED**	**MOST PREFERRED**	**MODERATELY PREFERRED**
Natural Environment			
Removal, disturbance, or enhancement of terrestrial habitat	• Established vegetation within and outside of the dyke footprint would be disturbed • Larger disturbance area than the 'hard' engineering solution	• Established vegetation within and outside of the dyke footprint would be disturbed • Smaller disturbance area than the 'soft' engineering solution	• No immediate disturbance from construction • Dyke failure could result in localized disturbance and habitat loss
Removal, disturbance, or enhancement of aquatic habitat	• Temporary disruption of creek banks due to construction • Opportunities for fish habitat and riparian enhancement	• Temporary disruption of creek banks due to construction • Opportunities for fish habitat and riparian enhancement	• No immediate disturbance from construction • Risk of channel bank erosion persists • Dyke failure could cause localized disturbance and send debris and sediment into the creek
SUMMARY	**LEAST PREFERRED**	**MOST PREFERRED**	**MODERATELY PREFERRED**
Technical Environment			
Compliant with current engineering design criteria for target flood protection level	• Provides target flood protection level (100 year) and satisfies all engineering design criteria	• Provides target flood protection level (100 year) and satisfies all engineering design criteria	• Current dyke does not satisfy engineering design criteria • Risk of dyke failure remains

EVALUATION CRITERIA	ALTERNATIVE 1: 'SOFT' ENGINEERING SOLUTION - 100-YR	ALTERNATIVE 2: 'HARD' ENGINEERING SOLUTION - 100-YR	ALTERNATIVE 3: DO-NOTHING
Compliant with provincial, policies, regulations, and guidelines	• Satisfies LRIA slope stability and seepage requirements	• Satisfies LRIA slope stability and seepage requirements	• Does not satisfy LRIA slope stability safety factors
Allows for future enhancement to a higher level of protection	• Allows for future upgrades to a higher level of protection	• Allows for upgrades to a higher level of protection; more complex as structural modifications would be needed	• Dykes in their current state do not satisfy engineering standards, and do not provide opportunity for enhancement
Construction constraints and complexities	• Allows for future upgrades to a higher level of protection	• More complex construction operation, including cranes and pile driving hammers than for the 'soft' engineering solution	• Moderate potential for significant future repairs • Repairs could be more complex due to access restrictions
SUMMARY	**MOST PREFERRED**	**MODERATELY PREFERRED**	**LEAST PREFERRED**
Costs			
Capital cost	• Moderate construction costs • Greatest amount of property easements or acquisitions needed resulting in significant cost	• Highest construction cost • Lesser amount of property easements or acquisitions needed	• No immediate construction costs, however future repair costs • No additional property needed
Cost of flood damages	• Lower potential flood damage costs	• Lower potential flood damage costs	• Higher potential flood damage costs
Operations and maintenance cost	• Regular inspection and maintenance required • Higher slope maintenance costs than the 'hard' engineering solution	• Regular inspection and maintenance required • Lowest slope maintenance costs	• Regular inspection and maintenance required • Highest potential costs associated with dyke repair
SUMMARY	**MODERATELY PREFERRED**	**MOST PREFERRED**	**LEAST PREFERRED**
OVERALL	**MODERATELY PREFERRED**	**MOST PREFERRED**	**LEAST PREFERRED**

TABLE 4-3: EVALUATION MATRIX – PICKERING DYKE SEGMENTS 3 TO 5

EVALUATION CRITERIA	ALTERNATIVE 1: 'SOFT' ENGINEERING SOLUTION - 100-YR	ALTERNATIVE 2: 'HARD' ENGINEERING SOLUTION - 100-YR	ALTERNATIVE 3: DO-NOTHING
Social Environment			
Mitigation of flood risk due to dyke failure	• Mitigates flood risk by addressing slope stability and seepage deficiencies	• Mitigates flood risk by addressing slope stability and seepage deficiencies	• Dyke deficiencies remain • Risk of impact to several properties and people's safety
Removal or disturbance to private and public property	• Avoids impacts to private property due to available space	• Avoids impacts to private property due to available space	• No immediate impacts to private or public property • Potential for moderate property damage associated with dyke failure
Effects on public recreational spaces	• Temporary disturbance to trail during construction • Opportunities for permanent trail improvements	• Temporary disturbance to trail during construction • Opportunities for permanent trail improvements	• Does not enhance public recreational spaces • Moderate impacts if dyke fails

EVALUATION CRITERIA	ALTERNATIVE 1: 'SOFT' ENGINEERING SOLUTION - 100-YR	ALTERNATIVE 2: 'HARD' ENGINEERING SOLUTION - 100-YR	ALTERNATIVE 3: DO-NOTHING
Disruption caused by construction activities	• Disturbance within and outside of existing dyke footprint • Typical temporary construction impacts (dust, noise, vibration, etc.)	• Disturbance within and outside of existing dyke footprint • Typical temporary construction impacts (dust, noise, vibration, etc.)	• No immediate construction impacts • Increased need for future repair work with associated construction disturbance
Effects to servicing, utilities, and infrastructure	• Due to shallower excavation there would be less opportunity for conflict with underground utilities than for the 'hard' engineering solution	• Deep sheet pile solution introduces more potential for conflict with underground utilities, but these can be resolved as part of the design of the solution • Design complexity to accommodate surface drainage	• No impact on servicing and utilities • Dyke failure would flood roads and could cause damages
Removal or disturbance of archaeological resources	• Poses potential for removal or disturbance of potential archaeological resources	• Poses potential for removal or disturbance of potential archaeological resources	• No disturbance or removal of potential archaeological resources
SUMMARY	**MODERATELY PREFERRED**	**MODERATELY PREFERRED**	**LEAST PREFERRED**
Natural Environment			
Removal, disturbance, or enhancement of terrestrial habitat	• Established vegetation within and outside of the dyke footprint would be disturbed • Larger disturbance area than the 'hard' engineering solution	• Established vegetation within and outside of the dyke footprint would be disturbed • Smaller disturbance area than the 'soft' engineering solution	• No immediate disturbance from construction • Dyke failure could result in localized disturbance and habitat loss
Removal, disturbance, or enhancement of aquatic habitat	• Dyke is farther away from the creek • Minimal impacts to aquatic habitat	• Dyke is farther away from the creek • Minimal impacts to aquatic habitat	• Risk of channel bank erosion persists • on a limited section of the creek
SUMMARY	**LEAST PREFERRED**	**MODERATELY PREFERRED**	**MOST PREFERRED**
Technical Environment			
Compliant with current engineering design criteria for target flood protection level	• Provides target flood protection level (100 year) and satisfies all engineering design criteria	• Provides target flood protection level (100 year) and satisfies all engineering design criteria	• Current dyke does not satisfy engineering design criteria • Risk of dyke failure remains
Compliant with provincial, policies, regulations, and guidelines	• Satisfies LRIA slope stability and seepage requirements	• Satisfies LRIA slope stability and seepage requirements	• Does not satisfy LRIA slope stability safety factors
Allows for future enhancement to a higher level of protection	• Allows for future upgrades to a higher level of protection	• Allows for upgrades to a higher level of protection; more complex as structural modifications would be needed	• Dykes in their current state do not satisfy engineering standards, and do not provide opportunity for enhancement
Construction constraints and complexities	• Standard equipment and construction methods required	• More complex construction operation, including cranes and pile driving hammers than for the 'soft' engineering solution	• Moderate potential for significant future repairs
SUMMARY	**MOST PREFERRED**	**MODERATELY PREFERRED**	**LEAST PREFERRED**
Cost			

EVALUATION CRITERIA	ALTERNATIVE 1: 'SOFT' ENGINEERING SOLUTION - 100-YR	ALTERNATIVE 2: 'HARD' ENGINEERING SOLUTION - 100-YR	ALTERNATIVE 3: DO-NOTHING
Capital cost	• Moderate construction costs	• Highest construction cost	• No immediate construction costs, however future repair costs
Cost of flood damages	• Lower potential flood damage costs	• Lower potential flood damage costs	• Higher potential flood damage costs
Operations and maintenance cost	• Regular inspection and maintenance required Higher slope maintenance costs	• Regular inspection and maintenance required • Lowest slope maintenance costs	• Regular inspection and maintenance required • Highest potential costs associated with dyke repair
SUMMARY	**MOST PREFERRED**	**MODERATELY PREFERRED**	**LEAST PREFERRED**
OVERALL	**MOST PREFERRED**	**MODERATELY PREFERRED**	**LEAST PREFERRED**

TABLE 4-4: EVALUATION MATRIX - AJAX DYKE SEGMENT 6

EVALUATION CRITERIA	ALTERNATIVE 1a: 'SOFT' ENGINEERING SOLUTION - 50-YR	ALTERNATIVE 1b: 'SOFT' ENGINEERING SOLUTION - 100-YR.	ALTERNATIVE 2a: 'HARD' ENGINEERING SOLUTION - 50-YR	ALTERNATIVE 2b: 'HARD' ENGINEERING SOLUTION - 100-YR	ALTERNATIVE 3: DO-NOTHING
Social Environment					
Mitigation of flood risk due to dyke failure	• Mitigates flood risk (up to 50-year event) by addressing slope stability and seepage deficiencies • Flood protection level is less than for the 100 yr. solutions	• Mitigates flood risk (up to 100-year event) by addressing slope stability and seepage deficiencies • Flood protection level is more than for the 50 yr. solutions	• Mitigates flood risk (up to 50-year event) by addressing slope stability and seepage deficiencies • Flood protection level is less than for the 100 yr solutions	• Mitigates flood risk (up to 100-year event) by addressing slope stability and seepage deficiencies • Flood protection level is more than for the 50 yr solutions	• Dyke deficiencies remain • Risk of impact to several properties and people's safety
Removal or disturbance to private and public property	• Minimal impact to private property at ends of dyke	• Minimal impact to private property at ends of dyke	• Minimal impact to private property at ends of dyke	• Minimal impact to private property at ends of dyke	• No immediate impacts to private or public property • Potential for property damage associated with dyke failure
Effects on public recreational spaces	• Temporary disturbance to trail during construction • Opportunities for permanent trail improvements	• Temporary disturbance to trail during construction • Opportunities for permanent trail improvements	• Temporary disturbance to trail during construction • Opportunities for permanent trail improvements	• Temporary disturbance to trail during construction • Opportunities for permanent trail improvements	• Does not enhance public recreational spaces • Moderate impacts if dyke fails
Disruption caused by construction activities	• Will cause disturbance within and outside of existing dyke footprint • Typical disruptions associated with construction (dust, noise, vibration, etc.)	• Will cause disturbance within and outside of existing dyke footprint; largest disturbance footprint of all solutions • Typical disruptions associated with construction (dust, noise, vibration, etc.)	• Will cause disturbance within and outside of existing dyke footprint, however on a narrower footprint than the 'soft' engineering solutions • Typical disruptions associated with construction (dust, noise, vibration, etc.)	• Will cause disturbance within and outside of existing dyke footprint, however on a narrower footprint than the 'soft' engineering solutions • Typical disruptions associated with construction (dust, noise, vibration, etc.)	• No immediate construction impacts • Increased need for future repair work with associated construction disturbance

EVALUATION CRITERIA	ALTERNATIVE 1a: 'SOFT' ENGINEERING SOLUTION - 50-YR	ALTERNATIVE 1b: 'SOFT' ENGINEERING SOLUTION - 100-YR.	ALTERNATIVE 2a: 'HARD' ENGINEERING SOLUTION - 50-YR	ALTERNATIVE 2b: 'HARD' ENGINEERING SOLUTION - 100-YR	ALTERNATIVE 3: DO-NOTHING
Effects to servicing, utilities, and infrastructure	• Due to shallower excavation there would be less opportunity for conflict with underground utilities than for the 'hard' engineering solutions	• Due to shallower excavation there would be less opportunity for conflict with underground utilities than for the 'hard' engineering solution	• Deep sheet pile solution introduces more potential for conflict with underground utilities, but these can be resolved as part of the design of the solution	• Deep sheet pile solution introduces more potential for conflict with underground utilities, but these can be resolved as part of the design of the solution	• No impact on servicing and utilities • Dyke failure would flood roads and could cause damages
Removal or disturbance of archaeological resources	• Poses potential for removal or disturbance of potential archaeological resources	• Poses potential for removal or disturbance of potential archaeological resources	• Poses potential for removal or disturbance of potential archaeological resources	• Poses potential for removal or disturbance of potential archaeological resources	• No disturbance or removal of potential archaeological resources
SUMMARY	**MODERATELY PREFERRED**	**MODERATELY PREFERRED**	**MODERATELY PREFERRED**	**MODERATELY PREFERRED**	**LEAST PREFERRED**
Natural Environment					
Removal, disturbance, or enhancement of terrestrial habitat	• Established vegetation would be disturbed on a larger area than the 'hard' engineering solutions. • Disturbance area is narrower than for 100 year 'soft' engineering solution	• Established vegetation would be disturbed on a larger area than the 'hard' engineering solutions	• Established vegetation would be disturbed on a smaller area than the 'soft' engineering solutions	• Established vegetation would be disturbed on a smaller area than the 'soft' engineering solutions	• No immediate disturbance from construction • Dyke failure could result in localized disturbance and habitat loss
Removal, disturbance, or enhancement of aquatic habitat	• Dyke is farther away from the creek. Minimal impacts to aquatic habitat.	• Dyke is farther away from the creek. Minimal impacts to aquatic habitat.	• Dyke is farther away from the creek. Minimal impacts to aquatic habitat.	• Dyke is farther away from the creek. Minimal impacts to aquatic habitat.	• Minimal or no impact on aquatic habitat.
SUMMARY	**LEAST PREFERRED**	**LEAST PREFERRED**	**MODERATELY PREFERRED**	**MODERATELY PREFERRED**	**MOST PREFERRED**
Technical					
Compliant with current engineering design criteria for target flood protection level	• Provides target flood protection level (100 year) and satisfies all engineering design criteria.	• Provides target flood protection level (100 year) and satisfies all engineering design criteria.	• Provides target flood protection level (50 year) and satisfies all engineering design criteria.	• Provides target flood protection level (50 year) and satisfies all engineering design criteria.	• Current dyke does not satisfy engineering design criteria • Risk of dyke failure remains
Compliant with provincial, policies, regulations, and guidelines	• Satisfies LRIA slope stability and seepage requirements.	• Satisfies LRIA slope stability and seepage requirements	• Satisfies LRIA slope stability and seepage requirements	• Satisfies LRIA slope stability and seepage requirements	• Does not satisfy LRIA slope stability safety factors
Allows for future enhancement to a higher level of protection	• Allows for future upgrades to a higher level of protection.	• Allows for future upgrades to a higher level of protection	• Allows for upgrades to a higher level of protection. • More complex as structural modifications would be needed.	• Allows for upgrades to a higher level of protection. • More complex as structural modifications would be needed.	• Dykes in their current state do not satisfy engineering standards, and do not provide opportunity for enhancement
Construction constraints and complexities	• Standard equipment and construction methods required	• Standard equipment and construction methods required	• More complex construction operation, including cranes and pile driving hammers than for the 'soft' engineering solutions.	• More complex construction operation, including cranes and pile driving hammers than for the 'soft' engineering solutions.	• Moderate potential for significant future repairs • Repairs could be more complex due to access restrictions

EVALUATION CRITERIA	ALTERNATIVE 1a: 'SOFT' ENGINEERING SOLUTION - 50-YR	ALTERNATIVE 1b: 'SOFT' ENGINEERING SOLUTION - 100-YR.	ALTERNATIVE 2a: 'HARD' ENGINEERING SOLUTION - 50-YR	ALTERNATIVE 2b: 'HARD' ENGINEERING SOLUTION - 100-YR	ALTERNATIVE 3: DO-NOTHING
SUMMARY	**MOST PREFERRED**	**MOST PREFERRED**	**MODERATELY PREFERRED**	**MODERATELY PREFERRED**	**LEAST PREFERRED**
Cost					
Capital cost	• Moderate construction costs and less costly than the corresponding 'soft' 100-year solution	• Moderate construction costs, but more costly than the corresponding 'soft' 50-year solution	• Higher construction cost than 'soft' engineering solutions	• Highest construction cost	• No immediate construction costs, but greater future repair costs.
Cost of flood damages	• Lower potential flood damage costs (however higher than corresponding 100-year solution)	• Lowest flood damage costs	• Lower potential flood damage costs (however higher than corresponding 100-year solution)	• Lowest flood damage costs	• Highest flood damage costs
Operations and maintenance cost	• Regular inspection and maintenance required; highest slope maintenance costs	• Regular inspection and maintenance required; highest slope maintenance costs	• Regular inspection and maintenance required; lowest slope maintenance costs	• Regular inspection and maintenance required; lowest slope maintenance costs	• Regular inspection and maintenance required • Highest potential costs associated with dyke repair
SUMMARY	**MODERATELY PREFERRED**	**MOST PREFERRED**	**MODERATELY PREFERRED**	**MODERATELY PREFERRED**	**LEAST PREFERRED**
OVERALL	**MODERATELY PREFERRED**	**MOST PREFERRED**	**MODERATELY PREFERRED**	**MODERATELY PREFERRED**	**LEAST PREFERRED**

4.6 Selection of the Preferred Alternative Solution

Based on the comparison shown in Tables 4-2 to 4-4, the following are the preferred Alternative Solutions that were carried forward to the next phase of the project for further development, as described in Section 5.0.

- Pickering Dyke Segments 1 and 2: 'Hard' Engineering Solution to a 100-year level of flood protection
- Pickering Dyke Segments 3 to 5: 'Soft' Engineering Solution to a 100-year level of flood protection
- Ajax Dyke Segment 6: 'Soft' Engineering Solution to a 100-year level of flood protection

Sketches illustrating these solutions are provided in Appendix G. Sketch 15 shows the preferred alternative solution for the Pickering Dyke, and Sketch 11, shows the preferred alternative solution for the Ajax Dyke.

5.0 EVALUATION OF DESIGN CONCEPTS FOR THE PREFERRED SOLUTION

The alternative solutions evaluated in Section 4.0 grouped the dyke rehabilitation solutions into two general categories: Hard engineering solutions were defined as those that contain one or more structural elements to provide or contribute to the stability of the dyke. Soft engineering solutions, in turn, were defined as those that rely on the stability provided by the slopes of the earthfill embankment, without the need of additional structural elements. The analysis and consultation process carried out as part of this EA allowed selecting preferred alternative solutions for specific segments of the Pickering and Ajax Dykes.

Solutions were advanced from a high-level stage (referred to as *alternative solutions)* to a more detailed stage (referred to as *design concepts)*. At the alternative solution level, general strategies to solve the problem were devised, without defining the specific components of the solution, which were then incorporated and supported with engineering analyses at the design concept level. It is important to note that the design concepts still need to go through more detailed design stages, subsequent to the EA completion, before they can be implemented.

In this section of the report, alternative design concepts are presented for each of the preferred solutions. These consist of engineering designs (at concept level) with defined geometry and specific components that allow achieving the proposed preferred type of solution on each dyke segment. Drawings of the design concepts referred to in this section, that correspond to a 30% level of engineering design, are provided in Appendix I. These design concepts will need to go through more detailed design stages, subsequent to the EA completion, before they can be implemented. Their supporting geotechnical analyses are provided in Appendix H.

To facilitate the analysis and evaluation of alternative solutions for the Pickering and Ajax Dykes, discussed in Section 4.0, they were divided into six segments. The segments were defined based on commonalities identified during the baseline inventory review, that suggested that the same solution would be applicable throughout each segment.

The analysis presented in Section 4.0 and the consultation process, which included input from TRCA, the City of Pickering, the Town of Ajax, Region of Durham and the public, resulted in the selection of the following preferred solutions for each dyke segment:

- Hard Engineering Solution for Dyke Segments 1 and 2 (Pickering Dyke)
- Soft Engineering Solution for Dyke Segments 3, 4 and 5 (Pickering Dyke) as well as for Dyke Segment 6 (Ajax Dyke)

The same approach of evaluating individual dyke segments was applied for assessing design concepts; but the with a reduced number of segments. To illustrate the correspondence between the naming conventions for these segments used in Section 4.0 and Section 5.0, they are presented in Table 5-1.

TABLE 5-1: DEFINITION OF DYKE SEGMENTS FOR THE ANALYSIS AND EVALUATION OF DESIGN CONCEPTS

New Segment Name (Section 5.0)	Old Segment Name (Section 4.0)	Preferred Alternative Solution
P1	1, 2	Hard Engineering Solution
P2	3, 4, 5	Soft Engineering Solution
A1	6	Soft Engineering Solution

The new Segment A1 consists of the entirety of the Ajax Dyke as illustrated in Drawing G-01 (Appendix I). The Pickering Dyke is divided into two new segments as illustrated in Drawing G-04. The division between these two segments occurs at Sta. 0+585, on Drawing G-04, but the exact location and extents of this transition area are to be refined in subsequent design stages following the Class EA. The alternative design concepts and the selection of the preferred design concept for each new dyke segment are discussed in the following sections.

5.1 Design Criteria and Objectives

A set of criteria and objectives were applied to the development of the design concepts. These were similar to those applied to alternative solutions, with the incorporation of findings achieved through the EA up to that stage. The design criteria required that the dyke rehabilitation ensured the following:

- A 100-year storm flood level of protection be provided by both the Pickering and Ajax Dykes and that the proposed crest elevation be no lower than existing.
- The design event for structural stability of the solution was the 500-year storm flood
- The rehabilitated dykes meet current applicable engineering design standards and FOS. This criterion is based on the technical bulletins associated with the LRIA and is further described in Appendix H
- The creek bank erosion in the areas that can affect the stability of the dykes is controlled, at minimum for a 25-year horizon
- The crest width of the future dykes provides safe access for maintenance staff and equipment. This criteria included a minimum crest width of 3m with an ideal crest width of 4m.
- The future dykes are free of vegetation that could compromise their integrity
- Minimize dyke footprint and construction disturbance area where there is encroachment into private property
- Minimize capital costs and maintenance costs

The objectives of the EA to be considered in the evaluation of design concepts include: preserving or enhancing the environmental and ecological features in the area (natural, cultural, socioeconomic) including minimizing private property impact, maintaining access to the creek as much as possible, maintaining natural appearance as much as possible, complying with the technical design criteria and improving resiliency of the flood protection infrastructure and accessibility to the dykes during a flood event, as well as minimizing cost (capital and maintenance) of the solution.

5.2 Description of the Design Concepts

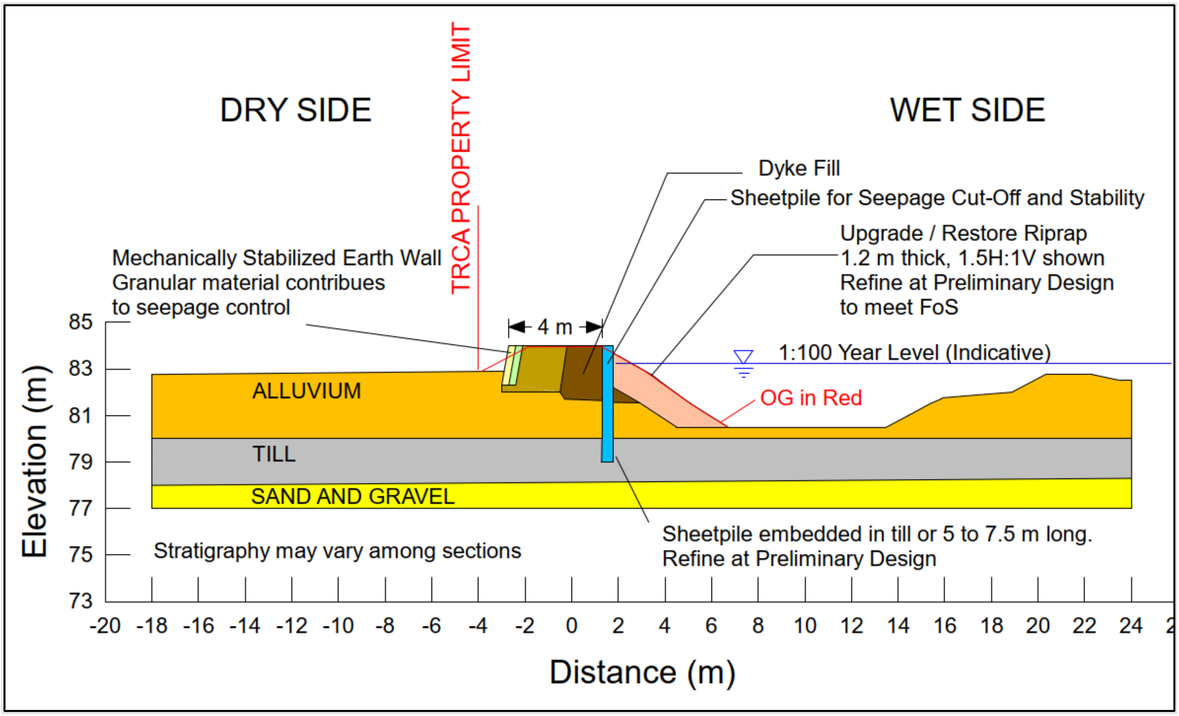
Seven design concepts were developed that correspond to the preferred alternative solutions for each dyke segment. They are listed below and each concept is elaborated upon in the following sub-sections. Supporting geotechnical considerations are provided in Appendix H.

- Design Concept H1 is a ‘hard’ type of solution and includes sheet pile and a mechanically stabilized earth (MSE) retaining wall. The footprint of this solution is illustrated in plan in Drawing G-05 for the Pickering (P1) Dyke. Cross-sections of this solution are also illustrated in Drawing G-07. Figure 5-1 illustrates a representative cross-section.
- Design Concept H2 is a ‘hard’ type of solution and includes sheet pile and modified embankment slope. The footprint of this solution is illustrated in plan in Drawing G-06 for the Pickering (P1) Dyke. Cross-sections of this solution are also illustrated in Drawing G-08. Figure 5-2 illustrates a representative cross-section.
- Design Concept H3 is a ‘hard’ type of solution and includes sheet pile and the existing embankment slopes. Figure 5-3 illustrates a representative cross-section and Figure 5-4 illustrates additional considerations for this solution.
- Design Concept H4 is a ‘hard’ type of solution and includes a concrete wall and modified embankment slope. Figure 5-5 illustrates a representative cross-section.
- Design Concept S1 is a ‘soft’ type of solution and includes modified embankment slopes and a filter. The footprint of this solution is illustrated in plan in Drawings G-01 for the Ajax Dyke (Segment A1) and G-09 for the Pickering Dyke Segment P2. Cross-sections of this solution are also illustrated in Drawing G-02 and G-11 for the A1 and P2 dyke segments, respectively. Figure 5-6 illustrates a representative cross-section of this solution.
- Design Concept S2 is a ‘soft’ type of solution and includes modified embankment slopes and a seepage cut-off. Figure 5-7 illustrates a representative cross-section of this solution where a low permeability till layer for the cut-off to tie-in to exists at a reasonable depth below the dyke. Figure 5-8 illustrates a representative cross-section of this solution where a low permeability layer was not consistently found at a relatively shallow depth that allows practical cut-off construction without the need of large equipment. In the latter case, a filter blanket on the toe of the dry side slope is also proposed. The soil stratigraphy should be confirmed with additional geotechnical investigations during subsequent design phases. The footprint of this solution is illustrated in plan in Drawing G-10 for Segment P2 of the Pickering Dyke, and the corresponding cross-sections, are shown in Drawing G-12. For the Ajax Dyke Segment A1, the footprint of this solution is illustrated in plan in Drawing G-01, and the corresponding cross-sections in Drawing G-03.

5.2.1 DESIGN CONCEPT H1 – SHEET PILE AND A MECHANICALLY STABILIZED EARTH (MSE) RETAINING WALL

This ‘hard’ design concept includes an MSE retaining wall replacing the dry side slope of the dyke and a sheet pile and modified slope on the wet side of the dyke. Figure 5-1 illustrates this solution and its various components. This solution applies to Dyke Segment P1, where the existing dyke is close to private properties and in some areas adjacent to the creek. The footprint of this solution is illustrated in plan in Drawing G-05 for the Pickering (P1) Dyke. Cross-sections of this solution are also illustrated in Drawing G-07.

FIGURE: 5-1: DESIGN CONCEPT H1



Note: OG indicates original ground

This design concept includes an engineered vegetated rock buttress (labelled as riprap on Figure 5-1) to allow for a free-draining wet side slope that matches the existing dyke slopes (varies from 1.5H:1V to 2H:1V). The vegetated rock buttress will be sufficiently thick in areas where the dyke and creek slopes blend, to limit the potential for shallow ravelling failures of the material supporting the sheet pile. In those locations where the dyke abuts the creek and the wet side slope would be a continuation of the channel bank, the vegetated rock buttress will be placed all the way down to the channel bed. These areas have been identified as having high erosion potential and some of them currently have rip-rap bank and dyke protection. The existing rip-rap is to be reconfigured to the slope and thickness identified as stable during the design, giving preference to sub-rounded, sub-angular or rounded stone as much as possible for the sake of fish habitat and, if necessary for that purpose, fully replaced. Sub-rounded or sub-angular stone have better interlock than round stone materials, and so are recommended for steeper slopes. Roundstone materials can be considered on very flat slopes. As indicated in the restoration plan, live staking will be incorporated to enhance natural features.

In the areas where the risk of erosion is high; but the dyke is not adjacent to the creek, the rock buttress will extend from the dyke crest to its toe. Provisions will be implemented to prevent future erosion of the dyke toe, by adding a capped rockfill trench all the way down to the creek bed depth, along the wet toe of the dyke. This solution, also referred to as "pre-charging the rock buttress", will be designed to provide sufficient volume of rock to ensure that the material will adopt a stable slope if and when the erosion processes reach the trench.

Where the vegetated rock buttress and where the rockfill trench will be installed, a detailed Erosion and Sediment Control (ESC) plan (including Work Site Isolation) must be developed and implemented considering the TRCA Erosion and Sediment Control Guidelines.

For the evaluation of this design concept, it has been considered that in areas where the dyke does not abut the creek and the risk of erosion potential has not been deemed to be high the rock buttress on the wet side slope will only extend from the dyke crest to its toe at a 2H:1V slope. In some of these areas, the dykes are far from the creek and the wet side slope could instead be made of earthfill material placed at a more gradual slope. To define the potential area of project disturbance on the wet side of the dyke it has been assumed that this material would be placed at a 4H:1V slope. The dyke footprint shown on Drawing G05 reflects the dyke dry side slope at a minimum 2:1 slope, however the potential additional disturbance area to implement a 4:1 dry side slope falls within the project footprint (green dashed line) illustrated on Drawing G05. The extent and thickness of the vegetated rock buttress, the provisions for rock pre-charge (or alternative means to protect the wet dyke toe from erosion) and the transitions from rock buttress to earthfill must be optimized in a subsequent design stage.

The sheet pile included in this design concept provides a barrier for seepage through and under the dyke as it will be embedded into the underlying till in Segment P1 or set to a sufficient depth (estimated up to a 7.5 m length of the sheet pile from the dyke crest) that would limit any residual seepage to an amount that can be controlled/filtered by the granular material of the MSE Wall. The sheet pile also improves stability on the wet side of the dyke as it would help force down any potential slope movements that could impact the dyke. The internal drainage system of the MSE wall will be designed to provide additional seepage control (filtering) in areas where the till layer is deep and it would be desirable to limit the sheet pile embedment to that which can be installed via excavator equipped with vibratory hammer for constructability purposes. A drainage swale will be provided on the dry side of the dyke. The swale and the grading of the internal drainage system will be designed to maintain existing internal drainage patterns towards the location of through-dyke culverts. For the development of this design concept, these culverts have been placed at the location of existing culverts; but this should be confirmed or refined through subsequent design phases with additional ground survey data.

This solution will utilize as much of the existing dyke material as possible, keeping the core dyke fill intact while modifying the wet and dry side slopes with the described stability and seepage control measures. It is expected that this option will be constructed as follows:

1. A rock buttress must be placed from crest of dyke to channel bottom at some locations. Therefore, an effective ESC plan that considers the TRCA Erosion and Sediment Control Guideline must be developed and implemented. Because the work extends into the wetted area of a watercourse, the ESC must also contain a Worksite Isolation Plan for In-stream Construction. It is anticipated that such a Worksite Isolation Plan would utilize Sediment / Turbidity Curtains or temporary Cofferdams constructed of pea-gravel bags, pre-cast concrete jersey barriers, sheet piling, or other suitable waterproof alternatives.
2. Excavate and replace the wet side slope of the existing dyke with the rock buttress. The length of open - but not yet backfilled- excavation will need to be limited where the dyke is closest in proximity to the creek to minimize the potential for undermining or sloughing of the existing dyke fill.
3. Drive sheet pile using existing dyke crest for access. In general, the dyke crest width varies from 3m to 4 m but the dyke crest can be modified to create the requisite access width because subsequent steps

require excavation of in-situ material to install MSE wall granular backfill and top-up dyke fill. Installation of the sheet pile is expected to be completed by an excavator equipped with a vibratory hammer.

4. Coordinate culvert installation as sheet pile installation approaches culvert locations. Old culverts are to be completely excavated and replaced with new ones equipped with flap gate on wet side of dyke and slide gate on dry side of dyke. Gaps in sheet pile or more extensive structural detailing of the sheet pile will be required at culvert locations. The optimal culvert to sheet pile interaction will be determined at detailed design. Similar considerations will be needed at private sump pump discharge lines.
5. Excavate into the dry side of the existing dyke and construct the MSE Wall. All excavated materials should be removed from site immediately. The internal drainage swale will also be constructed during this time. Construction using small equipment is anticipated to be feasible, which will minimize encroachment onto property not owned by TRCA. It is possible that this encroachment cannot be fully eliminated during construction, particularly in the most constricted areas. The disturbance area, on the dry side of the dyke is expected to be up to 5 metres from the end of the MSE wall.
6. Revegetate disturbed areas as per the site restoration plan. Restoration of the dyke crest and slopes should be limited to native grasses for ease of maintenance and also to minimize extent of tree root penetration into the dykes. Trees would be permissible beyond the wet and dry side toe of dyke. re

Inspections of the dyke should be completed on a yearly basis at minimum and prior to the spring freshet. Inspection access would be provided by the dyke crest but also as a 5 m wide strip along the dry side toe of dyke beyond the internal drainage swale. Attempts should be made to secure continuous access along the dry side toe of dyke for maintenance purposes even in areas where this maintenance access would extend onto private property. Regular maintenance of this solution is expected to consist of mowing the dyke crest and internal drainage swale as well as regular culvert clean-out and checks of slide gate operation. The MSE wall should also be checked for any signs of distress and the discharge points of the wall's weeping tile drainage system should be checked and cleaned out if necessary.

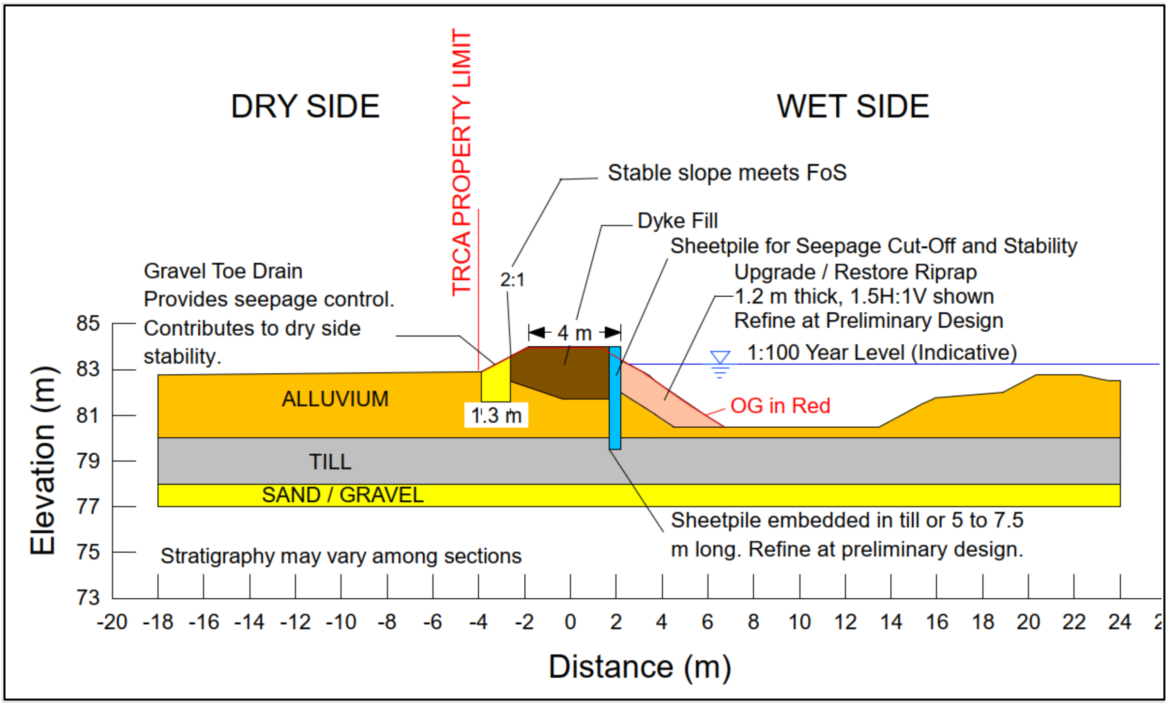
Access across the dyke for residents to traverse from the dry side to the wet side can be maintained by installing staircases at locations where there is sufficient space to construct them on the dry side of the dyke. Such an access point would need to be subject to engineering and review and approval by the flood protection designer to ensure that the integrity and function of the flood protection structure/dyke is not negatively impacted. On the wet side, there could be opportunities to construct sections of the wet slope with a more gradual earth slope rather than steep engineered rock buttresses to maintain access where there is room to construct a wider dyke.

The construction cost of this design option is estimated to be approximately $15,200 per metre of dyke or $7.2 Million for the entirety of Segment P1 including a 20% contingency.

5.2.2 DESIGN CONCEPT H2 – SHEET PILE AND MODIFIED EMBANKMENT SLOPE

This 'hard' design concept includes modifying the dry side slope of the dyke to include a gravel toe drain and a sheet pile and modified slope on the wet side. Figure 5-2 illustrates this solution and its various components. This solution applies to Dyke Segment P1, where the existing dyke is close to private properties and in some areas adjacent to the creek. The footprint of this solution is illustrated in plan in Drawing G-06 for the Pickering (P1) Dyke. Cross-sections of this solution are shown in Drawing G-08. Figure 5-2 illustrates this design concept on a representative cross-section.

FIGURE 5-2: DESIGN CONCEPT H2



Note: OG indicates original ground

This design concept includes an engineered vegetated rock buttress (labelled as riprap on Figure 5-2) to allow for a free-draining wet side slope that matches the existing dyke slopes (varies from 1.5H:1V to 2H:1V). The rock buttress will be sufficiently thick in areas where the dyke and creek slopes blend, to limit the potential for shallow ravelling failures of the material supporting the sheet pile. In those locations where the dyke abuts the creek and the wet side slope is a continuation of the channel bank, the vegetated rock buttress will be placed all the way down to the channel bed. These areas have been identified as having high erosion potential and some of them currently have rip-rap protecting the bank and dyke. The existing rip-rap is to be reconfigured to the slope and thickness identified as stable during the design, giving preference to sub-rounded, sub-angular or rounded stone as much as possible for the sake of fish habitat and, if necessary for that purpose, fully replaced. Sub-rounded or sub-angular stone have better interlock than round stone materials, and so are recommended for steeper slopes. Roundstone materials can be considered on very flat slopes. As indicated in the restoration plan, live staking will be incorporated to enhance natural features.

In the areas where the risk of erosion is high; but the dyke is not adjacent to the creek, the rock buttress will extend from the dyke crest to its toe. Provisions will be implemented to prevent future erosion of the dyke toe by adding a capped rockfill trench all the way down to the creek bed depth along the wet toe of the dyke. This solution, also referred to as “pre-charging the rock buttress”, will be designed to provide a sufficient volume of rock to ensure that the material will adopt a stable slope if and when erosion progresses to reach the trench.

Where the vegetated rock buttress and where the rockfill trench will be installed, a detailed Erosion and Sediment Control (ESC) plan (including Work Site Isolation) must be developed and implemented considering the TRCA Erosion and Sediment Control Guidelines.

For the evaluation of this design concept, it has been considered that, in areas where the dyke does not abut the creek and the risk of erosion potential is lower, the rock buttress on the wet side slope will only extend from the dike crest to its toe at a 2H:1V slope. In some of these areas, the dykes are far from the creek, and the wet side slope could instead be made of earthfill material placed at a more gradual slope. To define the potential area of project disturbance on the wet side of the dyke it has been assumed that this material would be placed at a 4H:1V slope. The dyke footprint shown on Drawing G-06 reflects the dyke dry side slope at a minimum 2:1 slope, however the potential additional disturbance area to implement a 4:1 dry side slope falls within the project footprint (green dashed line) illustrated on Drawing G-06. The extent and thickness of the rock buttress, the provisions for rock pre-charge (or alternative means to protect the wet dyke toe from erosion), and the transitions from vegetated rock buttress to earthfill must be optimized in a subsequent design stage.

The sheet pile provides a barrier for seepage through and under the dyke as it will be embedded into the underlying till in Segment P1 or set to a sufficient depth (estimated up to a 7.5 m length of the sheet pile from the dyke crest) to limit any residual seepage to an amount that can be controlled/filtered by the proposed toe drain. The sheet pile will also improve stability on the wet side of the dyke as it will force any potential slope movements that could impact the dyke to extend deeper than the sheet pile. The gravel toe drain provides additional seepage control (filtering) in areas where till is deep and it would be desirable to limit the sheet pile embedment to that which can be installed via excavator equipped with vibratory hammer for constructability purposes. This toe drain would be designed as a two stage sand and gravel filter with appropriately engineered soil gradations that allow for seepage water to weep out of the toe drain at surface and continue on to the internal drainage swale. The two stage filter could be constructed within the footprint of the dyke dry side slope. From the internal drainage swale, seepage water would continue to the culvert locations during a flood. Because the toe drain would need to be uncapped to function, it could be covered with a decorative stone trim to hide the engineered filter materials.

A drainage swale will be provided on the dry side of the dyke. The grading of the internal drainage system will be designed to maintain existing internal drainage patterns towards the proposed through-dyke culverts. For the development of this design concept, these culverts have been placed at the location of existing culverts; but this should be confirmed or refined through subsequent design phases with additional ground survey data.

This design concept will utilize as much of the existing dyke material as possible, keeping the core dyke fill intact while modifying the wet and dry side slopes with the described stability and seepage control measures. It is expected that this concept would be constructed as follows:

1. Same as Concept H1 – A rock buttress must be placed from crest of dyke to channel bottom at some locations. Therefore, an effective ESC plan that considers the TRCA Erosion and Sediment Control Guideline must be developed and implemented. Because the work extends into the wetted area of a watercourse, the ESC must also contain a Worksite Isolation Plan for In-stream Construction. It is anticipated that such a Worksite Isolation Plan would utilize Sediment / Turbidity Curtains or temporary

Cofferdams constructed of pea-gravel bags, pre-cast concrete jersey barriers, sheet piling, or other suitable waterproof alternatives.

2. Same as Concept H1 - Excavate and replace the wet side slope of the existing dyke with the rock buttress. The length of open -but not yet backfilled- excavation will need to be limited where the dyke is closest in proximity to the creek to minimize the potential for undermining or sloughing of the existing dyke fill.
3. Same as Concept H1 - Drive sheet pile using existing dyke crest for access. In general, the dyke crest width varies from 3 m to 4 m but the dyke crest can be modified to create the requisite access width because subsequent steps require excavation of in-situ material to install the gravel toe drain and top-up dyke fill. Installation of the sheet pile is expected to be completed by an excavator equipped with a vibratory hammer to reduce the space required for access during construction
4. Same as Concept H1 - Coordinate culvert installation as sheet pile installation approaches culvert locations. Old culverts are to be completely excavated and replaced with new ones equipped with a flap gate on wet side of dyke and a slide gate on dry side of the dyke. Gaps in sheet pile or more extensive structural detailing of the sheet pile will be required at culvert locations. The optimal culvert to sheet pile interaction will be determined at detailed design. Similar considerations will be required for private sump pump discharge lines.
5. Excavate into dry side of the existing dyke to construct the granular toe drain and ensure existing internal drainage patterns towards culvert locations are maintained. Small equipment should be anticipated which will minimize but not fully prevent encroachment onto property not controlled by TRCA; particularly during construction, and at constricted areas. The disturbance area on the dry side of the dyke is expected to be up to 5 metres from the dry side toe of dyke.
6. Revegetate disturbed areas as per the site restoration plan. Restoration of the dyke crest and slopes should be limited to native grasses for ease of maintenance and also to minimize extent of tree root penetration into the dykes. Trees would be permissible beyond the wet and dry side toe of dyke.

Inspections of the dyke should be completed on a yearly basis at minimum and prior to the spring freshet. Inspection access would be provided by the dyke crest but also via a 5 m wide strip along the dry side toe, within which the internal drainage swale will be excavated. This 5 m strip would provide the needed space for maintenance activities and equipment access and is to be refined during subsequent design phases. Attempts should be made to secure continuous access along the dry side toe of dyke for maintenance purposes even in areas where this maintenance access would extend onto private property. Regular maintenance of this solution is expected to consist of mowing the dyke crest, dry side slope, and internal drainage swale as well as regular culvert clean-out and checks of slide gate operation.

Informal passive access across the dyke from the dry side to the wet side would be available as the dry side slope would be maintained at 2H:1V. On the wet side, there would be opportunities to construct sections of the wet slope with a more gradual earth slope rather than steep engineered rock buttresses to maintain access where there is more room to construct a wider dyke.

The construction cost of this design option is estimated to be approximately $14,700 per metre of dyke or $7.0 Million for the entirety of Segment P1 including a 20% contingency.

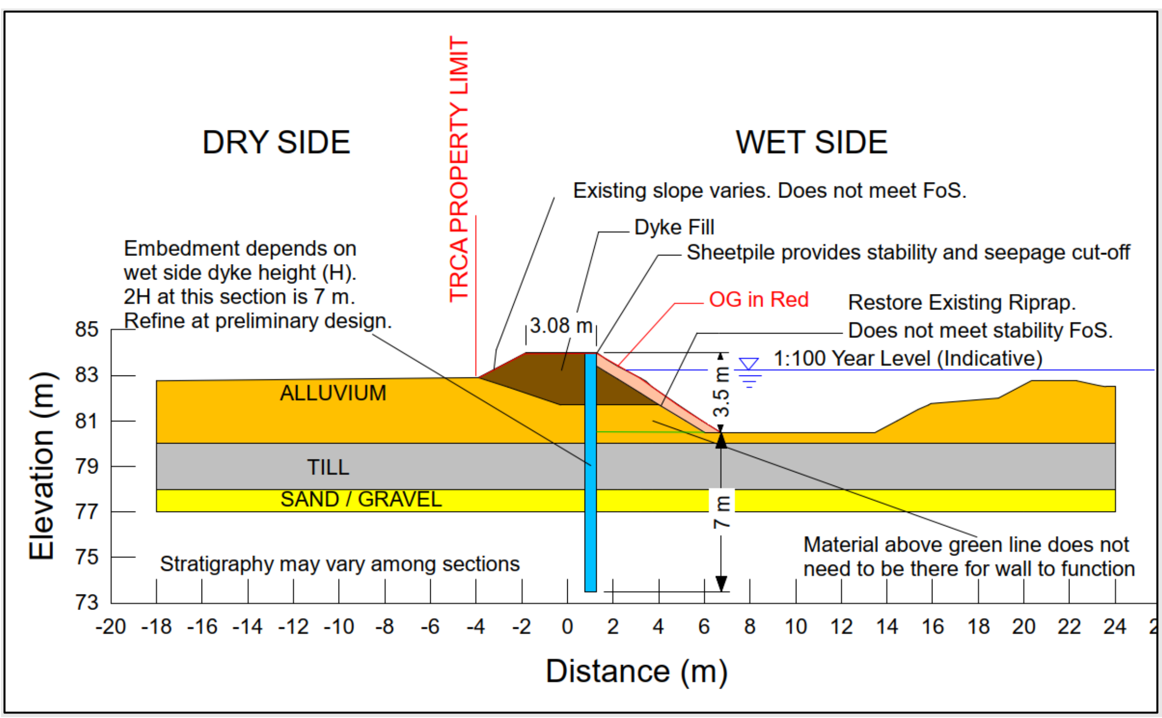
5.2.3 DESIGN CONCEPT H3 – DEEP SHEET PILE AND EXISTING EMBANKMENT SLOPES

This 'hard' design concept consists of driving sheet pile through the dyke and leaving the rest of the dyke at its current state. The objective of this option is to minimize visible changes to the dyke and reduce vegetation removal. The crest of the dyke will be topped up to the proposed crest level and rock placing on the wet side would only be required to arrest erosion at the base of the dyke. Figure 5-3 illustrates this solution and its various components. This solution applies to Dyke Segment P1, where the existing dyke is close to private properties and adjacent to the creek.

On the dry side, the slopes are not modified so some steep areas may not meet the required safety factor for slope stability. With the deep sheet pile installed, if a minor slope failure were to occur, there would be no loss in the available flood protection while the slope is rebuilt for maintenance and access purposes. A drainage swale should also be provided on the dry side of the dyke. The grading of the internal drainage system should be designed to maintain existing internal drainage patterns towards the existing through-dyke culverts.

Similarly, on the wet side, since no improvements are proposed, it is assumed that the dyke and bank could completely erode or slough and the sheet pile would still be able to stand as a cantilever structure. Some rock placing would still be required on the wet side where the dyke and creek are close, to ensure that the creek bed does not erode even lower, reducing the cantilever embedment depth required for this design concept. Because rock must be placed down to channel bottom, a detailed ESC plan (including Work Site Isolation) must be developed and implemented considering the TRCA Erosion and Sediment Control Guideline.

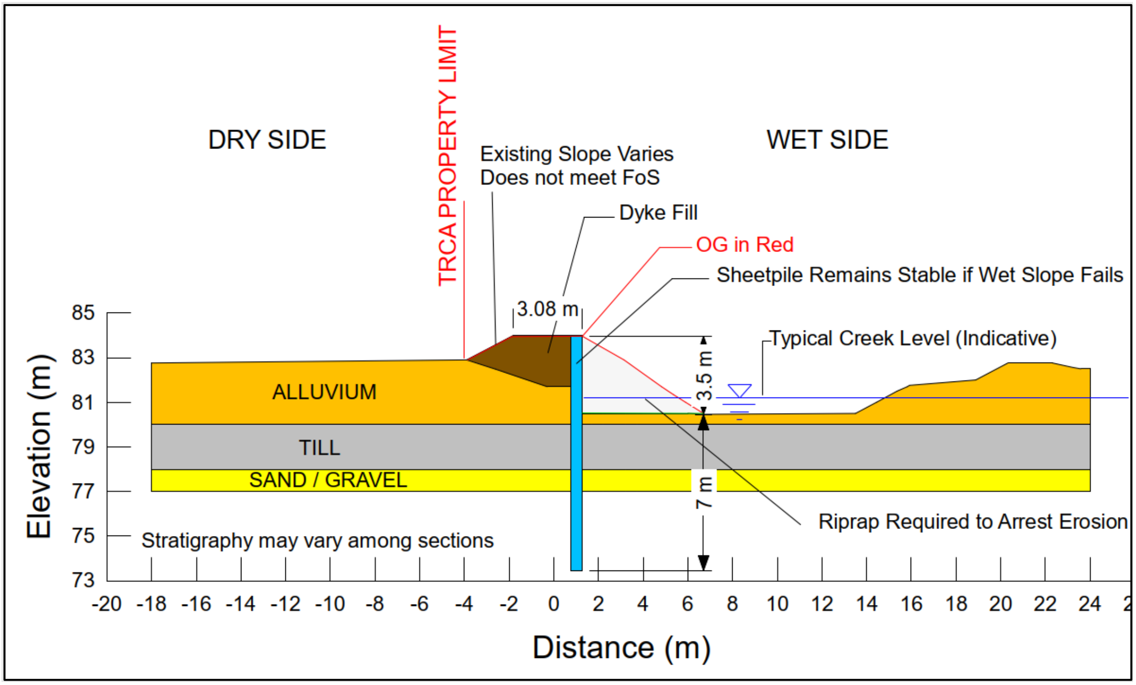
FIGURE 5-3: DESIGN CONCEPT H3



Note: OG indicates original ground

The critical design condition for this concept is a scenario in which the wet dyke slope has failed, and the river levels are low as illustrated in Figure 5-4. The sheet pile then would be supporting all the pressure from the dry side and it needs to be designed to withstand the corresponding forces and moments, working as a cantilever. The sheet pile needs to be embedded to a minimum of 2 times its height, with reference to the riverbed level. Therefore, this design concept requires a deeper and more robust sheet pile than what is proposed for Design Concepts H1 and H2. It would be more expensive to procure and to install.

FIGURE 5-4: DESIGN CONCEPT H3 IF EROSION OCCURS OVER TIME



Note: OG indicates original ground

The sheet pile for Design Concept H3 would be installed to a greater depth than the maximum depth of the boreholes dug as part of the geotechnical investigation carried out as part of this project in 2019 as well as the previous studies for this dyke. During the 2019 geotechnical investigation (Appendix B) there was one borehole (THP19-01) in which traces of shale rock were found near the bottom. It is possible that shale rock exists at a depth that impedes driving the sheet to as deep as required for it to work as a cantilever structure. If that is the case, then tie-backs (e.g. dead man anchors or grouted post-tensioned anchors) would be required to provide stability to the sheet pile. Building tie-backs would increase the complexity and the cost associated for this solution. It would also require a more elaborate ESC plan with the introduction of any anchors requiring drill cutting management or grouting. Similarly, weight-type tie backs would cause additional temporary disturbance on private properties.

For the best-case scenario that the sheet pile can be successfully installed to the required embedment depth without complication (i.e. no anchors required), it is expected that this alternative would be constructed as follows:

1. Rock must be placed down to channel bottom. Therefore, an effective ESC plan that considers the TRCA Erosion and Sediment Control Guideline must be developed and implemented. Because the work extends into the wetted area of a watercourse, the ESC must also contain a Worksite Isolation Plan for In-stream Construction. It is anticipated that such a Worksite Isolation Plan would utilize Sediment / Turbidity Curtains or temporary Cofferdams constructed of pea-gravel bags, pre-cast concrete jersey barriers, sheet piling, or other suitable waterproof alternatives.
2. Utilize cranes to install the sheet pile from the dry side toe of dyke. Cranes are required for this option since the required sheet pile would be longer than what is feasible with smaller equipment. This methodology is expected to require up to a 20 m wide working area from the dry side toe of dyke to situate the necessary construction equipment. Significantly greater than the disturbance footprint anticipated for options H1 and H2.
3. Same as Concepts H1 and H2 - Coordinate culvert installation as sheet pile installation approaches culvert locations. Old culverts are to be completely excavated and replaced with new ones equipped with a flap gate on wet side of dyke and a slide gate on dry side of the dyke. Gaps in sheet pile or more extensive structural detailing of the sheet pile would be required at culvert locations. The optimal culvert to sheet pile interaction will be determined at detailed design. Similar considerations will be required for buried utilities such as private sump discharge lines.
4. Restore rip-rap on wet side of sheet pile with conventional construction equipment working from the crest of the dyke.
5. Restore existing internal drainage patterns that may have been temporarily disturbed by sheet pile installation. Conventional construction equipment would install a swale to direct internal drainage towards culvert locations within 5 m of the toe of dyke.
6. Revegetate disturbed areas as per the site restoration plan. Restoration of the dyke crest and slopes should be limited to native grasses for ease of maintenance and also to minimize extent of tree root penetration into the dykes. Trees would be permissible beyond the wet and dry side toe of dyke.

Inspections of the dyke should be completed on a yearly basis at minimum and prior to the spring freshet. Inspection access would be provided by the dyke crest but may be limited to on-foot or ATV inspections as the intent of this solution is to top the dykes up to their required elevation without significant modifications to its overall footprint. Attempts should be made to secure continuous access along the dry side toe of dyke for maintenance purposes even in areas where this maintenance access would extend onto private property. Regular maintenance of this solution is expected to consist of mowing the dyke crest, dry side slope, and internal drainage swale as well as regular culvert clean-out and checks of slide gate operation. Additional maintenance may be required if slope failures develop that expose the sheet pile facing and require repairs.

Informal access across the dyke would be the same as current conditions as the sheet pile would be embedded completely within the existing dyke geometry.

The construction cost of this design option is estimated to be approximately $23,300 per metre of dyke or $11.1 Million for the entirety of Segment P1 including a 20% contingency. There is also risk of additional project costs to incorporate anchors or even filters on the dry side of the dyke in the event that the sheet pile cannot be driven to the required embedment depth.

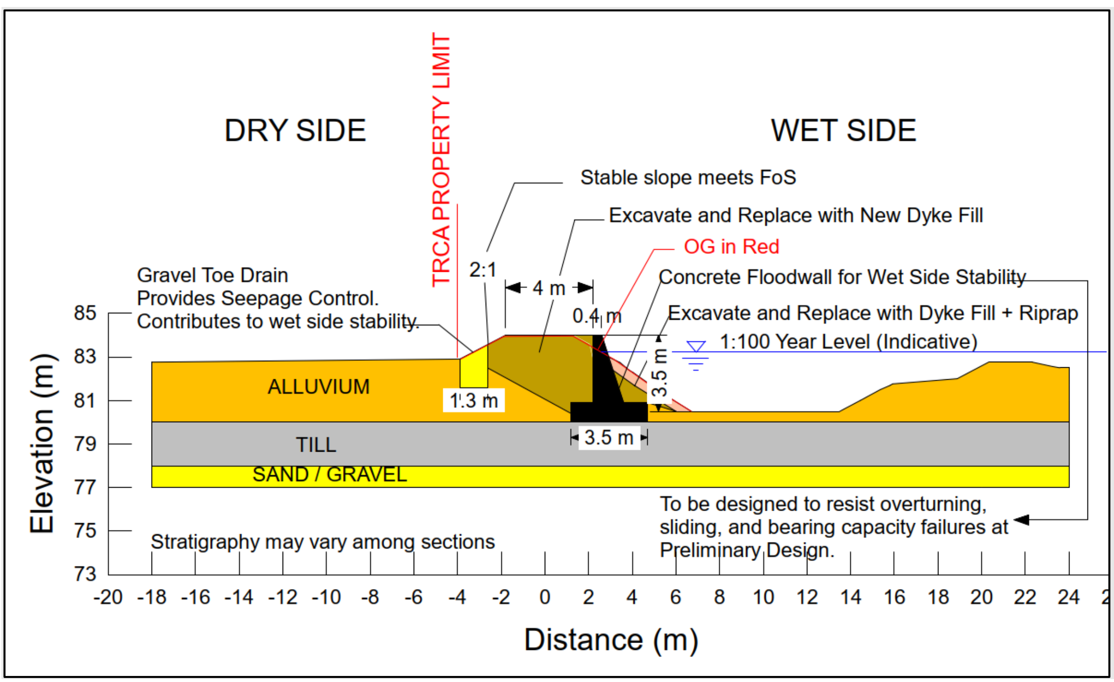
This option involves many uncertainties, and, even in the most optimistic scenario, it would result more expensive and complex than Design Concepts H2 and H3 and a more stringent quality control program. It would not minimize disturbances in the area around the dykes due to the required installation equipment and potential need of tie backs. The crest of dyke will have the same width as present (or possibly narrower if the crest is raised and the toe of dyke is not altered) so it would have a reduced crest width (and therefore limited access for maintenance) compared to other options.

5.2.4 DESIGN CONCEPT H4 –CONCRETE WALL AND A MODIFIED EMBANKMENT SLOPE

This 'hard' design concept includes modifying the dry side slope of the dyke to include a gravel toe drain and a concrete wall on the wet side. Figure 5-5 illustrates this solution and its various components. This solution applies to Dyke Segment P1, where the existing dyke is close to private properties and adjacent to the creek.

On the wet side, this design concept includes a concrete retaining wall that provides stability to the dyke. A vegetated rock buttress is required in the areas next to the creek or with risk of bank erosion to prevent undercutting of the wall foundation. On the dry side, similarly to Design Concept H2, the embankment would be modified to have a 2:1 slope with a toe drain filter. The granular toe drain intercepts and filters any seepage that may bypass beneath the concrete wall from gravel layers where the wall cannot be practically installed in till to provide seepage cut-off. It allows the 2H:1V slope to satisfy stability criteria for the dyke heights proposed in Dyke Segment P1, which are less than 2 m. This toe drain would be designed as a two-stage sand and gravel filter with appropriately engineered soil gradations that allow for seepage water to weep out of the toe drain at surface and continue on to the internal drainage swale. From the internal drainage swale, seepage water would continue to the culvert locations during a flood. Because the toe drain would need to be uncapped to function, it could be covered with a decorative stone trim to hide the engineered filter materials.

FIGURE 5-5: DESIGN CONCEPT H4



Note: OG indicates original ground

It is expected that this alternative would be constructed as follows:

1. The existing dyke and riverbank slopes must be excavated to construct this option and a rock buttress must be placed beyond the toe of the wall to protect the base of the wall from undercutting and erosion. Therefore, an effective ESC plan that considers the TRCA Erosion and Sediment Control Guideline must be developed and implemented. Because the work extends into the wetted area of a watercourse, the ESC must also contain a Worksite Isolation Plan for In-stream Construction. It is anticipated that such a Worksite Isolation Plan would utilize Sediment / Turbidity Curtains or temporary Cofferdams constructed of pea-gravel bags, pre-cast concrete jersey barriers, sheet piling, or other suitable waterproof alternatives.
2. Completely excavate the existing dyke as well as the underlying alluvium and till to install the concrete wall below the creek bed elevation. An extensive dewatering plan would also be required in order to ensure the base of the wall can be suitably prepared and the environment controlled during subsequent concrete placement.
3. Construct concrete formwork, set reinforcement, and pour concrete. The number of concrete pours required to construct the wall would be determined during detailed design.
4. Coordinate culvert installation with concrete casts to embed them through the wall. Similar provisions could be required for private sump pump lines.
5. Wait until the wall reaches required concrete strength before reconstructing the dyke behind the concrete wall.
6. Reconstruct the dyke behind the wall, install the granular toe drain, and construct dry side drainage swale to restore existing internal drainage patterns that may have been temporarily disturbed by access needed to construct the wall (construction access requirement expected to be 5 m beyond the existing dry side toe of dyke).
7. Conventional construction equipment would be used to install a swale to direct internal drainage towards culvert locations within 5 m of the toe of dyke.
8. Restore rock buttress on wet side of the wall with conventional construction equipment working from the crest of the dyke.
9. Revegetate disturbed areas as per the site restoration plan. Restoration of the dyke crest and slopes should be limited to native grasses for ease of maintenance and also to minimize extent of tree root penetration into the dykes. Trees would be permissible beyond the wet and dry side toe of dyke.

Inspections of the dyke should be completed on a yearly basis at minimum and prior to the spring freshet. Inspection access would be provided by the dyke crest but also as a 5 m wide strip along the dry side toe of dyke beyond the internal drainage swale. Attempts should be made to secure continuous access along the dry side toe of dyke for maintenance purposes even in areas where this maintenance access would extend onto private property. Regular maintenance of this solution is expected to consist of mowing the dyke crest, dry side slope, and internal drainage swale as well as regular culvert clean-out and checks of slide gate operation.

Access across the dyke would be the same as current conditions on the dry side. On the wet side, there would be opportunities to construct an earthfill slope or staircase from the top of the wall where there is more room to construct a wider dyke.

The construction cost of this design option is estimated to be approximately $22,500 per metre of dyke or $10.7 Million for the entirety of Segment P1 including a 20% contingency. There is also risk of additional project costs due to uncertainties regarding the feasibility of maintaining a dewatered excavation and working with concrete in close proximity to the creek bed. A robust environmental monitoring program would be required to monitor pH levels in the creek.

This option involves many uncertainties, and, even in the most optimistic scenario, it would be more expensive and complex than Design Concepts H1 and H2 and would require a more stringent quality control program. It would cause larger disturbances in the area around the dykes than other design concepts evaluated due to the required complete excavation of the existing dyke and creek bank. This option also would require a greater degree of preparation to mitigate flood risk during construction (see Section 5.1.7) as there would be greater instances in which the existing dyke would be completely excavated to permit construction of the concrete floodwall.

5.2.5 DESIGN CONCEPT S1 – MODIFIED DYKE SLOPES AND A FILTER

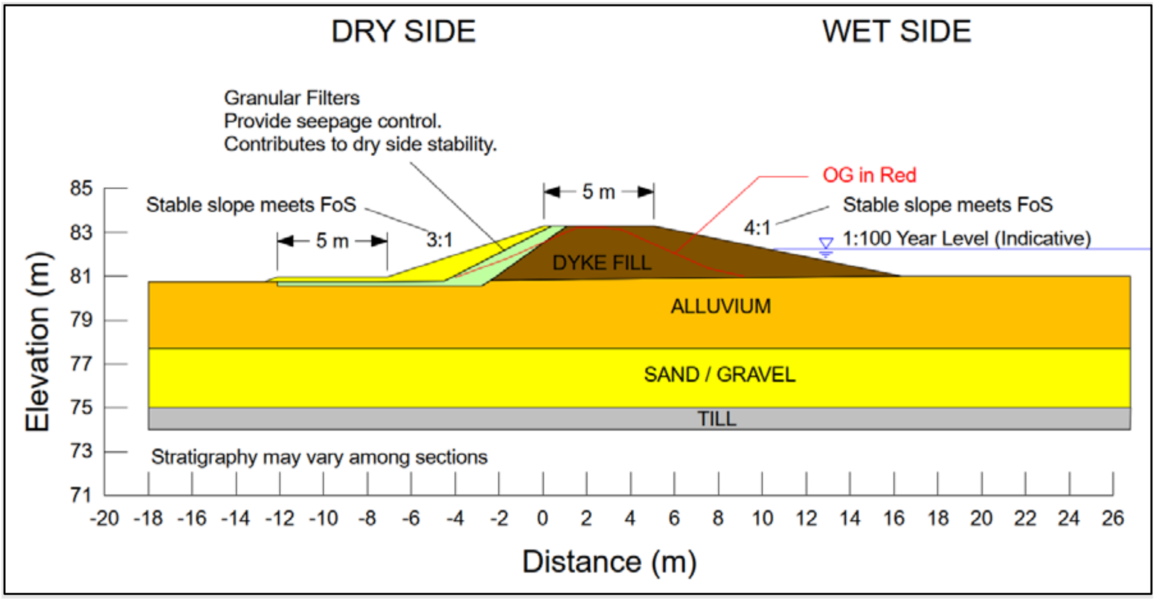
This ‘soft’ design concept includes modified embankment slopes (3:1 on the dry side and 4:1 on the wet side) that are more gradual than the present dyke slope conditions. The slopes provide the required factors of safety for stability. A granular filter on the dry side slope collects and controls seepage. Figure 5-6 illustrates this solution and its various components. This solution applies to Dyke Segments P2 and A1. Drawings G-01 and G-02 show the proposed solution with this design concept in the Ajax Dyke (Segment A1). Drawings G-09 and G-11 show this design concept on Segment P2 of the Pickering Dyke.

At this design concept stage, a 4H:1V wet side slope is set, based on conservative modelling of the drawdown scenario. At detailed design, there may be opportunities to optimize the wet side slope considering the recommended material parameters in the geotechnical investigation report (Appendix B) as well as the time-dependant nature of the drawdown. Both the duration of the design storm and the assumed drawdown rates required to achieve the requisite safety factors with a steeper slope should be qualified when optimizing the wet side slope. Any slope optimizations should also consider that slopes steeper than 3H:1V will present a maintenance challenge for mowing the grass on the slope.

The dry side granular filter configuration is expected to consist of a large two-stage filter, but it may be possible to optimize the filter configuration in the next stage of design, considering the recommended material parameters in the geotechnical investigation report (Appendix B) and the variations in thickness of the underlying soil layers along the profile of the dyke. The filter extends beyond the dry toe of the dyke, up to 5 m into the adjacent terrain. The last metre of filter is to be left uncapped to allow water to weep out at surface and continue to an adjacent drainage swale.

A drainage swale will be provided on the dry side of the dyke. The swale and the grading of the internal drainage system will be designed to maintain existing internal drainage patterns towards the location of through-dyke culverts. It should be assessed in detailed design if the number of through-dyke culverts can be reduced for the Pickering Dyke by modifying internal drainage patterns via swales without compromising the existing internal drainage patterns.

FIGURE 5-6: DESIGN CONCEPT S1



Note: OG indicates original ground

It is expected that this alternative would be constructed as follows:

1. Strip the existing dyke and the new expanded dyke footprint of trees, roots, and unsuitable organics.
2. Excavate benches into the existing dyke and scarify the in-situ dyke fill for improved bonding of existing and new dyke fill. Additional excavation of in-situ dyke fill would be required to construct the filters where the direction of expansion of the existing dyke is towards the creek.
3. Use suitable salvaged dyke fill, imported low permeability dyke fill, and filter materials to construct the expanded design geometry.
4. Existing culverts would require complete excavation and replacement with new longer culverts with a flap gate on the wet side of the dyke and a slide gate on the dry side of the dyke.
5. Construct/restore internal drainage swales to direct run-off to existing culvert locations.
6. Revegetate disturbed areas as per the site restoration plan. Restoration of the dyke crest and slopes and filter should be limited to native grasses for ease of maintenance and also to minimize extent of tree root penetration into the dykes. The last metre of the filter would need to be uncapped to function, and it can be covered with a decorative stone trim to hide the engineered filter materials. Trees would be permissible beyond the wet toe of dyke and beyond the granular filter strip on the dry side of the dyke.

This concept will have the least potential for interaction with buried utilities, compared to deep cut-off soft solution concepts.

Inspections of the dyke should be completed on a yearly basis at minimum and prior to the spring freshet. Inspection access would be provided by the dyke crest but also utilizing the 5 m wide filter strip along the dry side toe of dyke. Regular maintenance of this solution is expected to consist of mowing the dyke crest, both side slopes, and internal drainage swale, maintaining the integrity of the exposed stone trim, as well as regular culvert clean-out and checks of slide gate operation.

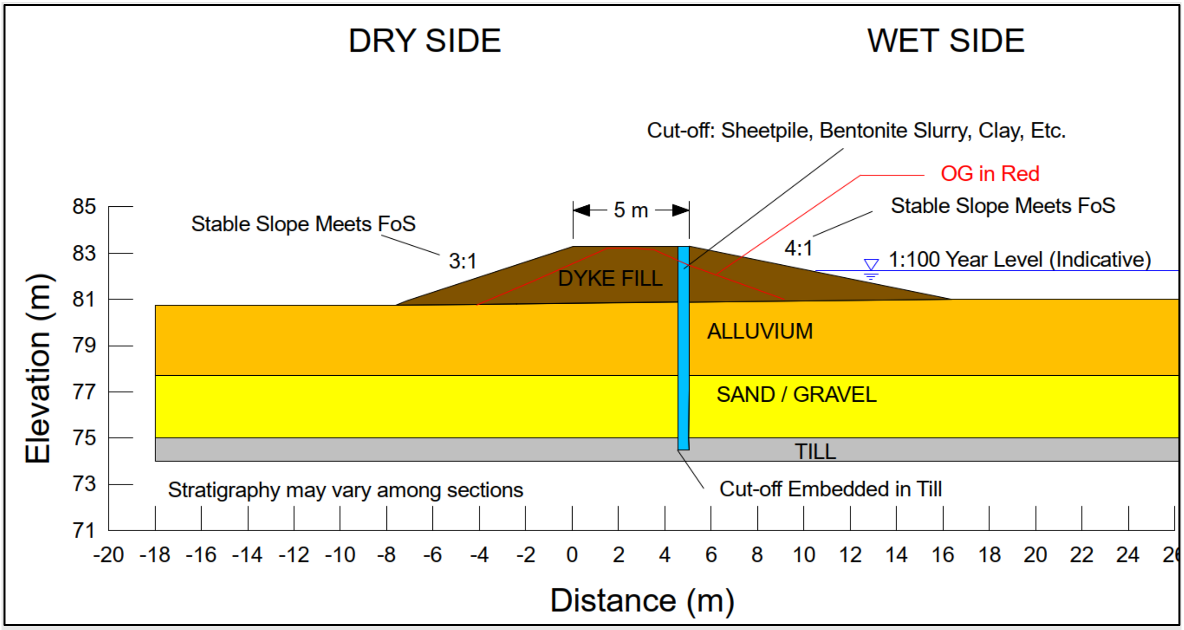
Informal passive access across the dyke from the dry side to the wet side would be maintained as the proposed side slopes are shallower than the existing dyke. The expanded dyke footprint will necessitate reconfiguration of sections of the existing recreational trail for the dykes but this is common to all soft design concepts. It is anticipated that the trail can either remain following the new wet side slope of the expanded dyke for the Pickering Dyke or be relocated entirely along the crest of the expanded Pickering Dyke. It is anticipated that the TransCanada Trail reconfiguration at the Ajax Dyke would still follow the crest of the upgraded dyke.

The construction cost of this design option is estimated to be approximately $4,400 per metre of the Pickering Dyke (P2) and $7,900 per metre of the Ajax Dyke (A1). Based on the lengths of these segments the estimated costs to construct this design concept would be $3.0 Million for Dyke Segment P2, and $2.6 Million for Dyke Segment A1. A 20% contingency has been applied for the Pickering Dyke and a 30% contingency has been applied for the Ajax Dyke to acknowledge increased uncertainty associated with the presence of aging underground infrastructure in the latter area. The larger contingency for the Ajax Dyke is to account for the unknown condition of buried sewers installed in the 1970's. The condition of these sewers should be assessed as part of detailed design to determine if it would be advantageous to complete sewer repairs or relocations at the same time as the proposed dyke rehabilitation. This would reduce the risk of potential future disturbance to the rehabilitated dykes.

5.2.6 DESIGN CONCEPT S2 – MODIFIED DYKE SLOPES AND A SEEPAGE CUT-OFF

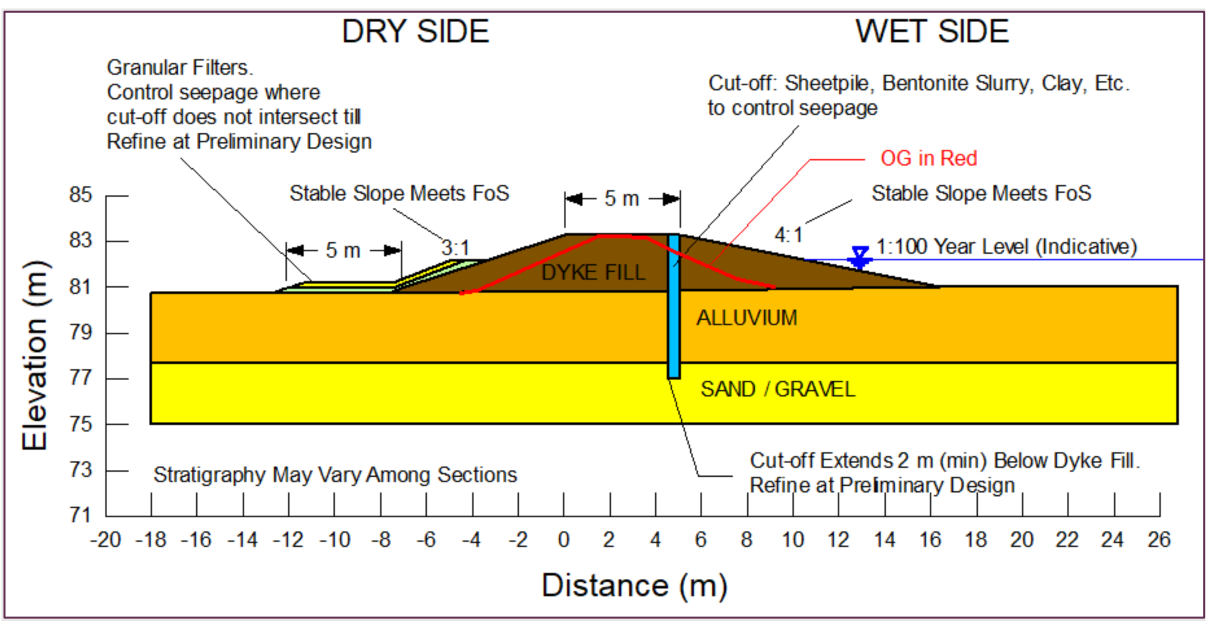
This 'soft' design concept is similar to Design Concept S1; but instead of the filter along the entire dry-side slope, it includes a seepage cut-off, which can be sheet pile, slurry wall, or clay filled trench. The cut-off must be extended into till to provide the required seepage control, as shown in Figure 5-7. Where an impervious till layer cannot be reached, and only partial cut-off can be achieved practically, the solution can be coupled with a filter, as shown in Figure 5-8. This filter, installed near the dry side toe, would collect and control seepage that may result from floodwater bypassing the partial cut-off through the deeper high permeability sand / gravel layer. Transient seepage modelling can be completed to refine the design. This Design Concept is shown in Drawings G-10 and G-12 for Dyke Segment P2 and in Drawings G-01 and G-03 for Dyke Segment A1. The drawings are based on existing information of the substrate and show the additional filter on Dyke Segment A1 as well as the east end of P2, since a deep layer of till to tie-in the cut-off was not observed in these areas during the geotechnical site investigations carried out as part of this and previous studies.

FIGURE 5-7: DESIGN CONCEPT S2 – WITH CUT-OFF TERMINATED IN TILL



Note: OG indicates original ground

FIGURE 5-8: DESIGN CONCEPT S2 – SEEPAGE CUT-OFF COUPLE WITH BACKSLOPE GRANULAR FILTERS



Note: OG indicates original ground

It is expected that this alternative would be constructed as follows:

1. Strip the existing dyke and the new expanded dyke footprint of trees, roots, and unsuitable organics.
2. Excavate benches into the existing dyke and scarify the in-situ dyke fill for improved bonding of existing and new dyke fill.
3. Use suitable salvaged dyke fill as well as imported low permeability dyke fill, and filter materials where applicable, to construct the expanded design geometry.
4. Existing culverts would require complete excavation and replacement with new longer culverts with a flap gate on the wet side of the dyke and a slide gate on the dry side of dyke. Gaps in sheet pile (if selected as preferred cut-off method) or more extensive structural detailing of the sheet pile would be required at culvert locations. Alternatively, if a slurry wall is to be constructed, it may be easier to complete culvert replacement following slurry wall construction and detail a method to provide continuity of the positive cut-off around the culvert. The optimal culvert to cut-off interaction will be determined at detailed design. Similar provisions are expected to be required for buried utilities.
5. Construct/restore internal drainage swales to direct run-off to the culvert locations.
6. Revegetate disturbed areas as per the site restoration plan. Restoration of the dyke crest and slopes should be limited to native grasses for ease of maintenance and also to minimize extent of tree root penetration into the dykes. Trees would be permissible beyond the wet and dry side toe of dyke.

This soft solution concept will have the most potential for interaction with buried utilities, relative to Design Concept S1. This interaction could potentially be reduced where the cut-off is installed to a shallower depth, as it could be if it is coupled with a filter. These are aspects to be considered during design phases.

Inspections of the dyke should be completed on a yearly basis at minimum and prior to the spring freshet. Inspection access would be provided by the dyke crest but also as a 5 m wide strip along the dry side toe of dyke beyond the internal drainage swale. Attempts should be made to secure continuous access along the dry side toe of dyke for maintenance purposes even in areas where this maintenance access would extend onto private property. Regular maintenance of the dyke is expected to consist of mowing the dyke crest, both side slopes, and internal drainage swale as well as regular culvert clean-outs and checks of slide gate operation.

Informal passive access across the dyke from the dry side to the wet side would be maintained as the proposed side slopes are no steeper than the existing dyke. The expanded dyke footprint will necessitate reconfiguration of sections of the existing recreational trails for the dykes but this is common to all soft design concepts. It is anticipated the trail can either remain following the new wet side slope of the expanded dyke for the Pickering Dyke or be relocated entirely along the crest of the expanded Pickering Dyke. It is anticipated that at the Ajax Dyke the TransCanada Trail reconfiguration would still follow the crest of the rehabilitated dyke.

The construction cost of this design option is estimated to be approximately $13,300 per metre for the Pickering Dyke (P2). Based on the length of P2, the estimated costs to construct this design concept would be $9.1 Million including a 20% contingency.

For the Ajax Dyke (A1), the construction cost of this design option is estimated to be approximately $14,300 per metre. Based on the length of A1, the estimated cost to construct this design concept would be $4.7 Million including a 30% contingency to acknowledge the increased uncertainty associated with the presence of aging underground infrastructure in that area.

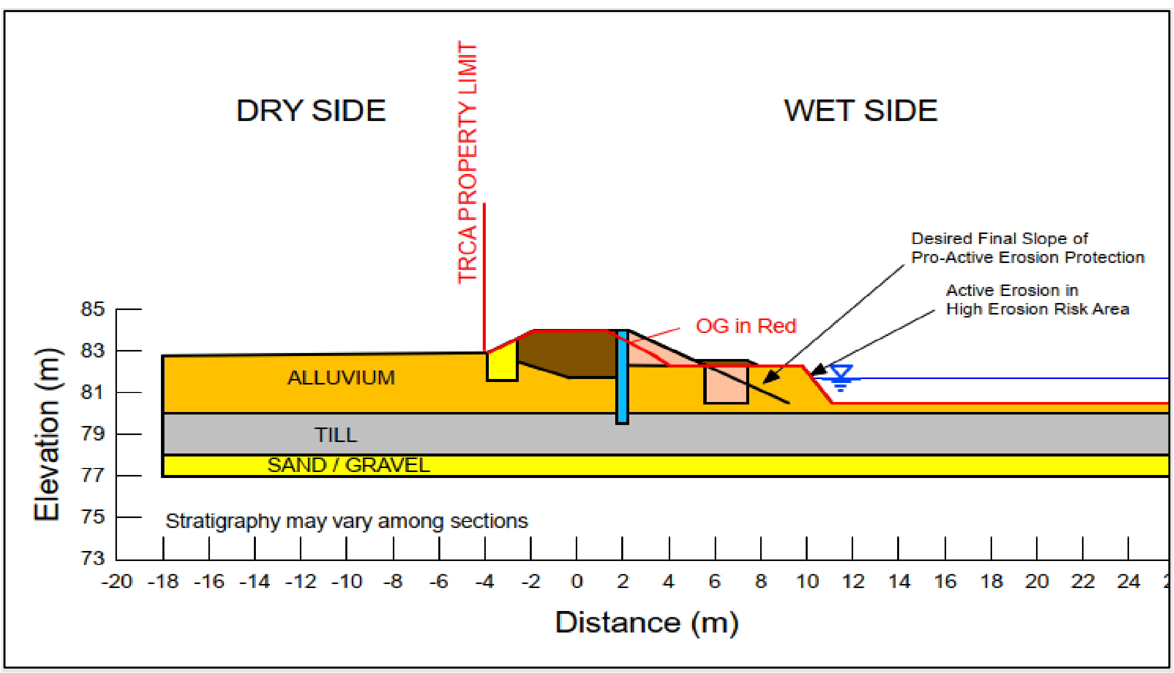
The larger contingency for the Ajax Dyke is to account for the unknown condition of buried sewers installed in the 1970's. The condition of these sewers should be assessed as part of detailed design to determine if it would be advantageous to complete sewer repairs or relocations at the same time as the proposed dyke rehabilitation. This would reduce the risk of potential disturbance to the rehabilitated dykes.

5.2.7 GENERAL CONSIDERATIONS

Creek Erosion Risks

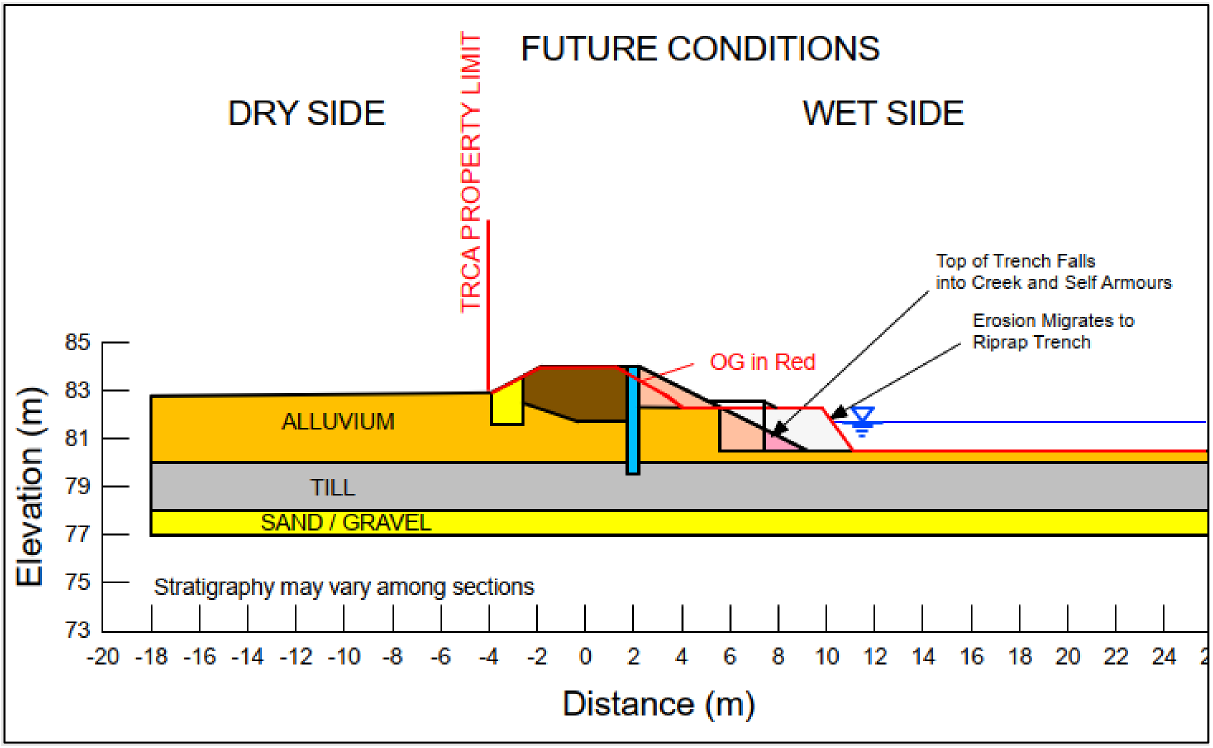
Erosion risk is common to all dyke remediation alternatives. A detailed discussion of erosion risks to the dykes caused by the creek can be found in the Fluvial Geomorphology Baseline Assessment of the Pickering and Ajax sites Memorandum included in Appendix C. The erosion risk to the dykes has been mapped as low, moderate, or high in Figure 2 of that memorandum. High erosion areas are those where the creek currently abuts the dyke or has the potential to abut the dyke within the next 25 years. Applying vegetated rock buttresses along the creek slopes as well as the dyke wet slope is recommended where a high erosion risk has been identified and the dykes abut the creek. It is also recommended at locations where the bank and dyke slope are currently protected with rip-rap. There are also, within these high erosion risk areas, locations where the dyke does not abut the creek channel. For those locations the vegetated rock buttress is proposed to be installed down to the dyke toe, and a capped rockfill trench is proposed along the toe to "pre-charge" the rock buttress, and prevent further erosion of the bank towards the dyke. Figure 5-9 illustrates this solution as proposed to be constructed, and Figure 5-10 illustrates the intended future condition if and when erosion would eventually reach the trench.

FIGURE 5-9: ROCKFILL TRENCH BEFORE BANK EROSION – WITH DESIGN CONCEPT H2



Note: OG indicates original ground

FIGURE 5-10: ROCKFILL TRENCH AFTER BANK EROSION – WITH DESIGN CONCEPT H2



Note: OG indicates original ground

Additionally, because the proposed expansion of the dyke footprint in the Pickering P2 segment would bring the existing dyke closer to the river, a rockfill trench could be needed near the M13 meander near Sta. 0+225 of the Pickering Dyke, to protect the trail if is relocated along the wet dyke toe and is within 5 m of the creek.

Erosion protection with rock buttresses is not required for moderate or low erosion risk segments because erosion is not expected to cause an issue with long-term stability of the dykes during the next 25 years.

High Water Erosion Risks

The results of the simulations of extreme flood events carried out by Valdor Engineering (2018) and by TRCA (100-year and 500-year, refer to Appendix H) show flow velocities along the wet side slopes of the dykes that are in all cases less than 1 m/s. These flow velocities are within the range that would not erode a dyke vegetated with grass or a dyke armored with vegetated rock buttresses, such as those proposed in the design concepts considered in this report.

Dyke overtopping, that could occur during floods exceeding the design event, could cause even higher flow velocities over the crest of the dyke and along the dry side slope. These velocities would exceed the resistance of grassed slopes, and, if sustained, they would start an erosion process that would propagate into the core of the dyke and cause its failure. Overtopping protection of earth structures is possible by armouring the slope with hard surface treatments (rip-rap, concrete elements, articulated concrete blocks, etc.). These are, however, expensive. Their use is generally limited to short sections of dams or at selected locations within long dyke systems, where a preferred breach location is practical and has the lowest potential consequence of flooding. It is recommended that a spillway, where overtopping would occur first, be included in each dyke and the spillway be armoured against erosion. This option can be considered in subsequent design stages.

Long Term Maintenance Access

Access points to the dykes from major roadways are illustrated in Drawings G01 and G04 (Appendix I). All of the proposed solutions are designed to have a minimum 4 m crest width and can support the weight of a loaded pick-up truck, with the exception of hard solution H3. The crest of the dyke would be the primary means of accessing the dyke for maintenance purposes. Additionally, soft solutions with a 5 m wide filter blanket extending beyond the dry side toe of the dyke can use the filter blanket as means of secondary access along the dry side toe of the dyke. For continuity of this secondary dry side access through the Pickering P1 dyke segment, it is recommended to work with adjacent property owners to secure a 5 m wide area beyond the dry side toe of dyke to be of use for maintenance access purposes. If this is not possible, continuous access along the dykes will be limited to the dyke crest. Access provisions are to be further refined during subsequent design stages.

Use of Existing Dyke Fill to Upgrade the Dykes

Based on the geotechnical investigations completed as part of this assignment, and also considering historic geotechnical investigations by others, the fine grained soil content of the existing dykes is high enough that the in-situ fill can be considered an effective material for flood protection purposes, particularly when coupled with the seepage control measures proposed as part of the hard and soft solutions. Most of the fill from the existing dykes is therefore expected to be salvageable and can be used in the construction of the upgraded dykes. Unsuitable fill from the existing dykes would be that which is rich in organics and can decay over time. Similarly, if during construction, sections of the dyke are found to contain higher permeability sandy soils, those materials would not be considered suitable and should be disposed of. Continuous inspection by an experienced geotechnical engineer or engineering technologist should be provided during construction. Part of the inspector’s role will be to identify and direct the contractor as to which parts of the existing dyke fill are suitable for use in the construction of the dyke upgrades and which parts should be discarded and hauled offsite. New dyke fill should have a minimum fines content of 15% and should be compacted to a minimum 95% Standard Proctor Maximum Dry Density in lifts no greater than 0.3 m thick (uncompacted thickness).

Groundwater Impacts

Cut-off solutions may have the potential to impact regional/local groundwater patterns. This impact is not expected to be significant given the limited length of the dyke. However, a groundwater study should be completed as part of detailed design to collect baseline data and confirm if the potential impacts of installing a cut-off solution are tolerable.

Ice Impact Resiliency

Historically ice jams have occurred within the study area. However, impact to the dyke by river ice is not anticipated to be major. Rock buttress size selection during the design must consider expected ice thickness (likely 0.3 m or less in this area) to ensure that the rock size is at minimum the same as the ice thickness.

Improving the resiliency of the dykes by bringing them up to engineering standards will also provide a benefit during winter floods events and ice jam events, which were not included specifically in the design criteria.

The design could also consider facilitating access to the creek to any identified locations of river ice recurrent occurrence where equipment could be needed to remove an ice jam. This is to be further investigated during subsequent design stages.

Freeboard Considerations

A minimum freeboard of 0.5 m has been included in the design of the dykes to address uncertainties in the parameters used in supporting models and analyses, as well as construction accuracy and long-term settlement of the dykes, among other factors. The proposed freeboard can be refined during subsequent design stages.

Climate Change

Climate change resiliency is inherently incorporated into the project because retrofitting existing infrastructure that is deficient improves the resiliency of the infrastructure.

Rehabilitating the Pickering and Ajax dykes, using the latest design standards, and advancements in engineering science and modelling, will ensure these two rehabilitated structures can be relied upon to provide the intended flood protection. Additionally, the above discussed freeboard incorporated into the design allows for future climate change resiliency.

Structural Condition Assessments and Vibration Monitoring

Construction vibrations have the potential to adversely impact nearby structures. Sheet pile cut-off solutions such as H1, H2, H3, and potentially S2 are more likely than other solutions to cause vibration induced damage if those vibrations are not continuously monitored during construction. Monitoring during construction allows for adjusting the work plan at earliest opportunity for construction induced vibrations to remain within tolerable vibration limits as works approach nearby residences. The contractor should be required to manage vibrations during construction such that they are below the frequency and peak particle velocity (PPV) limitations in City of Toronto Bylaw No. 514-2008. The Toronto bylaw was used as reference since a corresponding bylaw was not found for Pickering or Ajax.

Additionally, pre and post construction structural inspections should be completed on all residences in proximity to the construction works in order to objectively assess any claims of vibration induced damages that may arise both during and after construction.

Construction Staging Areas:

The proposed staging areas for construction are illustrated in Figures G-01 and G-04 (Appendix I) for the Ajax and Pickering Dykes, respectively. The proposed staging area footprints illustrated are those considered to be available on TRCA property but would require tree clearing and alteration of the general landscape. During construction, the contractor may elect to utilize a smaller area than illustrated and the effect of this decision could be reflected in the bid price. In order to minimize impacts to affected areas outside of the dyke construction corridor, it may be beneficial to incentivize a mandatory site visit for interested bidders. Other incentivization methods for utilizing a smaller staging area than that illustrated in Figures G-01 and G-04 can be explored at the time of bid preparation.

The contractor should also be required to submit a work plan demonstrating how they propose to utilize the staging area with attention to how they will mitigate the potential for damage to buried utilities that may traverse beneath the staging areas either by limiting the size and type of equipment used to upgrade the dykes, strategically locating equipment and stockpiles within the staging area, or by implementing means to better distribute loads, among other methods.

Construction Access:

Construction access is proposed to be from Church St. and Mill St. Intersection for the Ajax Dyke at the location of the existing dyke east tie-in. For the Pickering Dyke, access is proposed to be from:

1. Kingston Road at the location of the existing dyke east tie-in;
2. The Kingston Road and Notion Road intersection following TRCA property along the sewer north from the intersection;
3. The TRCA owned road, Bluebird Crescent, off of Finch Avenue and/or the existing trail off of Finch Avenue; and
4. Brock Road at the location of the existing dyke west tie-in.

Truck traffic at the Ajax Dyke will need to utilize the construction staging area for vehicle turnaround as there is only one access point to the dyke. Conversely, truck traffic at the longer Pickering Dyke will need to utilize multiple access points for through traffic as vehicle turnaround may be impractical or cumbersome in constrained areas such as dyke segment P1.

Access along the dyke is required to facilitate the construction works. It is expected that a 5 m construction corridor along the dry side toe will be sufficient for the necessary construction equipment unless a specific option is noted (such as H3 above) to warrant more complex construction equipment. The dyke crest can also be utilized for access by conventional construction equipment. In order to minimize impacts to affected areas outside of the dyke construction corridor, it may be beneficial to incentivize a mandatory site visit for interested bidders. Other incentivization methods for minimizing site disturbance by minimizing the required number of access points can be explored at the time of bid preparation. The contractor should also be required to submit a work plan demonstrating how they propose to develop the access with their chosen means and methods with attention paid to how they will mitigate the potential for damage to buried utilities that may be located beneath or in close proximity to the access roads. Methods may include limiting the size and type of equipment used to upgrade the dykes, or improving load distribution characteristics or the access roads to the underlying sub-grade, among other methods.

Timeline:

The estimated time to construct the works and anticipated restrictions are listed in Table 5.2

TABLE 5-2: ANTICIPATED CONSTRUCTION TIMELINE AND RESTRICTIONS

Activity	Estimated Duration	Working Window	Primary Restriction
Tree Removal (both dykes)	2 months	7 months (Sept 1 to Mar 31)	No tree clearing during bird breeding season from Apr 1 to Aug 31

Activity	Estimated Duration	Working Window	Primary Restriction
Segment A1 Dyke Remediation	3 months	5 months (May 1 to Nov 1)	No earthworks under frozen conditions estimated from Nov 1 to Apr 30
Segment P1 Dyke Remediation (in-water component)	1.5 months	2 months (July 15 to Sept 15)	In-water works should not be scheduled between Sept 16 and July 14 to mitigate risk to fish and fish habitat
Segment P1 Dyke Remediation (out of water component)	2 months	5 months (May 1 to Nov 1)	No earthworks under frozen conditions estimated from Nov 1 to Apr 30
Segment P2 Dyke Remediation	3 months	5 months (May 1 to Nov 1)	No earthworks under frozen conditions estimated from Nov 1 to Apr 30

This timeline considers:

- Tree removal must be outside of the bird nesting period from April 1 to August 30,
- Earthworks should occur during the summer months when frost is out of the ground,
- The in-water component of the works in Segment P1 must be completed within the 2-month working window between the spring and fall restricted activity timing windows for the protection of fish and fish habitat (July 15 to September 15),
- Typical production rates for the supply, placement, and compaction of the various earthwork materials and the anticipated sheet pile installation production rates, based on our previous experience and considering the size of equipment that may be required to complete the works in each dyke segment,
- Culvert replacements would occur in tandem with earthworks, and
- Approximately 1 week of production may be lost per month due to rain days

The contractor's actual production rate may vary depending on the resources that are assigned to the project. For all works to be completed within the anticipated 5 month working window under unfrozen conditions from May 1 to Nov 1, the works in each of the 3 dyke segment should occur concurrently with one another. The work can also be completed in two construction years, if desirable, depending on funding and work planning. A benefit of separating the work into two construction seasons would be that lower

construction bid prices could be received as the contractor's risk of being unable to complete the works due to a summer of above average rainfall would be reduced. In this case, consideration should be given to prioritizing upgrading the Ajax Dyke in the first construction season because the Ajax dyke currently has a lower level of flood protection than the Pickering Dyke.

Flood Risk Mitigation

The process of upgrading a dyke requires excavation into an existing dyke for several reasons such as: improving construction access, creating scarified benches for improved bonding of old and new material, or replacing through-dyke culverts. While necessary to improve flood protection on a permanent basis, the time during implementation of dyke upgrades is one when there is reduced reliability during a flood. Flood risks during construction can be mitigated by:

a. Scheduling the works to occur outside of the spring freshet period.
b. Preserving as much of the existing dyke fill in place as possible after stripping away unsuitable organics and roots. This will minimize the work required to shore up the incompletely upgraded dykes on an emergency temporary basis during construction.
c. Requiring a risk management plan to be prepared by the contractor to shore up the dykes to current flood protection levels within 24 hours notice of a potential flood event. Such a plan may rely on manual sandbagging, aquadams, or other emergency flood protection measures that can be established in adverse weather conditions.
d. Further subdividing the recommended phasing plan to rehabilitate smaller segments of the dyke at a time.

5.3 Evaluation of the Design Concepts

The alternative design concepts applicable to each dyke segment were evaluated to select the preferred one, based on a set of criteria that included consideration of the impact (positive or negative) to the natural environment, social environment, technical aspects as well as cost.

5.3.1 EVALUATION CRITERIA

The criteria adopted for the evaluation of design concepts was developed with input obtained from the project's Technical Advisory Committee, Executive Steering Committee, Community Liaison Committee, stakeholder agencies and from the general public during the project's first Public Information Centre. In these discussions input was received from representatives of the City of Pickering, the Town of Ajax, the Region of Durham, and the public. These criteria are listed below:

1. **Natural Environment**
    a. Removal, disturbance or enhancement of terrestrial habitat
    b. Removal, disturbance or enhancement of aquatic habitat

    Solutions that were assessed to have a greater degree of disturbance to the natural environment relative to other solutions were evaluated as less favourable solutions and vice-versa. The magnitude of disturbance was assessed based on comparing the expected area of the applicable habitat that would be disturbed by the construction of each solution.

2. **Social Environment**
    a. Removal or disturbance to private and public property not owned by TRCA
    b. Effects on public recreational spaces
    c. Disruption caused by construction activities
    d. Impact to servicing, utilities and infrastructure
    e. Removal or disturbance of potential archeological resources
    f. Aesthetics

Solutions that were assessed to have a greater degree of disturbance to the social environment relative to other solutions were evaluated as less preferred solutions and vice-versa. Footprint areas were used to compare the degree of disturbance a solution would cause in any of the sub-criteria. Additionally, the nature of how the solutions would be implemented was also considered, for example sheet pile cut-off solutions have the potential for greater interaction with deep utilities and more potential for construction vibrations, both of which were considered less favourable from a social environment perspective. Effects on public recreational spaces considered trails, public access to the creek, and hazards that may exist to the public using the space. Assessment of aesthetics favoured natural appearance per feedback received during the public consultation process so assessment generally favoured earthfill solutions over hard walls.

3. **Technical Aspects**
   a. Allowance for future enhancement to a higher level of flood protection
   b. Construction complexity and constraints
   c. Service life
   d. Maintenance requirements

   Solutions that could more easily be upgraded to a higher flood protection level, had less complexity and constraints, had longer service lives, and fewer maintenance requirements were assessed as most preferred and vice-versa. Solutions without cut-offs were generally evaluated as easier to upgrade to a higher level of protection since less material zoning or extension of structural elements would need to be considered. Conventional earthwork construction was generally evaluated as less complex than other solutions requiring more finesse labour such as MSE wall construction or some cut-off solutions such as deep sheet-pile or bentonite slurry cut-offs that would require specialty construction equipment. Solution service life was generally evaluated consistently as all solutions have comparable design lives. Maintenance requirements considered the area that would require routine mowing. Culvert inspections and gates would have common maintenance requirements for all solutions.

4. **Cost**
   a. Capital cost
   b. Operation and maintenance cost

   Solutions with higher capital cost and higher operation and maintenance costs were rated less preferable than other solutions. Relative differences were considered when ranking solutions.

5.3.2 RANKING SCHEME

For each dyke segment, the applicable design options were qualitatively ranked as either: “less preferred”, “moderately preferred” or “most preferred”. This ranking was based on comparing (with respect to each other) the various design options being considered for each specific dyke segment. That allowed rating these design concepts in order of overall preference, based on the number of more positive and less negative marks allotted including all the criteria. The results of the evaluation of design concepts are shown in Table 5.3 for Dyke Segment P1, Table 5.4 for Dyke Segment P2 and Table 5.5 for Dyke Segment A1.

TABLE 5-3: EVALUATION OF DESIGN CONCEPTS FOR PICKERING DYKE SEGMENT P1

Evaluation Criteria Natural Environment	H1 (MSE wall dry side)	H2 (Sheet pile in 2:1 slope)	H3 (Sheet pile in existing)	H4 (Concrete wall wet side)
Removal, Disturbance, or Enhancement of Terrestrial Habitat	• Moderate permanent disturbance as dyke has the smallest footprint. Footprint is similar to footprint of exiting dyke. • Requires removal of trees on dyke and restoration of dyke with native grasses. • Moderate temporary disturbance area during construction. • Potential to enhance ecological function in areas adjacent to the dyke.	• Moderate permanent disturbance as dyke has a small footprint. Footprint is a little larger than the footprint of the existing dyke. • Requires removal of trees on dyke and restoration of dyke with native grasses. • Moderate temporary disturbance area during construction. • Potential to enhance ecological function in areas adjacent to the dyke.	• Smallest permanent disturbance as dyke has the same footprint as existing and not all existing vegetation must be removed. • Requires removal of vegetation on dyke where needed for construction and restoration of dyke with native grasses, and shrubs/trees on the side slopes. • Largest temporary disturbance area during construction due to largest construction equipment (i.e. cranes) required to install the deep structural sheet pile. • Potential additional areas of disturbance if construction complications arise, (i.e. if tie-back anchors are required). • Potential to enhance ecological function in areas adjacent to the dyke.	• Moderate permanent disturbance as dyke has the smallest footprint. Footprint is similar to footprint of exiting dyke. • Requires removal of trees on dyke and restoration of dyke with native grasses. • Large temporary disturbance area during construction due to the significant excavation required to install the concrete wall. • Potential to enhance ecological function in areas adjacent to the dyke.
Removal, Disturbance, or Enhancement of Aquatic Habitat	• Moderate disturbance to aquatic habitat due to installation of erosion controls on channel banks. • More significant temporary impact to aquatic habitat during construction if channel must be used for construction access due to construction access constraints through private properties. • Reduction of in-stream erosion would improve long term aquatic habitat by reducing turbidity and restoration of the channel bank (i.e. live willow stakings in rock buttress) would lead to a more stable aquatic habitat and in/near-water vegetation. • Concepts H1 and H2 have similar conditions/impacts.	• Moderate disturbance to aquatic habitat due to installation of erosion controls on channel banks. • More significant temporary impact to aquatic habitat during construction if channel must be used for construction access due to construction access constraints through private properties. • Reduction of in-stream erosion would improve long term aquatic habitat by reducing turbidity and restoration of the channel bank (i.e. live willow stakings in rock buttress) would lead to a more stable aquatic habitat and in/near-water vegetation. • Concepts H1 and H2 have similar conditions/impacts.	• Smallest short-term disturbance to aquatic habitat during construction as channel bank erosion controls are limited, • Potential for largest long-term aquatic impacts if the channel bank erodes and the wet-side of the dyke fails. • Largest short-term disturbance to aquatic habitat if construction complications arise, (i.e. if tie-back anchors are required on the wet side).	• Largest short-term disturbance to aquatic habitat due to the significant excavation within/near the creek required to install the concrete wall. • Reduction of in-stream erosion would improve long term aquatic habitat by reducing turbidity and restoration of the channel bank (i.e. live willow stakings in rock buttress) would lead to a more stable aquatic habitat and in/near-water vegetation
	Most Preferred	**Most Preferred**	**Least Preferred**	**Least Preferred**
Evaluation Criteria Cultural/Social Environment	**H1**	**H2**	**H3**	**H4**
Removal or Disturbance to Private and Public Property not Owned by TRCA	• Smallest disturbance and impacts to private properties. • The dyke and drainage swale would be fully located within TRCA owned property.	• Moderate disturbance and impacts to private properties. • The dyke would be fully located within TRCA owned property, however a drainage swale along the dry-side toe would be located within the rear of private properties (up to 1.5m) at the most space-restricted	• Largest disturbance and impacts to private properties. • Limited alterations to the existing dyke structure on TRCA property, however a temporary construction access corridor up to 20 m wide will be required on the dry side of the dyke due to large construction equipment (i. e. cranes) required to install the deep	• Moderate disturbance and impacts to private properties. • The dyke would be fully located within TRCA owned property, however a drainage swale along the dry-side toe would be located within the rear of

	• There would be temporary impacts, of up to 5m, to the rear of private properties during construction to facilitate construction access. • The MSE wall limits the area of disturbance and impacts to private property.	areas where there is no land available within TRCA lands. • There would be additional temporary impacts, of up to 5 additional metres, to the rear of private properties during construction to facilitate construction access.	sheet pile. Up to 20m of the rear of private properties would be temporarily impacted. Construction impacts would be more significant if construction complications arise, (i.e. if tie-back anchors are required). • In some areas the existing dyke toe is at the property line, so in these areas a drainage swale along the dry-side toe would be located within the rear of private properties (up to 1.5m).	private properties (up to 1.5m) at the most space-restricted areas where there is no land available within TRCA lands. • There would be additional temporary impacts, of up to 5 additional metres, to the rear of private properties during construction to facilitate construction access.
Effects on Public Recreational Spaces	• Largest temporary and long-term impacts to public recreational spaces. • The formal recreational trail from Bluebird Crescent to the dyke structure will be temporarily closed during construction as it will be used for construction access. • The vertical MSE wall would require a fence/barrier (according to municipal building code) along the dry side crest to address safety concerns (fall hazard) • The vertical MSE wall and fall barrier would impede pedestrians from traversing over the dyke. • The vertical MSE wall would require the construction of a staircase on the dry side to maintain access to private property owners. • Opportunity to improve public realm/open space areas and formalize the informal trail along the existing dyke structure	• Minor temporary impacts to public recreational spaces. • The formal recreational trail from Bluebird Crescent to the dyke structure will be temporarily closed during construction as it will be used for construction access. • New dyke slopes would be a similar slope/incline as existing so there would be change to pedestrian's ability to traverse dyke. • Fall barrier may be needed in some areas with steeper slopes as required. • Opportunity to improve public realm/open space areas and formalize the informal trail along the existing dyke structure.	• Minor temporary impacts to public recreational spaces. • The formal recreational trail from Bluebird Crescent to the dyke structure will be temporarily closed during construction as it will be used for construction access. • New dyke slopes would be a similar slope/incline as existing so there would be no change to pedestrian's ability to traverse dyke. • Fall barrier may be needed in some areas with steeper slopes as required. • Less opportunity to improve public realm/open space areas and formalize the informal trail along the existing dyke structure since dyke crest will not be widened.	• Minor impacts to public recreational spaces. • The formal recreational trail from Bluebird Crescent to the dyke structure will be temporarily closed during construction as it will be used for construction access. • New dyke slopes would be a similar slope/incline as existing or shallower so there would be no negative change to pedestrian's ability to traverse dyke. • Existing creek access to private property owners will be maintained although creek access may be more difficult in some areas depending on grading of wet side. • Fall barrier may be needed in some areas with steeper slopes as required. • Opportunity to improve public realm/open space areas and formalize the informal trail along the existing dyke structure.
Disruption Caused by Construction Activities	• Moderate construction duration. • Disruptions during construction are anticipated to be typical of earthworks construction projects and include: noise, vibrations, dust, altered landscapes, and adjustments to traffic patterns at site access points. • Construction impacts for concept H1 and H2 are similar however the duration of construction for H1 would be longer due to additional effort to construct the MSE wall within a limited construction area.	• Shortest construction duration. • Disruptions during construction are anticipated to be typical of earthworks construction projects and include: noise, vibrations, dust, altered landscapes, and adjustments to traffic patterns at site access points. • Construction impacts for concept H2 and H1 are similar however the duration of construction for H2 would be shorter.	• Moderate construction period, with potential for prolonged construction period due to the use of tie-backs. • Significant construction disruptions due to large equipment (i.e. cranes) and hammering of deep sheet pile which would increase noise, vibration and dust.	• Longest construction duration. • Significant disruptions during construction are anticipated, typical of earthworks construction projects and include: noise, vibrations, dust, altered landscapes, and adjustments to traffic patterns at site access points with increased noise due to significant excavation and concrete trucks.

Impacts to Servicing, Utilities, and Infrastructure	• No public servicing or utilities are known to exist within the dyke segment P1 area. • Potential private utilities such as private sump pump discharge lines can be accommodated during construction.	• No public servicing or utilities are known to exist within the dyke segment P1 area. • Potential private utilities such as private sump pump discharge lines can be accommodated during construction.	• No public servicing or utilities are known to exist within the dyke segment P1 area. • Potential private utilities such as private sump pump discharge lines can be accommodated during construction.	• No public servicing or utilities are known to exist within the dyke segment P1 area. • Potential private utilities such as private sump pump discharge lines can be accommodated during construction.
Removal or Disturbance to Potential Archaeological Resources	• This concept has the smallest excavation footprint and therefore, this concept has the lowest chance of disturbing potential archaeological resources.	• This concept has a small excavation footprint and therefore, this concept has a low chance of disturbing potential archaeological resources.	• This concept has a small excavation footprint and therefore, this concept has a low chance of disturbing potential archaeological resources. • There is the possibility of significant disturbance should tie-backs be required.	• This concept has the largest excavation footprint and therefore, this concept has the highest chance of disturbing potential archaeological resources.
Aesthetics	• Low aesthetics value as the dry side of the dyke will have a MSE wall, and the rest of the dyke will have a natural appearance with native grasses. • Various options are available for appearance of MSE wall but will not look 'natural'.	• High aesthetics value as the entire dyke will have a natural appearance with native grasses.	• Highest aesthetics value as the entire dyke will have the most natural appearance with native grasses, shrubs and trees.	• Low aesthetics value as the wet side of the dyke will have a concrete wall, and the rest of the dyke will have a natural appearance with native grasses.
	Moderately Preferred	**Most Preferred**	**Least Preferred**	**Least Preferred**
Evaluation Criteria Technical Aspects	**H1**	**H2**	**H3**	**H4**
Allowance for Future Enhancement to a Higher Level of Flood Protection	• Dyke can be built upon to raise/enhance in the future with moderate efforts. • Potential to raise MSE wall with additional material added on top (i.e., blocks) and extend the sheet pile.	• Dyke can be built upon to raise/enhance in the future with moderate efforts, although easier than for H1. • A larger footprint would be required which will encroach into private properties.	• Dyke can be raised by extending the sheet pile and add fill to top-up the crest. • Higher, steeper slopes may result in increased maintenance and more difficultly to complete maintenance.	• Dyke can be built upon to raise/enhance in the future with moderate efforts. • Concrete wall could be raised by building upon it (with structural connections). Add fill to the crest and backslope (dry side). • A larger footprint would be required which will encroach into private properties.
Construction Complexity and Constraints	• Moderate construction constraints and complexities. • Typical earthworks construction practises, equipment and constraints with added complexities including installation of sheet pile and construction of MSE wall with small equipment in space-constrained conditions.	• Minimal construction constraints and complexities. • Typical earthworks construction practises, equipment and constraints with added complexity of installing sheet pile with small equipment in space-constrained conditions.	• Significant construction complexities due to large construction equipment operating within limited space • If tie-backs are required the complexity of the work and constraints increases	• Significant construction complexities due to excavation and concrete work in close proximity to the channel
Service Life	• Expected to have a minimum 50 year design life with regular maintenance and monitoring of creek bank erosion and with additional bank erosion mitigation measures taken when needed.	• Expected to have a minimum 50 year design life with regular maintenance and monitoring of creek bank erosion and with additional bank erosion mitigation measures taken when needed.	• Expected to have a minimum 50 year design life with regular maintenance and monitoring of creek bank erosion and with additional bank erosion mitigation measures taken when needed.	• Expected to have a minimum 50 year design life with regular maintenance and monitoring of creek bank erosion and with additional bank erosion mitigation measures taken when needed.

Maintenance Requirements	• Typical maintenance works are required on a regular basis (i.e., mowing, culvert cleaning). Potential maintenance of MSE wall, fence/barrier and bank erosion protection. • Lowest regular maintenance efforts required due to smallest area to mow.	• Typical maintenance works are required on a regular basis (i.e., mowing, culvert cleaning). Potential maintenance of bank erosion protection. • Low regular maintenance efforts required due to small area to mow.	• Typical maintenance works are required on a regular basis (i.e., mowing, culvert cleaning). Potential maintenance of bank erosion protection and repair of damage from tree failures. • Lowest regular maintenance efforts required due to smallest area to mow (crest only).	• Typical maintenance works are required on a regular basis (i.e., mowing, culvert cleaning). Potential maintenance of concrete wall and bank erosion protection. • Low regular maintenance efforts required due to small area to mow, however significant long-term maintenance/repairs to concrete wall which will be difficult due to proximity to creek.
	Most Preferred	**Most Preferred**	**Moderately Preferred**	**Least Preferred**
Evaluation Criteria Cost	**H1**	**H2**	**H3**	**H4**
Capital Cost	$7.2 Million	$7.0 Million	$11.1 Million	$10.7 Million
Operation and Maintenance Cost	• Low maintenance cost.	• Low maintenance cost.	• Moderate maintenance cost due to repairs of potential small/nuisance slope failures.	• Low maintenance cost.
	Moderately Preferred	**Most Preferred**	**Least Preferred**	**Least Preferred**
OVERALL EVALUATION	**Moderately Preferred**	**Most Preferred**	**Least Preferred**	**Least Preferred**

TABLE 5-4: EVALUATION OF DESIGN CONCEPTS FOR PICKERING DYKE SEGMENT P2

Evaluation Criteria Natural Environment	S1 (Drainage Filter only)	S2 (Seepage Cut-off)
Removal, Disturbance, or Enhancement of Terrestrial Habitat	• Largest permanent disturbance as dyke has the largest footprint. However, the area is only moderately larger than S2. • Requires removal of trees on dyke and restoration of dyke with native grasses. • Moderate temporary disturbance area during construction. • Potential to enhance ecological function in areas adjacent to the dyke.	• Smallest permanent disturbance as dyke has the smallest footprint. However, the area is only moderately smaller than S1. • Requires removal of trees on dyke and restoration of dyke with native grasses. • Moderate temporary disturbance area during construction. • Potential to enhance ecological function in areas adjacent to the dyke.
Removal, Disturbance, or Enhancement of Aquatic Habitat	• No disturbance to aquatic habitat due to dyke rehabilitation works. • Potential for temporary disturbance during installation of internal drainage pipe. (eg. culvert P3) depending on final location and arrangement of pipes.	• No disturbance to aquatic habitat due to dyke rehabilitation works. • Potential for temporary disturbance during installation of internal drainage pipe (eg. culvert P3) depending on final location and arrangement of pipes.
	Moderately Preferred	**Most Preferred**
Evaluation Criteria Cultural/Social Environment	**S1**	**S2**
Removal or Disturbance to Private and Public Property not Owned by TRCA	• No direct disturbance to private property is anticipated. • All components of this solution are contained entirely on TRCA property. • Construction can be facilitated entirely within TRCA property and public property.	• No direct disturbance to private or public property is anticipated. • All components of this solution are contained entirely on TRCA property. • Construction can be facilitated entirely within TRCA property and public property.

Effects on Public Recreational Spaces	• Minor temporary impacts and moderate long-term improvements to public recreational spaces. • Temporary removal of the TransCanada Trail and municipal recreational trail during dyke construction. • Opportunity to improve public realm / open space areas when rebuilding trail. • The rehabilitated dyke would have less steep side slopes in comparison to the existing dyke. This would make traversing the dyke easier and safer than current conditions.	• Minor temporary impacts and moderate long-term improvements to public recreational spaces. • Temporary removal of the TransCanada Trail and municipal recreational trail during dyke construction. • Opportunity to improve public realm / open space areas when rebuilding trail. • The rehabilitated dyke would have less steep side slopes in comparison to the existing dyke. This would make traversing the dyke easier and safer than current conditions.
Disruption Caused by Construction Activities	• Disruptions during construction are anticipated to be typical of earthworks construction projects and include: noise, vibrations, dust, altered landscapes, and adjustments to traffic patterns at site access points. • Shortest construction duration.	• Disruptions during construction are anticipated to be typical of earthworks construction projects and include: noise, vibrations, dust, altered landscapes, and adjustments to traffic patterns at site access points. • Potential for additional noise and vibrations if sheet pile is selected as preferred cut-off material (to be determined at detailed design). • Longest construction duration due to additional time to install seepage cut-off (regardless of material used for cut-off).
Impacts to Servicing, Utilities, and Infrastructure	• Lowest impact to existing servicing and utilities as construction activities and all dyke components occur above the pipes and the pipes can remain unexposed. • A sanitary sewer and watermain are known to pass under the dyke. • Requires coordination with multiple utility owners to assess condition of existing pipes and obtain permission to perform works over their infrastructure.	• Highest impact to existing servicing and utilities as seepage cut-off needs to be installed around and below them. • Pipes need to be exposed during dyke construction. Seepage cut-off would need to be restored by utility owner if they perform work to their infrastructure. • A sanitary sewer and watermain are known to pass under the dyke. • Requires coordination with multiple utility owners to assess condition of existing pipes and obtain permission to perform works around their infrastructure.
Removal or Disturbance of Potential Archaeological Resources	• This concept has the largest excavation footprint into previously undisturbed soil. Therefore, this concept has the highest chance of disturbing potential archaeological resources. However, the excavation footprint is only moderately larger than S2.	• This concept has the smallest excavation footprint into previously undisturbed soil. Therefore, this concept has the lowest chance of disturbing potential archaeological resources. However, the excavation footprint is only moderately smaller than S1.
Aesthetics	• High aesthetics value as the entire dyke will have a natural appearance with native grasses.	• High aesthetics value as the entire dyke will have a natural appearance with native grasses.
	Most preferred	**Moderately Preferred**
Evaluation Criteria Technical Aspects	**S1**	**S2**
Allowance for Future Enhancement to a Higher Level of Flood Protection	• Dyke can easily be built upon to raise/enhance in the future.	• Dyke can be built upon to raise/enhance in the future. • More complex to raise dyke as the seepage cut-off must be raised and positioned correctly within the dyke in order to function.
Construction Complexity and Constraints	• Typical earthworks construction practises, equipment and constraints. • Low complexity.	• Typical earthworks construction practises and equipment. • Moderate complexity and additional constraints due to installation of seepage cut-off.
Service Life	• Expected to have a minimum 50 year design life with regular maintenance.	• Expected to have a minimum 50 year design life with regular maintenance.
Maintenance Requirements	• Typical maintenance works are required on a regular basis (i.e., mowing, culvert cleaning). • Greatest maintenance efforts required due to largest area to mow. However, the area is only moderately larger than S2.	• Typical maintenance works are required on a regular basis (i.e., mowing, culvert cleaning). • Lowest maintenance efforts required due to smallest area to mow. However, the area is only moderately smaller than S1.
	Most Preferred	**Moderately Preferred**

Evaluation Criteria Cost	S1	S2
Capital Cost	$3.0 Million	$9.1 Million
Operation and Maintenance Cost	• Low maintenance cost and complexity. • Moderately higher maintenance cost than S2 due to larger area to mow.	• Low maintenance cost and complexity. • Moderately lower maintenance cost than S1 due to smaller area to mow.
	Most preferred	**Least Preferred**
OVERALL EVALUATION	**Most Preferred**	**Moderately Preferred**

TABLE 5-5: EVALUATION OF DESIGN CONCEPTS FOR AJAX DYKE SEGMENT A1

Evaluation Criteria Natural Environment	S1	S2
Removal, Disturbance, or Enhancement of Terrestrial Habitat	• Both concepts have a similar scale of impacts. • Large permanent disturbance area as dyke footprint is approximately double the existing footprint. • Requires removal of trees on dyke and restoration of dyke with native grasses. • Moderate temporary disturbance area during construction. • Potential to enhance ecological function in areas adjacent to the dyke.	• Both concepts have a similar scale of impacts. • Large permanent disturbance area as dyke footprint is approximately double the existing footprint. • Requires removal of trees on dyke and restoration of dyke with native grasses. • Moderate temporary disturbance area during construction. • Potential to enhance ecological function in areas adjacent to the dyke.
Removal, Disturbance, or Enhancement of Aquatic Habitat	• No disturbance to aquatic habitat.	• No disturbance to aquatic habitat.
	Most Preferred	**Most Preferred**
Evaluation Criteria Cultural/Social Environment	**S1**	**S2**
Removal or Disturbance to Private and Public Property not Owned by TRCA	• Both concepts have similar impacts. • A small portion of the dyke must be located on private property due to grading requirements to tie-into existing ground at the desired crest elevation. • Additionally, a portion of the temporary construction access corridor, up to 5m wide, is proposed on private properties at north and south ends of the dyke (up to 4 properties temporarily affected).	• Both concepts have similar impacts. • A small portion of the dyke must be located on private property due to grading requirements to tie-into existing ground at the desired crest elevation. • Additionally, a portion of the temporary construction access corridor, up to 5m wide, is proposed on private properties at north and south ends of the dyke (up to 4 properties temporarily affected).
Effects on Public Recreational Spaces	• Both concepts have similar impacts. Minor temporary impacts and moderate long-term improvements to public recreational spaces. • Temporary removal of the TransCanada Trail during dyke construction. • Opportunity to improve public realm / open space areas when rebuilding trail. • The rehabilitated dyke would have less steep side slopes in comparison to the existing dyke. This would make traversing the dyke easier and safer than current conditions.	• Both concepts have similar impacts. Minor temporary impacts and moderate long-term improvements to public recreational spaces. • Temporary removal of the TransCanada Trail during dyke construction. • Opportunity to improve public realm / open space areas when rebuilding trail. • The rehabilitated dyke would have less steep side slopes in comparison to the existing dyke. This would make traversing the dyke easier and safer than current conditions.
Disruption Caused by Construction Activities	• Disruptions during construction are anticipated to be typical of earthworks construction projects and include: noise, vibrations, dust, altered landscapes, and adjustments to traffic patterns at site access points. • Shortest construction duration.	• Disruptions during construction are anticipated to be typical of earthworks construction projects and include: noise, vibrations, dust, altered landscapes, and adjustments to traffic patterns at site access points. • Potential for additional noise and vibrations if sheet pile is selected as preferred cut-off material (to be determined at detailed design).

		• Longest construction duration due to additional time to install seepage cut-off (regardless of material used for cut-off).
Impacts to Servicing, Utilities, and Infrastructure	• Lowest impact to existing servicing and utilities as construction activities and all dyke components occur above the pipes and the pipes can remain unexposed. • Multiple sanitary sewers and possibly a watermain are known to pass under the dyke. • Requires coordination with multiple utility owners to assess condition of existing pipes and obtain permission to perform works over their infrastructure. • Potential opportunity for synergies with utility owner to relocate sewers if upgrade/replacement of aging underground infrastructure is identified by utility owner	• Highest impact to existing servicing and utilities as seepage cut-off needs to be installed around and below them. • Pipes need to be exposed during dyke construction. Seepage cut-off would need to be restored by utility owner if they perform work to their infrastructure. • Multiple sanitary sewers and possibly a watermain are known to pass under the dyke. • Requires coordination with multiple utility owners to assess condition of existing pipes and obtain permission to perform works around their infrastructure. • Potential opportunity for synergies with utility owner to relocate sewers if upgrade/replacement of aging underground infrastructure is identified by utility owner
Removal or Disturbance to Potential Archaeological Resources	• Both concepts have a similar scale of impacts. • Possibility for removal or disturbance of potential archaeological resources within footprint of new dyke structure.	• Both concepts have a similar scale of impacts. • Possibility for removal or disturbance of potential archaeological resources within footprint of new dyke structure.
Aesthetics	• High aesthetics value as the entire dyke will have a natural appearance with native grasses.	• High aesthetics value as the entire dyke will have a natural appearance with native grasses.
	Most preferred	**Moderately Preferred**
Evaluation Criteria Technical Aspects	**S1**	**S2**
Allowance for future enhancement to a Higher Level of Flood Protection	• Dyke can easily be built upon to raise/enhance in the future.	• Dyke can be built upon to raise/enhance in the future. • More complex to raise dyke as the seepage cut-off must be raised and positioned correctly within the dyke in order to function.
Construction complexity	• Typical earthworks construction practises, equipment and constraints. • Low complexity.	• Typical earthworks construction practises and equipment. • Moderate complexity and additional constraints due to installation of seepage cut-off.
Service life	• Expected to have a minimum 50 year design life with regular maintenance.	• Expected to have a minimum 50 year design life with regular maintenance.
Maintenance requirement	• Both concepts have similar maintenance requirements. • Typical maintenance works are required on a regular basis (i.e., mowing, culvert cleaning).	• Both concepts have similar maintenance requirements. • Typical maintenance works are required on a regular basis (i.e., mowing, culvert cleaning).
	Most Preferred	**Moderately Preferred**
Evaluation Criteria Cost	**S1**	**S2**
Capital Cost	$2.6 Million	$4.7 Million
Operation and Maintenance cost	• Both concepts have similar maintenance costs. • Low maintenance cost and complexity.	• Both concepts have similar maintenance costs. • Low maintenance cost and complexity.
	Most preferred	**Least Preferred**
OVERALL EVALUATION	**Most preferred**	**Least preferred**

5.4 Selection of Preferred Design Concept

Based on the comparison shown in Tables 5-3 to 5-5, the following are the preferred Design Concepts.

- Pickering Dyke Segment P1: Design Concept H2
- Pickering Dyke Segment P2: Design Concept S1
- Ajax Dyke Segment A1: Design Concept S1

Drawings illustrating these design concepts are provided in Appendix I. These drawings correspond to a 30% design level, a restoration plan of similar level of detail is provided in Appendix I. The drawings for each preferred design concept are as follows.

- Drawing G04 shows a general plan view of the preferred design concepts for the Pickering Dyke
- The preferred design concept (H2) for Dyke Segment P1 is shown in Drawing G06 in plan view and cross sections are provided in Drawing G08
- The preferred design concept (S1) for Dyke Segment P2 is shown in Drawing G09 in plan view and cross sections are provided in Drawing G11
- The preferred design concept (S1) for Dyke Segment A1 is shown in Drawing G01 in plan view and cross sections are provided in Drawing G02

6.0 DESCRIPTION OF THE PREFERRED DESIGN CONCEPT

In Section 5.0, the various design concepts considered for each dyke segment were discussed and compared based on a set of criteria devised and applied as part of the EA process, in consultation with stakeholders and the public. The comparison and the consultation allowed selecting a preferred design concept for each dyke segment. This section provides a more detailed description of these preferred design concepts and their implementation. Drawings of the preferred design concept, to a 30% level of design, are shown in Appendix I. The corresponding restoration plan is provided in Appendix I. Supporting geotechnical analyses are provided in Appendix H.

6.1 Dyke Segment P1 – Design Concept H2

Design Concept H2 is described in Section 5.1.2. It includes modifying the dry side slope of the dyke by adding a gravel toe drain at the toe of a 2H:1V slope. This design concept also includes a sheet pile that serves as seepage cut-off and contributes to stability of the dyke. On the wet side slope, it features an engineered vegetated rock buttress, at a relatively steep slope that at some locations matches and connects with the creek bank slope. Figure 5-2 illustrates this design concept on a representative cross-section. The footprint of this solution is illustrated in plan in Drawing G-06, and cross-sections are shown in Drawing G-08 (Appendix I). A number of elements, including the geometry and alignment of the rehabilitated dyke can be refined during subsequent design stages, for instance moving the dyke away from the creek at locations where it is possible within TRCA property and without impacting private properties.

The sheet pile and gravel toe drain will work in concert to control seepage. The length of sheet pile will be limited to that which can be installed using a vibratory hammer mounted to an excavator. This limitation is expected to result in sections of sheet pile that may not completely seal deeper sand and gravel layers in the dyke foundation soils. In those areas, the gravel toe drain would control potential seepage that may bypass beneath the sheet pile cut-off, by filtering the dyke and foundation soils. For the gravel toe drain to function as an effective filter, the top of the drain will need to remain uncapped (uncovered by topsoil and unvegetated) so that seepage water can emerge freely. It is anticipated that the gravel toe drain filter can be covered by a decorative stone to improve aesthetics. The final length of sheet pile, as well as the gravel toe drain gradation and dimensions, are to be optimized in the subsequent design phase. The structural details of the interaction between the sheet pile and the through-dyke culverts and the one existing private owner sump discharge lines will also need to be finalized as part of detailed design. Additionally, it is possible that a cut-off solution may impact local groundwater patterns. A groundwater study should be completed as part of detailed design to collect baseline data and confirm if the potential impacts of installing a cut-off solution are tolerable, and if not, design a mitigation system.

The wet side slope will be modified to consist of a vegetated buttress, comprised of angular cobble to boulder sized rocks that are designed to be stable in configurations as steep as some sections with existing 1.5H:1V average slopes in order prevent infilling into the creek. Riparian live stake plantings would be incorporated within the vegetated buttress. The vegetated buttress comprises the wet side slope and extends all the way down to the creek bed in those areas where there is no separation from the toe of dyke and edge of bank. Stone sizing for the vegetated buttress would need to be determined as part of detailed design considering factors like ice impact resiliency, and giving preference to sub-angular material where feasible. It should also be considered in detailed design if there are merits to creating access points to the creek near any identified locations prone to river ice occurrence for equipment to access and remove potential ice jams.

Sections 3.0 and 5.1.7 discuss areas of the dykes that are at high risk of adverse impacts from ongoing erosion and the provisions to protect these areas. The vegetated rock buttress would provide erosion protection in those areas where there is no separation between edge of bank and the toe of dyke slope. There are other areas that are at high risk of adverse impacts from erosion but there is more separation between the wet side toe of dyke and the edge of bank. In those areas, the buttress must be supplemented with a rock filled trench at the toe of the buttress. That rock filled trench would provide erosion protection in the future when continued creek bank erosion eventually migrates. Where the dyke is distant from the creek and the risk of bank erosion is not high, the buttress can be replaced with a typical earth embankment at a gradual slope, similar to that illustrated in Design Concept S1 (Section 5.1.5). The solution would transition from earthen slope to the vegetated buttress at appropriate locations, as dictated by creek bank slope stability analyses. Alternatively, the rock buttress could be implemented along the entire wet side of Segment P1, but it would be covered at appropriate locations with soil and grasses to provide a slope and surface that are safe to walk on and for equipment access. The purpose is to facilitate pedestrian access to the creek, across the dyke, as easily and safely as, or better than, what exists under current conditions, as well as opportunities for future maintenance and ice jam removal if necessary. This is an aspect that should be evaluated and refined in subsequent design phases.

This design concept includes the provision for a drainage swale that runs along the dry side of the dyke, at a short distance from the dyke toe (approximately 1 m or as per design). Any grading beyond the toe of dyke for a drainage swale would potentially occur on private properties in areas where the existing toe of dyke is within 5 m of the TRCA property line. The intent of the internal drainage swale grading is to ensure that the current internal drainage patterns are maintained (i.e. surface runoff from the dry side of the dyke is still directed to the through-dyke culverts after construction). It may be found in the detailed design of the internal drainage system that, because the location of the dry side toe of dyke is effectively maintained with design concept H2, little to no drainage modifications may in fact need to occur on private property but this would need to be confirmed during design of the internal drainage system. Alternative options that can be explored in subsequent design phases to minimize grading for internal drainage purposes on private property are to:

1. Add more through-dyke culverts or optimize the current culvert arrangement, if possible.
2. Apply Design Concept H1 locally in constricted areas. Design Concept H1 is described in Section 5.1.2 and is similar to Design Concept H2 except that the dry side gradual slope is replaced with an MSE wall. Replacing short sections of the dry slope with an MSE wall would provide more room on TRCA property for internal drainage grading. It will require considerations for landscaping and transitioning from the wall to the design dry side slope.

Operation and maintenance of Design Concept H2 is anticipated to consist of regular inspections, seasonal ice jam monitoring, vegetation management, culvert and internal drainage swale cleaning, culvert slide gate testing and repairs, periodic crest top-ups, repairs of defects such as animal burrows, and other requirements that may be identified as the detailed design develops. The frequency of vegetation maintenance should be such that allows proper inspection of the dykes and that does not permit the establishment of trees on them. Recommendations for operations and maintenance (O&M) of design concept H2 should be developed as part of detailed design and compiled in an O&M manual. The O&M manual should be prepared considering the recommendations in the International Levee Handbook and TRCA protocols. This manual should be finalized once as-built information is available following construction of the dyke remediations.

The construction of Design Concept H2 along Dyke Segment P1 can be implemented concurrently or in sequence with the solution for Dyke Segment P2. In both cases, and given their proximity, access and staging areas will be shared for the two segments. Scheduling limitations, considerations, and restrictions for deciding whether to construct the works concurrently or in sequence are discussed 5.1.7. Segment P1 is the only dyke segment with in-water works proposed. The in-water component of the works must be completed between July 15 and September 15 to mitigate risk of adverse impacts to fish and fish habitat. A detailed erosion and sediment control plan (ESC) including worksite isolation will need to be developed and implemented considering TRCA Erosion and Sediment Control Guidelines for any in-water works.

High water erosion risks can be considered as part of detailed design. The anticipated flow velocities for the design flood event are within the range that would not erode a dyke vegetated with grass or armoured by the vegetated rock buttress.

Drawings G06 and G09 illustrate potential construction access that can be shared for the construction of Segments P1 and P2, including:

1. Brock Rd at the west tie-in point of the existing dyke, and
2. Bluebird Crescent, from Finch Ave, approximately 300 m East of Brock Rd
3. Trail access from Finch Ave, approximately 350 m East of Brock Rd
4. From Kingston Rd W, across Notion Rd, through a strip of land owned by TRCA
5. At the east end of the Pickering Dyke, from Kingston Rd W, west of the crossing over Duffins Creek

Sub-surface utility mapping should be completed in these access areas in order to design the access roads to avoid damage to any buried utilities from construction traffic. Continuous access along the dyke will also be required to construct the works and it is expected that a 5 m construction corridor along the dry side toe would suffice for circuit traffic of haul trucks during construction. The project footprint illustrated on Drawing G06 shows this potential disturbance area extends on to private properties. As the design develops, focus should be placed on minimizing the amount of encroachment into private properties required. The potentially affected private property owners should be contacted to secure work access agreements to fully utilize a continuous access corridor beyond the dry side toe of dyke for construction access. Easements may also be required if it is determined that some grading needs to occur within this strip in order to maintain internal drainage characteristics (i.e. swale construction). Measures (for example mud mats) should be implemented to protect vulnerable areas and adjacent roads. Access areas and roads should be restored to at minimum pre-construction conditions, at the end of the project.

If it is not possible to secure access agreements to facilitate construction, the dyke itself would need to be used as an access corridor where feasible. This would entail either using smaller construction equipment, or temporarily modifying the dyke to permit access with larger equipment in areas where the dyke crest is currently too narrow for continuous access. Where modifying the dyke for construction access is not feasible the adjacent creek bed would need to be used for temporary short-duration construction access activities and then fully restored afterwards. Alternatively, temporary creek crossings could be constructed and the opposite (north) creek overbank area could be used for construction access. However, utilizing the creek bed for temporary access is expected to result in a lower net disturbance to the environment and be more efficient than utilizing the north overbank area. Exact means and methods for construction in this constricted area should be decided by the contractor.

The construction contractor would need to have a detailed emergency flood protection plan in place to immediately shore up any temporary modifications to the existing dyke during construction that are needed to facilitate access but also result in a temporary decrease in the available level of flood protection. Consideration should be given to stipulate a mandatory site visit during the tendering process so that contractors can understand the site constraints in Segment P1.

The proposed staging areas for construction of Design Concept H2 in Dyke Segment P1 and for the rehabilitation of Dyke Segment P2 are:

1. On the dry side of the dyke, immediately adjacent to the walking trail, and behind the condominium development on Finch Ave, as illustrated on Drawing G06.
2. On the dry side of the dyke, behind the Moody’s property, opposite to the location of the pedestrian crossing across Duffins Creek (between Sta. 0+300 and 0+450, as illustrated on Drawing G09).

The first of these proposed staging areas is approximately 1,500 m2, and the second staging area is approximately 5,050 m2; but incentivization methods for contractors to utilize a smaller work area should be explored as part of bid document preparation in detailed design.

Ground vibrations from construction of the remediation works, including the installation of sheet piles, will have the potential to adversely impact nearby structures. Pre and post construction inspections of nearby properties should be completed jointly by TRCA and the construction contractor. A vibration monitoring program should also be implemented during construction to ensure that measured peak particle velocity (PPV) and vibration frequencies (hertz) are below the limitations in City of Toronto Bylaw No. 514-2008.The Toronto bylaw was used as reference since a corresponding bylaw was not found for Pickering or Ajax.

6.2 Dyke Segment P2 – Design Concept S1

Design Concept S1 is described in Section 5.1.5. It includes modifying the dry side slope of the dyke by adding a downstream filter and providing a stable dry side slope of 3H:1V on the dry side and 4H:1V on the wet side. Figure 5-6 illustrates this design concept on a representative cross-section. The footprint of this solution is illustrated in plan in Drawing G-09, and cross-sections are shown in Drawing G-11 (Appendix I). A number of elements, including the geometry and alignment of the rehabilitated dyke, as well as the transition between the solutions implemented in Dyke Segments P1 and P2, are to be refined during subsequent design stages.

The downstream filter will control seepage by ensuring that flood water does not infiltrate through the dyke fill and saturate the dry side slope. For the filter to function effectively, the end metre or so of the filter must be uncapped (uncovered by topsoil and unvegetated) so that seepage water can emerge freely. It is anticipated that a decorative stone can be placed overtop the end of the exposed face of the filter to improve aesthetics of the filter at its discharge point. The filter gradations and dimensions should be optimized in the subsequent design phase. The proposed filter configuration considered for the 30% design level, as part of this study, satisfies steady-state seepage conditions as per the LRIA geotechnical design and factors of safety for the 500-year storm event. This means that the dry side slope would perform adequately for a flood of indefinite duration. It is anticipated that some efficiencies in the filter configuration can be realized using a transient (time dependent) seepage analysis that considers the recommended hydraulic conductivity parameters in the geotechnical design report (Appendix B) and the anticipated flood hydrograph. If a transient analysis is completed to optimize the final design, the desired duration for which the optimized design can be considered reliable should be determined in consultation with TRCA. The minimum duration should not only consider the current 500-year flood hydrograph, but also an additional factor of safety to account for inherent variability in flood forecasting, changes to the drainage basin over time, changes from alterations to land use and development, and the effects of climate change. That duration should be stated as a limitation in the subsequent design brief for the optimized solution. If there is no tolerance for risk considering a conservatively assumed maximum duration of the design flood event, then detailed design should proceed according to the assumption of steady-state seepage conditions.

The wet side slope will be modified to consist of a more gradual 4H:1V slope in order to remain stable under a rapid drawdown event. This has been developed considering an instantaneous rapid drawdown event after the design flood event, assuming floodwaters had fully permeated the dyke prior to the drawdown. Similar, to the dry side slope, it is anticipated that this slope can potentially be optimized in a later stage of design considering a transient seepage analysis with appropriately conservative assumptions, determined in consultation with TRCA, for both the duration of the design flood prior to the drawdown and the anticipated drawdown rate. It is possible that a more economical slope can be safely implemented but the duration of the flood prior to the drawdown, as well as the assumed drawdown rate, should be stated as a limitation in the subsequent design brief for the optimized solution. These minimum durations and drawdown rates should consider the anticipated flood hydrographs along with additional factors of safety applied to both the flood duration and rate of drawdown in order to account for inherent variability in flood forecasting, changes to the drainage basin over time, changes from alterations to land use and development, and the effects of climate change.

This design concept includes the provision for a drainage swale that runs along the dry side of the dyke, at a short distance from the filter blanket (approximately 1 m offset or as per design). The intent of the internal drainage swale grading is to ensure that the current internal drainage patterns are maintained (i.e. runoff on the inside of the dyke is still directed to the existing culvert locations after construction). Detailed design should assess the internal drainage patterns of the existing dyke and determine if, as part of the dyke remediations, the number of culverts through the dyke can be reduced, or their locations optimized.

Operation and maintenance of Design Concept S1 is anticipated to consist of regular inspections, seasonal ice jam monitoring, vegetation management, culvert and internal drainage swale cleaning, culvert slide gate testing and repairs, periodic crest top-ups, repairs of defects such as animal burrows, and other requirements that may be identified as the detailed design develops. The frequency of vegetation maintenance should be such that allows proper inspection of the dykes and that does not permit the establishment of trees on them. Recommendations for operations and maintenance (O&M) of design concept S1 should be developed as part of detailed design and compiled in an O&M manual. The O&M manual should be prepared considering the recommendations in the International Levee Handbook and TRCA protocols. This manual should be finalized once as-built information is available following construction of the dyke remediations.

Drawing G-09 illustrates that expanding the dyke footprint to the proposed geometry will require adjustments to the existing walking trail. As part of detailed design, it should be determined whether the preference is to relocate the trail to follow the new wet side toe of dyke or to relocate it onto the dyke crest. It should also be considered in detailed design if there are merits to creating access points to the creek on the wet side of the dyke near any identified locations prone to river ice occurrence for equipment to access and remove potential ice jams.

The construction of Design Concept S1 along Dyke Segment P2 can be implemented concurrently or in sequence with the solution for Dyke Segment P1. In both cases, and given their proximity, access and staging areas will be shared for the two segments. Scheduling limitations, considerations, and restrictions for deciding whether to construct the works concurrently or in sequence are discussed 5.1.7. In all cases measures should be implemented to protect vulnerable areas and adjacent roads, and access areas and roads should be restored to at minimum pre-construction conditions, at the end of the project.

High water erosion risks of this solution can be considered as part of detailed design. The anticipated flow velocities for the design flood event are within the range that would not erode a dyke vegetated with grass.

Drawings G06 and G09 illustrate potential construction access that can be shared for the construction of Segments P1 and P2, including:

1. Brock Rd at the west tie-in point of the existing dyke, and
2. Bluebird Crescent, from Finch Ave, approximately 300 m East of Brock Rd
3. Trail access from Finch Ave, approximately 350 m East of Brock Rd
4. From Kingston Rd W, across Notion Rd, through a strip of land owned by TRCA
5. At the east end of the Pickering Dyke, from Kingston Rd W, west of the crossing over Duffins Creek

Sub-surface utility mapping should be completed in these access areas in order to design the access roads to avoid damage to any buried utilities from construction traffic. Additionally, more in-depth sub-surface utility mapping should be completed to confirm the location and depth of any buried utilities through the dyke so that they can be appropriately protected during construction. In subsequent stages of design, specific utilities that would need to be considered or protected include the sanitary sewer near Sta 0+325 and the 1350 mm storm outfall culvert (Culvert P3). Detailed design should explore the option of implementing special provisions to protect this outfall pipe during construction rather than removing and replacing it. Similarly, the Region of Durham should be contacted to assist with determining the condition of the buried sanitary sewer near Sta 0+325, particularly if any major repairs are being considered in the future. It may be preferable to integrate the maintenance or relocation of these utilities into the dyke repairs in order to minimize potential disturbance to the dyke in the future while also facilitating the maintenance of this utility. If it is determined that it is not feasible to relocate or replace the utility as part of the dyke upgrades, a utility protection plan should be determined as part of detailed design considering the results of sub-surface utility mapping.

During construction of Option S1, continuous access along the dyke will also be required to construct the works and it is expected that a 5 m construction corridor beyond the toe of both sides of the dyke would suffice for circuit traffic of haul trucks during construction. Expanding the dyke footprint will require benching into the existing dyke fill and scarifying the existing soils to promote bonding between existing and new dyke fill. Similarly, the proposed alignment of the new dyke alternates between expanding the dyke footprint towards the wet side and the dry side depending on location and this may require temporary modifications to the dyke to facilitate continuous access for circuit haul truck traffic. The contractor must have a detailed emergency flood protection plan in place to immediately shore up any temporary modifications to the existing dyke during construction that are needed to facilitate access but also result in a temporary decrease in the available level of flood protection.

The proposed staging areas for construction of Segment P1 and Segment P2 are:

1. on the dry side of the dyke, immediately adjacent to the walking trail, and behind the condo development on Finch Ave, as illustrated on Drawing G06.
2. On the dry side of the dyke, behind the Moody’s property, opposite to the location of the pedestrian crossing across Duffins Creek (between Sta. 0+300 and 0+450, as illustrated on Drawing G09).

The first of these proposed staging areas is approximately 1,500 m2, and the second staging area is approximately 5,050 m2; but incentivization methods for contractors to utilize a smaller work area should be explored as part of bid document preparation in detailed design.

Ground vibrations from construction of the remediation works will have the potential to adversely impact nearby structures. Pre and post construction inspections of nearby properties should be completed jointly by TRCA and the construction contractor. A vibration monitoring program should also be implemented during construction to ensure that measured peak particle velocity (PPV) and vibration frequencies (hertz) are below the limitations in City of Toronto Bylaw No. 514-2008. The Toronto bylaw was used as reference since a corresponding bylaw was not found for Pickering or Ajax

6.3 Dyke Segment A1 – Design Concept S1

Design Concept S1 is described in Section 5.1.5. It includes modifying the dry side slope of the dyke by adding a downstream filter and providing a stable dry side slope of 3H:1V on the dry side and 4H:1V on the wet side. Figure 5-6 illustrates this design concept on a representative cross-section. The footprint of this solution is illustrated in plan in Drawing G-01, and cross-sections are shown in Drawing G-02 (Appendix I). A number of elements, including the geometry and alignment of the rehabilitated dyke are to be refined during subsequent design stages.

The downstream filter will control seepage by ensuring that flood water does not infiltrate through the dyke fill and saturate the dry side slope. For the filter to function effectively, the end metre or so of the filter must be uncapped (uncovered by topsoil and unvegetated) so that seepage water can emerge freely. It is anticipated that a decorative stone can be placed overtop the end of the exposed face of the filter to improve aesthetics of the filter at its discharge point. The filter gradations and dimensions should be optimized in the subsequent design phase. Currently, the proposed filter configuration satisfies steady-state seepage conditions and LRIA geotechnical design and factors of safety for the 500-year storm event. This means that the dry side slope would perform adequately for a flood of indefinite duration. It is anticipated that some efficiencies in the filter configuration can be realized using a transient (time dependent) seepage analysis that considers the recommended hydraulic conductivity parameters in the geotechnical design report (Appendix B) and the anticipated flood hydrograph. If a transient analysis is completed to optimize the final design, the desired duration for which the optimized design can be considered reliable should be determined in consultation with TRCA. The minimum duration should not only consider the current 500-year flood hydrograph, but also an additional factor of safety to account for inherent variability in flood forecasting, changes to the drainage basin over time, changes from alterations to land use and development, and the effects of climate change. That duration should be stated as a limitation in the subsequent design brief for the optimized solution. If there is no tolerance for risk considering a conservatively assumed maximum duration of the design flood event, then detailed design should proceed according to the assumption of steady-state seepage conditions.

The wet side slope will be modified to consist of a more gradual 4H:1V slope in order to remain stable under a rapid drawdown event. This has been developed considering an instantaneous rapid drawdown event after the design flood event, assuming floodwaters had fully permeated the dyke prior to the drawdown. Similar, to the dry side slope, it is anticipated that this slope can potentially be optimized in a later stage of design considering a transient seepage analysis with appropriately conservative assumptions, determined in consultation with TRCA, for both the duration of the design flood prior to the drawdown and the anticipated drawdown rate. It is possible that a more economical slope can be safely implemented but the duration of the flood prior to the drawdown, as well as the assumed drawdown rate, should be stated as a limitation in the subsequent design brief for the optimized solution. These minimum durations and drawdown rates should consider the anticipated flood hydrographs along with additional factors of safety applied to both the flood duration and rate of drawdown in order to account for inherent variability in flood forecasting, changes to the drainage basin over time, changes from alterations to land use and development, and the effects of climate change.

This design concept includes the provision for a drainage swale that runs along the dry side of the dyke. The intent of the internal drainage swale grading is to ensure that the current internal drainage patterns are maintained (i.e. runoff on the inside of the dyke is still directed to the through-dyke culverts after construction). Detailed design should assess the internal drainage patterns of the existing dyke and determine if, as part of the dyke remediations, the existing culvert arrangement, and the location of the drainage swale proposed in this study, can be optimized.

Operation and maintenance of Design Concept S1 is anticipated to consist of regular inspections, seasonal ice jam monitoring, vegetation management, culvert and internal drainage swale cleaning, culvert slide gate testing and repairs, periodic crest top-ups, repairs of defects such as animal burrows, and other requirements that may be identified as the detailed design develops. The frequency of vegetation maintenance should be such that allows proper inspection of the dykes and that does not permit the establishment of trees on them. Recommendations for operations and maintenance (O&M) of design concept S1 should be developed as part of detailed design and compiled in an O&M manual. The O&M manual should be prepared considering the recommendations in the International Levee Handbook and TRCA protocols. This manual should be finalized once as-built information is available following construction of the dyke remediations.

Drawing G01 illustrates that expanding the dyke footprint to the proposed geometry will require adjustments to the existing TransCanada Trail. It is proposed to keep the TransCanada trail on top of the remediated dyke crest. The current TransCanada Trail access point to the flood plain near Sta 0+150 can serve as a means to access the creek with equipment to remove potential ice jams. It should also be considered in detailed design if there are merits to creating additional access points to the creek on the wet side of the dyke near any identified locations prone to river ice occurrence.

The construction of Design Concept S1 along Dyke Segment A1 can be implemented concurrently or in sequence with the solution for Dyke Segment P1 and P2. Scheduling limitations, considerations, and restrictions for deciding whether to construct the works concurrently or in sequence are discussed 5.1.7.

High water erosion risks of this solution can be considered as part of detailed design. The anticipated flow velocities for the design flood event are within the range that would not erode a dyke vegetated with grass. It can be assessed as part of detailed design if there is an economic benefit to protect the dyke from damage during overtopping, particularly at the south end of the dyke at Church St S, where a reduced dyke crest level is proposed, to match the elevation of Church St S, as illustrated in profile in Drawing G01. If protection from overtopping is determined to be warranted in the next design phase, the selected method of overtopping protection should maintain access along the dyke crest for regular maintenance. Depending on the location of a suitable tie-in location, it may be determined that an emergency dyke top-up and road closure can be implemented to shore up this low point using sandbags or other emergency flood protection measures and this can be written into the dyke's O&M manual if it is determined to be a feasible solution. A temporary closure procedure may be preferable to providing protection of the dyke from overtopping.

Drawing G01 illustrates the current proposed access to Segment A1. It is anticipated that construction would need to utilize the proposed construction staging area for haul truck turnaround since there is only one access point at Church St South. Measures should be implemented to protect vulnerable areas and adjacent roads, and access areas and roads should be restored, if necessary, to at minimum pre-construction conditions, at the end of the project.

There are a number of in-service and abandoned sub-surface utilities in Dyke Segment A1. More in-depth sub-surface utility mapping should be completed as part of detailed design and the condition of all utilities running beneath of in proximity to the dyke should be assessed. The Region of Durham should be contacted to assist with determining the condition of these utilities, particularly if any major repairs are being considered in the future. It may be preferable to integrate the maintenance or relocation of these utilities into the dyke repairs in order to minimize potential disturbance to the dyke in the future while also facilitating the maintenance of these sub-surface utilities, and allowing optimization of the dyke alignment. It is important to note that the alignment shown in Drawing G01 was defined so that it minimizes impact to the sewers and manholes in the area. If the sewers can be relocated, that would allow more flexibility for the dyke alignment, so that it could be made shorter and moved to higher ground, which would reduce costs. That would also provide more distance between the dyke and the existing butternut tree in the area. If it is determined that it is not feasible to relocate or replace the subsurface utilities as part of the dyke upgrades, a utility protection plan should be determined as part of detailed design considering the results of sub-surface utility mapping. It must also be noted that for construction, TRCA will require an Encroachment Permit from the Region of Durham to occupy the sewer right-of-way, in addition to the contractor's Temporary Construction Access Permit.

During construction of Option S1, continuous access along the dyke will also be required to construct the works and it is expected that a 5 m construction corridor beyond the toe of both sides of the dyke would suffice for equipment access during construction. Expanding the dyke footprint will require benching into the existing dyke fill and scarifying the existing soils to promote bonding between existing and new dyke fill. Similarly, the proposed alignment of the new dyke alternates between expanding the dyke footprint towards the wet side and the dry side depending on location and this may require temporary modifications to the dyke to facilitate continuous access for circuit haul truck traffic. The contractor must have a detailed emergency flood protection plan in place to immediately shore up any temporary modifications to the existing dyke during construction that are needed to facilitate access but also result in a temporary decrease in the available level of flood protection.

The proposed staging area for construction of Design Concept S1 in Dyke Segment A1 is on the dry side of the dyke as illustrated on Drawing G01. The proposed staging area is approximately 4,000 m^2 but incentivization methods for contractors to utilize a smaller work area should be explored as part of bid document preparation in detailed design.

Ground vibrations from construction of the remediation works will have the potential to adversely impact nearby structures. Pre and post construction inspections of nearby properties should be completed jointly by TRCA and the construction contractor. A vibration monitoring program should also be implemented during construction to ensure that measured peak particle velocity (PPV) and vibration frequencies (hertz) are below the limitations in City of Toronto Bylaw No. 514-2008. The Toronto bylaw was used as reference since a corresponding bylaw was not found for Pickering or Ajax.

6.4 Long Term Maintenance Schedule Considerations

Inspections of the dyke should be completed on a yearly basis at minimum and prior to the spring freshet. Regular maintenance of the dykes is expected to consist of mowing the dyke crest and vegetated slopes, and internal drainage swale, potential maintenance of bank erosion protection, as well as regular culvert clean-out and checks of slide gate operation. Mowing would be completed two times a year (once in the summer and once in the fall), which would amount to approximately 40 hours or one week of work. Another week (40 hours) would be required per year for inspections and for cleaning gates. Ideally inspections would occur shortly after mowing to allow better assessment of the dyke. In addition, inspections would also be completed during winter to monitor for ice jams. It is expected that these inspections could amount to 40 hours or one week of work. All inspection and maintenance hours indicated include both dykes (Pickering and Ajax).

6.5 Summary of Recommendations for Subsequent Design Phases

Without limiting the items that need to be addressed when advancing the preferred design concept into the next stage of the design, the following is recommended:

Common to all Dyke Segments

- Optimize dyke alignment.
- Optimize dyke geometry.

- Complete basal area calculation for all impacted terrestrial areas. Finalize the compensation and restoration plans. A tree inventory should be completed as well as a BHA for any additional Butternut trees that were not assessed as part of this study and that might be impacted by the proposed solution.
- Develop a sediment and erosion control plan for the remediation works.
- Explore the merits of implementing additional creek access points to break up ice. Develop these details if warranted.
- Design the internal drainage system with the minimum requirement of maintaining existing drainage patterns. Optimize the current culvert arrangement, if possible.
- Prepare an O&M manual considering the suggested content of the International Levee Handbook. The content of the manual should be finalized after as-built information is available.
- Assess if there are merits to providing protection of the dyke from overtopping. Armored spillways to be considered. Develop these measures if they are determined to be economical for this application.
- Finalize construction access points and develop sub-surface utility protection details.

Segment P1

- Optimize wet side slope surface treatment to provide opportunities for pedestrian access across the dyke that are as easy and safe as available in current conditions, or better. This could include provision of gradual and smooth slopes covering the erosion protection vegetated rock buttress where suitable.
- Review construction access requirements and construction methodology to minimize private property impacts and plan for alternative access options where needed.
- Optimize the sheet pile and gravel toe drain configuration in Segment P1. Design the gravel toe drain gradation to function as a filter for the dyke and foundation soils.
- Determine the minimum requirements for dyke fill to be used as top-up material. Consider the gradation variation of the existing dyke fill when establishing the dyke fill requirements.
- Complete a groundwater study to verify there are no adverse impacts of implementing a cut-off on the local groundwater regime.
- Develop structural details for the interaction between the through dyke culverts, private owner sump discharge lines, and the proposed dyke sheet pile cut-off.
- Determine the gradation and material properties for rock fill that is to be used in the vegetated rock buttress.
- Design of rock trenches at the wet toe of the dyke, in those areas where there is a high risk of bank erosion affecting the dyke and where the vegetated rock buttress is not implemented all the way to the creek bed.
- Optimize dyke slopes, and potential transition from rock buttress to gentler embankment wet slope in areas where there is space between the dyke and the creek.
- Develop a sediment and erosion control plan including worksite isolation measures for in-water works.
- Determine the affected areas where work access agreements or easements will be required for construction on private properties.
- Optimize dyke design in areas of close proximity to private properties, with consideration of localized use of MSE walls to avoid extending the dry toe and/or drainage swale beyond the areas owned by TRCA.

- Review of public safety, including fall hazard in steep slope areas, and if necessary, implementation of preventive measures.
- Refine location and details of transition between Segments P1 and P2.

Segment P2

- Determine the dry side filter and dyke fill material properties. Consider the gradation variation of the existing dyke fill when establishing the dyke fill requirements.
- Explore the feasibility of optimizing the side slope and filter configuration via transient seepage analysis considering the recommended soil permeability parameters in the geotechnical investigation report and the anticipated flood hydrograph. Determine, in consultation with TRCA, a suitable minimum flood duration and maximum drawdown rates for which an optimized solution can be considered reliable. Ensure that the flood duration and drawdown rates are conservative, considering inherent variability in flood forecasting, changes to the drainage basin over time, changes from alterations to land use and development, and the effects of climate change.
- Develop a subsurface utility protection plan for the storm sewer near Sta 0+325. Contact the Durham Region to determine if any major repairs are being considered for this utility in the future and if those maintenance works can be integrated into the dyke remediation project. If it is determined that it is not feasible to relocate or replace the subsurface utilities as part of the dyke upgrades, a utility protection plan should be determined as part of detailed design considering the results of sub-surface utility mapping.
- Determine the inlet location of Culvert P3 and explore the viability of protecting this outfall culvert during construction rather than complete replacement.
- Finalize the relocation plan for the walking trail and design the path to be restored to equal or better conditions.
- Prepare an O&M manual considering the suggested content of the International Levee Handbook. The content of the manual should be finalized after as-built information is available.
- Refine transition between Segments P1 and P2 including general alignment of dyke with consideration to move dyke further from the creek where erosion concerns exist.

Segment A1

- Determine the dry side filter and dyke fill material properties. Consider the gradation variation of the existing dyke fill when establishing the dyke fill requirements.
- Explore the feasibility of optimizing the side slope and filter configuration via transient seepage analysis considering the recommended soil permeability parameters in the geotechnical investigation report and the anticipated flood hydrograph. Determine, in consultation with TRCA, a suitable minimum flood duration and maximum drawdown rates for which an optimized solution can be considered reliable. Ensure that the flood duration and drawdown rates are conservative, considering inherent variability in flood forecasting, changes to the drainage basin over time, changes from alterations to land use and development, and the effects of climate change.
- Develop a subsurface utility protection plan. Contact the Durham Region to determine if any major repairs are being considered for the subsurface utilities in the future and if those maintenance works can be integrated into the dyke remediation projected. If that is feasible, consider as part of dyke

alignment optimization. If it is determined that it is not feasible to relocate or replace the subsurface utilities as part of the dyke upgrades, a utility protection plan should be determined as part of detailed design considering the results of sub-surface utility mapping.

- Finalize the relocation plan for the TransCanada Trail and design the path to be restored to equal or better conditions.
- Determine if there is a feasible tie-in location east of Church Street for an emergency top-up. Develop these emergency procedures if feasible and include them in the O&M manual.

6.6 Recommended Studies for Subsequent Design Phases

Without limiting the items that need to be addressed when advancing the preferred design concept into the next stage of the design, the following is recommended, however, subject to studies applicable at the time of design:

- Topographic surveys of dykes and surrounding areas
- Additional geotechnical site investigations for Segment P1, where the use of sheet pile is proposed. The main purpose of this geotechnical investigation is to obtain information to determine the sheet pile type and driveability methods and identify any underlying bedrock or very hard glacial till layers and their elevations, in the area where sheet pile are proposed, along the wet side crest of the dyke. Based on the available information, a minimum of four test holes at a depth of 40 ft are recommended.
- Additional geotechnical site investigations in those areas where the dyke could be realigned. Dyke realignment could occur on the Ajax Dyke, if the design is optimized considering upgrades or replacement of the underground infrastructure. Depending on the new alignment, we anticipate that 5 to 6 test holes at 15 ft deep would be appropriate for this dyke segment (A1). Along the east end of Segment P2, approximately two additional test holes 15 ft deep.
- Groundwater study to evaluate impact of sheet pile in Segment P1
- Evaluation of conditions of underground utilities, particularly on the Ajax Dyke to evaluate the merits of relocation of these utilities
- Chemical analyses for off-site disposal of soil, as per detailed design and construction phase findings
- Fish and fish habitat assessment for in-water work permits by DFO and/or MNRF
- Species at Risk Surveys will be conducted during detailed design, with appropriate mitigation measures developed in consultation with the MECP, if required (Section 3.4.7) and can include bat and butternut surveys.
- Tree inventory studies or arborist reports, including any additional necessary BHAs
- Basal area study for compensation requirements
- Stage 2 Archaeological Assessment
- Utility Investigations Quality Level B, or A where required
- A construction vibration assessment report for the areas where construction is occurring in close proximity of residential buildings may be required by the municipalities
- Detailed design drawings and specifications for construction

6.7 Anticipated Construction Permits

Without limiting the items that need to be addressed when advancing the preferred design concept into the next stage of the design, the following is recommended, but will ultimately be subject to policies at the time of the design:

- In-water work permit from MNRF (typically obtained by the contractor) and any Fish and Wildlife Collection Permits (MNRF)
- Permit/authorization pursuant, as appropriate, under *Endangered Species Act* from MECP
- If access through the stream bed or the bank of West Duffins Creek opposite to the dykes is needed, DFO approval under *Federal Fisheries Act* and from Transport Canada Under the *Navigable Waters Protection Act* will be required
- An Encroachment Permit from the Region of Durham to occupy the sewer right-of-way, in addition to the contractor's Temporary Construction Access Permit
- Permit from TRCA for *Application for Development, Interference with Wetlands and Alteration to Shorelines and Watercourses (Pursuant to Ontario Regulation 166/06)*
- Other permits required by municipalities:
  - Fill and Topsoil Disturbance Permit (Pickering)
  - Road Occupancy Permit (Pickering)
  - Sediment and Erosion Control Permit (Ajax)
- Other construction permits and approvals as applicable and identified in detailed design
- Detailed design drawings and specifications for construction will be required

7.0 ENVIRONMENTAL SCREENING OF PREFERRED ALTERNATIVES

7.1 Detailed Environmental Analysis of the Preferred Alternative

To complete the detailed environmental analysis of the preferred alternatives, the information collected for the baseline inventory (Section 3.0) was examined in greater detail to confirm potential impacts and determine methods of mitigation. Impacts are defined as negative effects. The evaluation of impacts includes both temporary impacts during construction of the undertaking, and permanent impacts due to operation and maintenance of the works after construction. Table 7-1 screens the potential net positive and negative effects of the proposed undertaking on the environment during construction and long-term maintenance phases, after implementation of mitigation measures. It includes consideration of the magnitude, geographic extent, duration, frequency, permanence or reversibility, and ecological context of the effect, as well as proposed mitigation measures and any residual effects.

Mitigation measures for items in Table 7-1 that have been identified as influencing the environment, both positive and negative, are discussed in the following sections. Those that have been determined as not applicable (N/A) or having no effect (Nil) and not requiring mitigation, as identified in Table 7-1, have been omitted from further discussion.

TABLE 7-1: DETAILED ENVIRONMENTAL ANALYSIS OF THE PREFERRED DESIGN CONCEPT

Screening Criteria	Rating of Potential Effect								Comments
	-H	-M	-L	Nil	+L	+M	+H	NA	
Physical Environment									
Unique Landforms								x	• No Unique Landforms have been identified within the Project Study Area.
Existing Mineral or Aggregate Resource Extraction Industries								x	• No Mineral/Aggregate Resources are found within the Project Study Area.
Earth Science - Areas of Natural and Scientific Interest (ANSI)								x	• No Earth Science ANSI's have been identified within the Project Study Area.
Specialty Crop Areas								x	• No Specialty Crop Areas have been identified within the Project Study Area.
Agricultural Lands or Production								x	• No Agricultural Land have been identified within the Project Study Area.
Niagara Escarpment								x	• The Project Study Area is not located within the area of the Niagara Escarpment.
Oak Ridges Moraine								x	• The Project Study Area is not located within the area of the Oak Ridges Moraine.
Environmentally Sensitive/Significant Areas (Physical)				x					• No impacts to Environmentally Sensitive/Significant Areas (Physical) within the Project Study Area are expected during or after construction. See Section 7.2.1.
Air Quality			x						• Within the Project Study Area, it is anticipated that limited and short-term impacts to air quality may arise due to vehicle emissions from material hauling activities during construction of the proposed rehabilitation works. • Within the Direct Environmental Study Area, construction activities may result in short-term, localized effects to air quality associated with fugitive dust from disturbed ground surfaces, as well as vehicle and equipment emissions during construction. Mitigative measures would be taken to minimize impacts to air quality during construction. Mitigation measures are presented in section 7.2.2. • It is expected that air quality would revert to baseline conditions once construction is complete.
Agricultural Tile or Surface Drains								x	• No Agricultural Tile or Surface Drains are located within the Project Study Area.
Noise Levels and Vibrations			x						• Within the Project Study Area, it is anticipated that short-term impacts due to noise may arise due to construction activities and material hauling activities. • Within the Direct Environmental Study Area construction activities and use of equipment will result in a temporary but sustained increase in noise levels while construction activities are occurring as well as potential effects from vibrations. Mitigative measures would be taken to minimize noise and vibration impacts during construction. Mitigation measures are presented in Section 7.2.3 • It is expected that noise levels will revert to baseline conditions and vibrations will cease once construction is complete.
High/Storm Water Flow Regime							x		• Within the Project Study Area and Direct Environmental Study Area there is a potential for a temporary increased risk of flooding during construction if sections of the existing dyke need to be temporarily reduced or removed (if found to be unsuitable to retain). Mitigative measures would be taken during construction that can effectively control this risk, resulting in a net neutral effect on flood risk during construction. Mitigation measures are presented in Section 7.2.4. • After construction, vulnerability to flooding will be reduced by the restored and upgraded dykes, providing a benefit within the Project Study Area and Direct Environmental Study Area. Both the Pickering Dyke and Ajax Dyke will provide a level of protection up to the 100-year flood

Screening Criteria	Rating of Potential Effect								Comments
	-H	-M	-L	Nil	+L	+M	+H	NA	
									level. Segment P1 will require erosion protection (vegetated rock buttress (VRB)). VRB can locally increase the in-stream erosion potential along the unarmoured creek bed adjacent to the VRB and along the unarmoured bank immediately downstream See Section 7.6.1 for discussion and mitigation.
Low/Base Flow Water Regime				x					• Dyke rehabilitation is not expected to impact low/base flow regime of West Duffins Creek or Duffins Creek within the Project Study Area during or post construction. See Section 7.2.5.
Existing Surface Water Drainage and Groundwater Seepage					x				• Dyke rehabilitation is not expected to effect existing surface water drainage or groundwater seepage within the Project Study Area. • Surface water drainage may be temporarily impacted within the Direct Environmental Study Area during construction of the dyke rehabilitation. Installation of sheet pile/dyke seepage cut-off measures may impact local groundwater flow regime within the Direct Environmental Study Area in the vicinity of the P1 dyke segment. Impacts can be effectively mitigated resulting in a net neutral effect. Mitigation is provided in Section 7.2.6. • The rehabilitation design includes a permanent drainage swale to direct surface water to drainage culverts. Once construction is complete, this will result in a net positive effect to surface water drainage.
Groundwater Recharge/Discharge Zones				x					• Dyke rehabilitation is not expected to effect groundwater recharge/discharge zones within the Project Study Area during or after dyke rehabilitation. See Section 7.2.7.
Falls within Vulnerable Area as defined by *Clean Water Act*								x	• The Project Study Area is located within a vulnerable area as defined by the Clean Water Act. No impacts are expected with the implementation of mitigation measures provided in Section 7.2.8 for the prevention of accidental spills
Littoral Drift								x	• Littoral drift is not applicable to this Project.
Other Coastal Processes								x	• There are no coastal areas within the Project Study Area.
Water Quality				x					• Within the Project Study Area and Direct Environmental Study Area, construction activities have potential to result in short-term, localized surface water quality impairment due to erosion of exposed soils and accidental spills of potentially contaminating material (e.g. fuel, oil) throughout the construction process. Potential impacts can be effectively mitigated resulting in a net neutral effect during construction. Mitigation measures are provided in Section 7.2.8. • No impacts to water quality are expected once construction is complete.
Soil / Fill Quality				x					• No effects to soil/fill quality within the Project Study Area are expected. • Within the Direct Environmental Study Area, accidental spills of potentially contaminating material (e.g. fuel, oil, hydraulic oil) during construction could result in localized impacts to soil/fill quality. Potential impacts can be effectively mitigated ensuring contamination of soil on site does not occur. With mitigation measures there is a net neutral effect to soil/ fill quality during construction. Mitigation measures are presented in Section 7.2.9. • No impacts to soil/fill quality are expected after construction activities are completed.
Contaminated Soils/Sediments/Seeps				x					• Contaminated soils have not been identified within the Direct Environmental Study Area. Additional sampling will be required as part of detailed design and to develop an Excess Soil Management Plan (See Section 7.2.10).

Screening Criteria	Rating of Potential Effect								Comments
	-H	-M	-L	Nil	+L	+M	+H	NA	
Existing Transportation Routes			x						• Minor impacts to traffic patterns and routes are expected in the Project Study Area during construction due to material hauling activities. Most notably increased traffic and minor delays in the vicinity of the site can be expected. Mitigation measures are presented in Section 7.2.11. • Traffic volumes and patterns are expected to revert to baseline once construction is complete.
Constructed Crossings (e.g. Bridges, Culverts)				x					• Constructed crossings within the Project Study Area and Direct Environmental Study Area are not expected to be affected by construction activities. See Section 7.2.12.
Geomorphology				x					• Dyke rehabilitation is not expected to impact natural geomorphological process within the Project Study Area outside of the Direct Environmental Study Area. • Currently, the Pickering Dyke laterally confines the watercourse and has altered natural fluvial processes. The installation of erosion control (Vegetated Rock Buttress (VRB)) along the dyke surface will not significantly reduce the valley bottom width or change channel migration processes. Thus, the effects of VBR will be localized, and would not have reach scale effects. See section 7.2.13. .
Lake Simcoe Watershed								x	• The Project Study Area is not within the Lake Simcoe Watershed.
Biological Environment									
Wildlife Habitat, Linkages or Corridors, Wildlife/Bird Migration Patterns				x					• No effects to wildlife habitat, linkages, corridors or wildlife/bird migration patterns are expected within the Project Study Area outside of the Direct Environmental Study Area. • Dyke rehabilitation may result in disturbance of local wildlife in the immediate vicinity of the dyke and construction area within the Direct Environmental Study Area due to noise and human presence during the construction phase. Mitigation measures are provided in Section 7.3.1 No residual effects are expected after implementation of mitigation measures. • Wildlife usage of the area is expected to return to baseline after construction and post-construction revegetation has established.
Significant Vegetation Communities			x						• Significant vegetation communities have been identified within the Project and Direct Environmental Study Areas. • Dyke rehabilitation will require some vegetation removal as part of the project and for long term dyke maintenance resulting in a low negative impact within the Direct Environmental Study Area. Mitigation measures are provided in Section 7.3.2. • Post construction re-vegetation utilizing native species will be conducted. No woody species will be re-planted on the dykes, which will result in a permanent linear clearing along the dykes. Compensation planting will occur off-site or elsewhere within the Project Study Area as required.
Environmentally Sensitive/Significant Areas (biological)				x					• The dykes are located within the Duffin's Creek Major-Spink Environmentally Significant Area (ESA). Rehabilitation of the dykes is not expected to impact the ESA and its function. See Section 7.3.3
Fish Habitat			x						• Dyke rehabilitation is not expected to affect fish habitat within the Project Study Area outside of the Direct Environmental Study Area during or after construction. • The rehabilitation of the dykes (specifically in the Pickering Dyke) may locally impact fish habitat within the Duffins and West Duffins Creek from short term impacts to water quality during construction to long term changes in habitat due to the removal of riparian vegetation. Mitigation measures are provided in Section 7.3.4
Species of Concern				x					• Species of concern have been identified within the Project and Direct Environmental Study Areas.

Screening Criteria	Rating of Potential Effect								Comments
	-H	-M	-L	Nil	+L	+M	+H	NA	
									• Mitigation measures are provided in Section 7.3.5 including adherence to wildlife timing windows such that construction activities are undertaken during times of the year that will be least impactful to wildlife. No residual effects are expected after implementation of mitigation measures • No residual impacts to any Species of Concern are expected after the completion of construction and site restoration.
Exotic/Alien and Invasive Species						x			• Exotic/Alien and Invasive Species have been identified within the Project and Direct Environmental Study Areas. • Soil disturbance during construction may lead to an increase in exotic species. Mitigation measures are provided in section 7.3.6. • Post construction site restoration and re-vegetation with native species would result in a net positive effect.
Wetlands				x					• Wetlands identified within the Project Study Area are not expected to be impacted by dyke rehabilitation. See section 7.3.7.
Microclimate			x						• Within the Direct Environmental Study Area, dyke rehabilitation may have a long-term negative effect on local microclimate within the West Duffins and Duffins Creek due to the removal of riparian vegetation. Mitigation measures are provided in section 7.3.7.
Life Science ANSI's								x	• No Life Science ANSI's were identified within the Project Study Area.
Unique Habitats								x	• No unique habitat has been identified within the Project Study Area.
Cultural Environment									
Traditional Land Uses				x					• This project is located with the Traditional Territories and Treaty lands of the Williams Treaties First Nations and the Huron-Wendat Nation. No adverse effects on traditional land use were identified during engagement with Indigenous communities. See Section 7.4.1.
Indigenous Community or Reserve								x	• There are no Indigenous Communities or Reserves within the Project Study Area.
Outstanding Native Land Claim or Treaty Rights								x	• The Project Study Area is located within the Treaty Territory of the Williams Treaties First Nations and the traditional territory of the Huron-Wendat Nation. • Concern regarding potential impacts to archaeological resources was expressed by the Huron-Wendat Nation and Alderville First Nation. The completed Stage 1 Archaeological Assessment was provided. No cultural resources were identified during the assessment. Both nations requested that they be informed of any further archaeological assessments that may be required. • Alderville First Nation and Curve Lake First Nation expressed interest in completed environmental studies related to this Project, especially those related to waterways. Both nations were provided with summaries and copies of the completed studies.
Transboundary Water Management Issues								x	• There are no international boundary waters or internationally interconnecting channels within the Project Study Area.
Riparian Uses			x						• No effects within the Project Study Area are expected outside of the Direct Environmental Study Area. • Within the Direct Environmental Study Area, dyke rehabilitation construction will temporarily impact riparian use (primarily water access) within the construction area of the P1 dyke segment. Mitigation measures can minimize impacts during construction and are presented in Section 7.4.2. • No impacts are expected once construction is complete nor with ongoing maintenance of the dykes.
Recreational or Tourist Use of a Water Body and/or Adjacent Lands			x						• No effects within the Project Study Area are expected outside of the Direct Environmental Study Area.

Screening Criteria	Rating of Potential Effect								Comments
	-H	-M	-L	Nil	+L	+M	+H	NA	
									• Within the Direct Environmental Study Area, dyke rehabilitation construction will temporarily impact trail use as trails will be closed during construction activities. Mitigation measures can minimize impacts during the construction period, such as opening trails on weekends or evenings when it is safe to do so. Mitigation measures are presented in Section 7.4.3. • No impacts are expected once construction is complete nor with ongoing maintenance of the dykes. All impacted trails will be fully restored once dyke construction is complete.
Recreational or Tourist Use of Shoreline Access			x						• No effects within the Project Study Area are expected outside of the Direct Environmental Study Area. • Within the Direct Environmental Study Area, dyke rehabilitation construction will temporarily impact recreational shoreline access/use within the construction area of the P1 dyke segment. Mitigation measures can minimize impacts during construction and are presented in Section 7.4.4. • No impacts are expected once construction is complete nor with ongoing maintenance of the dykes.
Aesthetic or Scenic Landscape or Views			x						• No effects within the Project Study Area are expected outside of the Direct Environmental Study Area. • The presence of a temporary active construction site will have a short-term impact on aesthetics. Long term impacts to aesthetics would occur from removal riparian vegetation and vegetation along the dykes and if the implementation of vertical and hard design features is found to be needed. Mitigation measures are provided in Section 7.4.5.
Archaeological Resources, Built Heritage Resources and Cultural Heritage Landscapes				x					• No effect within the Project Study Area are expected as no construction activities or changes to the landscape are proposed outside of the Direct Environmental Study Area. • Within the Direct Environmental Study Area there is the potential for impacts to archaeological resources during construction due to excavation. Impacts can be effectively mitigated resulting in a net neutral effect during and after construction. Mitigation measures are presented in Section 7.4.6. • The south-eastern portion of the Direct Environmental Study Area surrounding the Pickering Dyke is designated as Pickering Village Heritage Conservation District. No construction activities or changes to the landscape are proposed within the Pickering Village Heritage Conservation District therefore no impacts are expected.
Historic Canals								x	• There are no Historic Canals within the Project Study Area.
Federal Property								x	• Dyke rehabilitation will not occur on any Federal Lands.
Heritage River System								x	• There are no Heritage River Systems within the Project Study Area.
Socio-Economic Environment									
Surrounding Neighborhood or Community						x			• It is expected that residents near the Direct Environmental Study Area within the Project Study Area will be temporarily impacted by the rehabilitation of the dykes during construction. Proposed mitigation measures are provided in Section 7.5.1. No impacts are expected after implementation of mitigation measures. • A positive impact is expected after dyke rehabilitation is complete due to reduced flood risk.
Surrounding Land Uses or Growth Pressure				x					• Dyke rehabilitation is not expected to impact surrounding land use or growth pressures within the Project Study area during or after construction (See Section 7.5.2).
Existing Infrastructure, Support Services, Facilities				x					• No impacts are expected within the Project Study Area outside of the Direct Environmental Study Area during or after construction.

Screening Criteria	Rating of Potential Effect								Comments
	-H	-M	-L	Nil	+L	+M	+H	NA	
									• Dyke rehabilitation may have a temporary impact on present underground utilities within the Direct Environmental Study Area and other construction projects within the Project Study Area. Mitigation measures are presented in Section 7.5.3. No effects are expected after implementation of mitigation measures.
Pedestrian Traffic Routes			X						• No direct impacts to pedestrian traffic routes are expected within the Project Study Area outside of the Direct Environmental Study Area, however the closure of trails within the Direct Environmental Study Area during construction will impact the continuity of the routes. • Within the Direct Study Environmental Study Area there will be temporary impacts to pedestrian traffic along the trail systems within this area during construction. Mitigation is provided in Section 7.5.4. • No impact to pedestrian traffic is expected after the completion of construction.
Property Values or Ownership			x						• No impacts are expected with respect to properties within the Project Study Area outside of the Direct Environmental Study Area. • Potential temporary and permanent impacts to properties adjacent to and within the proposed construction area within the Direct Environmental Study Area may be impacted due to site access and construction constraints. Detailed design will focus on eliminating impacts to properties where feasible. • Long term benefit and value added to properties within the floodplain that benefit from the improved flood protection that the rehabilitated dykes will provide once construction is complete. • See Section 7.5.5 for further description.
Existing Tourism								x	• No Tourist operations are found within the Project Study Area.
Property/Farm Accessibility				x					• Dyke rehabilitation is not expected to impact property accessibility within the Project Study Area outside of the Direct Environmental Study Area. • There will be some short-term accessibility restrictions within the area of construction due to public safety concerns, but these would be limited to the area of construction. Refinement of dyke rehabilitation design during the detailed design stage will focus on reducing the dyke footprint and construction access requirements. See Section 7.5.6.
Engineering / Technical									
Rate of Erosion in Ecosystem					x				• Dyke rehabilitation is not expected to impact the rate of erosion within the Project Study Area outside of the Direct Environmental Study Area. • Within the Direct Environmental Study Area erosion control (vegetated rock buttress (VRB)) will be placed in areas along the Pickering Dyke (Segment P1). The effects of VRB will be localized and would not have reach scale effects. VRB will locally decrease erosion of the protected bank but can locally increase the erosion potential along the unarmoured creek bed adjacent to the VRB and along the unarmoured bank immediately downstream. Mitigation measures to minimize additional erosion are provided in Section 7.6.1. • Overall, dyke rehabilitation is expected to mitigate present erosion occurring local to the Pickering Dyke resulting in a positive effect.
Sediment Deposition Zones in Ecosystem				x					• Bank stabilization will result in localized impacts to erosion and would not be expected to impact sediment deposition within the Project Study Area outside of the Direct Environmental Study Area. . • Localized impacts to sediment deposition patterns are possible. No impact to sediment deposition at the reach scale is expected. See Section 7.6.2.
Flood Risk in Ecosystem							x		• During construction, areas of the dyke could need to be removed, leaving areas within the Project Study Area and Direct Environmental Study Area temporality exposed to flooding.

Screening Criteria	Rating of Potential Effect								Comments
	-H	-M	-L	Nil	+L	+M	+H	NA	
									• The contractor will be required to prepare a Flooding Risk Management Plan to minimize exposure to flooding during construction and to restore existing protection level in short notice. See Section 7.6.3. • There is a positive long-term impact on flood protection by ensuring dyke stability and ensuring flood protection from an event in the order of the 100yr flood event. The project will improve riverine flood protection for properties within the Special Policy Areas.
Slope Stability							x		• Dyke rehabilitation will ensure that the dykes will meet required factors of safety and design criteria of the Lakes and Rivers Improvement Act Geotechnical Design and Factors of Safety Technical Bulletin, resulting in an improvement to slope stability. • Dyke rehabilitation will not have any impact on valley slopes or channel bank slopes within the Project Study Area outside of the Direct Environmental Study Area where erosion control measures will be installed. Additional information is provided in Section 7.6.4
Existing Structures				x					• Dyke rehabilitation has the potential to impact existing structures identified within the Project and Direct Environmental Study Areas (ex. bridges, houses) during construction. Mitigation measures are provided in Section 7.6.5. No impacts are expected after implementation of mitigation measures. No impacts are expected once construction is complete.
Hazardous Lands/Sites				x					• No impacts to hazardous lands/sites within the Project Study Area are expected during or after construction. Additional information is provided in Section 7.6.7.

7.2 Physical Environment

7.2.1 ENVIRONMENTALLY SENSITIVE / SIGNIFICANT AREA

The Project Study Area is considered part of an environmentally significant area. The Duffins Creek Corridor has an Environmental Protection Area designation, which protects natural areas, such as stream and valley corridors (TRCA 2003). Dyke rehabilitation activities will not impact the form or function of the Environmental Protection Area given the relatively small and localized extent of construction relative to the extent of the Duffins Creek Corridor. The Pickering and Ajax Dykes are presently in place and rehabilitation work will be localized to the existing area of the Dykes.

Portions of the Project Study area are located the regulatory floodplain and have been designated as Special Policy Area (SPA)'s in the City of Pickering and the City of Ajax Official Plans to allow for continued development in existing communities. Rehabilitation of the Dykes will not change the limits of the regulatory flood plain or the SPA designation.

7.2.2 AIR QUALITY

As discussed in Section 3.2.9, the Project and Direct Environmental Study areas are in an area with similar air quality to the Greater Toronto Area. Due to the urban and industrial nature of the area, any air quality impacts during the construction are expected to be limited to within the Direct Environmental Study Area. Effects to air quality during the construction phase could occur due to fugitive dust emissions and emissions of combustion by-products from equipment and vehicle use. These are described in the following sub-sections. The contractor will be required to prepare an Air Quality Management Plan as part of their overall Environmental Management Plan for the Project.

7.2.2.1 Dust

Dust may be mobilized due to vehicular / equipment traffic, particularly if fine soils (e.g. silt) are present, which could be mobilized. Excessive dust levels could cause human health concerns (i.e. lung and eye irritation) which may impact construction workers and potentially residents and recreational users in the area.

Fugitive dust could also negatively impact surface water quality and aquatic habitat and biota if it were to be deposited in the creek. Extremely high levels of dust may also result in the smothering of vegetation which could result in mortality due to the prevention of photosynthesis or increases in susceptibility to disease.

Dust generation is not expected to be a significant problem at the construction site since the potential impacts can be mitigated using construction site best management practices (BMPs) and mitigation measures. Mitigation measures that can be used, as required, to control dust include:

- Use of dust suppression (i.e. water) on exposed areas, as necessary.
- Use of appropriate personal protective equipment (e.g. masks) by workers as necessary.
- Road cleaning/sweeping of haul routes

Given the proposed mitigation and monitoring to be undertaken during construction, it is expected that dust generation will be relatively low in magnitude and limited in duration and geographic extent (i.e. the immediate dyke/construction site).

7.2.2.2 Vehicle and Equipment Pollutants

A variety of construction vehicles and potentially portable generators will be used on site during the construction period. Exhaust emissions contain carbon monoxide, nitrogen oxides and Sulphur oxides. As a BMP, vehicles should be run only when necessary and exhaust equipment should be inspected regularly. It is recommended that the Contractor limit idling of construction equipment when not involved in a construction activity and conform to the City of Pickering's (6297/04) and Town of Ajax's (18-2018) anti-idling by-laws.

7.2.3 NOISE LEVELS AND VIBRATIONS

Current noise and vibration levels within the Project and Direct Environmental Study Areas are typical of an urban environment due to traffic on local streets, arterials and Highway 401. During construction, noise and vibrations impacts would be limited to the direct construction site within the Direct Environmental Study Area and possibly adjacent properties.

Noise and vibration will be generated during construction due to equipment operation and the installation of sheet pile (at P1 dyke segment only). In order to mitigate the potential for negative effects due to noise, construction activities with potential for significant noise generation will be limited to daylight hours, and any restrictions in work hours established in existing municipal by-laws, such as the City of Pickering's Noise By-Law (6834/08) and Town of Ajax's Noise By-Law (38-2017). The contractor will be required to prepare a Noise Management Plan as part of their overall Environmental Management Plan for the Project, in addition to ensuring that all their equipment is in proper working order.

A vibration monitoring program will be developed at the detailed design phase of the project to monitor for potential effects of vibration to structures that may be impacted during the installation of sheet pile. This would include any bridges or residences identified as having the potential to be impacted, as determined during detailed design. Pre and post construction inspections of nearby properties and structures will be completed jointly by TRCA and the construction contractor. A vibration monitoring program should also be implemented during construction to ensure that measured peak particle velocity (PPV) and vibration frequencies (hertz) are below the limitations in City of Toronto Bylaw No. 514-2008.

7.2.4 HIGH/STORM WATER FLOW REGIME

The process of upgrading a dyke requires excavation into an existing dyke for several reasons such as: improving construction access, creating scarified benches for improved bonding of old and new material, or replacing through-dyke culverts. While necessary to improve flood protection on a permanent basis, the time during implementation of dyke upgrades is one when there is reduced reliability during a flood. The contractor will be required to prepare a Flooding Risk Management Plan to minimize exposure to flooding during construction and to restore existing protection level in short notice. Flood risks during construction will be mitigated by:

a. Scheduling the works to occur outside of the spring freshet period.

b. Preserving as much of the existing dyke fill in place as possible after stripping away unsuitable organics and roots. This will minimize the work required to shore up the incompletely upgraded dykes on an emergency temporary basis during construction.
c. Requiring a risk management plan to be prepared by the contractor to shore up the dykes to current flood protection levels within 24 hours notice of a potential flood event. Such a plan may rely on manual sandbagging, aquadams, or other emergency flood protection measures that can be established in adverse weather conditions.
d. Further subdividing the recommended phasing plan to rehabilitate smaller segments of the dyke at a time.

Rehabilitation work will be conducted in a manner that ensures that no adverse impacts on water levels, flood levels or in-stream erosion will occur both upstream and downstream of the project.

7.2.5 LOW/BASE WATER FLOW REGIME

Dyke rehabilitation would require limited in-water works. All construction would be undertaken in a way that would allow for continued base flow and ensure no adverse effects to water levels upstream and downstream of the project. Once construction is complete the low/base flow patterns would continue as existing conditions, with no long-term affects from the proposed works.

7.2.6 SURFACE WATER DRAINAGE AND GROUNDWATER SEEPAGE

Surface water is conveyed through the Pickering and Ajax Dykes under non-flood conditions via culverts and storm sewer lines. Additionally, some properties adjacent to the dyke have sump pumps that discharge to the surface and the water then flows through culverts/drainage pipes through the dyke. The current surface drainage system of culverts will be retained, and, where feasible, improved through the dyke rehabilitation works. This includes providing a means to facilitate the drainage of private sump pumps.

Improvements include formalizing a drainage swale system along the dyke to direct surface water from the dry side of the dykes to the culverts through the dykes and improving the culverts to reduce the risk of vandalism and malfunction during a flood event. During construction, surface water flow may be temporarily impacted as the contractor may need to implement temporary dykes to construct the proposed culvert modifications in dry conditions to facilitate compaction of culvert backfill materials. The implementation of an effective water management strategy during construction, including plans for temporary dykes and pumping, if required to maintain adequate construction conditions, would mitigate any potential impacts.

Rehabilitation of the dykes will not impact the groundwater flow regime within the Project Study Area. However, there may be a localized impact in the direct area of the dykes where sheet pile is installed below the water table. Prior to the development of mitigation measures, a groundwater study will be required to determine the nature and scale of impacts to groundwater flow, if any.

7.2.7 GROUNDWATER RECHARGE/DISCHARGE ZONES

Groundwater recharge occurs over most of the area of the Duffins Creek. Groundwater within the Direct Environmental Study Area discharges to the West Duffins Creek and Duffins Creek. Given the localized nature of the work and that the recharge / discharge characteristics of the area will remain unchanged, no impacts to groundwater recharge or discharge is expected.

7.2.8 WATER QUALITY

Construction activities have potential to result in short-term, localized surface water quality impairment due to erosion of exposed soils and accidental spills of potentially contaminating material (e.g. fuel, oil) throughout the construction process. Potential impacts can be effectively mitigated resulting in a net neutral effect during construction.

Adverse effects to water quality will be mitigated with standard mitigation methods such as erosion and sediment control plans (following TRCA's ESC Guidelines) and fuel management and spill response plans for work in and around water are expected to be effective in minimizing the potential for negative effects on surface water quality. Any minor potential effects that may occur would not be expected to have significant effects on receptors (e.g. aquatic biota). The Contractor will be required to develop an overall Environmental Management Plan which will include component management plans (sediment and erosion control plan, fuel management plan, spill response plan) to address potential water quality impacts.

Some construction activities have the potential to impact local surface water quality, with potential effects including increased turbidity and suspended solids associated with the erosion of soils from the construction site to the creeks, or accidental spills of hazardous/toxic substances such as fuels, lubricants and other hazardous materials, as well as construction debris (dust).

Potential sources of adverse water quality effects and proposed mitigation to minimize/prevent effects are discussed in the following sections.

7.2.8.1 Erosion and Sedimentation

Construction activities have the potential to disturb soils and sediments at the construction site and have the potential to result in increased sedimentation and erosion.

Mitigation measures proposed to limit erosion and sedimentation include the development and implementation of Erosion and Sediment Control Plans (ESC) that meet TRCA's Erosion and Sediment Control Guidelines for Urban Environments (TRCA 2006; TRCA 2019d). Preventing erosion from occurring is the primary goal of the ESC plan and measures such as proper construction phasing, minimizing the size and duration of soil disturbance are all identified as effective erosion control measures. Sediment control measures are the last line of defense and are implemented to ensure that eroded soils are not transported off site or to the Creek. Sediment control measures include silt fences and silt curtains, as appropriate, to trap and retain sediments.

Mitigation measures that can form the basis for the ESC plan include:

- Minimizing the size of the disturbed areas at the construction site and limit disturbance to existing open, harder packed areas adjacent to the dykes. Install limit of work devices to prevent the Contractor from operating outside the defined construction area.
- An adequate supply of erosion control devices (e.g. geotextiles, re-vegetation materials and sediment control devices (e.g., in-water silt barriers, silt fences) to be provided on site to control erosion and sedimentation and respond to unexpected events.

Monitoring will be conducted throughout the construction period to assess erosion potential, the effectiveness of mitigation measures and remedial requirements to account for any unforeseen circumstances. This, in conjunction with a construction monitoring program, will minimize the potential for negative effects on local surface water quality. It will be the responsibility of the Contractor to monitor local surface water quality conditions during construction using turbidity monitoring equipment, in line with the 2019 Erosion and Sediment Control Guide for Urban Construction, and take appropriate actions if unacceptable levels of turbidity are recorded. Work activities may need to stop until corrective measures can be taken to minimize further adverse effects.

7.2.8.2 Fuels and Lubricants

Fuels and lubricants will be used on the construction site. Activities during the construction phase that could potentially result in transport of these materials to Duffins Creek or West Duffins Creek, with subsequent negative effects on water quality include:

- Refueling and maintenance of equipment (e.g. accidental spill, improper disposal of waste fluids).
- Use of equipment containing fuels, lubricants or other materials in the vicinity of the Creek.
- Storage of fuels and lubricants (e.g. accidental spills, leaching and/or runoff of materials).

General mitigation measures to be followed by the Contractor during construction to minimize the potential for adverse environmental impacts associated with the storage, use and disposal of fuels and lubricants include:

- Establish designated refueling areas at least 30 m from the Creek and away from any drainage ditches, channels or other wet areas, including a perimeter containment barrier.
- Locate designated hazardous material storage areas (e.g. equipment fuel storage, if maintained on site) at least 30 m from the Creek. Storage areas should be above ground and should consist, at minimum, of double walled storage tanks, or bermed and fully contained (lined) storage areas for refueling canisters, including a perimeter containment barrier.
- Machinery is to arrive at the site in a clean condition and is to be maintained free of fluid leaks.
- Only machinery/equipment that is clean and well maintained (e.g. no leaks) should operate near the water or any drainage areas. No washing of equipment is to take place at the construction site.
- Provide adequate spill clean-up materials/equipment (e.g. absorbents) on site. The Contractor must prepare a spill clean-up procedure/emergency contingency plan, prior to commencement of work at the site. All staff should be trained in implementation of the procedure.

7.2.8.3 Construction Debris

In order to prevent construction waste from entering Duffins Creek, the Contractor will be required to adequately contain all debris materials within the construction area and remove all debris as required/ directed.

7.2.9 SOIL/FILL QUALITY

The quality of fill materials both imported to the site and exported from the site would be tested prior to placement/disposal to ensure the soil meets O.Reg. 153/04 Site Condition Standards and/or O.Reg. 406/19 On-Site and Excess Soil Management Guidelines and an appropriate method of soil disposal is selected.

Soil contamination during construction could potentially result from accidental spills of pollutants such as equipment fuels or lubricants associated with the construction process. The Contractor will be required to have a Spill Prevention and Contingency Plan as part of the overall construction Environmental Management Plan in place prior to commencement of any construction activities. The plan would need to satisfy TRCA's ESC Guidelines, and will specify roles, responsibilities and appropriate procedures for fuel handling, spill response, reporting and clean up, with reference to relevant legislative requirements. All site staff will be trained in proper implementation of the plan. Other mitigation measures to be implemented include:

- Machinery is to be operated in a manner that minimizes disturbance adjacent to the Creek.
- Machinery is to arrive on site in a clean condition and is to be maintained free of fluid leaks.
- Fuel and other materials will be stored away from the Creek to prevent any deleterious substances from entering the water.
- Machinery will be refueled and serviced away from the Creek to prevent any deleterious substances from entering the water.
- No equipment washing is to occur on-site.
- Emergency spill kits will be kept on-site in case of fluid leaks or spills from machinery.

7.2.10 CONTAMINATED SOILS/SEDIMENTS AND SEEPS

Contaminated soils have not been identified at the site. Prior to the removal of soils from the site, a Soils Management Plan will be completed. As part of this plan, soils that will be removed from the site will be sampled and analyzed to ensure that the soil meets appropriate Provincial standards (O.Reg. 153.04 Site Condition Standards or O.Reg. 409/19 Excess Soil Guidelines) for soil disposal or re-use.

7.2.11 EXISTING TRANSPORTATION ROUTES

Construction traffic related to the rehabilitation of the dykes is expected to be minimal and not result in any significant impacts to traffic patterns. Some minor delays in the vicinity of the site access may occur during construction. The contractor will be required to prepare a Traffic Control Plan as part of their overall Environmental Management Plan to mitigate any adverse effects. Mitigation may include signage, notices to local property owners detailing times of anticipated heavier construction traffic, and scheduling of hauling activities during off-peak hours where possible.

Additionally, the Contactor will be required to obtain a temporary construction access permit from the Region of Durham due to the use of regional roads. Construction traffic use of the Brock Road and Finch Ave intersection will require consultation with the Region of Durham.

7.2.12 CONSTRUCTED CROSSINGS

Constructed crossings located within the Project Study Area are listed in Section 3.3.20. None of the constructed crossings identified are expected to be impacted by rehabilitation of the dykes. The crossings are not located within the immediate construction area, and rehabilitation of the dykes will not affect the natural flow regime of Duffins Creek. However, based on decisions made at the detailed design stage, these structures may be incorporated within the Vibration Monitoring program to ensure they are not impacted during construction.

7.2.13 GEOMORPHOLOGY

Erosion control (Vegetated Rock Buttress (VRB)) will be placed along sections of Pickering Dyke (Segment 1) at risk from erosional processes. Currently, the Pickering Dyke laterally confines the watercourse and has altered natural fluvial processes. In comparison to existing conditions, VRB along the dyke surface will not significantly reduce the valley bottom width or change channel migration processes. Thus, the effects of VRB will be localized, and would not have reach scale effects. VRB can locally increase the erosion potential along the unarmoured creek bed adjacent to the VRB and along the unarmoured bank immediately downstream. To minimize additional erosion, the toe of the VRB will be embedded below the elevation of the adjacent bed to accommodate localized bed scour and mitigate undermining. The VRB will also be extended downstream of existing erosion to accommodate localized longitudinal migration.

7.3 Biological Environment

7.3.1 WILDLIFE HABITAT, LINKAGES AND CORRIDORS, WILDLIFE/BIRD MIGRATION PATTERNS

Construction activities may result in the disturbance of local wildlife in the immediate vicinity of the construction site due to noise and human presence. This may result in some localized avoidance of the area by wildlife. Given the abundance of relatively undisturbed natural habitat within the Duffins Creek corridor, some avoidance and use of adjacent habitats is not expected to have significant effects. Permanent vegetation removal is linear in comparison to valley scale and is not expected to be detrimental to overall terrestrial habitat value.

The following mitigation measures are proposed to minimize negative effects on wildlife:

- The project design limits the amount of area to be disturbed.
- Vegetation clearing will be limited to the dykes themselves, and areas immediately adjacent to the dykes required for construction and proposed laydown areas, which are not expected to provide significant wildlife habitat value.
- Clearing of vegetation will take place outside of the bird breeding period of April 1 to August 29, unless otherwise approved by MNRF.
- The Contractor will retain the services of a qualified biologist to verify the presence or absence of nesting birds should trees need to be removed within the bird breeding period.
- Completion of a re-vegetation program utilizing native plantings.
- Off-site compensation for permanent vegetation removal.

7.3.2 SIGNIFICANT VEGETATION COMMUNITIES

Rehabilitation of the dykes would have a low negative effect within the Direct Environmental Study Area as vegetation will be removed from the construction area. Approximately 2.7 ha of forest/woodland and thicket will be removed from the Pickering Dyke area and 1.4 ha of forest/woodland would be removed from the Ajax Dyke area. Significant vegetation communities adjacent to the Dykes will be impacted. These communities are shown on Figures 3-14 and 3-15 for the Pickering and Ajax Dykes respectively.

Every effort will be made to minimize the amount of vegetation to be cleared. Where appropriate, trees will be protected. Prior to construction the Contractor will be required to provide a vegetation clearing and grubbing plan that will show the limits of the work, and provide measures for vegetation protection, if required.

Re-vegetation will occur post construction and will utilize native plant species and will improve the vegetation community. No trees will be replanted within the limits of the dykes. Conceptual restoration plans are provided in Appendix I.

7.3.3 ENVIRONMENTALLY SENSITIVE/SIGNIFICANT AREAS

The dykes are located within the Duffin's Creek Major-Spink Environmentally Significant Area (ESA). Rehabilitation of the dykes is not expected to impact the ESA and its function given the dykes are presently located within this area and rehabilitation activities will occur within the present limits of the dykes.

7.3.4 FISH HABITAT

The rehabilitation of the dykes (specifically the Pickering Dyke) will likely require the completion of in-water works or works near water and the removal or riparian vegetation where these are located adjacent to the Duffins and West Duffins Creek. In addition, if the proposed construction access, for Dyke Segment P1, along the south bank of West Duffins Creek, is found to be not feasible then the adjacent creek bed would need to be used for temporary short-duration construction access activities and then fully restored afterwards. Alternatively, temporary creek crossings could be constructed and the opposite (north) creek overbank area could be used for construction access. However, utilizing the creek bed for temporary access is expected to result in a lower net disturbance to the environment and be more efficient than utilizing the north overbank area.

Plantings associated with slope stability measures may mitigate some of the impacts associated with the removal of riparian vegetation, however the removal of vegetation along the banks will result in a long-term change to riparian habitat especially if the alternative access as described above is required.

Redside Dace have been found within the Duffins Creek, but not the West Duffins Creek. Given the presence of Redside Dace in Duffins Creek, and the proximity of the proposed in-water/riparian work, appropriate best management practices following those outlined in the 2016 MNRF document "Guidance for development activities in Redside Dace protected habitat" will need to be utilized to minimize any short-term impacts to habitat within the West Duffins Creek where in-water work and riparian work will need to be completed. All in-water work will be completed during the in-water work timing window for Duffin's Creek, July 15 to October 15.

Changes to the riparian habitat in the area of Pickering Dyke are expected to be minimal given their limited extents under the proposed access scenario. The alternative access scenario of using the adjacent creek bed or crossing to the creek bank opposite to the dykes would result in a greater impact to riparian habitat and in-water habitat. In any case, the aquatic habitat would have to be fully restored after construction. The evaluation of harmful effect to fish habitat will occur during detailed design and appropriate mitigation measures will be developed along with any required compensation. Any creek features will be restored to pre-construction condition or better.

Indirect net effects on fish and fish habitat could occur due to accidental spills of potentially hazardous materials to the Creek, including eroded soils and sediments.

The following mitigation measures are proposed to minimize the net negative effects on fish and fish habitat:

- Erosion and sediment control measures will be implemented and monitored throughout the construction period to prevent transfer of soils and sediments to the Creek.
- Spill prevention and response measures will be implemented to prevent or minimize the potential for accidental transfer of potentially harmful materials to the Creek.
- Re-planting of riparian vegetation as appropriate.

7.3.5 SPECIES OF CONCERN

As discussed in Section 3.4.7, the following species at risk have been observed within the Project Study Area including:

- American Eel (*Anguilla rostrate*) – Threatened
- Bank Swallow *(Riparia riparia*) – Threatened
- Butternut (*Juglans cinereal*) – Endangered
- Red Mulberry (*Morus rubra*) – Endangered
- Redside Dace (*Clinostomus elongatus*) – Endangered
- Snapping Turtle (*Chelyddra serpentine*) Special Concern
- Chimney Swift (*Chaetura pelagica*) – Threatened
- Eastern Wood-pewee (*Contopus virens*) – Special Concern

The main concern with dyke remediation is the presence of Redside Dace within the main Duffins Creek. Although in-water work is limited to the West Duffins Creek, which is not presently designated, the utilization of appropriate best management practices following those outlined in the 2016 MNRF document "Guidance for development activities in Redside Dace protected habitat" will need to be utilized to minimize any short-term impacts to this species.

If any avian or reptilian species are present during the construction period, it is expected that they may show some avoidance of the area due to noise and human presence. Given the abundance of undisturbed habitat in the area, some temporary short-term avoidance of the area is not expected to have significant negative effects on species at risk. Any vegetation clearing would occur outside of the bird breeding season of April 1 to August 31.

In addition, the contractor will be required to prepare a Biological Resources Management Plan as part of their overall Environmental Management Plan that will address protocols and procedures to be employed should any species of concern be identified within the work area during construction.

As described in the Restoration Plan (Appendix I) for the Ajax dyke, Tree Protection Fencing (TPF) will be erected around the 25 m habitat of the Butternut tree identified nearby. The TPF should be tied into ESC fencing, or could be achieved by appropriate placement of ESC fencing without additional fencing requirements. The installation of the fencing avoids the 25 m habitat of this Endangered species thereby avoiding further obligations and requirements under the *Endangered Species Act*.

Species at Risk Surveys will be conducted during detailed design, with appropriate mitigation measures developed in consultation with the MECP, if required.

7.3.6 EXOTIC/ALIEN AND INVASIVE SPECIES

Project Study Area is part of the GTA, and therefore contains a high percentage of exotic and non-native species.

No significant residual impacts are expected as a result of dyke rehabilitation. The introduction of exotic invasive plant species is unlikely. Soil disturbance may lead to an increase in exotic plant species, however, the restoration plan would utilize native species to minimize the establishment of invasive plant communities.

The species to be planted in accordance with the restoration plan are native and, in that regard, this will constitute an improvement from present conditions. The restoration plan is provided in Appendix I.

7.3.7 WETLANDS

Wetlands have been identified within the Project Study Area. None of these wetlands are found within the Direct Environmental Study Area, and as such would not be impacted by dyke rehabilitation activities.

7.3.8 MICROCLIMATE

The removal of riparian vegetation may have a long-term effect on the local microclimate by removing available shading and allowing greater sun penetration in areas that area presently shaded. This may have a localized effect on water temperatures during times of low flow. This may have an impact on dissolved oxygen availability, as this is temperature dependent. Plantings associated with erosion protection may add some shading over the long term. No impact on water temperature would be expected during high flow conditions.

7.4 Cultural Environment

7.4.1 TRADITIONAL LAND USE

This project is located with the Traditional Territories and Treaty lands of the Williams Treaties First Nations and the Huron-Wendat Nation. No adverse effects on traditional land use were identified during engagement with Indigenous communities.

7.4.2 RIPARIAN USE

Present access to Duffin's Creek may be affected during construction. Alternative access will be facilitated where this can be achieved safely. The preferred design minimizes constraints to access to the creek. Some long-term access constraints may still occur at areas where space for the dyke is limited and steep slopes are present, depending on the dyke rehabilitation solution and public safety features, but means of accessing the creek and its shorelines will still be available throughout the Direct Environmental Study Area.

7.4.3 RECREATIONAL OR TOURIST USE OF A WATERBODY AND / OR ADJACENT LANDS

The Trans-Canada trail and other local trails are located within the Project and Direct Environmental Study Areas. Trails are used for walking/hiking as well as biking. Other recreational activities include canoeing and fishing on Duffins Creek.

Dyke rehabilitation will impact use of the trail during the time of construction. The public will be informed in advance of the temporary closure of the trails and safety measures will be implemented to prevent unauthorized access to construction areas. Where feasible, the contractor will be required to provide alternative routes connecting the walking trail. The use of the creek for fishing and canoeing will likely not be affected.

No impacts are expected post construction or with activities associated with the ongoing maintenance of the dyke.

7.4.4 RECREATIONAL OR TOURIST USE OF SHORELINE

Within the Direct Environmental Study Area, dyke rehabilitation construction will temporarily impact recreational shoreline access/use within the construction area of the P1 dyke segment. The public will be informed in advance of the any shoreline access restrictions and safety measures will be implemented to prevent unauthorized access to construction areas. Where feasible, the contractor will be required to provide alternative routes for shoreline access during construction. Depending on final design, shoreline access may not be feasible during construction, and alternative access will be provided. The final design of the rehabilitated dykes will incorporate features to allow safe access to the shoreline as easily as, or better than, what exits under pre-rehabilitation conditions, in areas where it is feasible and safe to do so. These will include optimization of the surface treatment on the wet side slope of Segment P1, that could include placing soil and grasses over the erosion protection vegetated rock buttress, where suitable.

7.4.5 AESTHETIC OR SCENIC LANDSCAPES OR VIEWS

The presence of an active construction site may result in some users of the area and residents perceiving a negative effect on views or aesthetics of this area. This would be short term and only last during the construction phase.

The long-term preferred solution favours a natural look, with grassy dyke slopes. Hard features, such as an MSE wall might be still required in specific locations where the corridor for the dyke is narrow, if preferred to reduce private property impacts as determined through consultations during detailed design. This will likely require a trade-off between aesthetics, private property encroachment, public safety and access to the creek across the dyke. If hard features are implemented, landscaping will be included in the design to mitigate aesthetic or scenic concerns.

The removal of vegetation along the dykes will change the long-term aesthetics of the area, however the natural aesthetics will be maintained with grasses. The disturbance of riparian vegetation and other vegetation along the construction access and staging areas will change the aesthetics of the area temporarily while the vegetation regenerates.

7.4.6 ARCHAEOLOGICAL RESOURCES, BUILT HERITAGE RESOURCES AND CULTURAL HERITAGE LANDSCAPES

A Stage 1 Archaeological Assessment for the Direct Environmental Study Area has been completed and identified the potential for buried archeological resources within the area. Mitigation includes the completion of a Stage 2 Archaeological Assessment prior to construction activities to confirm if archaeological resources are present. If present, additional appropriate mitigation measures would be undertaken.

7.5 Socio Economic Environment

7.5.1 SURROUNDING NEIGHBORHOOD OR COMMUNITY

Within the Project Study Area, residents and businesses may be impacted by construction noise and traffic. Sections 7.2.2 and 7.2.8 discuss potential impacts and provide mitigation measures to minimize construction impacts related to noise and traffic.

7.5.2 SURROUNDING LAND USES AND GROWTH PRESSURES

The project will not result in any changes to surrounding land use or impact on any development projects.

The project will not change Regulatory Flood Plain limits or the SPA designation and associated development restrictions within this area.

7.5.3 EXISTING INFRASTRUCTURE, SUPPORT SERVICES, FACILITIES

Underground utilities (water line, sanitary lines) are found within the limits of the dykes and construction area and will require an engineering assessment during detailed design (to assess potential loading on the sewers and other risk factors) and the implementation of protection measures during construction to mitigate impacts. Condition assessments of the sewers will be required pre-and post-construction, as expressed by the Region during consultations, to confirm the condition of the infrastructure and if damage was caused. The preferred concept design, however, minimizes conflict with underground infrastructure since it does not include sub-surface cut-off elements where underground infrastructure has been identified. Infrastructure could be upgraded or rebuilt (in coordination with the utility owners) during rehabilitation which could provide some positive benefit.

Construction timing may also conflict with the Durham BRT construction and will require co-ordination with the Region of Durham to mitigate any potential conflicts.

Measures should be implemented to protect vulnerable areas, services and adjacent roads from potential effects from construction traffic. Access areas and roads should be restored, if necessary, to at minimum pre-construction conditions, at the end of the project.

7.5.4 PEDESTRIAN TRAFFIC ROUTES

Portions of the Trans-Canada Trail and other trails that are within the direct construction area will need to be temporarily closed for safety purposes. The contractor will be required to provide signage and advance notice of trail closures. Where feasible and safe to do so, alternate routes will be provided and the trails will be opened during off-hours such as weekends. If necessary, these areas should be restored to, at minimum, pre-construction conditions, at the end of the project.

7.5.5 PROPERTY VALUES OR OWNERSHIP

In areas with limited room for construction, private property may be required for temporary construction access and for the permanent location of drainage swales. The necessity of these additional lands will be scrutinized during the detailed design stage. Detailed design will focus on minimizing and eliminating property impacts where feasible.

The rehabilitated dyke will provide more reliable flood protection than the existing dykes. This improved level of flood protection for the properties within the local Special Policy Areas will result in a benefit to property owners.

7.5.6 PROPERTY/FARM ACCESSIBILITY

Works associated with dyke development are not expected to impact private property accessibility. There will be some short-term accessibility restrictions within the area of construction due to public safety concerns, but these would be limited to the area of construction. Refinement of dyke rehabilitation design during the detailed design stage will focus on reducing the dyke footprint and construction access requirements.

7.6 Engineering / Technical

7.6.1 RATE OF EROSION IN ECOSYSTEM

As described in Section 7.2.13 erosion control (vegetated rock buttress (VRB))) will be placed in areas along the Pickering Dyke (Segment P1. The effects of VRB will be localized and would not have reach scale effects. VRB can locally increase the erosion potential along the unarmoured creek bed adjacent to the VRB and along the unarmoured bank immediately downstream. To minimize additional erosion, the toe of the VRB will be embedded below the elevation of the adjacent bed to accommodate localized bed scour and mitigate undermining. The VRB will also be extended downstream of existing erosion to accommodate localized longitudinal migration.

Presently creek banks local to the dyke are eroding. The stabilization of these areas as part of the project will mitigate erosion and result in a positive effect.

7.6.2 SEDIMENT DEPOSITION IN ECOSYTEM

As detailed above, bank stabilization results in a localized impact to erosion, and would not have a reach scale effect. However, localized impacts to sediment deposition patterns is possible. No impact to sediment deposition at the reach scale is expected.

7.6.3 FLOOD RISK IN ECOSYSTEM

During construction, areas of the dyke could need to be removed, leaving areas within the Project Study Area temporality exposed to flooding. The contractor will be required to prepare a Flooding Risk Management Plan to minimize exposure to flooding during construction and to restore existing protection level in short notice. Although there may be a short-term negative impact related to potential flooding during construction, this is expected to be mitigated with the implementation of the Flooding Risk Management Plan. Furthermore, there is a positive long-term impact on flood protection by ensuring dyke stability and ensuring flood protection from an event in the order of the 100yr flood event. The project will improve riverine flood protection for properties within the Special Policy Areas.

7.6.4 SLOPE STABILITY

The present dykes do not meet present factors of safety for slope stability. The preferred design concept ensures that the dykes will meet required factors of safety and design criteria of the Lakes and Rivers Improvement Act Geotechnical Design and Factors of Safety Technical Bulletin, resulting in an improvement to the dyke slope stability.

The slope stability of the channel banks will be improved relative to the existing conditions wherever the preferred design concept includes erosion protection along the channel banks. In areas where the dyke slope and channel bank form one continuous slope (i.e. Dyke Segment P1), the proposed erosion protection geometry will improve the stability of the combined channel bank / dyke slope to the level necessary to achieve the minimum recommended slope stability FOS, as documented in the Appendix H Geotechnical Design Rationale memorandum. Dyke rehabilitation will not have any impact on valley slopes or channel bank slopes within the Project Study Area outside of those where erosion control measures will be installed.

7.6.5 EXISTING STRUCTURES

Vibration will be generated during construction due to equipment and installation of sheet pile (Refer to Section 7.2.3. A vibration monitoring program will be developed at the detailed design phase of the project to monitor potential effects of vibration to structures that may be impacted during the installation of sheet pile. This would include any bridges or residences as determined during detailed design.

Minor structures such as sheds or decks located on private properties may need to be removed during construction to facilitate site access. Any damaged or removed structures would be rebuilt/replaced. Pre and post construction inspections of nearby properties and structures are recommended.

7.6.6 HAZARDOUS LANDS/SITES

Dyke rehabilitation will comply with the requirements of the *Conservation Authorities Act* R.S.O 1990 c. C.27 the *Planning Act* 1990 c. P. 13c. 23. and Provincial Policy Statement, 2020. There will be no impact to the Special Policy Area designation.

8.0 STAKEHOLDER AND PUBLIC CONSULTATIONS

Stakeholder Consultations in support of the Pickering and Ajax Dyke Rehabilitation Class Environmental Assessment were directed at three main groups: Public, Government Officials and Indigenous Communities.

The following summarizes the notice and outreach efforts that were employed to inform and solicit public comments concerning the rehabilitation of the Pickering and Ajax Dykes.

8.1 Project Initiation

On June 27, 2019 TRCA was authorized to undertake the Pickering and Ajax Dyke Rehabilitation Class EA to minimize risk to life and property as a result of the flooding while protecting and enhancing the environmental attributes of the surrounding area.

In accordance with the Class EA, a Notice of Intent/Commencement was prepared and distributed among stakeholders in the Pickering and Ajax communities and other potentially interested parties:

- Ad Placement: August 8, 2019
  - Ajax Pickering News Advertiser (circulation 54,000, approximately),
- Direct Mail/Email: August 2019
  - Municipal, regional, provincial, federal officials and politicians
  - Abutting Landowners and all properties within the Project Study Area (circulation 3,000 approximately)
  - User/Naturalist groups
  - Utilities
  - Indigenous communities and agencies
- Project Website: August 2019 - ongoing
  - https://trca.ca/PADR, where project material, e.g., background information, project updates and notices were posted for public review and comment.

There were no inquiries from the public expressing interest in the project following the Notice of Intent/Commencement.

See Appendix J for a complete list of stakeholders along with the notice of commencement provided to them.

8.2 Community Liaison Committee (CLC)

In accordance with the Class Environmental Assessment for Remedial Flood and Erosion Control Projects, a Community Liaison Committee (CLC) was formed. There were no inquires from the public expressing interest in the project following the Notice of Intent/Commencement. Thirty-six CLC Information Kits, provided in Appendix J, were hand-delivered (or mailed where hand-delivery was not possible) to community members – local business associations, local community associations/user groups and landowners of properties adjacent to the dykes –inviting them to participate in the Project's Community Liaison Committee.

As explained in the CLC Information Kit (Appendix J), the purpose of the CLC was to facilitate local stakeholder involvement throughout the EA process. In particular, the CLC was expected to identify items of public concern related to the impact and proposed/recommended design of the Project, and to offer potential advice or solutions to resolve identified concerns. The CLC was also expected to act as a “portal” with the broader community by assisting with the exchange of project information between the broader community and the Project Team.

Community members interested in participating as Project CLC Members were asked to sign a CLC Member’s Agreement committing individuals to participate in what was expected to be three or four meetings over the length of the EA process (September 2019 through May 2020). Twelve (12) community members opted to sign the CLC Member commitment agreement.

An effort was made to hold CLC Meetings, on an alternating basis, in the municipality of Pickering and Ajax, i.e., Chestnut Hill Development Recreation Complex and McLean Community Centre, respectively, between 6:30 and 8:30 pm.

The following subsections, along with their supporting material in Appendix J, provide summaries of the three CLC meetings that were held to solicit additional public input to the design and planning of the Pickering and Ajax Dykes Rehabilitation EA. Comments received are summarized in Appendix J.

8.2.1 CLC MEETING #1 – SEPTEMBER 11, 2019

After brief introductions by each of the six Project Team members, attendees were given a 17-slide project overview presentation, followed by a discussion of the role and format of the CLC going forward. The meeting provided project updates, solicited feedback from the CLC on the elements presented, and outlined the next steps for the project. It included a question and answer discussion period

Project Overview

- The Project Team presented an outline of the issues underlining the need for this dyke rehabilitation assessment, i.e., the dykes are deficient, they do not satisfy current engineering design standards and there is a risk that they could fail, and the broad categories of evaluation criteria (social, biological, technical, financial) typically applied to Class EA dyke rehabilitation projects.
- The baseline conditions information collected to date was presented. For design analysis purposes, the two dykes have been divided into six “segments” (five segments of the Pickering Dyke and one segment for the Ajax Dyke). Each segment of the dykes has distinct conditions that allow them to be evaluated separately in devising appropriate engineered solutions.
- It was indicated that two types of alternative solutions were being considered: those that include a structural component are labelled “hard” engineering solution, and those that do not are labelled “soft” engineering solutions. The “do-nothing” alternative was also considered.
- Members of the CLC were asked to consider what options might be applicable and were invited to offer additional criteria by which prospective rehabilitation option(s) might be assessed. Members of the CLC were also asked to provide any local knowledge of existing conditions within the study area.

Next Steps

- The timeline for the CLC's role in this Class EA was discussed with the next meeting scheduled for October 17, 2019 at the Pickering Recreation Complex, 1867 Valley Farm Rd (6:30 – 8:30p).
- CLC members were advised that based on their input (during the meeting and through their completed comment sheets), the Project Team would have preliminary preferred rehabilitation options for each distinct "segment" of the two dykes to present for discussion at the next CLC meeting.

The Consultation Report for this meeting is provided in Appendix J. It includes meeting minutes, presentation material and comment forms.

8.2.2 CLC MEETING #2 – OCTOBER 17, 2019

The second meeting of the Project's Community Liaison Committee (CLC) focussed largely on providing CLC members with an update on the evaluated alternative solutions and proposed preferred solution being considered for each of the six dyke segments. The meeting provided progress updates, requesting feedback from the CLC on the elements presented, and indicated the next steps for the project. It included a question and answer discussion period.

Project Update

- The Project Team reviewed the need for these dyke's rehabilitation assessments, explaining that the dykes are deficient, they do not satisfy current engineering design standards, and there is a risk that they could fail.
- The Project Team presented conceptual "hard" and "soft" engineered Alternative Solutions that have been developed for the five segments of the Pickering Dyke and for the single segment of the Ajax Dyke. Generalized plan views were presented that illustrated the amount of land that would be required to rehabilitate these six dyke segments (permanently), and, the land that would be temporarily required during construction.
- Applying the socioeconomic, natural, technical, and cost evaluation criteria presented at the first CLC Meeting (September 11, 2019), the Project Team presented the preliminary preferred Alternative Solution for each dyke segment.

Next Steps

- The Project Team explained that, with the input provided by CLC members, the next phase of the Project would develop more detailed (and site-specific) Design Concepts for each dyke segment including cross section profiles of the dykes at key locations along their lengths. Different options for these will be prepared and evaluated by the Project Team to select preferred Design Concepts.
- CLC members were provided an update on the schedule for the dyke designs and the continuing public/stakeholder consultation process.
- TRCA committed to formalizing a call-in number for reporting ice/debris jams, to address comments raised at the first CLC meeting.
- CLC members were reminded of the upcoming Public Information Centre, scheduled for October 30, 2019, where, it was explained, the preferred Alternative Solution for each of the six dyke segments would be presented for public review and comments.

The Consultation Report for this meeting is provided in Appendix J. It includes meeting minutes, presentation material and comment forms.

8.2.3 CLC MEETING #3 – MARCH 10, 2020

This third meeting of the Project's Community Liaison Committee (CLC) included a review of display panels and a 33-slide presentation describing the assessment of Design Concepts for the rehabilitation of the Pickering and Ajax dykes, and, the selection of the Preferred Design Concepts for each dyke segment. The meeting provided progress updates, solicited feedback from the CLC on the elements presented, and outlined the next steps for the project. It included a question and answer discussion period.

Project Update

- The Project Team provided a recap of the project background and of the work conducted to select Preferred Alternative Solutions for individual dyke segments during the previous project phases.
- The Project Team presented the rationale for consolidating the six dyke segments, employed in the earlier phases of the project, into three segments: two segments for the Pickering Dyke (P1 and P2) and a single segment for the Ajax Dyke (A1) based on which segments had the same preferred Alternative Solution from the previous project phase (hard engineered ("hard") solutions vs soft engineered ("soft") solutions). This segmentation was used to evaluate Design Concepts individually for each segment.
- The Project Team presented an overview of the Design Concepts evaluated for each preferred Alternative Solution and for each of the three consolidated dyke segments.
- The Project Team described the evaluation of the Design Concepts and presented the recommended Preferred Design Concepts, highlighting features specific to each dyke segment, their respective environmental effects, the measures proposed to mitigate undesirable effects, and, their predicted net impacts
- It was explained how consultations and engagement with the Project's Technical Advisory Committee and Executive Steering Committee, along with the input from the Community Liaison Committee and the October 30, 2019 Public Information Centre, informed the design of, and evaluation of potential Design Concepts.

Next Steps

- CLC members were provided an update on the next steps in the Class EA process and were asked if they would like to have a final CLC meeting to review the Environmental Study Report or if they preferred to review it and provide feedback individually.

The Consultation Report for this meeting is provided in Appendix J. It includes meeting minutes, presentation material and comment forms.

8.2.4 CLC MEETING #4 – AUGUST 5, 2020

The fourth meeting of the Project's Community Liaison Committee (CLC) was held on August 5, 2020, via videoconference and teleconference, using the platform GoToMeeting. It consisted of a session to respond to questions from members of the CLC after their review of the project's draft report: *Conservation Ontario Class Environmental Assessment for the Rehabilitation of the Pickering and Ajax Flood Control Dykes*, Draft Rev C. The project team responded to the questions of the CLC and received feedback from the CLC that was used to incorporate additional detail and clarifications into the report. Minutes of the meeting are provided in Appendix J.

8.3 Public Information Centres (PIC)

In accordance with the letter and spirit of Class Environmental Assessment for Remedial Flood and Erosion Control Projects, two widely advertised Public Information Centres (PIC) were held. The original plan was that one PIC would take place within each of the Pickering and Ajax communities. As explained in the subsequent sections the format of the second PIC had to be adjusted due to the COVID-19 pandemic that occurred during the time when this meeting was planned to take place. Comments received during the Public Information Centres are summarized in Appendix J.

8.3.1 PUBLIC INFORMATION CENTRE #1

The purpose of PIC #1 was to provide the community with:

- an introduction and background to the project
- an overview of the work completed to date, which included the baseline inventory and the assessments and analyses that resulted in the selection of preliminary preferred Alternative Solutions

General description of the format and content of PIC # 1 are provided below. The corresponding Consultation Report is provided in Appendix J. It includes meeting minutes, presentation material and exit questionnaire comment forms.

Date/Time: Wednesday, October 30, 2019

5:30 – 8:30pm

Venue: Chestnut Hill Developments Recreation Complex
Program Room A
1867 Valley Farm Road
Pickering, Ontario

Notice

Notice of the October 30, 2019 Pickering and Ajax Dykes Rehabilitation Public Information Centre (PIC) #1 was communicated to stakeholders through a variety of mechanisms including placement of a Notice of PIC in a local newspaper, and, to other prospective stakeholders via mail and/or email.

Broadcast Notice

Notice of the October 30, 2019 Public Information Centre was placed in the Ajax Pickering News Advertiser October 10 and 17, 2019. Each of these editions had a circulation of 54,400 (approximately).

Stakeholder Notice

In addition to the widely circulated Notice placed in two editions of the local paper, Notice of the PIC was also distributed to municipal, regional, provincial, and federal officials, abutting landowners, known user/naturalist groups, and utilities, as follows:

- Municipal, Regional, Provincial, Federal officials: 35 notices, via mail and email (on or about October 10 and 25, 2019)
- Neighbours/Abutting Landowners: All properties within the Project Study Area (Approximately 3000 people), via mail (October 21 - 25, 2019)
- User/Naturalist Groups: two, via email (on or about October 25, 2019)
- Utilities: five, via email (on or about October 25, 2019).
- Indigenous Peoples (Appendix J)

Meeting Format

The three-hour Public Information Centre (PIC) was organized around three discrete sections: open house display boards; presentation/Q&A; one-on-one breakout.

Upon arrival, attendees were asked to register and provide contact information (33 people registered), if they wished to be kept apprised of Project developments. Throughout the PIC, attendees were encouraged and reminded to complete a short exit questionnaire before leaving.

Display Boards

For the first hour attendees were able to peruse display boards (31) that explained the proposed Pickering and Ajax Dyke Rehabilitation Project. Project Team representatives were available to answer questions throughout the meeting. Specifically, the display boards described:

- the reasons for the proposed rehabilitation of the Pickering and Ajax dykes
- the Class Environmental Assessment, Project scope, and the regulatory/stakeholder review and approvals
- existing conditions within the Study Area
- the rationale for dividing the Pickering and Ajax dykes into six (6) segments for this analysis
- the Alternative Solutions considered, including the “soft” and “hard” engineering solutions, identified to rehabilitate the Pickering and Ajax dykes
- the preliminary preferred Alternative Solution for each of the six segments, and, the bases by which these were selected

Presentation

At approximately 6:30 pm attendees were invited to a PowerPoint presentation that provided an overview of the Project. The 20-minute presentation was followed by a facilitator-guided question/answer period, after which attendees were encouraged to peruse the display boards in greater detail, and/or, to seek out Project Team representatives to discuss particular interests or concerns.

Project Team Representation

The Open House and presentation portions of the PIC were supported by a 10-person team of Project specialists (TRCA and KGS) and a meeting Facilitator (ECCI) who were available to answer questions.

PIC Exit Questionnaire

Prior to leaving the PIC, attendees were asked to complete a short, five-question comment sheet. Of the 33 registered attendees, 10 complete or partially complete comment sheets were received.

8.3.2 PUBLIC INFORMATION CENTRE #2

The purpose of PIC #2 was to provide the community with:

- a recap, introduction and background to the project
- an overview of the work completed to date, which included the baseline inventory and the projects assessments and analyses and focused on the selection of preliminary preferred Design Concepts, as well as in the evaluation of project impact and mitigation measures.

General description of the format and content of PIC # 1 are provided below. The corresponding Consultation Report is provided in Appendix J. It includes notices, meeting minutes, presentation material and exit questionnaire comment forms.

This meeting, originally planned to take place in a community centre in Ajax, had to be modified to a web based format in order to follow public health guidelines implemented in response to the COVID 19 pandemic. This was achieved by using the platform GoToWebinar.

Date/Time: Tuesday, April 28, 2020
6:30 – 8:00pm

Venue: GoToWebinar
(web-based meeting platform)

Notice

Notice of a March 24, 2020 Public Information Centre (PIC) #2 appeared in the March 5, 2020 local newspaper and was distributed to stakeholders via Canada Post on or about March 9, 2020 and via email on March 6, 2020 (Appendix J).

In response to the COVID-19 pandemic, the PIC was rescheduled to Tuesday April 28, 2020 as an online meeting.

Stakeholders were notified of this needed change with a Notice of Postponement communicated through the same means as the original Notice of PIC as well as through multiple social media platforms. The Notice of Postponement of the PIC appeared in the March 19, 2020 local newspaper and was distributed to stakeholders via mail on or about March 19, 2020 and via email on March 17, 2020.

Broadcast Notice

Notice of Postponement that Public Information Centre #2 was to be rescheduled from March 24, 2020 to April 28, 2020 appeared in the March 19, 2020 edition of the Ajax Pickering News Advertiser (circulation 54,400 approximately).

Due to the need to quickly reschedule it, at the time of the print Notice some of the details of the PIC were unknown, only the date was set. As such, the Notice advertised that details would be provided on the project website (www.TRCA.ca/PADR) and directly sent to those registered on the project mailing list. It should be noted that 10 interested parties/individuals requested to be added to the project mailing list following advertisement of the Notice of PIC Postponement.

Notices advertising the online PIC were posted to TRCA's Facebook, Twitter and LinkedIn profiles on April 27, 2020 to further advertise the opportunity to participate. Posts included a link to the project webpage where interested parties could then click the registration link for the online PIC. A sample screenshot of the postings can be found in Appendix J.

Stakeholder Notice

The Notice of Postponement of the PIC was also distributed via mail or email to the following stakeholders:

- Municipal, Regional, Provincial, Federal officials: 37 notices via email (on April 23, 2020)
- Neighbours/Abutting Landowners: All properties within the indirect Study Area approximately 3000 people), via mail (week of March 23, 2020) received notices. Follow-up communication with PIC registration details were only sent to those on the project mailing list.
- User/Naturalist Groups: two, via email (on April 23, 2020)
- Utilities: five, via email (on April 23, 2020)
- Indigenous Peoples (Appendix J)
- Interested parties who requested to be on the project mailing list: 30, via email (on April 23, 2020).

A follow-up email with details of how to register for and participate in the PIC was also distributed via email to the project mailing list.

Meeting Format

The one and one-half hour Public Information Centre (PIC) webinar was organized around three discrete sections: open house style display boards, a one-hour, 35-slide PowerPoint presentation by TRCA's Project Manager followed by a Question & Answer (Q&A) period.

To promote public understanding of the project and the upcoming PIC (April 28, 2020), the PIC display boards were posted on the project website on April 24, 2020.

The PIC webinar was hosted using GoToWebinar, a freely available and easily accessible open software platform. Attendees were required to register to attend the webinar, either in advance or during the event. The registration process requires the name and email address of the registrant and provides a unique link to join to the meeting for each registrant. This provided a record of PIC attendance based on how many unique registrants joined the meeting, however it does not indicate if more than one person sat together to attend the PIC from the same device.

PIC webinar attendees were advised that they could post any questions at any time throughout the webinar, and, that the moderator would raise them for discussion during the Q&A period.

Of the 30 individuals who pre-registered for the webinar, 26 attended the event. The entire PIC webinar (presentation and Q&A) was recorded and posted on the project website.

The Project website included a comment form through which stakeholders could provide feedback for a seven-day period subsequent to the April 28, 2020 PIC. Additionally, stakeholders were encouraged to contact the Project Team via email at any time with questions or concerns.

Members of the public and stakeholders were offered the option to schedule an individual phone call with the project team to discuss the project, if they were uncomfortable with the webinar format, or unable to access all of the informational materials. No one made this request.

Display Material

To accommodate the fact that the Public Information Centre was to be held as a webinar, material that would normally have been on display at the PIC was posted on the project website April 24, 2020, in advance of the April 28, 2020 scheduled PIC webinar. This material included drawings of the preliminary preferred Design Concept as well as a table summarizing the evaluation of Design Concepts to select the preferred ones.

Presentation Material

As part of the PIC webinar, TRCA's Project Manager presented a 35-slide PowerPoint presentation. That presentation included:

Review of the reasons for the proposed rehabilitation of the Pickering and Ajax dykes

- Description of the Class Environmental Assessment process, Project scope and objectives, and the regulatory/stakeholder review and approvals
- A brief overview of existing conditions within the Study Area as it pertains to the selection of the preferred Alternative Solution and Design Concept and the rationale for dividing the Pickering and Ajax dykes into segments with consistent characteristics
- Review of the selection of the preferred Alternative Solutions which was presented in detail at PIC #1: "soft" and "hard" engineered solutions[2] to rehabilitate the Pickering and Ajax dykes, capable of providing 100-year storm flood protection
- The refinement of the preferred Alternative Solutions into six (6) more detailed Design Concepts, a description of each Design Concept's components, how it functions and the pros and cons
- Evaluation and the selection of the recommended preferred Design Concept for each dyke segment
- A discussion of the recommended Design Concepts' potential impacts, and, the measures proposed to mitigate undesirable impacts and the residual impacts after mitigation
- Focused discussion on changes/improvements to flood conditions
- Next Steps

Project Team Representatives

Project Team representatives were online and available throughout the webinar to answer questions. The Project Team consisted of five Project specialists (TRCA and KGS), a moderator (TRCA), and three support staff (TRCA, KGS and ECCI).

Exit Questionnaire

Of the 30 individuals who pre-registered for the webinar, 26 attended the event.

At various points throughout the webinar, attendees were encouraged to complete a short Comment Form. Three complete or partially complete comment forms were received. Following the PIC, two individuals contacted the Project Team via email with questions.

[2] "Soft" solutions rely on earth-fill to create stable dyke embankments. "Hard" solutions include one or more structural components to strengthen the above-ground portion of the dyke embankments.

8.4 Individual Meetings with Abutting Landowners

TRCA conducted meetings with individual landowners immediately adjacent to the anticipated dyke construction to allow for in-depth discussion of the proposed works and address any individual concerns or comments. TRCA offered one-on-one meetings with individual landowners. Individual meetings were held on March 4th, 5th and 10th, 2020. Site visits were also offered to view the dyke and/or landowner's property and further discuss the proposed works and potential impacts specific to their property. Participants were presented with plan view drawings and cross-sections of the recommended design concepts for the segment applicable to their properties, and the project team described the components of the dyke, what it would look like after construction and what impact could be expected during construction. A summary of the consultation with these individual land owners is provided in Appendix J.

8.5 Indigenous Communities Engagement

TRCA completed Indigenous Communities Engagement as part of this project. A summary of this engagement is found in TRCAs' report entitled "Indigenous Engagement: Pickering and Ajax Dykes Rehabilitation Project" dated April 2020. The report is provided in Appendix J.

8.6 Government Agencies

8.6.1 MINISTRY OF NATURAL RESOURCES AND FORESTRY (MNRF)

A notice of commencement and letter was sent to the MNRF on August 9, 2019 (Appendix J).

In response to the letter of commencement, representatives from the MNRF Aurora District invited members of the project team, from KGS Group and TRCA, to a meeting that took place on the district's office on September 3, 2019. Three staff from MNRF attended the meeting representing the areas of expertise: Planning, Natural Heritage, and Lands and Waters Technical Specialist. At the meeting the project team briefly described the project background, objectives, schedule and EA process to MNRF staff and asked what subsequent requirements from MNRF would be. MNRF staff indicated that:

- Ecological/biologic aspects of the project were to be discussed with the Ministry of the Environment, Conservation and Parks. Species at Risk screening is now done by MOECP as well.
- The Public Lands Act applies if the bed of the river to the water's edge is considered Navigable Water.
- They would like project information circulated to them via the MNRF Planner at the following key project milestones: PIC#1, PIC#2 and the draft ESR.
- If LRIA does not apply to the proposed works then MNRF's involvement will be limited to the above key milestone reviews. If LRIA does apply, the Project Team asked that MNRF be more involved throughout the EA.

MNRF indicated that they would initially evaluate the project description and provide guides regarding applicability of the LRIA. In a subsequent communication, the MNRF indicated that in these cases it is the applicant who should assess applicability of the LRIA, and that they could only provide an official response after reviewing a fully completed design and permit application.

It transpired from verbal communications with MNRF, however, that LRIA approval applies to structures that impound water, by being placed at least partially across a water course, and that limit the water course's natural conveyance. Given that the Pickering and Ajax Dykes extend longitudinally in the streamwise direction and do not limit the natural conveyance of the West Duffins Creek and the Duffins Creek, this interpretation of the guidelines suggest that they do not require approval under the LRIA.

8.6.2 MINISTRY OF ENVIRONMENT CONSERVATION AND PARKS (MECP)

A Notice of commencement was sent to the Species at Risk Branch of the Ministry of Environment Conservation and Parks on September 18,2019 along with some details of noted Species at Risk within the Project Study Area. The Ministry replied via e-mail on November 27, 2019 indicating that at that time, they had no comments and wished to be kept up to date on the project, at which point they were added to the project mailing list. Correspondence is provided in Appendix J.

8.6.3 REGION OF DURHAM

TRCA conducted a Stakeholder Meeting with the Region of Durham on November 5, 2019. The purpose of the meeting was to discuss the current EA status/ proposed works, confirm Regional infrastructure within the Direct Environmental Study Area and project next steps. The Region of Durham provided information as to their expectation for Works near their infrastructure. Minutes of the meeting are provided in Appendix J.

8.6.4 HYDRO ONE

Hydro One provided a letter to TRCA in September of 2019 regarding the project as it related to potential impacts to their high voltage line and any subsequent Hydro One requirements under the Class Environmental Assessment for Minor Transmission Facilities. Subsequent to this TRCA provide a follow up letter and Project Brief to Hydro One. A second letter was received by TRCA from Hydro One in March for 2020, again detailing potential Hydro One requirements should there be any impacts to their high voltage line and acknowledging that the presented Preferred Alternative Solution is in proximity to but does not directly affect the existing Hydro One high voltage facilities within the Study Area. Correspondence is provided in Appendix J.

8.7 Technical Advisory Committee

A Technical Advisory Committee (TAC) was established for this project. It included technical staff and representatives from the City of Pickering, Town of Ajax, Region of Durham and TRCA. The Project Team, consisting of TRCA's Project Manager and supporting staff and KGS Group's team, met with the TAC three times during the course of the project. These meetings are briefly described below.

8.7.1 TAC MEETING NUMBER 1

This meeting took place on September 4, 2019 at Ajax Town Hall. It was held to present and discuss the baseline inventory, preliminary Alternative Solutions and the preliminary evaluation criteria. The general approaches discussed in Section 5: 'hard' and 'soft' engineering solutions were described and specifics of each alternative were discussed. During this meeting, the TAC provided feedback on those aspects of the project as well as on the criteria to be used to evaluate the Alternative Solutions.

The project team was advised of the potential interaction of the project with the future Durham (Hwy 2) Bus Rapid Transit (BRT) project, and was recommended to look into the merits of implementing only minor repairs to the dykes, such as removing vegetation only, as well as of removing the dykes, as options. The TAC recommended to weight all evaluation criteria equally.

8.7.2 TAC MEETING NUMBER 2

This meeting took place on October 1, 2019 at Pickering City Hall. It was held to review the project progress to date, including presentation of the Alternative Solutions considered and how they were screened to pre-select the do-nothing alternative as well as the ‘hard’ and ‘soft’ engineering solutions, the evaluation of these alternatives and selection of preliminary preferred Alternative Solutions for each dyke segment. During this meeting, the TAC provided feedback on those aspects of the project as well as on the considerations for the subsequent refinement of the preliminary preferred Alternative Solutions (Section 5) into Design Concepts (Section 6).

Details of the evaluation were collectively discussed. The TAC recommended to confirm the applicability of LRIA to the proposed works before progressing too far. Also, to consider aspects related to access to the dyke, both for public recreational use and for facilitating maintenance.

8.7.3 TAC MEETING NUMBER 3

This meeting took place on February 25, 2020 at Ajax Town Hall. It was held to review the project progress to date, including presentation of the Design Concepts considered and their evaluation, impacts and proposed mitigation measures. The feedback received up to date from the various committees and the public was presented. During this meeting, the TAC provided feedback on those aspects of the project as well as on the preliminary preferred Design Concept.

A recommendation from this meeting was to consider recommending more natural rock protection over traditionally more angular rip-rap, for fish habitat improvement purposes. This recommendation was included in the study and proposed for subsequent designs with consideration of technical requirements. It was discussed that depending of the condition of the underground infrastructure, particularly in the area of the Ajax Dyke, there could be opportunities for optimizing the dyke alignment if the infrastructure merits major rehab or replacement. It was also discussed how the limiting condition for the level of flood protection on the Ajax Dyke is the elevation of Church St S, where the dyke ties in.

8.8 Executive Steering Committee

An Executive Steering Committee (ESC) was established for this project. It included senior leadership staff from the City of Pickering, Town of Ajax and TRCA. The Project Team met with the ESC two times during the course of the project. These meeting are briefly described below.

8.8.1 ESC MEETING NUMBER 1

This meeting took place on October 9, 2019 at Ajax Town Hall. It was held to present and discuss the project findings up to date including the Alternative Solutions and their evaluation as well as the input received from the TAC and the CLC. During this meeting, the ESC provided feedback on those aspects of the project as well as on the criteria to be used to identify and evaluate Design Concepts for the proposed solutions.

The ESC recommended to consider all costs when evaluating the alternatives, including those related to potential private property impacts, as well as long term maintenance of the dykes. It also recommended to consider access for maintenance and maintenance equipment.

8.8.2 ESC MEETING NUMBER 2

This meeting took place on February 28, 2020 at Pickering City Hall. It was held to present and discuss the project findings up to date, including the Design Concepts and their evaluation, impacts and proposed mitigation measures, and the input received from the TAC, CLC and PIC. The project team provided estimates of cost of the dyke rehabilitation as well as benefit/cost ratios. During this meeting, the ESC provided feedback on those aspects of the project and specifically the evaluation of Design Concepts and the preliminary preferred Design Concept.

It was recommended to consider site meetings with adjacent landowners during the detailed design process, and implementation of pre and post construction condition surveys for surrounding buildings and infrastructure. to the various departments within the municipalities that would be involved in subsequent design stages were noted.

8.9 Notice of Filing

On August 27, 2020 TRCA issued a Notice of Filing Document for Review of the Pickering and Ajax Dyke Rehabilitation Class EA Environmental Study Report, in accordance with the Class EA. The Notice of Filing Document for Review (included in Appendix J) was distributed among stakeholders in the Pickering and Ajax communities and other potentially interested parties:

- Ad Placement: August 27, 2020
  - Ajax Pickering News Advertiser (circulation 54,000, approximately),
- Direct Mail/Email: August 27, 2020
  - Municipal, regional, provincial, federal officials and politicians
  - Abutting Landowners and all properties within the Project Study Area (circulation 3,000 approximately)
  - User/Naturalist groups
  - Utilities
  - Indigenous communities and agencies
- Project Website: August 27, 2020 - ongoing
  - https://trca.ca/PADR, where the final report and project material, e.g., background information, project updates and notices were posted for public review and comment.

9.0 MONITORING

Monitoring programs have been developed for each of the three phases of the project, which include:

- Pre-Dyke Rehabilitation
- Dyke Rehabilitation Construction; and
- Post Dyke Rehabilitation

Pre-dyke rehabilitation phase monitoring will help to establish baseline aquatic conditions. Dyke rehabilitation construction phase monitoring will ensure that the construction activities are undertaken in an environmentally sound and responsible manner. Post-dyke rehabilitation phase monitoring will be undertaken to meet any regulatory guidelines and any impact offset monitoring requirements. Additional monitoring items may be required at the time of construction, due to new legislation requirements (e.g. Species at Risk), or items that arise during detailed design. Monitoring plans would be modified at the time of construction if required.

9.1 Pre-Dyke Rehabilitation Monitoring

The purpose of the pre-dyke rehabilitation monitoring will be to acquire general baseline, specifically within the West Duffins Creek local to where in-water and remedial bank work will occur. At a minimum, baseline data would be collected during the detailed design phase of the project and would be limited to the area where expected rehabilitation activities would occur. Additional structure baseline date would be acquired prior to construction as part of a Vibration Monitoring program. Baseline structure assessments procedures and protocols would be developed during detailed design.

TABLE 9-1: PRE-DYKE REHABILITATION PHASE MONITORING

Item	Description of Monitoring Activity
Aquatic	Conduct fish sampling and water temperature recording activities as per appropriate Provincial Protocols, to develop a baseline inventory within reaches of the West Duffins Creek where in-water or bank work will take place. Fish sampling upstream of the work area (at TRCA fish monitoring station DF003WM) is considered representative of the fish community within the work area as there are no fish barriers between the two areas. Water temperature recording downstream of the work area is recommended to monitor for stream thermal impacts.
Built Environment	Conduct baseline condition assessment of structures immediately prior to construction activities. Structures to be assessed includes buried sewers/pipes, above ground utility infrastructure, bridges, and private buildings such as homes and garages, that are within the construction area or reasonably close to the construction and access areas that vibration impacts are a consideration. The Region of Durham recommended a Quality Level B investigation of their buried sewers be conducted at the detailed design stage, with a Quality Level A being conducted where required. Ground vibrations from construction of the remediation works will have the potential to adversely impact nearby structures. Pre construction inspections of nearby properties/structures should be completed jointly by TRCA and the construction contractor. Similar inspections of properties/structures are recommended shortly after construction.

9.2 Dyke Rehabilitation Construction Monitoring

The purpose of the dyke rehabilitation construction monitoring program is to ensure that construction activities are being undertaken as per the contract plans and specifications, and that mitigation measures identified in the EA and the Contractors Environmental Management Plan are being carried out, as well as specific actions required in any permits and approvals. It will ensure that activities and/or mitigation measures are not creating unintended adverse environmental impacts and provide the information necessary to correct or develop alternative mitigation measures if required. In addition, it will provide a record of the construction process, typically in the form of daily and weekly inspection reports that will detail progress, issues and actions taken to resolve any issues. A 3rd-party Environmental Monitor may be retained to provide construction monitoring services. Table 9-2 summarizes the proposed monitoring program.

Site restoration and clean-up activities will be part of the Contractors responsibility upon completion of construction. Final inspection of construction works, and restoration activities would result in the preparation of a deficiencies list, if required, to be addressed by the Contractor, prior to final payment. TRCA or its site representative would undertake monitoring and documentation of this process. TRCA will be responsible for the review and acceptance of the constructed works prior to project completion.

TABLE 9-2: DYKE REHABILITATION CONSTRUCTION PHASE MONITORING

Item	Description of Monitoring Activity
Mitigation, Permitting and Monitoring Requirements	Monitor effectiveness of mitigation measures and contingency plans related to (but not limited to) the following Environmental Plan components; • Air Quality Management Plan • Noise and Vibration Monitoring • Erosion and Sediment Control Plan • Fuelling and Fuel Storage Plan • Spill Response Plan • Species at Risk Plan • Protection of Archaeological Values Plan • Traffic Control Plan • Site Access and Public Safety Plan • Fish and Wildlife Collection Plan Results of monitoring will be documented in daily and weekly inspection reports, including effectiveness of proposed mitigation, changes to proposed mitigation and any remedial actions completed.

9.3 Post-Dyke Rehabilitation Phase

The purpose of the post-dyke remediation phase monitoring will be to ensure that post construction rehabilitation measures and any regulatory requirements are being met, and that there have been no impacts to the local environment or structures. Post construction inspections of nearby properties and infrastructure are recommended.

One year after construction completion a Post Construction Monitoring Report shall be prepared and made available to parties whom expressed interest or government reviewers who expressed a concern during the Class EA process. The One Year Post-Construction Monitoring Report will include:

- An assessment of the effectiveness of the project in achieving its goals
- An assessment of the effectiveness of mitigation measures to eliminate or reduce impacts that were identified through the Class EA process (refer to Section 7.0)
- Documentation of changes in baseline site conditions (positive and negative) attributed to the remedial works undertaken (as opposed to natural processes or other causes), and measures that have/will be taken to address negative impacts
- Documentation of follow-up maintenance as necessary
- A schedule for ongoing monitoring

Additional monitoring activities are proposed beyond the one-year post-construction monitoring. A Monitoring Report documenting results should be prepared at the end of each respective monitoring period. This proposed post dyke remediation monitoring program is provided in Table 9-3.

TABLE 9-3: POST DYKE REHABILITATION MONITORING

Item	Description of Monitoring Activity
Aquatic	• Complete a fish inventory, conditional on approval from MECP due to presence of Redside Dace. Benthic inventory may be completed as an alternative if fish monitoring is not allowed. Monitoring would be completed in years 1, 3 and 5 after construction. • Fish/Benthic monitoring would be conducted upstream of Segment P1 (Pickering Dyke) and would be representative of the fish community throughout the P1 using Ontario Stream Assessment Protocols.
Physical	• Monitor stability of the channel over 5 years during alternating years. Monitoring would include completing channel cross-section measurements, and visually inspecting the stability of banks and effectiveness of erosion protection. • Monitor the dyke on an annual basis for settlement, complete culvert inspections and exercise flap gates. Complete post event inspections as required. • To determine the need for erosion protection in the “moderate” risk segments of the dykes, complete comparative overlay assessments every 5 years to monitor the proximity of the watercourse to both the Pickering and Ajax Dykes. At the Pickering Dyke, install benchmarks along the top of the dyke to monitor the distance from the benchmark to the water course. Measurements would be taken at a frequency of every 1 to 2 years.
On-site Re-vegetation	• Conduct visual inspection of grass /hydroseed placed on the dykes and restoration plantings within disturbed area beyond the dykes to ensure vegetation health and growth. Inspections to be completed as part of construction warranty, therefore in the first year and annually up to 3 years after completion of placement.
Off-Site Compensation Planting	• Visual woodland regeneration monitoring completed in years 1,3, and 5 after construction, to determine health and survivability of plants as well as to determine success of habitat restoration objectives. As appropriate, applicable faunal may accompany vegetation monitoring such as breeding birds and incidental observations.
Vibration Monitoring Program	• Conduct post construction condition assessment of structures immediately following the conclusion of construction activities to determine if any impacts from vibration.

Following the completion of the Post-Dyke Rehabilitation Phase monitoring, TRCA will continue to monitor the dykes following the recommendations listed in the Pickering and Ajax Dykes Operation and Maintenance Manual (O&M Manual) for ongoing inspections, maintenance and operation. It is expected that inspections will be completed annually, at a minimum. The O&M Manual is to be developed during the detailed design phase and should consider the suggested content of the International Levee Handbook and then should be finalized after as-built information is available.

10.0 REFERENCES

1. Ashmore, P., and Church, M., 2001. The Impact of Climate Change on Rivers and River Processes in Canada. Geological Survey of Canada, Bulletin 555, 58 p.
2. Canadian Herpetological Society. (2017). Grey Treefrog. Canadian Herpetology Society. Retrieved August 6, 2019, from http://canadianherpetology.ca/species/species_page.html?cname=Gray%20Treefrog
3. City of Pickering. 2018. Official Plan 8th Edition.
4. Conservation Ontario. 2002, amended 2013. Class Environmental Assessment for Remedial Flood and Erosion Control Projects.
5. Conservation Authorities Act, R.S.O. 1990, c. C.27. Retrieved July 24, 2019 from https://www.ontario.ca/laws/statute/90c27?search=Conservation+Authority+act.
6. EDDmapS Ontario. (2019). Early Detection and Distribution Mapping System. Retrieved from EDDmapS Ontario: https://www.eddmaps.org/ontario/
7. Geo-Canada Ltd. 1984. Geotechnical Investigation Proposed Dyking Duffin Creek Pickering, Ontario.
8. Geo-Canada Ltd. 1985. Subsurface Investigation Proposed Dyking Duffin Creek Pickering, Ontario.
9. Geomorphic Solutions – Sernas Group Ltd., 2009. Duffins Creek Flood Protection Dyke Erosion Risk, Level of Service Assessment and Maintenance and Improvement Study, Interm Report. Prepared for Toronto and Region Conservation Authority, June 2009.
10. Endangered Species Act, 2007, S.O. 2007, c. 6. https://www.ontario.ca/laws/statute/07e06
11. Government of Canada (2018). Williams Treaties First Nations Settlement Agreement. https://www.rcaanc cirnac.gc.ca/eng/1542370282768/1542370308434
12. Lakes and Rivers Improvement Act, R.S.O. 1990, c. L.3. Retrieved August 1, 2019 from https://www.ontario.ca/laws/statute/90l03.
13. Lee, H. T., Bakowsky, W. D., Riley, J., Bowles, J., Puddister, M., Uhlig, P., & McMurray, S. 1998). Ecological Land Classification for Southern Ontario: First Approximation and its Application. Ontario Ministry of Natural Resources, Southcentral Science Section, Science Development and Transfer Branch.
14. Ministry of Environment, Conservation and Parks 2019. Air Quality Data Sets. http://www.airqualityontario.com/science/data_sets.php
15. Ministry of Natural Resources and Forestry. (2014). Butternut Assessment Guidelines - Assessment of Butternut Tree Health for the Purposes of the Endangered Species Act, 2007: Version 2. Ministry of Natural Resources and Forestry.
16. Ministry of Natural Resources and Forestry. (2019). Make a Map: Natural Heritage Areas. Retrieved from Ministry of Natural Resources and Forestry - Make a Map: Natural Heritage Areas:

http://www.gisapplication.lrc.gov.on.ca/mamnh/Index.html?site=MNR_NHLUPS_NaturalHeritage&viewer=NaturalHeritage&locale=en-US

17. Ministry of Natural Resources and Forestry. (2019). Natural Heritage Information Centre Species Lists. Retrieved from Ministry of Natural Resources and Forestry: https://www.ontario.ca/page/get-natural-heritage-information
18. Ministry of Natural Resoures2002. Technical Guide: River & Stream Systems Flood Hazard Limit.
19. Ministry of Natural Resources. 2011. Lakes and Rivers Improvement Act Administrative Guide, Technical Bulletins and Best Management Practices
20. Ontario Geological Survey (OGS), 2010. Surficial Geology, Southern Ontario, Google Earth layer, accessed August 8, 2019 from: http://www.mndm.gov.on.ca/en/mines-and-minerals/applications/ogsearth/surficial-geology.
21. Ontario Ministry of Municipal Affairs and Housing. (2014). Provincial Policy Statement, 2014. Toronto, ON. doi:ISBN 978-1-4606-3522-3
22. Ontario Ministry of Municipal Affairs and Housing. (2017). Greenbelt Plan (2017). Ministry of Municipal Affairs and Housing: http://www.mah.gov.on.ca/Page13783.aspx
23. Ontario Ministry of Natural Resources. (2010). Natural Heritage Reference Manual for Natural Heritage Policies of the Provincial Policy Statement, 2005. Second Edition. Toronto: Queen's Printer for Ontario. Retrieved from http://cloca.ca/resources/Outside%20documents/Natural%20Heritage%20Policies%20of%20the%20Provincial%20Policy%20Statement%20MNR%202010.pdf
24. Ontario Ministry of Natural Resources and Forestry. (2014). Butternut Recovery Strategy. Retrieved from Ontario Ministry of Natural Resources and Forestry: https://www.ontario.ca/page/butternut-recovery-strategy
25. Ontario Ministry of Natural Resources and Forestry. (2015). Significant Wildlife Habitat Criteria Schedules for Ecoregion 6E. Peterborough: Ontario Ministry of Natural Resources and Forestry Regional Operations Division, Southern Region Resources Section.
26. R.R.O. 1990, Reg. 334: GENERAL under Environmental Assessment Act, R.S.O. 1990, c. E.18 https://www.ontario.ca/laws/regulation/900334.
27. Simcoe Engineering Limited. 1982. Preliminary Engineering Report for Flood Protection on the Duffins Creek in Pickering Ajax Area.
28. Toronto and Region Conservation Authority (TRCA), 2003. A Watershed Plan for Duffins Creek and Carruthers Creek, 237 p.
29. Toronto and Region Conservation Authority. 2004. Fisheries Management Plan for the Duffins Creek and Carruthers Creek. Toronto and Region Conservation Authority. https://s3-ca-central 1.amazonaws.com/trcaca/app/uploads/2016/08/17171718/2004_DuffinsCarruthers_FisheriesManagementPlan.pdf

30. Toronto and Region Conservation Authority (TRCA) 2006. Erosion and Sediment Control Guidelines for Upran Construction.
31. Toronto and Region Conservation Authority (TRCA) 2016. Annual Local Occurrence Score and Local Rank Update. Toronto and Region Conservation Authority: https://trca.ca/app/uploads/2016/02/Local-occurrence-update_2015.pdf
32. Toronto and Region Conservation Authority (TRCA) 2018. Duffins Creek Watershed Report Card. 2018. TRCA. https://reportcard.trca.ca/watershed-report-cards/duffins-creek/#surface-water
33. Toronto and Region Conservation Authority (TRCA) 2019a TRCA 2015-2016 Water Quality Data from Regional Watershed Monitoring Program Sites. https://data.trca.ca/dataset/water-quality-monitoring-trca/resource/170c3236-35fb-40f3-8c7b-006042916fd6
34. Toronto and Region Conservation Authority (TRCA) 2019b. TRCA 2015-2016 Water Quality Data from Regional Watershed Monitoring Program Sites. https://data.trca.ca/dataset/water-quality-monitoring-trca/resource/1501ff20-53ca-4231-9b92-650038bc355d
35. Toronto and Region Conservation Authority (TRCA) 2019c. Stage 1 Archaeological Assessment Ajax & Pickering Dykes Rehabilitation Class EA.
36. Toronto and Regioin Conservation Authority (TRCA) 2019d. Erosion and Sediment Control Guide for Urban Construction. www.sustainabletechnologies.ca. http://sustainabletechnologies.ca/app/uploads/2020/01/ESC-Guide-for-Urban-Construction.Final.pdf.
37. Town of Ajax. 2016. Official Plan.
38. Valdor Engineering Inc. 2018a. MIKE Flood 1D-2D Model Development and Regulatory Floodplain Mapping Pickering / Ajax SPA's.
39. Valdor Engineering Inc. 2018b. Dyke Level of Service and Rehabilitation Report Pickering/Ajax SPA's.
40. Valdor Engineering Inc. 2018c. Flood Characterization and Preliminary Remediation Investigations Pickering / Ajax SPA's.

APPENDIX A

Reference Maps from Previous Studies

APPENDIX B

Geotechnical Investigation (KGS Group 2019)

APPENDIX C

Geomorphology Technical Memo (Palmer 2020)

APPENDIX D

Natural Environment Investigation (Palmer 2020)

APPENDIX E

Stage 1 Archaeological Assessment (TRCA 2019)

APPENDIX F

Built Environment Records

APPENDIX G

10% Design Drawings of Alternative Solutions for the Pickering Ajax Dykes

APPENDIX H

Technical Analysis

APPENDIX I

Drawings of Design Concept for the Pickering and Ajax Dykes Rehabilitation

APPENDIX J

Record of Consultation

KGS GROUP

Experience in Action